Appendix A
Stormwater Capacity Analysis for Spout Run Watershed, Arlington County, Virginia

Stormwater Capacity Analysis for Spout Run Watershed, Arlington County, Virginia

PREPARED FOR: Arlington County, Virginia

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DATE: July 6, 2012

PROJECT NUMBER: 240033.T3.SP.02.03

Contents

Appendixes

Tables

Figures

Executive Summary

Arlington County, Virginia, has initiated a project to analyze storm sewer capacity issues, identify problem areas, develop and prioritize solutions, and provide support for public outreach and education. The project is being implemented in phases by watershed.

The objective of this study is to identify areas in the stormwater collection system that do not have adequate capacity. Two rainfall events were modeled: (1) the June 25, 2006, storm event based on the rain gauge data at the Donaldson Run lift station and (2) a 10-year, 24-hour (10yr-24hr) storm based on the Soil Classification System (SCS) Type II distribution.

This technical memorandum (TM) focuses on the hydrologic and hydraulic analyses of the Spout Run watershed using the model PCSWMM 2011. It summarizes the County's existing storm sewer system in the watershed, the model development steps, data sources and gaps, and a summary of model assumptions and results.

The total rainfall for the June 2006 storm event is higher than that for the 10yr-24hr SCS Type II storm. Consequently, the results of the hydrologic analysis show that the June 2006 storm event produces more stormwater runoff (17 million cubic feet) than the 10yr-24hr SCS Type II storm (13 million cubic feet).

However, since the peak rainfall intensity for the 10yr-24hr SCS Type II storm (6.74 in./hr) is higher than the June 2006 storm event's (4.80 in./hr), the 10yr-24hr SCS Type II storm results in the watershed's having more conveyance capacity limitations. **Table 1** shows the summary of conveyance capacity limitations for each storm event.

The hydraulic modeling results presented in this TM should be reviewed with the understanding that several assumptions, primarily about pipe inverts, were made to fill data gaps. All assumptions should be verified when infrastructure is designed on the basis of this preliminary capacity modeling. This TM does not include an analysis of capacity upgrades to stormwater infrastructure designed to reduce the capacity limitations of the stormwater conveyance system.

TABLE 1
Summary of Conveyance Capacity Limitations

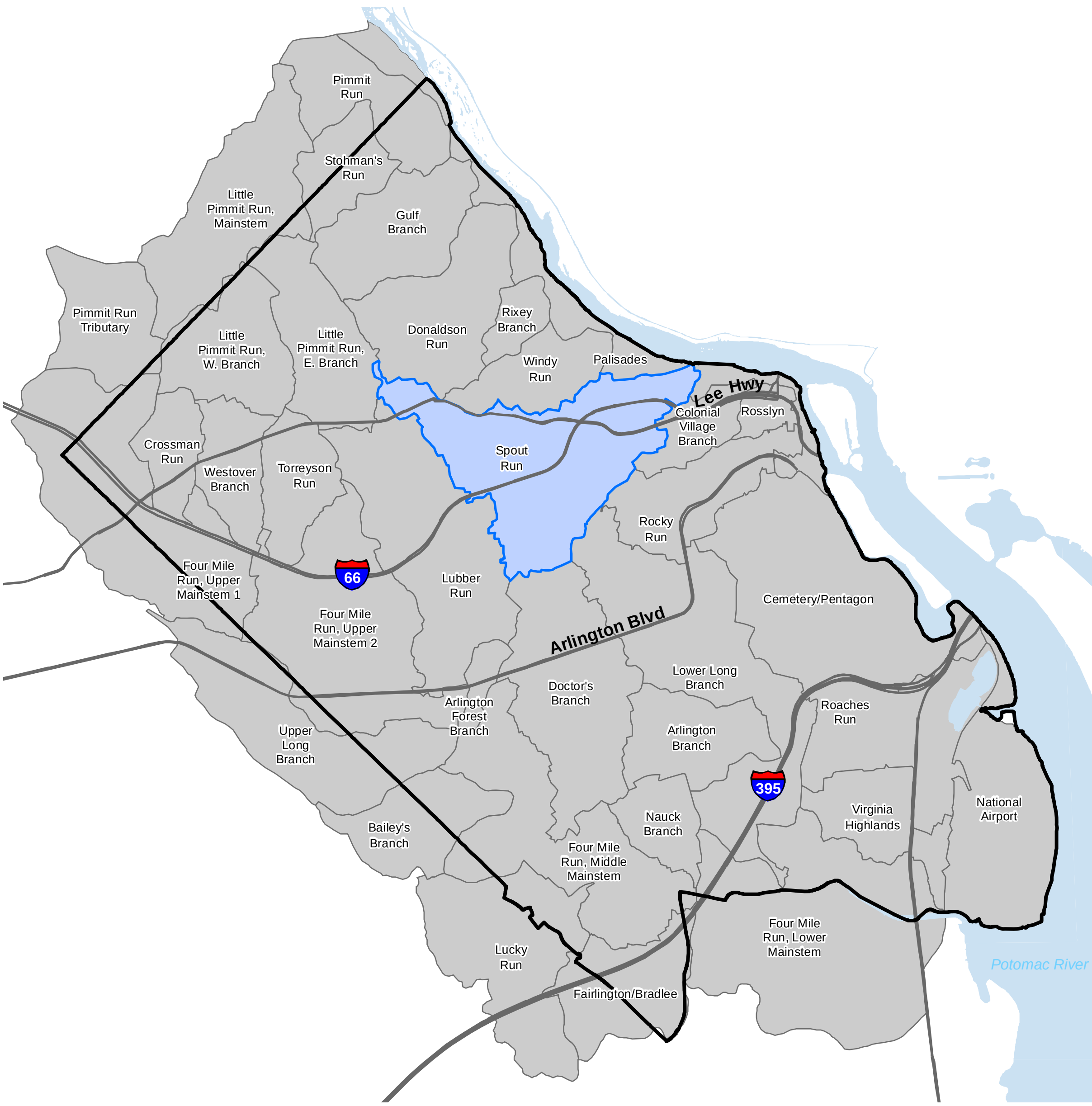
Scenario (with Storage)	Modeled System (Linear Feet)[a]	HGL Flooding Ground Surface		HGL Within 1 Foot of Ground Surface		HGL Surcharging Pipe Crown		Capacity Limitations	
		Linear Feet	Percent	Linear Feet	Percent	Linear Feet	Percent	Linear Feet	Percent
June 2006 storm event	41,411	3,503	8	4,856	12	11,186	27	19,544	47
10yr-24hr SCS Type II storm	41,411	9,662	23	14,725	36	10,979	27	35,366	85

HGL, hydraulic grade line.
[a]The modeled system in this table includes the closed pipe network described in Table 2. It does not include natural stream channels.

1 Introduction and Project Objectives

The work described in this TM is one of the major elements of a storm sewer capacity analysis project. Based on discussions with Arlington County staff, it is understood that the County is undertaking a larger effort to update and combine the 1996 Stormwater Master Plan and the 2001 Watershed Management Plan. This TM is part of the project that focuses on the storm sewer capacity issues.

FIGURE 1
Watersheds, Arlington County, Virginia (Spout Run Highlighted)



The purpose of this TM is to conduct a stormwater capacity analysis of the existing stormwater collection system for the Spout Run watershed, and to identify areas of the stormwater collection system that may not have adequate capacity based on two storm events: the June 2006 and the 10yr-24hr SCS Type II. **Figure 1** shows the various drainage watersheds for Arlington County.

2 Description of Existing Stormwater Collection System

2.1 Existing Versus Modeled Stormwater Collection System

The Spout Run watershed is approximately 1,123 acres and is the third largest watershed in Arlington County. The zoning is predominantly residential and commercial; the remaining area consists of a mix of industrial, institutional, and highways.

In general, stormwater runoff is collected by storm sewers and flows northeast to two large box culverts southeast of Interstate 66. The box culverts discharge to Spout Run along Spout Run Pkwy., which outlets to the Potomac River.

The stormwater collection system elements include the following:

- Closed conduits, such as gravity sewers and culverts
- Stream channel segments and ditches
- One pond (not modeled)
- Drainage inlets and junctions, such as roadside curb inlets, manholes, catchbasins, and yard and grate inlets

Elements of the ArcGIS existing stormwater collection system and the corresponding stormwater model developed for the Spout Run watershed are summarized in **Table 2**. The modeling effort includes the storm sewer network of pipes 36 inches in diameter and larger.

TABLE 2
Comparison of Existing Spout Run Stormwater System and Modeled System

Stormwater System Element	Existing	Modeled
Drainage area (acres)	1,123	1,071
Number of conveyance segments in stormwater system[a]	2,396	381
Total length of conveyance segments in stormwater system (linear feet)[b]	179,894	44,873
Size range (in.)[c]	4–125	30–120
Number of circular pipe segments	2,242	316
Number of noncircular pipe segments	60	38
Number of stream channel and ditch segments	81	21
Total length of stream channel segments (linear feet)	9,445	3,462
Number of other segments	13	0
Total length of other segments (linear feet)	489	0

TABLE 2 (CONTINUED)
Comparison of Existing Spout Run Stormwater System and Modeled System

Stormwater System Element	Existing	Modeled
Total inlets/junctions/end points (model nodes)	2,339	373
Catchbasins	1,042	53
Manholes	764	226
Yard inlets	52	13
Grate inlets	239	21
End walls	77	9
Junction chambers	75	50
Detention outlets	58	1
BMPs	1	0
Unknown types of nodes	30	0

[a]Segments include circular pipes, box culverts, elliptical pipes, ditches and streams.
[b]Includes streams and ditches.
[c]Modeling scope is limited to stormwater conveyance system pipes 36 inches in diameter and larger. Smaller diameter pipes are included only if they convey flows from pipes 36 inches in diameter and larger.

Observations

- Drainage area: The modeled drainage area is smaller than the existing drainage area received initially from the County. This is because of adjustments made to the watershed boundary during this project. The modeled drainage area was reduced because no major storm sewers discharge to the stream along Spout Run Parkway downstream of 21st Court N. Details on the adjustments are provided in as discussed in Section 2.3.
- Detention outlet: The County defines a detention outlet as an element connected to a detention pipe. These detention storage pipes are large-diameter pipes connected to downstream pipes typically having a diameter smaller (sometimes less than 36 inches) than that of the upstream pipe. In the Spout Run watershed, 58 detention outlets were identified in the ArcGIS PGDB (personal geodatabase), but only one is included in the model.
- BMP and unknown types of nodes: The "BMP" and "unknown types of nodes" are not modeled because they are connected to pipes with a diameter less than 36 inches.

Figure 2 shows the existing stormwater collection system in the Spout Run watershed; **Figure 3** shows the modeled system.

2.2 Data Sources

The storm drainage network data was provided by Arlington County in ESRI ArcGIS format for the entire County. As-built drawings were also provided by the County in February 2011 for the Spout Run existing stormwater collection system.

Initial base layers (GIS shapefiles) were obtained from Arlington County in June 2010. CH2M HILL worked with the County from September to November to complete the storm sewer data gathering for the Spout Run watershed. The final ArcGIS PGDB was delivered to CH2M HILL in June 2011.

During a preliminary review of the ArcGIS PGDB, it was determined that there was a need to survey key stream cross sections. CH2M HILL staff met with County staff to examine this issue in more detail. Surveyed data were delivered to CH2M HILL in November 2010.

The final data for the Spout Run watershed model were evaluated for quality. CH2M HILL found that 98 nodes and 153 links had missing data and/or anomalies. A data gaps TM detailing the suggested assumptions to fill in the gaps was prepared for the County in October 2011. (See **Appendix A**.)

2.3 Watershed Boundary Anomalies

The Spout Run watershed boundary was provided by the County. Anomalies were identified, and the boundary was adjusted as needed based on topographic data, orthophotos, and the stormwater collection system connectivity. The details of these changes are described in the data gaps TM (**Appendix A**).

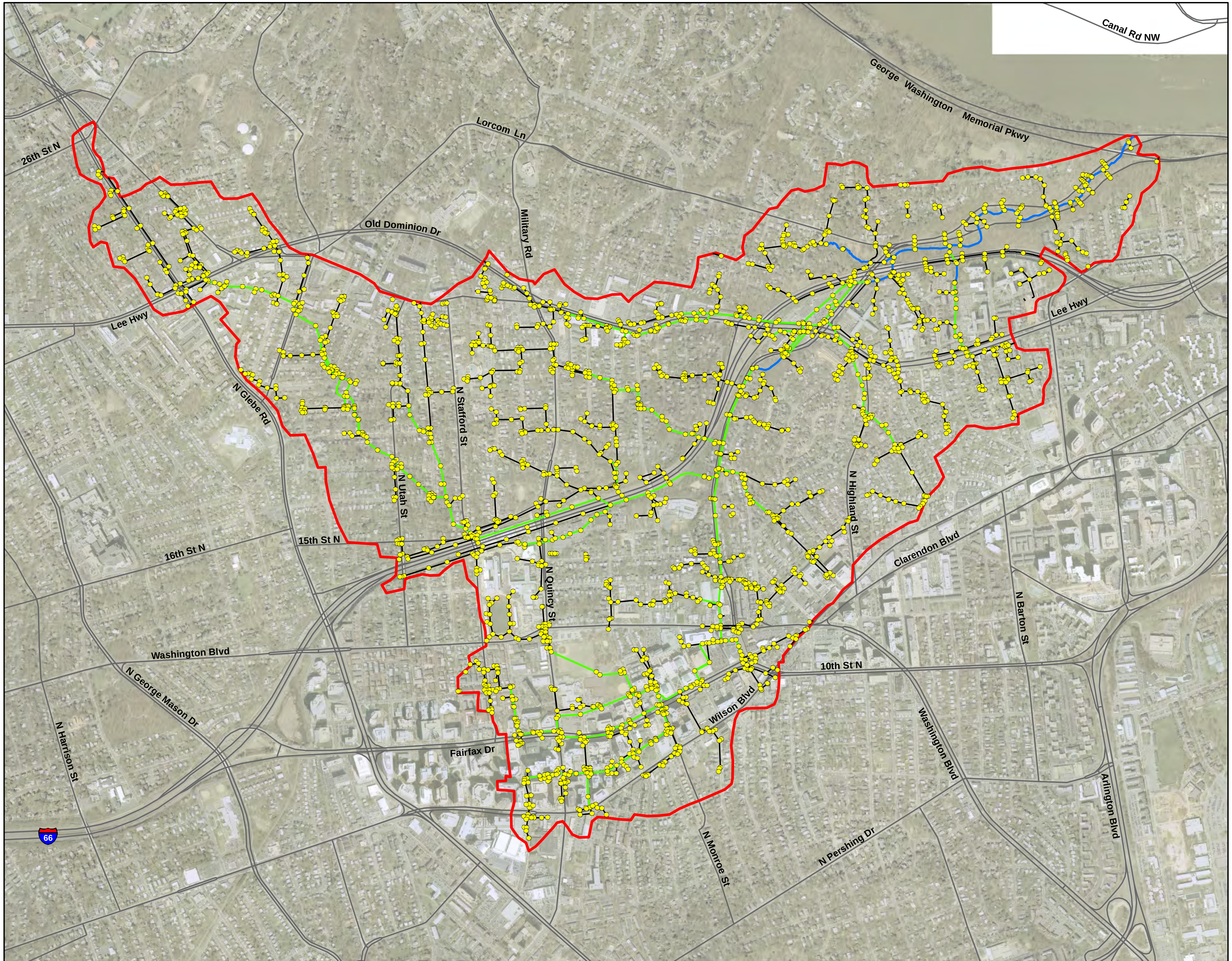
3 Technical Approach

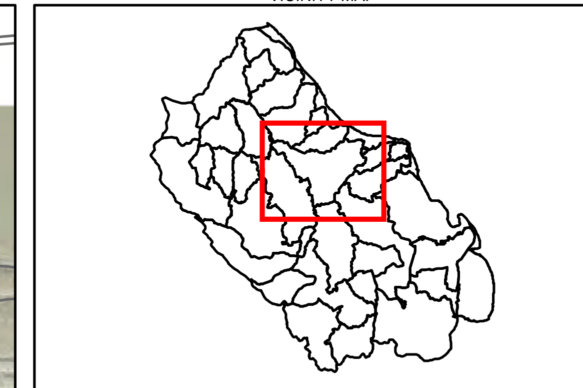
This section describes the hydraulic evaluation of the Spout Run stormwater system under various hydrologic scenarios. A dynamic stormwater model was developed as the evaluation tool using PCSWMM 2011.

3.1 Methodology

The hydrologic and hydraulic model involves the following steps:

- Hydrology
    1. Define the subwatershed boundaries
    2. Identify the hydrologic node connections
    3. Estimate the hydrologic parameters for each subwatershed
    4. Identify the rainfall distribution to analyze
- Hydraulics
    1. Import the stormwater network and physical data (inverts, ground elevation, pipe length, size, material)
    2. Define the boundary conditions for each hydrologic scenario
    3. Evaluate the hydraulic performance of the stormwater drainage system for two storm event scenarios





Legend

- Stormwater Junctions
- Stormwater Mains ≥ 36"
- Stormwater Mains < 36"
- Streams
- Roads
- Original Watershed Boundary

0 600 1,200
Feet

FIGURE 2
Existing Stormwater Collection System
Spout Run Watershed
Arlington County Storm Capacity Analysis

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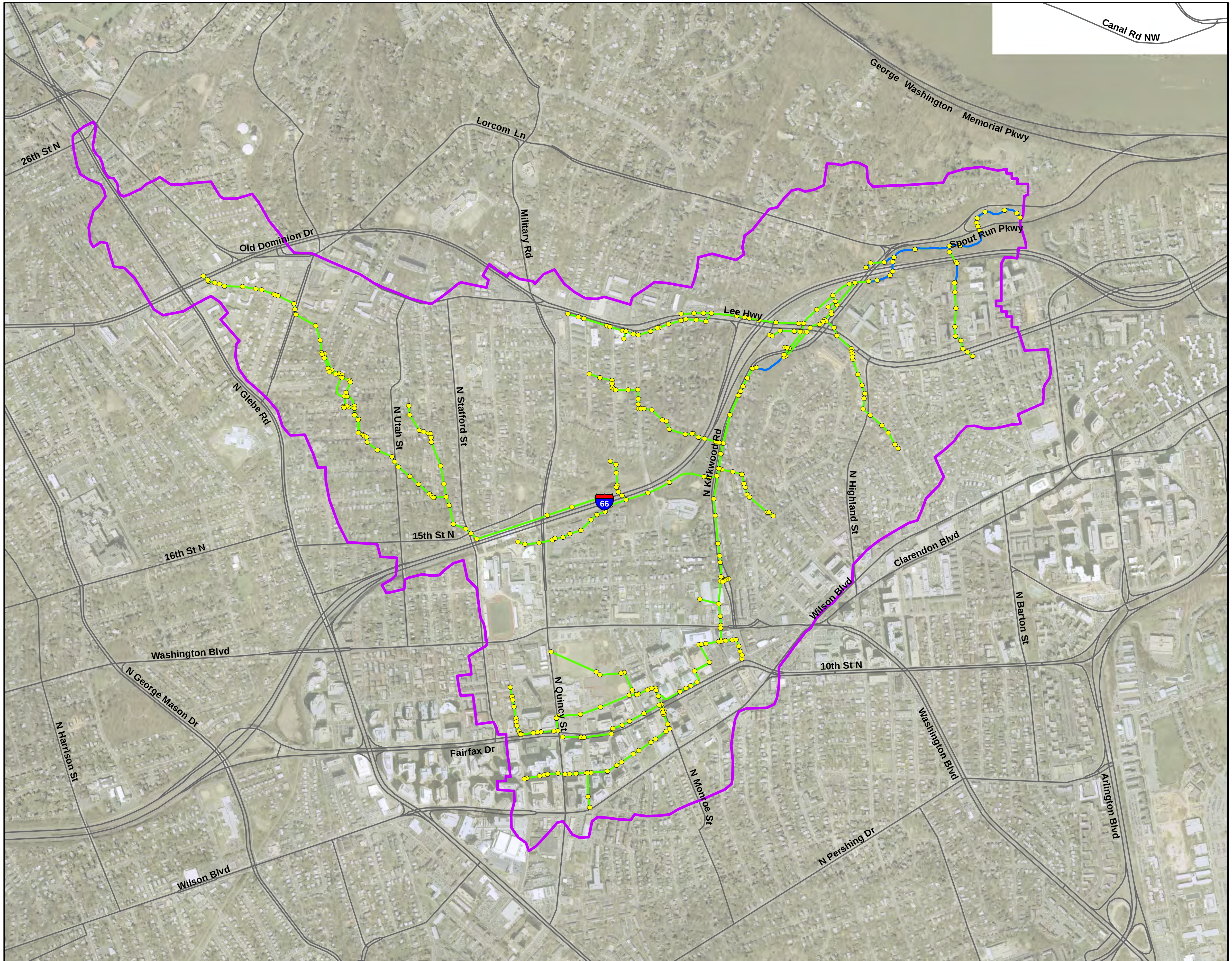
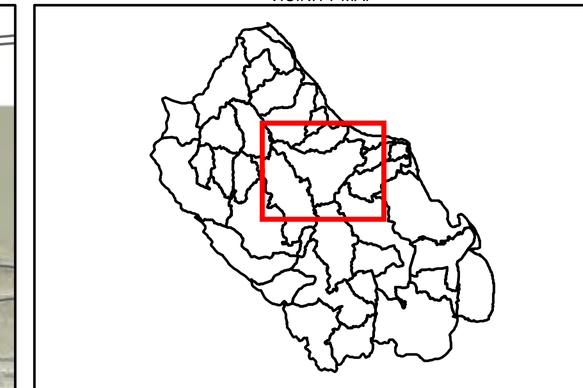


VICINITY MAP



Legend

- Modeled Stormwater Junctions
- Modeled Stormwater Mains ≥ 36"
- Streams
- Roads
- Modeled (Revised) Watershed Boundary

N

0 600 1,200
Feet

FIGURE 3
Modeled Stormwater Collection System
Spout Run Watershed
Arlington County Storm Capacity Analysis

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Arlington County provided the following required data:

- Arlington.mdb: geodatabase for stormwater collection system and watershed boundary shapefile
- 2009 data CD files: Arlington County's GIS data (shape files), such as topographic data, soil maps, cadastral data, and impervious information
- 2007 orthophotos
- 2006 rainfall event

The following sections describe the hydrologic and hydraulic modeling for the Spout Run watershed.

3.2 Hydrologic Modeling

The hydrologic modeling consisted of two major components:

- Hydrologic parameters: delineation of subwatersheds and computation of hydrologic parameters such as drainage areas, basin slope, basin width, and percent impervious for each subwatershed
- Rainfall: modeled the June 2006 storm event and the 10yr-24hr SCS Type II storm

Most hydrologic parameters were estimated using Arc Hydro Tools 9.3 and the ArcGIS version of HEC-GeoHMS. The Arc Hydro tools are a set of public domain utilities developed jointly by the Center for Research in Water Resources (http://www.crwr .utexas.edu) of the University of Texas at Austin, and the Environmental Systems Research Institute, Inc. These tools provide functionalities for terrain processing, watershed delineation, and attribute management. They operate on top of the Arc Hydro data model in the ArcGIS environments.

HEC-GeoHMS is geospatial hydrologic modeling software developed and maintained by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (USACE). The model allows users to visualize spatial information, perform spatial analysis, delineate subwatersheds, and estimate subwatershed hydrologic parameters. The model uses the Digital Elevation Model (DEM) for the subject watershed to compute the hydrologic parameters. The "burning in" technique allows the user to impose the drainage system on the terrain to better produce the watershed boundaries.[1]

[1] USACE, *User's Manual, Geospatial Hydrologic Modeling Extension HEC-GeoHMS*, Version 1.1. Hydrologic Engineering Center, 2003.

3.3 Subwatersheds Delineation

The Arc Hydro tools were used to delineate the subwatersheds based on the DEM and stormwater network. Some of the automatically delineated subwatershed boundaries were adjusted before proceeding with the calculation of the hydrologic parameters. HEC-GeoHMS was used to compute the following hydrologic parameters: drainage areas, slope, and longest flow path. Width is calculated by dividing the area by the longest flow path.

3.4 Percent Impervious

The percent impervious of each subwatershed was determined by overlaying the impervious coverage information with the delineated subwatersheds in ArcGIS. The impervious coverage is represented by building and paved features (e.g., driveways, handicap ramps, paved medians, sidewalks). It was assumed the impervious coverage is 100 percent impervious. **Figure 4** shows the impervious areas used in the hydrologic analysis. The following shapefiles were used for the impervious calculation:

- Building_arc.shp
- Driveway_poly
- Parkinglot_poly
- Road_poly_split
- Alley_Poly
- Handicapramp_poly
- PavedMedian_poly
- Sidewalk_poly

3.5 Hydrologic Parameter Summary

The schematic of the hydrologic model for the watershed is presented in **Figure 5**. The schematic model shows the basin ID, delineated boundaries, centroidal longest flow path, and drainage inlet for each subwatershed.

The hydrologic parameters for each subwatershed are presented in **Table 3**. The following are the major drainage characteristics for the watershed:

- Total drainage area is 1,071 acres.
- Spout Run watershed is divided into 101 subwatersheds.
- Approximately 49.6 percent of the total drainage area is impervious (range across the subwatersheds of 9.9–91.9).
- Flows were introduced at 97 of 374 inlets (26 percent).
- Average basin area is 11 acres (range of 0.3–45).
- Average basin slope is 7.0 percent (range of 0.9–19.3).
- Average basin width is 789 feet (range of 189–1,606).

TABLE 3
Hydrologic Parameters

		Area				
Subwatershed	**Inlet**	**Total (Acres)**	**Impervious (Acres)**	**Percent Impervious Area**	**Slope (%)**	**Width (ft)**
W1000	7099	30	16.7	55.1	2.5	1606
W1001	6821	4	1.6	44.3	9.7	675
W1010	6541	10	2.2	22.9	10.1	699
W1020	6844	20	5.5	27.2	6.4	841
W1030	6860	9	3.3	36.0	13.8	754
W1040	6795	4	0.6	15.7	5.7	390
W1041	6389	3	1.3	41.4	4.4	251
W1050	6988	3	0.8	29.0	19.3	195
W1051	7331	9	3.2	35.9	6.8	606
W1060	6955	10	4.9	50.2	13.6	310
W1070	7331	6	2	32.8	7.1	478
W1080	7040	17	8.9	53.4	5.3	1064
W1090	7377	13	5.4	39.8	8.9	676
W1110	7849	8	4.1	53.4	5.1	566
W1120	7879	19	14.1	74.4	4.0	1100
W1130	8132	23	10.8	46.5	2.0	1057
W1131	8185	3	2.3	72.7	5.9	741
W1140	8430	8	7	85.9	3.5	655
W1150	24434	13	10.4	81.4	4.4	1212
W1160	9281	10	7.3	70.7	2.1	827
W1161	9221	11	1	9.9	1.9	789
W1170	8831	12	10.7	88.4	2.2	1160
W1180	9666	10	7.4	71.5	2.0	1077
W1181	9700	1	1	86.8	0.9	324
W1210	9158	18	12	67.1	2.5	823
W1230	9357	4	3.4	80.8	3.5	506
W1231	9584	4	3.5	84.2	2.7	733
W1232	9720	1	1.3	88.8	1.6	313
W1233	9724	5	3.9	83.7	2.7	1147
W1240	24487	9	6.6	75.2	4.8	635
W1241	9623	14	8.5	62.2	2.5	741

TABLE 3 (CONTINUED)
Hydrologic Parameters

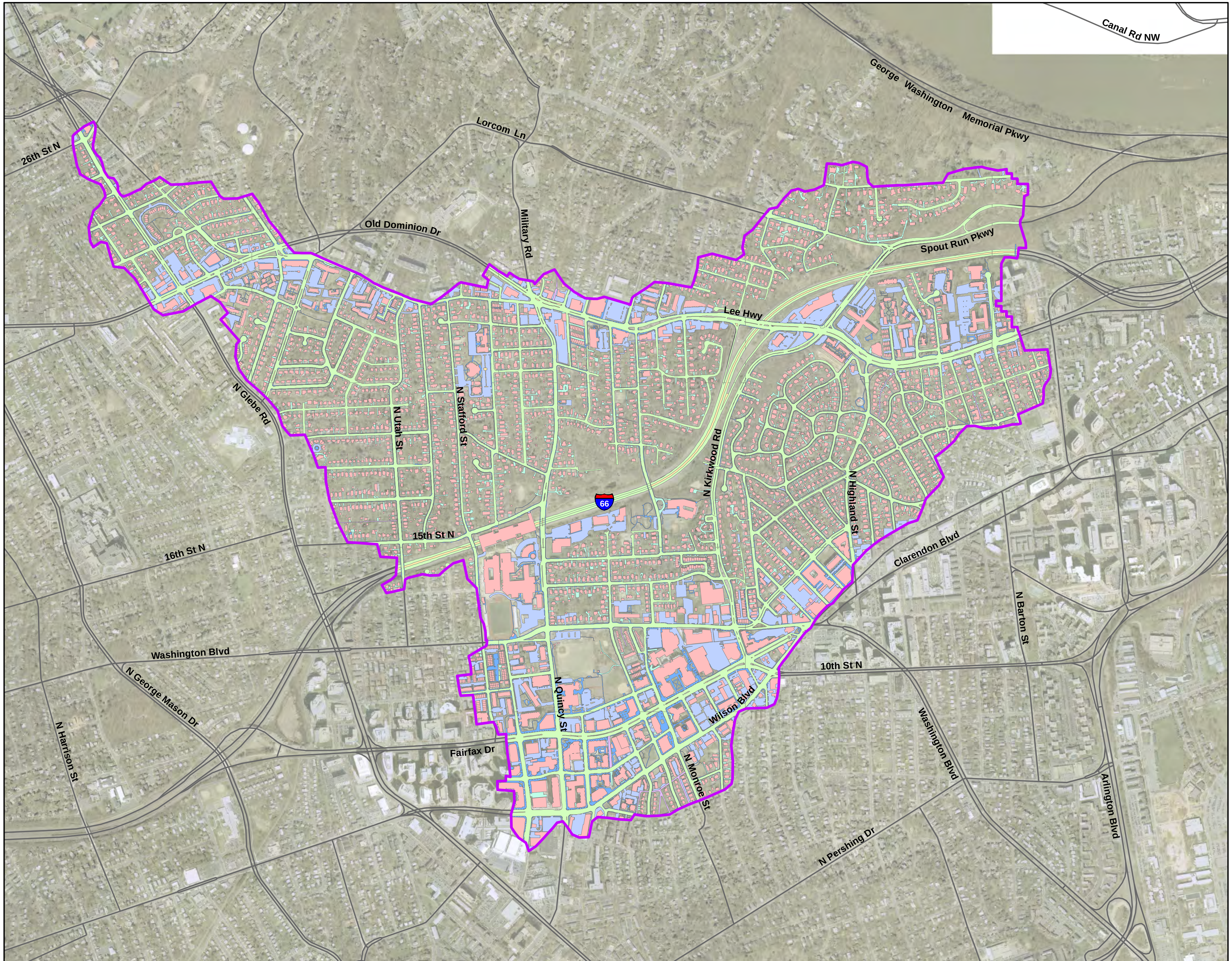
		Area				
Subwatershed	**Inlet**	**Total (Acres)**	**Impervious (Acres)**	**Percent Impervious Area**	**Slope (%)**	**Width (ft)**
W1250	22872	11	8.6	81.5	2.5	1246
W1251	10529	6	4.5	82.6	1.4	690
W1252	10266	8	7.7	91.9	1.5	784
W6370	4204	6	4.4	73.9	5.2	620
W6371	4122	4	2.1	49.3	7.8	477
W6372	4279	2	0.8	36.8	9.2	428
W6373	4359	3	0.9	32.9	9.8	571
W6380	5203	6	2.4	42.8	7.7	693
W6390	5716	5	1.9	39.2	7.7	530
W6580	24258	8	5.7	71.0	4.8	795
W6581	7407	6	2.4	39.3	10.0	316
W6590	8753	21	10	48.8	2.2	1165
W6600	9180	11	7.9	71.0	1.9	1110
W6620	9375	10	7.1	69.3	1.9	774
W670	3386	23	4.6	19.8	16.6	1122
W6740	7420	7	3.2	45.3	9.7	694
W6780	6762	9	2.9	34.3	6.8	934
W6790	5534	14	5.6	40.4	5.6	1189
W6791	5804	6	2.5	42.5	3.7	579
W6800	5197	28	14.5	52.7	6.4	1137
W6850	4452	5	3.1	65.7	9.5	753
W6851	4504	2	1.6	72.7	11.0	346
W6940	4661	7	3.3	46.5	11.2	565
W6950	4483	6	2.5	38.3	16.5	407
W6960	4820	2	1.9	84.3	4.7	403
W6970	3901	6	3.3	60.5	11.9	694
W6980	3623	12	4.9	40.4	16.2	996
W6981	4076	12	7.5	63.5	7.9	1355
W700	3849	45	23.8	53.0	2.7	1480
W7020	4458	9	5.3	58.7	9.0	639
W7021	4350	7	4.5	66.1	7.8	591

TABLE 3 (CONTINUED)
Hydrologic Parameters

		Area				
Subwatershed	**Inlet**	**Total (Acres)**	**Impervious (Acres)**	**Percent Impervious Area**	**Slope (%)**	**Width (ft)**
W7022	4341	9	3.8	43.3	8.4	795
W7030	23364	3	1.3	51.7	5.5	585
W7031	4603	3	2.8	9.0	3.2	471
W7032	4540	7	5.2	71.6	3.8	1129
W7040	6241	8	2.7	31.6	7.3	791
W7050	4979	7	2.6	37.8	7.7	720
W7080	5188	3	1.1	33.4	9.6	406
W7120	6077	21	8.9	42.0	7.0	980
W720	3722	40	12.9	32.5	10.5	1579
W730	3441	13	3.1	24.7	11.9	1167
W740	4961	22	10.2	47.0	3.3	1379
W741	4836	8	5.2	64.6	4.9	896
W760	3963	8	2.4	28.8	10.3	528
W770	3776	11	5.5	48.6	13.4	829
W790	4108	9	5.7	60.7	8.4	869
W800	4122	14	8.8	62.6	4.5	809
W810	3894	4	3.6	90.3	3.4	436
W820	4907	10	4.9	49.8	6.8	765
W830	3939	0.9	0.6	65.4	13.0	246
W831	24389	4	3.4	77.3	6.5	628
W832	4354	0.3	0.3	79.8	7.8	189
W840	4348	20	13.9	69.6	7.5	1002
W850	4969	5	1.4	27.6	16.7	685
W860	23331	8	2.9	37.0	10.7	851
W870	6148	14	4.3	29.9	9.6	1195
W871	5719	13	5.1	38.7	4.4	1072
W880	6215	21	10	47.5	3.1	1055
W890	4838	21	11.4	54.5	4.5	911
W900	5409	17	6.7	38.3	9.4	1009
W910	5681	19	8.3	43.1	6.1	1051
W920	5490	7	2.7	36.3	13.8	611

TABLE 3 (CONTINUED)
Hydrologic Parameters

		Area				
Subwatershed	**Inlet**	**Total (Acres)**	**Impervious (Acres)**	**Percent Impervious Area**	**Slope (%)**	**Width (ft)**
W921	5794	11	4.6	40.7	7.6	835
W940	5693	14	5.4	39.7	8.1	641
W950	6819	7	2.3	33.6	8.4	958
W951	6415	19	6.7	34.3	7.3	1506
W960	6359	25	7.5	30.3	6.8	1031
W970	6819	8	2.7	33.7	8.1	576
W980	6148	5	2.1	41.7	10.1	619
W990	6437	14	5.7	41.2	5.8	861



VICINITY MAP

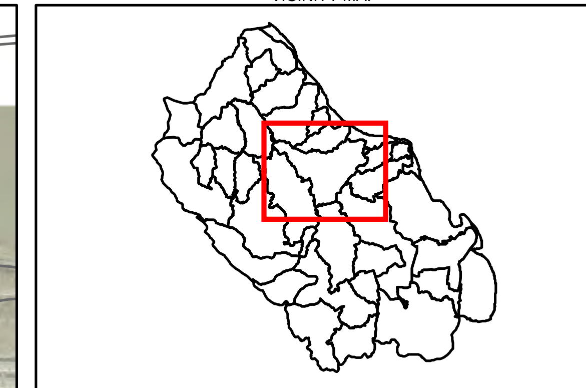


FIGURE 4
Impervious Areas
Spout Run Watershed
Arlington County Storm Capacity Analysis

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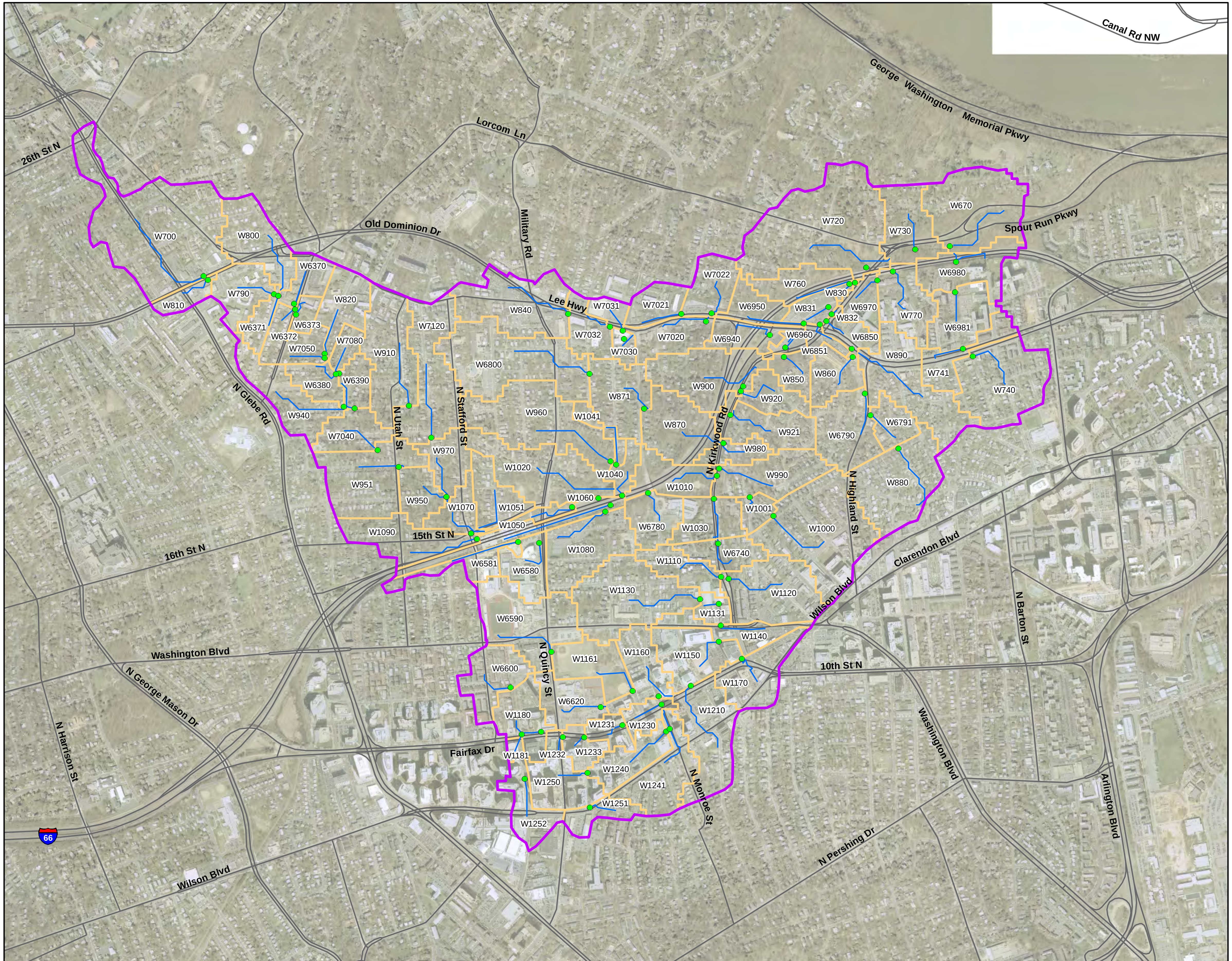

