Technical Memorandum

Sewershed and Watershed Delineations

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Consolidated TMDL Implementation Plan – Draft Comprehensive Baseline Analysis
August 29, 2014

DISTRICT DEPARTMENT OF THE ENVIRONMENT

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1 Introduction

The District Department of Environment (DDOE) is required to develop a Consolidated Total Maximum Daily Load (TMDL) Implementation Plan (IP) as established in the District's Municipal Separate Storm Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) permit (U. S. EPA 2011 and U. S. EPA 2012). The IP will define and organize a multi-year process centered on reducing pollutant loads originating within the District MS4. The level of pollutant control will be based on past TMDL studies performed to protect impaired water bodies in the District. The IP will include a summary of the regulatory compliance strategy to satisfy TMDL-related permit requirements, a summary of data and methods used to develop the IP, specific prioritized recommendations for stormwater control measures, a schedule for implementation and attainment of Waste Load Allocations (WLAs), and a method for tracking progress. Substantial public involvement will be sought in plan development.

This Technical Memorandum on *Sewershed and Watershed Delineations* is one in a series of technical memoranda that provide detailed information on research, analysis, programs and procedures that support development of the Consolidated TMDL IP.

2 Purpose

The delineation of watersheds and sewersheds is critical to identifying where MS4 WLAs and nonpoint source LAs apply on the ground. By identifying the spatial extent of each TMDL watershed and sewershed, it is possible to calculate the current pollutant loads being generated, plan for the implementation of BMPs in specific locations, track the load reduction from BMP implementation, and evaluate load reduction to track progress towards meeting applicable MS4 WLAs and LAs.

The methods for delineating MS4 and nonpoint source direct drainage areas, assigning WLAs and LAs to GIS polygons based on those delineations, and performing QA/QC on the delineations and assignments, are discussed under **Technical Approach** below. The **Results and Discussion** section presents the results of the delineations and assignment of WLAs and LAs and the ramifications of these results on load calculations, load reduction tracking, and development and implementation of the Consolidated TMDL IP.

3 Technical Approach

3.1 Initial Delineation of MS4 and Mainstem Direct Drainage Areas

DDOE performed an initial delineation of watersheds and subsheds (including both subwatersheds and subsewersheds) that were divided into distinct categories. District GIS data was the primary source of information for the manual delineation of subsheds using 2-foot contour lines. Manual delineation – instead of a DEM-based automated delineation – was chosen in order to account for the complexities of delineation in an urban environment. The other significant source that was consulted was a sewer infrastructure geodatabase owned and maintained by DC Water, which included networks of sanitary sewer, combined sewer system (CSS), and MS4 pipes as well as and CSS and MS4 outfalls.

The categories of watersheds and sewersheds delineated by DDOE included:

- **TMDL Subsheds:** Subsheds representing drainage areas to each TMDL waterbody. These subsheds were delineated based on topography and include both MS4 and direct-drainage overland flow components.

- **Direct Drain Overland:** Areas that have no contributions from the MS4 or CSS service areas. Flow from these areas terminates directly into a mainstem water body, and are not part of a TMDL subshed. This data set also includes overland flow along the DC-Maryland border that drains into Maryland, and areas with indeterminate (MS4 or overland) drainage sources.
- **Direct Drain Sewersheds:** Subsheds that represent MS4 area delineations, by MS4 outfall, that drain directly to a mainstem water body, and are not part of a TMDL subshed.
- **CSS Subsheds:** Subsheds representing drainage areas of the CSS that were delineated based on topography and the DC Water sewers geodatabase.
- **All Merge:** An amalgamation of TMDL subsheds, direct drain overland, direct drain sewersheds, and CSS subsheds layers.

All categories were represented by two different data sets, one with water bodies included and one representing land area only. MS4-related delineation included any area with flow that was ultimately served by MS4 infrastructure, even if there was an overland-flow component upstream of the MS4 portion.

