Appendix A
Stormwater Capacity Analysis for Doctor's Branch Watershed, Arlington County, Virginia (Task 2)

Stormwater Capacity Analysis for Doctor's Branch Watershed, Arlington County, Virginia

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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 Doctor's Branch 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 (13 million cubic feet) than the 10yr-24hr SCS Type II storm (10 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 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

		HGL Flooding Ground Surface		HGL Within 1 Foot of Ground Surface		HGL Surcharging Pipe Crown		Capacity Limitations	
Scenario (with Storage)	Modeled System (Linear Feet)[a]	Linear Feet	Percent of Modeled System	Linear Feet	Percent of Modeled System	Linear Feet	Percent of Modeled System	Linear Feet	Percent of Modeled System
June 2006 storm event	30,496	2,549	8	4,703	15	7,826	26	15,078	49
10yr-24hr SCS Type II storm	30,496	8,235	27	7,374	24	9,005	30	24,614	81

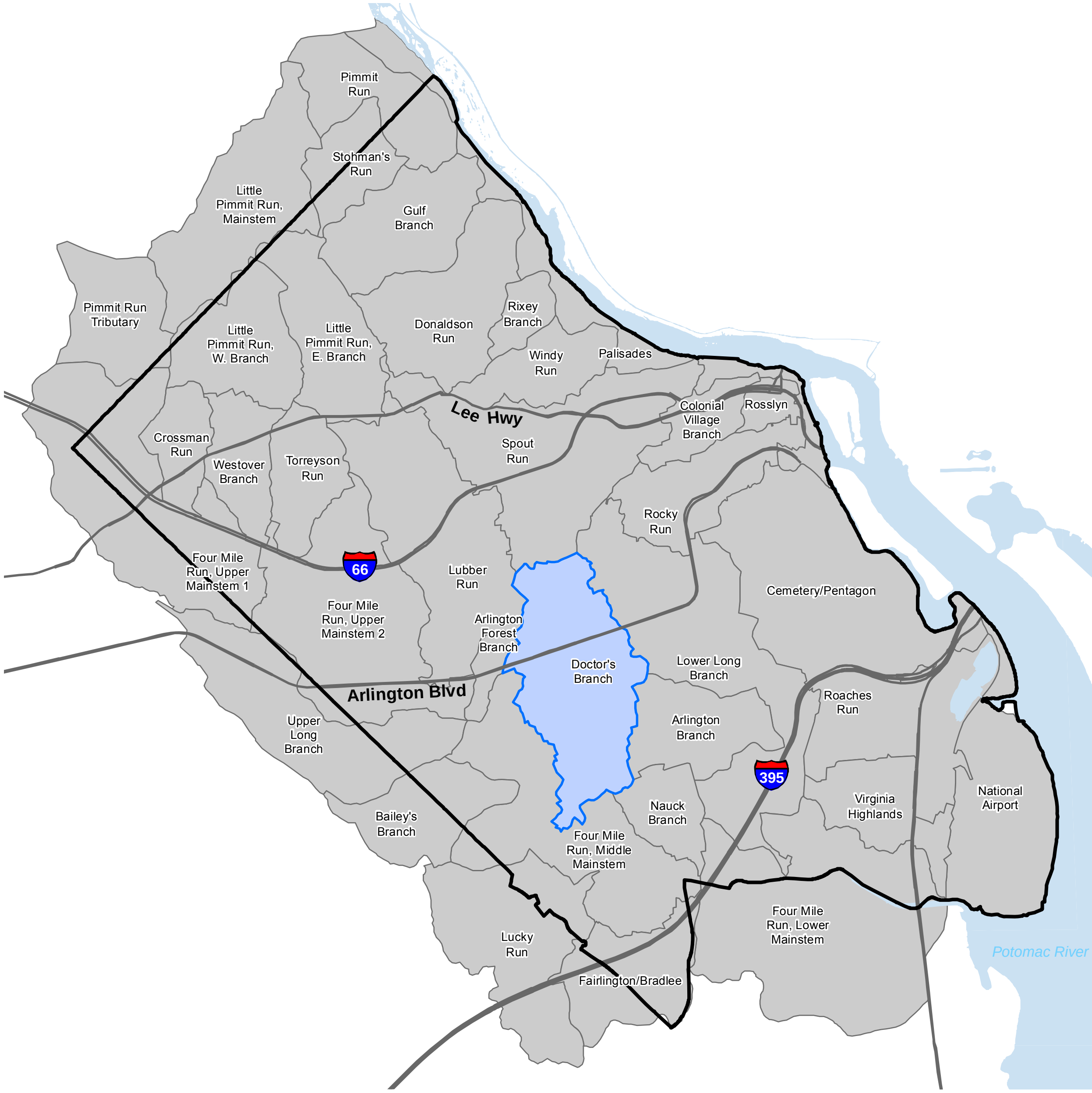
HGL, hydraulic grade line.
[a]The modeled system in this table includes the closed pipe network described in Table 2. It does not include natural stream channels.

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.

The purpose of this TM is to conduct a stormwater capacity analysis of the existing stormwater collection system for the Doctor's Branch 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.

FIGURE 1
Watersheds, Arlington County, Virginia (Doctor's Branch Highlighted)



2 Description of Existing Stormwater Collection System

2.1 Existing Versus Modeled Stormwater Collection System

The Doctor's Branch watershed is approximately 888 acres and is the eighth largest watershed in Arlington County. The zoning is predominantly residential; the remaining area consists of a mix of commercial, industrial, institutional, highways and parks.

In general, stormwater runoff is collected by storm sewers and flows south to Doctor's Branch east of George Mason Drive. The stormwater collection system has a number of parallel pipe systems. Doctor's Branch outlets to Four Mile Run south of Four Mile Run Drive.

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 Doctor's Branch 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 Doctor's Branch Stormwater System and Modeled System

Stormwater System Element	Existing	Modeled
Drainage area (acres)	888	886
Number of conveyance segments in stormwater system[a]	1,386	286
Total length of conveyance segments in stormwater system (linear feet)[b]	115,926	34,630
Size range (in.)[c]	4–96	15–96
Number of circular pipe segments	1,307	228
Number of noncircular pipe segments	37	37
Number of stream channel and ditch segments	42	21
Total length of stream channel segments (linear feet)	5,040	4,134
Number of other segments	0	0
Total length of other segments (linear feet)	0	0
Total inlets/junctions/end points (model nodes)	1,374	268
Catchbasins	642	43
Manholes	399	150
Yard inlets	47	5
Grate inlets	105	12
End walls	37	12
Junction chambers	42	34

TABLE 2 (CONTINUED)
Comparison of Existing Doctor's Branch Stormwater System and Modeled System

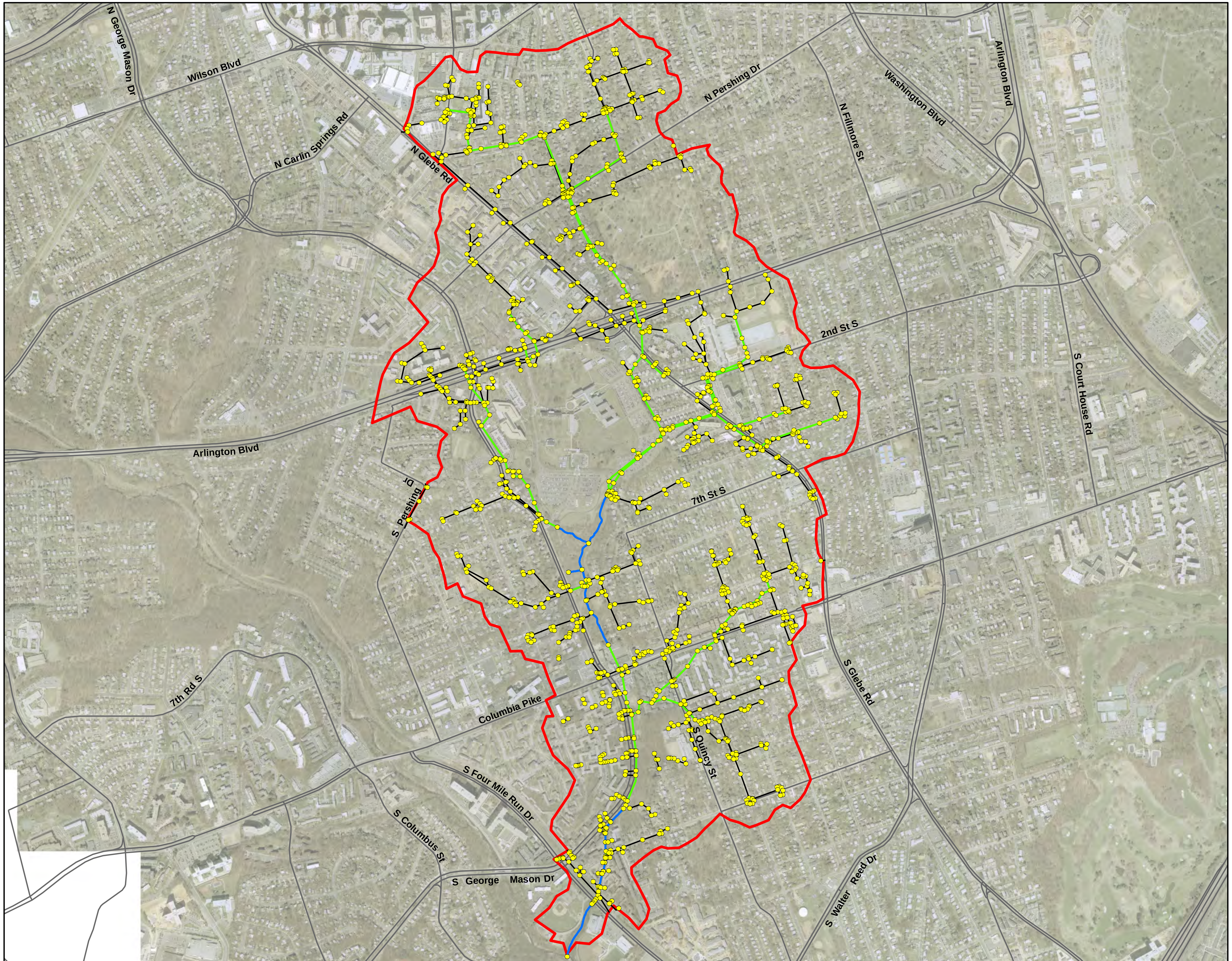
Stormwater System Element	Existing	Modeled
Detention outlets	34	0
Unknown types of nodes	68	12

[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 if they convey flows from pipes 36 inches in diameter and larger or if they are part of a multipipe system that has a combined effective diameter of 36 inches or larger. Further review of the as-built drawings shows that the parallel pipe system between nodes 11468 and 11906 was abandoned. Therefore, it was removed from the modeled pipe network.

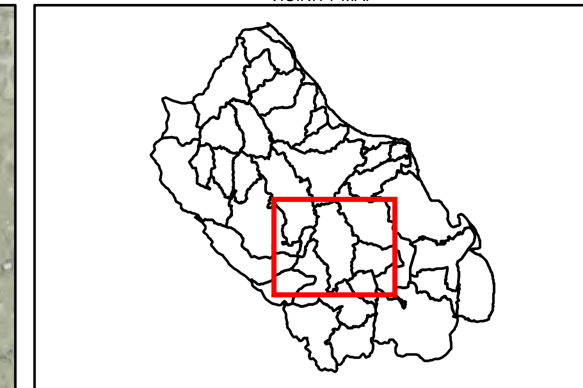
Observations

- Drainage area: The modeled drainage area is smaller than the existing drainage area received initially from the County. This is because of minor adjustments made to the watershed boundary during this project as discussed in Section 2.3.
- Detention outlet: The County defines a detention outlet as an element connected to a detention pipe or storage structure. 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 Doctor's Branch watershed, 34 detention outlets were identified in the ArcGIS PGDB (personal geodatabase), but none are included in the model because they are not connected to pipes that are integral to the model network.
- Unknown types of nodes: Some nodes are not characterized in the ArcGIS PGDB but have been included if they are integral to the model network.
- Parallel pipe systems: Unique features observed in the Doctor's Branch watershed included a system of parallel pipes connected with overflow links. In almost all cases, these connecting links or parts of circular networks had diameters smaller than 36 inches. Despite these links falling under the limit of 36 inches, they were selected for inclusion in the model because the parallel pipe system was effectively acting as a pipe with a diameter of at least 36 inches.
- National Foreign Affairs Training Center: As described in the data gaps TM (**Appendix A**), the National Foreign Affairs Training Center area was excluded from this study due to its sensitive nature. The runoff from this area is routed through a storage node (see Section 4.4) that represents a detention pond discharging to a modeled stream segment. Flow from the storm sewer segment at N. Trenton St. and Arlington Blvd. (node 13616) was connected to the County system northeast of S. Quincy St. and 6th St. S. (node 14607). Due to the sensitive nature of this area, the specifics of this part of the system will not be discussed in this or in future TMs.

Figure 2 shows the existing stormwater collection system in the Doctor's Branch watershed; **Figure 3** shows the modeled system.



VICINITY MAP



Legend

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

N

0 600 1,200
Feet

FIGURE 2
Existing Stormwater Collection System
Doctor's Branch Watershed
Arlington County Storm Capacity Analysis

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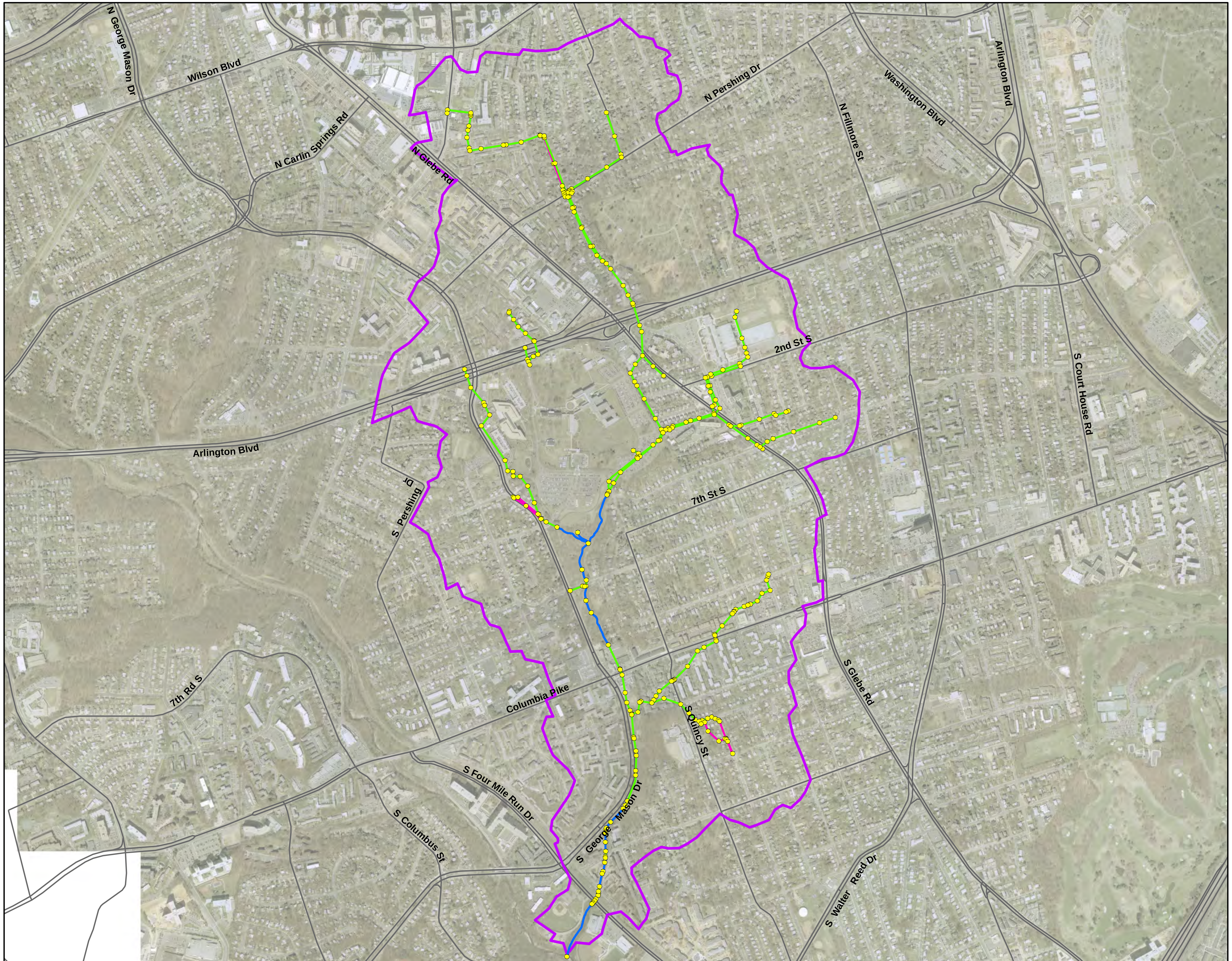
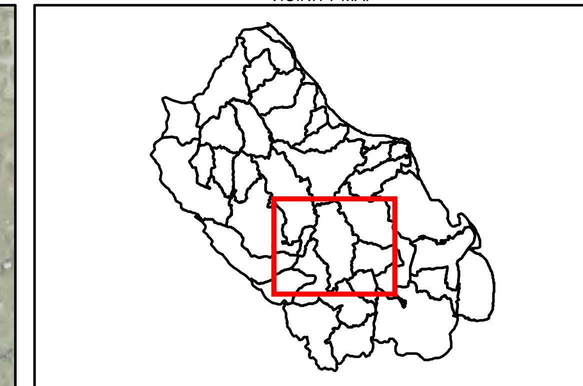


VICINITY MAP



Legend

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

N

0 600 1,200
Feet

FIGURE 3
Modeled Stormwater Collection System
Doctor's Branch Watershed
Arlington County Storm Capacity Analysis

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2.2 Data Sources

The storm drainage network data were 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 Doctor's Branch existing stormwater collection system.

Initial base layers (GIS shapefiles) were obtained from Arlington County in June 2010. CH2M HILL worked closely with the County to complete the storm sewer data gathering for the Doctor's Branch watershed. The final ArcGIS PGDB was delivered to CH2M HILL in June 2011. Further updates were made by the County to the PGDB in order to include the stormwater network at the Army National Guard Bureau and to make other adjustments. This updated PGDB was delivered in October 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 August 2011.

The final data for the Doctor's Branch watershed model were evaluated for quality. CH2M HILL found that 121 nodes and 150 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 November 2011. (See **Appendix A**.)

2.3 Watershed Boundary Anomalies

The Doctor's Branch 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 Doctor's Branch 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

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 Doctor's Branch 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 area 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]

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-

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

GeoHMS was used to compute the following hydrologic parameters: drainage areas, slope, longest flow path, and width.

3.4 Imperviousness

The percent imperviousness 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 886 acres.
- Doctor's Branch watershed is divided into 97 subwatersheds.
- 42.9 percent of the total drainage area is impervious (range across the subwatersheds of 7.0–89.6).
- Flows were introduced at 91 of 268 inlets (34 percent).
- Average basin area is 9.1 acres (range of 1–55).
- Average basin slope is 6.2 percent (range of 0.6–17.5).
- Average basin width is 626 feet (range of 232–1,561).

TABLE 3
Hydrologic Parameters

		Area				
Subwatershed	Inlet	Total (Acres)	Impervious (Acres)	Percent Impervious Area	Slope (%)	Width (ft)
W10010	12080	12	4.5	38.6	2.5	451
W10110	11706	8	4.1	48.4	2.7	628
W10130	12647	20	2.2	11.3	6.1	1000
W10170	12964	21	16.3	76.4	2.7	530
W10340	12089	1	0.5	42.2	4.5	256

TABLE 3 (CONTINUED)
Hydrologic Parameters

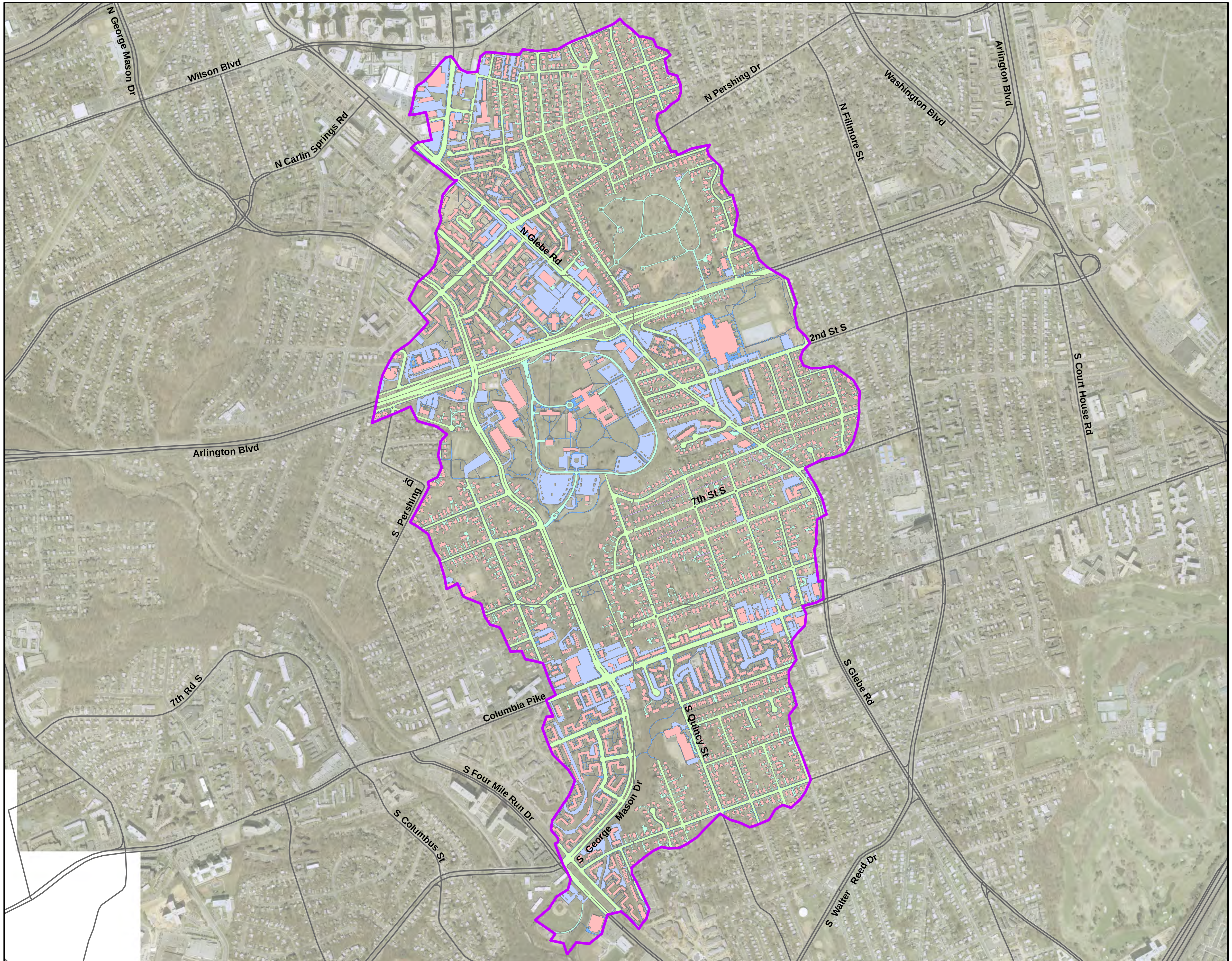
		Area				
Subwatershed	Inlet	Total (Acres)	Impervious (Acres)	Percent Impervious Area	Slope (%)	Width (ft)
W10370	11979	8	3.8	49.2	4	703
W10780	11465	12	4.5	38.3	2.7	728
W10800	11464	10	5.7	54.5	2.8	643
W10870	23816	8	6.5	77.1	1.4	737
W11030	11457	5	2.4	46.7	3	386
W11070	11554	2	1.4	59.5	3.4	244
W11110	11274	26	11.1	42.5	2.4	1561
W11120	23810	2	1.7	89.6	0.6	407
W11220	11578	8	4.7	60.7	2.6	549
W11280	11906	6	2	32.8	3.6	487
W11350	11650	6	2.2	37.3	2.7	692
W11360	11554	3	1.6	46.2	2.9	394
W11390	11595	2	1.5	62.7	1.8	331
W11450	12269	5	2.6	49.4	5.2	450
W11480	12462	3	0.6	17.4	6.9	439
W11481	12269	2	0.4	18	5.7	403
W11750	12547	3	1.2	44.2	8.3	343
W12140	12940	6	2	32.1	12.1	691
W12300	13022	25	13.3	52	3.5	1235
W12420	13750	14	7.6	53.7	4.6	612
W12530	13154	7	1.6	21.5	6	378
W12670	13600	8	3.2	38.7	4.2	467
W12740	13323	7	4.1	58.1	7.5	735
W12770	13026	26	6.5	25.2	4.9	1062
W12890	13497	5	3.3	64.9	6.4	428
W12920	13154	10	5.7	58	11	743
W13120	13394	16	7.6	47.7	3.5	712
W13190	13687	2	1.1	48.2	3.9	367
W13220	13642	12	3.5	30.5	2.1	728
W13270	13569	6	3.5	55.5	11.9	486
W13400	13818	3	1.2	45.5	1.8	410
W13470	13497	3	1.5	45.6	7	438
W13680	14202	6	4.9	78.2	3.1	676

TABLE 3 (CONTINUED)
Hydrologic Parameters

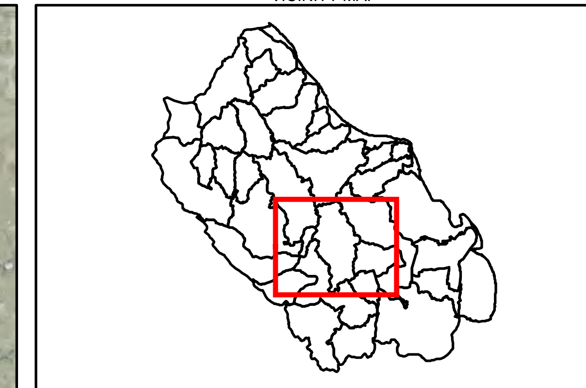
		Area				
Subwatershed	**Inlet**	**Total (Acres)**	**Impervious (Acres)**	**Percent Impervious Area**	**Slope (%)**	**Width (ft)**
W13720	24883	7	2.9	42.4	1.5	770
W13790	13940	2	1.1	49.4	7.5	462
W13880	24759	10	3.9	38.3	1.1	887
W13950	14099	23	12.9	56.8	4	910
W14000	14247	9	4.1	44.9	6	652
W14190	14320	8	4.4	58.6	2.8	670
W14330	14490	2	0.9	36.8	6.4	402
W14380	14717	4	1.8	43.8	10.5	432
W14410	24885	7	2.3	33.3	2.1	747
W14510	24888	3	1.1	41.7	2.3	394
W14600	14267	6	2.5	40.3	5.2	682
W14890	14587	12	6	48.4	3.1	769
W14910	90000	55	22.1	40	5.9	1306
W14980	24945	13	5.7	43.1	8.6	678
W15250	15031	28	9.1	32.4	5.7	1177
W15650	15308	8	2.6	33	6.7	721
W15651	15056	18	5.6	31.9	6.2	994
W15652	15058	3	1	32.4	6.5	468
W16060	15479	7	0.5	7	17.5	678
W16190	15803	14	5.2	36.2	3	887
W16220	15787	12	5.5	47.5	2.9	784
W16240	15921	15	4.4	28.9	8.9	837
W16430	15965	33	11.4	34.1	5.9	1125
W16650	16169	11	3.8	34.5	3.6	711
W16950	16264	4	1.9	51.2	5.5	860
W16951	23714	5	2.8	54.5	4.9	566
W17090	16050	11	3.6	32.5	10	674
W17160	16866	17	6.1	36.7	5.6	683
W17280	16475	3	0.5	15.1	11.8	442
W17330	16387	8	6.2	76.3	4.1	453
W17340	16159	11	4.8	42.1	8.4	742
W17560	16730	5	2.4	50.2	12.6	418
W17590	16441	7	3.9	56.3	4.6	435

TABLE 3 (CONTINUED)
Hydrologic Parameters

		Area				
Subwatershed	Inlet	Total (Acres)	Impervious (Acres)	Percent Impervious Area	Slope (%)	Width (ft)
W17620	16869	7	4.4	61.2	7	584
W17660	16723	9	7.5	79.7	9.8	759
W17890	17109	8	3.7	43.8	5.8	434
W18020	17109	2	1.1	56	9.5	272
W18070	17159	15	8.8	58.1	8.4	969
W18080	17054	2	0.6	27	11.2	455
W18110	17085	2	1.4	60.8	3.8	334
W18310	17184	8	3.7	48.2	6.7	489
W18340	17403	6	1.4	23.2	9.7	735
W18370	17259	2	0.5	21.7	10.7	254
W18380	17219	9	3	35.4	5.6	557
W18440	17412	1	0.3	23.4	8.6	232
W18580	17562	15	5.8	39.7	11	975
W18780	17535	22	8.6	38.5	4	1082
W18880	18036	10	3.5	34.8	14	1024
W18940	18080	6	1.6	26.2	12.7	447
W19090	18246	3	0.8	31.2	13.3	498
W19110	18411	3	1.6	47.5	17.2	432
W19120	18990	8	4.1	49.9	9.4	515
W19170	18641	9	3.6	41	11.3	528
W19220	18581	3	1.3	50.1	11.1	325
W19360	25018	4	2.3	58.9	6.9	526
W19380	18977	5	2.3	46	5.3	626
W19500	19064	9	1.8	20.3	5.6	1170
W23460	13785	1	0.7	69.3	6.1	236
W9900	11906	3	1.6	49.7	3.4	348