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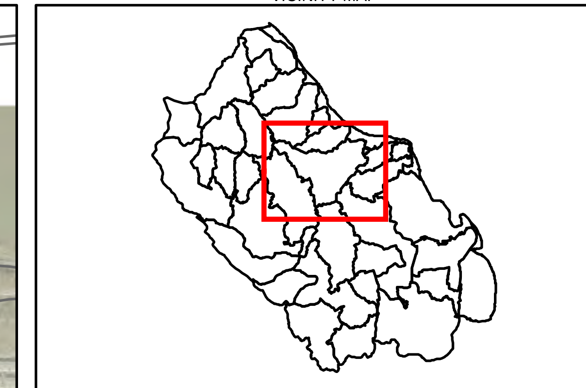

Legend

- Runoff Input Junction
- Centroidal Longest Flow Path
- Subwatershed
- Roads
- Modeled (Revised) Watershed Boundary

N

0 600 1,200
Feet

FIGURE 5
Hydrologic Model Schematic
Spout Run Watershed
Arlington County Storm Capacity Analysis

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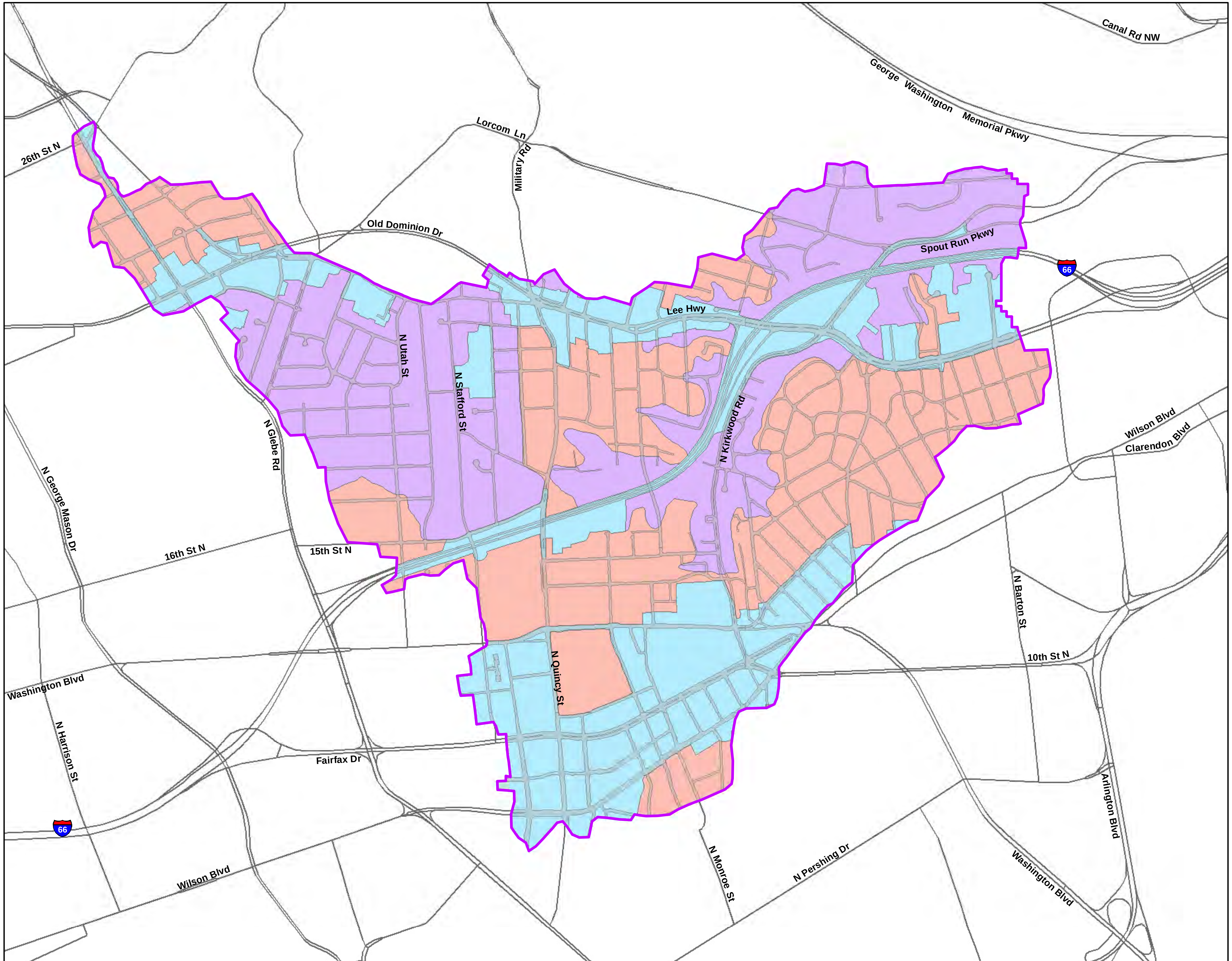
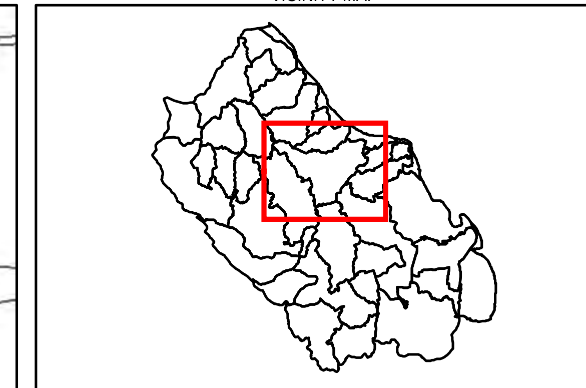


VICINITY MAP



Legend

Soil Type

- Loam
- Sandy loam
- Silty loam
- Roads
- Modeled (Revised) Watershed Boundary

N

0 600 1,200

Feet

FIGURE 6
Soil Map
Spout Run Watershed
Arlington County Storm Capacity Analysis

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3.6 Infiltration Parameters

Infiltration was modeled using the Green-Ampt method. To calculate the infiltration parameters, the digital soil maps were overlaid with the subwatersheds to assign respective soils map unit symbology (MUSYM). The MUSYM was then correlated with the Arlington County soil survey to determine the soil name and characteristics. It was determined that approximately 32 percent of the soil in Spout Run is loam, 36 percent is sandy loam, and 32 percent is silty loam. The infiltration parameters adopted for the three types of soil are listed in **Table 4**.

TABLE 4
Soil Infiltration Parameters

Soil Texture Class	Soil Map Units	Percent of Soil	Hydraulic Conductivity (in./hr)	Suction Head (in.)	Initial Deficit (Fraction)
Loam	12	32	0.13	3.50	0.23
Sandy loam	4A, 4B, 11B	36	0.43	4.33	0.26
Silty loam	6D, 7B-7D, 10B	32	0.26	6.69	0.22

Source: Rawls, Walter J., Donald L. Brakensiek, and Norman Miller, "Green-Ampt Infiltration Parameters from Soils Data," *Journal of Hydraulic Engineering*, vol. 109, no. 1, January 1983, pp. 62–70 (doi: http://dx.doi.org/10.1061/(ASCE)0733-9429(1983)109:1(62)).

The infiltration parameters of each subwatershed were determined by intersecting the soil map with the delineated subwatersheds in ArcGIS to calculate the area-weighted value. **Figure 6** shows the soil map for the Spout Run watershed. **Appendix B** provides details on soil texture class and soil map units

3.7 Surface Roughness and Depression Storage

Table 5 shows parameters used for pervious and impervious area in the model. Depression storage is set at zero to reduce the time for hydrologic flow to enter the hydraulic system.

TABLE 5
Surface Roughness and Depression Storage

	Areas	
Description	Impervious	Pervious
Manning's *n*	0.014	0.3
Depression storage	0	0

Source: Source: James, W., *User's Guide to SWMM5*. 12th ed., CHI, 2008. p. 766.

3.8 Rainfall Distributions

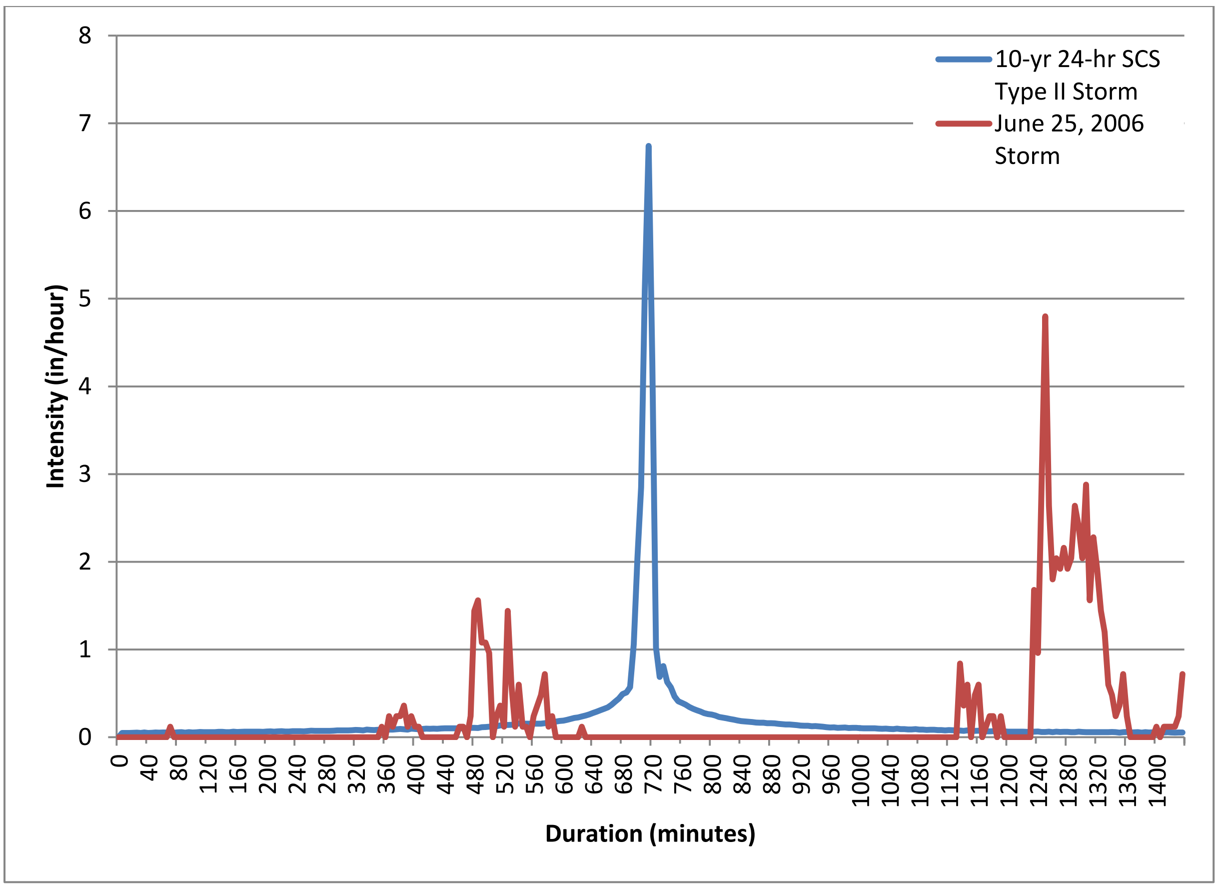
Choosing the correct rainfall distribution as well as frequency and duration are important factors in the development of the hydrologic model and the results of the hydraulic model. Arlington County decided to proceed with two storms of interest:

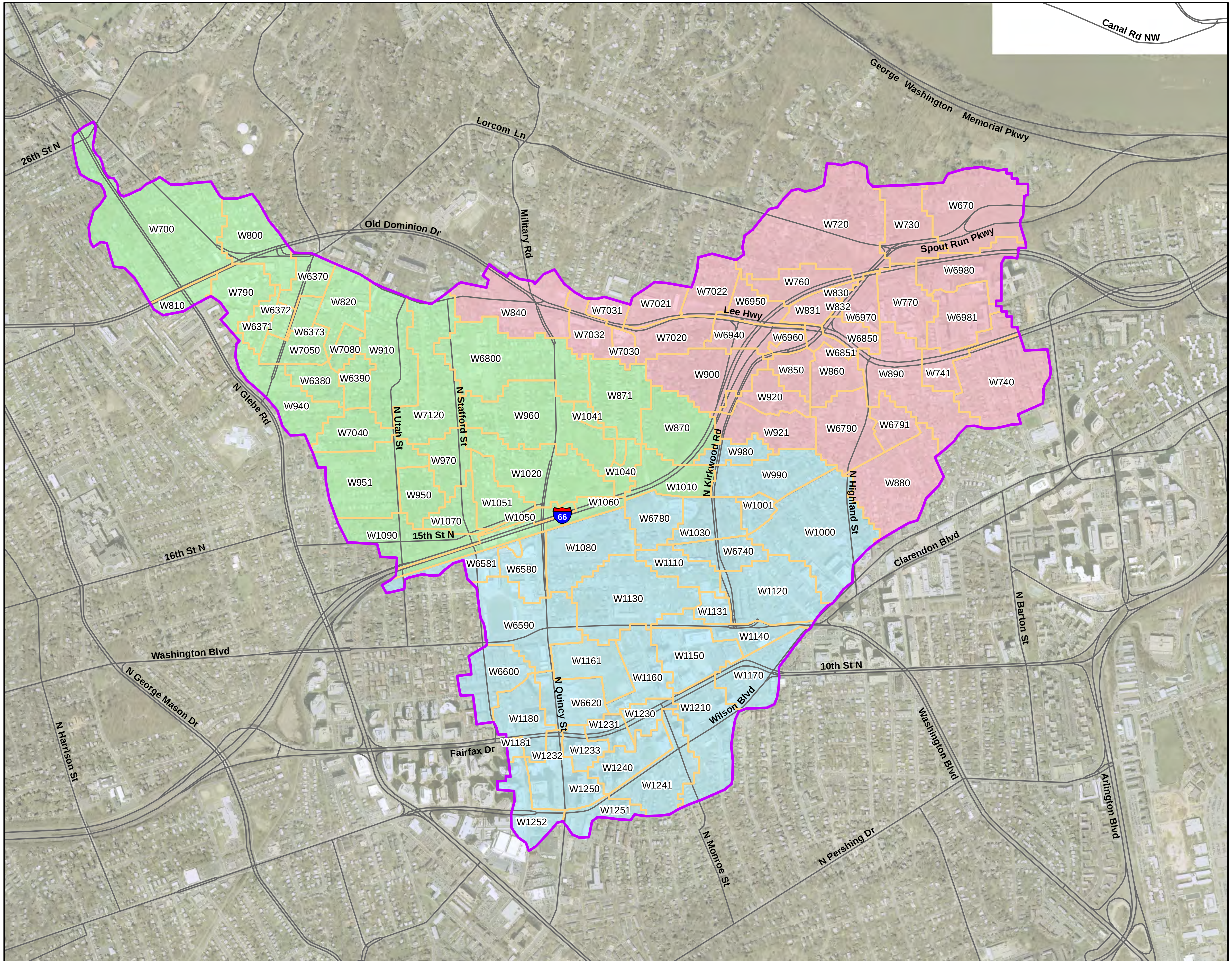
- June 2006 storm event based on the rain gauge data at the Donaldson Run lift station; total rainfall volume of 5.84 inches
- 10-year, 24-hour storm based on SCS Type II distribution: the 10yr-24 hr storm volume was obtained from VDOT “Hydraulic Advisory 05-04.3,” January 2008; total volume of 4.84 inches

The County has maintained a list and map of flooding complaints from the June 2006 storm, and this was used as anecdotal information for comparison purposes. Although not a true calibration, model results for the June 2006 storm event were compared to the flooding complaint map to see how the results align. (See Section 5.1.)

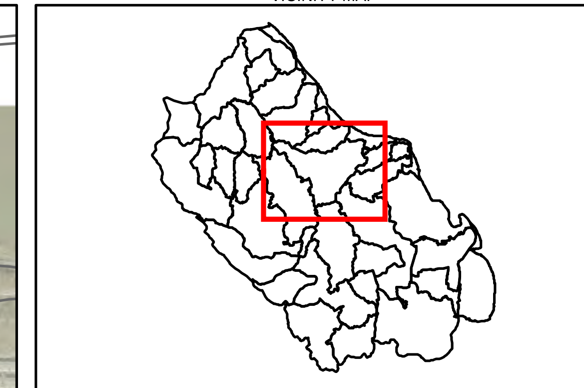
The 5-minute-duration hyetograph data for the two storms are provided in **Appendix C** and in **Figure 7**.

FIGURE 7
Storm Hyetographs





VICINITY MAP



Legend

- Subwatershed
- Area 1
- Area 2
- Area 3
- Roads
- Modeled (Revised) Watershed Boundary

N

0 600 1,200

Feet

FIGURE 8
Subwatersheds
Spout Run Watershed
Arlington County Storm Capacity Analysis

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\\ORION\PROJ\ARLINGTONVACOUNTYOF\392309STORMWATERCAP\WSSPOUT\WORKINGGIS\LAYOUT\INTERNAL\STORMWATER_CAPACITY_ANALYSIS_TM\FIGURE8_SUBWATERSHEDS.MXD FCAIN 4/26/2012 11:27:46 AM

3.9 Simulation of Stormwater Runoff

The private domain software PCSWMM 2011 was used to simulate natural rainfall-runoff processes from the watershed. Hydrologic parameters such as area, slope, and width for 86 subwatersheds were estimated using Arc Hydro Tools 9.3 and ArcGIS version of HEC-GeoHMS, as described earlier. The percent imperviousness of each subwatershed was determined by overlaying the impervious coverage information with the delineated subwatersheds in ArcGIS. These hydrologic parameters, listed in **Table 3**, were used as input to the subwatersheds. The two hyetographs were also used as input to the subwatersheds of PCSWMM 2011. The U.S. Environmental Protection Agency (EPA) SWMM Runoff Non-linear Reservoir Method was used to simulate stormwater runoff from each subwatershed in response to each of the hyetographs. Groundwater and snow pack are not included in the hydrologic analysis.

For presentation purposes, the watershed was divided into three areas (see **Figure 8**):

- Area 1: north of I-66
- Area 2: south of I-66
- Area 3: north of 18th Rd. N.

Figures 9, **10**, and **11** show the peak runoff at storm drain inlets for the two storm events. The peak runoff for the June 2006 storm is lower than the 10yr-24hr storm's, as expected. Caution should be taken when comparing the results in this figure because the runoff is related to the tributary area of each subwatershed, and the subwatersheds are not homogeneous in size.

FIGURE 9
Peak Runoff—Area 1: North of Interstate 66

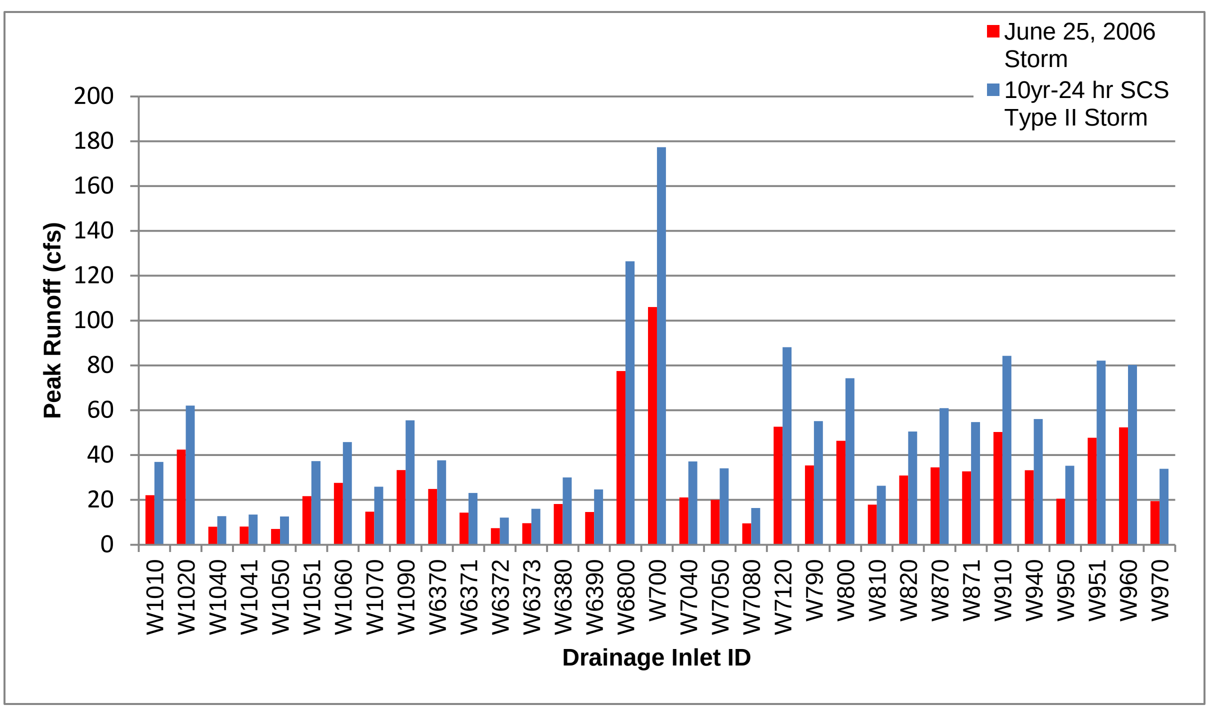


FIGURE 10
Peak Runoff—Area 2: South of Interstate 66

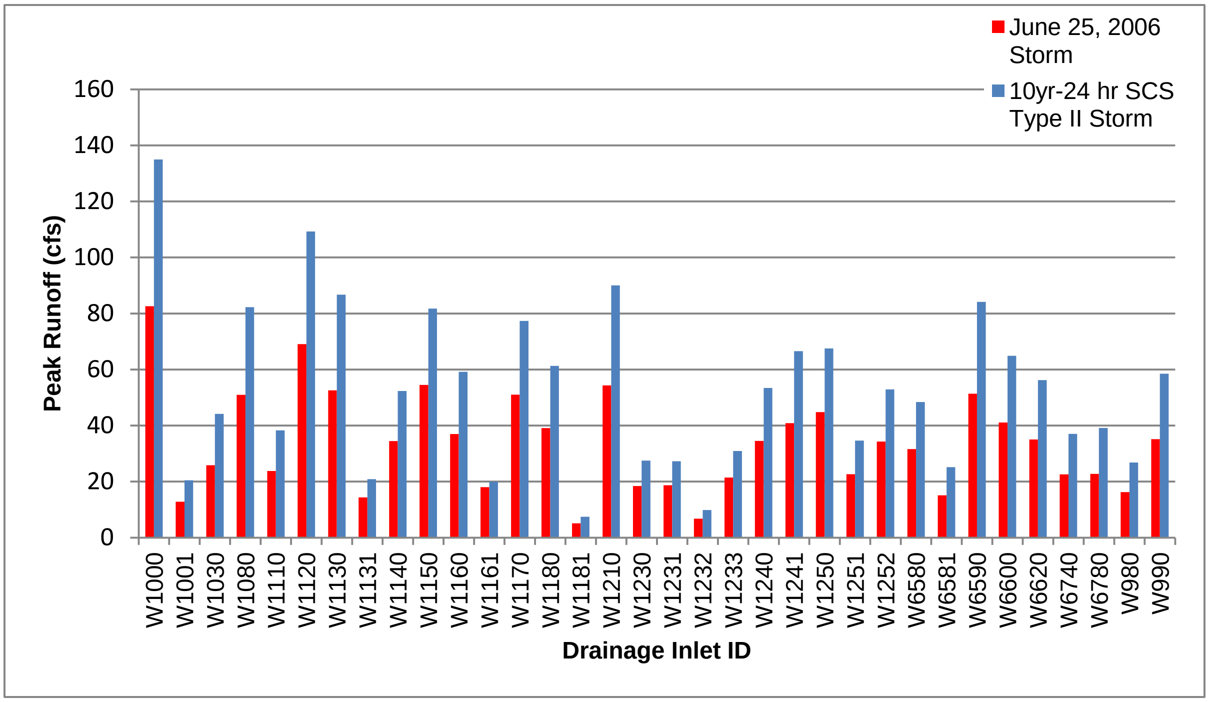
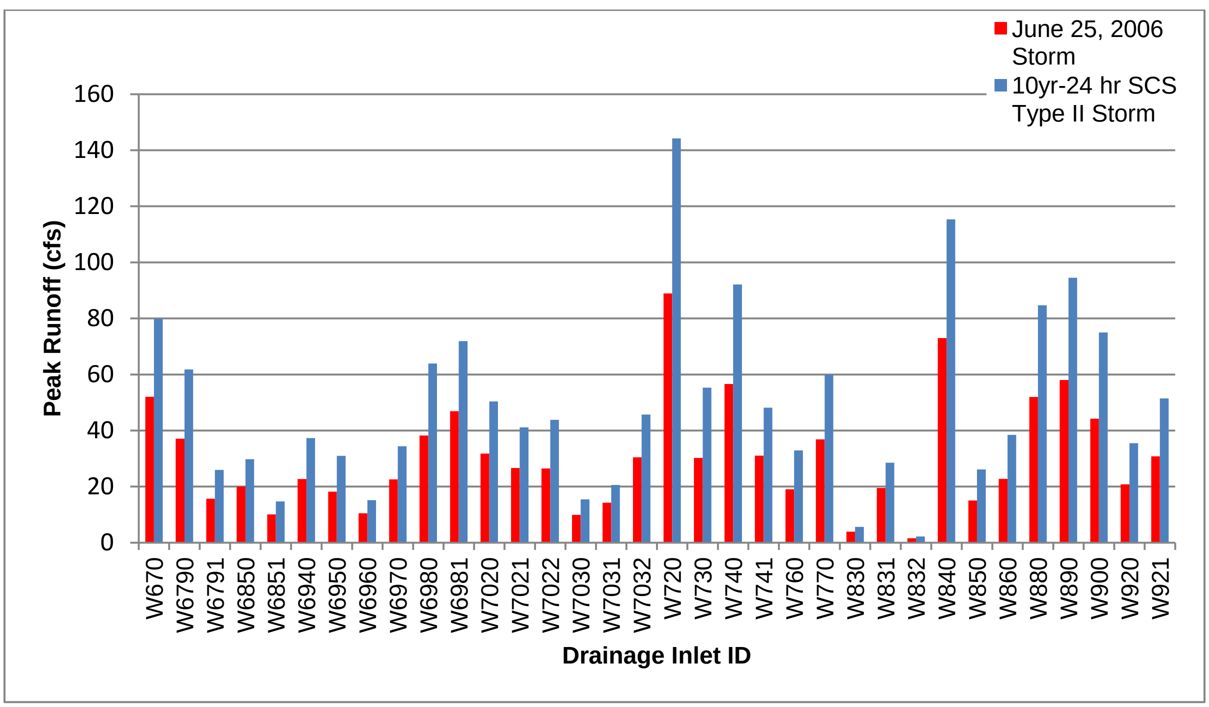


FIGURE 11
Peak Runoff—Area 3: North of 18th Road North



4 Hydraulic Modeling

The watershed was analyzed using the widely used and industry-accepted private domain stormwater management computer model PCSWMM 2011. The core simulation engine of this model is based on the EPA's SWMM 5. PCSWMM 2011 was used to simulate the hydraulic performance of the stormwater collection system.

4.1 Simulation for Two Storm Events

Hydraulic simulations were performed for two different rainfall distributions:

- June 2006 storm event based on the rain gauge at the Donaldson Run lift station
- 10yr-24 hr storm based on SCS Type II distribution

4.2 Drainage Network

The physical data for the stormwater collection system were imported into the model from the geodatabase provided by the County. This geodatabase was updated for the missing physical data using methods detailed in **Appendix A**. Model input data included the following:

- Physical data for nodes (catchbasin, manhole, junction, etc.), such as invert and crown elevations
- Physical data for conduits, such as invert elevations, size, shape, material, and length
- Transect data for stream segments

4.3 Stream Segments

County staff provided transects of stream segments indicating the following elevations: (1) centerline of stream, (2) top of bank, and (3) break lines of changes in slope. This information was incorporated in the model.

4.4 Detention Ponds

There is one detention pond in the Spout Run watershed. The pond is connected to the portions of the stormwater collection system that are smaller than 36 inches in diameter and was not modeled.

4.5 Head Losses

4.5.1 Inlet and Outlet Losses

Energy losses were assigned to represent losses encountered going from one pipe to another through an access hole. Manhole losses were applied at junctions labeled "manholes" in the GIS, and inlet losses were applied at all other junctions (i.e., catchbasins, detention outlets, end walls, grate inlets, junctions) between pipes, between culverts, and between pipes and culverts. Inlet losses were also applied at junctions between streams and both culverts and pipes. The head loss coefficients are listed in **Table 6**.

TABLE 6
Standard Head Loss Coefficients

Structure Configuration	Loss Coefficient
Inlet—straight run	0.50
Inlet—angled through	
90°	1.50
60°	1.25
45°	1.10
22.5°	0.70
Manhole—straight run	0.15
Manhole—angled through	
90°	1.00
60°	0.85
45°	0.75
22.5°	0.45

Source: U.S. DOT, *Urban Drainage Design Manual,* 2nd ed., Hydraulic Engineering Circular No. 22, 2001.

4.5.2 Friction Head Losses

Values for roughness were set using established or previously reported values. **Tables 7** and **8** list standard roughness values used in the model for the different conduit types and natural streams, respectively.

TABLE 7
Standard Roughness Values for Pipes and Culverts

Element	Manning's *n*
Concrete pipe	0.014
Concrete rectangular conduit	0.015

Source: James, W., *User's Guide to SWMM5*. 12th ed., CHI, 2008. p. 766.

TABLE 8
Standard Roughness Values for Natural Streams

Element	Manning's *n*
Main channel	0.028
Overbanks	0.035

Sources: James, W., *User's Guide to SWMM5*. 12th ed., CHI, 2008. p. 766; surveyor-provided photos.

4.6 Boundary Conditions

The modeled outfall is approximately 100 vertical feet above the Potomac River. Therefore, the boundary condition was modeled as a free outfall.

4.7 Storage Node

When a rainfall event is input into a model node and the flow exceeds the capacity of that node, the excess volume floods to the ground surface and is lost to the conveyance system. However, this flooding is almost never representative of field conditions and the model should be adjusted. This is often the case in models that represent a portion of the stormwater collection system. In the Spout Run watershed model, 25 percent of the length of the piping network, albeit the largest pipes, is included in the model. Runoff can be restricted at inlet nodes and never enter the modeled system when, in fact, they are attenuated through the piping network upstream that is not included in the model and conveyed through the existing stormwater collection system. Therefore, if needed, the maximum storage capacity of the piping network upstream of the model can be calculated, and storage nodes can be added to the model.

4.8 Simulation Options

4.8.1 Routing Method

Dynamic wave was selected as the routing method for the following reasons:

- It solves the complete one-dimensional Saint Venant flow equations and therefore produces the most theoretically accurate results.
- It can account for channel storage, backwater, entrance/exit losses, and flow reversal.

4.8.2 Time Step

Generally, it is recommended that the time steps be the same for runoff computation, routing computation, and reporting. The time steps selected for the Spout Run watershed model are as follows:

- Runoff computation
  - Dry weather: 2 seconds
  - Wet weather: 2 seconds
- Routing computation: 2 seconds
- Reporting: 2 seconds

5 Hydraulic Model Results

5.1 Comparison of Data to Reports of Flooding

The Spout Run watershed model results were compared to the anecdotal flooding reports for the June 2006 storm event provided by the County. Of the eight anecdotal flooding reports, four are along the modeled system and two are along the collection system that is smaller than 36 inches in diameter; two are not near the collection system. (See **Figure 12**.)

5.2 Inlet Capacity

As mentioned in Section 4, storage will be added to the most upstream nodes if there are restrictions routing the total runoff.

Storage was initially added at some nodes to reflect the amount of storage capacity that exists in the upstream piping network (pipes smaller than 36 inches). However, for the inlet nodes that still reported flooding after this initial amount of storage was added, storage volume continued to be increased incrementally until the inlet node no longer flooded. Therefore, the modeled storage volume is either equal to the system storage capacity upstream of the inlet node or the maximum storage volume required to convey the storm hyetograph.

Table 9 shows (1) the nodes with restricted inlet capacity, (2) the calculated storage capacity of the piping network upstream of the inlet node (pipes smaller than 36 inches), and (3) the average and maximum storage volume used for each storm event. The average storage volume used reflects the average (zero to maximum) storage volume used over the entire storm event (24 hours). **Figure 13** shows the location of the restricted nodes identified in **Table 9**.

TABLE 9
Storage Node Summary

		June 2006 Storm Event			10yr-24hr SCS Type II Storm		
Node ID	System Storage Capacity Upstream of Inlet Node	Modeled Storage Capacity	Average Storage Used	Maximum Storage Used	Modeled Storage Capacity	Average Storage Used	Maximum Storage Used
3849	17,527	NA	NA	NA	35,400	2,298	35,360
4348	5,415	NA	NA	NA	29,000	2,334	21,380
5197	9,617	9,616	1,042	4,858	38,100	4,253	37,146
5681	7,587	NA	NA	NA	7,583	419	4,804
5693	2,770	NA	NA	NA	38,800	3,750	32,299
6215	6,561	NA	NA	NA	6,565	319	5,133
6359	7,584	NA	NA	NA	8,030	681	7,924
7099	13,720	NA	NA	NA	13,721	1,109	13,216
7879	7,759	15,420	2,207	14,318	77,250	10,229	75,598
8753	3,888	NA	NA	NA	3,887	320	2,588
8831	5,402	NA	NA	NA	5,403	285	4,500
9180	2,254	2,254	234	1,187	28,750	2,960	24,216
9720	1,430	NA	NA	NA	1,430	37	601
10266	2,879	2,880	236	1,214	20,001	1,627	14,754
10529	853	NA	NA	NA	847	25	372
23364	771	NA	NA	NA	771	49	660

All values in cubic feet. NA, not applicable.