3.2 Additional Delineation of Small Tributaries - Open and Closed Channels and Direct Drainage

As described above, the initial delineation separated the District into TMDL subwatersheds, direct drainage areas flowing to main stem waterbodies, and CSS service areas. Parallel to this initial delineation effort, drainage areas used in the original TMDL modeling were researched. Comparison of the initial delineation to the subsheds used in the modeling revealed that the initial delineation required further refinement. In order to model the watersheds appropriately, the delineation needed to differentiate between open and closed channel (i.e., piped) streams. It also needed to separate direct drainage from sewered flow at the subwatershed scale.

According to the TMDL documentation for organics and metals in the Anacostia River and tributaries, the assessment at the subwatershed level (e.g., Texas Avenue Tributary, Hickey Run, etc.) included areas that drain to the tributaries and excluded downstream areas that drain to a closed pipe system with an outfall on the Anacostia River (Figure 1). To delineate the closed channel and open channel areas, a combination of aerial imagery, topography, pipe networks, and stream lines were used. Each subwatershed was reviewed to identify the furthest downstream point where a stream is day lighted. The final inlet to the piped system was then used as a pour point for delineation purposes.

Next, it was necessary to distinguish between the direct drainage and sewered areas of the open channel stream segments. To accomplish this task, MS4 catchment areas were intersected with the TMDL subwatershed level. The direct drainage to an open channel stream was then hand delineated (See Figure 1 for an example).