VICINITY MAP



Legend

- Alley
- Driveway
- Handicap Ramp
- Parking Lot
- Paved Median
- Road
- Sidewalk
- Building
- Roads
- Modeled (Revised) Watershed Boundary

FIGURE 4
Impervious Areas
Doctor's Branch Watershed
Arlington County Storm Capacity Analysis

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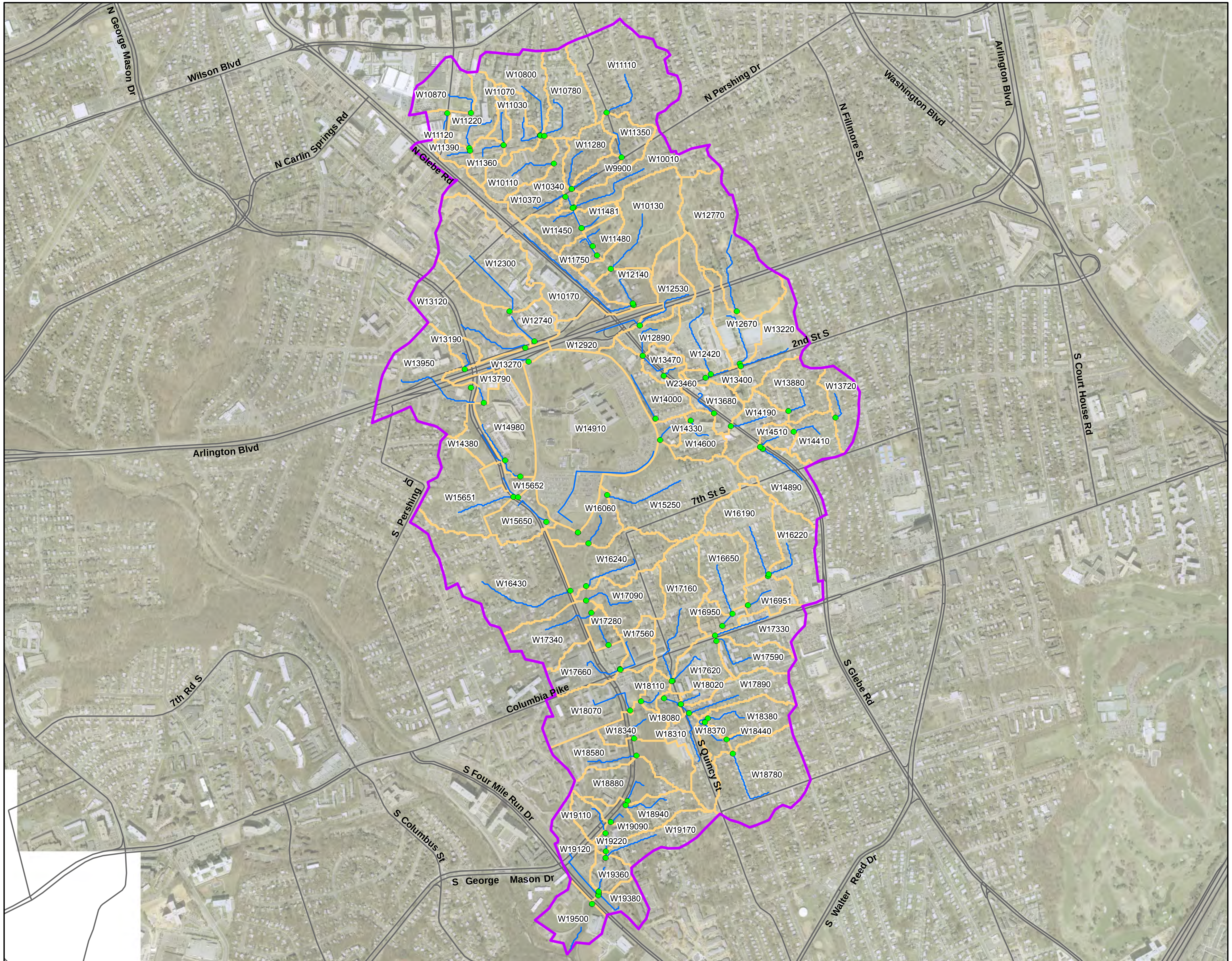
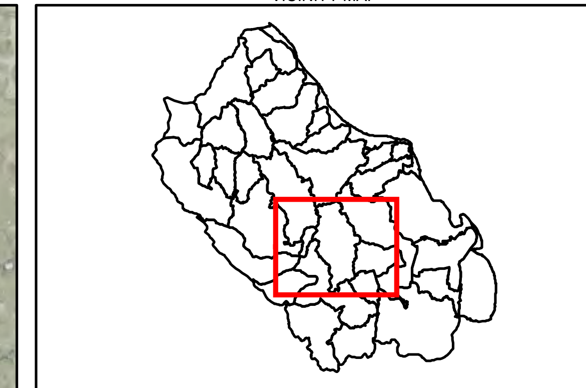


VICINITY MAP



Legend

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

FIGURE 5
Hydrologic Model Schematic
Doctor's Branch Watershed
Arlington County Storm Capacity Analysis

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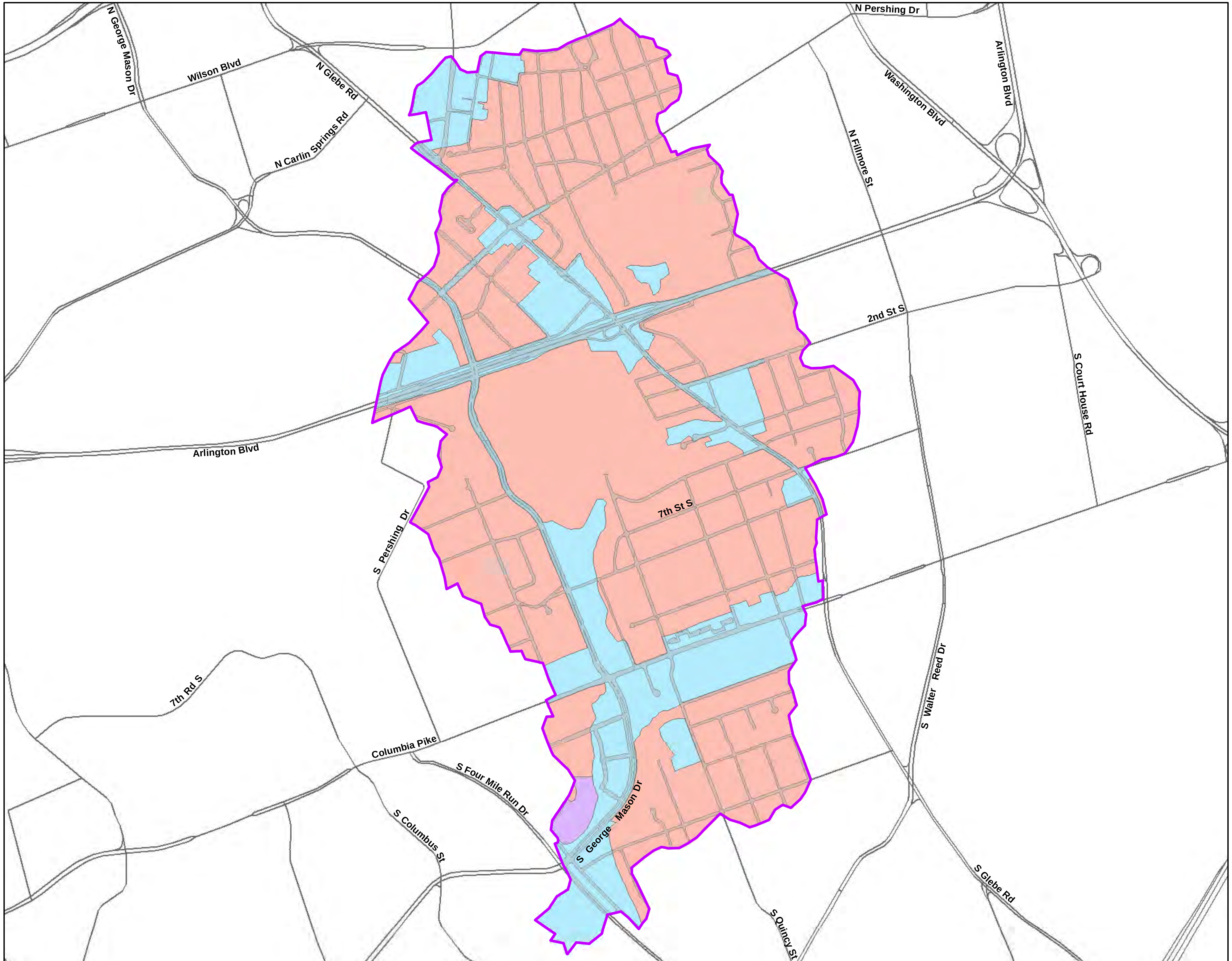
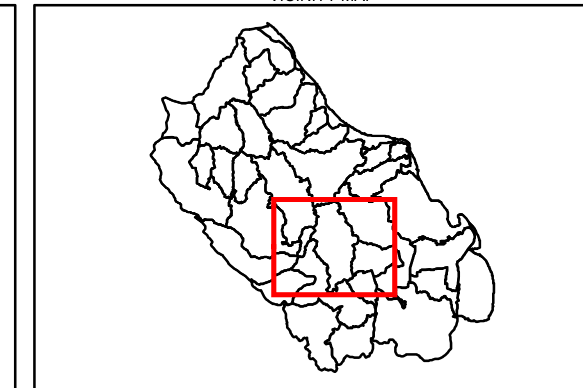
\\ORION\PROJ\ARLINGTONVACOUNTYOF\392309STORMWATERCAP\WSDOCTORSBRANCH\WORKINGGIS\LAYOUT\CAPACITYTM\FIGURE5_HYDROLOGIC_MODEL_SCHEMATIC.MXD FCAIN 4/20/2012 3:24:59 PM





Legend

Soil Type

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

N

0 600 1,200
Feet

FIGURE 6
Soil Map
Doctor's Branch Watershed
Arlington County Storm Capacity Analysis

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\\ORION\PROJ\ARLINGTONVACOUNTYOF\392309STORMWATERCAP\WSDOCTORSBRANCH\WORKINGGIS\LAYOUT\CAPACITYTM\FIGURE6_SOILS.MXD FCAIN 4/17/2012 8:57:55 PM

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 74 percent of the soil in Doctor's Branch is sandy loam, 25 percent is loam, and 1 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, 13	25	0.13	3.50	0.23
Sandy loam	4A-C, 9C, 11C, 15D	74	0.43	4.33	0.26
Silty loam	10D	1	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 Doctor's Branch 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

Description	Areas	
	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

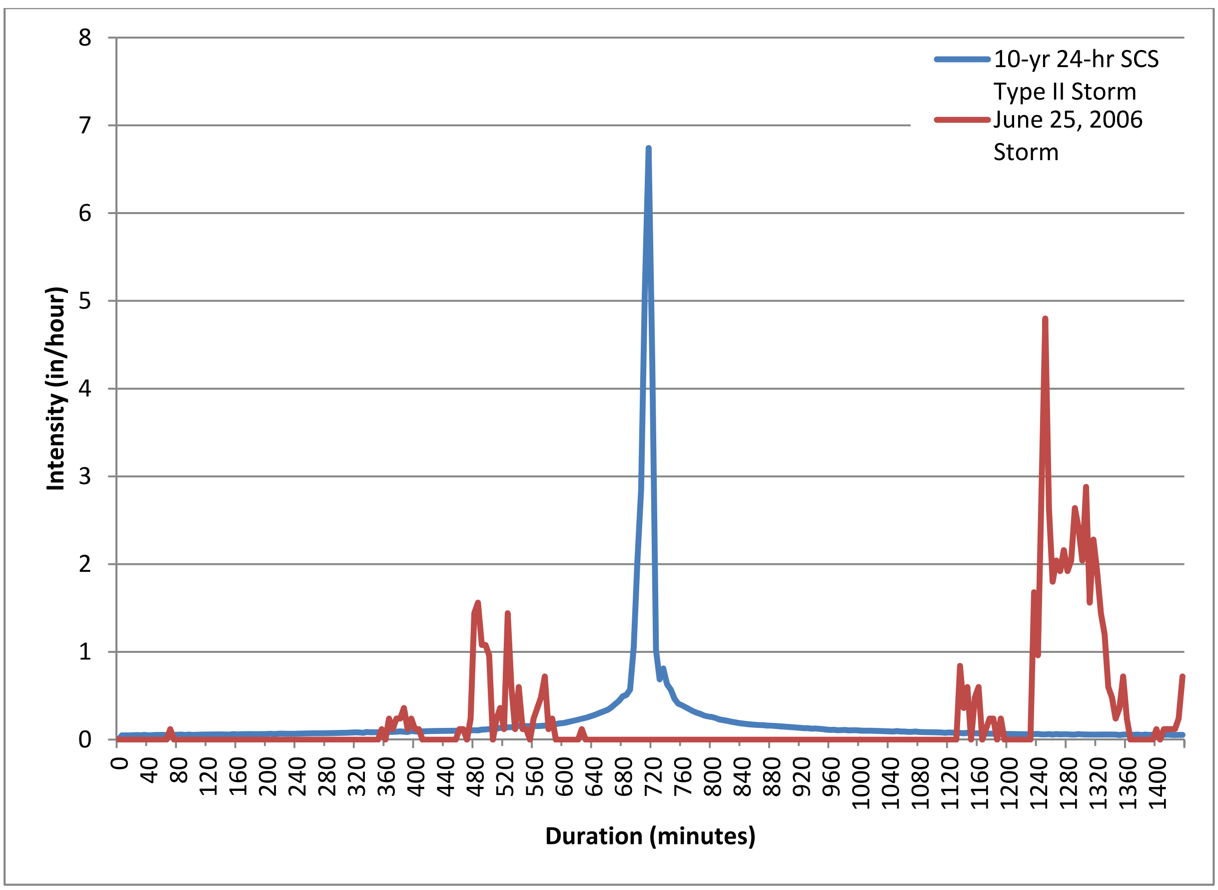
Choosing the correct rainfall distribution as well as frequency and duration are important factors in the development of the hydrologic model and the results of the hydraulic model. Arlington County decided to proceed with two storms of interest:

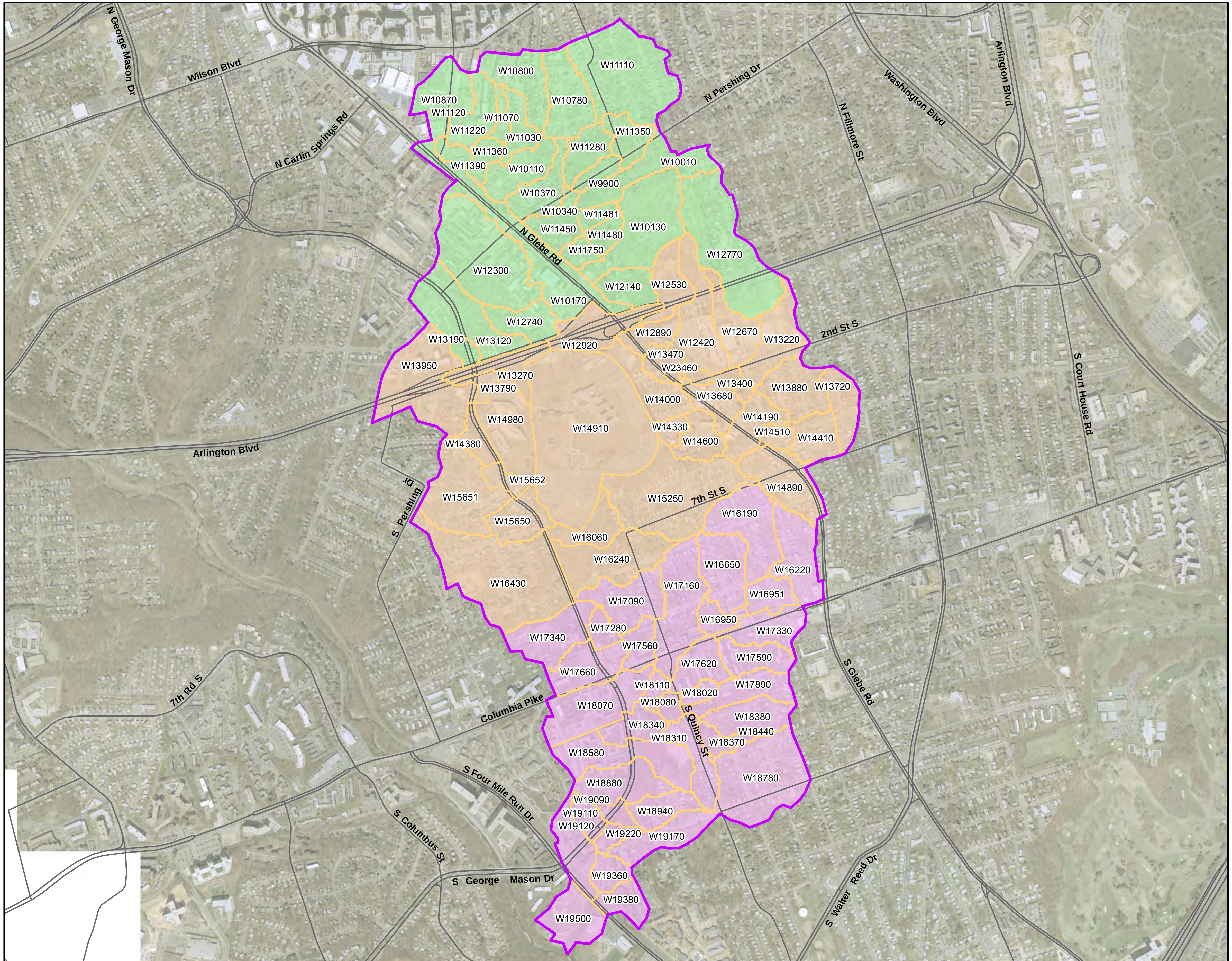
- June 2006 storm event based on the rain gauge data at the Donaldson Run lift station; total rainfall volume of 5.84 inches
- 10-year, 24-hour storm based on SCS Type II distribution: the 10yr-24 hr storm volume was obtained from VDOT "Hydraulic Advisory 05-04.3," January 2008; total volume of 4.84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





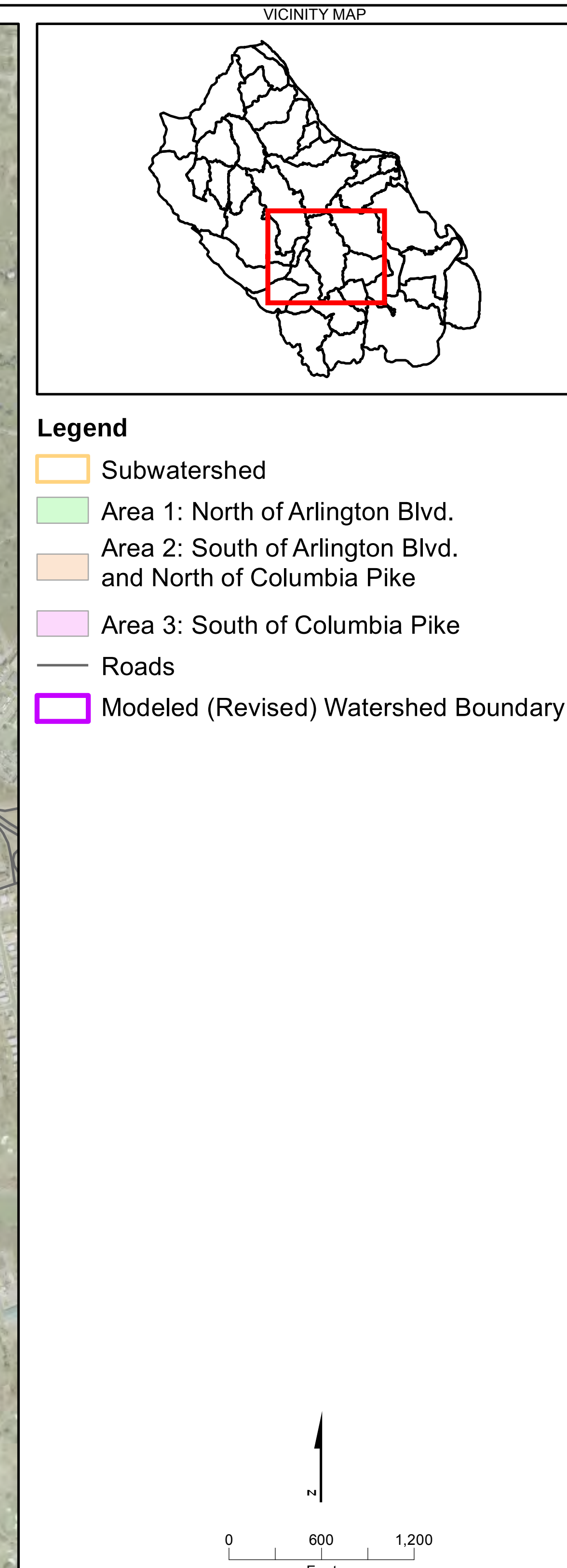


FIGURE 8
Subwatersheds
Doctor's Branch Watershed
Arlington County Storm Capacity Analysis

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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 97 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 Arlington Blvd.
- Area 2: south of Arlington Blvd. and north of Columbia Pike
- Area 3: south of Columbia Pike

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 Arlington Blvd.

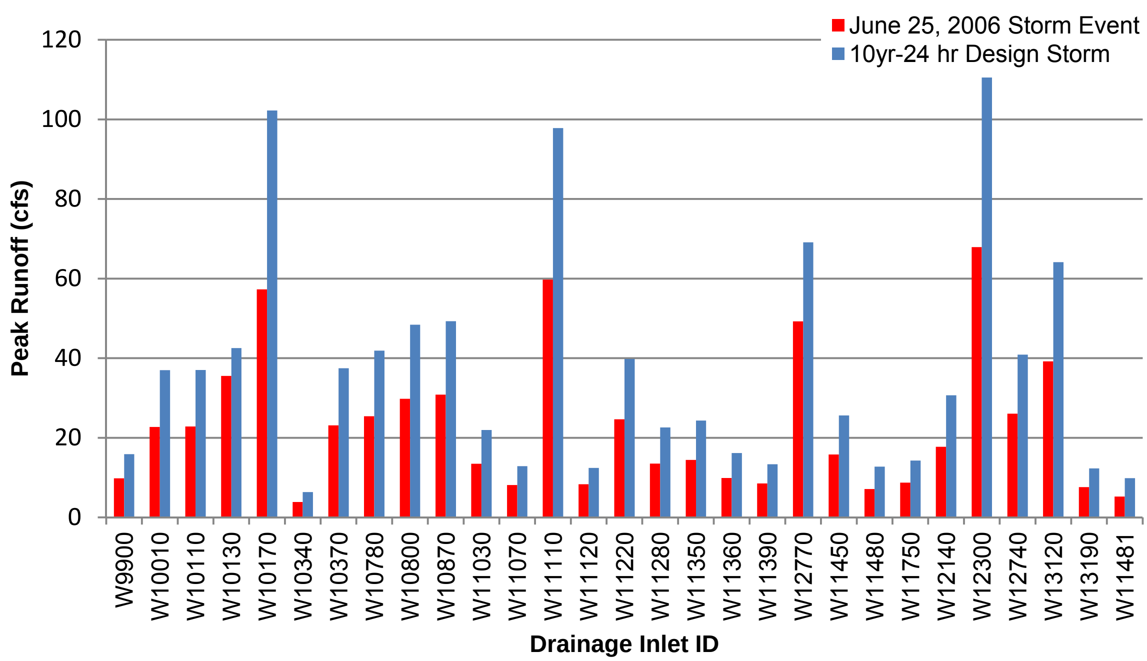


FIGURE 10
Peak Runoff—Area 2: South of Arlington Blvd and North of Columbia Pike

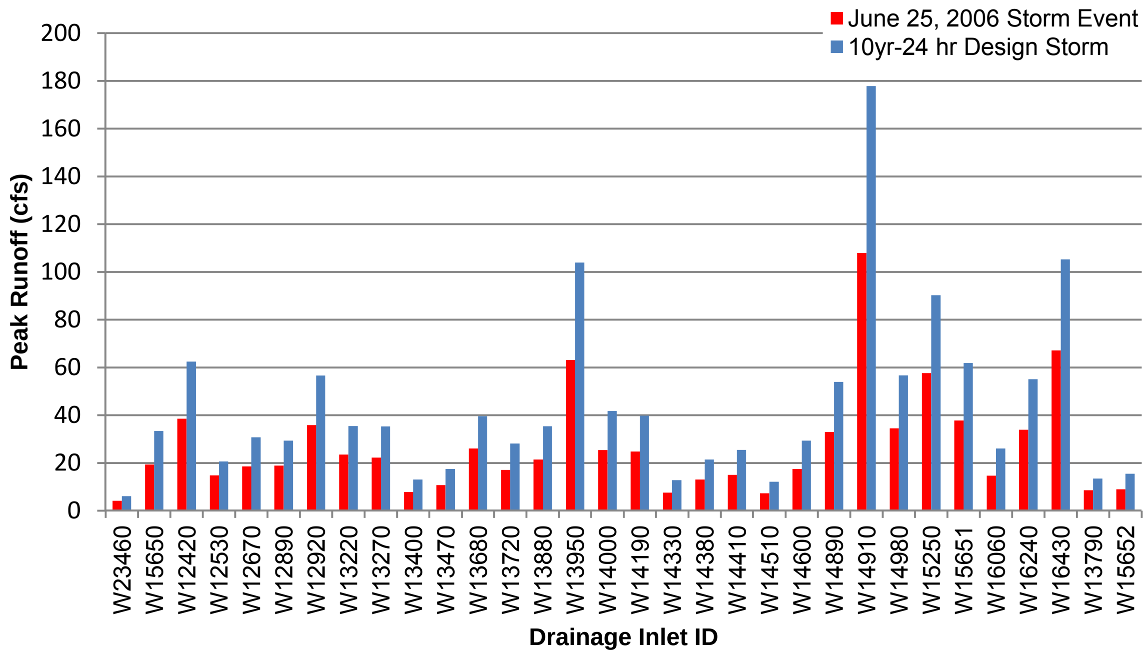
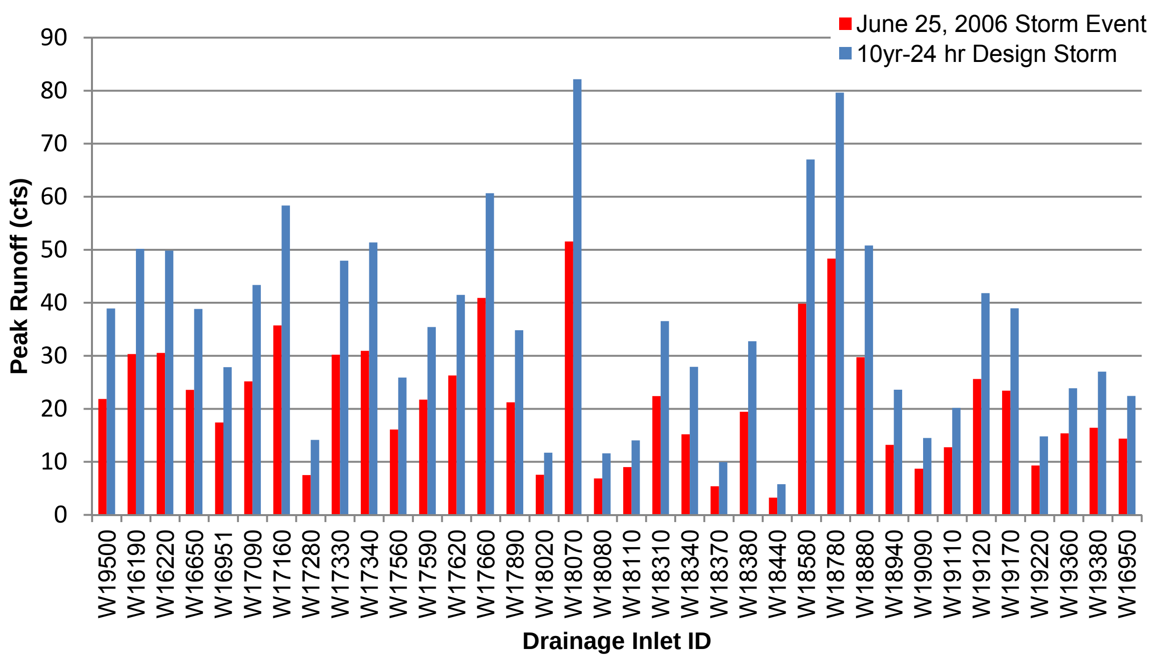


FIGURE 11
Peak Runoff—Area 3: South of Columbia Pike



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-24hr 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 (where available)

4.3 Stream Segments

County staff provided transects where available 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. The transects for two other stream segments were developed by CH2M HILL based on photographs provided by the County; this information was then incorporated into the model.

4.4 Detention Ponds

As described in Section 2.1, there is one detention pond in the Doctor's Branch watershed that receives runoff from the National Foreign Affairs Training Center. Runoff from the Center was routed through a storage node (see Section 4.7). The storage node volume was calculated on the basis of the area of the contours of the pond.