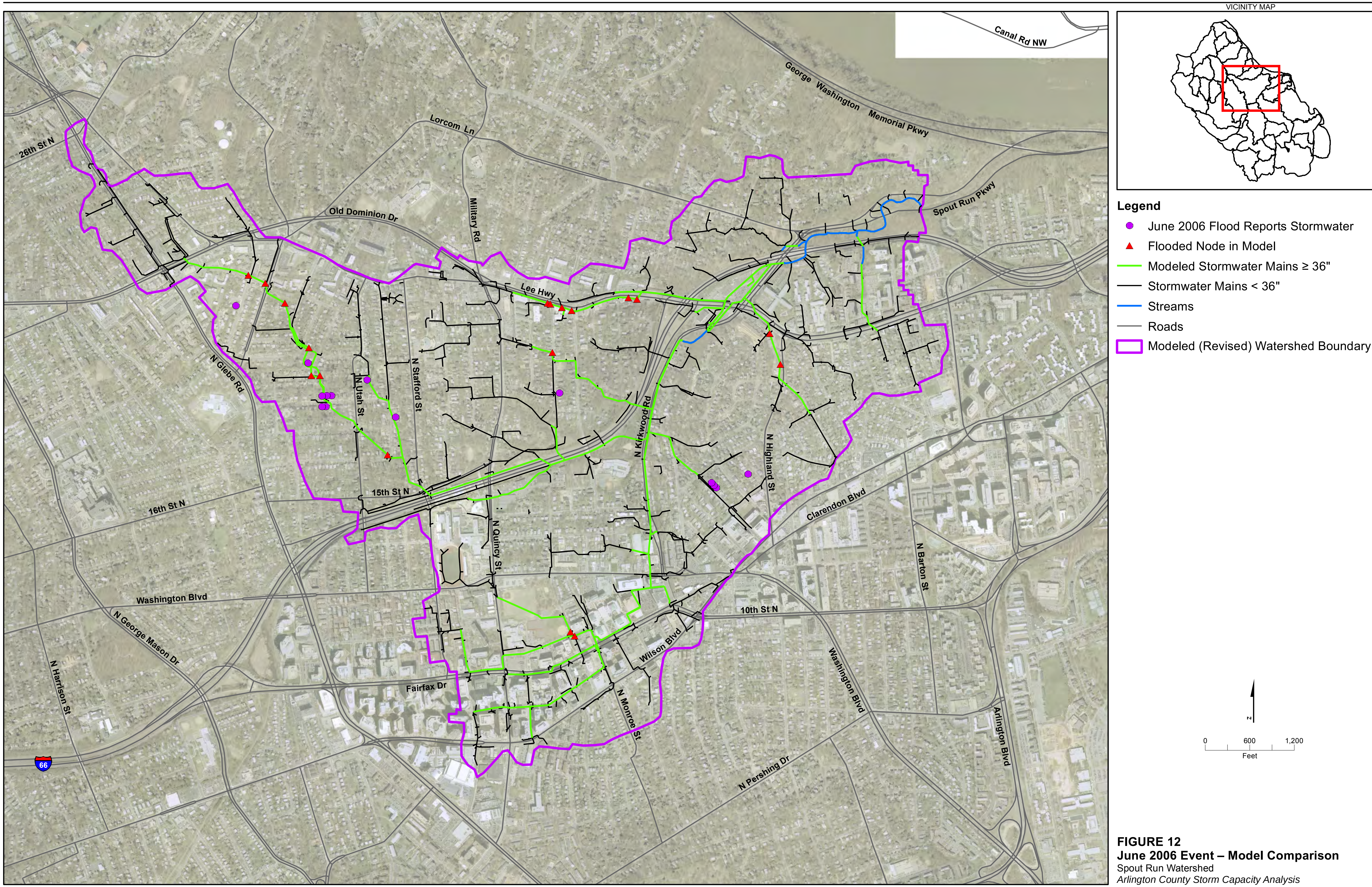


FIGURE 12
June 2006 Event – Model Comparison
Spout Run Watershed
Arlington County Storm Capacity Analysis

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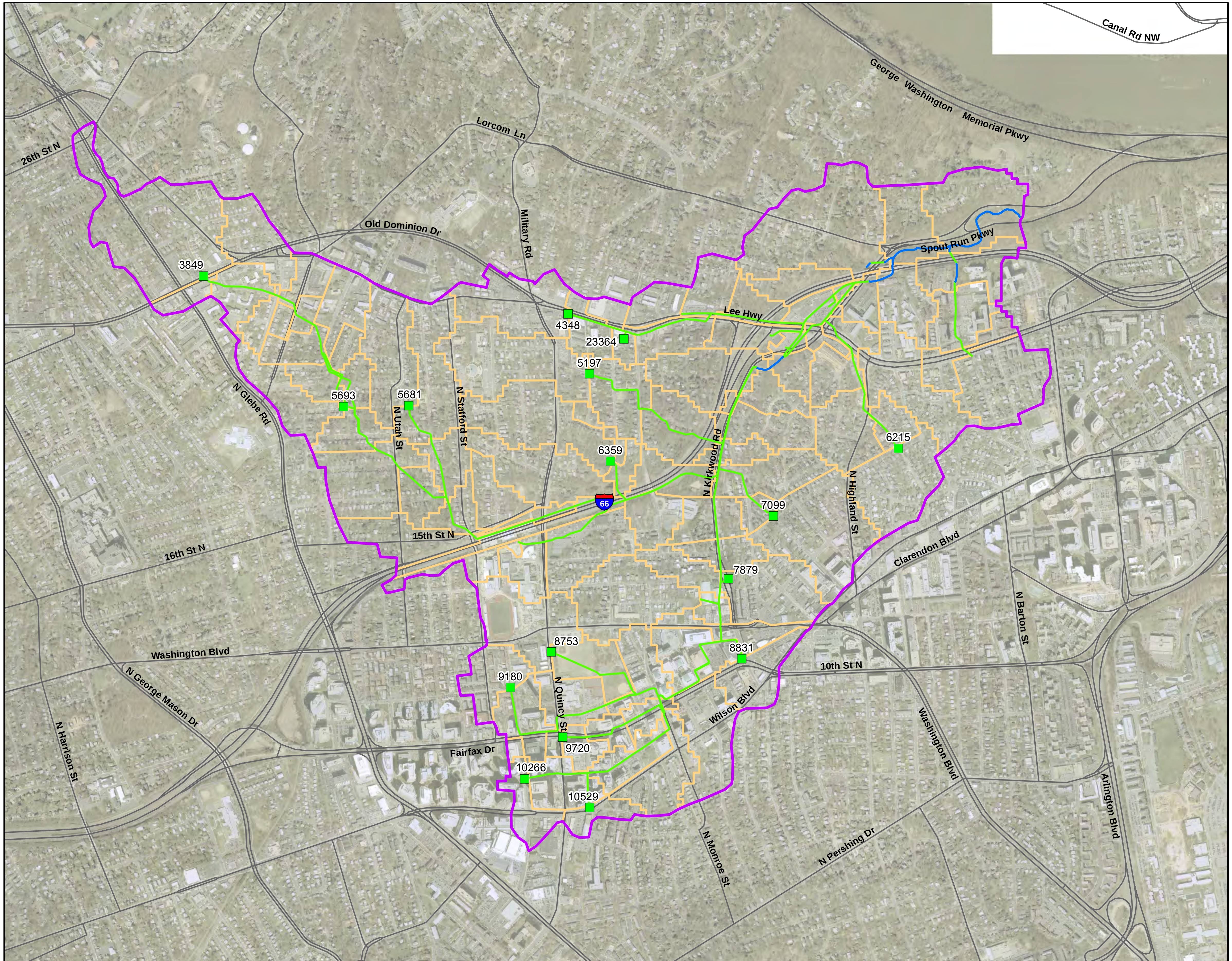
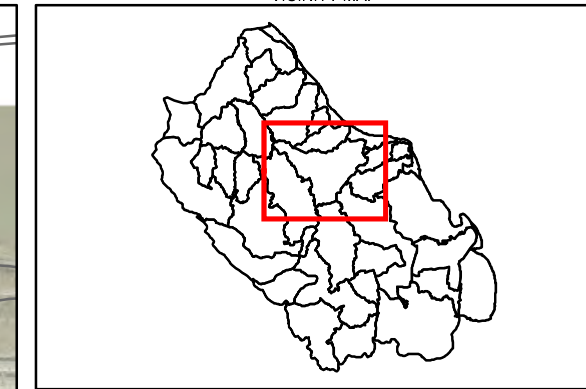


VICINITY MAP



Legend

- Storage Node
- Modeled Stormwater Mains ≥ 36"
- Streams
- Subwatershed
- Roads
- Modeled (Revised) Watershed Boundary

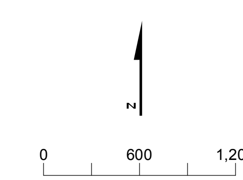


FIGURE 13
Storage Nodes
Spout Run Watershed
Arlington County Storm Capacity Analysis

5.3 Conveyance Capacity

The conveyance capacity of the existing stormwater collection system during the storm events listed in Section 4 was evaluated based on these evaluation criteria:

- If the hydraulic grade line (HGL) rose above the ground surface, the structure was considered flooded.
- If the HGL rose to within 1 foot of the ground surface, the structure was considered to have insufficient "freeboard."
- If the HGL rose above the crown of the pipe but below the insufficient freeboard mark, the structure was considered surcharged.
- At stream-to-pipe or pipe-to-stream nodes (or connections), if the HGL rose above the pipe crown (pipe submerged), this node was also considered surcharged.

Pipes were evaluated for these conditions on the upstream and downstream ends and categorized based on the least desirable condition. Results are summarized in **Table 10** for the June 2006 storm event and the 10yr-24 hr SCS Type II storm.

The hydraulic model predicts that approximately 47 percent of the Spout Run stormwater collection system is experiencing capacity limitations during the June 2006 event and 85 percent is experiencing capacity limitations during the 10yr-24hr SCS Type II storm.

The details on the pipes with flooding, insufficient freeboard, and surcharged conditions are summarized in **Tables 11** and **12. Tables 13** and **14** provide details on the stream segments.

As discussed previously, cross-section information was provided as input to the model. All flows from both storms stayed within the cross section and were not lost from the model. In some cases, the HGL did reach above the top of bank but still stayed within the combined stream and floodplain cross section information provided; that is, the streams fully conveyed the flow within the model. A plan view of the watershed depicting the inlets, manholes, and other point structures experiencing these conditions is provided in **Figures 14** and **15**.

TABLE 10
Summary of Conveyance Capacity Limitations

Scenario (with Storage)	Modeled System (Linear Feet)[a]	HGL Flooding Ground Surface		HGL Within 1 Foot of Ground Surface		HGL Surcharging Pipe Crown		Capacity Limitations	
		Linear Feet	Percent	Linear Feet	Percent	Linear Feet	Percent	Linear Feet	Percent
June 2006 storm event	41,411	3,503	8	4,856	12	11,186	27	19,544	47
10yr-24hr SCS Type II storm	41,411	9,662	23	14,725	36	10,979	27	35,366	85

HGL, hydraulic grade line.
[a]The modeled system in this table includes the closed pipe network described in Table 2. It does not include natural stream channels.

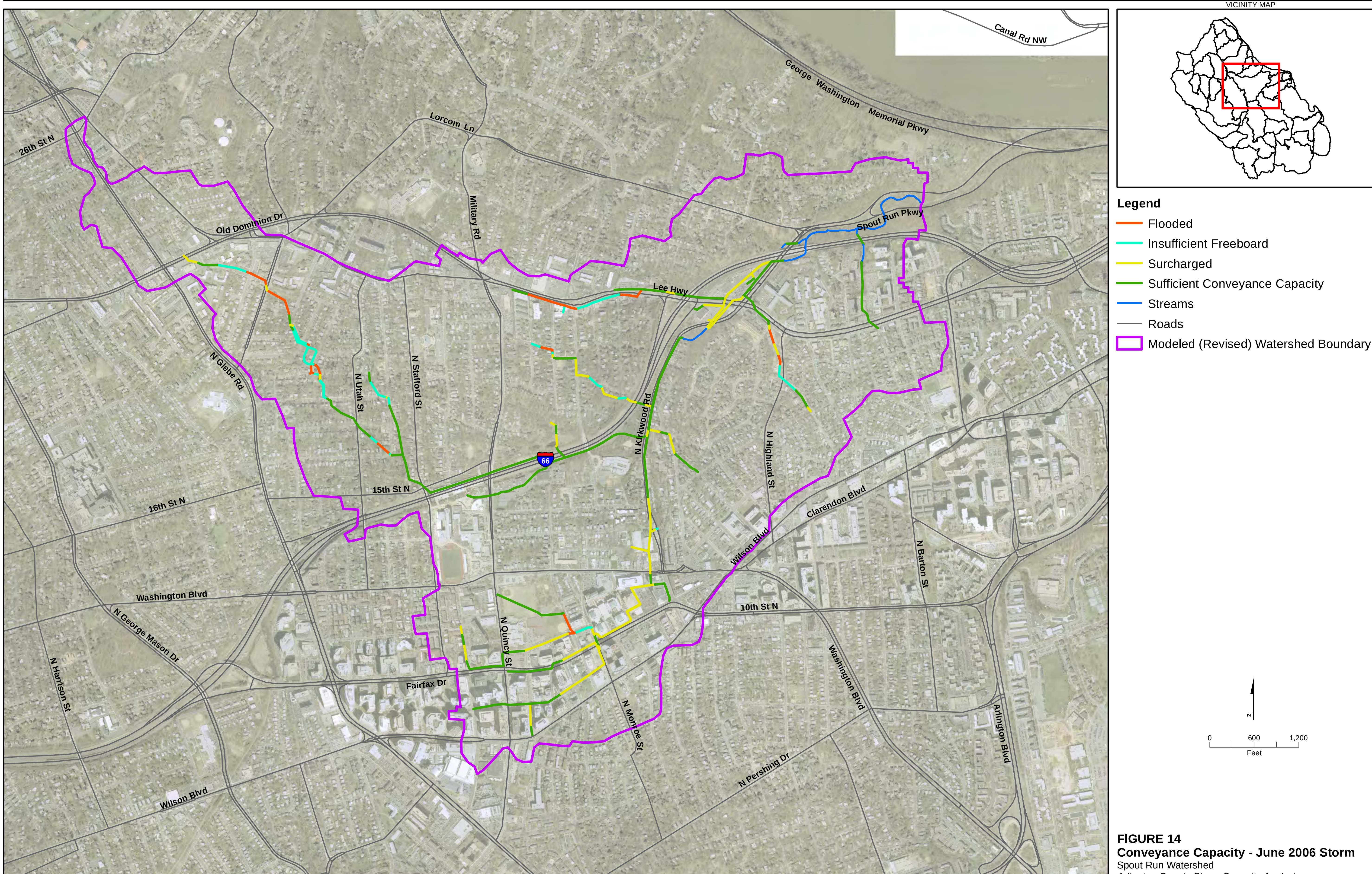


FIGURE 14
Conveyance Capacity - June 2006 Storm
Spout Run Watershed
Arlington County Storm Capacity Analysis

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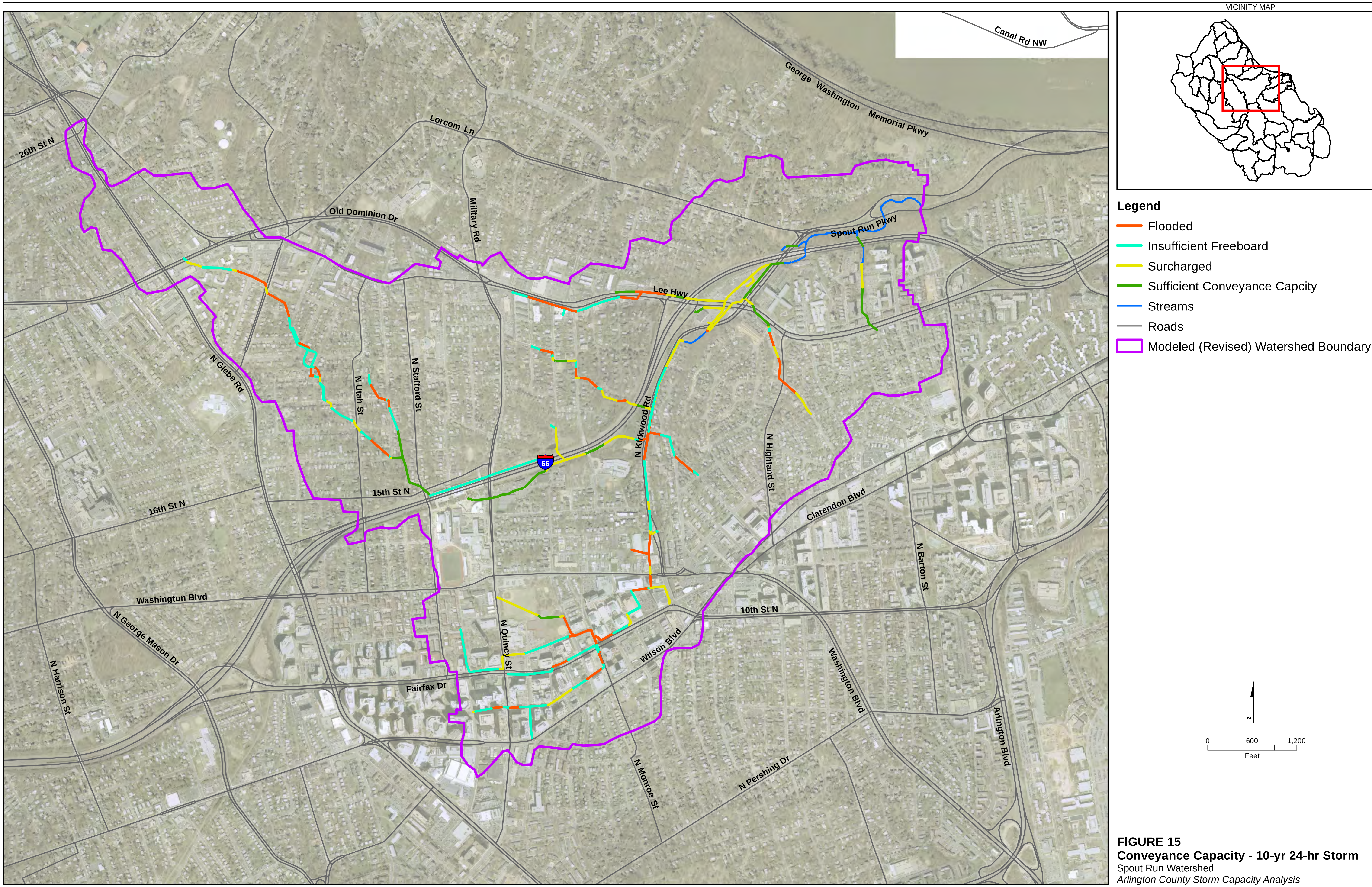

FIGURE 15
Conveyance Capacity - 10-yr 24-hr Storm
Spout Run Watershed
Arlington County Storm Capacity Analysis

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TABLE 11
Pipes Experiencing Surcharging or Higher Conditions in the 2006 Storm Event (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
1269	3946	3930	10	4	130.8	13.8	0	0	0	0	N	N	N	N	0.41	N	Surcharge
1333	4035	4048	71	4	123.5	10.4	8.4	3	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
1364	4048	4108	158	4	123.5	9.8	3	80.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
1424	4122	4204	215	4	194.6	15.5	4.2	83.4	0	4.8	N	2,940	0.54	Y	Y	Y	Flooding
1479	4204	4279	70	4.5	201.9	12.7	83.4	81	4.8	0	2,940	N	Y	N	Y	6.14	Flooding
1531	4279	4359	64	4.5	207.5	13.0	81	12.6	0	0	N	N	N	N	6.14	5.68	Surcharge
1559	4372	4399	95	3.5	129.0	14.7	0	2.4	0	0	N	N	N	N	N	0.22	Surcharge
1565	4399	4415	59	3.5	129.0	14.2	2.4	0	0	0	N	N	N	N	0.52	N	Surcharge
1573	4426	4434	128	3	97.6	13.8	77.4	79.8	0	13.2	N	8,354	0.07	Y	Y	Y	Flooding
1579	4442	4426	59	3	97.6	13.8	28.2	77.4	0	0	N	N	0.18	0.07	Y	Y	Ins. freeboard
1589	4434	4458	118	3	82.1	11.6	79.8	85.8	13.2	76.8	8,354	63,610	Y	Y	Y	Y	Flooding
1611	4497	4442	157	3	97.6	17.5	8.4	28.2	0.6	0	N	N	RIM	0.18	Y	Y	Ins. freeboard
1618	4504	4466	55	10	952.4	10.1	16.8	0	0	0	N	N	N	N	0.23	N	Surcharge
1630	4419	4527	293	3	72.5	12.7	0	5.4	0	1.2	N	127	N	Y	N	Y	Flooding
1631	4359	4529	276	4.5	216.2	13.6	12.6	52.8	0	22.2	N	20,060	N	Y	9.13	Y	Flooding
1639	4527	4540	36	3	69.9	9.9	5.4	6	1.2	3	127	873	Y	Y	Y	Y	Flooding
1655	4565	4497	129	3	97.6	16.8	7.2	8.4	0	0.6	N	N	N	RIM	3.48	Y	Ins. freeboard
16669	8453	8430	37	5	450.7	7.6	0	3.6	0	0	N	N	N	N	1.74	0.66	Surcharge
16692	9217	9221	11	4	44.7	5.6	47.4	46.2	6	0	1,604	N	Y	0.31	Y	Y	Flooding
1677	4540	4603	166	3	91.7	13.0	6	7.8	3	4.2	873	1,888	Y	Y	Y	Y	Flooding
1695	4663	4611	154	3	100.8	14.6	6	10.2	0.6	0	N	N	RIM	0.15	Y	Y	Ins. freeboard
1697	4650	4663	62	3	106.3	15.0	8.4	6	4.8	0.6	1,640	N	Y	RIM	Y	Y	Flooding
17053	9221	9258	70	4.5	61.5	4.6	46.2	20.4	0	5.4	N	3,615	0.31	Y	Y	Y	Flooding
1723	4529	4722	186	4.5	182.6	12.7	52.8	0	22.2	0	20,060	N	Y	N	Y	N	Flooding
1782	4832	4625	255	5	610.9	11.7	31.8	63.6	0	0	N	N	N	N	0.88	2.26	Surcharge
1829	4890	4907	39	2.75	49.1	8.7	0	0	0	0	N	N	N	N	0.75	N	Surcharge
1835	4918	4878	30	3	74.6	11.1	6	0	0	0	N	N	N	N	0.13	N	Surcharge
1836	4890	4925	23	4.5	137.9	9.7	0	0	0	0	N	N	N	N	0.12	N	Surcharge
1939	4979	5125	133	4.5	154.0	12.9	0	36	0	0.6	N	N	N	RIM	0.37	Y	Ins. freeboard
1953	4907	5151	221	3.5	78.9	11.0	0	47.4	0	0.6	N	N	N	RIM	N	Y	Ins. freeboard
1954	5125	5151	52	4	34.3	6.9	36	47.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
1960	5125	5159	43	4.5	120.5	9.5	36	61.8	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
1980	5151	5188	94	4.5	112.3	7.1	47.4	77.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
1990	5159	5203	81	4.5	120.5	7.7	61.8	58.8	0.6	0	N	N	RIM	0.77	Y	Y	Ins. freeboard

TABLE 11 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 2006 Storm Event (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
1993	5207	4994	194	2.5	64.2	13.1	89.4	92.4	0	81	N	30,770	N	Y	7.52	Y	Flooding
1998	5188	5217	45	4.5	121.8	7.7	77.4	79.8	0.6	37.8	N	36,900	RIM	Y	Y	Y	Flooding
2022	5217	5254	31	4.5	97.2	6.2	79.8	55.8	37.8	0.6	36,900	N	Y	RIM	Y	Y	Flooding
2023	5203	5254	79	5	138.3	7.0	58.8	55.8	0	0.6	N	N	0.77	RIM	Y	Y	Ins. freeboard
2027	5197	5260	136	3	70.6	11.9	0	6.6	0	0	N	N	N	0.89	N	Y	Ins. freeboard
20299	7594	7420	151	7	578.4	16.1	6	0	0	0	N	N	N	N	0.34	N	Surcharge
2031	5254	5266	13	4.5	138.1	8.7	55.8	48	0.6	0	N	N	RIM	0.55	Y	Y	Ins. freeboard
20374	6073	6085	74	3.5	87.2	10.1	3.6	0	0	0	N	N	N	N	0.09	N	Surcharge
20378	6670	6697	26	3	59.3	8.8	6	0	0	0	N	N	N	N	0.33	N	Surcharge
20408	5687	5716	32	3	68.0	9.7	84	82.2	79.8	0	44,280	N	Y	N	Y	0.66	Flooding
20429	5254	5572	304	3.5	92.1	10.4	55.8	84.6	0.6	0	N	N	RIM	0.05	Y	Y	Ins. freeboard
20440	4003	4035	166	3.5	123.5	13.7	0	8.4	0	0.6	N	N	N	RIM	N	Y	Ins. freeboard
2060	5266	5317	96	4.5	129.4	8.4	48	70.2	0	0	N	N	0.55	N	Y	2.08	Ins. freeboard
20673	8132	8185	235	4.5	52.3	11.0	0	7.2	0	0	N	N	N	N	N	1.5	Surcharge
20681	9186	9213	27	5.5	137.8	6.0	14.4	7.8	0	0	N	N	N	N	1.27	0.7	Surcharge
20682	9213	9281	77	5.5	137.9	8.1	7.8	0	0	0	N	N	N	N	0.7	0.74	Surcharge
20686	8616	8603	10	8	452.3	10.0	7.8	0	0	0	N	N	N	N	0.76	N	Surcharge
20737	9418	9398	33	3	0.6	0.6	30.6	39	0	0	N	N	N	N	1.4	1.53	Surcharge
2075	5317	5342	21	4.5	129.4	8.5	70.2	49.2	0	0	N	N	N	N	2.13	1.84	Surcharge
2101	5389	5207	139	2.5	64.2	13.1	87	89.4	0	0	N	N	N	N	6.61	7.52	Surcharge
2134	5435	5462	26	3	59.1	8.7	46.8	0	0	0	N	N	N	N	0.5	N	Surcharge
2159	5342	5511	138	4.5	129.4	9.6	49.2	80.4	0	0	N	N	N	0.73	1.84	Y	Ins. freeboard
2170	5534	5389	106	2.5	64.2	13.1	87	87	75	0	50,620	N	Y	N	Y	6.61	Flooding
2196	5511	5572	50	4.5	129.4	8.1	80.4	84.6	0	0	N	N	0.73	0.05	Y	Y	Ins. freeboard
2210	5591	5534	59	3.5	64.5	6.7	85.2	87	0.6	75	N	50,620	RIM	Y	Y	Y	Flooding
2212	5466	5596	109	3	60.4	11.4	0	10.8	0	0	N	N	N	N	N	2.69	Surcharge
22163	4458	4341	119	3	76.6	11.0	85.8	0	76.8	0	63,610	N	Y	N	Y	N	Flooding
2253	5572	5683	117	4.5	144.3	9.1	84.6	88.8	0	81.6	N	184,400	0.05	Y	Y	Y	Flooding
2256	5683	5688	26	4.5	138.9	8.8	88.8	82.8	81.6	0	184,400	N	Y	0.47	Y	Y	Flooding
2260	5693	5683	16	3	33.2	9.2	82.2	88.8	0	81.6	N	184,400	0.50	Y	Y	Y	Flooding
22662	22789	22872	288	3	22.3	5.2	0	0	0	0	N	N	N	N	N	0.31	Surcharge
2268	5707	5693	13	3	0.6	1.3	85.8	82.2	0	0	N	N	0.48	0.50	Y	Y	Ins. freeboard
2275	5720	5719	39	3	60.5	10.3	30	20.4	0	0	N	N	N	N	3.58	2.97	Surcharge
2282	5727	5591	129	3.5	64.5	10.1	80.4	85.2	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard

TABLE 11 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 2006 Storm Event (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
2292	5719	5739	100	3	88.1	13.8	20.4	45	0	0	N	N	N	N	2.97	5.50	Surcharge
23169	4820	23301	25	4	11.1	5.4	0	6.6	0	0	N	N	N	N	N	0.21	Surcharge
23170	23301	4832	26	4	14.9	7.3	6.6	31.8	0	0	N	N	N	N	0.21	0.88	Surcharge
2320	5716	5801	82	4.5	143.6	9.5	82.2	86.4	0	0	N	N	N	N	2.78	1.54	Surcharge
23205	4994	23331	30	2.5	61.0	12.4	92.4	93.6	81	0	30,770	N	Y	N	Y	3.20	Flooding
23207	23331	4918	33	2.5	74.6	15.2	93.6	6	0	0	N	N	N	N	3.20	0.46	Surcharge
23234	23364	23365	91	3	9.9	2.8	7.2	7.2	0.6	0	N	N	RIM	0.14	Y	Y	Ins. freeboard
23235	4603	23365	39	3	97.2	13.8	7.8	7.2	4.2	0	1,888	N	Y	0.14	Y	Y	Flooding
23236	23365	4650	99	3	106.3	15.0	7.2	8.4	0	4.8	N	1,640	0.14	Y	Y	Y	Flooding
23424	5311	23512	40	3	59.1	8.4	48	37.8	18	0	4,229	N	Y	0.99	Y	Y	Flooding
23425	23512	5408	32	3	59.1	8.4	37.8	39	0	0	N	N	0.99	N	Y	0.45	Ins. freeboard
23426	5408	5435	19	3	59.2	8.4	39	46.8	0	0	N	N	N	N	0.54	0.5	Surcharge
2343	5801	5858	74	4.5	143.6	10.1	86.4	88.2	0	0	N	N	N	0.76	1.79	Y	Ins. freeboard
2345	5739	5861	174	3	88.1	12.5	45	40.2	0	0.6	N	N	N	RIM	5.5	Y	Ins. freeboard
23471	23554	9957	175	4.5	85.1	6.2	0	3.6	0	0	N	N	N	N	N	0.4	Surcharge
2349	5861	5871	50	3	88.2	12.5	40.2	78	0.6	0	N	N	RIM	N	Y	5.02	Ins. freeboard
2368	5918	5804	190	3	50.7	12.1	0	78	0	0.6	N	N	N	RIM	N	Y	Ins. freeboard
2389	5871	5958	105	3	88.2	12.9	78	0	0	0	N	N	N	N	5.02	N	Surcharge
2404	5798	5979	222	3	48.9	7.7	0	38.4	0	0	N	N	N	0.12	N	Y	Ins. freeboard
2424	5979	5999	52	3	48.9	6.9	38.4	27.6	0	0.6	N	N	0.12	RIM	Y	Y	Ins. freeboard
2434	5858	6017	158	4.5	143.6	9.0	88.2	87	0	0	N	N	0.76	0.35	Y	Y	Ins. freeboard
24343	4108	24212	17	4	155.7	12.4	80.4	40.2	0.6	2.4	N	1,839	RIM	Y	Y	Y	Flooding
24345	24212	4122	39	4	141.2	11.3	40.2	4.2	2.4	0	1,839	N	Y	0.54	Y	Y	Flooding
24370	5688	24235	21	4.5	137.1	8.6	82.8	84	0	0	N	N	0.47	0.96	Y	Y	Ins. freeboard
24371	24235	5716	73	4.5	136.9	11.2	84	82.2	0	0	N	N	0.96	N	Y	0.87	Ins. freeboard
2438	5999	6021	66	3	48.9	6.9	27.6	42.6	0.6	0	N	N	RIM	N	Y	2.23	Ins. freeboard
24406	6035	24259	78	3.5	87.8	9.5	44.4	0	0	0	N	N	N	0.10	1.79	Y	Ins. freeboard
24407	24259	6028	17	3.5	87.4	9.1	0	4.8	0	0	N	N	0.10	N	Y	0.15	Ins. freeboard
24428	4611	24273	86	3	100.8	14.3	10.2	36	0	0.6	N	N	0.15	RIM	Y	Y	Ins. freeboard
24429	24273	4565	22	3	100.8	14.7	36	7.2	0.6	0	N	N	RIM	N	Y	3.38	Ins. freeboard
2443	6021	6027	24	3	48.9	6.9	42.6	43.8	0	0	N	N	N	N	2.23	2.53	Surcharge
2449	5958	6035	208	3	87.8	12.6	0	44.4	0	0	N	N	N	N	N	2.2	Surcharge
2454	6017	6042	54	5	201.4	10.4	87	0	0	0	N	N	0.35	N	Y	N	Ins. freeboard
24551	4607	24373	170	4.5	22.4	9.5	0	7.2	0	0	N	N	N	N	N	0.15	Surcharge

TABLE 11 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 2006 Storm Event (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
24552	24373	24374	75	4.5	23.4	7.8	7.2	55.2	0	0	N	N	N	N	0.15	2.55	Surcharge
24553	24374	4625	14	4.5	22.9	8.4	55.2	63.6	0	0	N	N	N	N	2.55	2.26	Surcharge
24555	4625	4483	102	5	615.0	10.5	63.6	0	0	0	N	N	N	N	2.26	2.23	Surcharge
24557	24377	4627	390	10	948.5	9.7	0	44.4	0	0	N	N	N	N	N	1.05	Surcharge
24558	24377	24376	28	4	29.9	3.2	0	21	0	0	N	N	N	N	0.71	0.71	Surcharge
24560	4969	24377	27	10	950.9	10.2	0	0	0	0	N	N	N	N	0.38	N	Surcharge
24561	4969	24376	29	5	618.8	11.1	0	21	0	0	N	N	N	N	1.83	0.99	Surcharge
24562	24376	4832	97	5	617.0	12.5	21	31.8	0	0	N	N	N	N	0.99	0.88	Surcharge
24572	4173	24390	79	3	19.4	9.5	0	76.2	0	0	N	N	N	N	N	4.8	Surcharge
24578	4483	24392	234	5	724.3	12.7	0	58.8	0	0	N	N	N	N	2.23	2.72	Surcharge
24579	24392	24390	263	5	724.3	12.5	58.8	76.2	0	0	N	N	N	N	2.72	4.8	Surcharge
24580	24390	3963	245	5	732.1	12.2	76.2	79.8	0	0	N	N	N	N	4.8	1.82	Surcharge
24594	5804	5727	114	3.5	64.5	8.3	78	80.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
24619	24431	24432	28	7	382.6	6.2	16.2	8.4	0	0	N	N	N	N	1.78	0.97	Surcharge
24620	24432	24433	56	7	382.7	6.3	8.4	22.8	0	0	N	N	N	N	0.97	1.7	Surcharge
24621	24433	24434	155	7	382.7	6.1	22.8	11.4	0	0	N	N	N	N	1.7	2.22	Surcharge
24622	24434	8616	32	8	416.3	8.3	11.4	7.8	0	0	N	N	N	N	1.26	0.76	Surcharge
24623	8871	24431	250	7	382.6	6.1	3	16.2	0	0	N	N	N	N	1.62	1.78	Surcharge
24624	24435	8616	56	3	50.3	12.7	0	7.8	0	0	N	N	N	N	0.34	2.26	Surcharge
24636	9226	24445	82	6	351.3	7.3	11.4	9	0	0	N	N	N	N	1.03	0.62	Surcharge
24637	24445	9158	69	6	351.3	7.5	9	2.4	0	0	N	N	N	N	0.62	0.16	Surcharge
24638	9158	24446	89	6	395.3	9.7	2.4	0	0	0	N	N	N	N	0.16	N	Surcharge
24639	24446	9002	157	6	391.7	10.5	0	3.6	0	0	N	N	N	N	N	0.27	Surcharge
24640	9022	9217	232	4	47.6	5.5	0	47.4	0	6	N	1,604	N	Y	N	Y	Flooding
24651	6780	24457	92	3	92.9	14.8	0	1.2	0	0	N	N	N	N	0.11	0.86	Surcharge
24652	24457	24458	49	3	92.9	13.7	1.2	2.4	0	0	N	N	N	N	0.86	1.08	Surcharge
24653	24458	6518	115	3	92.9	13.1	2.4	1.8	0	0	N	N	N	N	1.08	0.57	Surcharge
24685	9746	24487	156	4.5	85.4	5.4	7.2	10.8	0	0	N	N	N	N	1.65	1.87	Surcharge
24686	24487	9623	55	4.5	111.6	7.0	10.8	9	0	0	N	N	N	N	1.89	1.57	Surcharge
2471	6028	6073	78	3.5	87.3	9.1	4.8	3.6	0	0	N	N	N	N	0.52	0.08	Surcharge
2473	6027	6077	48	3.5	48.9	5.1	43.8	42.6	0	0	N	N	N	0.97	2.03	Y	Ins. freeboard
25069	7849	7661	176	7	578.4	15.0	6	10.8	0	0	N	N	N	N	0.84	1.05	Surcharge
25072	6541	24828	90	8	676.1	14.7	0	0	0	0	N	N	N	N	0.4	N	Surcharge
2513	6077	6138	58	3.5	100.4	10.6	42.6	0	0	0	N	N	0.97	N	Y	N	Ins. freeboard

TABLE 11 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 2006 Storm Event (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
2514	6123	6139	43	3.5	87.2	9.7	0	0	0	0	N	N	N	N	0.3	N	Surcharge
2558	6215	6171	60	3	52.1	7.7	0.6	0	0	0	N	N	N	N	0.08	N	Surcharge
2648	6359	6389	79	3	52.3	8.4	0.6	0	0	0	N	N	N	N	0.02	N	Surcharge
2683	6471	6449	142	3.5	92.8	12.2	0	28.2	0	0	N	N	N	N	N	0.74	Surcharge
2711	6518	6515	7	3.5	92.9	11.0	1.8	0	0	0	N	N	N	N	0.21	N	Surcharge
2804	6542	6652	147	5.5	266.0	13.3	0	69.6	0	0.6	N	N	N	RIM	N	Y	Ins. freeboard
2819	6489	6670	154	3	59.3	9.3	0	6	0	0	N	N	N	N	N	0.23	Surcharge
2891	6775	6806	36	5.25	251.3	7.2	86.4	84	38.4	0	14,680	N	Y	0.80	Y	Y	Flooding
2907	6806	6829	29	5.25	251.3	7.2	84	82.8	0	0	N	N	0.80	N	Y	0.58	Ins. freeboard
5028	3849	3894	72	4	106.1	6.6	11.4	6	0	0	N	N	N	N	2.85	2.19	Surcharge
5033	3894	3914	17	4	124.0	7.8	6	7.2	0	0	N	N	N	N	2.19	2.02	Surcharge
5039	3937	3964	65	3.5	124.1	13.6	0.6	0	0	0	N	N	N	N	0.29	N	Surcharge
6515	3914	3937	77	3.5	124.0	12.9	7.2	0.6	0	0	N	N	N	N	2.52	0.29	Surcharge
6557	5716	5791	80	3	64.1	9.3	82.2	82.8	0	0	N	N	N	N	1.7	1.77	Surcharge
6558	5791	5850	72	3	61.7	9.9	82.8	82.8	0	0.6	N	N	N	RIM	1.77	Y	Ins. freeboard
6559	5850	6017	167	3	57.8	8.2	82.8	87	0.6	0	N	N	RIM	0.35	Y	Y	Ins. freeboard
6560	5577	5687	154	3.5	77.7	8.5	0	84	0	79.8	N	44,280	N	Y	N	Y	Flooding
6561	5572	5577	33	3.5	78.1	8.7	84.6	0	0	0	N	N	0.05	N	Y	N	Ins. freeboard
6594	6652	6775	175	5.25	266.0	7.6	69.6	86.4	0.6	38.4	N	14,680	RIM	Y	Y	Y	Flooding
6600	6829	6827	7	5.5	251.3	11.7	82.8	0	0	0	N	N	N	N	1.07	N	Surcharge
6619	3963	3939	68	5	748.3	12.5	79.8	0	0	0	N	N	N	N	1.82	0.8	Surcharge
6646	5260	5311	151	3	70.7	10.0	6.6	48	0	18	N	4,229	0.89	Y	Y	Y	Flooding
6665	4627	4559	67	10	948.5	9.5	44.4	44.4	0	0	N	N	N	N	1.05	0.93	Surcharge
6666	4559	4504	123	10	948.5	9.5	44.4	16.8	0	0	N	N	N	N	0.93	0.23	Surcharge
6682	5596	5664	71	3	60.4	12.1	10.8	19.2	0	0	N	N	N	N	2.89	2.62	Surcharge
6683	5664	5718	51	3	60.5	9.0	19.2	82.2	0	0	N	N	N	N	2.62	4.79	Surcharge
6685	5718	5720	25	3	60.5	8.6	82.2	30	0	0	N	N	N	N	4.97	3.58	Surcharge
6694	6139	6148	50	3	87.2	14.0	0	0	0	0	N	N	N	N	0.99	1.64	Surcharge
6718	6449	6437	33	3.5	92.8	9.8	28.2	0	0	0	N	N	N	N	1.09	0.75	Surcharge
8713	8430	8323	113	7	472.0	12.3	3.6	9	0	0	N	N	N	N	1.96	2.17	Surcharge
8714	8323	8185	152	7	472.0	12.3	9	7.2	0	0	N	N	N	N	2.17	1.5	Surcharge
8746	7879	7886	29	3	48.7	6.9	25.2	52.8	0	0	N	N	0.37	0.80	Y	Y	Ins. freeboard
8747	7886	7899	9	3	48.7	6.9	52.8	15.6	0	0	N	N	0.80	N	Y	1.54	Ins. freeboard
8748	7899	7914	21	3	48.7	6.9	15.6	12	0	0	N	N	N	N	1.54	1.41	Surcharge

TABLE 11 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 2006 Storm Event (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
8749	7914	7923	25	3	48.4	7.3	12	12	0	0	N	N	N	N	1.41	1.58	Surcharge
8750	7923	7917	22	3	48.2	9.1	12	7.2	0	0	N	N	N	N	1.58	1.16	Surcharge
8753	8185	7917	276	7	519.0	13.5	7.2	7.2	0	0	N	N	N	N	1.5	1.126	Surcharge
8754	7917	7849	53	7	562.0	14.8	7.2	6	0	0	N	N	N	N	1.21	0.84	Surcharge
8757	7661	7594	82	7	578.4	15.0	10.8	6	0	0	N	N	N	N	1.05	0.34	Surcharge
8875	9180	9286	111	3	39.7	5.9	0.6	0	0	0	N	N	N	N	0.03	N	Surcharge
8886	9269	9258	93	5	99.3	5.4	13.2	20.4	0	5.4	N	3,615	N	Y	1.46	Y	Flooding
8903	9362	9357	28	4	40.2	3.2	12	0	0	0	N	N	N	N	1.16	0.38	Surcharge
8906	9398	9362	67	3	2.2	1.5	39	12	0	0	N	N	N	N	1.79	1.16	Surcharge
8908	9258	9250	22	5.5	137.7	5.8	20.4	29.4	5.4	0	3,615	N	Y	0.35	Y	Y	Flooding
8909	9250	9210	123	5.5	137.7	5.8	29.4	30.6	0	0	N	N	0.35	0.04	Y	Y	Ins. freeboard
8910	9210	9187	51	5.5	137.7	5.8	30.6	33.6	0	0	N	N	0.04	0.53	Y	Y	Ins. freeboard
8913	9187	9186	50	5.5	137.7	5.8	33.6	14.4	0	0	N	N	0.53	N	Y	1.27	Ins. freeboard
8916	9281	9226	302	6	351.4	7.3	0	11.4	0	0	N	N	N	N	0.71	1.03	Surcharge
8918	9002	8871	208	4.5	149.5	10.1	3.6	3	0	0	N	N	N	N	1.28	0.17	Surcharge
8919	9002	8871	208	5.5	236.7	11.7	3.6	3	0	0	N	N	N	N	1.18	0.26	Surcharge
8944	9375	9269	376	5	99.3	6.1	0	13.2	0	0	N	N	N	N	0.92	1.26	Surcharge
9088	9496	9546	44	3	38.5	5.6	11.4	0	0	0	N	N	N	N	0.69	N	Surcharge
9089	9546	9597	50	3	38.4	5.6	0	0	0	0	N	N	N	N	N	0.24	Surcharge
9136	9370	9496	144	3	38.5	5.5	0	11.4	0	0	N	N	N	N	N	0.66	Surcharge
9138	9443	9375	261	4.5	73.1	6.2	0	0	0	0	N	N	N	N	0.1	N	Surcharge
9139	9584	9535	99	3.5	42.2	5.5	0	1.2	0	0	N	N	N	N	N	0.07	Surcharge
9140	9535	9425	201	3.5	41.1	4.8	1.2	6	0	0	N	N	N	N	0.17	0.41	Surcharge
9168	9623	9569	62	5	146.7	7.5	9	6	0	0	N	N	N	N	1.29	0.45	Surcharge
9169	9569	9442	131	5	146.7	7.5	6	9	0	0	N	N	N	N	0.6	0.71	Surcharge
9173	9957	9899	76	4.5	84.7	5.4	3.6	4.8	0	0	N	N	N	N	0.5	0.51	Surcharge
9174	9899	9790	175	4.5	85.0	6.1	4.8	0	0	0	N	N	N	N	0.61	N	Surcharge
9175	9790	9746	72	4.5	85.4	6.9	0	7.2	0	0	N	N	N	N	0.87	0.98	Surcharge
9203	9425	9362	211	4	40.2	3.2	6	12	0	0	N	N	N	N	0.41	1.06	Surcharge
9204	9412	9391	35	5	146.7	7.9	1.8	0	0	0	N	N	N	N	0.16	N	Surcharge
9205	9442	9412	29	5	146.7	7.5	9	1.8	0	0	N	N	N	N	0.81	0.05	Surcharge

US, upstream; DS, downstream; Y, yes; N, no; Ins., insufficient.