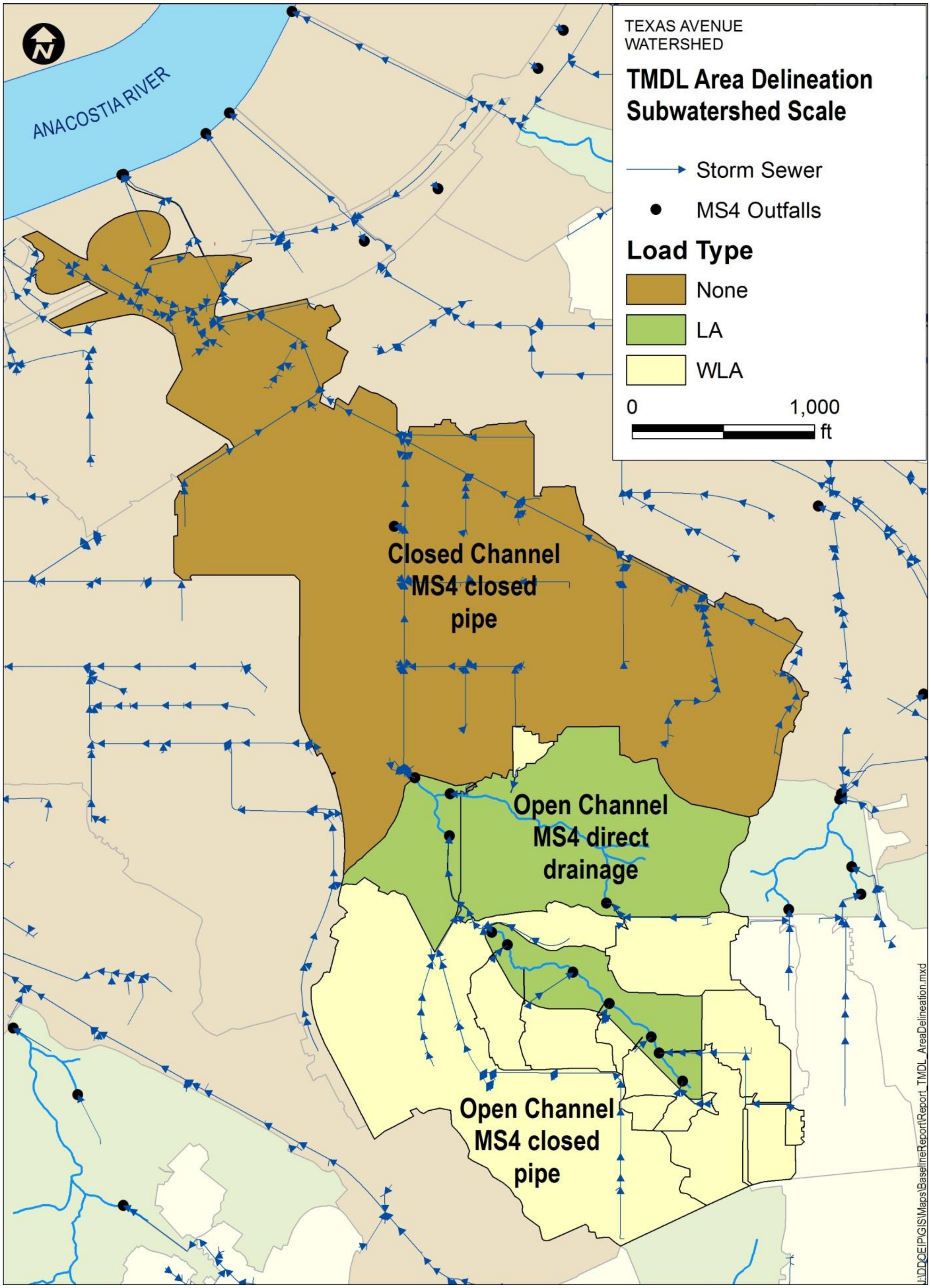

Figure 1: Illustration of delineation for open and closed channels and direct drainage

The additional delineation lead to the development of 727 features in the watershed delineation feature class. Each feature represented the finest level of detail needed for all of the TMDLs being consolidated.

Tables 1 through 3 and Figures 2 through 4 show the mainstem subsheds, the tributary and sewershed subsheds, and the Chesapeake Bay subsheds, respectively, as delineated by this process. The tables include summaries of the areas of the MS4 system, the direct drainage, and the CSS area in each subshed. Table 1 for the tributary and sewershed subsheds also shows the MS4 portion and the direct drainage of the open channel areas, as well as the closed channel parts of the MS4 system.

Table 1: MS4, Direct Drainage, and CSS Areas of Mainstem Segments

Mainstem Segment	MS4 Area (acres)	Direct Drainage Area (acres)	CSS Area (acres)	Grand Total (acres)
Anacostia Lower	1567.5	631.8		2199.3
Anacostia Upper	7112.7	2195.3		9308.0
Potomac Lower	3561.4	348.0		3909.3
Potomac Middle	783.4	679.0		1462.3
Potomac Upper	2692.2	931.2		3623.4
Rock Creek Lower	1010.2	688.5		1698.7
Rock Creek Upper	3022.6	1756.5		4779.1
CSS			12218.1	12218.1
Grand Total	**19750.0**	**7230.2**	**12218.1**	**39198.3**

Table 2: MS4, Direct Drainage, and CSS Areas of Tributary and Sewershed Segments

Main-stem Segment	Subshed	MS4 Area - Closed Channel (acres)	MS4 Area – Open Channel (acres)	Open Channel Direct Drainage Area (acres)	Mainstem Direct Drainage Area (acres)	CSS Area (acres)	Grand Total (acres)
Anacostia Lower	695 SE	6.9					6.9
	Buzzard Point SW	78.5					78.5
	Fairlawn SE	26.1					26.1
	Fort Stanton Tributary	156.2	29.5	92.1			277.8
	Historic Anacostia SE	29.0					29.0
	Nationals Park SE	25.2					25.2
	Navy Yard	24.4					24.4
	Naylor	131.0					131.0
	Suitland-Stickfoot	1060.8		16.3			1077.0