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. 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 outfall boundary condition of Four Mile Run was provided by the Northern Virginia Regional Commission, which provided a time series of depth results from the Four Mile Run watershed for the two selected storm events listed above and extracted the water depth at the confluence of Doctor's Branch with Four Mile Run. These depths were converted to water level by adding the invert elevation of the outfall for each point in the time series. These data will be delivered to the County with the final model delivery.

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 Doctor's Branch watershed model, 30 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 Doctor's Branch 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 Doctor's Branch watershed model results were compared to the anecdotal flooding reports for the June 2006 storm event provided by the County. Most of the anecdotal flooding complaints from the June 2006 storm event are in the vicinity of the flooding nodes reported by the Doctor's Branch watershed model, as shown in **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**
11274	8,069	NA	NA NA		8,069	667	6,063
13022	4,433	4,433	515	2,632	44,400	4,653	39,569
13394	563	560	68	528	44,700	3,006	42,416
13785	262	NA	NA NA		262	11	246
15056	2,879	NA	NA NA		2,879	218	2,572
15787	5,265	5,266	416	3,245	24,570	1,852	24,570
23810	560	772	45	693	1,158	71	1,036
24883	731	NA	NA NA		2,502	120	2,173
90000[a]	40,424	40,424	2,260	9,170	40,424	1,805	12,394

All values in cubic feet. NA, not applicable.
[a]Storage node 90000 represents the National Foreign Affairs Training Center pond.

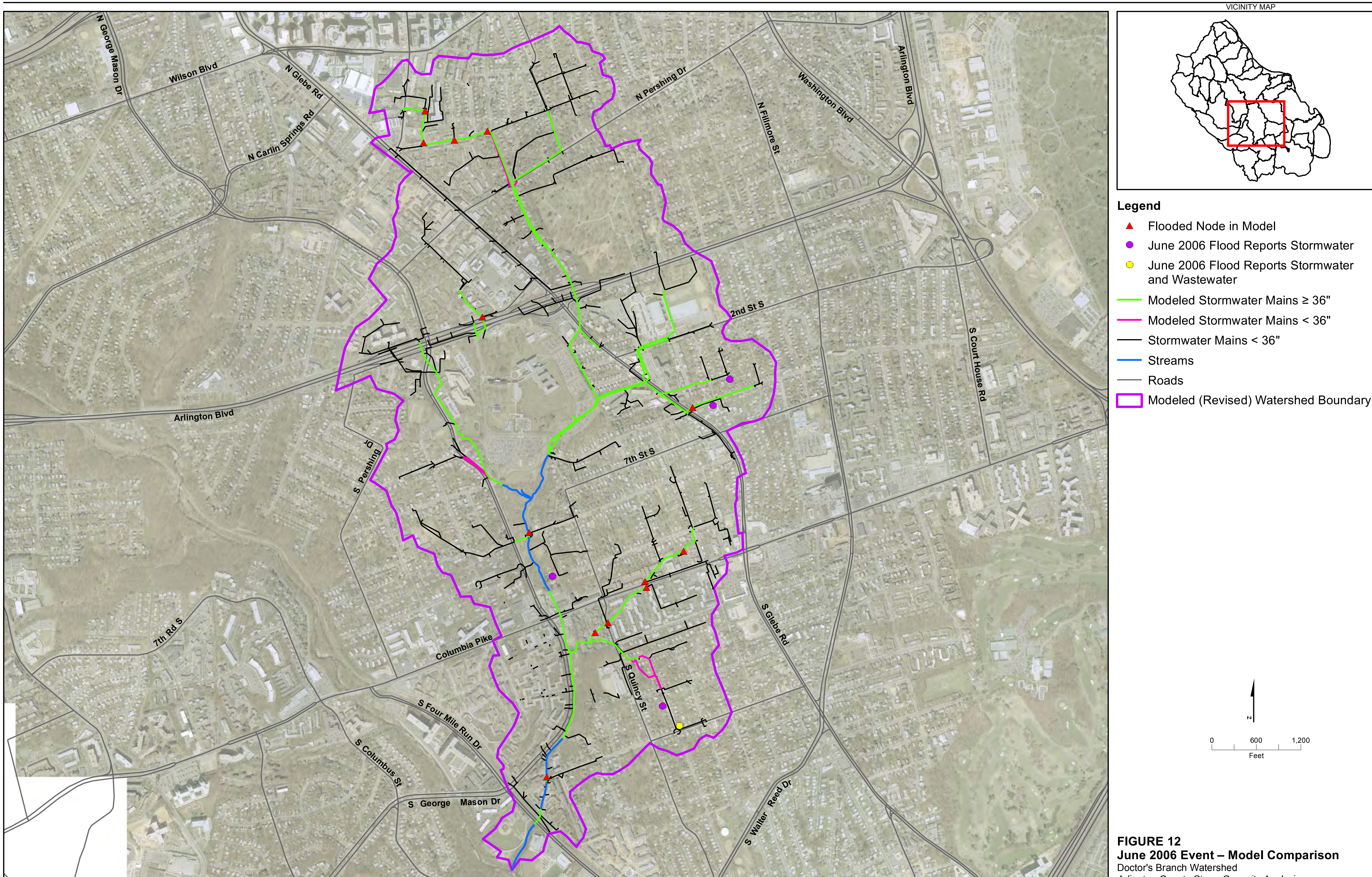


FIGURE 12
June 2006 Event – Model Comparison
Doctor's Branch Watershed
Arlington County Storm Capacity Analysis

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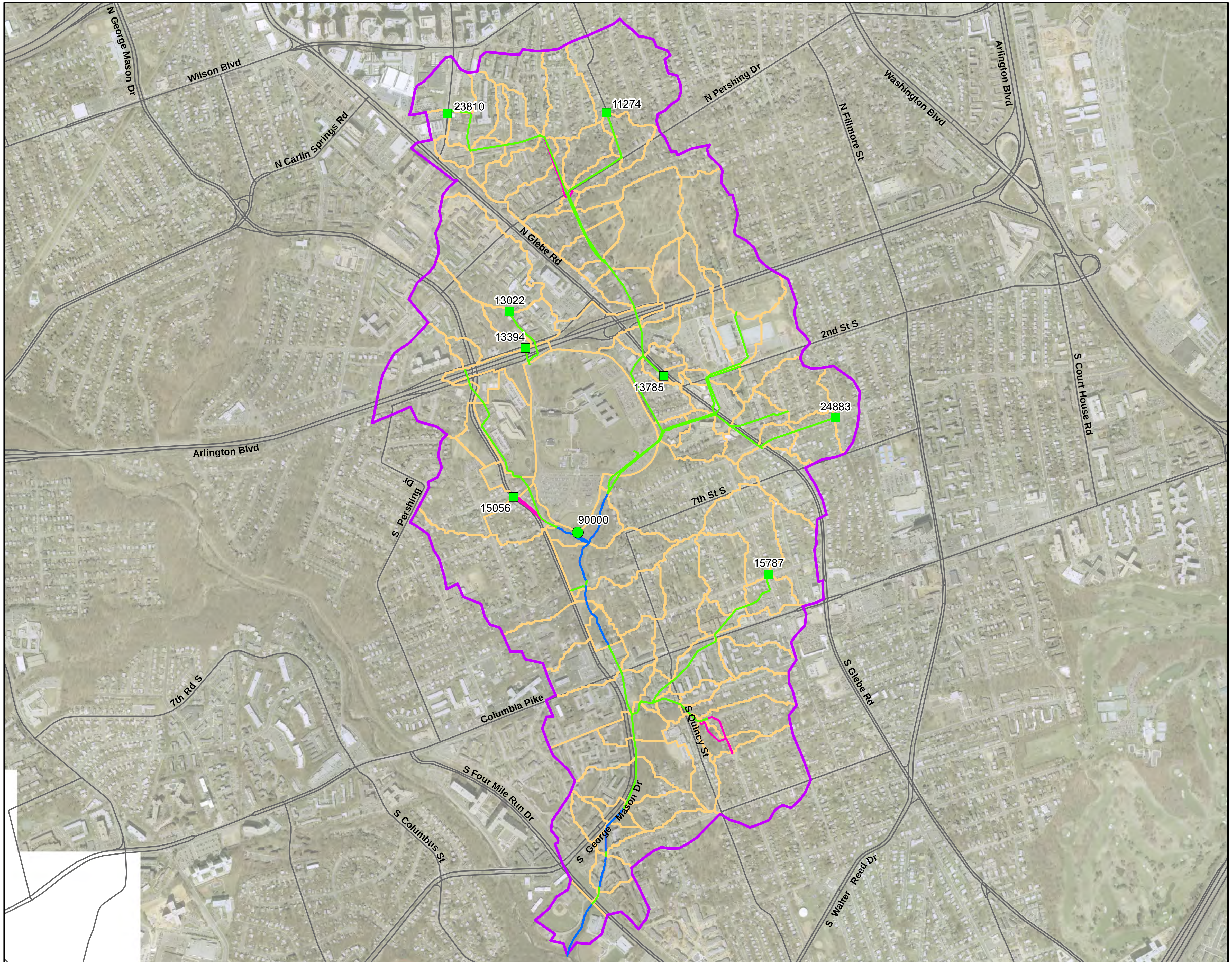

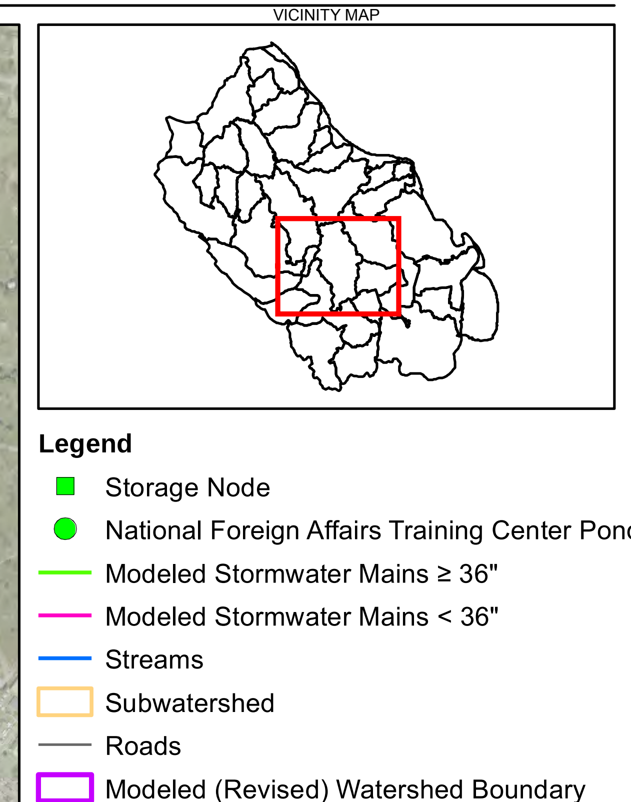

FIGURE 13
Storage Nodes
Doctor's Branch Watershed
Arlington County Storm Capacity Analysis

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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 49 percent of the Doctor's Branch stormwater collection system is experiencing capacity limitations during the June 2006 event and 81 percent is experiencing capacity limitations during the 10yr-24hr SCS Type II storm.

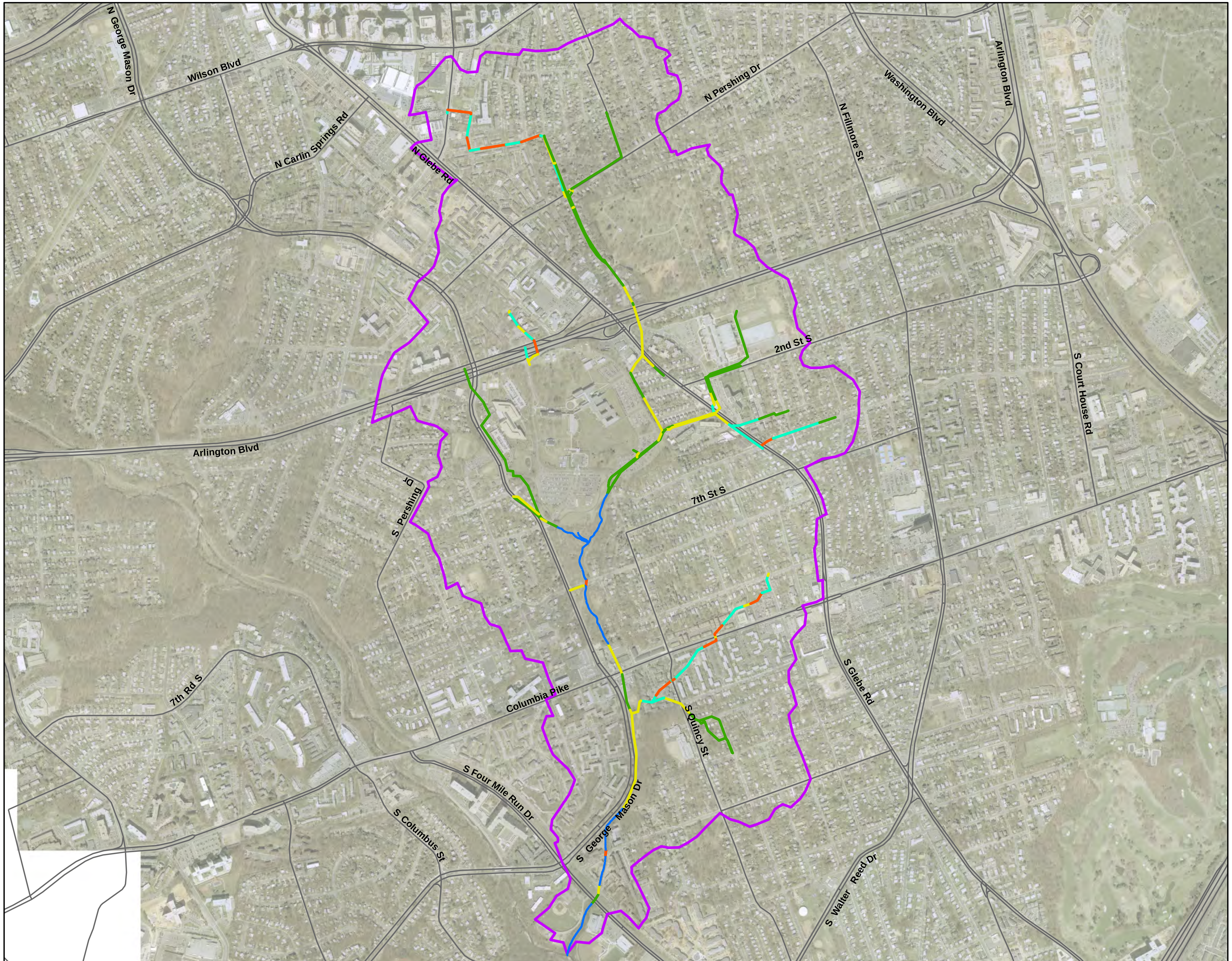
The details on the pipes with flooding, insufficient freeboard, and surcharged conditions are summarized in **Tables 11** and **12. Tables 13** and **14** provide details on the stream segments.

As discussed previously, cross-section information was provided as input to the model. In almost all cases, flows from both storms stayed within the cross sections 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. However, in two cases, nodes connected to streams were flooded and flow was lost from the system. These two nodes were connected to the stream on the upstream end and a culvert on the downstream end. The culverts are restricting the flow in the model, and the details of that specific culvert flooding are shown in **Tables 11** and **12**. A plan view of the watershed depicting the inlets, manholes and other point structures experiencing these conditions is provided in **Figures 14** and **15**.

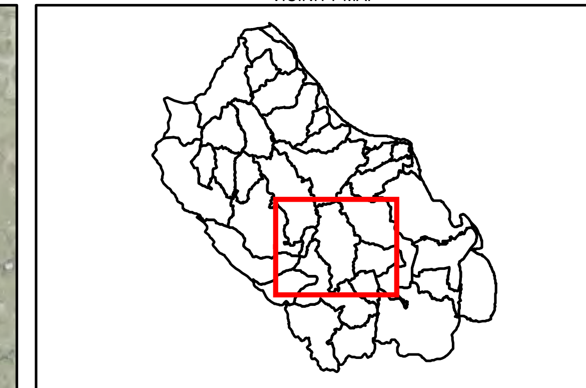
TABLE 10
Summary of Conveyance Capacity Limitations

		HGL Flooding Ground Surface		HGL Within 1 Foot of Ground Surface		HGL Surcharging Pipe Crown		Capacity Limitations	
Scenario (with Storage)	**Modeled System (Linear Feet)[a]**	**Linear Feet**	**Percent of Modeled System**	**Linear Feet**	**Percent of Modeled System**	**Linear Feet**	**Percent of Modeled System**	**Linear Feet**	**Percent of Modeled System**
June 2006 storm event	30,496	2,549	8	4,703	15	7,826	26	15,078	49
10yr-24hr SCS Type II storm	30,496	8,235	27	7,374	24	9,005	30	24,614	81

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.



VICINITY MAP



Legend

- Flooded
- Insufficient Freeboard
- Surcharged
- Sufficient Conveyance Capacity
- Streams
- Roads
- Modeled (Revised) Watershed Boundary

N

0 600 1,200
Feet

FIGURE 14
Conveyance Capacity - June 2006 Storm
Doctor's Branch Watershed
Arlington County Storm Capacity Analysis

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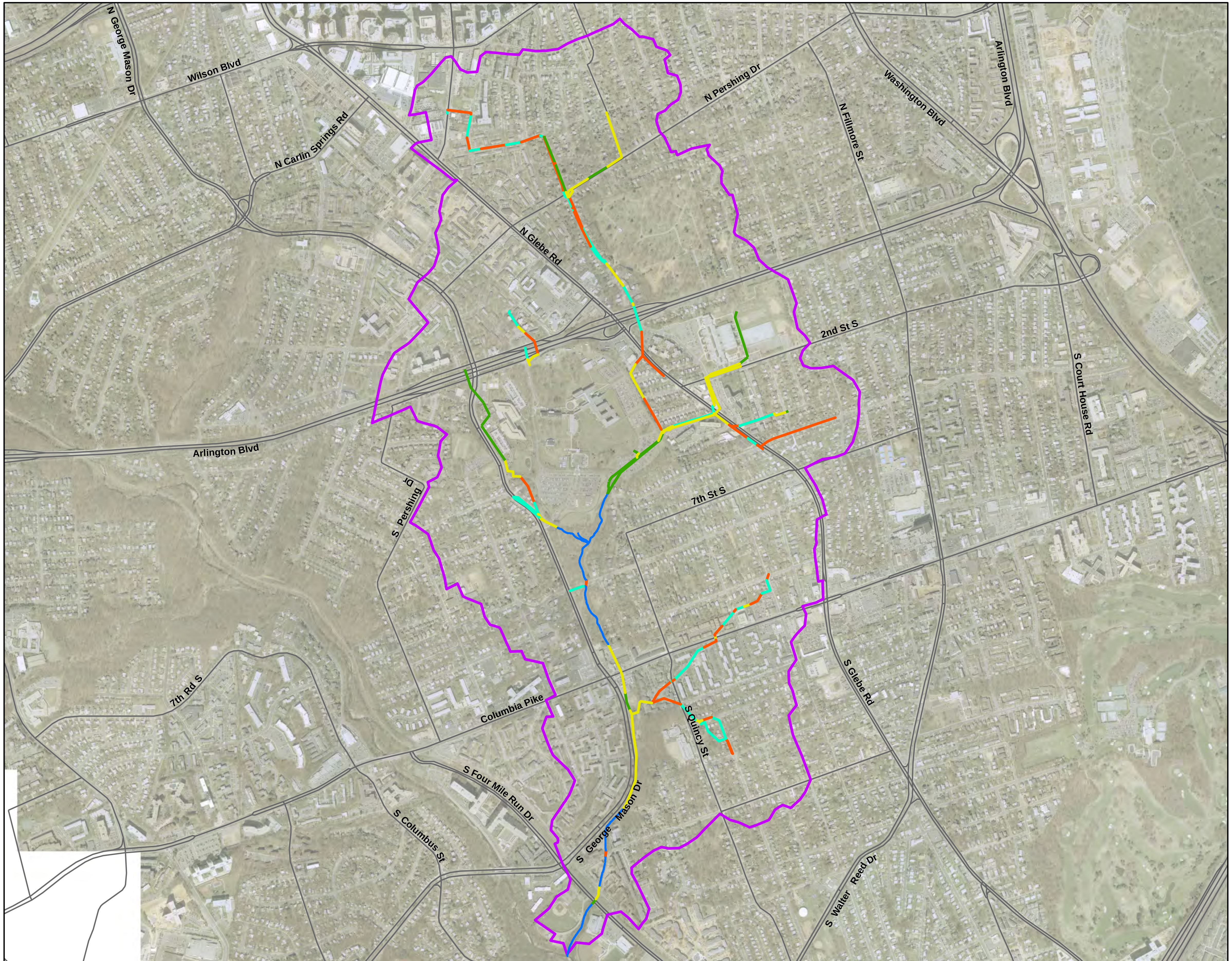
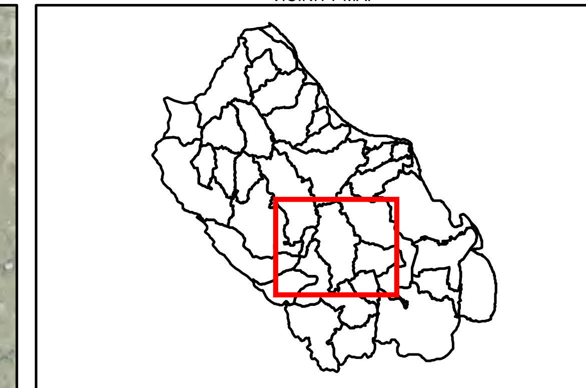


VICINITY MAP



Legend

- Flooded
- Insufficient Freeboard
- Surcharged
- Sufficient Conveyance Capcity
- Streams
- Roads
- Modeled (Revised) Watershed Boundary