TABLE 12
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
1269	3946	3930	10	4	205.6	19.9	12	0	0	0	N	N	N	N	4.62	N	Surcharge
1333	4035	4048	71	4	149.7	11.9	22.2	18.6	0	0	N	N	N	N	5.14	4.61	Surcharge
1347	4076	3946	113	4	205.5	16.4	9	12	0	0	N	N	N	N	6.62	3.87	Surcharge
1364	4048	4108	158	4	149.7	11.9	18.6	27	0	14.4	N	18,650	N	Y	4.61	Y	Flooding
1424	4122	4204	215	4	205.0	16.3	17.4	28.8	0	15	N	27,380	0.95	Y	Y	Y	Flooding
1466	4264	4076	195	4	141.0	13.5	0	9	0	0	N	N	N	N	N	6.62	Surcharge
1479	4204	4279	70	4.5	202.6	12.7	28.8	27.6	15	0	27,380	N	Y	N	Y	5.37	Flooding
1520	4344	4341	94	3	41.0	7.5	0	9	0	2.4	N	348	N	Y	N	Y	Flooding
1531	4279	4359	64	4.5	207.6	13.1	27.6	20.4	0	0	N	N	N	N	5.37	4.14	Surcharge
1537	4341	4372	313	3.5	142.4	15.8	9	9	2.4	0	348	N	Y	N	Y	0.53	Flooding
1559	4372	4399	95	3.5	142.4	14.8	9	13.8	0	0	N	N	N	N	0.63	1.04	Surcharge
1565	4399	4415	59	3.5	142.4	15.2	13.8	0	0	0	N	N	N	N	1.34	N	Surcharge
1573	4426	4434	128	3	97.6	13.8	25.8	27	0	22.2	N	19,350	0.11	Y	Y	Y	Flooding
1579	4442	4426	59	3	97.6	13.8	22.8	25.8	0	0	N	N	0.09	0.11	Y	Y	Ins. freeboard
1585	4452	4435	23	4.5	199.8	16.8	1.2	0	0	0	N	N	N	N	0.15	N	Surcharge
1589	4434	4458	118	3	82.1	11.6	27	30	22.2	25.8	19,350	57,440	Y	Y	Y	Y	Flooding
1598	4440	4471	209	3.5	143.7	19.7	0	0.6	0	0	N	N	N	N	N	0.09	Surcharge
1605	4471	4480	276	4.5	143.0	11.1	0.6	13.8	0	0	N	N	N	N	0.09	1.51	Surcharge
1606	4480	4483	59	4.5	143.2	12.5	13.8	15	0	0	N	N	N	N	1.51	1.42	Surcharge
1611	4497	4442	157	3	97.6	17.4	20.4	22.8	0.6	0	N	N	RIM	0.09	Y	Y	Ins. freeboard
1618	4504	4466	55	10	1,039.4	10.8	20.4	0	0	0	N	N	N	N	1.1	N	Surcharge
1630	4419	4527	293	3	83.8	12.7	13.2	18.6	0.6	15	N	8,450	RIM	Y	Y	Y	Flooding
1631	4359	4529	276	4.5	219.9	13.8	20.4	25.2	0	21.6	N	40,520	N	Y	7.59	Y	Flooding
1639	4527	4540	36	3	80.0	11.3	18.6	19.2	15	12.6	8,450	10,770	Y	Y	Y	Y	Flooding
1654	4563	4452	128	4.5	172.1	13.0	0	1.2	0	0	N	N	N	N	N	0.15	Surcharge
1655	4565	4497	129	3	97.6	16.7	19.8	20.4	0	0.6	N	N	N	RIM	3.35	Y	Ins. freeboard
16666	8603	8453	149	8	518.6	12.3	0.6	11.4	0	11.4	N	49,440	0.54	Y	Y	Y	Flooding
16669	8453	8430	37	5	459.4	7.6	11.4	14.4	11.4	0	49,440	N	Y	N	Y	2.1	Flooding
16692	9217	9221	11	4	40.1	5.2	23.4	22.8	16.2	0	29,990	N	Y	0.27	Y	Y	Flooding
1677	4540	4603	166	3	91.7	13.0	19.2	20.4	12.6	13.8	10,770	11,470	Y	Y	Y	Y	Flooding
1695	4663	4611	154	3	100.3	14.5	18.6	21.6	0.6	0	N	N	RIM	0.06	Y	Y	Ins. freeboard
1697	4650	4663	62	3	105.4	14.9	20.4	18.6	17.4	0.6	6,974	N	Y	RIM	Y	Y	Flooding
17053	9221	9258	70	4.5	53.5	4.0	22.8	20.4	0	16.2	N	48,770	0.27	Y	Y	Y	Flooding

TABLE 12 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
17054	9037	9022	44	4	77.1	7.9	0	9.6	0	0	N	N	N	N	0.66	0.49	Surcharge
1723	4529	4722	186	4.5	182.6	12.7	25.2	0	21.6	0	40,520	N	Y	N	Y	N	Flooding
1782	4832	4625	255	5	630.1	11.5	21	24.6	0	0	N	N	N	N	3.03	4.36	Surcharge
1816	4722	4890	151	4.5	183.7	14.1	0	10.2	0	0	N	N	N	0.16	N	Y	Ins. freeboard
1829	4890	4907	39	2.75	49.4	8.7	10.2	10.2	0	0	N	N	0.16	0.94	Y	Y	Ins. freeboard
1835	4918	4878	30	3	77.8	11.2	16.8	0	0	0	N	N	N	N	0.55	N	Surcharge
1836	4890	4925	23	4.5	139.8	9.6	10.2	10.2	0	0	N	N	0.16	0.72	Y	Y	Ins. freeboard
1867	4925	4979	51	4.5	139.7	11.5	10.2	13.2	0	0	N	N	0.72	0.61	Y	Y	Ins. freeboard
1939	4979	5125	133	4.5	173.3	12.8	13.2	22.2	0	0.6	N	N	0.61	RIM	Y	Y	Ins. freeboard
1953	4907	5151	221	3.5	92.7	10.9	10.2	23.4	0	0	N	N	0.94	0.02	Y	Y	Ins. freeboard
1954	5125	5151	52	4	44.6	6.9	22.2	23.4	0.6	0	N	N	RIM	0.02	Y	Y	Ins. freeboard
1960	5125	5159	43	4.5	128.8	9.5	22.2	25.2	0.6	0	N	N	RIM	0.16	Y	Y	Ins. freeboard
1980	5151	5188	94	4.5	137.3	8.6	23.4	26.4	0	9.6	N	4,584	0.02	Y	Y	Y	Flooding
1990	5159	5203	81	4.5	128.8	8.1	25.2	24.6	0	0	N	N	0.16	0.88	Y	Y	Ins. freeboard
1993	5207	4994	194	2.5	64.2	13.1	33.6	39	0	24	N	19,030	N	Y	7.39	Y	Flooding
1998	5188	5217	45	4.5	135.8	8.5	26.4	27.6	9.6	22.2	4,584	55,760	Y	Y	Y	Y	Flooding
2022	5217	5254	31	4.5	100.1	6.3	27.6	24.6	22.2	0.6	55,760	N	Y	RIM	Y	Y	Flooding
2023	5203	5254	79	5	158.8	8.1	24.6	24.6	0	0.6	N	N	0.88	RIM	Y	Y	Ins. freeboard
2027	5197	5260	136	3	83.0	11.8	17.4	24	0	0	N	N	0.13	N	Y	1.78	Ins. freeboard
20299	7594	7420	151	7	596.7	16.2	15.6	0	0	0	N	N	N	N	1.5	N	Surcharge
2031	5254	5266	13	4.5	141.3	8.9	24.6	23.4	0.6	0	N	N	RIM	0.79	Y	Y	Ins. freeboard
20374	6073	6085	74	3.5	88.3	10.1	15.6	0	0	0	N	N	N	N	0.24	N	Surcharge
20378	6670	6697	26	3	79.2	11.2	17.4	3.6	0	0	N	N	N	N	2.03	0.76	Surcharge
20379	6750	6795	63	3.5	79.5	8.4	10.8	6	0	0	N	N	N	N	1.46	0.57	Surcharge
20380	6795	6874	72	3.5	91.6	11.8	6	2.4	0	0	N	N	N	N	0.69	0.30	Surcharge
20408	5687	5716	32	3	70.9	10.5	28.8	27.6	26.4	0	20,940	N	Y	N	Y	0.73	Flooding
20429	5254	5572	304	3.5	93.6	10.5	24.6	29.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
20440	4003	4035	166	3.5	149.7	15.6	12.6	22.2	0	0	N	N	0.20	N	Y	5.54	Ins. freeboard
2060	5266	5317	96	4.5	138.7	8.7	23.4	25.2	0	0	N	N	0.79	N	Y	3.00	Ins. freeboard
20673	8132	8185	235	4.5	86.8	10.4	0	16.2	0	9.6	N	17,940	N	Y	N	Y	Flooding
20681	9186	9213	27	5.5	142.4	6.1	19.8	17.4	0	0.6	N	N	0.18	RIM	Y	Y	Ins. freeboard
20682	9213	9281	77	5.5	143.5	8.3	17.4	10.8	0.6	0.6	N	87	RIM	Y	Y	Y	Flooding
20686	8616	8603	10	8	518.0	10.5	16.8	0.6	0	0	N	N	N	0.54	2.75	Y	Ins. freeboard

TABLE 12 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
20737	9418	9398	33	3	0.6	0.1	22.8	23.4	0	0.6	N	N	N	RIM	4.80	Y	Ins. freeboard
2075	5317	5342	21	4.5	138.6	8.7	25.2	23.4	0	0	N	N	N	N	3.05	2.88	Surcharge
2101	5389	5207	139	2.5	64.2	13.1	30	33.6	0	0	N	N	N	N	6.55	7.39	Surcharge
2134	5435	5462	26	3	59.1	8.7	28.2	0	0	0	N	N	N	N	0.50	N	Surcharge
2138	5468	5466	117	3	61.3	14.1	0	13.8	0	0	N	N	N	N	N	5.33	Surcharge
2159	5342	5511	138	4.5	131.5	9.8	23.4	27	0	0	N	N	N	0.36	2.88	Y	Ins. freeboard
2170	5534	5389	106	2.5	64.2	13.1	29.4	30	20.4	0	57,900	N	Y	N	Y	6.55	Flooding
21901	6437	6280	180	8	827.1	17.2	11.4	13.2	0.6	0.6	158	N	Y	RIM	Y	Y	Flooding
2196	5511	5572	50	4.5	131.8	8.3	27	29.4	0	0.6	N	N	0.36	RIM	Y	Y	Ins. freeboard
2210	5591	5534	59	3.5	74.5	7.8	27	29.4	11.4	20.4	703	57,900	Y	Y	Y	Y	Flooding
2212	5466	5596	109	3	62.1	11.4	13.8	16.2	0	0.6	N	N	N	RIM	6.11	Y	Ins. freeboard
22163	4458	4341	119	3	76.7	11.0	30	9	25.8	2.4	57,440	348	Y	Y	Y	Y	Flooding
2253	5572	5683	117	4.5	149.0	9.4	29.4	35.4	0.6	26.4	N	76,650	RIM	Y	Y	Y	Flooding
2256	5683	5688	26	4.5	129.4	8.5	35.4	28.2	26.4	0	76,650	N	Y	0.39	Y	Y	Flooding
22570	10186	22803	80	3.08	44.3	5.5	11.4	12	1.2	0.6	269	N	Y	RIM	Y	Y	Flooding
22571	22803	10172	121	3.08	47.7	6.4	12	10.2	0.6	0	N	N	RIM	0.08	Y	Y	Ins. freeboard
2260	5693	5683	16	3	42.5	8.2	25.2	35.4	0	26.4	N	76,650	0.04	Y	Y	Y	Flooding
22662	22789	22872	288	3	37.1	5.3	9	13.2	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
22663	10529	22789	134	3	37.1	7.0	7.8	9	0	0.6	N	N	N	RIM	2.47	Y	Ins. freeboard
22664	10171	22872	8	4.5	50.4	4.1	11.4	13.2	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
2268	5707	5693	13	3	0.2	0.6	33	25.2	0	0	N	N	0.01	0.04	Y	Y	Ins. freeboard
2275	5720	5719	39	3	62.1	11.0	19.8	17.4	0	0	N	N	N	N	5.95	5.61	Surcharge
2282	5727	5591	129	3.5	75.6	10.1	22.8	27	11.4	11.4	10,170	703	Y	Y	Y	Y	Flooding
2292	5719	5739	100	3	102.3	14.5	17.4	27.6	0	10.2	N	3,921	N	Y	5.61	Y	Flooding
23169	4820	23301	25	4	18.8	5.4	18.6	19.2	0	0	N	N	N	N	2.70	2.15	Surcharge
2317	5681	5798	114	3	75.8	12.2	9.6	13.2	0	0.6	N	N	N	RIM	2.10	Y	Ins. freeboard
23170	23301	4832	26	4	24.2	7.0	19.2	21	0	0	N	N	N	N	2.15	3.03	Surcharge
2320	5716	5801	82	4.5	143.9	9.5	27.6	31.2	0	0	N	N	N	N	2.85	1.72	Surcharge
23205	4994	23331	30	2.5	60.9	12.4	39	39.6	24	0	19,030	N	Y	0.84	Y	Y	Flooding
23207	23331	4918	33	2.5	77.8	15.8	39.6	16.8	0	0	N	N	0.84	N	Y	0.88	Ins. freeboard
23234	23364	23365	91	3	15.5	2.8	19.2	19.8	0	0	N	N	0.85	0.40	Y	Y	Ins. freeboard
23235	4603	23365	39	3	101.9	14.4	20.4	19.8	13.8	0	11,470	N	Y	0.4	Y	Y	Flooding
23236	23365	4650	99	3	106.4	15.1	19.8	20.4	0	17.4	N	6,974	0.40	Y	Y	Y	Flooding

TABLE 12 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
23355	4348	23454	132	3	83.9	12.3	10.8	14.4	0	0	N	N	N	0.08	1.28	Y	Ins. freeboard
23356	23454	4419	69	3	83.9	12.2	14.4	13.2	0	0.6	N	N	0.08	RIM	Y	Y	Ins. freeboard
23424	5311	23512	40	3	59.1	8.4	28.8	27.6	25.8	0	24,960	N	Y	0.99	Y	Y	Flooding
23425	23512	5408	32	3	59.1	8.4	27.6	27.6	0	0	N	N	0.99	N	Y	0.45	Ins. freeboard
23426	5408	5435	19	3	59.3	8.4	27.6	28.2	0	0	N	N	N	N	0.54	0.50	Surcharge
2343	5801	5858	74	4.5	143.9	10.1	31.2	34.2	0	0	N	N	N	0.54	1.97	Y	Ins. freeboard
2345	5739	5861	174	3	91.9	13.0	27.6	22.2	10.2	0.6	3,921	N	Y	RIM	Y	Y	Flooding
23470	10086	23554	73	4.5	104.4	6.9	13.2	13.8	0	0	N	N	N	N	3.68	3.61	Surcharge
23471	23554	9957	175	4.5	104.4	6.6	13.8	15	0	0	N	N	N	N	3.61	3.46	Surcharge
2349	5861	5871	50	3	91.9	13.0	22.2	29.4	0.6	0	N	N	RIM	N	Y	6.29	Ins. freeboard
2368	5918	5804	190	3	76.3	12.0	12	21	0	3.6	N	374	N	Y	4.22	Y	Flooding
2389	5871	5958	105	3	91.9	13.0	29.4	14.4	0	0	N	N	N	N	6.29	4.48	Surcharge
2404	5798	5979	222	3	75.8	10.7	13.2	19.2	0.6	12.6	N	10,340	RIM	Y	Y	Y	Flooding
2424	5979	5999	52	3	55.2	7.8	19.2	18.6	12.6	14.4	10,340	11,940	Y	Y	Y	Y	Flooding
2431	6015	5918	119	3	76.3	10.8	13.8	12	0	0	N	N	N	N	4.96	4.22	Surcharge
2434	5858	6017	158	4.5	143.9	9.1	34.2	32.4	0	0	N	N	0.54	0.11	Y	Y	Ins. freeboard
24343	4108	24212	17	4	158.4	12.6	27	24.6	14.4	16.8	18,650	29,640	Y	Y	Y	Y	Flooding
24345	24212	4122	39	4	157.3	12.5	24.6	17.4	16.8	0	29,640	N	Y	0.95	Y	Y	Flooding
24370	5688	24235	21	4.5	128.7	8.1	28.2	28.8	0	0	N	N	0.39	0.83	Y	Y	Ins. freeboard
24371	24235	5716	73	4.5	128.0	11.3	28.8	27.6	0	0	N	N	0.83	N	Y	0.94	Ins. freeboard
2438	5999	6021	66	3	53.0	7.5	18.6	19.8	14.4	0	11,940	N	Y	0.78	Y	Y	Flooding
24406	6035	24259	78	3.5	91.5	9.5	25.2	13.8	0	13.2	N	2,644	N	Y	2.03	Y	Flooding
24407	24259	6028	17	3.5	88.7	9.2	13.8	15.6	13.2	0	2,644	N	Y	N	Y	0.26	Flooding
24428	4611	24273	86	3	100.3	14.2	21.6	23.4	0	0.6	N	N	0.06	RIM	Y	Y	Ins. freeboard
24429	24273	4565	22	3	100.3	14.4	23.4	19.8	0.6	0	N	N	RIM	N	Y	3.25	Ins. freeboard
2443	6021	6027	24	3	53.0	7.5	19.8	19.8	0	0	N	N	0.78	N	Y	3.3	Ins. freeboard
2449	5958	6035	208	3	91.5	12.9	14.4	25.2	0	0	N	N	N	N	4.48	2.44	Surcharge
2454	6017	6042	54	5	201.9	10.4	32.4	0	0	0	N	N	0.11	N	Y	N	Ins. freeboard
24551	4607	24373	170	4.5	39.7	9.7	0	19.2	0	0	N	N	N	N	N	2.38	Surcharge
24552	24373	24374	75	4.5	39.7	7.3	19.2	24	0	0	N	N	N	N	2.38	4.02	Surcharge
24553	24374	4625	14	4.5	39.8	7.8	24	24.6	0	0	N	N	N	N	4.02	4.36	Surcharge
24555	4625	4483	102	5	642.3	10.8	24.6	15	0	0	N	N	N	N	4.36	4.45	Surcharge
24557	24377	4627	390	10	1,037.0	10.4	18	22.8	0	0	N	N	N	N	1.49	2.27	Surcharge

TABLE 12 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
24558	24377	24376	28	4	34.6	3.2	18	20.4	0	0	N	N	N	N	2.53	2.5	Surcharge
24560	4969	24377	27	10	1,047.2	10.5	17.4	18	12.6	0	113,600	N	Y	N	Y	1.49	Flooding
24561	4969	24376	29	5	637.7	11.2	17.4	20.4	12.6	0	113,600	N	Y	N	Y	2.78	Flooding
24562	24376	4832	97	5	631.8	12.3	20.4	21	0	0	N	N	N	N	2.78	3.03	Surcharge
24571	24389	4173	112	3	29.0	11.0	0	3	0	0	N	N	N	N	N	2.30	Surcharge
24572	4173	24390	79	3	29.9	9.5	3	26.4	0	0	N	N	N	N	2.75	8.76	Surcharge
24578	4483	24392	234	5	769.9	12.8	15	24	0	0	N	N	N	N	4.45	5.97	Surcharge
24579	24392	24390	263	5	769.9	12.8	24	26.4	0	0	N	N	N	N	5.97	8.76	Surcharge
24580	24390	3963	245	5	795.6	13.3	26.4	28.2	0	0	N	N	N	N	8.76	2.71	Surcharge
2459	6042	6052	20	5.5	201.8	9.8	0	0	0	0	N	N	N	N	0.06	N	Surcharge
24594	5804	5727	114	3.5	96.7	10.1	21	22.8	3.6	11.4	374	10,170	Y	Y	Y	Y	Flooding
24609	8831	24423	47	3	69.3	9.8	11.4	10.2	0	0	N	N	N	N	5.61	4.48	Surcharge
24610	24423	24424	46	3	69.3	9.8	10.2	10.2	0	0	N	N	N	N	4.73	4.16	Surcharge
24611	24424	24425	67	3	69.3	9.8	10.2	10.8	0	0	N	N	N	N	4.41	3.71	Surcharge
24612	24425	24426	87	3	69.3	9.8	10.8	11.4	0	0	N	N	N	N	3.96	3.53	Surcharge
24613	24426	24427	49	3	69.3	9.8	11.4	11.4	0	0	N	N	N	N	3.78	4.45	Surcharge
24614	24427	24435	79	3	69.3	9.8	11.4	12	0	0	N	N	N	N	4.7	2.55	Surcharge
24619	24431	24432	28	7	404.6	6.4	19.8	16.8	0.6	0	N	N	RIM	0.33	Y	Y	Ins. freeboard
24620	24432	24433	56	7	404.9	6.4	16.8	20.4	0	8.4	N	9,874	0.33	Y	Y	Y	Flooding
24621	24433	24434	155	7	394.1	6.3	20.4	18.6	8.4	0	9,874	N	Y	0.71	Y	Y	Flooding
24622	24434	8616	32	8	465.8	9.3	18.6	16.8	0	0	N	N	0.71	N	Y	2.75	Ins. freeboard
24623	8871	24431	250	7	404.5	6.4	13.8	19.8	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
24624	24435	8616	56	3	69.3	12.2	12	16.8	0	0	N	N	N	N	3.65	4.25	Surcharge
24636	9226	24445	82	6	366.1	7.6	19.8	17.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
24637	24445	9158	69	6	365.5	7.6	17.4	14.4	0.6	0	N	N	RIM	0.18	Y	Y	Ins. freeboard
24638	9158	24446	89	6	439.2	9.7	14.4	13.2	0	0	N	N	0.18	N	Y	9.06	Ins. freeboard
24639	24446	9002	157	6	417.4	10.5	13.2	14.4	0	0	N	N	N	N	9.06	6.65	Surcharge
24640	9022	9217	232	4	77.1	6.1	9.6	23.4	0	16.2	N	29,900	N	Y	0.93	Y	Flooding
24651	6780	24457	92	3	115.4	16.3	16.2	16.8	0	0.6	N	N	0.5	RIM	Y	Y	Ins. freeboard
24652	24457	24458	49	3	115.4	16.3	16.8	17.4	0.6	0	N	N	RIM	N	Y	5.77	Ins. freeboard
24653	24458	6518	115	3	115.4	16.3	17.4	16.8	0	0	N	N	N	0.15	5.77	Y	Ins. freeboard
24654	7099	7051	65	3	108.3	15.3	10.2	15.6	0	0	N	N	0.19	0.65	Y	Y	Ins. freeboard
24659	22872	10168	40	4.5	104.4	6.6	13.2	13.8	0.6	0	N	N	RIM	0.49	Y	Y	Ins. freeboard

TABLE 12 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
2467	6052	6069	38	5.5	201.7	9.4	0	0.6	0	0	N	N	N	N	N	0.01	Surcharge
24679	10222	24482	61	3	40.2	5.7	12.6	13.2	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
24680	24482	10190	39	3	40.2	5.7	13.2	12	0.6	10.2	N	11,020	RIM	Y	Y	Y	Flooding
24685	9746	24487	156	4.5	93.7	5.9	17.4	20.4	10.2	0	24,290	N	Y	0.14	Y	Y	Flooding
24686	24487	9623	55	4.5	116.7	7.3	20.4	18.6	0	0	N	N	0.14	0.08	Y	Y	Ins. freeboard
2471	6028	6073	78	3.5	88.6	9.2	15.6	15.6	0	0	N	N	N	N	0.63	0.23	Surcharge
2473	6027	6077	48	3.5	53.1	5.5	19.8	19.8	0	10.2	N	6,667	N	Y	2.80	Y	Flooding
25069	7849	7661	176	7	596.7	15.5	15.6	18	0	0	N	N	N	0.51	2.79	Y	Ins. freeboard
25072	6541	24828	90	8	782.1	15.8	15	11.4	12	0	119,200	N	Y	0.73	Y	Y	Flooding
25074	6860	6437	375	8	670.4	15.9	6.6	11.4	0	0.6	N	158	N	Y	3.23	Y	Flooding
25076	24828	24829	180	8	751.6	16.4	11.4	13.8	0	0	N	N	0.73	0.78	Y	Y	Ins. freeboard
25077	24829	6148	135	8	750.2	16.6	13.8	13.2	0	0	N	N	0.78	N	Y	3.85	Ins. freeboard
25078	6148	24830	355	8	864.6	17.5	13.2	14.4	0	0.6	N	N	N	RIM	3.85	Y	Ins. freeboard
25080	24830	24831	259	9	851.4	13.4	14.4	16.2	0.6	0	N	N	RIM	N	Y	2.45	Ins. freeboard
25081	24831	5409	123	9	851.7	13.4	16.2	15.6	0	0	N	N	N	N	2.45	1.81	Surcharge
25082	5409	24843	114	9	923.8	14.5	15.6	18	0	0	N	N	N	0.98	1.81	Y	Ins. freeboard
25083	24843	24844	129	9	923.9	14.9	18	13.8	0	0	N	N	0.98	N	Y	0.86	Ins. freeboard
25084	24844	5114	63	9	923.9	17.8	13.8	0	0	0	N	N	N	N	0.86	N	Surcharge
2512	6069	6136	63	5.5	201.6	10.1	0.6	0	0	0	N	N	N	N	0.19	N	Surcharge
2513	6077	6138	58	3.5	104.5	10.9	19.8	14.4	10.2	0	6,667	N	Y	0.66	Y	Y	Flooding
2514	6123	6139	43	3.5	90.5	9.7	0	13.8	0	0	N	N	N	N	3.1	2.58	Surcharge
2531	6171	6015	166	3	76.3	10.8	13.8	13.8	0	0	N	N	N	N	6.84	4.96	Surcharge
2558	6215	6171	60	3	76.3	10.8	15.6	13.8	0	0	N	N	N	N	8.31	6.84	Surcharge
2571	6136	6241	158	5.5	202.0	9.7	0	0	0	0	N	N	N	0.98	0.54	Y	Ins. freeboard
2611	6241	6314	195	5.5	236.6	10.9	0	3.6	0	0	N	N	0.98	N	Y	0.31	Ins. freeboard
2630	6314	6361	68	5.5	237.3	13.1	3.6	0	0	0	N	N	N	N	0.31	N	Surcharge
2648	6359	6389	79	3	69.9	9.9	15	12.6	0	0	N	N	0.1	N	Y	2.84	Ins. freeboard
2659	6361	6415	81	5.5	239.3	13.6	0	11.4	0	0	N	N	N	N	N	2.22	Surcharge
2683	6471	6449	142	3.5	114.7	12.0	13.2	20.4	0.6	7.8	N	6,242	RIM	Y	Y	Y	Flooding
2693	6389	6489	98	3	79.2	11.8	12.6	6	0	0	N	N	N	N	3.34	0.46	Surcharge
2710	6515	6471	107	3.5	115.2	15.3	10.8	13.2	0	0.6	N	N	N	RIM	2.54	Y	Ins. freeboard
2711	6518	6515	7	3.5	115.5	12.8	16.8	10.8	0	0	N	N	0.15	N	Y	2.51	Ins. freeboard
2733	6415	6542	177	5.5	314.3	13.2	11.4	12	0	0	N	N	N	0.94	2.22	Y	Ins. freeboard

TABLE 12 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
2752	6546	6568	62	9	911.9	14.3	15	13.2	0	0	N	N	N	0.29	3.93	Y	Ins. freeboard
2793	6630	6546	458	9	911.8	14.3	0	15	0	0	N	N	N	N	5.28	3.93	Surcharge
2804	6542	6652	147	5.5	314.4	13.2	12	19.8	0	5.4	N	1,294	0.94	Y	Y	Y	Flooding
2819	6489	6670	154	3	79.2	11.2	6	17.4	0	0	N	N	N	N	1.59	1.93	Surcharge
2860	6697	6750	60	3.5	79.5	8.5	3.6	10.8	0	0	N	N	N	N	0.36	1.41	Surcharge
2891	6775	6806	36	5.25	251.5	7.2	32.4	30	18	0	43,580	N	Y	0.79	Y	Y	Flooding
2903	6821	6780	43	3	115.4	17.5	14.4	16.2	11.4	0	6,913	N	Y	0.5	Y	Y	Flooding
2907	6806	6829	29	5.25	251.6	7.2	30	27.6	0	0	N	N	0.79	N	Y	0.59	Ins. freeboard
2931	6874	6762	279	9	874.4	14.3	2.4	0	0	0	N	N	N	N	1.47	N	Surcharge
2977	6955	6874	200	9	787.7	12.4	7.8	2.4	0	0	N	N	N	N	2.96	1.12	Surcharge
2978	6844	6955	170	9	594.4	9.3	10.2	7.8	0	0	N	N	0.35	N	Y	2.86	Ins. freeboard
2993	6988	6844	339	9	538.5	8.5	9.6	10.2	0.6	0	N	N	RIM	0.35	Y	Y	Ins. freeboard
3019	7040	6955	102	7	153.3	8.1	0	7.8	0	0	N	N	N	N	1.2	1.86	Surcharge
3039	7079	6988	316	8	527.3	10.5	10.2	9.6	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
3046	7091	6860	203	7	629.8	19.9	6	6.6	0.6	0	N	N	RIM	N	Y	3.23	Ins. freeboard
3192	7420	7091	340	7	631.4	18.6	0	6	0	0.6	N	N	N	RIM	N	Y	Ins. freeboard
5028	3849	3894	72	4	138.2	8.6	22.2	21	0	0	N	N	0.02	N	Y	8.82	Ins. freeboard
5033	3894	3914	17	4	149.7	9.4	21	21.6	0	0	N	N	N	N	8.82	8.31	Surcharge
5039	3937	3964	65	3.5	149.7	15.6	16.8	10.8	0	0	N	N	N	N	4.5	2.39	Surcharge
5049	3964	3993	65	3.5	149.7	16.5	10.8	8.4	0	0	N	N	N	N	2.39	2.01	Surcharge
5051	3993	4003	217	3.5	149.6	18.8	8.4	12.6	0	0	N	N	N	0.2	2.01	Y	Ins. freeboard
6515	3914	3937	77	3.5	149.7	15.6	21.6	16.8	0	0	N	N	N	N	8.81	4.5	Surcharge
6557	5716	5791	80	3	63.8	9.2	27.6	28.2	0	0	N	N	N	N	1.77	1.96	Surcharge
6558	5791	5850	72	3	61.3	9.9	28.2	28.2	0	0.6	N	N	N	RIM	1.96	Y	Ins. freeboard
6559	5850	6017	167	3	58.0	8.2	28.2	32.4	0.6	0	N	N	RIM	0.11	Y	Y	Ins. freeboard
6560	5577	5687	154	3.5	78.2	8.6	0	28.8	0	26.4	N	20,940	N	Y	N	Y	Flooding
6561	5572	5577	33	3.5	78.2	9.1	29.4	0	0.6	0	N	N	RIM	N	Y	N	Ins. freeboard
6594	6652	6775	175	5.25	305.1	8.7	19.8	32.4	5.4	18	1,294	43,580	Y	Y	Y	Y	Flooding
6596	6138	6407	310	3.5	104.5	13.1	14.4	0	0	0	N	N	0.66	N	Y	N	Ins. freeboard
6597	7377	7079	903	8	527.3	13.6	0	10.2	0	0.6	N	N	N	RIM	N	Y	Ins. freeboard
6600	6829	6827	7	5.5	251.6	11.7	27.6	0	0	0	N	N	N	N	1.08	N	Surcharge
6619	3963	3939	68	5	826.6	13.8	28.2	0	0	0	N	N	N	N	2.71	1.42	Surcharge
6646	5260	5311	151	3	83.0	11.7	24	28.8	0	25.8	N	24,960	N	Y	1.88	Y	Flooding

TABLE 12 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
6665	4627	4559	67	10	1,037.0	10.4	22.8	22.8	0	0	N	N	N	N	2.27	2.06	Surcharge
6666	4559	4504	123	10	1,037.0	10.4	22.8	20.4	0	0	N	N	N	N	2.06	1.1	Surcharge
6682	5596	5664	71	3	62.1	12.1	16.2	17.4	0.6	11.4	N	5,131	RIM	Y	Y	Y	Flooding
6683	5664	5718	51	3	62.1	9.2	17.4	31.8	11.4	0	5,131	N	Y	N	Y	6.77	Flooding
6685	5718	5720	25	3	62.1	8.8	31.8	19.8	0	0	N	N	N	N	6.95	5.95	Surcharge
6687	6280	6148	133	8	819.0	17.7	13.2	13.2	0.6	0	N	N	RIM	N	Y	3.85	Ins. freeboard
6688	6148	5794	353	8	836.4	16.6	13.2	15	0	0	N	N	N	N	3.85	4.06	Surcharge
6694	6139	6148	50	3	90.5	12.8	13.8	13.2	0	0	N	N	N	N	5.33	7.58	Surcharge
6696	5490	5269	181	9	917.7	14.4	12	17.4	0	0	N	N	N	N	1.18	2.02	Surcharge
6697	5559	5490	56	9	885.8	14.0	17.4	12	0	0	N	N	N	N	2.66	1.18	Surcharge
6698	5794	5559	259	9	885.9	13.9	15	17.4	0	0	N	N	N	N	3.06	2.66	Surcharge
6699	5269	5128	129	9	917.6	14.7	17.4	12	0	0	N	N	N	N	2.02	0.7	Surcharge
6700	5128	5114	59	9	914.5	17.5	12	0	0	0	N	N	N	N	0.7	0.05	Surcharge
6718	6449	6437	33	3.5	114.7	11.9	20.4	11.4	7.8	0.6	6,242	158	Y	Y	Y	Y	Flooding
6721	6568	6541	99	9	911.9	14.3	13.2	15	0	12	N	119,200	0.29	Y	Y	Y	Flooding
6726	7051	7047	21	3	108.3	15.5	15.6	10.8	0	0	N	N	0.65	N	Y	1.95	Ins. freeboard
6728	7047	6821	283	3	108.3	19.1	10.8	14.4	0	11.4	N	6,913	N	Y	2.2	Y	Flooding
8713	8430	8323	113	7	478.3	12.4	14.4	17.4	0	0	N	N	N	N	3.4	3.63	Surcharge
8714	8323	8185	152	7	478.3	12.4	17.4	16.2	0	9.6	N	17,940	N	Y	3.63	Y	Flooding
8746	7879	7886	29	3	53.3	7.5	30	36	0	0	N	N	0.1	0.38	Y	Y	Ins. freeboard
8747	7886	7899	9	3	53.3	7.5	36	28.8	0	0	N	N	0.38	N	Y	2.13	Ins. freeboard
8748	7899	7914	21	3	53.3	7.5	28.8	21.6	0	0	N	N	N	N	2.13	2.25	Surcharge
8749	7914	7923	25	3	53.3	7.6	21.6	18.6	0	0	N	N	N	N	2.25	2.78	Surcharge
8750	7923	7917	22	3	53.9	9.4	18.6	16.2	0	0	N	N	N	N	2.78	2.8	Surcharge
8753	8185	7917	276	7	543.5	14.1	16.2	16.2	9.6	0	17,940	N	Y	N	Y	2.77	Flooding
8754	7917	7849	53	7	572.5	14.9	16.2	15.6	0	0	N	N	N	N	2.85	2.79	Surcharge
8757	7661	7594	82	7	596.7	15.5	18	15.6	0	0	N	N	0.51	N	Y	1.5	Ins. freeboard
8861	8753	9019	598	3.5	77.6	8.3	7.2	0	0	0	N	N	N	N	1	N	Surcharge
8875	9180	9286	111	3	45.1	6.4	16.2	13.8	0	0.6	N	N	0.91	RIM	Y	Y	Ins. freeboard
8876	9286	9317	41	3	45.1	6.8	13.8	13.2	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
8877	9317	9370	85	3	45.1	7.5	13.2	15.6	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
8886	9269	9258	93	5	152.5	7.8	19.8	20.4	0	16.2	N	48,770	0.07	Y	Y	Y	Flooding
8903	9362	9357	28	4	56.3	4.5	20.4	10.2	0.6	0	N	N	RIM	0.16	Y	Y	Ins. freeboard