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Table 2: MS4, Direct Drainage, and CSS Areas of Tributary and Sewershed Segments							
Main-stem Segment	**Subshed**	**MS4 Area - Closed Channel (acres)**	**MS4 Area – Open Channel (acres)**	**Open Channel Direct Drainage Area (acres)**	**Mainstem Direct Drainage Area (acres)**	**CSS Area (acres)**	**Grand Total (acres)**
	Mainstem Direct Drainage				523.4		523.4
Anacostia Lower (Total)		**1567.5**	**29.5**	**108.4**	**523.4**		**2199.3**
Anacostia Upper	Benning-ecap	898.7					898.7
	DC Jail SE	19.0					19.0
	Fairlawn SE	10.7					10.7
	Fort Chaplin Tributary	140.3	132.2	20.5			293.0
	Fort Davis Tributary	130.3	59.7	44.1			234.1
	Fort Dupont Tributary		49.8	382.1			431.9
	Fort Lincoln NE	222.9					222.9
	Hickey Run		825.6	268.6			1094.2
	Kingman Lake		295.6	295.5			591.2
	Lower Beaverdam Creek		1.9	28.8			30.6
	Nash Run		296.7	12.3			309.0
	Northwest Branch		1976.4	11.7			1988.1
	Pope Branch	43.6	171.9	64.9			280.5
	Ridge	127.5					127.5
	Sligo Creek	240.6					240.6
	Texas Avenue Tributary	130.7	74.2	44.4			249.3
	To MD - Anacostia	238.6					238.6
	US National Arboretum at New York Ave NE	6.6					6.6

Table 2: MS4, Direct Drainage, and CSS Areas of Tributary and Sewershed Segments							
Main-stem Segment	Subshed	MS4 Area - Closed Channel (acres)	MS4 Area – Open Channel (acres)	Open Channel Direct Drainage Area (acres)	Mainstem Direct Drainage Area (acres)	CSS Area (acres)	Grand Total (acres)
	Watts Branch		1019.2	231.1			1250.3
	Mainstem Direct Drainage				791.3		791.3
Anacostia Upper (Total)		**7112.7**	**4903.2**	**1404.0**	**791.3**		**9308.0**
Potomac Lower	295 at Overlook Ave SW	102.8					102.8
	295 SW	37.7					37.7
	Blue Plains	26.2					26.2
	Oxon Cove	60.6					60.6
	Oxon Run		1808.9	345.9			2154.7
	Shepherd Parkway SE	321.5					321.5
	Mainstem Direct Drainage				2.1		2.1
	DC Water-Bolling	1203.5					1203.5
Potomac Lower (Total)		**3561.4**	**1808.9**	**345.9**	**2.1**		**3909.3**
Potomac Middle	East Potomac Park	19.0					19.0
	George-town at 30th Street	0.9					0.9
	George-town at Water Street	4.9					4.9
	Kennedy Center	30.8					30.8
	Lincoln Memorial	41.3					41.3
	Tidal Basin		247.0	54.5			301.4
	Washington Ship Channel		439.6	176.2			615.8

Table 2: MS4, Direct Drainage, and CSS Areas of Tributary and Sewershed Segments							
Main-stem Segment	**Subshed**	**MS4 Area - Closed Channel (acres)**	**MS4 Area – Open Channel (acres)**	**Open Channel Direct Drainage Area (acres)**	**Mainstem Direct Drainage Area (acres)**	**CSS Area (acres)**	**Grand Total (acres)**
	Mainstem Direct Drainage				448.3		448.3
Potomac Middle (Total)		**783.4**	**686.6**	**230.7**	**448.3**		**1462.3**
Potomac Upper	Arizona Ave NW	157.4					157.4
	Battery Kemble Creek		92.0	139.6			231.6
	C&O Canal		490.0	97.2			587.2
	Dalecarlia Tributary		977.8	114.0			1091.8
	Foundry Branch	595.1	217.1	322.0			1134.2
	To Little Falls	162.9					162.9
	Mainstem Direct Drainage				258.5		258.5
Potomac Upper (Total)		**2692.2**	**1776.9**	**672.7**	**258.5**		**3623.4**
Rock Creek Lower	Adams Morgan at Belmont Road NW	4.8					4.8
	Cleveland Park NW	247.9					247.9
	Dumbarton Oaks		12.1	123.9			136.1
	Dupont Circle NW	3.3					3.3
	Foggy Bottom NW	9.8					9.8
	Georgetown at Q Street NW	2.0					2.0
	Kalorama NW	15.5					15.5
	Klingle Road NW	7.1					7.1