N

0 600 1,200
Feet

FIGURE 15
Conveyance Capacity - 10-yr 24-hr Storm
Doctor's Branch 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	
10443	11278	11299	21	3	33.2	6.6	6.6	6.6	0.6	0	N	N	RIM	0.17	Y	Y	Ins. freeboard
10445	11413	11480	90	3	30.8	7.0	9	9.6	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
10446	11480	11578	134	3	30.8	5.4	9.6	30.6	0.6	6.6	N	2,033	RIM	Y	Y Y		Flooding
10447	11578	11595	29	3	47.1	6.7	30.6	40.2	6.6	0	2,033	N	Y	0.13	Y	Y	Flooding
10460	11519	11457	241	3	66.1	9.4	81.6	91.2	0.6	82.8	N	107,800	RIM	Y	Y Y		Flooding
10461	11457	11464	9	3	46.6	6.6	91.2	89.4	82.8	0	107,800	N	Y	0.67	Y	Y	Flooding
10462	11464	11471	44	3	64.9	9.8	89.4	0	0	0	N	N	0.67	N	Y	0.85	Ins. freeboard
10463	11471	11706	345	2.25	24.2	7.6	0	3	0	0	N	N N N N				5.42	Surcharge
10464	11706	11881	292	2.5	36.4	7.4	3	88.8	0	0	N	N N		0.96	5.27	Y	Ins. freeboard
10465	11881	11915	53	2.5	36.4	7.4	88.8	88.2	0	0	N	N	0.96	N	Y	3.34	Ins. freeboard
10485	11920	11929	13	4	67.9	5.4	0.6	0	0	0	N	N N N			0.01	N	Surcharge
10503	11706	11701	138	1.25	10.5	9.1	3	0 0 0			N	N	N	N	1.07	N	Surcharge
10598	11969	11979	19	2.5	36.6	7.5	87	83.4	0	0	N	N N N			2.61	2.01	Surcharge
10599	11979	11984	34	2.5	59.3	12.5	83.4	0	0	0	N	N N N			2.23	N	Surcharge
10637	13022	13035	156	3	63.6	9.6	3	0 0 0			N	N	N	N	0.3	N	Surcharge
10638	13094	13169	103	3	62.5	10.1	0.6	6.6	0	0	N	N	0.92	N	Y	1.47	Ins. freeboard
10639	13169	13240	1,221	3	62.5	10.2	6.6	10.8	0	0	N	N N N			1.47	1	Surcharge
10640	13240	13317	132	3.5	62.6	7.3	10.8	85.2	0	0.6	N	N N		RIM	0.54	Y	Ins. freeboard
10641	13317	13323	13	3	62.6	10.7	85.2	85.8	0.6	82.8	N	123,000	RIM	Y	Y Y		Flooding
10642	13323	13487	164	3	46.5	9.3	85.8	91.2	82.8	0	123,000	N	Y N Y			11.26	Flooding
10660	12756	12846	1,314	6	301.3	11.1	0	6	0	0	N	N N N N				0.24	Surcharge
10670	13227	13497	292	7	400.9	10.4	5.4	45	0	0	N	N N N			0.93	1.72	Surcharge
10727	13540	13569	30	3	39.3	5.6	92.4	94.8	0	0	N	N N N			12.65	13.28	Surcharge
10732	14053	14247	273	7	420.1	13.0	0	72	0	0	N	N N N N				2.27	Surcharge
10733	14247	14357	151	8	439.0	8.7	72	79.2	0	0	N	N N N			2.27	1.86	Surcharge
10734	14357	14377	25	8	439.0	8.7	79.2	0	0	0	N	N N N			1.86	0.84	Surcharge
10736	14202	14243	1,897	4.5	128.5	8.1	72.6	47.4	0	0	N	N N N			3.3	1.83	Surcharge
10737	14279	14318	165	4.5	142.2	9.2	51	0	0	0	N	N N N			1.22	N	Surcharge
10760	14152	14212	103	5	106.8	7.6	1.8	7.2	0	0	N	N N N			0.17	0.63	Surcharge
10761	14212	14338	535	5	106.7	5.4	7.2	54	0	0	N	N N N			0.86	1.41	Surcharge
10762	14338	14362	412	5	106.7	5.4	54	59.4	0	0	N	N N N			1.41	1.27	Surcharge
10763	14362	14364	50	5	106.7	5.4	59.4	0	0	0	N	N N N			1.27	1	Surcharge
10778	14128	14138	27	3	19.9	3.8	42.6	45	0	0.6	N	N N		RIM	4.65	Y	Ins. freeboard
10779	14138	14202	90	3	19.9	3.4	45	72.6	0.6	0	N	N	RIM	N	Y	3.25	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	
10780	14463	14320	255	3	59.2	9.4	41.4	46.2	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
10786	14313	14320	108	3.5	22.6	4.3	41.4	46.2	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
10787	14308	14313	22	3.5	22.6	4.4	38.4	41.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
10791	14243	14267	107	4.5	128.5	8.1	47.4	43.2	0	0	N	N N N			1.83	1.37	Surcharge
10792	14267	14279	62	4.5	142.2	8.9	43.2	51	0	0	N	N N N			1.37	1.22	Surcharge
11639	15056	15058	54	2.25	30.9	8.3	0	0 0 0			N	N	N	N	0.6	N	Surcharge
11640	15058	15229	3,189	2.25	38.7	10.4	0	50.4	0	0	N	N N N N				0.32	Surcharge
11641	15229	15236	16	2.25	38.7	9.9	50.4	0	0	0	N	N N N			0.46	N	Surcharge
11663	14377	14499	125	8	565.6	11.7	0	0 0 0			N	N	N	N	1.32	N	Surcharge
11665	14644	14677	52	4	82.22	6.7	0	0 0 0			N	N	N	N	0.19	0.97	Surcharge
11695	14540	14463	137	3.5	62.2	7.7	40.8	41.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
11716	15965	15922	160	3	67.06	11.3	0	40.8	0	0	N	N N N N				0.88	Surcharge
11717	15922	15928	24	3	67.06	9.8	40.8	0	0	0	N	N N N			1.58	N	Surcharge
11743	15276	15308	72	1.75	6.78	4.2	0	0	0	0	N	N N N N				0.41	Surcharge
11772	15803	15860	53	3	53.7	7.7	11.4	10.8	0	0	N	N N		0.48	1.71	Y	Ins. freeboard
11773	15860	15963	129	3	53.2	8.2	10.8	12	0	0.6	N	N	0.48	RIM	Y	Y	Ins. freeboard
11778	15787	15803	26	3	29.29	5.2	6.6	11.4	0	0	N	N N N			0.6	1.51	Surcharge
11852	16855	16861	12	4	134.4	10.7	83.4	85.8	0	46.8	N	45,730	N	Y	7.95	Y	Flooding
11853	16861	16866	14	4	114.3	9.1	85.8	85.2	46.8	0	45,730	N	Y	0.22	Y	Y	Flooding
11854	16866	16869	16	4	138.8	11.1	85.2	84	0	0	N	N	0.22	0.85	Y	Y	Ins. freeboard
11872	15999	16057	110	3	53.3	8.2	13.8	36.6	0.6	3	N	218	RIM	Y	Y Y		Flooding
11873	15963	15999	105	3	53.2	8.4	12	13.8	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
11940	17184	17109	1,499	3	94.7	13.5	0	0 0 0			N	N	N	N	2.64	N	Surcharge
13511	18036	18080	555	6	1,395.6	11.6	90.6	91.8	0	0	N	N N N			2.25	1.95	Surcharge
13512	18080	18120	49	6	1,407.3	11.7	91.8	0	0	0	N	N N N			1.95	0.14	Surcharge
13551	17717	17761	55	6	1,374.8	13.0	41.4	39	0	0	N	N N N			1.23	1	Surcharge
13643a	18581	18628	65	6	448.6	16.1	39	0	33.6	0	71,130	N	Y N Y N				Flooding
13643b	18581	18628	66	6	437.5	15.7	39	0	33.6	0	71,130	N	Y N Y N				Flooding
13643c	18581	18628	68	6	482.0	18.5	39	0	33.6	0	71,130	N	Y N Y N				Flooding
17426	11554	11549	31	3	66.1	10.2	36	37.2	3	0.6	343	N	Y	RIM	Y	Y	Flooding
17427	11549	11519	189	3	66.1	9.9	37.2	81.6	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
17431	11471	11479	14	2	40.8	13.0	0	0 0 0			N	N	N	N	3.28	N	Surcharge
17440	11906	11920	33	4	67.9	5.5	0	0.6	0	0	N	N N N N				0.01	Surcharge
17441	11906	11931	35	1.5	9.3	5.3	0	0	0	0	N	N N N			1.07	0.73	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	
17442	11906	11931	34	1.75	13.1	5.5	0	0 0 0			N	N	N	N	1.07	N	Surcharge
17508	11951	11969	25	2.5	36.5	7.4	86.4	87	0	0	N	N N N			2.89	2.56	Surcharge
17510	11915	11951	408	2.5	36.4	7.4	88.2	86.4	0	0	N	N N N			3.34	2.69	Surcharge
17582	13394	13540	142	3	39.3	7.7	90	92.4	0	0	N	N	0.86	N	Y	12.65	Ins. freeboard
17614	12846	12940	113	6	301.3	11.4	6	0 0 0			N	N	N	N	0.24	N	Surcharge
17617	12964	13154	258	7	368.9	13.5	0	6.6	0	0	N	N N N N				1.1	Surcharge
17654	13569	13616	415	3	83.4	11.8	94.8	95.4	0	0	N	N N N			13.28	11.53	Surcharge
17670	13497	13608	1,347	7	420.4	10.9	45	6	0	0	N	N N N			1.72	0.31	Surcharge
17671	13621	13497	1,797	3	7.91	1.1	0	45	0	0	N	N N N			1.3	5.72	Surcharge
17672	13608	13742	124	7	420.78	11.0	6	0 0 0			N	N	N	N	0.31	N	Surcharge
17772b	15861	15921	70	6	403.4	14.6	72.6	0	66.6	0	457,300	N	Y N Y N				Flooding
17772a	15861	15921	69	6	458.3	17.0	72.6	0	66.6	0	457,300	N	Y N Y N				Flooding
17814	16723	16730	11	6	1,028.5	14.3	88.8	82.2	0	0	N	N N N			1.77	0.78	Surcharge
17815	16730	16818	67	6	1,039.6	14.7	82.2	0	0	0	N	N N N			0.84	N	Surcharge
17816	16475	16723	324	6	1,006.4	14.0	0	88.8	0	0	N	N N N			3.77	1.77	Surcharge
17847	16110	16130	110	3	65.8	14.6	7.2	41.4	0	0	N	N N		0.64	3.66	Y	Ins. freeboard
17848	16130	16150	33	3	65.8	9.3	41.4	43.2	0	0	N	N	0.64	0.11	Y	Y	Ins. freeboard
17854	16057	16108	94	3	53.3	7.5	36.6	67.8	3	0	218	N	Y N Y			4.59	Flooding
17855	16441	16493	164	3.5	134.3	14.9	25.8	43.8	3.6	0	1,109	N	Y N Y			9.49	Flooding
17856	16493	16535	93	3.5	134.4	16.7	43.8	49.2	0	0.6	N	N N		RIM	9.49	Y	Ins. freeboard
17857	16535	16698	223	3.5	134.3	16.0	49.2	80.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
17859	16387	16430	54	4	120.5	8.0	40.8	24	0	0	N	N N N			6.02	5.01	Surcharge
17860	16430	16441	18	4	120.6	8.8	24	25.8	0	3.6	N	1,109	N	Y	5.34	Y	Flooding
17866	16169	16264	194	3.5	86.5	9.0	45.6	64.2	0	0	N	N	0.72	N	Y	8.17	Ins. freeboard
17868	16264	16378	138	3.5	99.4	10.3	64.2	81.6	0	3	N	809	N	Y	8.17	Y	Flooding
17869	16378	16387	10	4	94.7	5.9	81.6	40.8	3	0	809	N	Y N Y			6.02	Flooding
17911	17159	17190	50	6	1,073.9	16.0	0	0	0	0	N	N N N N				0.44	Surcharge
17915	17190	17198	10	6	1,331.7	12.4	0	0 0 0			N	N	N	N	0.44	N	Surcharge
17928	17390	17403	17	6	1,333.6	12.1	7.2	6.6	0	0	N	N N N			0.69	0.6	Surcharge
17929	17403	17509	151	6	1,346.2	12.4	6.6	8.4	0	0	N	N N N			0.6	0.55	Surcharge
17932	17109	17054	215	4	121. 8	14.2	0	0.6	0	0	N	N N N N				0.54	Surcharge
17933	17054	17099	159	4	126.6	12.0	0.6	78.6	0	0	N	N N		0.86	0.54	Y	Ins. freeboard
17934	17099	17085	134	5	261.4	13.3	78.6	81	0	0	N	N	0.86	N	Y	1.99	Ins. freeboard
17935	17085	17096	23	5.5	269.4	11.3	81	15	0	0	N	N N N			1.99	0.63	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	
17936	17096	17178	120	5.5	270.01	11.6	15	4.8	0	0	N	N N N			0.63	0.3	Surcharge
17937	16964	17022	70	4	149.4	11.9	87.6	87	49.8	0.6	33,620	N	Y	RIM	Y	Y	Flooding
17940	16869	16964	190	4	157.9	12.6	84	87.6	0	49.8	N	33,620	0.85	Y	Y Y		Flooding
17941	17178	17190	83	5.5	269.07	14.2	4.8	0	0	0	N	N N N			0.3	N	Surcharge
17942	17562	17717	186	6	1,374.9	13.1	5.4	41.4	0	0	N	N N N			0.37	1.23	Surcharge
17944	17198	17390	271	6	1,331.6	12.9	0	7.2	0	0	N	N N N N				0.69	Surcharge
20886	13035	13094	102	3	63.3	10.5	0	0.6	0	0	N	N N		0.92	N	Y	Ins. freeboard
21240	16150	16153	7	3	65.9	11.4	43.2	42.6	0	0	N	N	0.11	0.45	Y	Y	Ins. freeboard
21241	16153	16169	26	3.5	66.0	7.6	42.6	45.6	0	0	N	N	0.45	0.72	Y	Y	Ins. freeboard
21242	16698	16855	227	4	134.3	10.7	80.4	83.4	0.6	0	N	N	RIM	N	Y	7.95	Ins. freeboard
21252	17022	17074	57	4	149.4	11.9	87	88.8	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
21253	17074	17099	42	4	149.4	11.9	88.8	78.6	0.6	0	N	N	RIM	0.86	Y	Y	Ins. freeboard
21415	18977	18990	239	8	1,411.3	8.9	3.6	0	0	0	N	N N N			0.02	N	Surcharge
21418	17761	18036	331	6	1,374.9	11.5	39	90.6	0	0	N	N N N			1	2.25	Surcharge
22216	13154	13227	81	7	408.8	12.1	6.6	5.4	0	0	N	N N N			1.1	0.63	Surcharge
23682	16108	23714	33	3	53.3	7.6	67.8	17.4	0	0	N	N N N			4.72	4.1558	Surcharge
23683	23714	16110	47	3	63.7	12.0	17.4	7.2	0	0	N	N N N			4.1558	3.66	Surcharge
23813	23810	23811	40	3.17	15.7	3.9	0.6	1.2	0	0	N	N	0.40	0.28	Y	Y	Ins. freeboard
23818	23811	23816	285	3.08	16.0	1.3	1.2	10.8	0	3	N	850	0.28	Y	Y Y		Flooding
23820	23816	11278	17	2.25	33.5	8.4	10.8	6.6	3 0.6		850	N	Y	RIM	Y	Y	Flooding
24909	11299	24672	124	3	33.2	7.1	6.6	8.4	0 0.6		N	N	0.17	RIM	Y	Y	Ins. freeboard
24910	24672	11413	52	3	30.7	6.9	8.4	9	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
24945	14063	14152	116	4.5	106.7	10.4	0	1.8	0	0	N	N N N N				0.64	Surcharge
24949	14320	24753	26	3.5	94.2	9.8	46.2	54	0.6	0	N	N	RIM	N	Y	3.87	Ins. freeboard
24950	24753	14202	239	3.5	94.2	9.79	54	72.6	0	0	N	N N N			4.37	3.46	Surcharge
24954	24756	14308	229	3	22.6	7.4	0	38.4	0	0.6	N	N N		RIM	N	Y	Ins. freeboard
25030	24787	14128	165	3	19.9	4.1	0	42.6	0	0	N	N N N N				4.62	Surcharge
25117	24884	24885	332	2	17.5	4.3	0	10.8	0	0.6	N	N N		RIM	N	Y	Ins. freeboard
25118	24885	24886	261	2.25	32.7	5.8	10.8	33	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
25119	24886	24887	81	2.25	32.5	5.5	33	34.2	0.6	0.6	N	85	RIM	Y	Y Y		Flooding
25120	24887	24888	110	2.42	33.8	5.5	34.2	39	0.6	0.6	85	N	Y	RIM	Y	Y	Flooding
25126	14587	24888	43	3.5	33.3	3.6	40.2	39	0	0.6	N	N N		RIM	3.53	Y	Ins. freeboard
25127	24888	14540	42	3.5	64.3	7.2	39	40.8	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
25129	17509	17562	58	6	1,348.3	13.0	8.4	5.4	0	0	N	N N N			0.55	0.37	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	
25140	11595	24901	140	3	52.8	7.5	40.2	21	0	0.6	N	N	0.13	RIM	Y	Y	Ins. freeboard
25141	24901	11554	276	3	52.8	7.6	21	36	0.6	3	N	343	RIM	Y	Y Y		Flooding
25155	12080	12089	20	2.25	9.34	4.8	0	0 0 0			N	N	N	N	0.18	0.77	Surcharge
25289	18925	25018	62	8	1,388.9	8.7	0	35.4	0	0	N	N N N			0.2	0.08	Surcharge
25290	25018	18977	24	8	1,398.7	8.7	35.4	3.6	0	0	N	N N N			0.08	0.02	Surcharge
25443	13487	25169	62	3	46.52	7.5	91.2	91.8	0	0	N	N N N			11.26	11.526	Surcharge
25444	25169	13569	86	3	46.53	6.6	91.8	94.8	0	0	N	N N N			11.526	13.28	Surcharge
25444	25169	13569	86	3	46.53	6.6	91.8	94.8	0	0	N	N N N			11.526	13.28	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	
10443	11278	11299	21	3	33.1	6.6	15.6	15	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
10445	11413	11480	90	3	31.4	7.0	17.4	18	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
10446	11480	11578	134	3	32.1	5.4	18	21	0.6	15	N	17,660	RIM	Y	Y	Y	Flooding
10447	11578	11595	29	3	47.4	6.7	21	22.8	15	0	17,660	N	Y	0.12	Y	Y	Flooding
10460	11519	11457	241	3	66.1	9.4	25.8	37.2	0.6	27	N	65,070	RIM	Y	Y	Y	Flooding
10461	11457	11464	9	3	47.4	6.7	37.2	33.6	27	0	65,070	N	Y	0.28	Y	Y	Flooding
10462	11464	11471	44	3	66.8	9.8	33.6	0	0	0	N	N	0.28	N	Y	1.12	Ins. freeboard
10463	11471	11706	345	2.25	24.5	7.4	0	15	0	2.4	N	160	N	Y	N	Y	Flooding
10464	11706	11881	292	2.5	43.5	8.9	15	33	2.4	10.2	160	4,545	Y	Y	Y	Y	Flooding
10465	11881	11915	53	2.5	37.5	7.6	33	31.8	10.2	0	4,545	N	Y	0.21	Y	Y	Flooding
10482	11620	11650	36	4	86.6	6.9	8.4	6.6	0	0	N	N	N	N	0.59	0.39	Surcharge
10484	11650	11739	219	4	107.2	10.0	6.6	0	0 0		N	N	N	N	0.89	N	Surcharge
10485	11920	11929	13	4	106.2	8.5	15.6	15.6	0	0	N	N	N	N	2.64	2.14	Surcharge
10503	11706	11701	14	1.25	15.5	12.6	15	0	2.4	0	160	N	Y	N	Y	N	Flooding
10598	11969	11979	19	2.5	37.5	7.6	30	25.2	0	0	N	N	0.52	0.74	Y	Y	Ins. freeboard
10599	11979	11984	33	2.5	69.4	14.1	25.2	7.8	0	0	N	N	0.74	N	Y	3.04	Ins. freeboard
10600	12132	12269	214	4.5	165.1	12.0	10.8	12	0.6	3.6	N	913	RIM	Y	Y	Y	Flooding
10601	12590	12610	55	4.5	192.9	12.5	13.8	9	0 0		N	N	0.51	N	Y	1.47	Ins. freeboard
10602	12610	12647	85	5.5	351.1	16.6	9	2.4	0	0	N	N	N	N	1.07	0.4	Surcharge
10603	11978	12080	141	4	138.8	14.0	0	10.2	0	9	N	20,330	N	Y	N	Y	Flooding
10604	12080	12262	261	4	139.1	12.1	10.2	11.4	9	0.6	20,330	N	Y	RIM	Y	Y	Flooding
10609	11929	11946	20	4	106.2	8.5	15.6	13.2	0	0	N	N	N	N	2.14	1.48	Surcharge
10610	11946	11978	52	4	106.2	8.9	13.2	0	0 0		N	N	N	N	1.36	N	Surcharge
10611	11949	11978	50	2.5	32.7	6.7	10.2	0	0 0		N	N	N	N	1.01	0.72	Surcharge
10613	11940	11984	64	3.67	100.0	10.6	0	7.8	0	0	N	N	N	N	N	2.65	Surcharge
10637	13022	13035	16	3	68.8	9.7	20.4	15.6	0	0	N	N	0.60	N	Y	1.20	Ins. freeboard
10638	13094	13169	103	3	68.8	10.2	18	22.8	0	0	N	N	0.04	N	Y	1.39	Ins. freeboard
10639	13169	13240	122	3	68.8	10.4	22.8	24.6	0	0	N	N	N	N	1.39	1.18	Surcharge
10640	13240	13317	132	3.5	68.8	7.3	24.6	33	0	10.8	N	1,073	N	Y	0.72	Y	Flooding
10641	13317	13323	13	3	66.0	10.7	33	33.6	10.8	30.6	1,073	79,240	Y	Y	Y	Y	Flooding
10642	13323	13487	164	3	61.6	9.2	33.6	50.4	30.6	0	79,240	N	Y	N	Y	10.47	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	
10660	12756	12846	131	6	384.0	13.6	14.4	16.8	0	0	N	N	N	0.34	1.99	Y	Ins. freeboard
10663	12647	12756	253	5.5	384.0	16.6	2.4	14.4	0	0	N	N	N	N	0.6	2.49	Surcharge
10670	13227	13497	292	7	591.7	15.4	16.8	21	0 12		N	61,090	0.91	Y	Y	Y	Flooding
10727	13540	13569	30	3	42.7	6.0	55.8	57	0	0	N	N	N	N	12.72	13.43	Surcharge
10730	13873	13909	56	7	470.6	13.7	15	0	0 0		N	N	N	N	0.5	N	Surcharge
10731	13909	14053	184	7	471.3	18.2	0	11.4	0	0	N	N	N	N	N	0.6	Surcharge
10732	14053	14247	273	7	471.2	12.9	11.4	23.4	0	12	N	19,220	N	Y	0.60	Y	Flooding
10733	14247	14357	151	8	485.3	9.7	23.4	23.4	12	0	19,220	N	Y	0.09	Y	Y	Flooding
10734	14357	14377	25	8	485.3	9.7	23.4	16.2	0	0	N	N	0.09	N	Y	1.77	Ins. freeboard
10736	14202	14243	190	4.5	131.4	8.3	24.6	20.4	0	0	N	N	N	0.43	5.04	Y	Ins. freeboard
10737	14279	14318	165	4.5	159.8	10.1	21	9	0 0		N	N	0.99	N	Y	0.34	Ins. freeboard
10738	14318	14341	66	4.5	159.8	10.7	9	0	0 0		N	N	N	N	0.34	N	Surcharge
10739	14341	14364	36	4.5	159.8	11.6	0	12	0	0	N	N	N	N	1.1	0.44	Surcharge
10755	13750	13808	55	4.5	147.6	9.3	10.8	9	0 0		N	N	N	N	2.01	1.19	Surcharge
10756	13808	13911	109	4.5	165.5	10.8	9	0	0 0		N	N	N	N	1.37	N	Surcharge
10757	13911	14063	185	4.5	165.4	16.4	0	7.8	0	0	N	N	N	N	N	5.65	Surcharge
10760	14152	14212	103	5	165.4	8.4	14.4	16.2	0	0	N	N	N	N	8.03	7.11	Surcharge
10761	14212	14338	535	5	165.4	8.4	16.2	22.2	0	0	N	N	N	N	7.34	3.7	Surcharge
10762	14338	14362	41	5	165.4	8.4	22.2	22.2	0	0	N	N	N	N	3.7	3.08	Surcharge
10763	14362	14364	50	5	165.4	8.4	22.2	12	0	0	N	N	N	N	3.08	2.06	Surcharge
10764	14364	14397	47	4.5	170.6	11.1	12	0	0 0		N	N	N	N	0.44	N	Surcharge
10766	13642	13789	368	3	33.6	6.7	0	6.6	0	0	N	N	N	N	N	3.42	Surcharge
10767	13789	13808	54	3	33.6	6.9	6.6	9	0 0		N	N	N	N	3.54	1.01	Surcharge
10770	13818	13808	28	3	20.3	3.9	7.8	9	0 0		N	N	N	N	0.98	0.98	Surcharge
10775	13818	13922	109	3	28.0	6.4	7.8	11.4	0	0	N	N	N	N	1.03	1.51	Surcharge
10778	14128	14138	27	3	28.0	4.0	19.2	19.8	0	0.6	N	N	N	RIM	4.89	Y	Ins. freeboard
10779	14138	14202	90	3	28.0	4.0	19.8	24.6	0.6	0	N	N	RIM	N	Y	4.99	Ins. freeboard
10780	14463	14320	255	3	61.9	9.3	20.4	21	0.6	15	N	35,970	RIM	Y	Y	Y	Flooding
10786	14313	14320	108	3.5	34.5	4.2	19.2	21	0.6	15	N	35,970	RIM	Y	Y	Y	Flooding
10787	14308	14313	22	3.5	34.5	4.3	18.6	19.2	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
10791	14243	14267	107	4.5	131.4	8.3	20.4	19.8	0	0.6	N	N	0.43	RIM	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	
10792	14267	14279	62	4.5	159.8	10.1	19.8	21	0.6	0	N	N	RIM	0.99	Y	Y	Ins. freeboard
10797	13742	13873	116	7	470.3	12.2	16.8	15	0	0	N	N	N	N	1.56	0.5	Surcharge
11635	14939	15127	221	3.5	146.0	16.0	10.8	12	9.6	0.6	21,350	N	Y	RIM	Y	Y	Flooding
11636	15127	15236	153	3.5	146.0	16.0	12	9	0.6	0	N	N	RIM	N	Y	2.79	Ins. freeboard
11637	15236	15272	58	4	188.8	17.3	9	12	0	0	N	N	N	N	2.79	2.33	Surcharge
11639	15056	15058	54	2.25	33.2	8.4	10.2	10.8	0	0	N	N	0.76	0.42	Y	Y	Ins. freeboard
11640	15058	15229	318	2.25	46.5	11.7	10.8	20.4	0	0	N	N	0.42	N	Y	1.45	Ins. freeboard
11641	15229	15236	16	2.25	46.5	11.7	20.4	9	0 0		N	N	N	N	1.59	0.69	Surcharge
11642	15066	15149	174	1.75	25.1	11.2	4.2	5.4	0 0.6		N	N	N	RIM	0.97	Y	Ins. freeboard
11643	15149	15276	244	1.75	24.2	10.9	5.4	0	0.6	0	N	N	RIM	N	Y	N	Ins. freeboard
11663	14377	14499	125	8	619.7	12.6	16.2	0	0 0		N	N	N	N	2.25	N	Surcharge
11665	14644	14677	52	4	83.3	6.8	0	0	0 0		N	N	N	N	1.07	1.29	Surcharge
11695	14540	14463	137	3.5	62.7	7.7	21	20.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
11716	15965	15922	160	3	105.3	14.9	6	18	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
11717	15922	15928	24	3	103.1	14.6	18	0	0.6	0	N	N	RIM	N	Y	N	Ins. freeboard
11742	15272	15308	70	4	188.8	15.0	12	12	0	0	N	N	N	N	3.35	2.22	Surcharge
11743	15276	15308	72	1.75	24.3	10.4	0	12	0	0	N	N	N	N	N	3.59	Surcharge
11744	15308	15348	148	4.5	242.7	20.8	12	0	0 0		N	N	N	N	2.38	N	Surcharge
11772	15803	15860	53	3	58.1	8.2	24.6	24	6	0	3,134	N	Y	0.38	Y	Y	Flooding
11773	15860	15963	129	3	58.1	8.2	24	25.2	0	0.6	N	N	0.38	RIM	Y	Y	Ins. freeboard
11778	15787	15803	26	3	37.9	5.4	21.6	24.6	4.8	6	2,652	3,134	Y	Y	Y	Y	Flooding
11852	16855	16861	12	4	134.4	10.7	30.6	33.6	0 20.4		N	50,830	N	Y	7.95	Y	Flooding
11853	16861	16866	14	4	114.9	9.1	33.6	32.4	20.4	0	50,830	N	Y	0.16	Y	Y	Flooding
11854	16866	16869	16	4	139.3	11.1	32.4	31.2	0	0	N	N	0.16	0.87	Y	Y	Ins. freeboard
11872	15999	16057	110	3	58.1	8.2	26.4	28.8	0.6	14.4	N	11,710	RIM	Y	Y	Y	Flooding
11873	15963	15999	105	3	58.1	8.4	25.2	26.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
11930	17535	17436	160	2.25	39.9	11.8	2.4	7.8	0 3.6		N	1,220	0.25	Y	Y	Y	Flooding
11931	17404	17250	223	2.25	41.4	10.5	7.8	12	0	0	N	N	0.27	0.48	Y	Y	Ins. freeboard
11932	17250	17235	21	2.25	41.5	10.4	12	9	0 0		N	N	0.48	N	Y	2.25	Ins. freeboard
11933	17235	17223	42	2.25	41.5	13.1	9	9.6	0 0.6		N	N	N	RIM	2.39	Y	Ins. freeboard
11934	17223	17210	49	2.5	41.5	10.7	9.6	10.2	0.6	0	N	N	RIM	0.14	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	
11935	17210	17219	51	2.5	41.5	8.4	10.2	10.8	0	9.6	N	9,758	0.14	Y	Y	Y	Flooding
11936	17219	17237	72	3	61.1	9.5	10.8	10.8	9.6	0	9,758	N	Y	N	Y	2.81	Flooding
11937	17237	17249	38	3	82.7	11.7	10.8	10.2	0	0	N	N	N	N	2.93	3.84	Surcharge
11938	17249	17230	52	3	96.2	14.6	10.2	11.4	0	0	N	N	N	N	3.7	2.8	Surcharge
11939	17230	17184	110	3	96.2	15.3	11.4	12	0	0	N	N	N	0.82	3.23	Y	Ins. freeboard
11940	17184	17109	149	3	126.3	17.9	12	4.2	0	0	N	N	0.82	N	Y	0.66	Ins. freeboard
11950	17405	17429	81	2	35.5	11.3	8.4	5.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
11951	17429	17336	179	2	33.4	11.8	5.4	7.8	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
11952	17336	17259	114	2	33.3	10.8	7.8	9.6	0.6	0	N	N	RIM	0.12	Y	Y	Ins. freeboard
11953	17272	17249	39	2	19.17	6.21	7.8	10.2	0	0	N	N	N	N	2.74	1.82	Surcharge
13511	18036	18080	55	6	1,549.5	12.91	21.6	19.2	0	0	N	N	N	N	1.76	1.23	Surcharge
13512	18080	18120	49	6	1,570.7	15.3	19.2	0	0 0		N	N	N	N	1.23	N	Surcharge
13551	17717	17761	55	6	1,507.9	13.4	12	10.8	0	0	N	N	N	N	1.44	0.99	Surcharge
13643a	18581	18628	65	6	448.6	16.1	17.4	0	15.6	0	151,900	N	Y	N	Y	N	Flooding
13643b	18581	18628	66	6	437.5	15.7	17.4	0	15.6	0	151,900	N	Y	N	Y	N	Flooding
13643c	18581	18628	68	6	482.0	18.5	17.4	0	15.6	0	151,900	N	Y	N	Y	N	Flooding
17426	11554	11549	31	3	66.1	10.0	21	21.6	14.4	0.6	7,501	N	Y	RIM	Y	Y	Flooding
17427	11549	11519	189	3	66.1	9.8	21.6	25.8	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
17431	11471	11479	14	2	42.3	13.5	0	0	0 0		N	N	N	N	3.55	N	Surcharge
17440	11906	11920	34	4	106.2	8.5	10.8	15.6	0	0	N	N	N	N	2.98	2.64	Surcharge
17441	11906	11931	35	1.5	13.6	7.7	10.8	15.6	0	0	N	N	N	N	4.28	2.87	Surcharge
17442	11906	11931	34	1.75	19.1	7.9	10.8	15.6	0	0	N	N	N	N	4.28	2.12	Surcharge
17443	11931	11949	23	2.5	32.7	6.7	15.6	10.2	0	0	N	N	N	N	2.12	1.01	Surcharge
17493	12089	12132	53	4.5	165.1	11.9	10.2	10.8	0	0.6	N	N	0.98	RIM	Y	Y	Ins. freeboard
17501	12262	12269	13	2	19.8	6.6	11.4	12	0.6	3.6	N	913	RIM	Y	Y	Y	Flooding
17503	12262	12462	264	4	144.8	11.6	11.4	12	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
17504	12462	12610	275	4	155.8	12.4	12	9	0.6	0	N	N	RIM	N	Y	2.32	Ins. freeboard
17506	12468	12547	135	4.5	180.0	11.3	14.4	15	0	1.2	N	N	0.24	RIM	Y	Y	Ins. freeboard
17507	12547	12590	98	4.5	192.9	12.1	15	13.8	1.2	0	N	N	RIM	0.51	Y	Y	Ins. freeboard
17508	11951	11969	25	2.5	37.5	7.6	29.4	30	0	0	N	N	0.18	0.52	Y	Y	Ins. freeboard
17510	11915	11951	40	2.5	37.5	7.6	31.8	29.4	0	0	N	N	0.21	0.18	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	
17516	11984	12089	142	4.5	165.2	12.4	7.8	10.2	0	0	N	N	N	0.98	2.71	Y	Ins. freeboard
17517	12269	12468	250	4.5	180.0	11.4	12	14.4	3.6	0	913	N	Y	0.24	Y	Y	Flooding
17571	12940	12964	25	7	413.8	14.2	0	11.4	0	0	N	N	N	N	4.18	3.58	Surcharge
17582	13394	13540	142	3	42.4	7.7	48	55.8	0	0	N	N	0.76	N	Y	12.72	Ins. freeboard
17614	12846	12940	113	6	384.0	13.9	16.8	0	0 0		N	N	0.34	N	Y	N	Ins. freeboard
17617	12964	13154	258	7	515.6	13.5	11.4	17.4	0	0	N	N	N	0.20	3.58	Y	Ins. freeboard
17654	13569	13616	41	3	83.6	11.8	57	57.6	0	0	N	N	N	N	13.43	11.65	Surcharge
17668	14364	14377	427	6	152.2	8.4	12	16.2	0	0	N	N	N	N	1.06	0.83	Surcharge
17669	13785	13621	174	3	21.5	3.5	14.4	16.2	0	15	N	29,730	0.33	Y	Y	Y	Flooding
17670	13497	13608	135	7	470.3	12.2	21	17.4	12	0	61,090	N	Y	N	Y	2.74	Flooding
17671	13621	13497	179	3	32.4	4.6	16.2	21	15	12	29,730	61,090	Y	Y	Y	Y	Flooding
17672	13608	13742	124	7	470.3	12.2	17.4	16.8	0	0	N	N	N	N	2.74	1.56	Surcharge
17772b	15861	15921	70	6	403.4	14.6	21.6	0	21	0	449,900	N	Y	N	Y	N	Flooding
17772a	15861	15921	69	6	457.5	16.9	21.6	0	21	0	449,900	N	Y	N	Y	N	Flooding
17814	16723	16730	11	6	1,082.5	15.0	33	28.2	0	0	N	N	N	N	3.28	2.3	Surcharge
17815	16730	16818	67	6	1,102.5	15.31	28.2	19.8	0	0	N	N	N	N	2.36	1.36	Surcharge
17816	16475	16723	324	6	1,053.0	14.6	12.6	33	0	0	N	N	N	N	5.58	3.28	Surcharge
17847	16110	16130	110	3	69.5	14.5	15.6	22.8	0	0	N	N	N	0.14	3.24	Y	Ins. freeboard
17848	16130	16150	33	3	69.6	9.8	22.8	22.8	0	6	N	1,472	0.14	Y	Y	Y	Flooding
17854	16057	16108	94	3	58.1	8.2	28.8	31.8	14.4	0	11,710	N	Y	N	Y	4.27	Flooding
17855	16441	16493	164	3.5	134.3	14.9	18.6	20.4	14.4	0	14,960	N	Y	N	Y	9.68	Flooding
17856	16493	16535	93	3.5	134.4	16.8	20.4	21.6	0	0.6	N	N	N	RIM	9.68	Y	Ins. freeboard
17857	16535	16698	223	3.5	134.3	15.8	21.6	27	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
17859	16387	16430	54	4	127.1	7.9	20.4	18	0	0	N	N	N	N	6.04	4.96	Surcharge
17860	16430	16441	18	4	127.1	8.9	18	18.6	0 14.4		N	14,960	N	Y	5.29	Y	Flooding
17866	16169	16264	194	3.5	92.5	9.6	24	28.8	0	0	N	N	0.32	N	Y	8.87	Ins. freeboard
17868	16264	16378	138	3.5	113.8	11.8	28.8	31.8	0 13.8		N	18,250	N	Y	8.87	Y	Flooding
17869	16378	16387	10	4	95.0	5.9	31.8	20.4	13.8	0	18,250	N	Y	N	Y	6.04	Flooding
17911	17159	17190	50	6	1,165.5	15.9	0	3	0 0		N	N	N	N	N	2.1	Surcharge
17914	16818	16980	216	6	1,102.7	13.8	19.8	0	0 0		N	N	N	N	1.36	N	Surcharge
17915	17190	17198	10	6	1,432.6	12.9	3	4.2	0	0	N	N	N	N	2.1	0.83	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	
17918	17436	17412	30	2.25	41.8	10.5	7.8	9	3.6	1.2	1,220	N	Y	RIM	Y	Y	Flooding
17919	17412	17404	10	2.25	47.0	11.8	9	7.8	1.2	0	N	N	RIM	0.27	Y	Y	Ins. freeboard
17923	17535	17436	162	2.25	39.7	11.7	2.4	7.8	0 3.6		N	1,220	0.25	Y	Y	Y	Flooding
17924	17259	17237	42	2	23.9	12.6	9.6	10.8	0	0	N	N	0.12	N	Y	2.31	Ins. freeboard
17928	17390	17403	17	6	1,433.8	12.3	9.6	9	0 0		N	N	N	N	1.79	1.6	Surcharge
17929	17403	17509	151	6	1,455.5	12.8	9	8.4	0	0	N	N	N	N	1.6	1.28	Surcharge
17932	17109	17054	215	4	172.8	14.2	4.2	15	0	10.8	N	13,270	N	Y	1.83	Y	Flooding
17933	17054	17099	159	4	155.8	12.4	15	22.8	10.8	0	13,270	N	Y	N	Y	4.62	Flooding
17934	17099	17085	134	5	276.9	14.1	22.8	24.6	0	0	N	N	N	N	4.62	3.78	Surcharge
17935	17085	17096	23	5.5	288.9	12.2	24.6	16.8	0	0	N	N	N	N	3.78	2.32	Surcharge
17936	17096	17178	120	5.5	288.9	12.2	16.8	13.2	0	0	N	N	N	N	2.32	1.83	Surcharge
17937	16964	17022	70	4	148.4	11.8	36	36	21	0.6	41,050	N	Y	RIM	Y	Y	Flooding
17938	17436	17405	42	2	29.6	9.5	7.8	8.4	3.6	0.6	1,220	N	Y	RIM	Y	Y	Flooding
17939	17404	17405	8	2	5.9	2.5	7.8	8.4	0	0.6	N	N	0.27	RIM	Y	Y	Ins. freeboard
17940	16869	16964	190	4	166.6	13.3	31.2	36	0 21		N	41,050	0.87	Y	Y	Y	Flooding
17941	17178	17190	83	5.5	288.2	14.2	13.2	3	0 0		N	N	N	N	1.83	0.66	Surcharge
17942	17562	17717	186	6	1,507.9	13.5	7.2	12	0	0	N	N	N	N	0.95	1.44	Surcharge
17944	17198	17390	271	6	1,433.4	13.1	4.2	9.6	0	0	N	N	N	N	0.83	1.79	Surcharge
20873	11274	11468	302	4	86.4	6.9	7.8	6.6	0	0	N	N	N	N	1.23	0.62	Surcharge
20874	11468	11620	235	4	86.4	6.9	6.6	8.4	0	0	N	N	N	N	0.62	0.59	Surcharge
20886	13035	13094	102	3	68.8	10.6	15.6	18	0	0	N	N	N	0.04	1.40	Y	Ins. freeboard
21166	15056	15066	13	1.75	25.9	10.8	10.2	4.2	0	0	N	N	0.76	N	Y	0.97	Ins. freeboard
21240	16150	16153	7	3	69.6	11.2	22.8	22.2	6	0	1,472	N	Y	0.20	Y	Y	Flooding
21241	16153	16169	26	3.5	69.7	8.0	22.2	24	0	0	N	N	0.20	0.32	Y	Y	Ins. freeboard
21242	16698	16855	227	4	134.4	10.7	27	30.6	0.6	0	N	N	RIM	N	Y	7.95	Ins. freeboard
21252	17022	17074	57	4	148.4	11.8	36	37.8	0.6	8.4	N	2,231	RIM	Y	Y	Y	Flooding
21253	17074	17099	42	4	148.4	11.8	37.8	22.8	8.4	0	2,231	N	Y	N	Y	4.62	Flooding
21415	18977	18990	23	8	1453.4	9.08	10.2	7.8	0	0	N	N	N	N	0.27	0.18	Surcharge
21416	18990	19005	54	8	1493.1	9.6	7.8	0	0 0		N	N	N	N	0.18	N	Surcharge
21418	17761	18036	331	6	1,508.3	12.6	10.8	21.6	0	0	N	N	N	N	0.99	1.76	Surcharge
22216	13154	13227	81	7	591.7	15.4	17.4	16.8	0	0	N	N	0.20	0.91	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	
23682	16108	23714	33	3	58.1	8.2	31.8	19.8	0	0	N	N	N	N	4.4	4.0158	Surcharge
23683	23714	16110	47	3	67.1	12.2	19.8	15.6	0	0	N	N	N	N	4.0158	3.24	Surcharge
23813	23810	23811	40	3.17	17.7	3.8	1.2	8.4	0 0.6		N	N	0.41	RIM	Y	Y	Ins. freeboard
23818	23811	23816	285	3.08	18.0	1.5	8.4	18.6	0.6	13.2	N	15,200	RIM	Y	Y	Y	Flooding
23820	23816	11278	17	2.25	33.5	8.4	18.6	15.6	13.2	0.6	15,200	N	Y	RIM	Y	Y	Flooding
24909	11299	24672	124	3	33.0	7.1	15	16.8	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
24910	24672	11413	52	3	31.1	6.9	16.8	17.4	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
24945	14063	14152	116	4.5	165.4	10.4	7.8	14.4	0	0	N	N	N	N	6.93	8.5	Surcharge
24949	14320	24753	26	3.5	94.8	9.9	21	23.4	15	0	35,970	N	Y	N	Y	3.85	Flooding
24950	24753	14202	229	3.5	94.8	9.9	23.4	24.6	0	0	N	N	N	N	4.35	5.2	Surcharge
24952	24757	24755	27	3	34.5	4.9	9.6	9	0 0		N	N	N	N	1.2	0.76	Surcharge
24953	24755	24756	193	3	34.5	5.3	9	10.2	0	0.6	N	N	N	RIM	0.89	Y	Ins. freeboard
24954	24756	14308	229	3	34.5	7.2	10.2	18.6	0.6	0.6	N	N	RIM	RIM	Y	Y	Ins. freeboard
24955	24758	24757	127	3	34.5	5.8	0	9.6	0	0	N	N	N	N	N	1.11	Surcharge
25030	24787	14128	165	3	28.0	4.1	13.8	19.2	0	0	N	N	N	N	4.05	4.86	Surcharge
25035	13922	24787	77	3	28.0	7.4	11.4	13.8	0	0	N	N	N	N	1.56	4.05	Surcharge
25116	24883	24884	204	2	25.9	5.4	12	15	0	0.6	N	70	0.55	Y	Y	Y	Flooding
25117	24884	24885	332	2	25.9	4.3	15	17.4	0.6	7.8	70	2,372	Y	Y	Y	Y	Flooding
25118	24885	24886	261	2.25	41.7	5.8	17.4	19.2	7.8	10.8	2,372	3,226	Y	Y	Y	Y	Flooding
25119	24886	24887	81	2.25	37.9	5.3	19.2	19.2	10.8	14.4	3,226	4,558	Y	Y	Y	Y	Flooding
25120	24887	24888	110	2.42	39.7	5.5	19.2	20.4	14.4	13.8	4,558	16,240	Y	Y	Y	Y	Flooding
25126	14587	24888	43	3.5	53.9	5.6	20.4	20.4	0 13.8		N	16,240	N	Y	3.49	Y	Flooding
25127	24888	14540	42	3.5	65.1	7.2	20.4	21	13.8	0.6	16,240	N	Y	RIM	Y	Y	Flooding
25129	17509	17562	58	6	1,455.7	13.4	8.4	7.2	0	0	N	N	N	N	1.28	0.95	Surcharge
25140	11595	24901	140	3	52.6	7.5	22.8	19.8	0	0.6	N	N	0.12	RIM	Y	Y	Ins. freeboard
25141	24901	11554	276	3	52.6	7.6	19.8	21	0.6	14.4	N	7,501	RIM	Y	Y	Y	Flooding
25145	24902	11906	234	4	107.4	11.1	0	10.8	0	0	N	N	N	N	N	1.78	Surcharge
25155	12080	12089	20	2.25	17.9	4.5	10.2	10.2	9	0	20,330	N	Y	0.98	Y	Y	Flooding
25179	13600	24948	218	4.5	92. 9	8.3	0	7.8	0	0	N	N	N	N	N	1.078	Surcharge
25180	24948	13750	155	4.5	92.9	5.9	7.8	10.8	0	0	N	N	N	N	1.078	2.01	Surcharge
25197	14717	24941	133	4.5	144.3	11.6	0	4.2	0	0	N	N	N	N	0.05	1.85	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	
25200	24941	24942	64	4.5	144.3	9.4	4.2	7.8	0	0	N	N	N	N	2.1	2.21	Surcharge
25201	24942	24944	55	4.5	144.3	9.1	7.8	7.8	0	0	N	N	N	N	2.46	2.11	Surcharge
25202	24944	24945	83	4.5	144.3	9.3	7.8	8.4	0	0	N	N	N	N	2.36	1.8	Surcharge
25214	24945	14939	147	4.5	197.6	13.2	8.4	10.8	0	9.6	N	21,350	N	Y	1.92	Y	Flooding
25235	17259	17272	50	2	19.2	6.1	9.6	7.8	0	0	N	N	0.12	N	Y	1.12	Ins. freeboard
25289	18925	25018	62	8	1,407.0	8.8	0	13.8	0	0	N	N	N	N	0.5	0.35	Surcharge
25290	25018	18977	24	8	1,428.5	8.9	13.8	10.2	0	0	N	N	N	N	0.35	0.27	Surcharge
25443	13487	25169	62	3	61.6	8.7	50.4	54	0	0	N	N	N	N	10.47	11.646	Surcharge
25444	25169	13569	86	3	61.6	8.7	54	57	0	0	N	N	N	N	11.646	13.43	Surcharge