TABLE 12 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
8904	9357	9281	108	5.5	241.0	12.0	10.2	10.8	0	0.6	N	87	0.16	Y	Y	Y	Flooding
8905	9391	9357	61	5	169.3	9.4	11.4	10.2	0.6	0	N	N	RIM	0.16	Y	Y	Ins. freeboard
8906	9398	9362	67	3	1.9	0.5	23.4	20.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
8908	9258	9250	22	5.5	142.4	6.0	20.4	21	16.2	0	48,770	N	Y	0.22	Y	Y	Flooding
8909	9250	9210	123	5.5	142.3	6.0	21	21.6	0	13.8	N	53,710	0.22	Y	Y	Y	Flooding
8910	9210	9187	51	5.5	142.3	6.0	21.6	22.2	13.8	0.6	53,710	125	Y	Y	Y	Y	Flooding
8913	9187	9186	50	5.5	142.4	6.0	22.2	19.8	0.6	0	125	N	Y	0.18	Y	Y	Flooding
8916	9281	9226	302	6	366.2	7.6	10.8	19.8	0.6	0.6	87	N	Y	RIM	Y	Y	Flooding
8918	9002	8871	208	4.5	158.2	10.1	14.4	13.8	0	0.6	N	N	N	RIM	7.66	Y	Ins. freeboard
8919	9002	8871	208	5.5	248.5	11.6	14.4	13.8	0	0.6	N	N	N	RIM	7.56	Y	Ins. freeboard
8944	9375	9269	376	5	152.5	7.8	9.6	19.8	0.6	0	N	N	RIM	0.07	Y	Y	Ins. freeboard
9053	10266	10259	31	3	40.2	5.7	12.6	12	0	0	N	N	N	N	1.46	1.16	Surcharge
9054	10259	10222	157	3	40.2	5.7	12	12.6	0	0.6	N	N	N	RIM	1.27	Y	Ins. freeboard
9056	10190	10178	128	3	40.3	5.8	12	12	10.2	0.6	11,020	N	Y	RIM	Y	Y	Flooding
9057	10178	10193	85	3	40.6	6.5	12	10.8	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
9058	10193	10186	54	3.08	42.0	5.1	10.8	11.4	0.6	1.2	N	269	RIM	Y	Y	Y	Flooding
9060	10172	10171	9	4	49.9	11.7	10.2	11.4	0	0.6	N	N	0.08	RIM	Y	Y	Ins. freeboard
9062	10168	10156	207	4.5	104.4	6.6	13.8	13.8	0	0	N	N	0.49	N	Y	4.32	Ins. freeboard
9063	10156	10086	131	4.5	104.4	6.6	13.8	13.2	0	0	N	N	N	N	4.42	3.68	Surcharge
9088	9496	9546	44	3	45.1	6.4	24	12.6	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
9089	9546	9597	50	3	45.1	6.4	12.6	11.4	0.6	0	N	N	RIM	0.03	Y	Y	Ins. freeboard
9090	9597	9657	67	3.5	45.1	5.1	11.4	7.2	0	0	N	N	0.03	0.52	Y	Y	Ins. freeboard
9091	9657	9694	33	3.5	45.7	6.7	7.2	7.2	0	0	N	N	0.52	0.69	Y	Y	Ins. freeboard
9092	9694	9701	11	3.5	46.1	6.7	7.2	7.2	0	0	N	N	0.69	0.56	Y	Y	Ins. freeboard
9093	9701	9700	13	4	46.5	7.1	7.2	7.2	0	0	N	N	0.56	0.46	Y	Y	Ins. freeboard
9102	9700	9677	143	4	53.3	6.2	7.2	9	0	0	N	N	0.46	0.15	Y	Y	Ins. freeboard
9103	9677	9670	52	4	54.5	6.0	9	10.2	0	0	N	N	0.15	0.3	Y	Y	Ins. freeboard
9104	9670	9666	43	4	54.8	5.7	10.2	10.8	0	0.6	N	N	0.3	RIM	Y	Y	Ins. freeboard
9105	9666	9656	156	4	96.6	7.7	10.8	12	0.6	0	N	N	RIM	N	Y	5.29	Ins. freeboard
9106	9656	9652	46	4	96.6	7.7	12	12	0	0	N	N	N	N	5.81	5.8	Surcharge
9107	9471	9443	271	4.5	96.7	6.1	10.8	12.6	0	0	N	N	N	N	4.31	4.1	Surcharge
9108	9652	9498	153	4.5	96.6	6.1	12	12	0	0	N	N	N	N	5.41	4.72	Surcharge

TABLE 12 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
9109	9498	9471	36	4.5	96.7	6.1	12	10.8	0	0	N	N	N	N	4.76	4.28	Surcharge
9119	9720	9722	221	3	13.6	3.5	2.4	3	0	0.6	N	N	N	RIM	1.04	Y	Ins. freeboard
9120	9722	9724	39	3.5	14.1	3.8	3	3.6	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
9121	9724	9695	334	3.5	42.5	5.7	3.6	10.8	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
9122	9695	9617	65	3.5	42.5	4.7	10.8	10.8	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
9136	9370	9496	144	3	45.1	6.4	15.6	24	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
9138	9443	9375	261	4.5	96.7	6.1	12.6	9.6	0	0.6	N	N	N	RIM	4.3	Y	Ins. freeboard
9139	9584	9535	99	3.5	56.3	5.9	12.6	14.4	3	0.6	1,351	N	Y	RIM	Y	Y	Flooding
9140	9535	9425	201	3.5	56.3	5.9	14.4	15.6	0.6	0	N	N	RIM	N	Y	3.69	Ins. freeboard
9168	9623	9569	62	5	169.0	8.6	18.6	16.2	0	0	N	N	0.08	0.99	Y	Y	Ins. freeboard
9169	9569	9442	131	5	169.0	8.6	16.2	18	0	6.6	N	2,765	0.99	Y	Y	Y	Flooding
9173	9957	9899	76	4.5	104.4	6.6	15	15.6	0	0	N	N	N	0.44	3.56	Y	Ins. freeboard
9174	9899	9790	175	4.5	104.4	6.6	15.6	13.2	0	0.6	N	N	0.44	RIM	Y	Y	Ins. freeboard
9175	9790	9746	72	4.5	104.4	7.1	13.2	17.4	0.6	10.2	N	24,290	RIM	Y	Y	Y	Flooding
9203	9425	9362	211	4	56.3	4.5	15.6	20.4	0	0.6	N	N	N	RIM	3.69	Y	Ins. freeboard
9204	9412	9391	35	5	169.1	8.6	14.4	11.4	0	0.6	N	N	0.2	RIM	Y	Y	Ins. freeboard
9205	9442	9412	29	5	169.0	8.6	18	14.4	6.6	0	2,765	N	Y	0.2	Y	Y	Flooding
9212	9617	9584	126	3.5	42.3	4.4	10.8	12.6	0.6	3	N	1,351	RIM	Y	Y	Y	Flooding

US, upstream; DS, downstream; Y, yes; N, no; Ins., insufficient.

TABLE 13
2006 Storm Event Stream Results

Conduit ID	Node ID		Length (ft)	Depth (ft)	Maximum Flow (ft^3/s)
	US	DS			
1194	3776	3630	115	7.69	1,861.4
1226	3841	3776	61	11.40	1,838.2
1251	3901	3841	170	11.40	1,838.3
1262	3930	3655	237	11.26	130.6
6190	3087	3040	58	22.47	2,601.3
6191	3040	2954	125	22.47	2,429.3
6367	2935	2974	168	8.21	2,220.3
6368	2954	2935	255	26.55	2,264.8
6639	3630	3561	58	7.69	1,861.3
6640	3561	3441	290	19.51	1,946.3
6641	3377	3084	391	18.02	2,152.1
6642	3084	3085	58	7.00	2,803.5
6643	3085	3087	50	19.40	2,679.9
20310	5114	4969	392	10.80	1,532.8
20312	3916	3901	106	11.40	1,826.5
20314	3722	3648	81	3.00	88.9
20317	3641	3561	138	3.00	88.6
20318	3386	3377	131	20.14	2,217.4
20319	3483	3386	76	6.33	165.1
20321	3441	3386	437	16.31	1,974.5
22288	2974	22546	66	8.21	2,219.7

TABLE 14
10-Year, 24-Hour SCS Type II Stream Results

Conduit ID	Node ID		Length (ft)	Depth (ft)	Maximum Flow (ft^3/s)
	US	DS			
1194	3776	3630	115	7.69	2,152.8
1226	3841	3776	61	11.40	2,102.3
1251	3901	3841	170	11.40	2,103.9
1262	3930	3655	237	11.26	205.1
6190	3087	3040	58	22.47	2,802.6
6191	3040	2954	125	22.47	2,676.6
6367	2935	2974	168	8.21	2,656.2
6368	2954	2935	255	26.55	2,660.0
6639	3630	3561	58	7.69	2,153.1
6640	3561	3441	290	19.51	2,282.9
6641	3377	3084	391	18.02	2,653.7
6642	3084	3085	58	7.00	2,921.2
6643	3085	3087	50	19.40	2,872.2
20310	5114	4969	392	10.80	1,962.1
20312	3916	3901	106	11.40	2,072.7
20314	3722	3648	81	3.00	144.0
20317	3641	3561	138	3.00	143.0
20318	3386	3377	131	20.14	2,737.5
20319	3483	3386	76	6.33	265.9
20321	3441	3386	437	16.31	2,334.3
22288	2974	22546	66	8.21	2,655.6

Data Gaps

Appendix A
Technical Memorandum: GIS Data Gaps in the Storm Sewer System

GIS Data Gaps and Anomalies—Spout Run

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DATE:	October 7, 2011
PROJECT NUMBER:	392309

1 Introduction

This technical memorandum describes the Spout Run storm sewer data obtained from Arlington County staff and the work performed to identify and resolve the data gaps and anomalies in the storm sewer network. These data gaps and anomalies were examined in light of the necessary information for use in PC-SWMM (a hydrologic and hydraulic computer model used to simulate storm sewer systems).

For the purpose of this analysis, the major storm sewer network has been divided into 18 segments, which are shown in **Figure 1-1**. Descriptions of the 18 segments are found in **Table 1-1**. All figures are found at the end of this document.

TABLE 1-1
Spout Run Watershed—Major Storm Sewer Network Segments

Segment	Description
1	20th Road N. from Lee Highway to N. Woodstock Street
2	20th Road N. and N. Woodstock Street to 16th Street N. and N. Taylor Street
3	19th Street N. cul-de-sac (west of N. Utah Street) to N. Stafford Street and Interstate 66
4	Interstate 66 from N. Stafford Street to N. Kirkwood Road and 17th Street N.
5	South of N. Nelson Street and 17th Street N. to N. Nelson and Interstate 66
6	Northwest of N. Quincy Street and 14th Street N. to Interstate 66 at N. Nelson Street
7	20th Street N. and N. Oakland Street to north of Kirkwood Road and 17th Street N.
8	Kirkwood Road/Spout Run Parkway from Washington Boulevard to Interstate 66
9	South of Washington Boulevard and N. Quincy Street to N. Nelson Street and 10th Street N.
10	N. Randolph Street and 11th Street N. to N. Monroe Street and 10th Street N.
11	Fairfax Drive from N. Quincy Street to N. Monroe Street
12	9th Street N. from N. Randolph Street to N. Monroe Street (includes N. Pollard from 9th Street N. to Wilson Boulevard)
13	Fairfax Drive and N. Monroe Street to southwest of Kirkwood Road and Washington Boulevard

TABLE 1-1
Spout Run Watershed—Major Storm Sewer Network Segments

Segment	Description
14	Key Boulevard and N. Herndon Street to Kirkwood Road and 17th Street N.
15	Key Boulevard and N. Edgewood Street to Lee Highway and Spout Run Parkway
16	Lee Highway from N. Pollard Street to Kirkland Road
17	N. Barton Street and Lee Highway to east of 20th Street N. cul-de-sac at N. Cleveland Street
18	Stream along Spout Run Parkway

2 Storm Data Files

2.1 GIS Database

Initial base layers consisting of geographic information system (GIS) shapefiles were obtained from Arlington County in June 2010. Arlington County staff exhausted the record drawings available directly through the County and completed data updates in the County's Cassworks database program. Arlington County GIS staff exported this information to an ArcGIS PGDB (personal geodatabase), which was linked with GIS shapefiles obtained in June 2010. The ArcGIS PGDB was delivered to CH2M HILL in February 2011.

2.2 Record Drawings

In addition to the ArcGIS PGDB, the County also provided the storm sewer record drawings for the Spout Run watershed in February 2011. The record drawings were used in conjunction with the ArcGIS PGDB to resolve the data gaps and anomalies.

2.3 Survey Information

The Spout Run storm system contains a natural stream system directly connected to the storm pipe network. The stream channels which are directly connected to pipes equal or larger than 36 inches will also be modeled.

During a preliminary review of the ArcGIS PGDB, it was determined that there was a need to survey key stream cross sections from Interstate 66 to George Washington Memorial Parkway. In March 2011, CH2M HILL submitted three drawings suggesting 17 locations along the stream to be surveyed and identifying locations where invert and headwall elevations of existing culverts into those streams were required. Following a review of the drawings, the County recommended that 11 of the 17 locations be surveyed, including all of the culvert locations. The survey data collection was received in June 2011.

2.4 Methodology

The information provided by the County was used to find solutions to the data gaps and anomalies (described in Section 3) found in the ArcGIS PGDB. The data gaps and anomalies were resolved by (in order of precedence):

1. Reviewing the information in the ArcGIS PGDB
2. Reviewing the record drawings
3. Interpolating across two or more links

If a solution could not be found, the issue was discussed with the County, or a field survey was requested from the County. The record drawings were reviewed for large structures, such as box culverts, even if no anomaly was apparent in the GIS data because these structures are considered critical parts of the major storm sewer network.

3 Types of Data Gaps and Anomalies

3.1 Watershed Boundary Anomalies

The watershed boundary provided by the County as part of the ArcGIS PGDB was developed on the basis of contour information; as such, several minor links and nodes of the Spout Run stormwater piping network were not included within the boundary. In February 2011, CH2M HILL submitted figures showing the locations of the boundary anomalies. The boundary was modified to include all of the Spout Run minor links and nodes. Attachment A provides documentation of all changes to the watershed boundary.

3.2 Link and Network Gaps and Anomalies

Link gaps and anomalies occur when a link has an incorrect size, type, material, or upstream and/or downstream node information. Link anomalies were resolved by reviewing the record drawings.

Network anomalies occur when the downstream link has a smaller diameter than the upstream link. This may indicate that the downstream storm sewer is undersized.

Table 3-1, provided at the end of this document, shows the identified link and network anomalies as well as their respective solutions.

3.3 Invert and Rim Elevation Data Gaps and Anomalies

Invert and rim elevation data gaps occur when a node is missing its invert and/or rim elevation or when a link is missing its upstream and/or downstream invert elevation. Rim elevation data gaps were resolved by interpolating from the contour information. Invert elevation data gaps were resolved by using known invert elevations from connected links or nodes, reviewing the record drawings, or interpolating between upstream and downstream nodes.

The following types of invert anomalies were identified:

- Upstream link invert was higher than the upstream node invert

- Downstream link invert was lower than the downstream node invert
- Difference in invert between connected links was greater than 4 feet
- Link has 0 percent slope

Tables 3-2a (links) and **3-2b** (nodes), provided at the end of this document, show the identified invert data gaps and anomalies as well as their respective solutions.

3.4 Storage Structures

Several large-diameter links are not connected to the major (greater than 36 inches in diameter) storm sewer network. Review of the GIS data shows that the downstream node of these links is classified as a Best Management Practice (BMP) or a Detention Outlet (DO) node. CH2M HILL's review of the record drawings confirmed that these links represent storage structures that do not need to be modeled. **Figures 3-1** and **3-2** show the storage structures that were identified, and **Table 3-3** provides additional details for each storage structure.

TABLE 3-3
Storage Links

Link GID	US Node GID	DS Node GID	Link Size (in.)	Length (ft)	Link Type	Approximate Location
22996	23141	23261	48	78	Circular pipe	Lee Highway and N. Albemarle Street
23295	23408	4197	54	136	Circular pipe	N. Tazewell Court and Lee Highway
23017	23156	23157	36	55	Circular pipe	N. Stafford Street and 21st Street N.
22974	23274	23112	125	44	Circular pipe	Lee Highway and N. Randolph Street
24582	24398	24394	48	Missing	Circular pipe	Old Dominion Drive and Lee Highway
23229	23359	23360	48	60	Circular pipe	N. Nelson Street and Lee Highway
23345	23439	23445	36	71.5	Circular pipe	N. Filmore Street and Lorcom Lane
24361	24229	24227	48	64.4	Circular pipe	20th Street N. and N. Vance Street
23192	23319	23317	60	64.7	Circular pipe	N. Daniel Street and Lee Highway
23377	22648	23477	48	100	Circular pipe	N. Johnson Street and 15th Street N.
23166	23298	23299	60	112	Circular pipe	Between Lee Highway and N. Kirkwood Road
20396	4533	4574	10 × 3.8 ft	102	Box culvert	Lee Highway and N. Nelson Road

Note: GID, unique feature ID used in GIS; US, upstream; DS, downstream.

4 Results

In total, 251 data gaps and anomalies were identified; this represents 31 percent of the major storm sewer network. All of these data gaps were resolved by reviewing the GIS data and record drawings and through interpolation and discussion with the County. Attachment B provides additional correspondence on the final resolution of some data gaps and anomalies.

TABLE 3-1
Network and Link Data Gaps and Anomalies

Segment	Link GID	US Node GID	DS Node GID	Link Size	Link Type	Data Gap/Anomaly	Solution	Comment
2	6560	5577	5687	42 in.	Circular pipe	Diameter does not match record drawing	Record drawing shows diameter = 36 in.; size will be changed to match record drawing	N/A
4	6597	7377	7079	96 in.	Circular pipe	US and DS nodes are reversed	GIS data shows that flow direction is towards the northeast; therefore, US and DS nodes will be switched	N/A
6	24403	7443	24258	84 × 60 in.	Box culvert	An 84-by-60-in. box culvert discharges to a 15-in. pipe	The County confirmed that the 15-in. pipe (GID = 24405) is actually an 84-by-60-in. box culvert	Confirmed with the County on 4/28/11
8	25081	5490	5269	108 in.	Circular pipe	Two links with GID 25081	Pipes represent twin 108 in storm sewers; change link GID on the east side of Kirkwood Road to 6696. Node GIDs for link 6696: US node = 5490 and DS Node = 5269	Confirmed with the County on 4/28/11; links not shown in record drawing
8	20308	4969	4959	0	Other	Link is not shown in record drawing; missing link size	Configuration does not match record drawing; therefore, remove link (since link will be removed, size is not required)	Confirmed with the County on 4/28/11
8	24561	4959	4832	12 × 5 ft	Box culvert	GIS data from shapefile does not match GIS plan data	The County recommended that the US node = 4959 and DS node = 4376	—
8	24558	24377	24376	48 in.	Circular pipe	Incorrect location	The County advised that this pipe is 23 ft north of the US node; County provided the US and DS inverts	Confirmed with the County on 8/18/11
10	9094	9762	9700	36 in.	Circular pipe	Diameter does not match record drawing	Record drawing shows diameter = 30 in.; therefore, remove link	N/A
11	8906	9398	9362	36 in.	Circular pipe	US invert lower than DS invert	Record drawings show conflicting information (different flow directions); County advised that the GIS inverts in the record drawing are to be used in the model	Confirmed with the County on 7/28/11
12	25071	24831	24483	36 in.	Circular pipe	US and DS invert missing	The County advised that this pipe is a private storm sewer. Therefore, remove links 25071 and 24683 and nodes 24831 and 24833	Confirmed with the County on 4/28/11
13	8918	—	—	—	—	Missing link type, size, US and DS node	Add link information: type = circular pipe; diameter = 54 in; US node = 9002; DS node = 8871	N/A
13	24619 to 24623	varies	varies	84 to 96 in.	Box culvert and circular pipe	Alignment and pipe length incorrect	GIS alignment updated to match record drawing alignment and lengths	Confirmed with the County on 8/18/11
15	2170	5534	5389	30 in.	Circular pipe	A 42-in. pipe discharges to a 30-in. pipe	Pipe downsize was confirmed by the County	Pipe downsize confirmed at meeting on 4/28/11; 30-in. pipe run also includes links 2101, 1993, 23205, and 23207 and nodes 5207, 4994, 23331, and 4918. There are no reports of flooding in this area
16	24431	4591	24272	36 in.	Circular pipe	Link is not connected to the storm pipe network	Record drawing shows diameter = 300 mm = 12 in.; therefore, remove link	N/A
16	24562	24376	4832	12 × 5 ft	Box culvert	A 12-by-5-ft box culvert discharges to an 18-in. pipe; incorrect US and DS node information	Record drawing plan shows diameter = 18 in.; County confirmed that the US Node ID=4886 and DS Node ID=4850. This pipe will not be modeled since it is less than 36 in.	The County confirmed that the incorrect US and DS nodes were a result of an error in the ArcGIS PDGB

Note: GID, unique feature ID used in GIS; US, upstream; DS, downstream; HEC-RAS, modeling software.

TABLE 3-2A
Link Invert Elevation Data Gaps and Anomalies

Segment	Link GID	US Node GID	DS Node GID	Link Size	Link Type	Data Gap/Anomaly	Solution	Comment
1	5028	3849	3894	4 × 4 ft	Box culvert	DS invert missing	Use invert provided by the County	Refer to node data gap in Table 3-2b
1	5033	3894	3914	4 × 4 ft	Box culvert	US and DS invert missing	Use inverts provided by the County	Refer to node data gap in Table 3-2b
1	6515	3914	3937	42 in.	Circular pipe	US and DS invert missing	Use US invert provided by the County; interpolate DS invert from County data	Refer to node data gap in Table 3-2b
1	5039	3937	3964	42 in.	Circular pipe	US and DS invert missing	Interpolate inverts from County data	Refer to node data gap in Table 3-2b
1	5049	3964	3993	42 in.	Circular pipe	US and DS invert missing	Interpolate US invert from County data; use DS invert provided by the County	Refer to node data gap in Table 3-2b
1	5051	3993	4003	42 in.	Circular pipe	US invert missing	Use invert provided by the County	Refer to node data gap in Table 3-2b
1	1479	4204	4279	54 in.	Circular pipe	DS invert lower than DS node invert	Interpolate invert from slope of pipe from record drawing data	N/A
2	1954	5125	5151	48 in.	Circular pipe	US invert higher than US node invert	Record drawing confirms GIS data	Elevation difference = 0.12 ft; if error in model results, invert will be adjusted
2	2023	5203	5254	60 in.	Circular pipe	DS invert lower than DS node invert	Record drawing confirms GIS data	Elevation difference = 0.07 ft; DS node invert will be lowered to reduce model error
2	20429	5254	5572	42 in.	Circular pipe	Incorrect US invert	Use invert from record drawing	N/A
2	24370	5688	24235	54 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
2	24371	24235	5716	54 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
2	6557	5716	5791	36 in.	Circular pipe	US invert higher than US node invert	Record drawing confirms GIS data	Elevation difference = 2.58 ft; if error in model results, invert will be adjusted
2	2659	6361	6415	66 in.	Circular pipe	US invert higher than US node invert. DS invert lower than DS node invert	Use inverts from record drawing	Refer to node data gap in Table 3-2b
2	2891	6775	6806	98 × 63 in.	Elliptical	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
2	2907	6806	6829	98 × 63 in.	Elliptical	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
2	6600	6829	6827	66 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
2	6601	6827	6819	66 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
3	2317	5681	5798	36 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Link not shown in record drawing
3	2404	5798	5979	36 in.	Circular pipe	US and DS invert missing	Interpolate US invert from GIS data; use DS invert from record drawing	N/A
3	2424	5979	5999	36 in.	Circular pipe	US and DS invert missing	Use US invert from record drawing; use DS invert provided by the Count on July 28, 2011	Refer to node data gap in Table 3-2b
3	2438	5999	6021	36 in.	Circular pipe	US and DS invert missing; incorrect DS invert	Use inverts provided by the County on July 28, 2011	Refer to node data gap in Table 3-2b
3	2443	6021	6027	36 in.	Circular pipe	Link has 0% slope	Use inverts provided by the County on July 28, 2011	Refer to node data gap in Table 3-2b
3	6591	6640	6819	42 in.	Circular pipe	Incorrect DS invert	Use invert from record drawing	N/A
3	6592	6819	6960	84 in.	Circular pipe	DS invert lower than DS node invert	Record drawing confirms GIS data	Elevation difference = 0.10 ft
4	6597	7079	7377	96 in.	Circular pipe	US and DS invert missing	Use inverts from GIS data	N/A

TABLE 3-2A
Link Invert Elevation Data Gaps and Anomalies

Segment	Link GID	US Node GID	DS Node GID	Link Size	Link Type	Data Gap/Anomaly	Solution	Comment
4	2793	6630	6546	108 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
4	2752	6546	6568	108 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
5	2860	6697	6750	42 in.	Circular pipe	US invert higher than US node invert	US node invert is incorrect; GIS link data is correct	Confirmed with the County on 4/28/11
6	21783	7407	7443	84 × 60 in.	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b Interpolated across 4 links
6	24403	7443	24258	84 × 60 in.	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b; interpolated across 4 links
6	24405	24258	7384	15 in.	Circular pipe	US and DS invert missing	Interpolate US invert from GIS data; use DS invert from GIS data	Refer to node data gap in Table 3-2b; diameter changed to 84-by-60-in. box; interpolated across 4 links
7	23424	5311	23512	36 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
7	23425	23512	5408	36 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
7	6685	5718	5720	36 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
7	2275	5720	5719	36 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
8	20686	8616	8603	96 in.	Circular pipe	DS invert higher than US node invert	Use invert from record drawing	N/A
8	20673	8132	8185	54 in.	Circular pipe	US and DS invert missing	Interpolate invert from slope of pipe from record drawing data	N/A
8	25069	7849	7661	84 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
8	8757	7661	7594	84 in.	Circular pipe	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
8	20299	7594	7420	84 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
8	3192	7420	7091	84 in.	Circular pipe	US invert higher than US node invert	Use inverts from record drawing	N/A
8	6698	5794	5559	108 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
8	6697	5559	5490	108 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
8	6699	5269	5128	108 in.	Circular pipe	DS invert missing	Use invert from GIS data	Link not shown in record drawing
8	6700	5128	5114	108 in.	Circular pipe	US invert missing	Use invert from GIS data	Link not shown in record drawing
8	25080	24830	24831	108 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
8	25081	24831	5409	108 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
8	25083	24843	24844	108 in.	Circular pipe	DS invert missing	Use invert from GIS data	Link not shown in record drawing
8	25084	24844	5114	108 in.	Circular pipe	US invert missing	Use invert from GIS data	Link not shown in record drawing
8	24561	4959	24376	12 × 5 ft	Box culvert	US and DS invert missing	Use US invert from record drawing; interpolate DS invert from GIS data	Refer to node data gap in Table 3-2b
8	1782	4832	4625	12 × 5 ft	Box culvert	US and DS invert missing	Interpolate US invert from GIS data; use DS invert provided by the County	Refer to node data gap in Table 3-2b
8	24555	4625	4483	12 × 5 ft	Box culvert	US and DS invert missing	Use US invert provided by the County; interpolate DS invert from GIS data	Refer to node data gap in Table 3-2b
8	24578	4483	24392	12 × 5 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
8	24579	24392	24390	12 × 5 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b

TABLE 3-2A
Link Invert Elevation Data Gaps and Anomalies

Segment	Link GID	US Node GID	DS Node GID	Link Size	Link Type	Data Gap/Anomaly	Solution	Comment
8	24580	24390	3963	12 × 5 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
8	6619	3963	3939	12 × 5 ft	Box culvert	US and DS invert missing	Interpolate US invert from GIS data; use DS invert from record drawing	Refer to node data gap in Table 3-2b
8	24560	4969	24377	10 × 10 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
8	24557	24377	4627	10 × 10 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
8	6665	4627	4559	10 × 10 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
8	6666	4559	4504	10 × 10 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
8	1618	4504	4466	10 × 10 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
8	1595	4466	4435	10 × 10 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
8	1574	4435	4308	10 × 10 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
8	1499	4308	4218	10 × 10 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
8	6620	4218	3939	10 × 10 ft	Box culvert	US and DS invert missing	Interpolate US invert from GIS data; use DS invert from record drawing	Refer to node data gap in Table 3-2b
8	6618	3939	3916	12 × 5 ft	Box culvert	US and DS invert missing	Use inverts from record drawing	Refer to node data gap in Table 3-2b
8	23169	4820	23301	48 in.	Circular pipe	US invert missing	Use invert provided by the County	Refer to node data gap in Table 3-2b
8	23170	23301	4832	48 in.	Circular pipe	DS invert missing	Use invert from GIS data	N/A
8	1528	4354	4308	42 in.	Circular pipe	US and DS invert missing	Use US invert from record drawing; interpolate DS invert from GIS data	N/A
8	24571	24389	4173	36 in.	Circular pipe	US and DS invert missing	Use inverts provided by the County	Refer to node data gap in Table 3-2b
8	24572	4173	24390	36 in.	Circular pipe	US and DS invert missing	Use inverts provided by the County	Refer to node data gap in Table 3-2b
9	24640	9022	9217	48 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
9	16692	9217	9221	48 in.	Circular pipe	US invert missing; DS invert lower than DS node invert	Interpolate US invert from GIS data; use DS invert from record drawing	Refer to node data gap in Table 3-2b
10	9093	9701	9700	48 in.	Circular pipe	DS invert missing	Use invert from GIS data	N/A
10	9102	9700	9677	48 in.	Circular pipe	US invert missing	Use invert from GIS data	N/A
10	9094	9762	9700	36 in.	Circular pipe	DS invert missing	Use invert from GIS data	N/A
10	9104	9670	9666	48 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
10	9105	9666	9656	48 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
10	8909	9250	9210	66 in.	Circular pipe	US invert higher than US node invert; link has 0% slope	Interpolate US invert from record drawing; use DS invert from record drawing	N/A
10	8908	9258	9250	66 in.	Circular pipe	Incorrect DS invert	Interpolate invert from GIS data	N/A
10	20681	9186	9213	66 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
10	20682	9213	9281	66 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
11	9119	9720	9722	36 in.	Circular pipe	DS invert lower than DS node invert	Use invert from record drawing	N/A
11	9121	9724	9695	42 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b

TABLE 3-2A
Link Invert Elevation Data Gaps and Anomalies

Segment	Link GID	US Node GID	DS Node GID	Link Size	Link Type	Data Gap/Anomaly	Solution	Comment
11	9122	9695	9617	42 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
11	9203	9425	9362	48 in.	Circular pipe	US invert higher than US node invert	Use invert from record drawing	N/A
11	9140	9535	9425	42 in.	Circular pipe	Incorrect DS invert	Use invert from record drawing	N/A
11	8903	9362	9357	48 in.	Circular pipe	US invert missing	Use invert from GIS data	N/A
12	9174	9899	9790	54 in.	Circular pipe	Link has 0% slope	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
12	24685	9746	24487	54 in.	Circular pipe	US invert higher than US node invert	Use invert from record drawing	N/A
13	8916	9281	9226	8 × 6 ft	Box culvert	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
13	24636	9226	24445	8 × 6 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
13	24637	24445	9158	8 × 6 ft	Box culvert	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
13	24638	9158	24446	8 × 6 ft	Box culvert	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
13	24623	8871	24431	9 × 7 ft	Box culvert	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
13	24619	24431	24432	9 × 7 ft	Box culvert	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
13	24620	24432	24433	9 × 7 ft	Box culvert	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
13	24621	24433	24434	9 × 7 ft	Box culvert	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
13	24622	24434	8616	96 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
14	24654	7099	7051	36 in.	Circular pipe	US invert missing	Use invert from record drawing	N/A
14	24651	6780	24457	36 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
14	24652	24457	24458	36 in.	Circular pipe	US and DS invert missing	Interpolate US invert from GIS data; use DS invert from GIS data	Refer to node data gap in Table 3-2b
15	2282	5727	5591	42 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b; interpolated across 5 links
15	2210	5591	5534	42 in.	Circular pipe	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b; interpolated across 5 links
15	2170	5534	5389	30 in.	Circular pipe	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b; interpolated across 5 links
15	2101	5389	5207	30 in.	Circular pipe	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b; interpolated across 5 links
15	1993	5207	4994	30 in.	Circular pipe	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b; interpolated across 5 links
15	1835	4918	4878	36 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b; interpolated across 6 links
15	1809	4878	4838	36 in.	Circular pipe	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b; interpolated across 6 links
15	1788	4838	4672	54 in.	Circular pipe	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b; interpolated across 6 links
15	1700	4672	4563	54 in.	Circular pipe	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b; interpolated across 6 links
15	1654	4563	4452	54 in.	Circular pipe	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b; interpolated across 6 links
15	1585	4452	4435	54 in.	Circular pipe	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b; interpolated across 6 links
16	1695	4663	4611	36 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
16	24428	4611	24273	36 in.	Circular pipe	US and DS invert missing	Interpolate inverts from GIS data	Refer to node data gap in Table 3-2b
16	24429	24273	4565	36 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
16	1706	4661	4677	48 in.	Circular pipe	US and DS invert missing	Use inverts provided by the County on 7/28/11	Refer to node data gap in Table 3-2b

TABLE 3-2A
Link Invert Elevation Data Gaps and Anomalies

Segment	Link GID	US Node GID	DS Node GID	Link Size	Link Type	Data Gap/Anomaly	Solution	Comment
16	1705	4677	4607	68 × 43 in.	Elliptical	US and DS invert missing	Use inverts provided by the County on 7/28/11	Refer to node data gap in Table 3-2b
16	24551	4607	24373	54 in.	Circular pipe	US and DS invert missing	Use US invert provided by the County; interpolate DS invert from County data	Refer to node data gap in Table 3-2b
16	24552	24373	24374	54 in.	Circular pipe	US invert missing; incorrect DS invert	Interpolate inverts from County data	Refer to node data gap in Table 3-2b
16	24553	24374	4625	54 in.	Circular pipe	DS invert missing; incorrect DS invert	Interpolate US invert from County data; interpolate DS invert by matching crown of pipe to 12-by-5-ft box culvert	Refer to node data gap in Table 3-2b
17	1725	4723	4685	48 in.	Circular pipe	DS invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
17	1709	4685	4541	48 in.	Circular pipe	US invert missing	Interpolate invert from GIS data	Refer to node data gap in Table 3-2b
17	1269	3946	3930	48 in.	Circular pipe	DS invert missing	Field-confirm	Survey provided by the County in June 2011
17	1141	3655	3623	5 × 5 ft	Box culvert	US invert missing	Field-confirm	Survey provided by the County in June 2011
17	1127	3623	3483	5 × 5 ft	Box culvert	US invert missing	Field-confirm	Survey provided by the County in June 2011
18	—	—	—	—	Stream channel	US and DS invert missing; cross section missing	Survey stream cross sections	Survey provided by the County in June 2011

Note: GID, unique feature ID used in GIS; US, upstream; DS, downstream; HEC-RAS, modeling software.