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

TABLE 13
2006 Storm Event Stream Results

Conduit ID	Node ID US	Node ID DS	Length (ft)	Depth (ft)	Maximum Flow (ft^3/s)
11745	15479	15750	364.9	50.0	1,084.4
13524	18120	18246	224.4	10.3	1,407.2
13526	18246	18327	92.8	9.9	1,413. 8
13528	18327	18351	21.3	9.6	1,414.4
13530	18351	18411	44.8	9.4	1,414.7
13532	18411	18502	106.8	8.8	1,422.5
13660	18679	18758	110.9	13.8	1,388.2
13661	18758	18792	30.3	13.5	1,388.2
13664	18502	18581	112.0	7.0	1,422.7
13674	18628	18641	12.9	14.0	1,368.1
13675	18641	18679	57.8	14.1	1,388.2
17769	16050	16159	162.2	10.9	983.2
17773	15750	15861	144	24.7	1,084.9
17774	15921	16050	179.5	10.7	959.7
17775	15928	15921	17.5	4.8	117.6
21168	15016	15031	13.9	12.8	768.4
21169	15031	15479	663.5	10.7	817.1
21173	15348	15479	438.5	4.3	179.6
21412	18792	18925	160.4	9.4	1,388.1
21431	19064	19532	718.2	11.4	1,453.1
25283	16159	16475	457.0	9.1	1,004.2

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

Conduit ID	Node ID US	Node ID DS	Length (ft)	Depth (ft)	Maximum Flow (ft^3/s)
11745	15479	15750	364.9	30.7	1,385.2
13524	18120	18246	224.4	17.9	1,576.5
13526	18246	18327	92.8	16.3	1,600.7
13528	18327	18351	21.3	15.5	1,604.8
13530	18351	18411	44.8	14.6	1,607.0
13532	18411	18502	106.8	12.3	1,627.5
13660	18679	18758	110.9	13.9	1,409.3
13661	18758	18792	30.3	13.7	1,406.8
13664	18502	18581	112.0	8.3	1,631.7
13674	18628	18641	12.9	14.0	1,368.6
13675	18641	18679	57.8	14.2	1,407.2
17769	16050	16159	162.2	11.1	1,050.4
17773	15750	15861	144	15.6	1,385.8
17774	15921	16050	179.5	10.8	1,011.1
17775	15928	15921	17.5	4.9	120.0
21168	15016	15031	13.9	13.2	882.1
21169	15031	15479	663.5	10.6	962.2
21173	15348	15479	438.5	3.2	242.3
21412	18792	18925	160.4	9.5	1,405.4
21431	19064	19532	718.2	11.7	1,532.5
25283	16159	16475	457.0	9.1	1,093.8

Data Gaps

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

GIS Data Gaps and Anomalies—Doctor's Branch

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DATE: March 23, 2012

PROJECT NUMBER: 392309

1 Introduction

This technical memorandum describes the Doctor's Branch 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 to prepare the data 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 20 segments, which are shown in **Figure 1-1**. The outfall of the stormwater network is south of S. Four Mile Run Dr. Descriptions of the 20 segments are found in **Table 1-1.** All figures are found at the end of this document.

TABLE 1-1
Doctor's Branch Watershed—Major Storm Sewer and Stream Network Segments

Segment	Description
1	S. Four Mile Run Dr. to 12th Rd. S., along S. George Mason Dr. (stream segments)
2	S. George Mason Dr. and 12th Rd. S. to 14th St. S. and S. Pollard St.
3	S. Quebec St. to Columbia Pike and S. Monroe St.
4	12th Rd. S to 8th St. S., parallel to S. George Mason Dr. (stream segments)
5	8th St. S. towards 7th St. S. and S. Quincy St., East of S. George Mason Dr. (stream segments)
6	7th St. S. and S. Quincy St. towards Arlington Blvd, along S. George Mason Dr. (stream segments)
7	7th St. S. and S. Quincy St. to 6th St. S. and S. Quincy St. (stream)
8	6th St. S and S. Quincy St. to 3rd St. S. and S. Oakland Dr. (parallel to segment 9)
9	6th St. S and S. Quincy St. to 3rd St. S. and S. Oakland Dr. (parallel to segment 8)
10	3rd St. S. and S. Oakland Dr. to 2nd St. S. and S. Old Glebe Rd. (parallel in parts to segment 14)
11	6th St. S. to 3rd St. S., along S. Old Glebe Rd.

TABLE 1-1 (CONTINUED)
Doctor's Branch Watershed—Major Storm Sewer and Stream Network Segments

Segment	Description
12	S. Glebe Rd. to S. Jackson St., along 5th St. S.
13	S. Glebe Rd. and S. Irving St., along 6th St. S.
14	3rd St. S. and S. Oakland Dr. towards Arlington Blvd. and N. Jackson St. (parallel in parts with segment 10)
15	3rd St. S. to S. Old Glebe Rd., along S. Oakland Dr.
16	1st Rd. S. to 360 linear ft north along S. Glebe Rd.
17	Crossing Arlington Blvd. between S. Glebe Rd. 360 linear ft north of 1st Rd. S. and N. Oakland St. 300 linear ft south of 2nd St. N.
18	300 linear ft south of 2nd St. N. along N. Oakland St. to 5th St. N. and N. Monroe St. (parallel in parts to segment 19)
19	300 linear ft south of 2nd St. N. along N. Oakland St. to 5th Rd. N. and N. Quincy St. (parallel in parts to segment 18)
20	Crossing Arlington Blvd. between 200 linear ft south of 2nd St N. to 75 linear ft south of Arlington Blvd. along N. Trenton St.

Note: "Stream" indicates a segment wholly made up of a natural stream. "Stream segments" indicates a segment made up of both stream channel and closed pipe network. The lack of a qualifier indicates that the segment is made up wholly of closed pipe network.

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 delivered to CH2M HILL in June 2011. Further updates were made by the County to the PGDB in order to include the stormwater network at the Army National Guard Bureau and to make other adjustments. This updated PGDB was provided in October 2011.

2.2 Record Drawings

In addition to the ArcGIS PGDB, the County provided the storm sewer record drawings for the Doctor's Branch watershed in June 2011. The record drawings were used in conjunction with the ArcGIS PGDB to resolve the data gaps and anomalies.

2.3 Survey Information

The Doctor's Branch storm sewer system has two natural stream segments directly connected to its storm pipe network. One stream segment extends from the corner of S. Quincy St. and 6th St. S. to the north side of Columbia Pike and is shown by segments 4 to 7 in Figure 1-1. The other stream segment extends from 13th Rd. S. to S. Four Mile Run Dr. and is shown by segment 1 in Figure 1-1. These stream channels are directly connected to pipes equal to or larger than 36 inches in diameter and thus will be included in the model, as seen in Figure 3-4 Modeled Network Segments..

During a preliminary review of the ArcGIS PGDB, it was determined that there was a need to survey key stream cross sections and culverts connected to these streams. In May 2011, CH2M HILL submitted two maps with notations suggesting seven locations along the stream and identifying seven locations where invert and headwall elevations of existing culverts were required. Following a review of the drawings, the County recommended that all of the culverts and five of the seven locations be surveyed. The survey data, including photos of stream channels and end walls, 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
4. Extrapolating from adjacent 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, some minor links and nodes of the Doctor's Branch storm sewer network were not included within the boundary, and some links and nodes belonging to other watersheds were included. The boundary was modified to include all of the Doctor's Branch links and nodes and exclude all links and nodes belonging to other watersheds. Attachment A documents all the changes made to the watershed boundary.

3.2 Link and Network Gaps and Anomalies

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

Network anomalies included a cluster of links disconnected from the network with diameters of 99 inches west of S. George Mason Dr., with Columbia Pike to the north and 13th St. S. to the south, as illustrated in **Figure 3-1**. After communication with the County, these pipe segments were identified to have diameters smaller than 36 inches and hence will be excluded from the model.

Another anomaly was abandoned pipe segments in the watershed. Links 17656, 20889, 10720, 10719, and 10718 **(Figure 3-2)** were found to have been abandoned, based on further discussions with the County. They will not be included in the model.

Other link and network anomalies and their respective solutions are provided at the end of this document, in **Table 3-1.**

A significant anomaly observed was a large area with no storm sewer system shown in the initial GIS data set received from the County. This area, in the vicinity of the National Foreign Affairs Training Center, near the intersection of George Mason Dr. and Arlington Blvd., was excluded due to its sensitive nature. Subsequently, information on the storm sewer system in this area was provided, for modeling purposes only, by the County. It was determined that the bulk of the system serving the National Foreign Affairs Training Center is independent of the County system and flows to an onsite stormwater management pond. This system will not be modeled, but the flow will be included at the location the pond outfalls to the stream channel. (See **Figure 3-3**.) It was also determined that a large storm sewer segment owned by the County conveys runoff through the National Foreign Affairs Training Center, from node 13616 of segment 20 to node 14607 of segment 8. This segment will be modeled and its capacity will be analyzed. However, due to the sensitive nature of this area, the specifics of this part of the system will not be discussed in this or in future technical memorandums.

Unique features observed in the Doctor's Branch watershed included a network of links and parallel pipes connected with overflow links. In almost all cases, these connecting links or parts of circular networks had diameters smaller than 36 inches. Despite these links falling under the limit of 36 inches, they were selected for inclusion in the model due to the fact that the parallel pipe system was effectively acting as a pipe with a diameter of at least 36 inches. **Figure 3-4** illustrates the network of major and minor links to be modeled.

3.3 Invert and Rim Elevation Data Gaps and Anomalies

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

The following types of invert anomalies were identified:

- Invert of incoming link lower than node invert
- Invert of outgoing link lower than node invert
- Invert of outgoing link higher than the invert of incoming link at a node
- Invert of incoming link more than 4 feet higher than the node invert (drop over 4 feet)
- Downstream invert is higher than upstream invert of a link (negative slope)
- Link has zero percent slope
- Upstream link invert is different than the value in as-built drawings/survey photos
- Downstream link invert is different than the value in as-built drawings/survey photos
- Node invert is different than the value in as-built drawings

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.

Figures 3-5 and **3-6** show the location of invert and rim data gaps and anomalies.

3.4 Storage Structures

Several large-diameter pipes are not connected to the major (greater than 36 inches in diameter) storm and stream conveyance network. Review of the GIS data showed that the downstream nodes of these links were classified as detention outlets. CH2M HILL's review of the record drawings confirmed that these links represent storage structures that do not need to be modeled. The County was also consulted to confirm the categorization of links at the corner of S. Randolph St. and Columbia Pike as storage structures. **Table 3-3** and **Figures 3-7** though **3-11** show the identified storage structures.

TABLE 3-3
Storage Links

GID				Link			
Link	US Node	DS Node	Figure Number	Size (in.)	Length (ft)	Type	Approximate Location
23666[a]	23690	23689	3-10	84 (two)	65	Circular pipe	S. Randolph St. and Columbia Pike
23667	23689	23728	3-10	84 (two)	39	Circular pipe	S. Randolph St. and Columbia Pike
23679	23703	23713	3-11	72	70	Circular pipe	S. Oakland St. and Columbia Pike
23715	23738	23736	3-11	49 × 33	202.5	Elliptical	S. Lincoln St. and Columbia Pike
24943	24751	24750	3-8	48	Missing	Circular pipe	Arlington Blvd. and West of S. George Mason Dr.
25193	24956	24964	3-9	36	Missing	Circular pipe	S Glebe Rd. and 5th St. S.

TABLE 3-3 (CONTINUED)
Storage Links

	GID			Link			
Link	US Node	DS Node	Figure Number	Size (in.)	Length (ft)	Type	Approximate Location
25194	24955	24964	3-9	36	Missing	Circular pipe	S Glebe Rd. and 5th St. S.
25223	24967	24961	3-9	42	Missing	Circular pipe	S. Glebe Rd. and 5th St. S.
25238	24983	24981	3-10	60	Missing	Circular pipe	West of S. Quincy St. and 13th St. S.
25241	24976	24982	3-10	60	Missing	Circular pipe	Between S. Randolph St. and S. Quincy St near 14th St. S.
25297[b]	25028	25029	3-7	36	59.7	Circular pipe	N. Quincy St. and 5th Rd. N.

Note: GID, unique feature ID used in GIS; US, upstream; DS, downstream.
[a]Associated detention outlet is node 23728.
[b]Associated detention outlet is node 25021.

4 Results

In total, 139 links and 113 nodes were identified with data gaps and anomalies. These represent 51 percent of the links (273, excluding stream segments) and 44 percent of the nodes (258, excluding nodes on the stream) selected for the model. All of these data gaps were resolved by reviewing the record drawings and through interpolation and discussions with the County.

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
N/A	17862	16415	16441	21 in.	Circular pipe	Incorrect size	GIS stated 42 in.; County confirmed in 10/20/11 e-mail that pipe is 21 in.	Pipe will not be modeled since the corrected diameter is smaller than 36 in.
N/A	24957	24760	24758	24 in.	Circular pipe	Missing length; diameter on record drawings different than in GIS	Use length and diameter from record drawings	Pipe will not be modeled since the corrected diameter is smaller than 36 in.
1	21416	18990	19005	8 ft × 10 ft	Box culvert	Incorrect length	Scale length from record drawing	—
1	21415	18977	18990	8 ft × 10 ft	Box culvert	Incorrect length	Scale length from record drawing	—
1	25290	25018	18977	8 ft × 10 ft	Box culvert	Missing length	Scale length from record drawings	—
1	25289	18925	25018	8 ft × 10 ft	Box culvert	Missing length	Scale length from record drawings	—
1	13643	18581	18628	72 in.	Circular pipe	Incorrect diameter	Use diameter from the survey photo	—
2	25235	17259	17272	24 in.	Circular pipe	Missing length	Use length from GIS	—
2	17923	17535	17436	27 in.	Circular pipe	Missing US node ID, DS node ID, and length	Use the features from parallel link 11930	—
3	17856	16493	16535	42 in.	Circular pipe	Missing length	Length from record drawings; GIDs 17856 + 17855 = 258 ft	Slope from record drawings
3	17855	16441	16493	42 in.	Circular pipe	Missing length	Length from record drawings; GIDs 17856 + 17855 = 258 ft	Slope from record drawings
4	17816	16475	16723	6 ft × 6 ft	Box culvert	Incorrect width and link type	Width and link type corrected based on survey photo	Previously "arch" for link type
6	25214	24945	14939	54 in.	Circular pipe	Missing length and material	Use values from the design drawings for ARNG headquarters readiness center wing addition; for material, assume same as upstream link	—
6	25202	24944	24945	54 in.	Circular pipe	Missing length and material	Use values from the design drawings for ARNG Headquarters Readiness Center wing addition	—
6	25201	24942	24944	54 in.	Circular pipe	Missing length and material	Use values from the design drawings for ARNG Headquarters Readiness Center wing addition	—
6	25200	24941	24942	54 in.	Circular pipe	Missing length and material	Use values from the design drawings for ARNG Headquarters Readiness Center wing addition	—
6	25197	14717	24941	54 in.	Circular pipe	Missing length and material	Use values from the design drawings for ARNG Headquarters Readiness Center wing addition	—
6	25195	24936	14717	54 in.	Circular pipe	Missing length and material	Use values from the design drawings for ARNG Headquarters Readiness Center wing addition	—
6	25191	24935	24936	54 in.	Circular pipe	Missing length and material	Use values from the design drawings for ARNG Headquarters Readiness Center wing addition	—
6	25190	24934	24935	54 in.	Circular pipe	Missing length	Use values from the design drawings for ARNG Headquarters Readiness Center wing addition	—
6	25189	14099	24934	48 in.	Circular pipe	Missing length and material	Use values from the design drawings for ARNG Headquarters Readiness Center wing addition	—
8	21898	14991	15016	6.9 ft × 6.7 ft	Box culvert	Missing height and width; incorrect DS invert	Use height, width, and DS invert from survey photo	—
8	17717	14916	14991	6.9 ft × 6.7 ft	Box culvert	Incorrect height	Use height from survey photo	—
8	17730	14825	14916	66 in.	Circular pipe	Missing link type, US node ID, DS node ID, length, material, and diameter	Use length and US and DS node IDs from parallel link 17731; populate all other values and features from the record drawings	—

TABLE 3-1 (CONTINUED)
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
8	21875	14688	14825	66 in.	Circular pipe	Missing link type, US node ID, DS node ID, length, material and diameter	Use length and US and DS node IDs from parallel link 21874; populate all other values and features from the record drawings	—
8	21179	14668	14688	66 in.	Circular pipe	Missing link type, US node ID, DS node ID, length, material and diameter	Use length and US and DS node IDs from parallel link 21178; populate all other values and features from the record drawings	—
13	25120	24887	24888	29 in. × 45 in.	Box culvert	Incorrect link type	Use link type from record drawing	Previously circular pipe; slope from record drawings
13	25119	24886	24887	27 in. × 42 in.	Box culvert	Incorrect link type	Use link type from record drawing	Previously circular pipe; slope from record drawings
13	25118	24885	24886	27 in. × 42 in.	Box culvert	Incorrect link type	Use link type from record drawing	Previously circular pipe; slope from record drawings
13	25117	24884	24885	24 in. × 38 in.	Box culvert	Incorrect link type	Use link type from record drawing	Previously circular pipe; slope from record drawings
13	25116	24883	24884	24 in. × 38 in.	Box culvert	Incorrect link type	Use link type from record drawing	Previously circular pipe; slope from record drawings
14	25030	24787	14128	36 in.	Circular pipe	Incorrect US node ID and DS node ID on the GIS link attribute table	Insert correct US and DS node IDs	—
15	10734	14357	14377	96 in.	Circular pipe	Incorrect node type for US node	Referenced as yard inlet in GIS but record drawing 4620-224 shows it as a manhole	—
18	10610	11946	11978	48 in.	Circular pipe	Incorrect node type of DS node	Use node type “catchbasin” from record drawings (had been “manhole”)	—
18	17441	11906	11931	18 in.	Circular pipe	Incorrect diameter	Use correct diameter from record drawing	—
18	17442	11906	11931	21 in.	Circular pipe	Missing link type, US node ID, DS node ID, length, material and diameter	Use length and US and DS node IDs from parallel link 17441; populate all other values and features from the record drawings	—
18	17435	11659	11688	21 in.	Circular pipe	Missing link type, US node ID, DS node ID, length, material and diameter	Use US and DS node information from GIS node layer; populate rest of values and features from record drawings	—
19	23820	23816	11278	27 in.	Circular pipe	38 in.× 24 in. elliptical drains to a 27-in. circular pipe, which drains to a 36-in. circular pipe downstream	Sizes correct according to record drawings except fix of elliptical to 37 in. × 24 in.	Will revisit if modeling shows errors or flooding in this area
19	25155	12080	12089	27 in.	Circular pipe	Missing length	Length from Shape_Length on ArcGIS PGDB	—
20	17654	13616	13569	36 in.	Circular pipe	Direction of flow was reversed based on US and DS node IDs	Edit and correct US and DS node IDs (had been designated incorrectly in GIS)	—
20	10727	13569	13540	36 in.	Circular pipe	Direction of flow was reversed based on US and DS node IDs	Edit and correct US and DS node IDs (had been designated incorrectly in GIS)	—
20	25444	25169	13569	36 in.	Circular pipe	Missing length and material	Use same material as upstream links; length from Shape_Length	—
20	25443	13487	25169	36 in.	Circular pipe	Missing length and material	Use same material as upstream links; length from Shape_Length	—