TABLE 3-2B
Node Invert and Rim Elevation Data Gaps and Anomalies

Segment	Node GID	Node Type	Data Gap/Anomaly	Solution	Comment
1	3894	Junction	Invert and rim missing	Use invert provided by the County	Invert provided by the County on 7/28/11
1	3914	Manhole	Invert and rim missing	Use invert provided by the County	Invert provided by the County on 7/28/11
1	3937	Grate Inlet	Invert and rim missing	Interpolate from County data	N/A
1	3964	Manhole	Invert and rim missing	Interpolate from County data	N/A
1	3993	Manhole	Invert and rim missing	Use invert provided by the County	Invert provided by the County on 7/28/11
1	4108	Manhole	Invert and rim missing	Use link 24343 DS invert; take rim from contour data	N/A
1	24212	Catchbasin	Invert missing	Use link 24345 DS invert	N/A
1	4359	Grate Inlet	3.45-ft drop	Record drawing confirms GIS data	N/A
2	24235	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
2	6806	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
2	6827	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
3	5798	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
3	5979	Manhole	Invert and rim missing	Use invert from record drawing; take rim from contour data	N/A
3	6021	Manhole	Incorrect invert	Use invert provided by the County	Invert provided by the County on 7/28/11
3	5999	Junction	Invert and rim missing	Use invert provided by the County; take rim from contour data	Invert provided by the County on 7/28/11
3	7331	Manhole	17.81-ft drop	Record drawing confirms GIS data	Confirmed large drop with the County on 5/9/11
4	7377	Manhole	3.90-ft drop	Record drawing confirms GIS data	Confirmed large drop with the County on 4/28/11
4	6874	Catchbasin	6.67-ft drop	Record drawing confirms GIS data	N/A
4	6630	Manhole	8.95-ft drop	Record drawing confirms GIS data	Confirmed large drop with the County on 4/28/11
4	6546	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
5	6697	Manhole	3.77-ft drop	Use US invert of link 2860 from GIS data	Confirmed with the County on 4/28/11
6	7407	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	Interpolated across 4 links; County confirmed that there is no invert data available
6	7443	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	Interpolated across 4 links; County confirmed that there is no invert data available
6	24258	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	Interpolated across 4 links; County confirmed that there is no invert data available
6	7040	Manhole	8.85-ft drop	Record drawing confirms GIS data	N/A
7	23512	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
7	5720	Catchbasin	Invert missing	Interpolate from GIS data; take rim from contour data	N/A
7	6123	Manhole	4.90-ft drop	Record drawing confirms GIS data	N/A
7	6139	Catchbasin	32.25-ft drop	Use new invert from the County	The County provided a new invert on 5/9/11
8	8616	Junction	Invert and rim missing	Interpolate from record drawing data; take rim from contour data	N/A
8	8603	Manhole	Incorrect invert	Use invert from record drawing	N/A
8	8132	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	7661	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	7594	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	5559	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A

TABLE 3-2B
Node Invert and Rim Elevation Data Gaps and Anomalies

Segment	Node GID	Node Type	Data Gap/Anomaly	Solution	Comment
8	24831	Detention Outlet	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	5114	End Wall	Invert and rim missing	Use link 6700 DS invert; take rim from contour data	N/A
8	4959	End Wall	Invert and rim missing	Field-confirm	Survey provided by the County in June 2011
8	4969	End Wall	Invert and rim missing	Field-confirm	Survey provided by the County in June 2011
8	24376	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	4832	Junction	Incorrect invert	Interpolate from GIS data; take rim from contour data	N/A
8	4625	Junction	Incorrect invert	Use invert provided by the County; take rim from contour data	Invert provided by the County on 8/18/11
8	4483	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	24392	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	24390	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	3963	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	24377	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	4627	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	4559	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	4504	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	4466	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	4308	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	4218	Grate Inlet	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
8	3939	Junction	Invert and rim missing	Use invert from record drawing; take rim from contour data	N/A
8	4820	Manhole	Invert and rim missing	Use invert from record drawing; take rim from contour data	N/A
8	4173	Grate Inlet	Invert and rim missing	Use invert and rim provided by the County	Invert and rim provided by the County on 4/28/11
8	24389	Grate Inlet	Invert and rim missing	Use invert and rim provided by the County	Invert and rim provided by the County on 4/28/11
9	9217	Catchbasin	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
10	9666	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
10	9443	Manhole	Incorrect invert	Use invert from record drawing	N/A
10	9250	Manhole	Incorrect invert	Interpolate from GIS data; invert	N/A
10	9213	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
11	9695	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
11	9617	Manhole	Incorrect invert	Use invert from record drawing	N/A
11	9425	Manhole	Incorrect invert	Use invert from record drawing	N/A
11	9362	Manhole	Incorrect invert	Use invert from record drawing	N/A
12	10190	Manhole	Invert and rim missing	Use link 9056 US invert. Take rim from contour data.	N/A
13	9226	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
13	24445	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
13	9158	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A

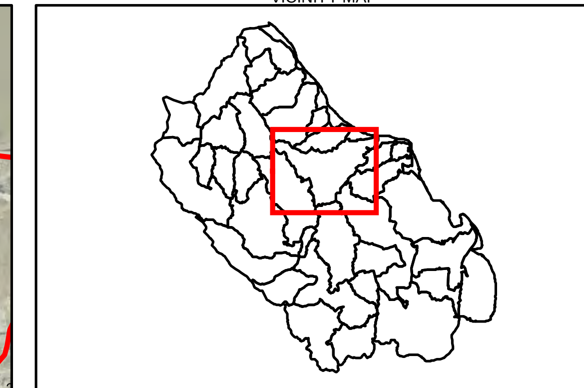
TABLE 3-2B
Node Invert and Rim Elevation Data Gaps and Anomalies

Segment	Node GID	Node Type	Data Gap/Anomaly	Solution	Comment
13	24431	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
13	24433	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
14	7099	Manhole	Invert and rim missing	Use invert from record drawing	Record drawing shows pipe leaving node as 18-in. diameter instead of 36 in.
14	24457	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
15	5591	Grate Inlet	Invert and rim missing	Interpolate from GIS data; take rim from contour data	Interpolated across 5 links
15	5534	Grate Inlet	Invert and rim missing	Interpolate from GIS data; take rim from contour data	Interpolated across 5 links
15	5389	Grate Inlet	Invert and rim missing	Interpolate from GIS data; take rim from contour data	Interpolated across 5 links
15	5207	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	Interpolated across 5 links
15	4878	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	Interpolated across 6 links
15	4838	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	Interpolated across 6 links
15	4672	Catchbasin	Invert and rim missing	Interpolate from GIS data; take rim from contour data	Interpolated across 6 links
15	4563	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	Interpolated across 6 links
15	4452	Grate Inlet	Invert and rim missing	Interpolate from GIS data; take rim from contour data	Interpolated across 6 links
15	4435	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
15	4354	Grate Inlet	Invert and rim missing	Use invert from record drawing; take rim from contour data	N/A
16	4611	Junction	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
16	24273	Catchbasin	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
16	4340	Catchbasin	Invert and rim missing	Use link 1522 DS invert; take rim from contour data	N/A
16	4661	Catchbasin	Invert and rim missing	Use invert provided by the County; take rim from contour data	Invert provided by the County on 7/28/11
16	4677	Yard Inlet	Invert and rim missing	Use invert provided by the County; take rim from contour data	Invert provided by the County on 7/28/11
16	4607	Manhole	Invert and rim missing	Use invert provided by the County; take rim from contour data	Invert provided by the County on 7/28/11
16	24373	Junction	Invert and rim missing	Interpolate from County data; take rim from contour data	N/A
16	24374	Manhole	Incorrect invert	Interpolate from County data	N/A
17	4685	Manhole	Invert and rim missing	Interpolate from GIS data; take rim from contour data	N/A
17	3655	End Wall	Invert and rim missing	Field-confirm	Survey provided by the County in June 2011
17	3483	Manhole	Invert and rim missing	Field-confirm	Survey provided by the County in June 2011
17	3623	End Wall	Invert and rim missing	Field-confirm	Survey provided by the County in June 2011
18	—	—	Invert and rim missing	Survey stream cross sections	Survey provided by the County in June 2011

Note: GID, unique feature ID used in GIS; US, upstream; DS, downstream; HEC-RAS, modeling software.

Figures

VICINITY MAP



Legend

Spout Run Boundary

Segment Number

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18

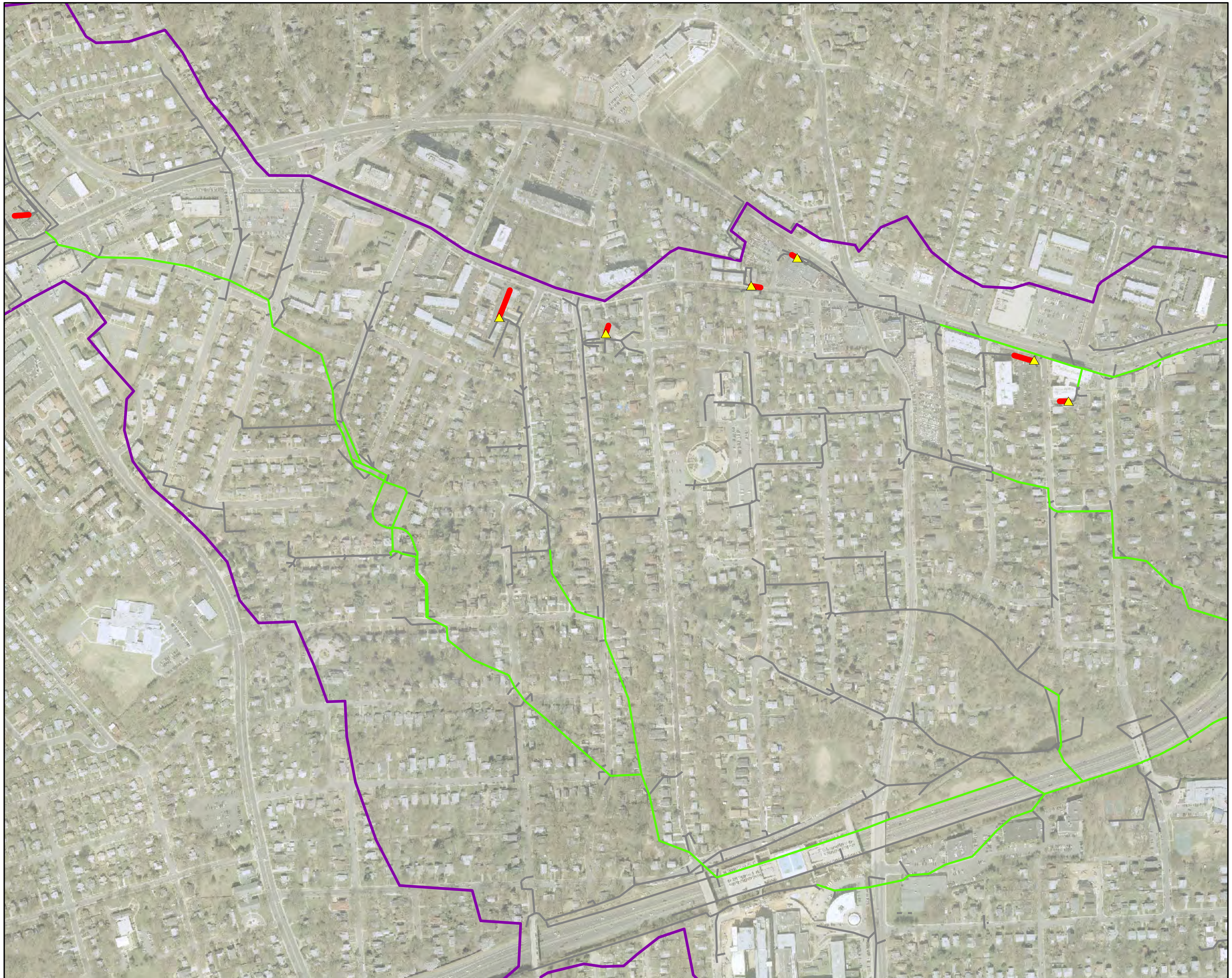
N

0 500 1,000

Feet

FIGURE 1-1
Major Storm Sewer Network Segments
GIS Data Gaps and Anomalies - Spout Run
Arlington County Storm Capacity Analysis

CH2MHILL



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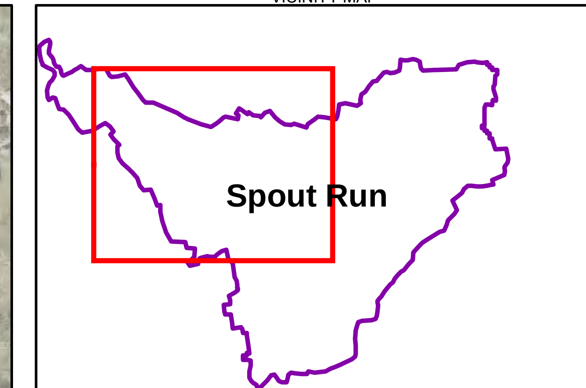


Legend

- Spout Run Boundary
- Detention Outlet
- Storage Structure
- Stormwater Mains ≥ 36"
- Stormwater Mains < 36"

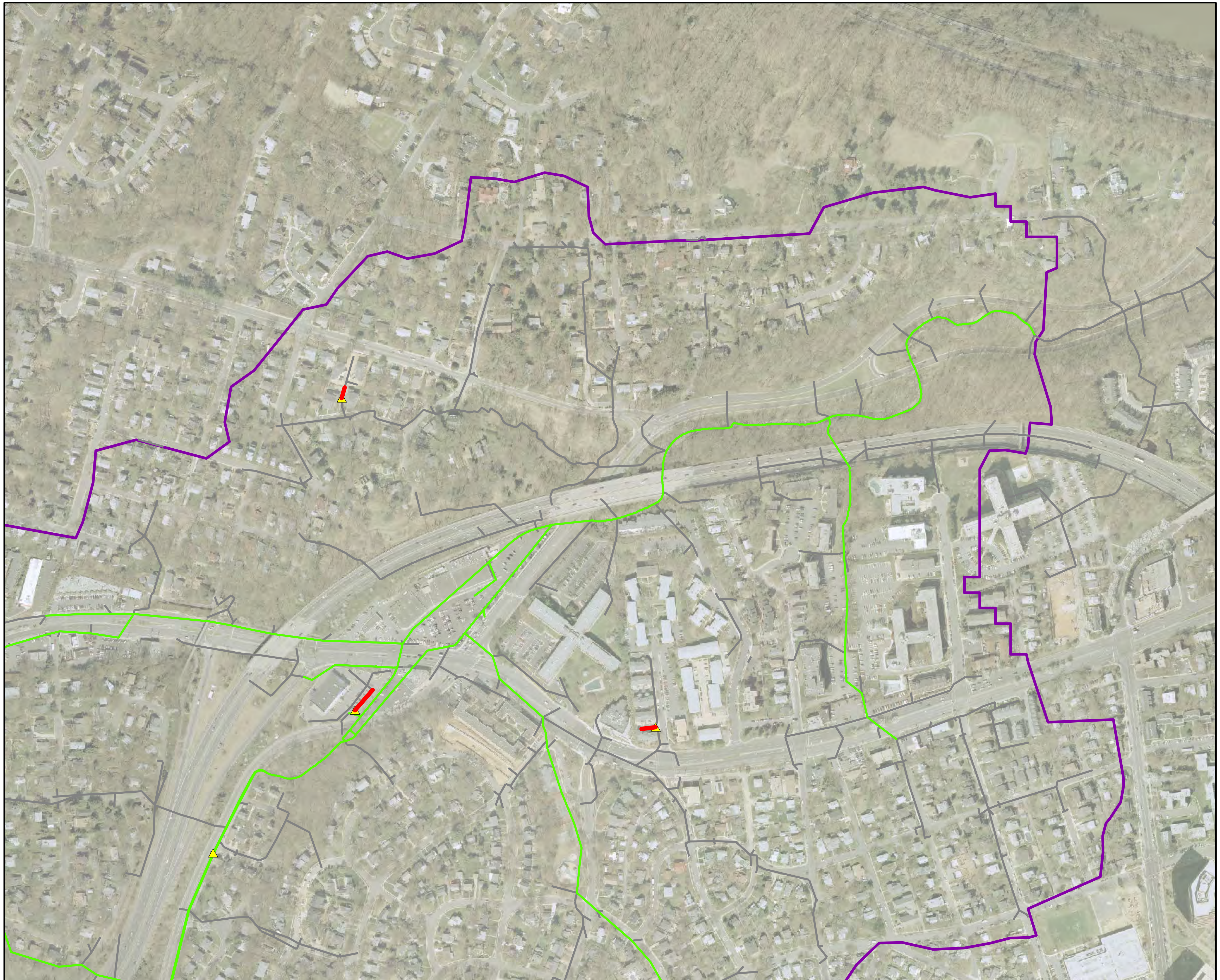
N

0 125 250 375 500

Feet

FIGURE 3-1
Spout Run Watershed - Storage Structures
GIS Data Gaps and Anomalies - Spout Run
Arlington County Storm Capacity Analysis

CH2MHILL



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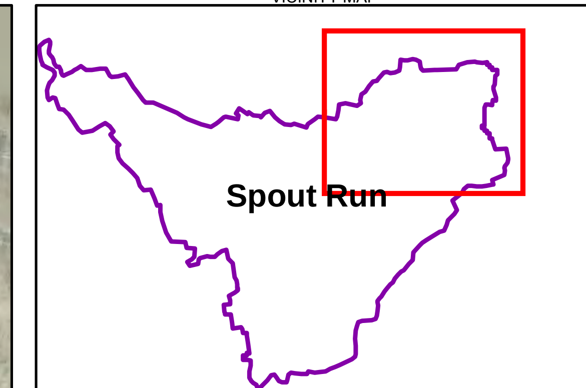


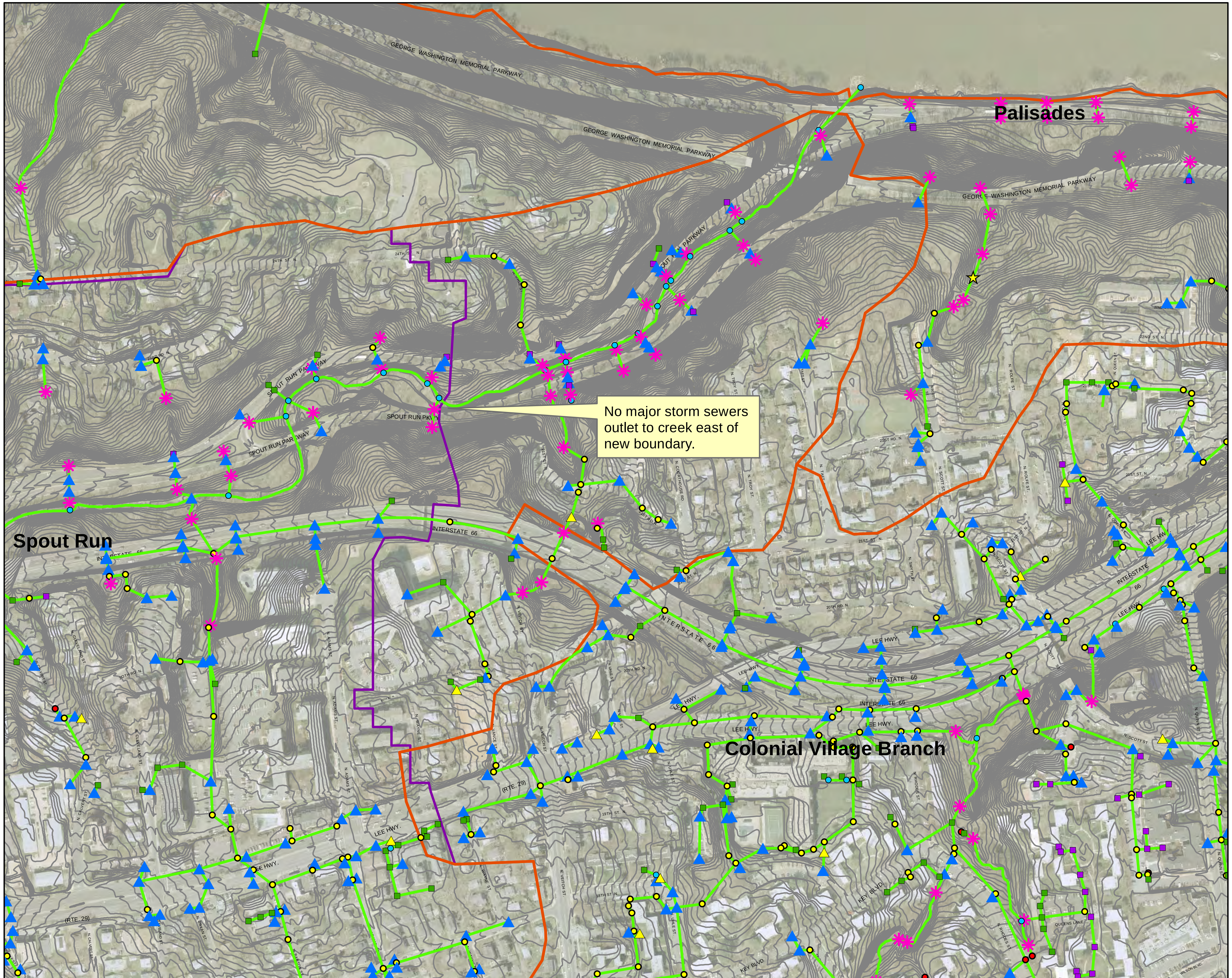
Legend

- Spout Run Boundary
- Detention Outlet
- Storage Structures
- Stormwater Mains ≥ 36"
- Stormwater Mains < 36"

FIGURE 3-2
Spout Run Watershed - Storage Structures
GIS Data Gaps and Anomalies - Spout Run
Arlington County Storm Capacity Analysis

H:\ARLINGTONVACOUNTYOF\392309STORMWATERCAP\WSSPOUT\WORKINGGIS\LAYOUT\INTERNAL\DATAGAPTM_FIGS\DGTMFIGURE3-2.MXD ZVALCHAR 10/7/2011 11:10:07 AM

Attachment A



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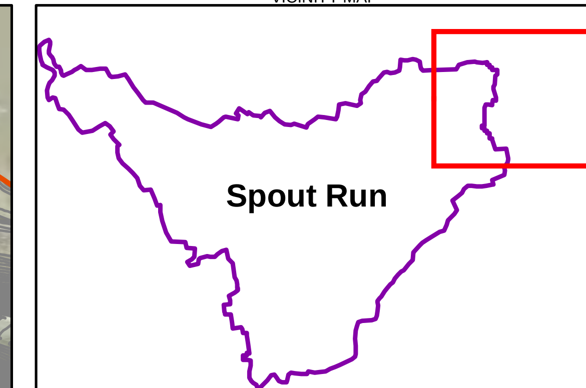


Legend

Stormwater Junctions

- BMP Structure
- Catchbasin
- Detention Outlet
- End Wall
- Grate Inlet
- Yard Inlet
- Junction
- Manhole
- Other

Stormwater Mains

Original Watershed Boundary

Revised Watershed Boundary

Arlington Co. 2 ft Contours

N

0 175 350

Feet

FIGURE A1

Boundary Anomalies

GIS Data Gaps and Anomalies - Spout Run

Arlington County Storm Capacity Analysis

CH2MHILL

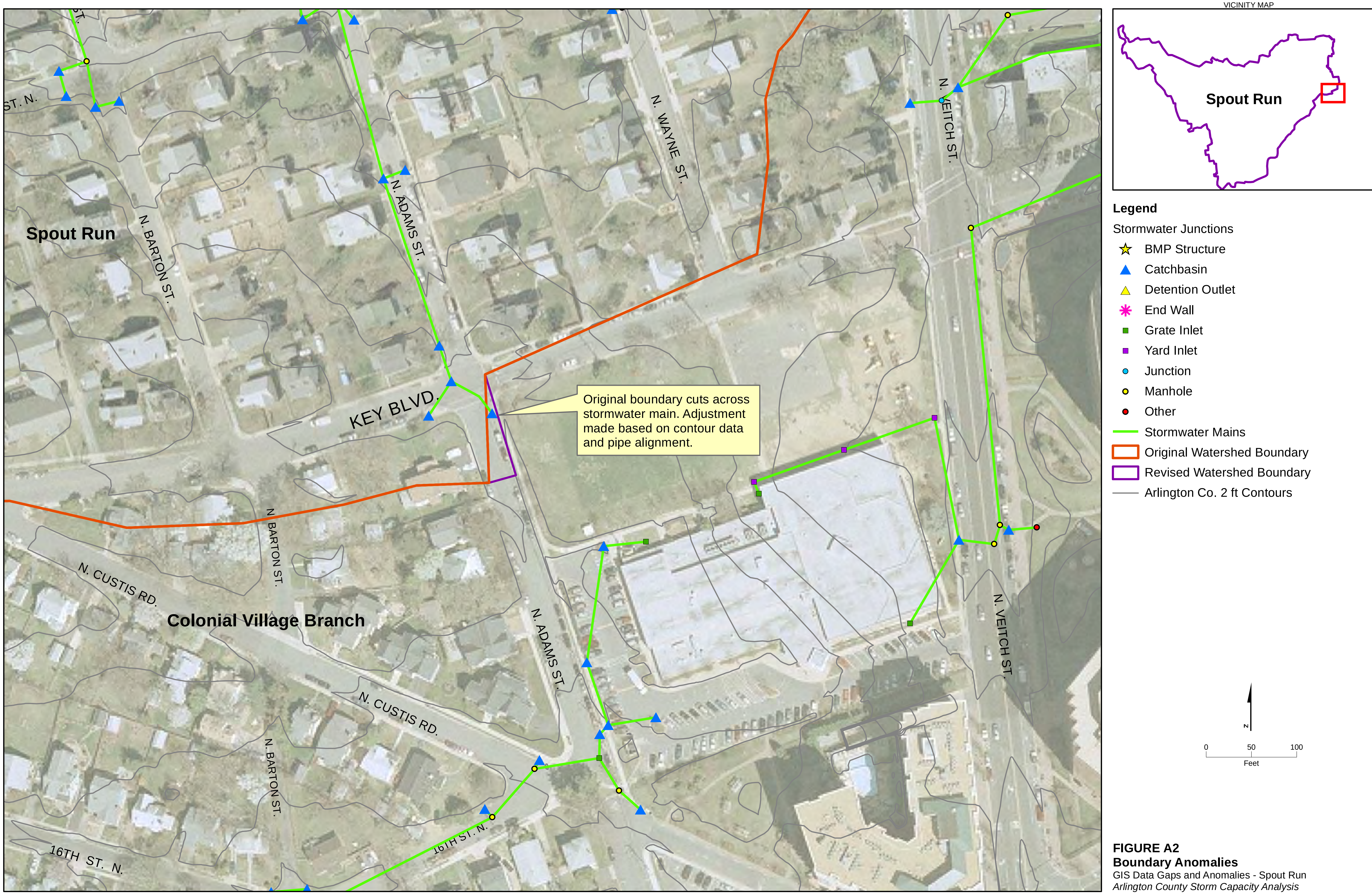
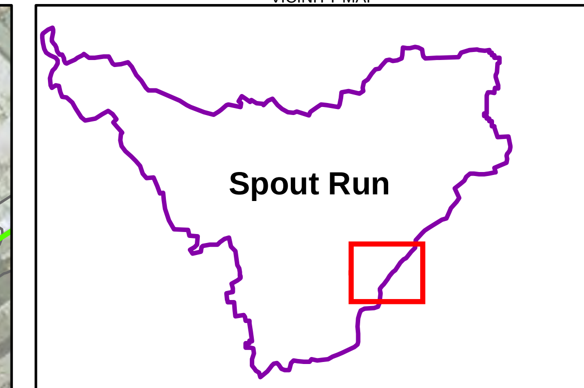


FIGURE A2
Boundary Anomalies
GIS Data Gaps and Anomalies - Spout Run
Arlington County Storm Capacity Analysis

CH2MHILL

\\ORION\Proj\ArlingtonVACountyOf\392309StormWaterCap\WSSpout\WorkingGIS\Layout\Internal\Appendix_A\Figure_A2_Boundary_Anomalies.mxd

VICINITY MAP



Legend

Stormwater Junctions

- BMP Structure
- Catchbasin
- Detention Outlet
- End Wall
- Grate Inlet
- Yard Inlet
- Junction
- Manhole
- Other

Stormwater Mains

Original Watershed Boundary

Revised Watershed Boundary

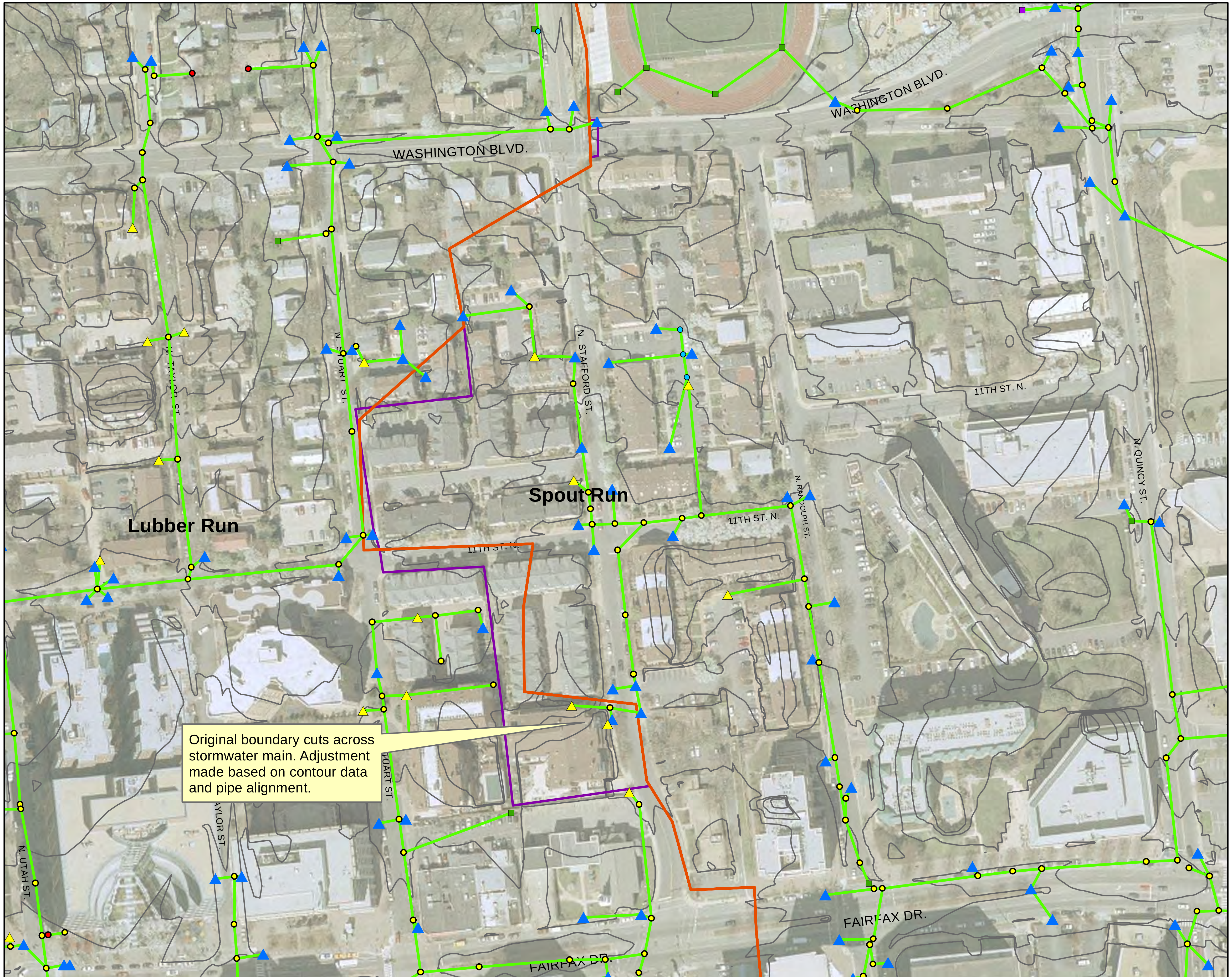
Arlington Co. 2 ft Contours

N

0 75 150

Feet

FIGURE A3
Boundary Anomalies
GIS Data Gaps and Anomalies - Spout Run
Arlington County Storm Capacity Analysis



VICINITY MAP

Legend

Stormwater Junctions
- BMP Structure
- Catchbasin
- Detention Outlet
- End Wall
- Grate Inlet
- Yard Inlet
- Junction
- Manhole
- Other

Stormwater Mains

Original Watershed Boundary

Revised Watershed Boundary

Arlington Co. 2 ft Contours

N

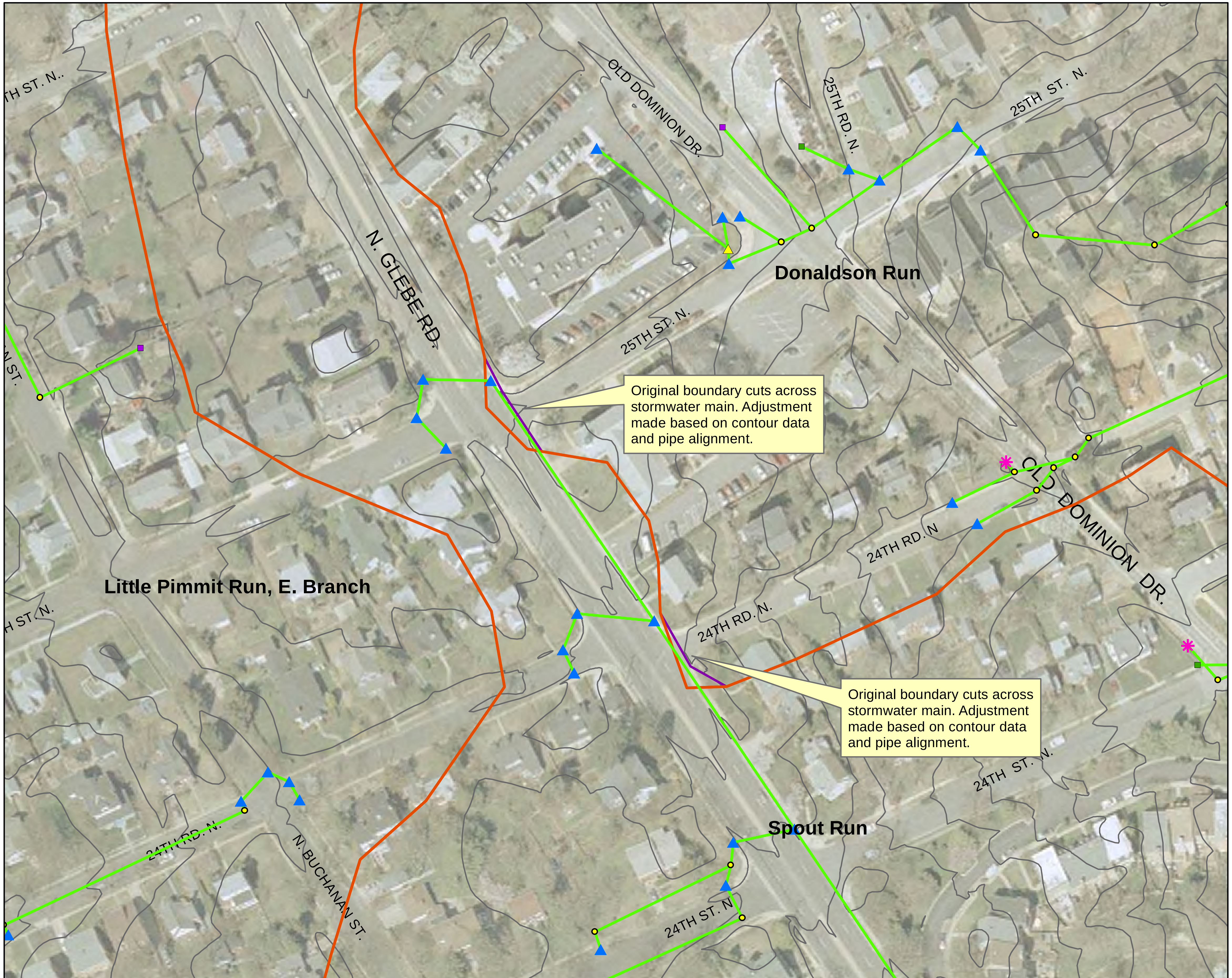
0 75 150

Feet

FIGURE A4
Boundary Anomalies
GIS Data Gaps and Anomalies - Spout Run
Arlington County Storm Capacity Analysis

\\ORION\Proj\ArlingtonVACountyOf\392309StormWaterCap\WSSpout\WorkingGIS\Layout\Internal\Appendix_A\Figure_A4_Boundary_Anomalies.mxd

CH2MHILL



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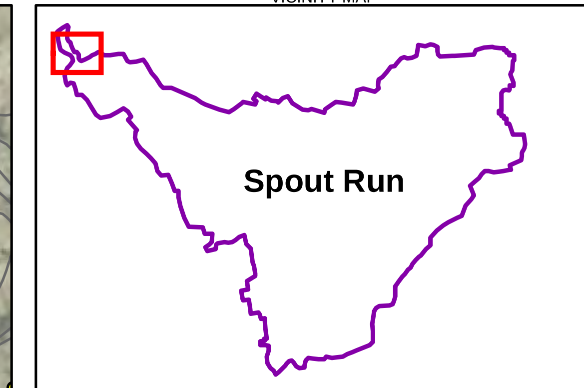

Legend

Stormwater Junctions

- BMP Structure
- Catchbasin
- Detention Outlet
- End Wall
- Grate Inlet
- Yard Inlet
- Junction
- Manhole
- Other
- Stormwater Mains
- Original Watershed Boundary
- Revised Watershed Boundary
- Arlington Co. 2 ft Contours

N

0 50 100
Feet

FIGURE A5
Boundary Anomalies
GIS Data Gaps and Anomalies - Spout Run
Arlington County Storm Capacity Analysis

\\ORION\Proj\ArlingtonVACountyOf\392309StormWaterCap\WSSpout\WorkingGIS\Layout\Internal\Appendix_A\Figure_A5_Boundary_Anomalies.mxd

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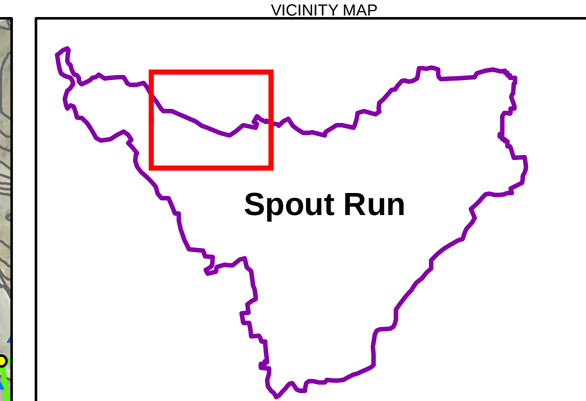
VICINITY MAP



Legend

Stormwater Junctions

- BMP Structure
- Catchbasin
- Detention Outlet
- End Wall
- Grate Inlet
- Yard Inlet
- Junction
- Manhole
- Other
- Stormwater Mains
- Original Watershed Boundary
- Revised Watershed Boundary
- Arlington Co. 2 ft Contours

0 125 250
Feet

FIGURE A6
Boundary Anomalies
GIS Data Gaps and Anomalies - Spout Run
Arlington County Storm Capacity Analysis

\\ORION\Proj\ArlingtonVACountyOf\392309StormWaterCap\WSSpout\WorkingGIS\Layout\Internal\Appendix_A\Figure_A6_Boundary_Anomalies.mxd

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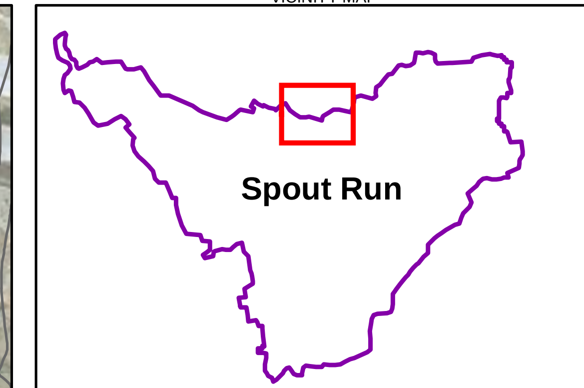

Legend

Stormwater Junctions

- BMP Structure
- Catchbasin
- Detention Outlet
- End Wall
- Grate Inlet
- Yard Inlet
- Junction
- Manhole
- Other
- Stormwater Mains
- Original Watershed Boundary
- Revised Watershed Boundary
- Arlington Co. 2 ft Contours

N

0 75 150
Feet

FIGURE A7
Boundary Anomalies
GIS Data Gaps and Anomalies - Spout Run
Arlington County Storm Capacity Analysis

\\ORION\Proj\ArlingtonVACountyOf\392309StormWaterCap\WSSpout\WorkingGIS\Layout\Internal\Appendix_A\Figure_A7_Boundary_Anomalies.mxd

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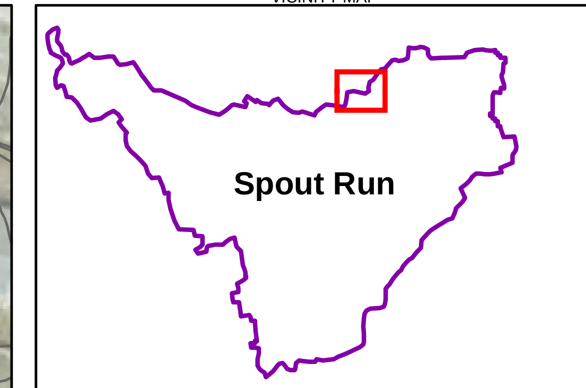


Legend

Stormwater Junctions

- BMP Structure
- Catchbasin
- Detention Outlet
- End Wall
- Grate Inlet
- Yard Inlet
- Junction
- Manhole
- Other
- Stormwater Mains
- Original Watershed Boundary
- Revised Watershed Boundary
- Arlington Co. 2 ft Contours

N

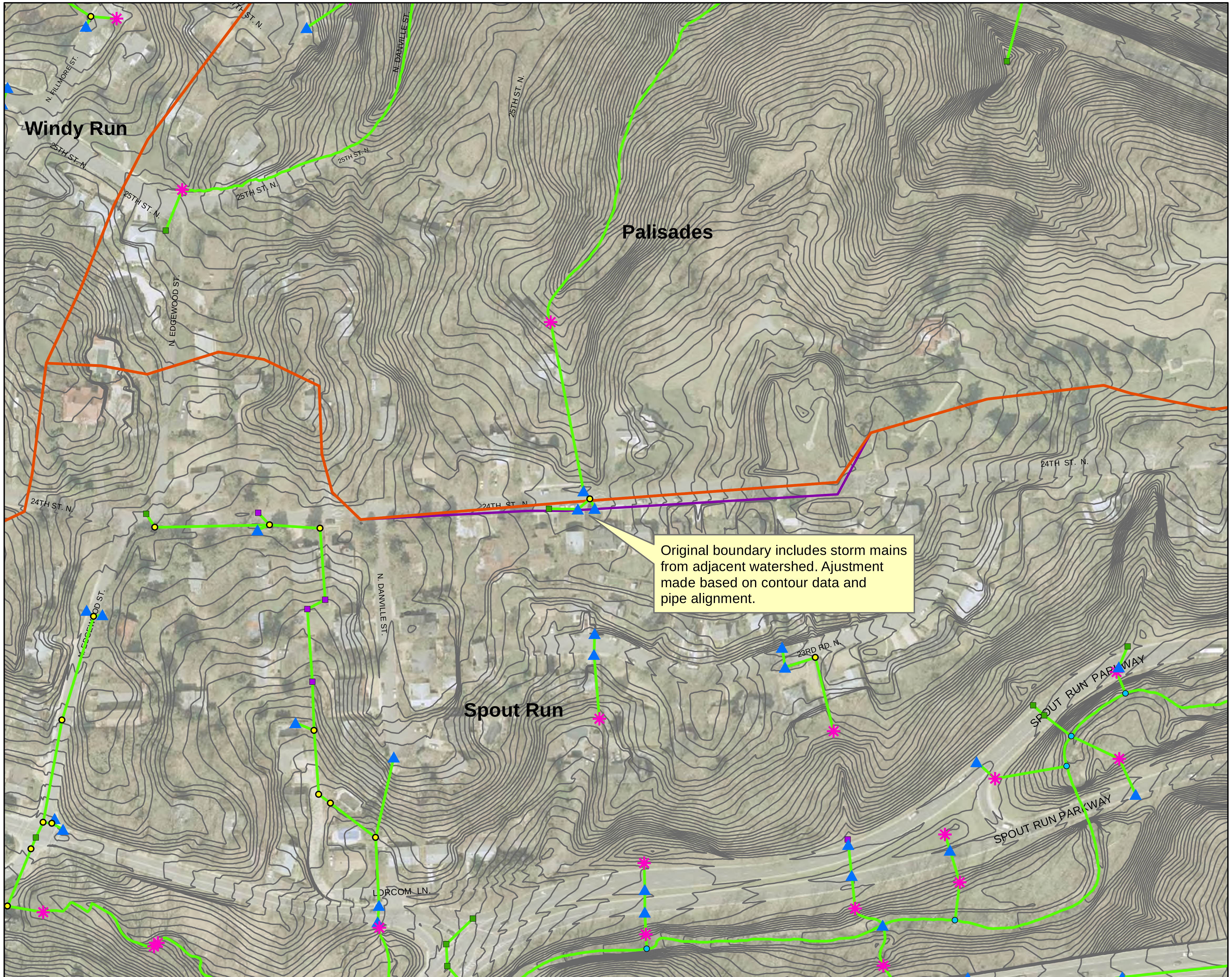
0 50 100

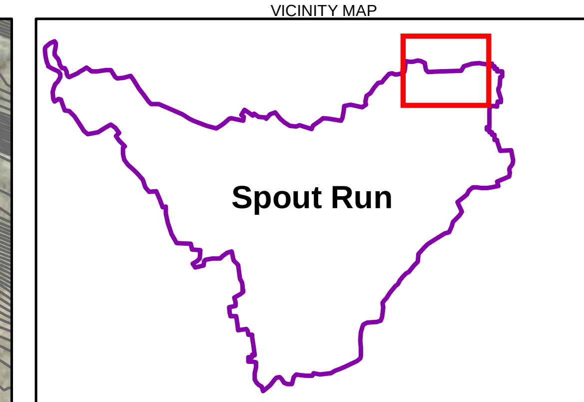
Feet

FIGURE A8
Boundary Anomalies
GIS Data Gaps and Anomalies - Spout Run
Arlington County Storm Capacity Analysis

CH2MHILL

\\ORION\Proj\ArlingtonVACountyOf\392309StormWaterCap\WSSpout\WorkingGIS\Layout\Internal\Appendix_A\Figure_A8_Boundary_Anomalies.mxd





Legend

Stormwater Junctions

- BMP Structure
- Catchbasin
- Detention Outlet
- End Wall
- Grate Inlet
- Yard Inlet
- Junction
- Manhole
- Other
- Stormwater Mains
- Original Watershed Boundary
- Revised Watershed Boundary
- Arlington Co. 2 ft Contours

N

0 90 180
Feet

FIGURE A9
Boundary Anomalies
GIS Data Gaps and Anomalies - Spout Run
Arlington County Storm Capacity Analysis

CH2MHILL

\\ORION\Proj\ArlingtonVACountyOf\392309StormWaterCap\WSSpout\WorkingGIS\Layout\Internal\Appendix_A\Figure_A9_Boundary_Anomalies.mxd

Attachment B

From: Joanne Gabor [Jgabor@arlingtonva.us]
Sent: Thursday, August 18, 2011 3:31 PM
To: Ajello, Tara/WDC
Subject: RE: Spout Run Data Gaps - comments/ discrepancies

Tara,
I reviewed the Spout Run Data Gaps memo dated August 11, 2011 and offer the following resolutions for the issues. I probably should have emphasized more that only the highlighted information was to be used - that would have cleared up some confusion in a couple of these items.

1.1 - The equalizer pipe should be 23' from the headwall and use the invert of 167.5 for the equalizer pipe as highlighted on Item 1A.PDF.
On the Item 1B.PDF I was noting the invert of the culverts at the equalizer pipe 23' from the headwall as shown in black, not the invert of the equalizer pipe itself. I had also marked it up to show that the location of the equalizer pipe you had originally shown in red was incorrect per the plan.
1.2 - Have the 54" pipe match crowns with the box culvert and adjust the inverts of the pipes from 4607-4625 accordingly.
1.3 - Use the centerline invert.
For this planning level study, the difference in 0.3' of the right side vs. centerline vs. left side isn't going to make much difference so we should use the centerline for simplicity.
1.4 - For node 8616 use an invert = 228.28'
1.5 - The distance from node 24432 and 24434 should be 250.9 as stated. I wasn't able to determine where the GIS distance of 106.8' was taken from. When I reviewed the link lengths in our GIS system I was getting about 240', not 106.8'.
1.6 - My notation regarding the invert of 225.88 should be ignored.

Please let me know if you have any further questions and we can set up a time to talk the questions out.
Thanks.
Joanne

-----Original Message-----
From: Tara.Ajello@CH2M.com [mailto:Tara.Ajello@CH2M.com]
Sent: Friday, August 12, 2011 12:12 PM
To: Joanne Gabor
Cc: Justin.Cheng@ch2m.com; Rita.Fordiani@CH2M.com
Subject: Spout Run Data Gaps - comments/ discrepancies

Joanne -

After further review of the comments we received in late July, we have a few questions. There are 6 areas that we need some additional clarification/ confirmation from you on that are documented in the attached document and figures. I would be happy to discuss these with you over the phone or in person next week, but I thought this was the clearest way of providing the information to you first.

Thank you. Have a great weekend.

From: Ajello, Tara/WDC
Sent: Friday, August 12, 2011 12:12 PM
To: 'Joanne Gabor'
Cc: Cheng, Justin/VBC; Fordiani, Rita/BOS
Subject: Spout Run Data Gaps - comments/ discrepancies
Attachments: MemoDataGapDiscrp2011 08 11revTA.docx; Item1A.pdf; Item1B.pdf; Item1C.pdf; Item2A.pdf; Item2B.pdf; Item3A_4620-171markup.pdf; Item3B.pdf; Item4A_4631-197markup.pdf; Item4B.pdf; Item4C.pdf; Item5.pdf; Item6.pdf

Joanne -

After further review of the comments we received in late July, we have a few questions. There are 6 areas that we need some additional clarification/ confirmation from you on that are documented in the attached document and figures. I would be happy to discuss these with you over the phone or in person next week, but I thought this was the clearest way of providing the information to you first.

Thank you. Have a great weekend.

Tara

Arlington Stormwater - Spout Run - Data Gap Solution Discrepancies

TO: Joanne Gabor/ Arlington County

COPIES:

FROM: CH2M HILL

DATE: August 11, 2011

PROJECT NUMBER: 392309.T3.SP.02.01

1.1 Pipe GID 24458 – 48" Equalizer Pipe – Kirkwood Rd, South of Lee Hwy

- Original Data Gap / Anomaly: Missing upstream and downstream inverts for a 48″ equalizer pipe between a 10x10′ (east) and 12x5′ (west) box culvert.
- Record Drawings: 4620-169 pg.4 shows equalizer pipe in plan, but does not show inverts.
- Discrepancy: The inverts for the 48″equalizer pipe are shown on 2 different sketches in the Spout Run Data Gaps Memo markups, one plan and one profile.
    - Plan (Item1A.pdf): Shows both the upstream and downstream inverts = 167.50 ft.
    - Profile (Item1B.pdf): Shows the invert at the 12x5′ box culvert end = 167.23 ft. Also shows the location of the 48″ equalizer 23′ downstream of the headwall. (We believe that this is correct and that the equalizer pipe is moved in this drawing compared to the GIS.)
    - Please confirm which inverts to use and the location of the 48″ equalizer pipe.
- Note: If the invert of the 48″ equalizer pipe is greater than 1 ft higher than the invert of the 12x5′ box culvert, the top of the 48″ equalizer will lie above the 12x5′ box culvert. (Which could occur if the updated inverts are used and the equalizer pipe stays in the same place as in the GIS as shown in Item1C.pdf.)

1.2 Pipe GID 23170 – 54" Pipe – Lee Highway, North of Kirkwood Rd

- Original Data Gap / Anomaly: Missing downstream invert for a 54″ pipe which ties into a 12x5′ box culvert. (Node ID 4625)
- Discrepancy: The sketch (Item2A.pdf) shows the inverts for the 54″pipe = 164.31 ft and the 12x5′ box culvert = 162.44 ft.
    - Using these inverts will result in the top of the 54″ pipe being higher than the top of the 12x5′ box culvert by 1.37 ft. (Item2B.pdf)
- Note: Changes to node 4625 will impact additional inverts along that line.

1.3 Node GID 3939 – Junction – Spout Run Pkwy and Interstate 66

- Original Data Gap / Anomaly: Missing invert and rim elevation.
- Record Drawings: 4620-171 pg.1 shows 3 inverts for this node which represents the inlet of a twinned 10x10' box culvert. The drawing shows a 10x10' box culvert and an open channel flowing into the inlet, but the 10x10' and 12x5' box culvert appear to discharge directly to the twinned 10x10' box culvert according to the GIS. The drawing also shows an inlet headwall built at an angle to the alignment of the twinned 10x10' box which is why 3 inverts are shown. (Item3A_4620-171markup.pdf)
    - Right side of twinned box = 153.63 ft.
    - Centerline of twinned box = 153.75 ft.
    - Left side of twinned box = 153.93.
- Discrepancy: The sketch (Item3B.pdf) shows 2 inverts for this node: 153.63 ft and 153.92 ft with some additional notation that I cannot read.
- Suggestion based on this interpretation: The centerline invert of the twinned 10x10' box culvert should be used. This invert also affects the interpolation of the upstream 10x10' and 12x5' box culverts and nodes.

1.4 Node GID 8616 – Junction – Southwest of Kirkwood Rd and Washington Blvd

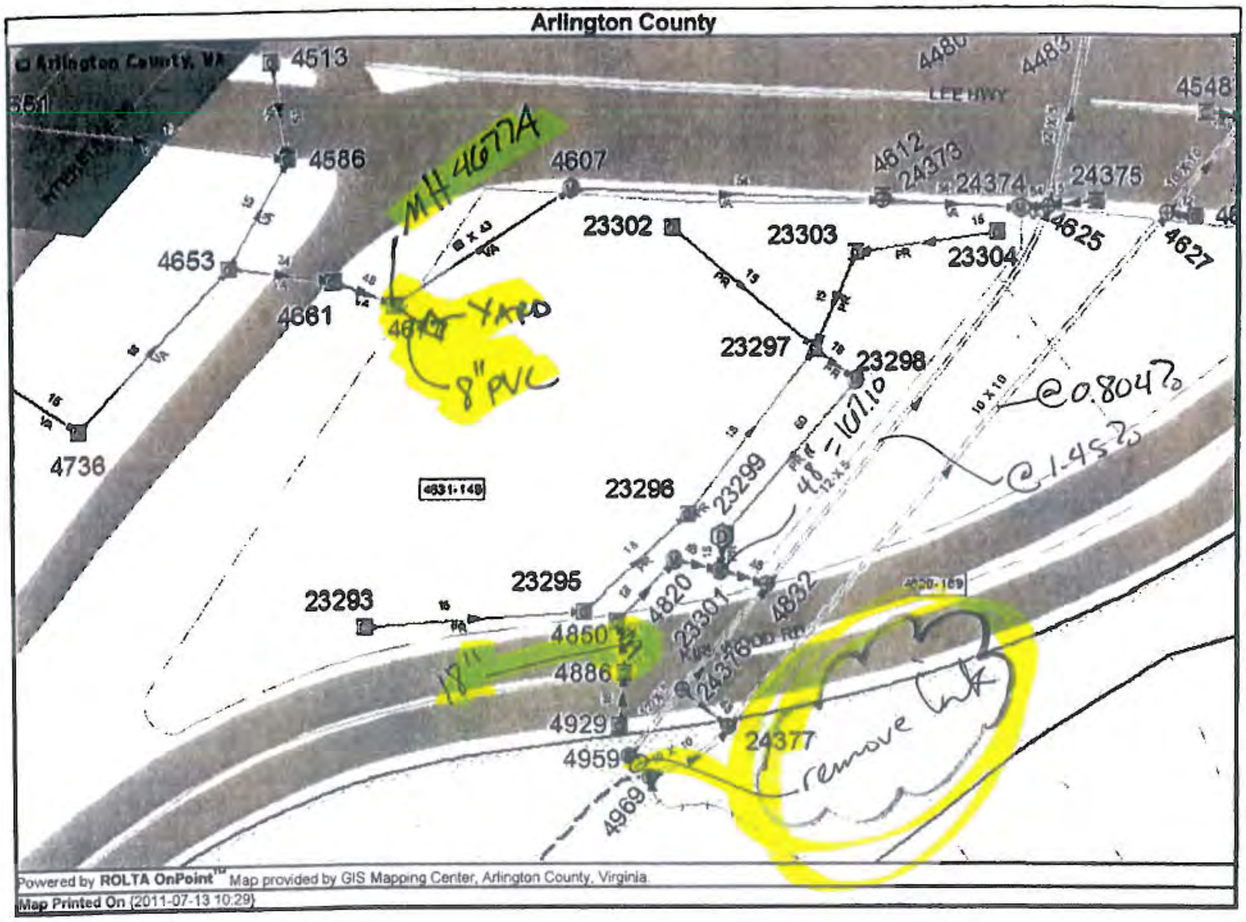
- Original Data Gap / Anomaly: Missing invert and rim elevation.
- Record Drawings: 4631-197 (Item4A_4631-197markup.pdf) shows the latest revision date in April 2010. 4630-223 shows the latest revision date in May 1986. Assume 4631-197 applies.
    - Review of the drawing and GIS data shows that structure JB3 (in drawing) is node 24434, EX MH8 is node 8603 and the tie-in point of the 36" pipe to the 96" bend is node 8616.
    - The 96" pipe is graded at 1.1% for 33 ft between node 24434 and 8603.
    - The distance (based on stations from the profile) between node 24434 and 8616 is 23 ft. Therefore, the interpolated invert for node 8616 = 228.28 ft.
- Discrepancy: The sketch (Item4B.pdf) shows the invert for this node = 229.30 ft. If this invert is used, pipe 24622 will have a negative slope (Item4C.pdf). The sketch seems to be based on the older record drawing. Please let us know if the newer one that we found (which seems to be an as-built, not just a design drawing) is incorrect.

1.5 Storm sewer alignment – Southwest of Kirkwood Rd and Washington Blvd

- Data Gap / Anomaly: GIS alignment does not match record drawing alignment. (This was not an original question from the memo).
- Angle: 4631-197 (Also in Item4A_4631-197markup.pdf) shows pipe 8919 and 24623 to be at 90° to each other, but the GIS data shows the angle to be greater than 90°.
- Distance: 4631-197 shows the distance between JB2 (node 24432) and JB3 (24434) = 250.9 ft. The GIS data shows the distance between the same nodes = 106.8 ft.
- Recommendation: See Item5.pdf

1.6 Pipe GID 16669 – 5x7' box culvert – Washington Blvd West of Kirkwood Rd

- Data Gap / Anomaly: None.
- Sketch (Also in Item4B.pdf): Shows upstream invert of pipe = 225.88 ft.
- Discrepancy: If this invert is used, pipe 16669 will have a negative slope unless the downstream invert is also adjusted. See Item 6.pdf. Please advise how to proceed.



(4)

~~4677~~ 4661 = 3618 VDOT inv = 173.09

4677 A = 3116 VDOT inv out = 172.02
INV in 48" = 172.17

24376-24377 48" equalizer pipe INV = 167.5 @ both locations

4607 = 3615 VDOT inv in = 169.11
inv out = 169.01

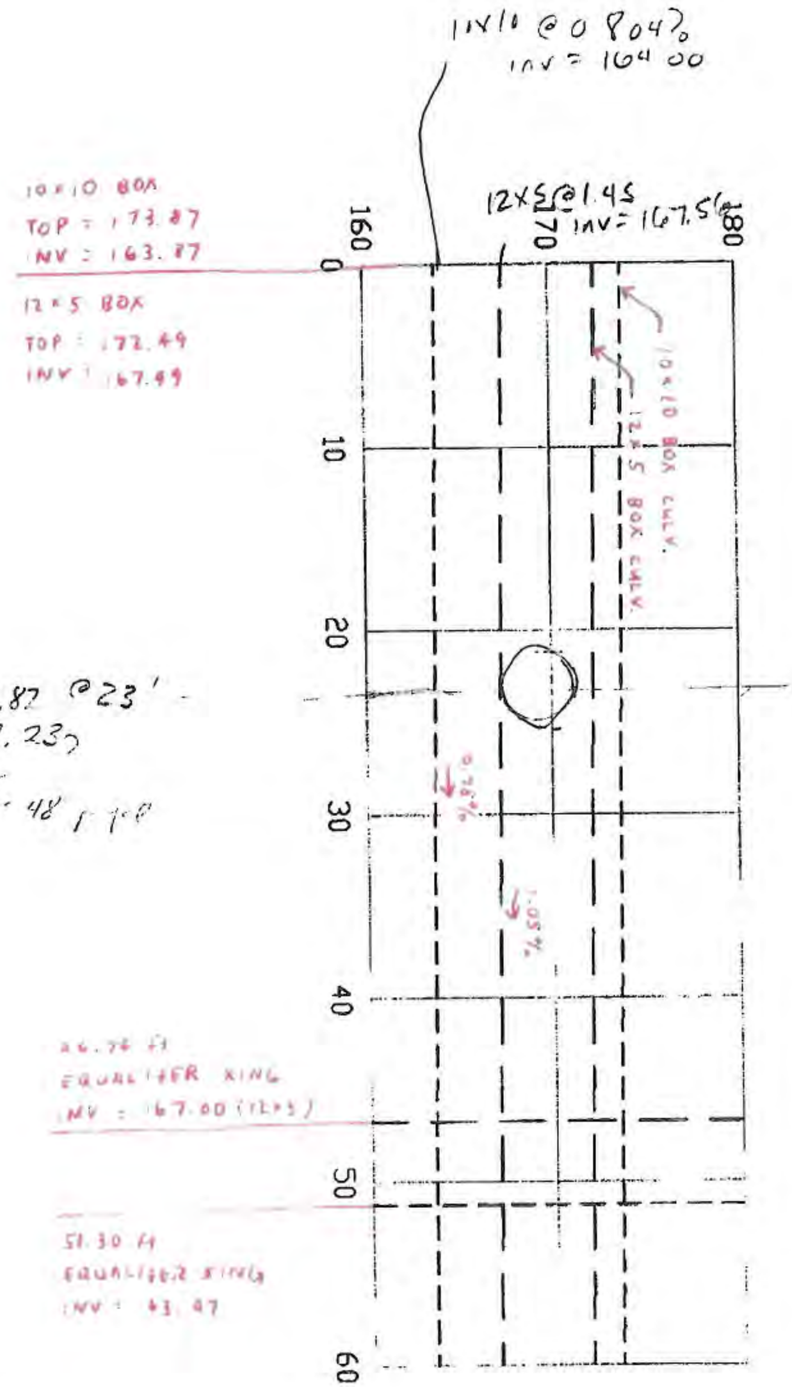
4820 out inv = 167.41 ~~167.50~~
(4620-169)

4625 = 3611 VDOT inv box = 162.44
inv in 54" = 164.31

24373 | 24374 interpolate

Item 1A

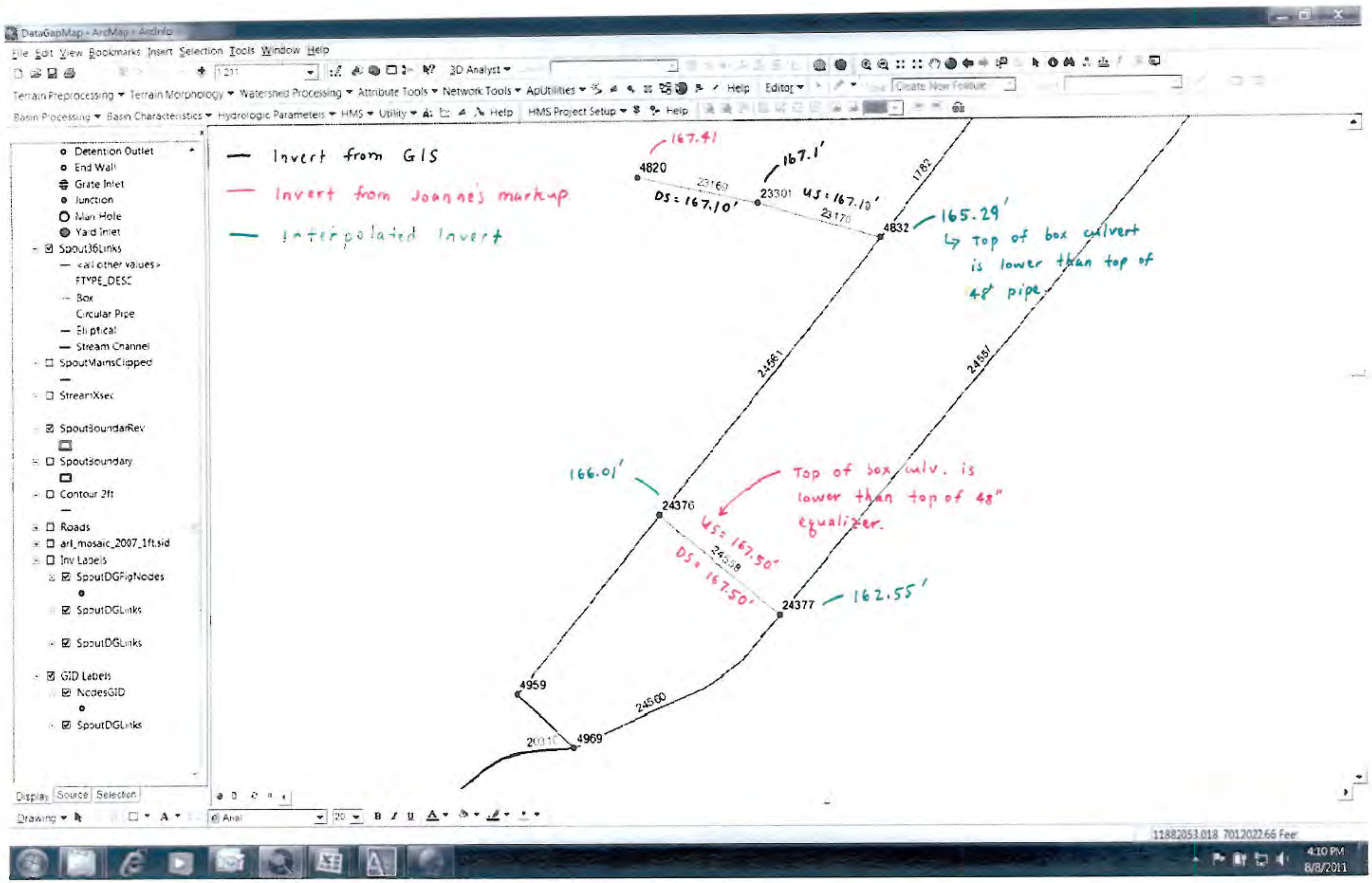
Italian Store Area



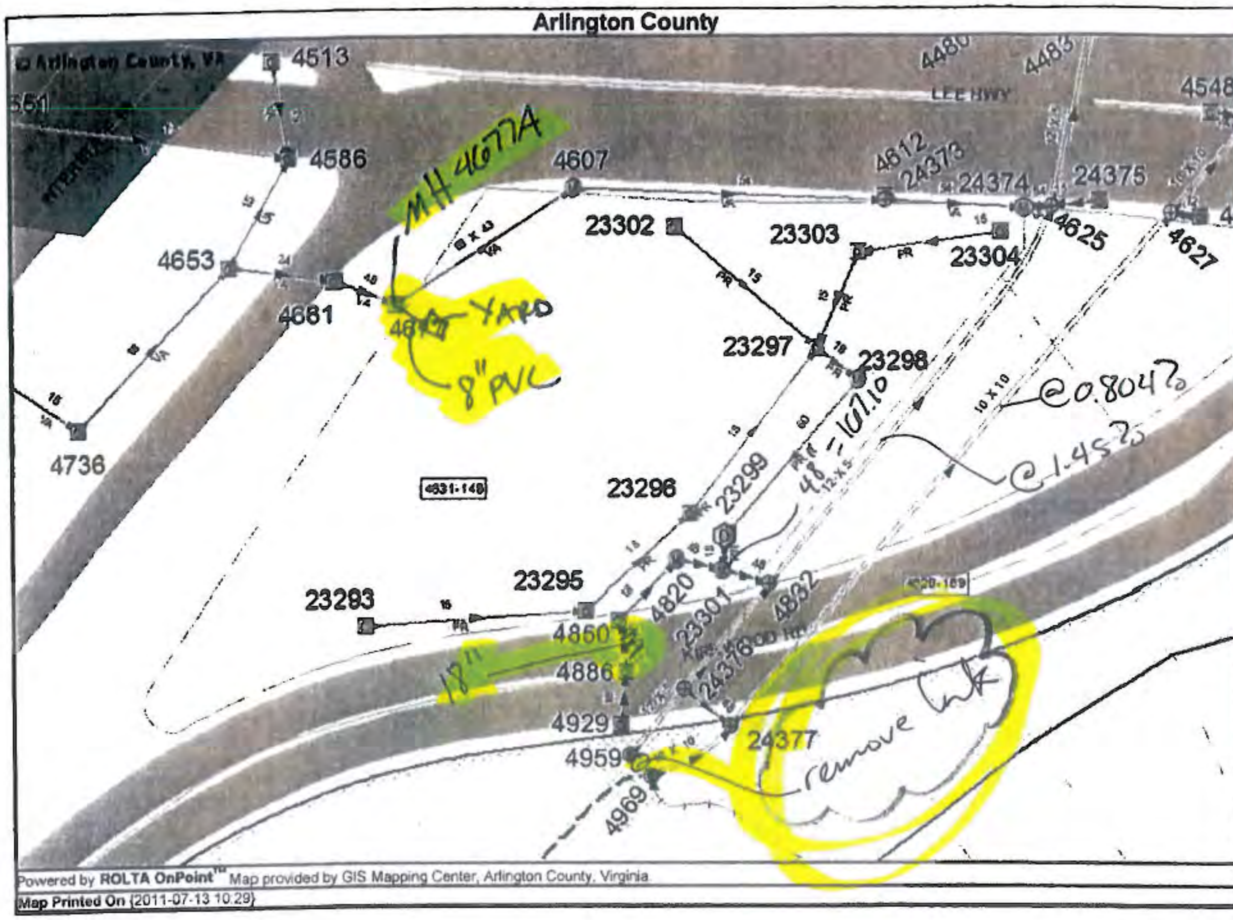
73.12 10x10 inv = 163.87 @ 23'

72.23 12x5 inv 167.23

G - 48


DataGapMap - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help
Terrain Preprocessing Terrain Morphology Watershed Processing Attribute Tools Network Tools ApUtilities Help Editor
Basin Processing Basin Characteristics Hydrologic Parameters HMS Utility Help HMS Project Setup Help
Detention Outlet
End Wall
Grate Inlet
Junction
Man Hole
Yard Inlet
Spout36Links
<all other values>
FTYPE_DESC
Box
Circular Pipe
Elliptical
Stream Channel
SpoutMainsClipped
StreamXsec
SpoutBoundaryRev
SpoutBoundary
Contour 2ft
Roads
arl_mosaic_2007_1ft.sid
Inv Labels
SpoutDGFigNodes
SpoutDGLinks
SpoutDGLinks
GID Labels
NodesGID
SpoutDGLinks
Display Source Selection
Drawing
Invert from GIS
Invert from Joanne's markup
Interpolated Invert
167.41
4820
23169
DS = 167.10'
167.1'
23301
US = 167.10'
23170
1782
4832
165.29'
↳ Top of box culvert is lower than top of 48" pipe.
24561
24551
166.01'
24376
Top of box culv. is lower than top of 48" equalizer.
US = 167.50'
24558
DS = 167.50'
24377
162.55'
4959
24560
20310
4969
11882053.018 7012022.66 Feet
4:10 PM
8/8/2011

ItemIC



(4)

~~4677~~ 4661 = 3618 VDOT inv = 173.09

4677 A = 3116 VDOT inv out = 172.02
INV in 48" = 172.17

4607 = 3615 VDOT inv in = 169.11
inv out = 169.01

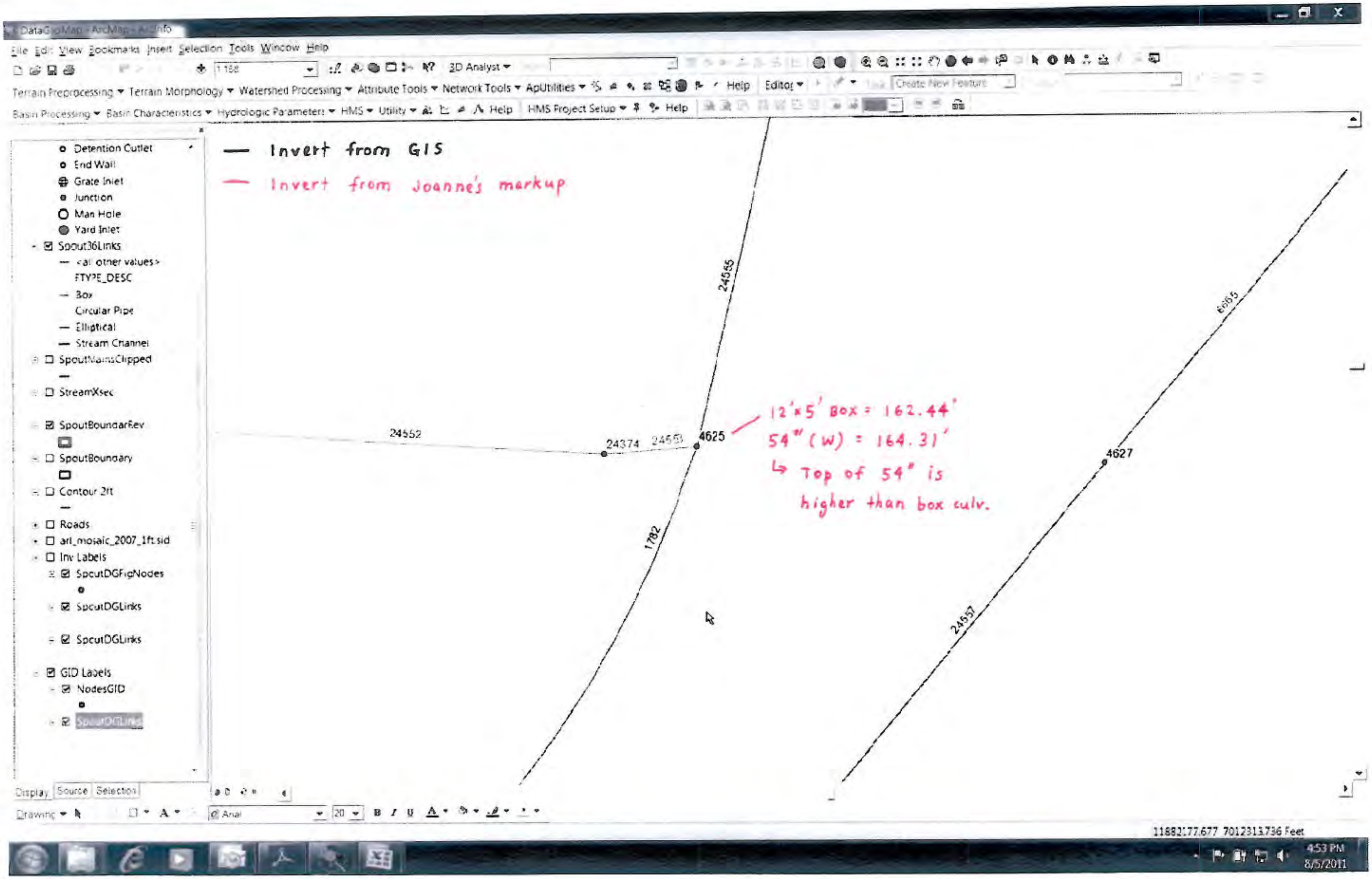
4625 = 3611 VDOT inv box = 162.44
inv in 54" = 164.31

24376-24377
48" equalizer pipe
INV = 167.5
@ 6th location

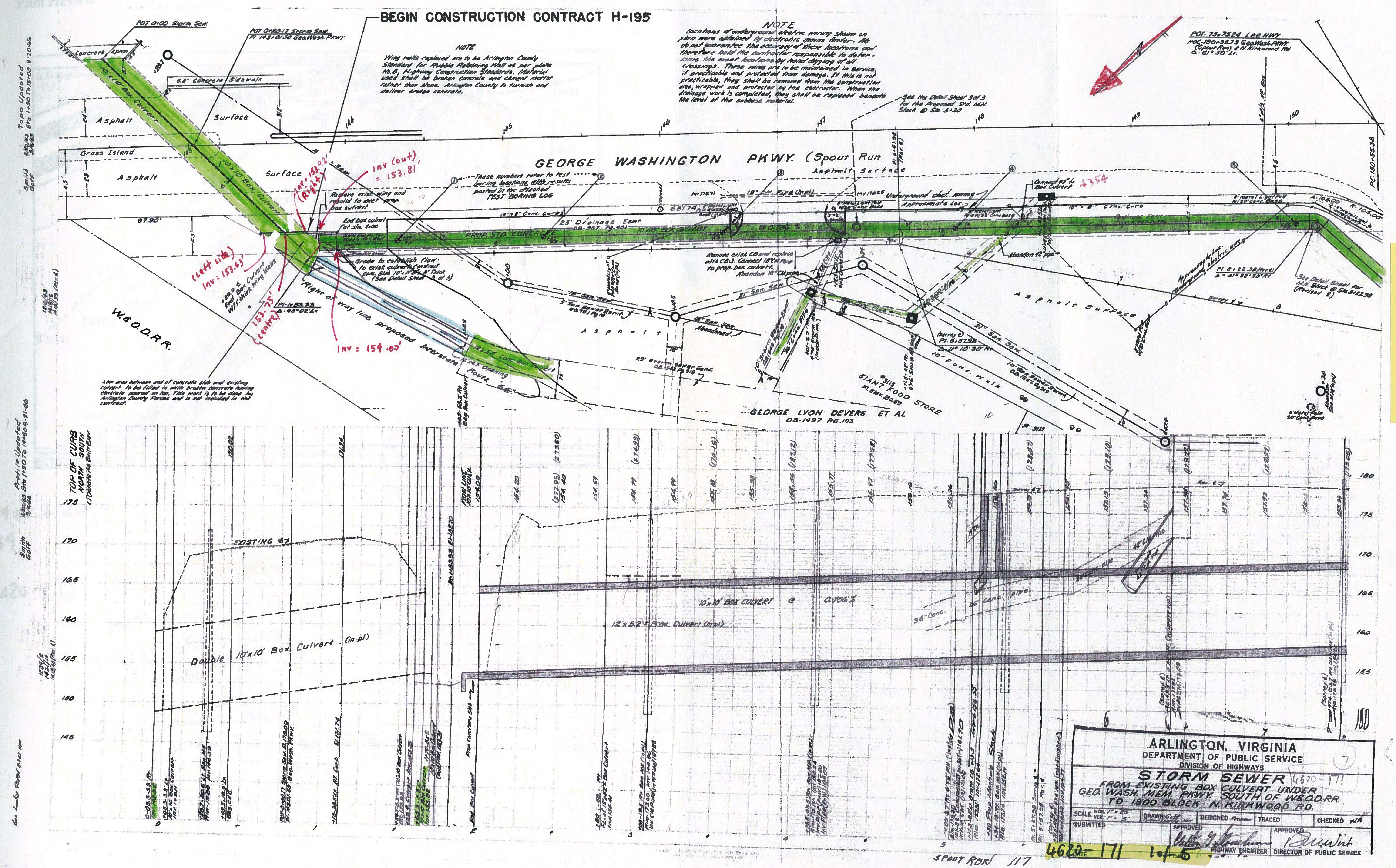
4820 out inv = 167.41
~~167.50~~
(4620-169)