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

TABLE 3-2A
Link Invert Data Gaps and Anomalies

Segment	Link GID	US Node GID	DS Node GID	Link Size	Link Type	Data Gap/Anomaly	Solution	Comment
2	17939	17404	17405	24 in.	Circular pipe	Missing US invert and DS invert; negative slope	Use inverts received from County on 10/26/2011	See node data gap in Table 3-2b
2	17938	17436	17405	24 in.	Circular pipe	Missing US invert and DS invert	Use inverts received from County on 10/26/2011	See node data gap in Table 3-2b
2	17919	17412	17404	27 in.	Circular pipe	Missing US invert and DS invert	Use inverts received from County on 10/26/2011	See node data gap in Table 3-2b
2	17918	17436	17412	27 in.	Circular pipe	Missing DS invert and US invert	Use inverts received from County on 10/26/2011	See node data gap in Table 3-2b
2	11930	17535	17436	27 in.	Circular pipe	Missing US invert and DS invert	Use inverts received from County on 10/26/2011	See node data gap in Table 3-2b
2	17923	17535	17436	24 in.	Circular pipe	Missing US invert and DS invert	Use inverts received from County on 10/26/2011	See node data gap in Table 3-2b
3	21253	17074	17099	48 in.	Circular pipe	Missing US invert	Interpolate US invert from GIS data	See node data gap in Table 3-2b
3	21252	17022	17074	48 in.	Circular pipe	Missing DS invert	Interpolate DS invert from GIS data	See node data gap in Table 3-2b
3	17856	16493	16535	42 in.	Circular pipe	Missing US invert	Interpolate US invert from GIS data using slope from record drawing	See node data gap in Table 3-2b
3	17855	16441	16493	42 in.	Circular pipe	Missing DS invert	Interpolate DS invert from GIS data using slope from record drawing	See node data gap in Table 3-2b
3	17860	16430	16441	4 ft × 4 ft	Box culvert	US invert 0.33 ft lower than US node invert	Use inverts provided on record drawing 4220-228	See node data gap in Table 3-2b
3	17859	16387	16430	4 ft × 4 ft	Box culvert	US invert 0.90 ft lower than US node invert	Use US invert from record drawing	See data gap Table 3-2b
3	17869	16378	16387	4 ft × 4 ft	Box culvert	DS invert 0.90 ft lower than DS node invert; negative slope	Use invert on record drawing	Corrected inverts result in negative slope
3	17866	16169	16264	42 in.	Circular pipe	DS link invert is 2.80 ft below DS node invert	Use DS invert from record drawing	—
3	17847	16110	16130	36 in.	Circular pipe	Missing US invert	Use US node invert	—
3	23682	16108	23714	36 in.	Circular pipe	Missing DS invert	Interpolate DS invert from GIS data	See node data gap in Table 3-2b
3	23683	23714	16110	36 in.	Circular pipe	Missing US invert	Interpolate US invert from GIS data	See node data gap in Table 3-2b
4	17911	17159	17190	6 ft × 7 ft	Box culvert	Missing US invert	Interpolate US invert from GIS data	See node data gap in Table 3-2b; interpolation results in a slope of 6%
4	17910	17097	17159	6 ft × 7 ft	Box culvert	Missing US invert and DS invert	Use US invert from record drawings; interpolate DS invert from GIS data	See node data gap in Table 3-2b; interpolation results in a slope of 6%
4	17909	16980	17097	6 ft × 7 ft	Box culvert	Missing US invert and DS invert; near 0% slope	Interpolate US invert from GIS data; use DS node invert for DS invert	See node data gap in Table 3-2b
4	17914	16818	16980	6 ft × 7 ft	Box culvert	Missing US invert and DS invert; near 0% slope	Use US invert from record drawings; interpolate DS invert from GIS data	See node data gap in Table 3-2b
4	17815	16730	16818	6 ft × 6 ft	Box culvert	Missing US invert and DS invert	Use US invert from record drawing; interpolate US invert from information from record drawing	See node data gap in Table 3-2b
4	17814	16723	16730	6 ft × 6 ft	Box culvert	Missing US invert and DS invert	Interpolate inverts from GIS data	See node data gap in Table 3-2b
4	17816	16475	16723	6 ft × 6 ft	Box culvert	Missing US invert and DS invert	Use US invert from survey photo, both culverts had same inverts; Interpolate DS invert from GIS data	See node data gap in Table 3-2b
4	11717	15922	15928	36 in.	Circular pipe	Missing DS invert	Extrapolate DS invert from GIS data	See node data gap in Table 3-2b
5	17772	15861	15921	72 in.	Circular pipe	Incorrect US invert and DS invert	Use US invert and DS invert from survey photos	See node data gap in Table 3-2b
6	25214	24945	14939	54 in.	Circular pipe	Missing US invert and DS invert	Use US invert from the design drawings for ARNG Headquarters Readiness Center wing addition; used DS node invert for DS invert	See node data gap in Table 3-2b
6	25202	24944	24945	54 in.	Circular pipe	Missing US invert and DS invert	Use inverts from the design drawings for ARNG Headquarters Readiness Center wing addition	See node data gap in Table 3-2b
6	25201	24942	24944	54 in.	Circular pipe	Missing US invert and DS invert	Use inverts from the design drawings for ARNG Headquarters Readiness Center wing addition	See node data gap in Table 3-2b

TABLE 3-2A (CONTINUED)
Link Invert Data Gaps and Anomalies

Segment	Link GID	US Node GID	DS Node GID	Link Size	Link Type	Data Gap/Anomaly	Solution	Comment
6	25200	24941	24942	54 in.	Circular pipe	Missing US invert and DS invert	Use inverts from the design drawings for ARNG Headquarters Readiness Center wing addition	See node data gap in Table 3-2b
6	25197	14717	24941	54 in.	Circular pipe	Missing US invert and DS invert	Use inverts from the design drawings for ARNG Headquarters Readiness Center wing addition	See node data gap in Table 3-2b
6	25195	24936	14717	54 in.	Circular pipe	Missing US invert and DS invert	Use inverts from the design drawings for ARNG Headquarters Readiness Center wing addition	See node data gap in Table 3-2b
6	25191	24935	24936	54 in.	Circular pipe	Missing US invert and DS invert	Interpolate US invert from GIS data; use DS invert from the design drawings for ARNG Headquarters Readiness Center wing addition	See node data gap in Table 3-2b
6	25190	24934	24935	54 in.	Circular pipe	Missing US invert and DS invert	Interpolate inverts from GIS data	See node data gap in Table 3-2b
6	25189	14099	24934	48 in.	Circular pipe	Missing US invert and DS invert	Use US node invert for US invert; DS invert interpolated	See node data gap in Table 3-2b
6	6898	13940	14099	36 in.	Circular pipe	Missing US invert	Extrapolate using the slope County provided and invert of DS link	See node data gap in Table 3-2b; County provided 2% slope on 10/26/2011
6	6897	13788	13940	36 in.	Circular pipe	Missing US invert and DS invert	Extrapolate using County-provided slope and inverts of DS link	See node data gap in Table 3-2b; County provided 2% slope on 10/26/2011
6	6896	13687	13788	36 in.	Circular pipe	Missing US invert and DS invert	Extrapolate using the slope County provided and invert of DS link	See node data gap in Table 3-2b; County provided 2% slope on 10/26/2011
8	21898	14991	15016	6.9 ft × 6.7 ft	Box culvert	Missing US invert; DS invert incorrect	Interpolate US invert; use DS link from survey photo	See node data gap in Table 3-2b
8	17717	14916	14991	6.9 ft × 6.7 ft	Box culvert	Missing DS invert	Interpolate DS invert from GIS data	See node data gap in Table 3-2b
8	17732	14677	14688	48 in.	Circular pipe	Missing US invert; possible negative slope; DS invert in GIS differs from record drawing	Interpolate US invert from links 17728 and 11664; use downstream invert of link 17732 from record drawing 4620-098. These 2 new inverts result in negative slope	See node data gap in Table 3-2b; pipe is an overflow pipe that connect 96- and 66-in. pipes
8	11665	14644	14677	48 in.	Circular pipe	Missing US invert and DS invert	Use US invert from record drawing; interpolate DS invert	See node data gap in Table 3-2b
8	11662	14607	14644	48 in.	Circular pipe	Missing US invert and DS invert	Interpolate US invert; use DS invert from record drawings	See node data gap in Table 3-2b
8	10764	14364	14397	54 in.	Circular pipe	Missing US invert; 0% slope	Use US invert from record drawing	Updated invert results in 0% slope
8	17730	14825	14916	66 in.	Circular pipe	Missing US invert and DS invert	Use US invert and DS invert from the record drawings	—
8	21875	14688	14825	66 in.	Circular pipe	Missing US invert and DS invert	Use US invert and DS invert from the record drawings	—
8	21179	14668	14688	66 in.	Circular pipe	Missing US invert and DS invert	Use US invert and DS invert from record drawings	—
9	21172	14904	15016	96 in.	Circular pipe	Missing DS invert and US invert	Use DS invert from survey photo; use DS invert of US link for US invert	See node data gap in Table 3-2b
9	17728	14677	14904	96 in.	Circular pipe	Missing US invert and DS invert	Interpolate US invert using DS invert and slope from record drawing; use DS invert from record drawing	See node data gap in Table 3-2b; slope from record drawings
9	11664	14542	14677	96 in.	Circular pipe	Missing DS invert	Interpolate DS invert from GIS data using slope from record drawing	See node data gap in Table 3-2b; slope from record drawing
9	17668	14364	14377	72 in.	Circular pipe	Missing US invert and DS invert	Use US invert from record drawings; calculate DS invert using US invert and slope	See node data gap in Table 3-2b
10	10760	14152	14212	60 in.	Circular pipe	US invert of DS link is higher than DS invert of US link at MH 14212	Use US invert of DS link 10761 was incorrect on ArcGIS PGDB; using the referenced record drawing	See node data gap in Table 3-2b
10	10761	14212	14338	60 in.	Circular pipe	Incorrect US invert	Use US invert from record drawing	See node data gap in Table 3-2b
11	24949	14320	24753	42 in.	Circular pipe	0% slope	GIS information matches record drawing	See node data gap in Table 3-2b
13	25120	24887	24888	29 in. × 45 in.	Box culvert	Missing US invert and DS invert	Use node inverts from record drawing	See node data gap in Table 3-2b; slope from record drawings

TABLE 3-2A (CONTINUED)
Link Invert Data Gaps and Anomalies

Segment	Link GID	US Node GID	DS Node GID	Link Size	Link Type	Data Gap/Anomaly	Solution	Comment
13	25119	24886	24887	27 in. × 42 in.	Box culvert	Missing US invert and DS invert	Use node inverts from record drawing	See node data gap in Table 3-2b; slope from record drawings
13	25118	24885	24886	27 in. × 42 in.	Box culvert	Missing US invert and DS invert	Use node inverts from record drawing	See node data gap in Table 3-2b; slope from record drawings
13	25117	24884	24885	24 in. × 38 in.	Box culvert	Missing US invert and DS invert	Use node inverts from record drawing	See node data gap in Table 3-2b; slope from record drawings
13	25116	24883	24884	24 in. × 38 in.	Box culvert	Missing US invert and DS invert	Use node inverts from record drawing	See node data gap in Table 3-2b; slope from record drawings
14	10739	14341	14364	54 in.	Circular pipe	Incorrect DS invert	Use DS invert from record drawing	Record drawing: 4620-224
14	10791	14243	14267	54 in.	Circular pipe	Missing US invert	Interpolate US invert from GIS data	See node data gap in Table 3-2b
14	10736	14202	14243	54 in.	Circular pipe	Missing DS invert	Interpolate DS invert from GIS data	See node data gap in Table 3-2b
14	25030	24787	14128	36 in.	Circular pipe	Missing US invert and DS invert	Use US node invert for US invert; use DS invert from record drawing	Record drawing 4620-220
14	20900	13627	13642	21 in.	Circular pipe	Missing US invert and DS invert	Use inverts from record drawing 4620-222	See node data gap in Table 3-2b
14	20899	13600	13627	21 in.	Circular pipe	Missing US invert and DS invert; negative slope	Interpolate US invert from GIS data; use DS invert from record drawings	See node data gap in Table 3-2b; interpolation results in negative slope
14	25180	24948	13750	54 in.	Circular pipe	Missing US invert	Interpolate US invert from GIS data	See node data gap in Table 3-2b
14	25179	13600	24948	54 in.	Circular pipe	Missing US invert and DS invert	Interpolate inverts from GIS data	See node data gap in Table 3-2b
14	17662	13508	13600	54 in.	Circular pipe	Missing DS invert	Interpolate DS invert from GIS data	See node data gap in Table 3-2b
15	10734	14357	14377	96 in.	Circular pipe	0% slope	Incorrect US and DS inverts; inverts from record drawing corrected slope	See node data gap in Table 3-2b
15	10731	13909	14053	84 in.	Circular pipe	Missing US invert	Interpolate US invert from GIS data	See node data gap in Table 3-2b
15	10730	13873	13909	84 in.	Circular pipe	Missing DS invert	Interpolate DS invert from GIS data	See node data gap in Table 3-2b
18	17504	12462	12610	48 in.	Circular pipe	Missing US invert	Use DS invert of US pipe	See node data gap in Table 3-2b
18	17503	12262	12462	48 in.	Circular pipe	Missing DS invert	Interpolate DS invert from GIS data	See node data gap in Table 3-2b
18	10604	12080	12262	48 in.	Circular pipe	Missing US invert and DS invert	Use US invert received from the county on 10/13/2011; use US invert of DS pipe for DS invert	See node data gap in Table 3-2b
18	10603	11978	12080	48 in.	Circular pipe	Missing US invert and DS invert	Use DS invert of US pipe for US invert; DS invert received from the country on 10/13/2011	See node data gap in Table 3-2b
18	10611	11949	11978	30 in.	Circular pipe	Missing US invert and DS invert	Interpolate US invert from GIS data; put DS invert same as US node invert which was obtained from record drawings	See node data gap in Table 3-2b; US invert (236.36) provided by County on 10/26/2011; generates negative slope so was not used on this junction
18	10610	11946	11978	48 in.	Circular pipe	US link invert below US node invert; negative slope	Use US node invert received from County on 10/26/2011 (matches record drawing); use DS node invert from record drawings	See node data gap in Table 3-2b
18	17443	11931	11949	30 in.	Circular pipe	Missing US invert and DS invert	Interpolate inverts from GIS data	See node data gap in Table 3-2b
18	10609	11929	11946	48 in.	Circular pipe	DS link invert is below DS node invert; negative slope	Use DS node invert received from County on 10/26/2011 (matches record drawing); US node invert from GIS matches the value on the record drawing	See node data gap in Table 3-2b
18	10485	11920	11929	48 in.	Circular pipe	Missing US invert	Interpolate US invert from GIS data	See node data gap in Table 3-2b
18	17440	11906	11920	48 in.	Circular pipe	Missing DS invert	Interpolate DS invert from GIS data	See node data gap in Table 3-2b
18	17441	11906	11931	18 in.	Circular pipe	Missing US invert and DS invert	Use US invert from County's e-mail on 10/11/2011; interpolate DS invert from US invert and calculated slope	See node data gap in Table 3-2b
18	25145	24902	11906	48 in.	Circular pipe	Missing US invert	Interpolate US invert from GIS data	See node data gap in Table 3-2b

TABLE 3-2A (CONTINUED)
Link Invert Data Gaps and Anomalies

Segment	Link GID	US Node GID	DS Node GID	Link Size	Link Type	Data Gap/Anomaly	Solution	Comment
18	25144	11739	24902	48 in.	Circular pipe	Missing DS invert	Interpolate DS invert from GIS data	See node data gap in Table 3-2b
18	17442	11906	11931	21 in.	Circular pipe	Missing US invert and DS invert	Use US invert received from County in e-mail on 10/11/2011; DS from the record drawings	See node data gap in Table 3-2b
19	17501	12269	12262	24 in.	Circular pipe	Missing US invert and DS invert; 0% Slope	Use inverts from County's notes on Storm Water 63 NW Map received on 10/11/2011	County's note: 24-in. pipe MH 12269-12262 has 0% slope, inverts 2 ft higher than main pipe
19	25155	12080	12089	27 in.	Circular pipe	Missing US invert and DS invert	Use inverts received from County on 10/13/2011	See node data gap in Table 3-2b
19	10599	11979	11984	30 in.	Circular pipe	Missing US invert and DS invert	Use inverts received from County on 10/26/2011	See node data gap in Table 3-2b
19	10613	11940	11984	44 in. × 72 in.	Arch	US link invert below US node invert	Record drawing confirms GIS	See node data gap in Table 3-2b; elevation difference is 0.02 ft; if error in model results, invert will be adjusted
19	10598	11969	11979	30 in.	Circular pipe	Missing US invert and DS invert	Use inverts received from County on 10/26/2011	See node data gap in Table 3-2b
19	10478	11701	11940	54 in.	Circular pipe	US invert lower than US node invert	Incorrect US invert on ArcGIS PGDB; use invert from record drawing: 240.51	See node data gap in Table 3-2b
19	17508	11951	11969	30 in.	Circular pipe	Missing US invert and DS invert	Use inverts received from County on 10/26/2011	See node data gap in Table 3-2b
19	17510	11915	11951	30 in.	Circular pipe	Missing US invert and DS invert	US invert Interpolated; DS invert received from County on 10/26/2011	See node data gap in Table 3-2b
19	17431	11471	11479	24 in.	Circular pipe	Drop of 4.80 ft at DS node	Use inverts in GIS match record drawing	See node data gap in Table 3-2b
19	10462	11464	11471	36 in.	Circular pipe	Drop of 5.80 ft at DS node	Use inverts in GIS match record drawing	See node data gap in Table 3-2b
19	10465	11881	11915	30 in.	Circular pipe	Missing US invert and DS invert	Use interpolate inverts from GIS data	See node data gap in Table 3-2b
19	10464	11706	11881	30 in.	Circular pipe	Missing US invert and DS invert	Use US invert received from the county on 10/13/2011; interpolate DS invert	See node data gap in Table 3-2b
19	10503	11706	11701	15 in.	Circular pipe	Missing US invert and DS invert; drop of 4.65 ft at DS node	Use inverts received from the county on 10/13/2011 (match record drawing)	See node data gap in Table 3-2b
19	10463	11471	11706	27 in.	Circular pipe	Missing US invert and DS invert	Use US invert from County's note on Storm Water 63 NW Map received on 10/11/2011; use DS invert received from the County on 10/13/2011	See node data gap in Table 3-2b
20	17654	13616	13569	36 in.	Circular pipe	Missing US invert and DS invert	Interpolate inverts from GIS data	See node data gap in Table 3-2b
20	10727	13569	13540	36 in.	Circular pipe	Missing US invert and DS invert	Interpolate US invert; use DS invert received from County on 10/26/2011	See node data gap in Table 3-2b
20	17582	13394	13540	36 in.	Circular pipe	Missing US invert and DS invert	Interpolate US invert; use DS invert received from County on 10/26/2011	See node data gap in Table 3-2b
20	25444	25169	13569	36 in.	Circular pipe	Missing US invert and DS invert	Interpolate inverts from GIS data	See node data gap in Table 3-2b
20	25443	13487	25169	36 in.	Circular pipe	Missing US invert and DS invert	Use US node invert for US invert; interpolate DS invert	See node data gap in Table 3-2b
20	10642	13323	13487	36 in.	Circular pipe	Missing DS invert	Use DS node invert	No invert available in the record drawing
20	10641	13317	13323	36 in.	Circular pipe	US link invert below US node invert	Record drawing has DS invert of US pipe (US of 13317) at 228.36 and outgoing link invert at 228.59. GIS has 228.59 for the node invert; use 228.36 for the US node invert	See node data gap in Table 3-2b; minor sump in node 13317 created
20	10640	13240	13317	42 in.	Circular pipe	US link invert below US node invert; DS link invert below DS node invert	Incorrect US invert and DS node invert; use correct inverts from the record drawing	See node data gap in Table 3-2b
20	10637	13022	13035	36 in.	Circular pipe	Missing US invert	Interpolate using record drawing	Slope interpolated from record drawing

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

TABLE 3-2B
Node Data Gaps and Anomalies

Segment	Node GID	Node Type	Data Gap/Anomaly	Solution	Comment
1	17390	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
1	17403	Yard inlet	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	Interpolate from GIS across 3 links
1	17509	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	Interpolate from GIS across 4 links
1	17562	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	Interpolate from GIS across 5 links
1	17717	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	Interpolate from GIS across 4 links
1	17761	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	Interpolate from GIS across 3 links
1	18036	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
1	18080	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
1	18120	End wall	Missing invert elevation and rim elevation	Use invert and rim elevations from survey photos	—
1	18581	End wall	Missing invert elevation and rim elevation	Use invert and rim elevations from survey photos	Put invert of east pipe (91.64); comment has invert of center (91.58) and west pipe (91.57)
1	18628	End wall	Missing invert elevation and rim elevation	Use invert and rim elevations from survey photos	Put invert of east pipe (91.21); comment has invert of center (91.67) and west pipe (91.39)
1	18925	End wall	Missing invert elevation and rim elevation	Use invert elevation from US invert of DS pipe; rim elevation from contours	—
1	18977	Junction	Missing invert elevation and rim elevation	Interpolate invert using slope provided by County; rim elevation from contours	Slope of 1.2% received from County in e-mail 10/12/11
1	18990	Junction	Missing invert elevation and rim elevation	Interpolate invert using slope provided by County; rim elevation from contours	Interpolate across 3 links; slope of 1.2% received from County in e-mail 10/12/11
1	19005	Catchbasin	Missing invert elevation and rim elevation	Interpolate invert using slope provided by County; rim elevation from contours	Interpolate across 4 links; slope of 1.2% received from County in e-mail 10/12/11
1	19024	Catchbasin	Missing invert elevation and rim elevation	Interpolate invert using slope provided by County; rim elevation from contours	Interpolate across 5 links; slope of 1.2% received from County in e-mail 10/12/11
1	19043	Catchbasin	Missing invert elevation and rim elevation	Interpolate invert using slope provided by County; rim elevation from contours	Interpolate across 6 links; slope of 1.2% received from County in e-mail 10/12/11
1	19064	End wall	Missing invert elevation and rim elevation	Use invert and rim elevations from survey photo	—
1	25018	Catchbasin	Missing invert elevation and rim elevation	Interpolate invert elevation using US invert from survey photo and the slope provided by County; rim elevation from contours	Slope of 1.2% received from County in e-mail 10/12/11
2	17054	Grate inlet	Missing rim elevation	Use rim elevation from contours	—
2	17099	Grate inlet	Missing rim elevation	Use rim elevation from contours	—
2	17184	Grate inlet	5.10-ft drop; US invert of DS pipe higher than node invert	Use US invert of DS pipe invert and rim elevations which results in 4.45-ft drop	—
2	17198	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
2	17210	Catchbasin	Missing invert elevation and rim elevation	Use invert and rim elevations from record drawing 4620-229	—
2	17223	Catchbasin	Missing invert elevation and rim elevation	Use invert and rim elevations from record drawing 4620-229	—
2	17235	Catchbasin	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
2	17250	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
2	17259	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
2	17272	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
2	17336	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—

TABLE 3-2B (CONTINUED)
Node Data Gaps and Anomalies

Segment	Node GID	Node Type	Data Gap/Anomaly	Solution	Comment
2	17404	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
2	17405	Catchbasin	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
2	17412	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
2	17429	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
2	17436	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
2	17535	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
3	16430	Box culvert	US invert 0.33 ft lower than US node invert	Use inverts as provided on the referenced record drawing	—
3	16493	Catchbasin	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
3	16964	Catchbasin	Missing rim elevation	Use rim elevation from contours	—
3	17022	Catchbasin	Missing rim elevation	Use rim elevation from contours	—
3	17074	Yard inlet	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
3	23714	Grate inlet	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
4	15921	End wall	Missing invert elevation and rim elevation	Use invert elevation from survey photo; rim elevation from contours	—
4	15928	End wall	Missing invert elevation and rim elevation	Extrapolate invert elevation from GIS data; rim elevation from contours	—
4	16475	End wall	Missing invert elevation and rim elevation	Use invert and rim elevations from survey photos	—
4	16723	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
4	16730	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
4	16818	Junction	Missing invert elevation and rim elevation	Use invert elevation pulled from US invert of DS pipe (record drawing); rim elevation from contours	—
4	16980	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
4	17159	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
5	15861	End wall	Missing invert elevation and rim elevation	Use invert elevation from survey photo; rim elevation from contours	—
5	15921	End wall	Missing invert elevation and rim elevation	Use invert elevation from survey photo; rim elevation from contours	—
6	13687	Manhole	Missing invert elevation and rim elevation	Extrapolate invert elevation; rim elevation = 2 ft ground cover + crown of the link as determined by 2% slope communicated by County on 10/26/2011	—
6	13788	Catchbasin	Missing invert elevation and rim elevation	Extrapolate invert elevation; rim elevation = 2 ft ground cover + crown of the link as determined by 2% slope communicated by County on 10/26/2011	—
6	13940	Manhole	Missing invert elevation and rim elevation	Extrapolate invert elevation; rim elevation from contours	—
6	14717	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from the design drawings for ARNG Headquarters Readiness Center wing addition	—
6	15348	End wall	Missing invert elevation and rim elevation	Use DS invert of US pipe as node invert; rim elevation from contours	—
6	24934	Manhole	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; use rim elevation from the design drawings for ARNG Headquarters Readiness Center wing addition	—
6	24935	Manhole	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; use rim elevation from the design drawings for ARNG Headquarters Readiness Center wing addition	—
6	24936	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from the design drawings for ARNG Headquarters Readiness Center wing addition	—
6	24941	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from the design drawings for ARNG Headquarters Readiness Center wing addition	—

TABLE 3-2B (CONTINUED)
Node Data Gaps and Anomalies

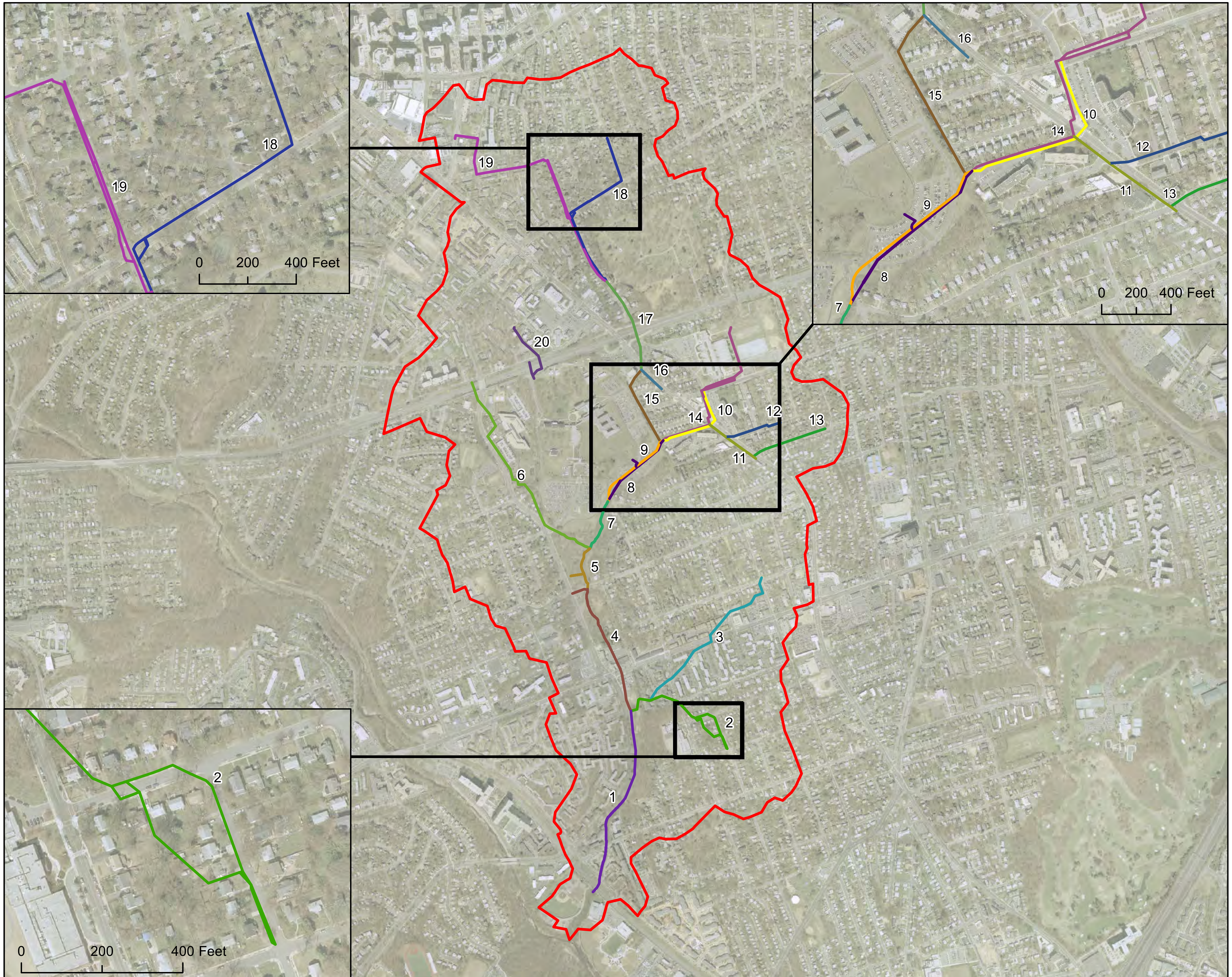
Segment	Node GID	Node Type	Data Gap/Anomaly	Solution	Comment
6	24942	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from the design drawings for ARNG Headquarters Readiness Center wing addition	—
6	24944	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from the design drawings ARNG Headquarters Readiness Center wing addition	—
6	24945	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from the design drawings ARNG Headquarters Readiness Center wing addition	—
8	14607	Other	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
8	14644	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from record drawing	—
8	14677	Manhole	Missing invert elevation and rim elevation; negative slope of DS link 17732	Interpolate invert elevation from GIS data; rim elevation from contours	Interpolation results in negative slope
8	14991	Junction	Missing invert elevation and rim elevation	Use invert elevation pulled from US invert of DS pipe; rim elevation from contours	—
9	14904	Manhole	Missing invert elevation and rim elevation	Use invert elevation pulled from DS invert of US pipe; rim elevation from contours	—
9	15016	End wall	Missing invert elevation and rim elevation	Use invert and rim elevations from survey photos	—
10	14212	Manhole	US invert of DS link is higher than DS invert of US link	US invert of the DS link 10761 was incorrect on ArcGIS PGDB, correct using the referenced record drawing	—
10	14364	Manhole	Missing rim elevation	Rim elevation from contours	—
11	24753	Manhole	Missing invert elevation and rim elevation	Use invert elevation pulled from US invert of DS pipe; rim elevation from contours	—
11	24888	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from record drawing	—
12	24760	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from record drawing	—
13	24883	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from record drawing	—
13	24884	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from record drawing	—
13	24885	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from record drawing	—
13	24886	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from record drawing	—
13	24887	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations from record drawing	—
14	13600	Manhole	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	Interpolation results in negative slope
14	13627	Yard inlet	Missing invert elevation and rim elevation; negative slope of US link 20899	Use invert elevation pulled from US invert of DS pipe (from record drawing 4620-222); rim elevation from record drawing	—
14	14243	Grate inlet	Missing invert elevation	Interpolate invert elevation from GIS data	—
14	24948	Manhole	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
15	13909	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
15	14357	Yard inlet	Incorrect invert elevation. Missing rim elevation	Use invert from record drawing; rim elevation from contours	Use record drawing 4620-224
17	12940	Manhole	Drop of 4.58 ft at the node	Inverts in GIS match record drawing	—
18	11620	Manhole	Missing rim elevation	Rim elevation from contours	—
18	11920	Catchbasin	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
18	11931	Catchbasin	Missing invert elevation and rim elevation	Use invert elevation pulled from US invert of DS pipe; rim elevation from record drawing	—
18	11946	Manhole	US link invert below the node invert; negative slope of DS link 10610	Node invert received from County on 10/26/2011; matches record drawing	—
18	11949	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—

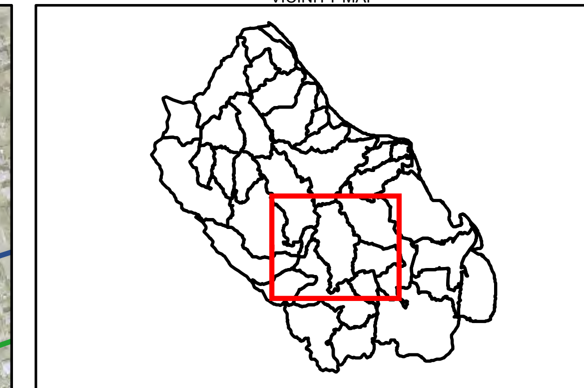
TABLE 3-2B (CONTINUED)
Node Data Gaps and Anomalies

Segment	Node GID	Node Type	Data Gap/Anomaly	Solution	Comment
18	11978	Catchbasin	Missing invert elevation and rim elevation	Use invert elevation and rim elevation from record drawing	—
18	12080	Manhole	Missing invert elevation and rim elevation	Use invert elevation pulled from US invert of DS pipe from information received from County on 10/13/11; rim elevation from contours	—
18	12462	Junction	Missing invert elevation and rim elevation	Use invert elevation pulled from US invert of DS pipe; rim elevation from contours	—
18	24902	Manhole	Missing invert elevation and rim elevation	Interpolate invert from GIS; rim elevation from contours	—
19	11471	Manhole	Drop of 5.80 ft the node	Use inverts as provided on the record drawing	—
19	11479	Manhole	Drop of 4.80 ft at the node	Use inverts as provided on the record drawing	—
19	11701	Manhole	Drop of 4.65 ft at the node; US invert of DS link 10477 lower than the node invert	Use DS invert of US link and the node invert as provided on the record drawing. Incorrect US link invert on ArcGIS PGDB; use invert from record drawing	—
19	11706	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/13/2011	—
19	11881	Manhole	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
19	11915	Catchbasin	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; elevation from contours	—
19	11940	Manhole	US invert of DS link 10613 below the node invert	Record drawing confirms GIS	Elevation difference = 0.02 ft; if error in model results, invert will be adjusted
19	11951	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
19	11969	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
19	11979	Manhole	Missing invert elevation and rim elevation	Use invert and rim elevations received from County on 10/26/2011	—
20	13240	Manhole	US link invert of DS link 10640 is below the node invert	Incorrect link invert corrected from record drawing; use node invert from record drawing	—
20	13317	Manhole	DS invert of US link 10640 below node invert	Use node invert from record drawing	—
20	13394	Manhole	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
20	13540	Catchbasin	Missing invert elevation and rim elevation	Use invert elevation received from County on 10/26/2011; rim elevation from contours	—
20	13569	Junction	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
20	13616	Other	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—
20	25169	Catchbasin	Missing invert elevation and rim elevation	Interpolate invert elevation from GIS data; rim elevation from contours	—

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

Figures





Legend

Doctor's Branch Boundary

Segment Number

- 1 (Stream Segments)
- 2
- 3
- 4 (Stream Segments)
- 5 (Stream Segments)
- 6 (Stream Segments)
- 7 (Stream)
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20

Note: "Stream" indicates a segment whollly made up of a natural stream. "Stream Segments" indicates a segment made up of both stream channel and closed pipe networks. The lack of qualifier indicates that the segment is wholly made up of a closed pipe network.

N

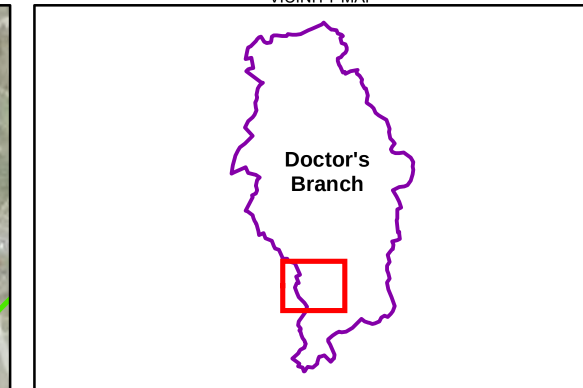
0 375 750 1,500

Feet

FIGURE 1-1
Major Storm Sewer Network Segments
GIS Data Gaps and Anomalies – Doctor's Branch
Arlington County Storm Capacity Analysis

CH2MHILL

VICINITY MAP



Legend

- Doctor's Branch Boundary
- Link and Network Anomaly
- Stormwater Mains ≥ 36"

N

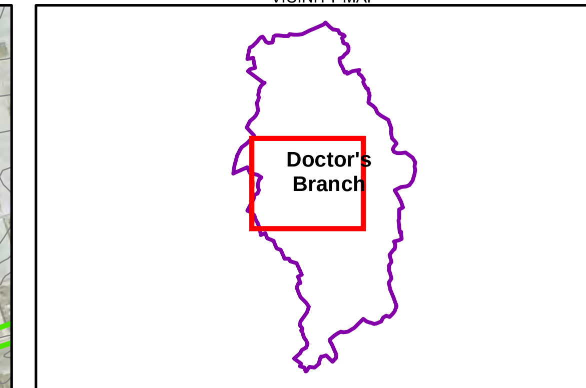
0 40 80 160
Feet

FIGURE 3-1
Network Anomalies
GIS Data Gaps and Anomalies – Doctor's Branch
Arlington County Storm Capacity Analysis

FIGURE 3-2
Network Anomalies
GIS Data Gaps and Anomalies – Doctor's Branch
Arlington County Storm Capacity Analysis

CH2MHILL

VICINITY MAP



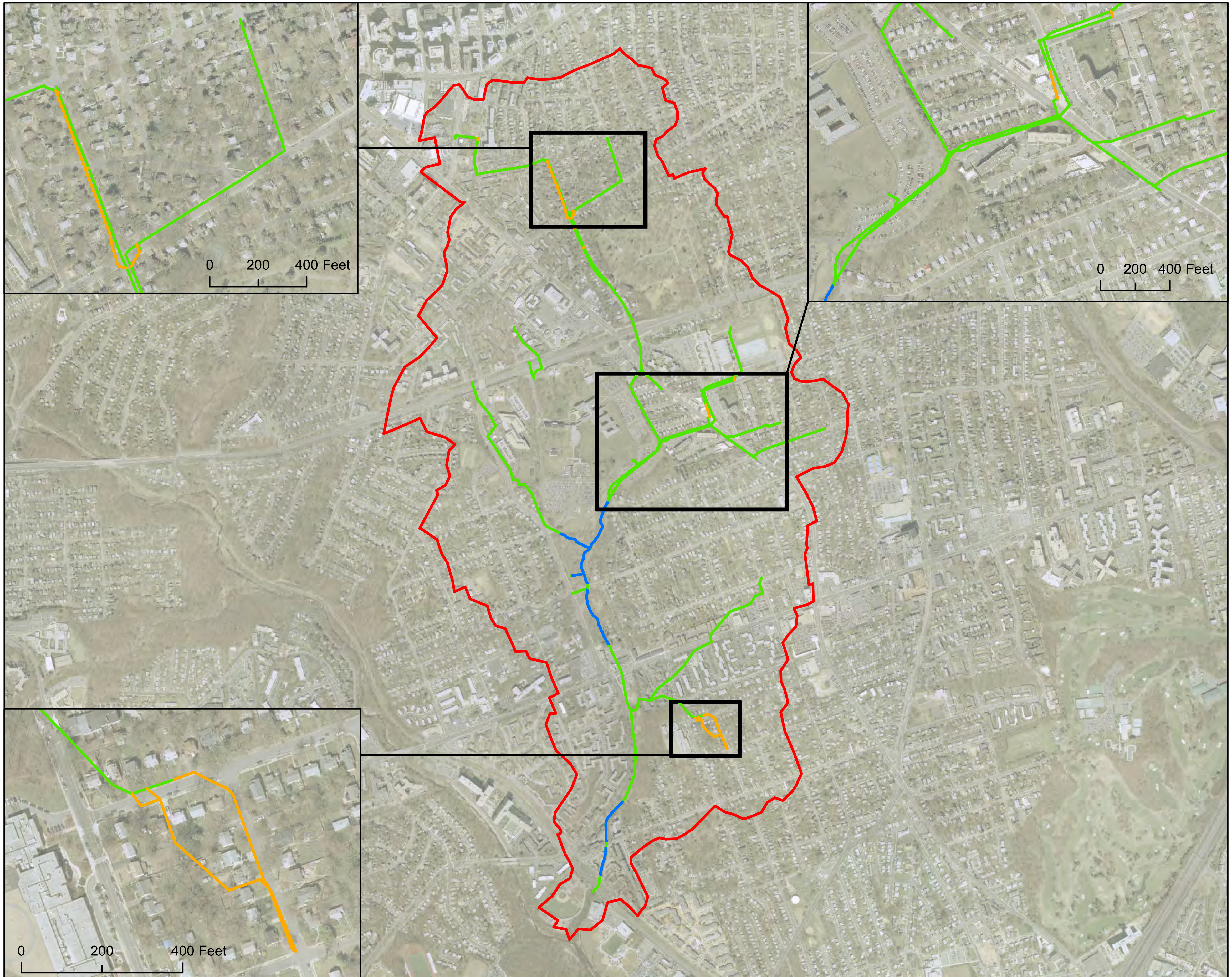
Legend

- Doctor's Branch Boundary
- Link and Network Anomaly
- Stormwater Mains ≥ 36"
- Arlington Co. 2ft Contours

N

0 80 160 320
Feet

FIGURE 3-3
Network Anomalies
GIS Data Gaps and Anomalies – Doctor's Branch
Arlington County Storm Capacity Analysis



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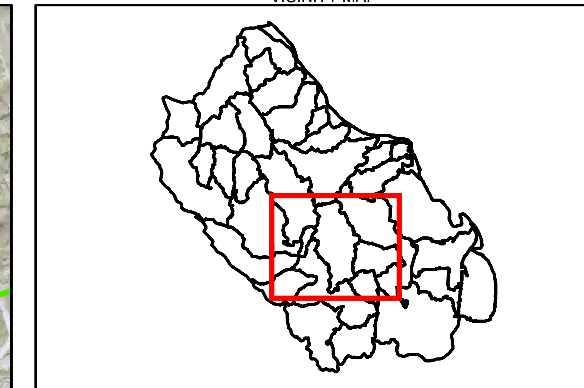
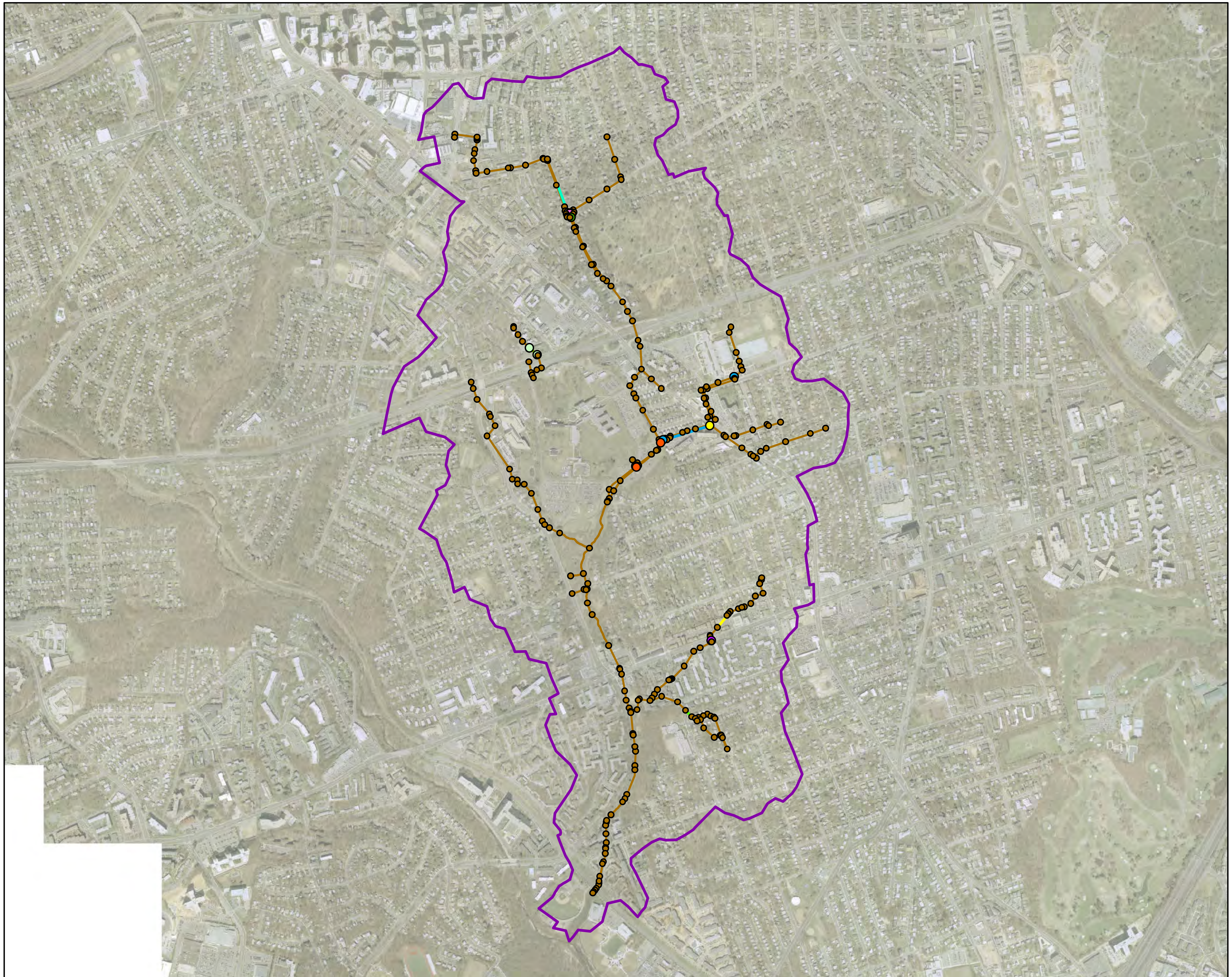


Legend

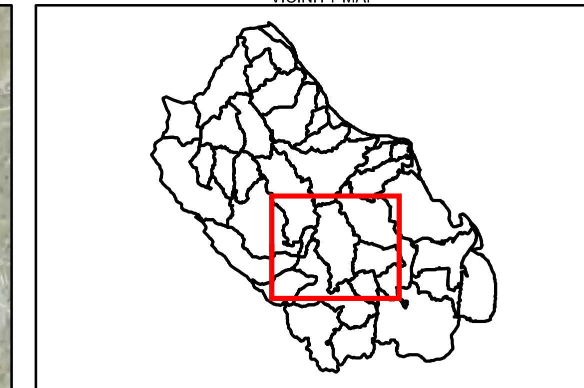
- Doctor's Branch Boundary
- Modeled Stormwater Mains ≥ 36"
- Modeled Stormwater Mains < 36"
- Stream

0 375 750 1,500
Feet

FIGURE 3-4
Modeled Network Segments
GIS Data Gaps and Anomalies – Doctor's Branch
Arlington County Storm Capacity Analysis



VICINITY MAP



Legend

Stormwater Junctions

- Incorrect Node Type; Negative slope of US link
- Negative slope of DS link
- Negative slope of US link
- US Invert lower than US node invert
- US Invert of DS link is below node invert
- US Invert of DS link is higher than DS Invert of US link
- US link invert below the node invert and Negative slope of DS link
- No Problems

Stormwater Mains ≥ 36"

- 0% Slope
- DS Invert lower than DS node invert
- DS Invert lower than DS node invert and Negative slope
- Drop of greater than 4 feet
- Incorrect Inverts
- Negative Slope
- US Invert higher than DS Invert
- US Invert lower than US node invert
- US Invert lower than US node invert and DS link invert below DS node invert
- US Invert lower than US node invert and Negative slope
- No Problems
- Revised Watershed Boundary

Note:
US: upstream
DS: downstream

N

0 250 500 1,000 1,500
Feet

FIGURE 3-5
Invert Anomalies
GIS Data Gaps and Anomalies - Doctor's Branch
Arlington County Storm Capacity Analysis

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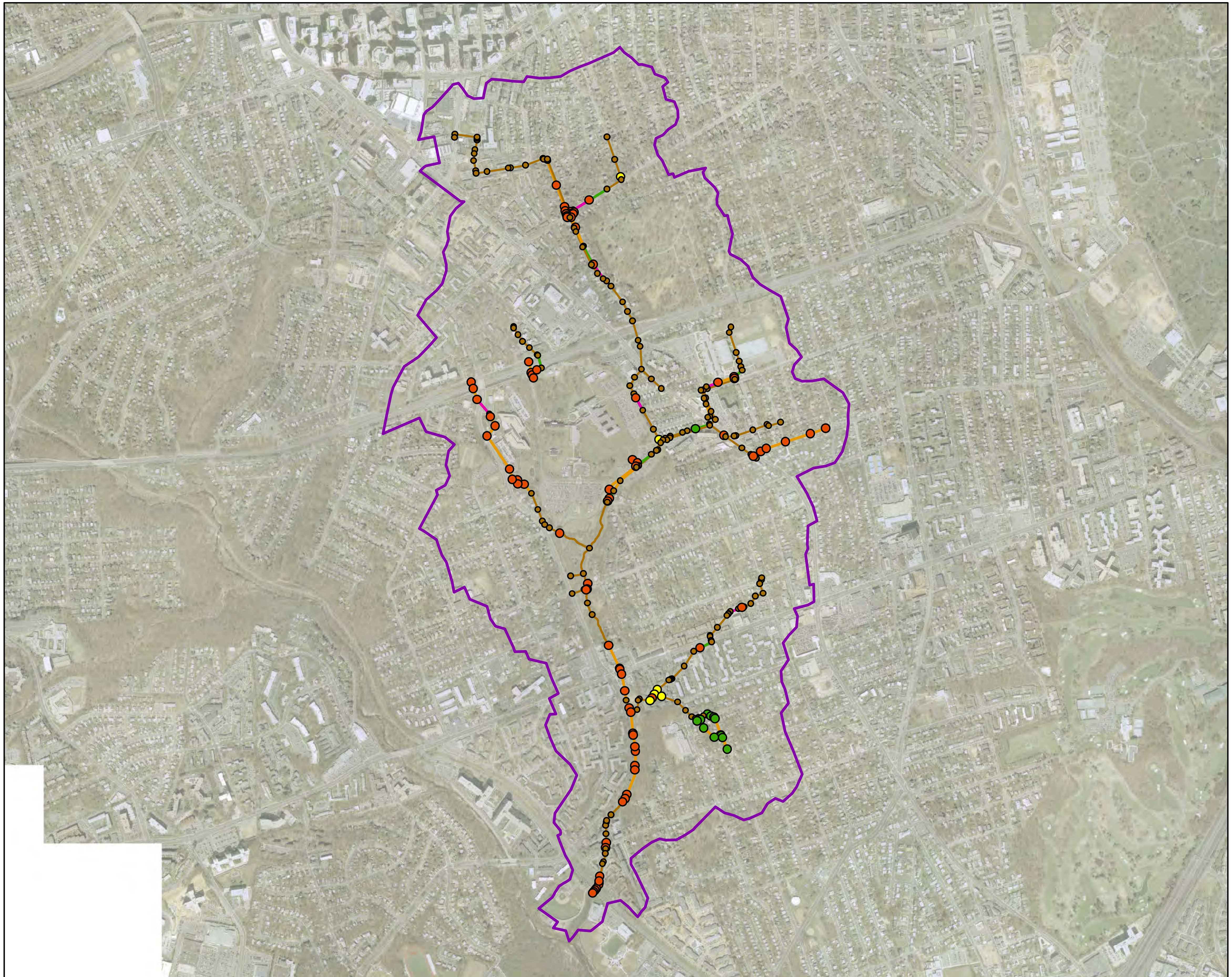
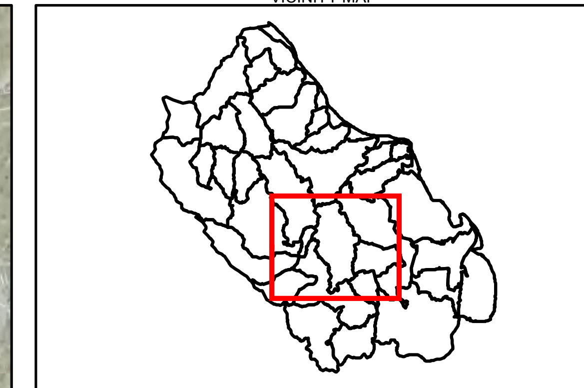


VICINITY MAP



Legend

Stormwater Junctions

- Missing Invert elevation
- Missing Invert elevation and Rim elevation
- Missing Rim elevation
- No Problems

Stormwater Mains ≥ 36"

- Missing US Invert
- Missing US and DS Invert
- Missing DS Invert
- Missing US Invert and incorrect DS Invert
- No Problems
- Revised Watershed Boundary

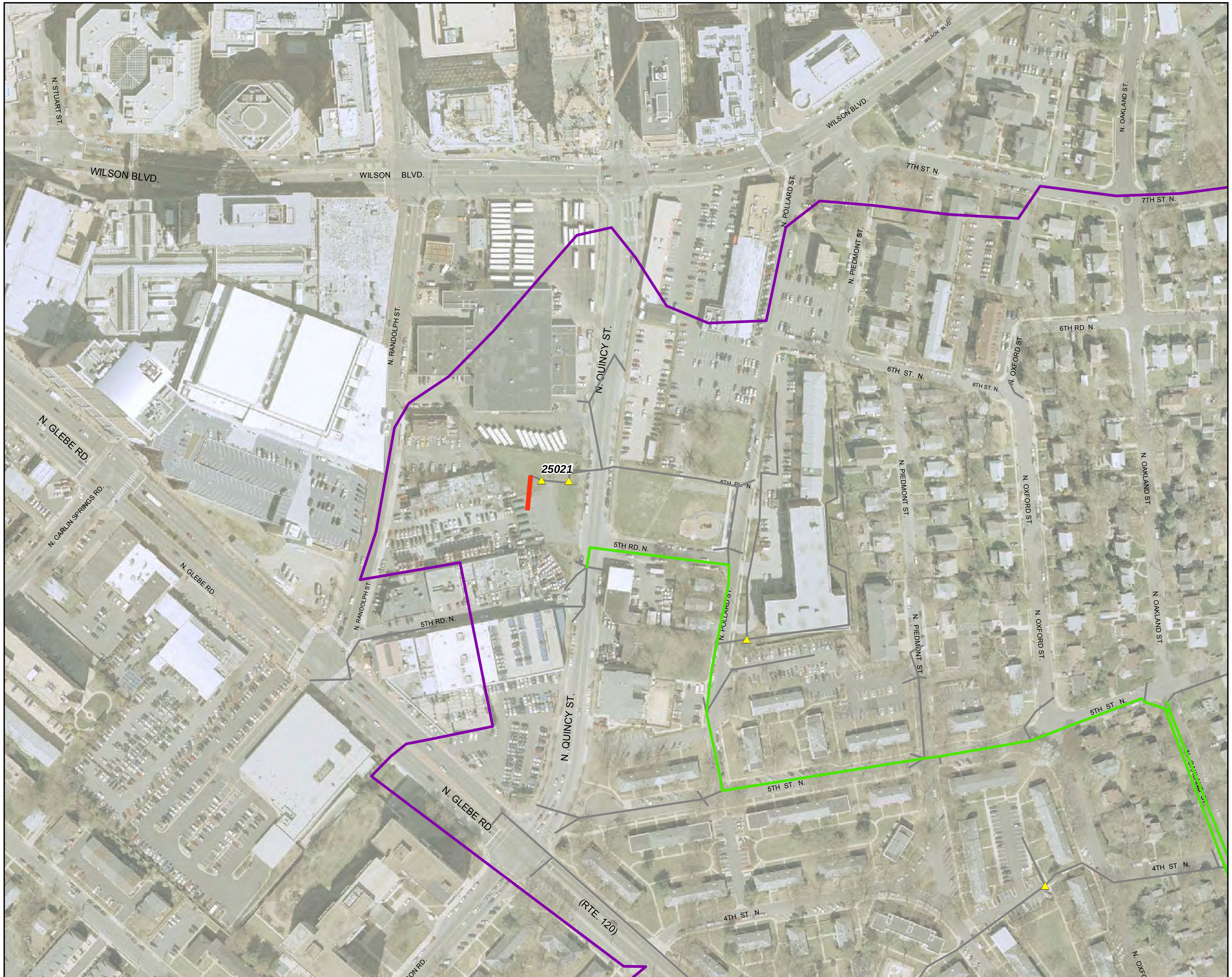
Note:
US: upstream
DS: downstream

N

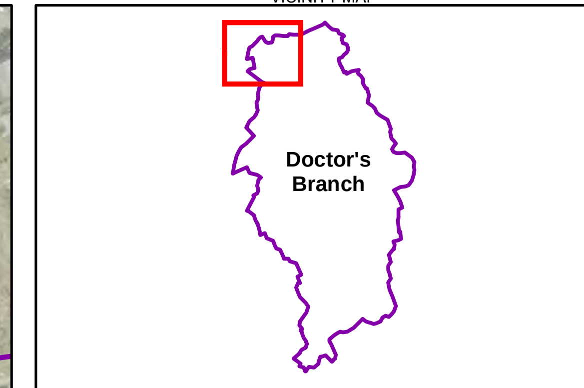
0 250 500 1,000 1,500
Feet

FIGURE 3-6
Invert and Rim Elevation Data Gaps
GIS Data Gaps and Anomalies - Doctor's Branch
Arlington County Storm Capacity Analysis