24373 / 24374 interpolate

Item 2A

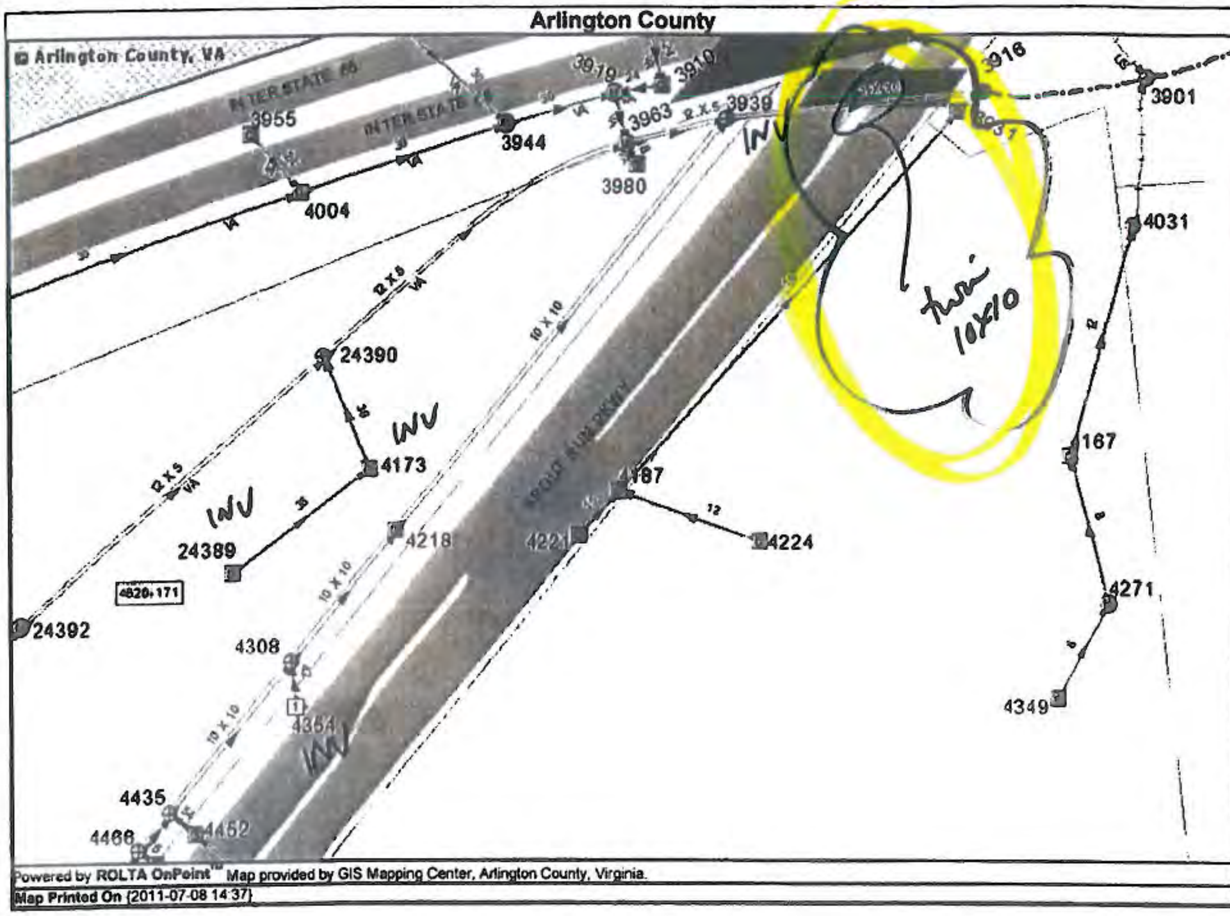

DataGisMap - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help
Detention Outlet
End Wall
Grate Inlet
Junction
Man Hole
Yard Inlet
Spout36Links
<all other values>
FTYPE_DESC
Box
Circular Pipe
Elliptical
Stream Channel
SpoutMainsClipped
StreamXsec
SpoutBoundarRev
SpoutBoundary
Contour 2ft
Roads
arl_mosaic_2007_1ft.sid
Inv Labels
SpoutDGFigNodes
SpoutDGLinks
SpoutDGLinks
GID Labels
NodesGID
— Invert from GIS
— Invert from Joanne's markup
24555
24552
24374
24553
4625
1782
6665
4627
24557
12'x5' Box = 162.44'
54"(W) = 164.31'
↳ Top of 54" is higher than box culv.
11882177.677 7012313.736 Feet
4:53 PM
8/5/2011

Item 28



BEGIN CONSTRUCTION CONTRACT H-195
NOTE
Wing walls replaced are to be Arlington County Standard for Rubble Retaining Wall as per plate No.8, Highway Construction Standards. Material used shall be broken concrete and cement mortar rather than stone. Arlington County to furnish and deliver broken concrete.
NOTE
Locations of underground electric wiring shown on plan were obtained by electronic means finder. We do not guarantee the accuracy of these locations and therefore hold the contractor responsible to determine the exact locations by hand digging at all crossings. These wires are to be maintained in service, if practicable and protected from damage. If this is not practicable, they shall be removed from the construction area, wrapped and protected by the contractor. When the drainage work is completed, they shall be replaced beneath the level of the subbase material.
GEORGE WASHINGTON PKWY. (Spout Run
Asphalt Surface
Grass Island
W.&O.D.R.R.
Right of way line proposed Interstate Route 66
GIANT FOOD STORE
GEORGE LYON DEVERS ET AL
DB-1497 PG.103
Inv (out) = 153.81
Inv: 154.00'
TOP OF CURB
EXISTING 67
Double 10'x10' Box Culvert (in pl.)
10'x10' BOX CULVERT @ 0.906%
12'x5.2' Box Culvert (in pl.)
Low area between end of concrete slab and existing culvert to be filled in with broken concrete having concrete poured on top. This work is to be done by Arlington County Forces and is not included in the contract.
ARLINGTON, VIRGINIA
DEPARTMENT OF PUBLIC SERVICE
DIVISION OF HIGHWAYS
STORM SEWER
FROM EXISTING BOX CULVERT UNDER GEO. WASH. MEM. PKWY. SOUTH OF W.&O.D.R.R. TO 1900 BLOCK N. KIRKWOOD RD.
HIGHWAY ENGINEER
DIRECTOR OF PUBLIC SERVICE
SPOUT RUN 117
4620-171
1 of 6

Item 3A



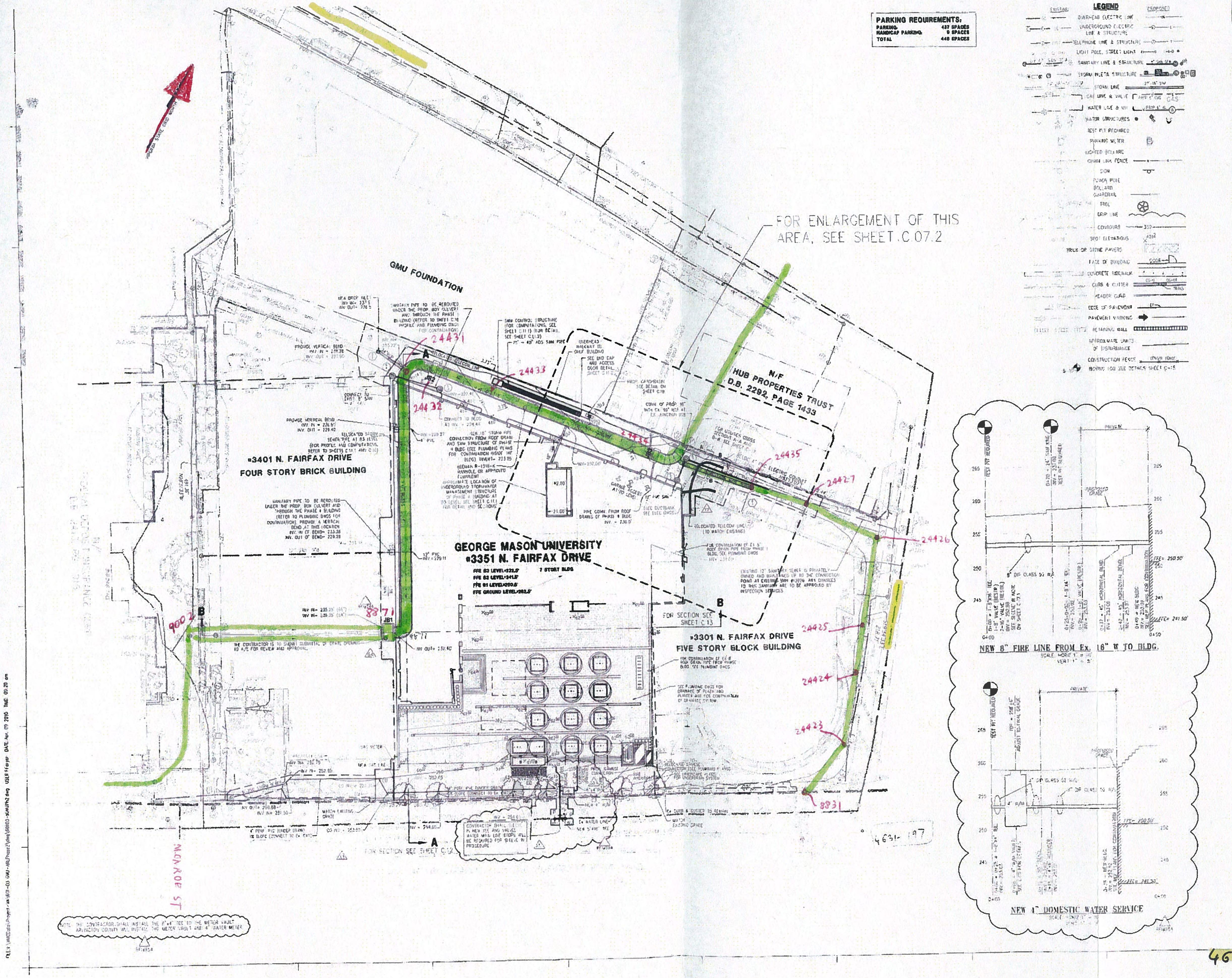
3939 inv in dwg
4354

(4620-171)

4354 inv = 172.09
24389 inv = 164.77
4173 .36" in = 161.70
36" out = 161.25

3939 at inv = 153.63
10x10 inv in = 153.92

Item 3B



George Mason University

Academic II - Arlington

VA BCOM Project Code: 247-16523

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SEALS AND SIGNATURES

KEY PLAN

PROJECT NORTH | VA STATE GRID NORTH

DRAWING TITLE

SITE PLAN

4631-197

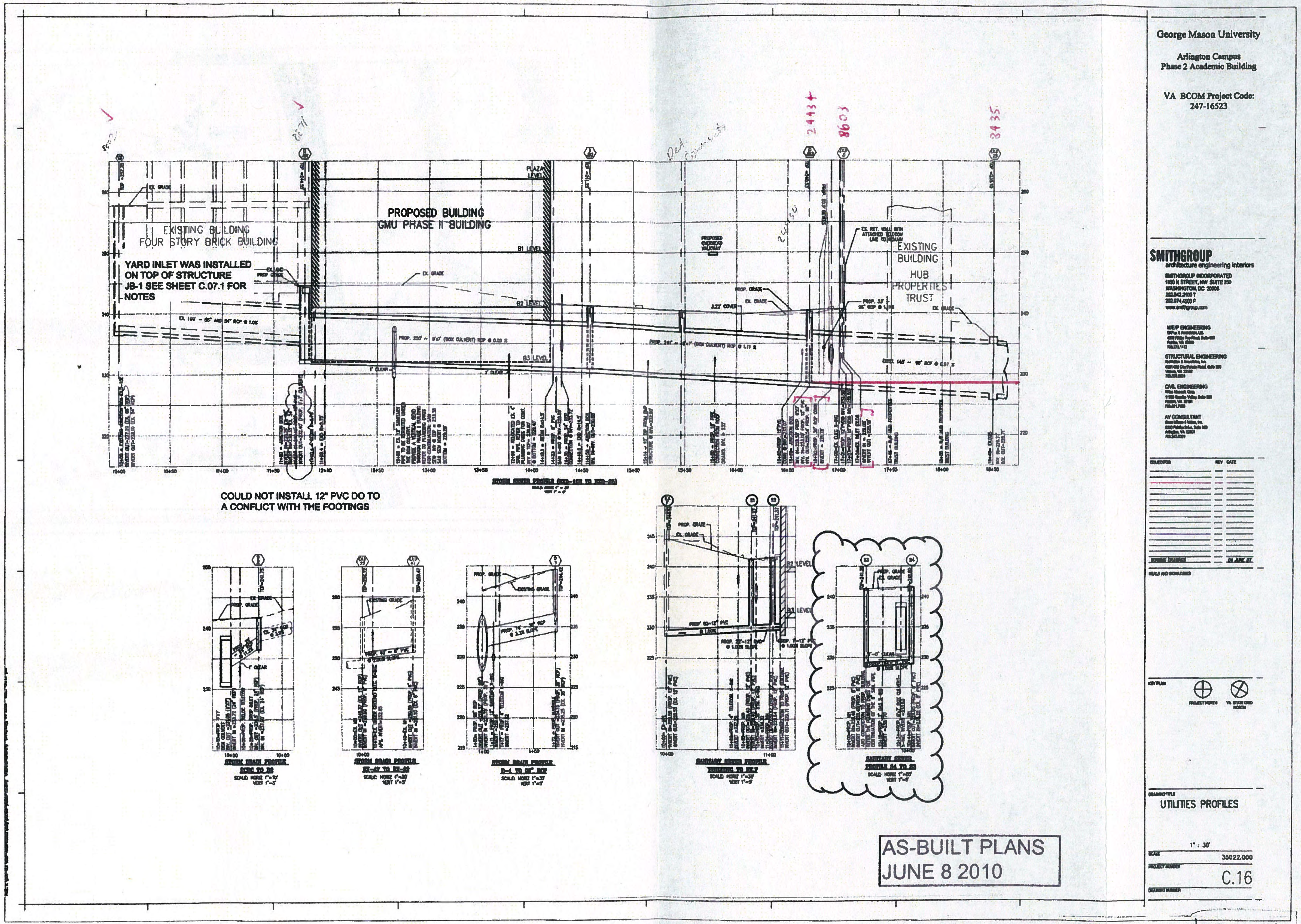
SCALE 1" = 30'

PROJECT NUMBER

C.07.1

4631-197 1 of 2

Item 4A

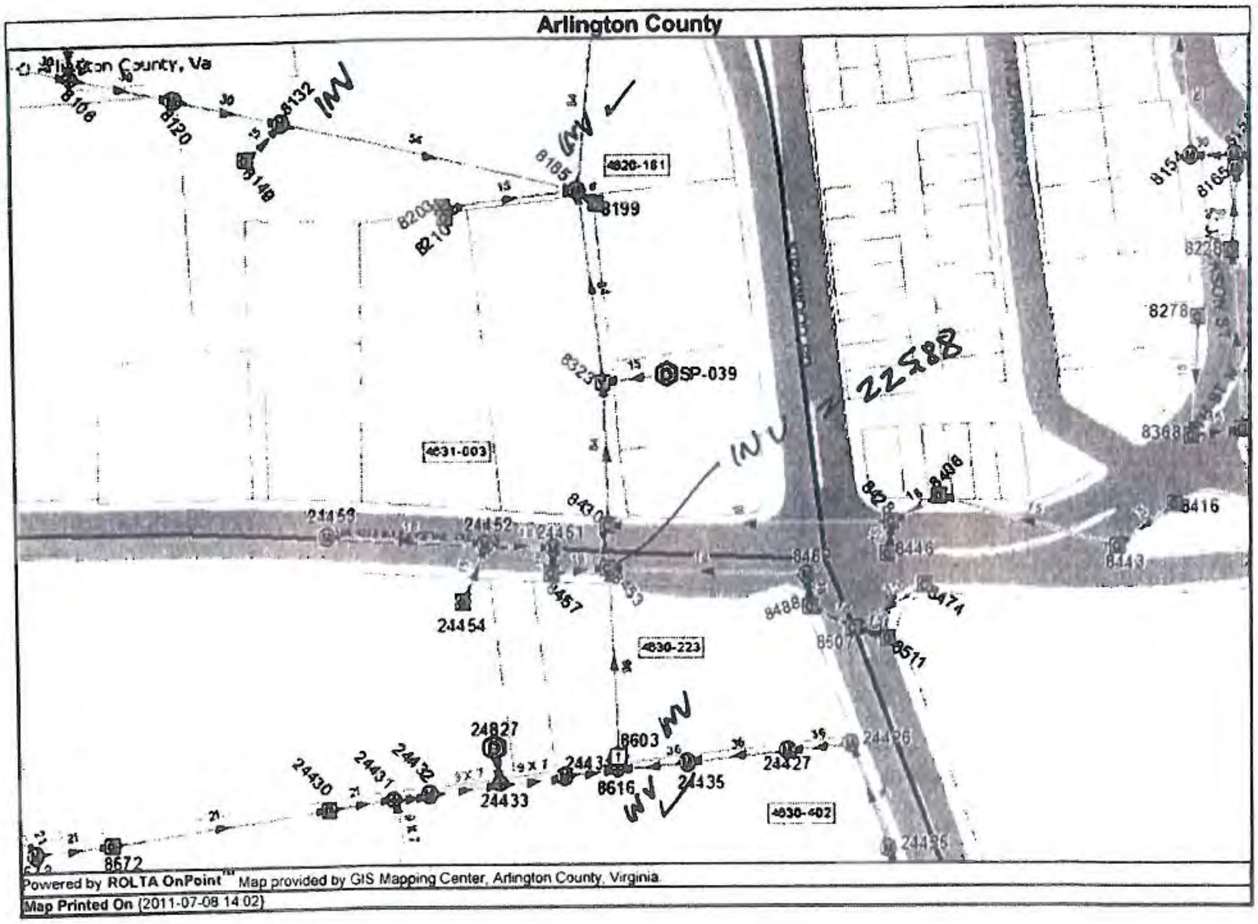


4631-197

4631- 197 2 of 2

ITem 4A

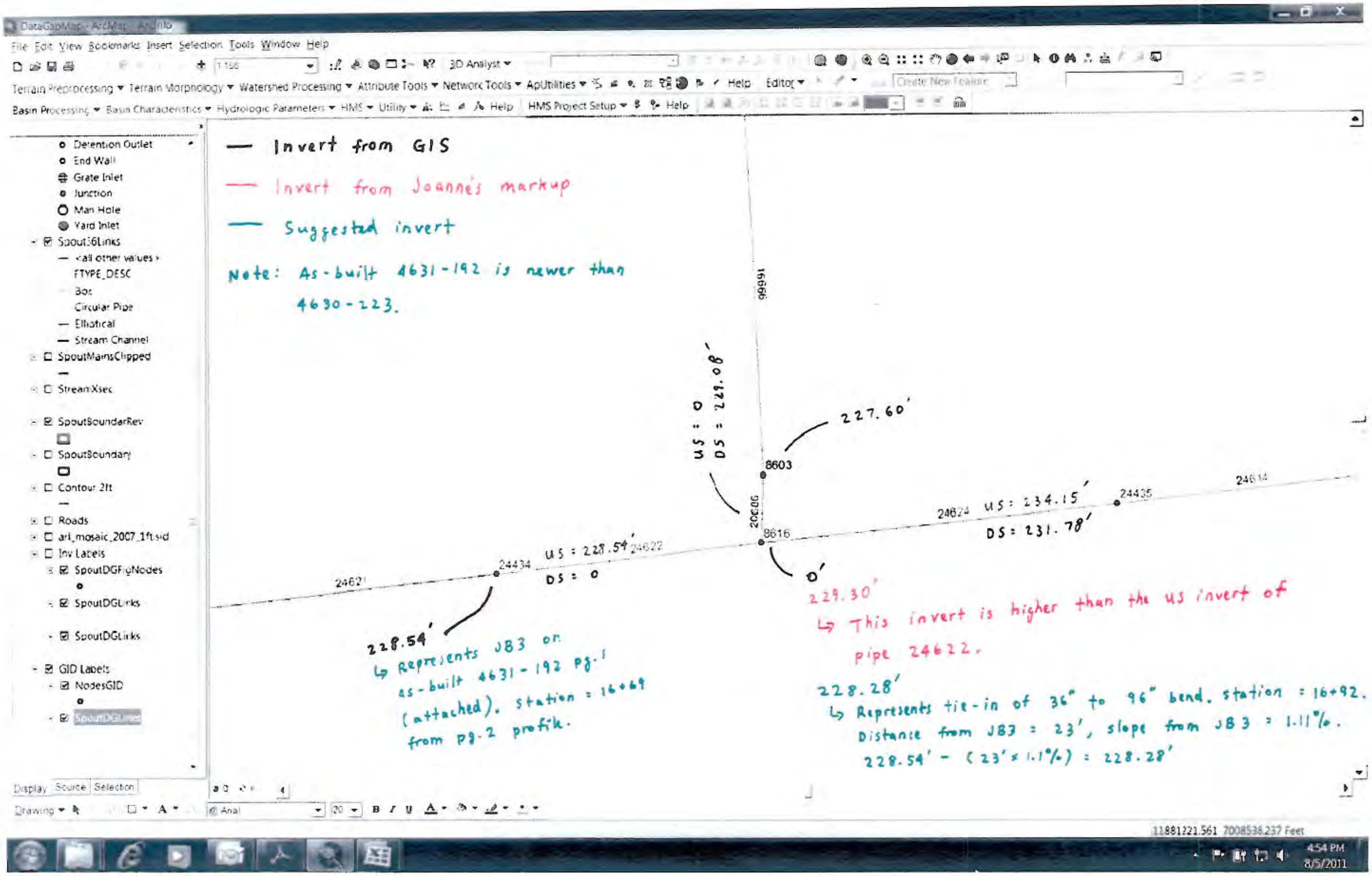
(2)



4620-181 8185 inv =216.00

4630-223 8616 | ~~8603~~ inv = 229.3

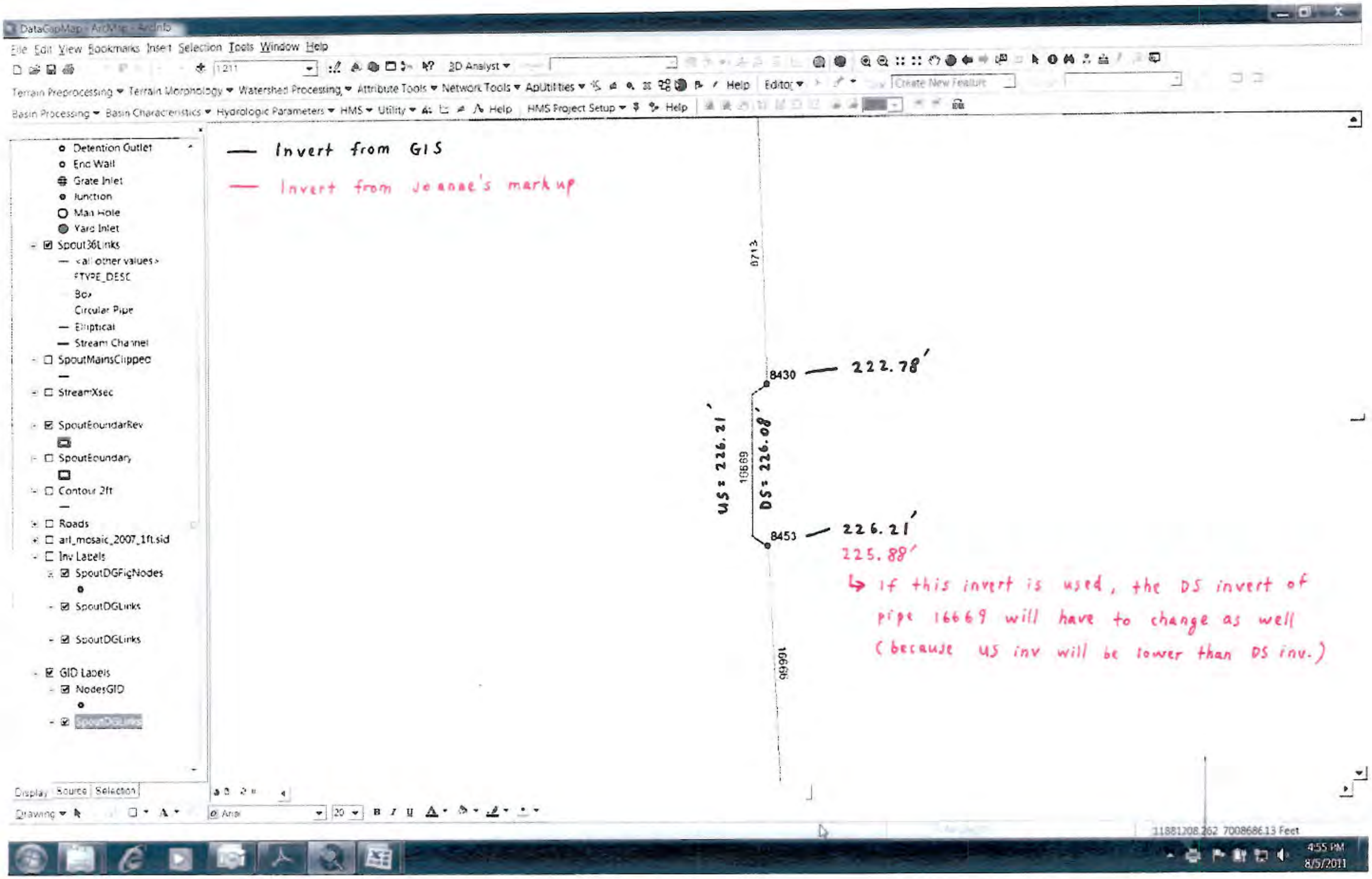
Item 4B


DataGapMap - ArcMap - ArcInfo
— Invert from GIS
— Invert from Joanne's markup
— Suggested invert
Note: As-built 4631-192 is newer than 4630-223.
US : 0
DS = 229.08'
227.60'
8603
8616
US : 234.15'
DS : 231.78'
24435
US : 228.54'
DS : 0
24434
0'
229.30'
↳ This invert is higher than the US invert of pipe 24622.
228.54'
↳ Represents JB3 on as-built 4631-192 pg. 1 (attached). Station = 16+69 from pg. 2 profile.
228.28'
↳ Represents tie-in of 36" to 96" bend. Station = 16+92. Distance from JB3 = 23', slope from JB3 = 1.11%.
228.54' − (23' × 1.1%) = 228.28'
4:54 PM
8/5/2011

Item 4C


DataGapMap - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help
— Suggested Alignment (based on as-built 4631-192)
KIRKWOOD RD.
24431
24432
24433
24434
8603
8616
24624
24435
24614
24427
24426
24425
24424
24423
8831
8871
24623
Spout36Nodes
FTYPE_DESC
Catchbasin
Detention Outlet
End Wall
Grate Inlet
Junction
Man Hole
Yard Inlet
Spout36Links
Box
Circular Pipe
Elliptical
Stream Channel
StreamXsec
SpoutBoundary
Contour 2ft
Roads
Inv Labels
GID Labels
NodesGID
9:24 AM
8/3/2011

Item 5



DataGapMap - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help
— Invert from GIS
— Invert from Joanne's markup
Detention Outlet
End Wall
Grate Inlet
Junction
Man Hole
Yard Inlet
Spout36Links
<all other values>
FTYPE_DESC
Box
Circular Pipe
Elliptical
Stream Channel
SpoutMainsClipped
StreamXsec
SpoutBoundarRev
SpoutBoundary
Contour 2ft
Roads
arl_mosaic_2007_1ft.sid
Inv Labels
SpoutDGFigNodes
SpoutDGLinks
SpoutDGLinks
GID Labels
NodesGID
0713
8430 — 222.78'
US = 226.21'
16669
DS = 226.08'
8453 — 226.21'
225.88'
↳ If this invert is used, the DS invert of pipe 16669 will have to change as well (because US inv will be lower than DS inv.)
16669
11881208.262 7008686.13 Feet
4:55 PM
8/5/2011

Item 6

Appendix B
Arlington County Soil Profile Assumptions Used in PCSWMM File

APPENDIX B
Arlington County Soil Profile Assumptions Used in PCSWMM Files

Soil Map Units	Composition and Profile	Assumption[a]	Selected Model Profile
4A	Sassafras 40% (0–6 inches sandy loam); urban 35%; Neabsco 15% (0–8 inches loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
4B	Urban 70%; Sassafras 15% (0–6 inches sandy loam); Neabsco 10% (0–8 inches loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
6D	Glenelg 50% (0–1 inch loam; 1–6 inches silt loam); Manor 45% (0–6 inches sandy loam)	Pervious, mostly Glenelg; 1–6 inches	Silty loam
7B	Glenelg 45% (0–1 inch loam; 1–6 inches silt loam); urban 40%	Pervious, mostly Glenelg; 1–6 inches	Silty loam
7C	Glenelg 45% (0–1 inch loam; 1–6 inches silt loam); urban 40%	Pervious, mostly Glenelg; 1–6 inches	Silty loam
7D	Glenelg 45% (0–1 inch loam; 1–6 inches silt loam); urban 40%	Pervious, mostly Glenelg; 1–6 inches	Silty loam
10B	Urban 70%; Glenelg 20% (0–1 inch loam; 1–6 inches silt loam)	Pervious, mostly Glenelg; 1–6 inches	Silty loam
11B	Urban 70%; Sassafras 25% (0–6 inches sandy loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
12	Urban 85%; Udorthents 15%	Pervious Udorthents	Loam

Note: Soil composition and profile information from USDA and NRCS, 2007, "Soil Survey of Arlington County, Virginia" (available at http://soildatamart.nrcs.usda.gov/Manuscripts/VA013/0/Arlington.pdf.
[a] Selected characteristics of top 6 inches of soil profile for modeling runoff.

Appendix C
Hyetograph Data

APPENDIX C
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
0	0.000	0.0000
5	0.000	0.0484
10	0.000	0.0486
15	0.000	0.0476
20	0.000	0.0509
25	0.000	0.0525
30	0.000	0.0482
35	0.000	0.0535
40	0.000	0.0491
45	0.000	0.0507
50	0.000	0.0540
55	0.000	0.0530
60	0.000	0.0533
65	0.000	0.0532
70	0.120	0.0534
75	0.000	0.0524
80	0.000	0.0558
85	0.000	0.0574
90	0.000	0.0530
95	0.000	0.0583
100	0.000	0.0539
105	0.000	0.0556
110	0.000	0.0589
115	0.000	0.0578
120	0.000	0.0581
125	0.000	0.0582
130	0.000	0.0573
135	0.000	0.0615
140	0.000	0.0618
145	0.000	0.0570
150	0.000	0.0584
155	0.000	0.0632
160	0.000	0.0587
165	0.000	0.0604
170	0.000	0.0637

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
175	0.000	0.0627
180	0.000	0.0629
185	0.000	0.0629
190	0.000	0.0631
195	0.000	0.0621
200	0.000	0.0654
205	0.000	0.0672
210	0.000	0.0626
215	0.000	0.0674
220	0.000	0.0688
225	0.000	0.0641
230	0.000	0.0643
235	0.000	0.0685
240	0.000	0.0677
245	0.000	0.0678
250	0.000	0.0672
255	0.000	0.0707
260	0.000	0.0732
265	0.000	0.0724
270	0.000	0.0726
275	0.000	0.0726
280	0.000	0.0728
285	0.000	0.0720
290	0.000	0.0745
295	0.000	0.0780
300	0.000	0.0774
305	0.000	0.0775
310	0.000	0.0769
315	0.000	0.0801
320	0.000	0.0836
325	0.000	0.0806
330	0.000	0.0775
335	0.000	0.0871
340	0.000	0.0839
345	0.000	0.0810

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
350	0.000	0.0844
355	0.120	0.0876
360	0.000	0.0870
365	0.240	0.0872
370	0.120	0.0866
375	0.240	0.0898
380	0.240	0.0933
385	0.360	0.0903
390	0.120	0.0871
395	0.240	0.0968
400	0.120	0.0936
405	0.120	0.0906
410	0.000	0.0941
415	0.000	0.0973
420	0.000	0.0967
425	0.000	0.0969
430	0.000	0.0962
435	0.000	0.0997
440	0.000	0.1022
445	0.000	0.1015
450	0.000	0.1017
455	0.000	0.1016
460	0.120	0.1018
465	0.120	0.1011
470	0.000	0.1035
475	0.240	0.1072
480	1.440	0.1063
485	1.560	0.1057
490	1.080	0.1146
495	1.080	0.1158
500	0.960	0.1199
505	0.000	0.1267
510	0.240	0.1259
515	0.360	0.1348
520	0.120	0.1400

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
525	1.440	0.1403
530	0.600	0.1413
535	0.120	0.1477
540	0.600	0.1555
545	0.120	0.1550
550	0.120	0.1548
555	0.000	0.1549
560	0.240	0.1550
565	0.360	0.1547
570	0.480	0.1550
575	0.720	0.1594
580	0.120	0.1630
585	0.240	0.1697
590	0.000	0.1788
595	0.000	0.1854
600	0.000	0.1892
605	0.000	0.1972
610	0.000	0.2096
615	0.000	0.2192
620	0.000	0.2261
625	0.120	0.2356
630	0.000	0.2481
635	0.000	0.2599
640	0.000	0.2757
645	0.000	0.2920
650	0.000	0.3083
655	0.000	0.3238
660	0.000	0.3407
665	0.000	0.3692
670	0.000	0.4054
675	0.000	0.4416
680	0.000	0.4925
685	0.000	0.5096
690	0.000	0.5696
695	0.000	1.0590

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
700	0.000	2.0449
705	0.000	2.8482
710	0.000	5.0925
715	0.000	6.7422
720	0.000	4.2836
725	0.000	1.0223
730	0.000	0.6866
735	0.000	0.8119
740	0.000	0.6292
745	0.000	0.5675
750	0.000	0.4643
755	0.000	0.4088
760	0.000	0.3917
765	0.000	0.3718
770	0.000	0.3449
775	0.000	0.3235
780	0.000	0.3083
785	0.000	0.2922
790	0.000	0.2750
795	0.000	0.2644
800	0.000	0.2585
805	0.000	0.2473
810	0.000	0.2308
815	0.000	0.2234
820	0.000	0.2155
825	0.000	0.2072
830	0.000	0.1994
835	0.000	0.1910
840	0.000	0.1832
845	0.000	0.1795
850	0.000	0.1755
855	0.000	0.1716
860	0.000	0.1669
865	0.000	0.1644
870	0.000	0.1645

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
875	0.000	0.1598
880	0.000	0.1599
885	0.000	0.1573
890	0.000	0.1528
895	0.000	0.1486
900	0.000	0.1449
905	0.000	0.1455
910	0.000	0.1418
915	0.000	0.1376
920	0.000	0.1331
925	0.000	0.1305
930	0.000	0.1306
935	0.000	0.1259
940	0.000	0.1261
945	0.000	0.1235
950	0.000	0.1190
955	0.000	0.1147
960	0.000	0.1111
965	0.000	0.1118
970	0.000	0.1067
975	0.000	0.1095
980	0.000	0.1102
985	0.000	0.1056
990	0.000	0.1066
995	0.000	0.1069
1000	0.000	0.1025
1005	0.000	0.1012
1010	0.000	0.1017
1015	0.000	0.1018
1020	0.000	0.1015
1025	0.000	0.0970
1030	0.000	0.0963
1035	0.000	0.0977
1040	0.000	0.0943
1045	0.000	0.0926

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
1050	0.000	0.0971
1055	0.000	0.0920
1060	0.000	0.0924
1065	0.000	0.0884
1070	0.000	0.0889
1075	0.000	0.0917
1080	0.000	0.0867
1085	0.000	0.0875
1090	0.000	0.0826
1095	0.000	0.0854
1100	0.000	0.0858
1105	0.000	0.0818
1110	0.000	0.0822
1115	0.000	0.0772
1120	0.000	0.0817
1125	0.000	0.0797
1130	0.000	0.0773
1135	0.840	0.0764
1140	0.360	0.0724
1145	0.600	0.0776
1150	0.000	0.0739
1155	0.480	0.0718
1160	0.600	0.0733
1165	0.000	0.0716
1170	0.120	0.0674
1175	0.240	0.0676
1180	0.240	0.0686
1185	0.000	0.0640
1190	0.240	0.0647
1195	0.000	0.0676
1200	0.000	0.0624
1205	0.000	0.0629
1210	0.000	0.0631
1215	0.000	0.0627
1220	0.000	0.0635

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
1225	0.000	0.0618
1230	0.000	0.0579
1235	1.680	0.0626
1240	0.960	0.0640
1245	2.880	0.0590
1250	4.800	0.0601
1255	2.640	0.0624
1260	1.800	0.0578
1265	2.040	0.0632
1270	1.920	0.0586
1275	2.160	0.0609
1280	1.920	0.0620
1285	2.040	0.0570
1290	2.640	0.0584
1295	2.400	0.0631
1300	2.040	0.0592
1305	2.880	0.0575
1310	1.560	0.0583
1315	2.280	0.0580
1320	1.920	0.0581
1325	1.440	0.0581
1330	1.200	0.0581
1335	0.600	0.0579
1340	0.480	0.0586
1345	0.240	0.0569
1350	0.360	0.0530
1355	0.720	0.0578
1360	0.240	0.0592
1365	0.000	0.0542
1370	0.000	0.0552
1375	0.000	0.0575
1380	0.000	0.0530
1385	0.000	0.0583
1390	0.000	0.0538
1395	0.000	0.0561

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
1400	0.120	0.0571
1405	0.000	0.0521
1410	0.120	0.0536
1415	0.120	0.0583
1420	0.120	0.0544
1425	0.120	0.0527
1430	0.240	0.0534
1435	0.720	0.0532

Appendix B
GIS Updates from March 2012 and Rim Updates from September 2012

GIS Updates from March 2012

ID	Asset Type	Update Description
22405	Conduit	Diameter updated from 7 ft to 6 ft.
4048	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from catchbasin to a manhole.
3993	Junction	Updated rim elevation.
4480	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from manhole to a catchbasin.
4677	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from catchbasin to a manhole.

Rim Elevation Updates from September 2012

Junction ID	Original Model Rim Elevation (ft)	Revised Rim Elevation (ft)
3849	392.61	390.60
3894	393.10	390.41
3914	393.50	390.46
3993	381.66	378.98
4003	370.14	368.00
5719	245.87	243.26
5999	292.00	293.00
6073	212.71	216.00
6795	230.20	228.00
7298	239.16	242.00
7407	256.00	258.06
8603	237.00	244.00
8616	242.00	244.00