CH2MHILL



VICINITY MAP



Legend

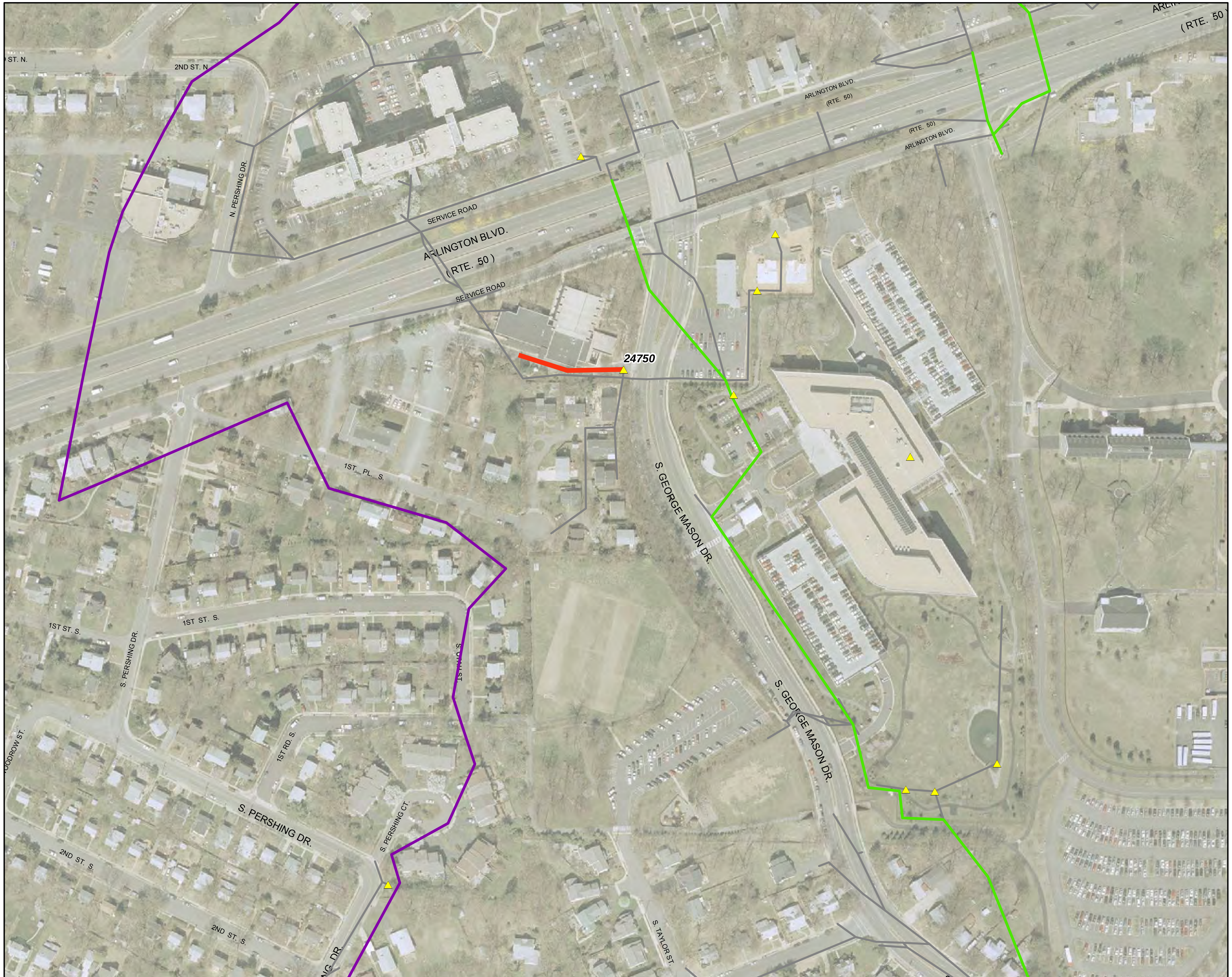
- Doctor's Branch Boundary
- Detention Outlet
- Storage Structure
- Stormwater Mains ≥ 36"
- Stormwater Mains < 36"

N

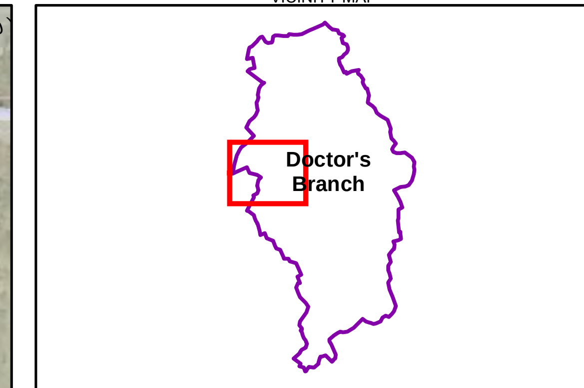
0 55 110 220
Feet

FIGURE 3-7
Doctor's Branch Storage Structures
GLS Data Gaps and Anomalies – Doctor's Branch
Arlington County Storm Capacity Analysis

CH2MHILL



VICINITY MAP



Legend

- Doctor's Branch Boundary
- Detention Outlet
- Storage Structure
- Stormwater Mains ≥ 36"
- Stormwater Mains < 36"

N

0 55 110 220

Feet

FIGURE 3-8
Doctor's Branch Storage Structures
GIS Data Gaps and Anomalies – Doctor's Branch
Arlington County Storm Capacity Analysis

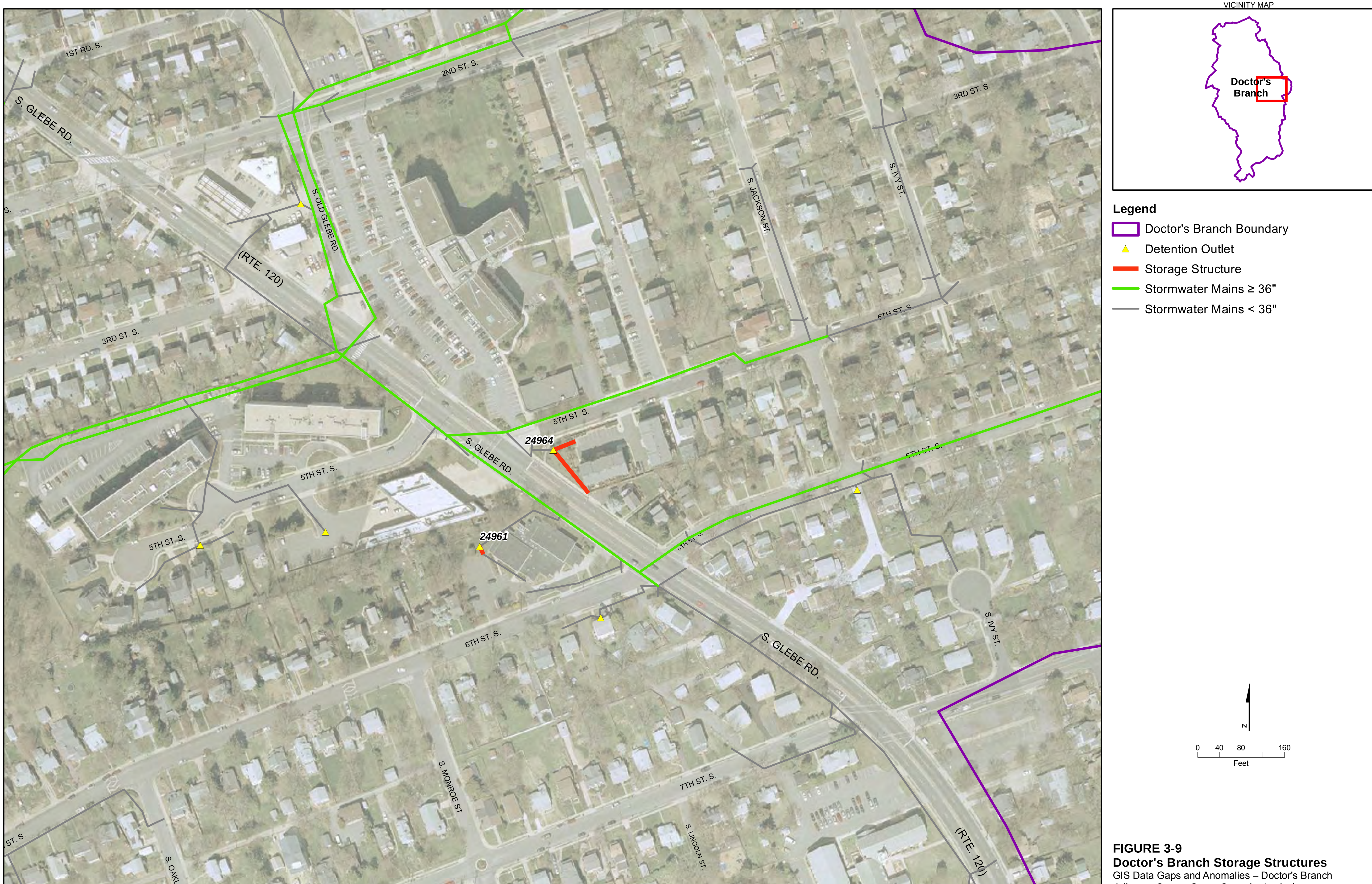


FIGURE 3-9
Doctor's Branch Storage Structures
GIS Data Gaps and Anomalies – Doctor's Branch
Arlington County Storm Capacity Analysis

\\orion\Proj\ArlingtonVACountyOf\392309StormWaterCap\WSDoctorsBranch\WorkingGIS\Layout\DataGapsTM\Figure3-9_StorageStructures.mxd

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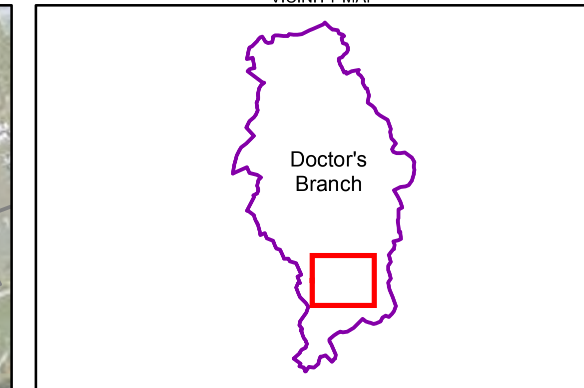

Legend

- Doctor's Branch Boundary
- Detention Outlet
- Storage Structure
- Modeled Stormwater Mains< 36"
- Stormwater Mains ≥ 36"
- Stormwater Mains < 36"

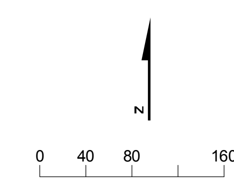

FIGURE 3-10
Doctor's Branch Storage Structures
GIS Data Gaps and Anomalies – Doctor's Branch
Arlington County Storm Capacity Analysis

\\orion\Proj\ArlingtonVACountyOf\392309StormWaterCap\WSDoctorsBranch\WorkingGIS\Layout\DataGapsTM\Figure3-10_StorageStructures.mxd

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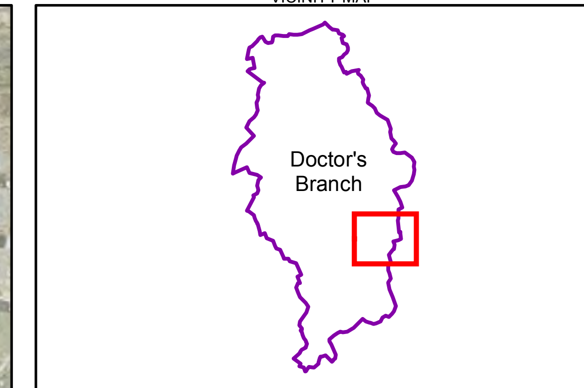


Legend

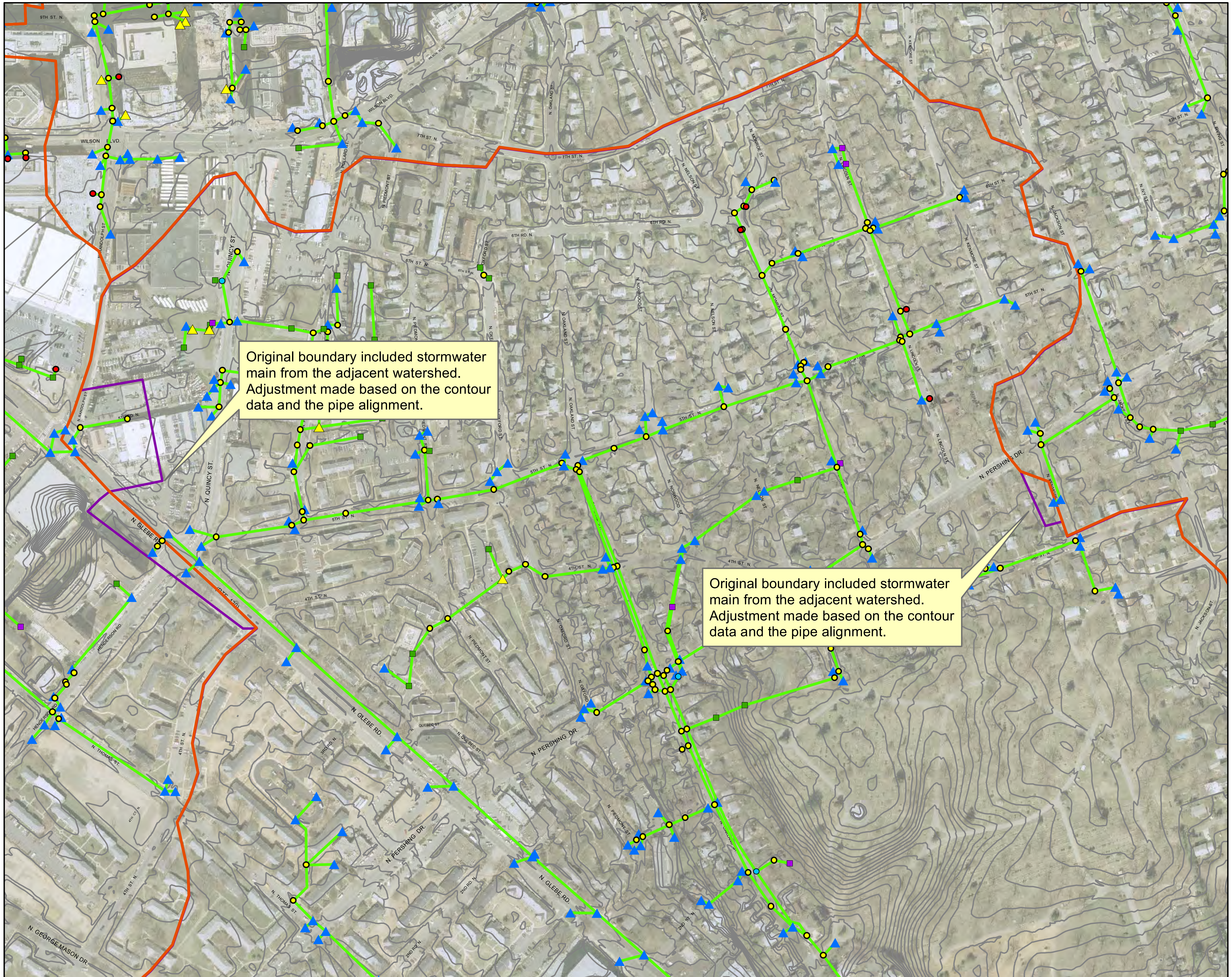
- Doctor's Branch Boundary
- Detention Outlet
- Storage Structure
- Stormwater Mains ≥ 36"
- Stormwater Mains < 36"

N

0 40 80 160 Feet

FIGURE 3-11
Doctor's Branch Storage Structures
GIS Data Gaps and Anomalies – Doctor's Branch
Arlington County Storm Capacity Analysis

Attachment A



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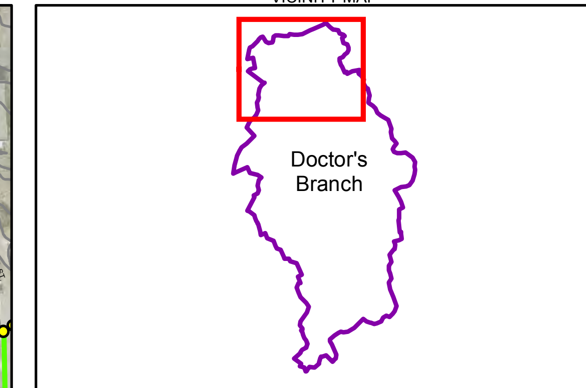

Legend

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

0 100 200 400
Feet

FIGURE A1
Boundary Anomalies
GIS Data Gaps and Anomalies - Doctor's Branch
Arlington County Storm Capacity Analysis

\\orion\Proj\ArlingtonVACountyOf\392309StormWaterCap\WSDoctorsBranch\WorkingGIS\Layout\DataGapsTM\Figure_A1_Boundary_Anomalies.mxd

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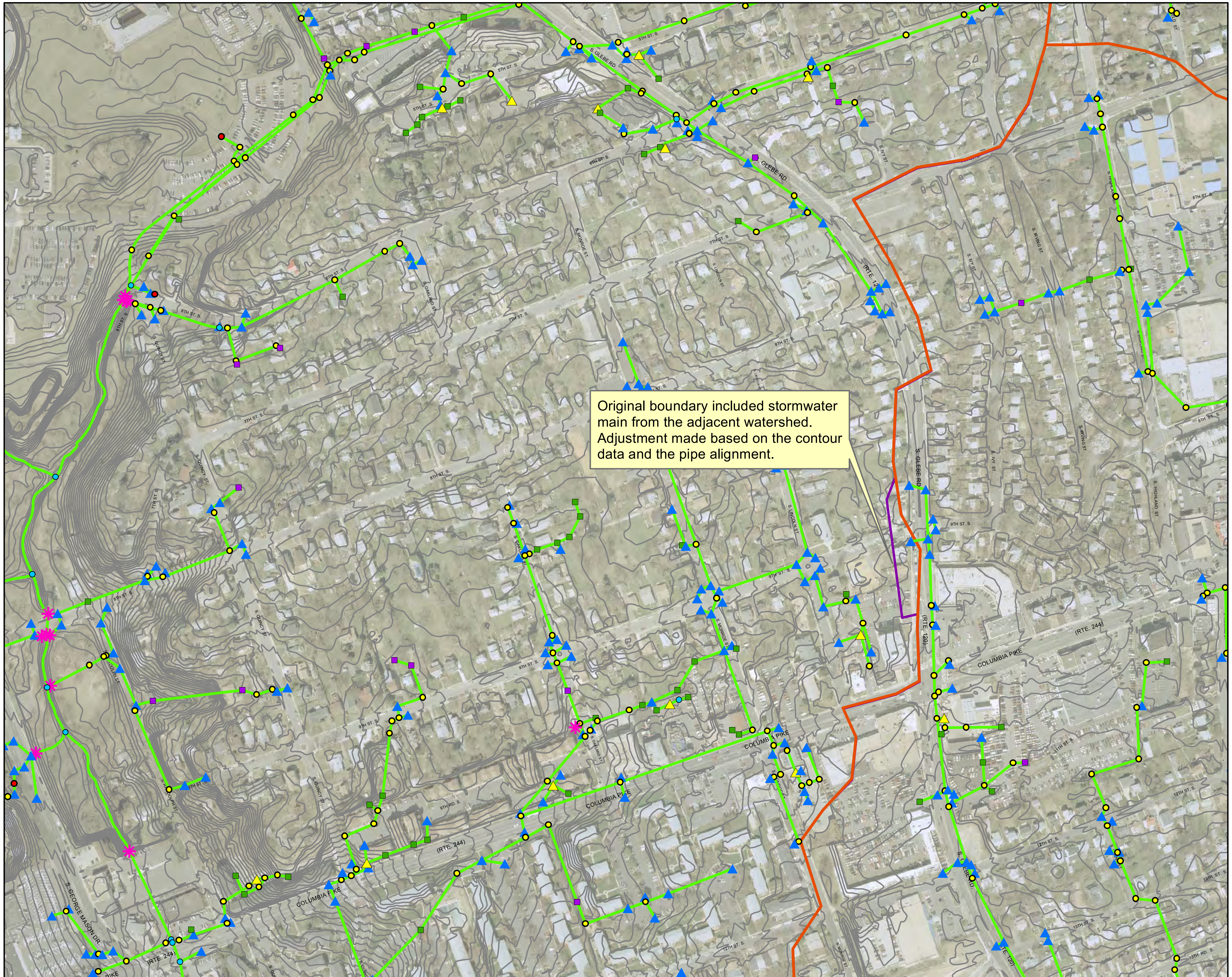
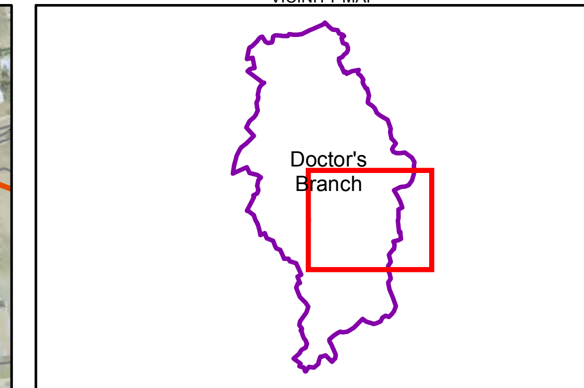


VICINITY MAP



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

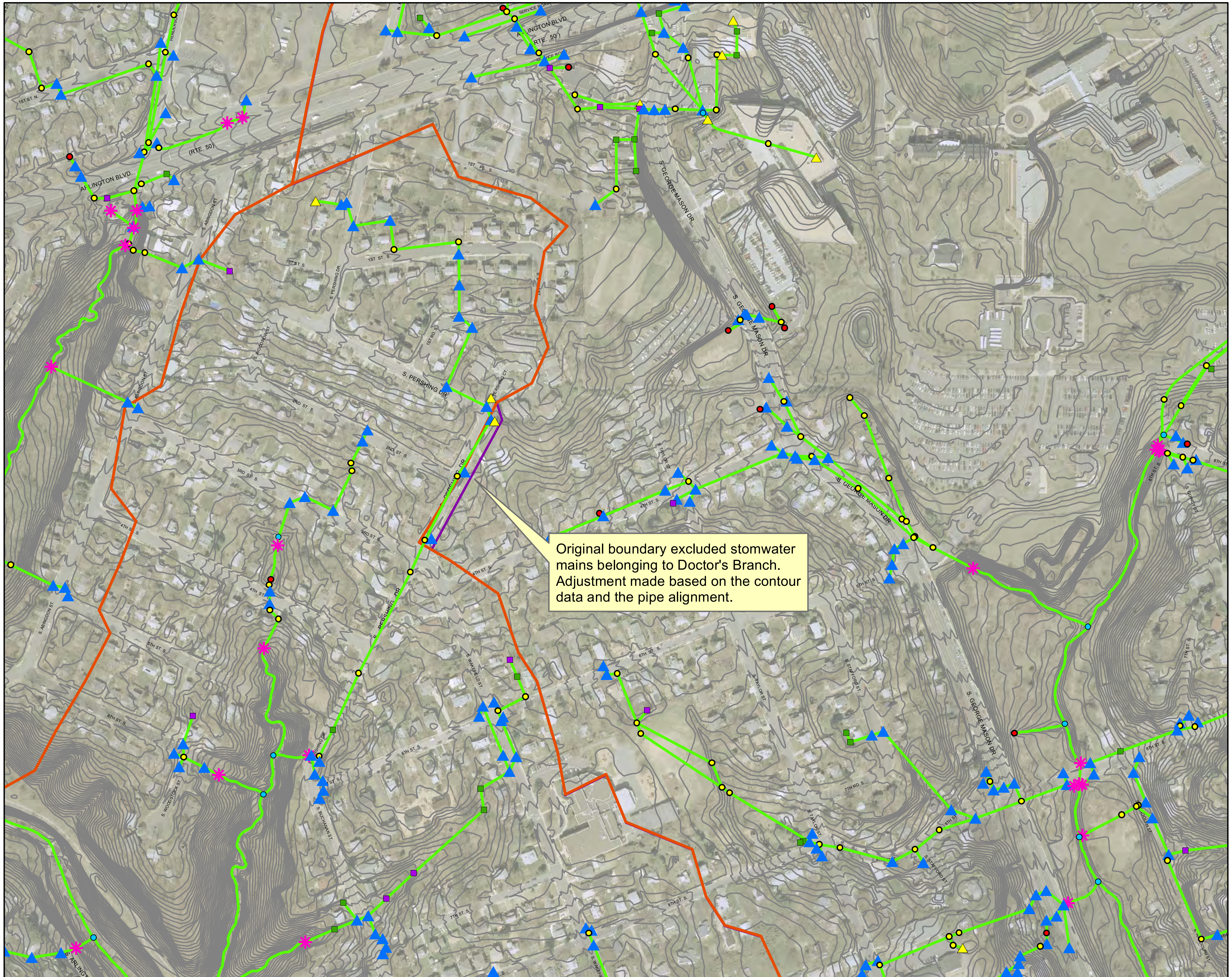
Arlington Co. 2 ft Contours

0 100 200 400
Feet

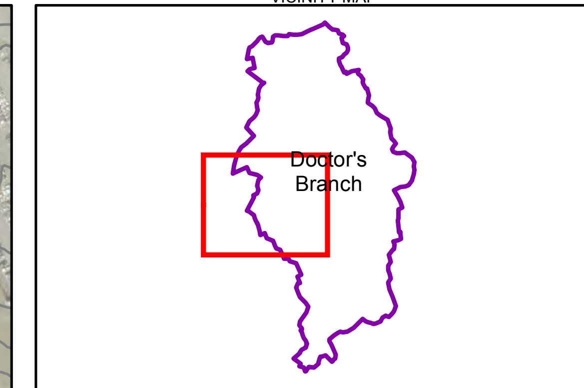
FIGURE A2
Boundary Anomalies
GIS Data Gaps and Anomalies - Doctor's Branch
Arlington County Storm Capacity Analysis

\\orion\Proj\ArlingtonVACountyOf\392309StormWaterCap\WSDoctorsBranch\WorkingGIS\Layout\DataGapsTM\Figure_A2_Boundary_Anomalies.mxd

CH2MHILL



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

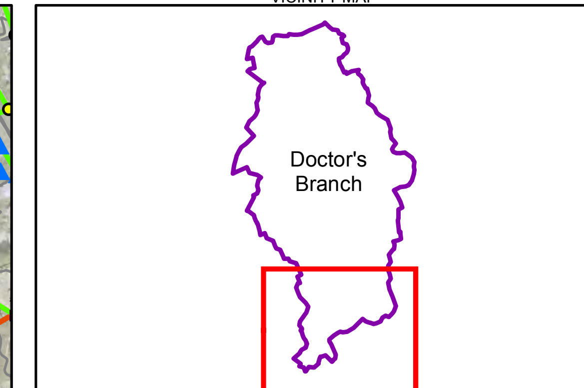
N

0 100 200 400
Feet

FIGURE A3
Boundary Anomalies
GIS Data Gaps and Anomalies - Doctor's Branch
Arlington County Storm Capacity Analysis

\\orion\Proj\ArlingtonVACountyOf\392309StormWaterCap\WSDoctorsBranch\WorkingGIS\Layout\DataGapsTM\Figure_A3_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

0 100 200 400
Feet

FIGURE A4
Boundary Anomalies
GIS Data Gaps and Anomalies - Doctor's Branch
Arlington County Storm Capacity Analysis

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
4C	Urban 70%; Sassafras 15% (0–6 inches sandy loam); Neabsco 10% (0–8 inches loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
9C	Sassafras 85% (0–6 inches sandy loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
10D	Urban 70%; Glenelg 20% (0–1 inch loam; 1–6 inches silt loam)	Pervious, mostly Glenelg; 1–6 inches	Silty loam
11C	Urban 70%; Sassafras 15% (0–6 inches sandy loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
12	Urban 85%; Udorthents 15%	Pervious Udorthents	Loam
13	Udorthents 90%	Pervious Udorthents	Loam
15D	Sassafras 45% (0–6 inches sandy loam); urban 40%	Pervious, mostly Sassafras; 0–6 inches	Sandy 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
11471	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from an unknown junction to a manhole.
11479	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from an unknown junction to a manhole.
11701	Junction	Updated rim data.
12269	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from an unknown junction to a manhole.
12940	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from an unknown junction to a manhole. Updated rim data.
13487	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from catchbasin to a manhole.
13569	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from an unknown junction to a manhole.
14377	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from an unknown junction to a manhole.
16264	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from an unknown junction to a manhole.
16387	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from an unknown junction to a manhole. Updated invert data.
17184	Junction	Updated invert data.

Rim Elevation Updates from September 2012

Junction ID	Original Model Rim Elevation (ft)	Revised Rim Elevation (ft)
12846	214.92	217.25
13154	207.80	211.95
14364	188.00	185.78
14490	183.38	190.00
14499	185.00	190.00
14542	183.00	188.07
14607	188.00	186.00
14644	178.07	186.00
14668	177.60	185.78
14688	177.37	185.52
14825	171.94	184.98
16110	190.72	188.58
16441	171.00	174.61
16535	161.00	171.81
16698	157.50	163.59
16855	152.50	144.77
16980	140.00	137.45
17159	132.00	129.76
17178	125.80	128.00
17198	128.00	126.73
17235	173.25	170.59
17249	167.23	165.19
17250	173.55	171.17
17272	167.20	166.32
23714	192.00	189.22
25018	96.00	94.00