Table 2: MS4, Direct Drainage, and CSS Areas of Tributary and Sewershed Segments							
Main-stem Segment	**Subshed**	**MS4 Area - Closed Channel (acres)**	**MS4 Area – Open Channel (acres)**	**Open Channel Direct Drainage Area (acres)**	**Mainstem Direct Drainage Area (acres)**	**CSS Area (acres)**	**Grand Total (acres)**
	Klingle Valley Run		125.5	46.3			171.7
	Mass Ave Heights NW	34.1					34.1
	Melvin Hazen Valley Branch		109.0	65.3			174.3
	Mt. Pleasant NW	9.3					9.3
	Norman-stone Creek		165.6	51.3			216.8
	Piney Branch		44.7	55.1			99.6
	Tilden St NW	61.1					61.1
	US Naval Observatory NW	48.9					48.9
	Woodley Park at Beach Dr NW	15.8					15.8
	Woodley Park NW	93.9					93.9
	Mainstem Direct Drainage				346.6		346.6
Rock Creek Lower (Total)		**1010.2**	**456.8**	**341.8**	**346.6**		**1698.7**
Rock Creek Upper	16th Street Heights	8.5					8.5
	Beach Drive NW in Rock Creek Park	16.8					16.8
	Bingham Run		85.7	80.4			166.2
	Blagden Run		193.7	10.2			203.9
	Broad Branch		899.9	244.7			1144.6

Table 2: MS4, Direct Drainage, and CSS Areas of Tributary and Sewershed Segments							
Main-stem Segment	**Subshed**	**MS4 Area - Closed Channel (acres)**	**MS4 Area – Open Channel (acres)**	**Open Channel Direct Drainage Area (acres)**	**Mainstem Direct Drainage Area (acres)**	**CSS Area (acres)**	**Grand Total (acres)**
	Colonial Village	44.5					44.5
	Crestwood NW	12.5					12.5
	Fenwick Branch		161.7	57.5			219.1
	Luzon Branch		590.6	52.9			643.4
	Military Road NW	87.8					87.8
	Milkhouse Run		25.4	40.6			66.1
	Pinehurst Branch		246.0	200.6			446.6
	Portal Branch		62.0	8.8			70.8
	Shepherd Park NW	99.9					99.9
	Soapstone Creek		410.8	103.6			514.4
	Walter Reed Army Medical Center	37.6					37.6
	Western Ave Near 32nd Street	39.3					39.3
	Mainstem Direct Drainage				957.1		957.1
Rock Creek Upper (Total)		**3022.6**	**2675.7**	**799.4**	**957.1**		**4779.1**
CSS						**12218.1**	**12218.1**
Grand Total		**19750.0**		**3902.8**	**3327.4**	**12218.1**	**39198.3**

Table 3: MS4, Direct Drainage, and CSS Areas of Chesapeake Bay Segments				
Chesapeake Bay Segment	**MS4 Area (acres)**	**Direct Drainage Area (acres)**	**CSS Area (acres)**	**Grand Total (acres)**
ANATF_DC	6893.2	2952.0		9845.2
ANATF_MD	2522.2	105.8		2628.0
POTTF_DC	9200.8	4021.9		13222.7
POTTF_MD	1133.8	150.5		1284.4
CSS			12218.1	12218.1
Grand Total	**19750.0**	**7230.2**	**12218.1**	**39198.3**

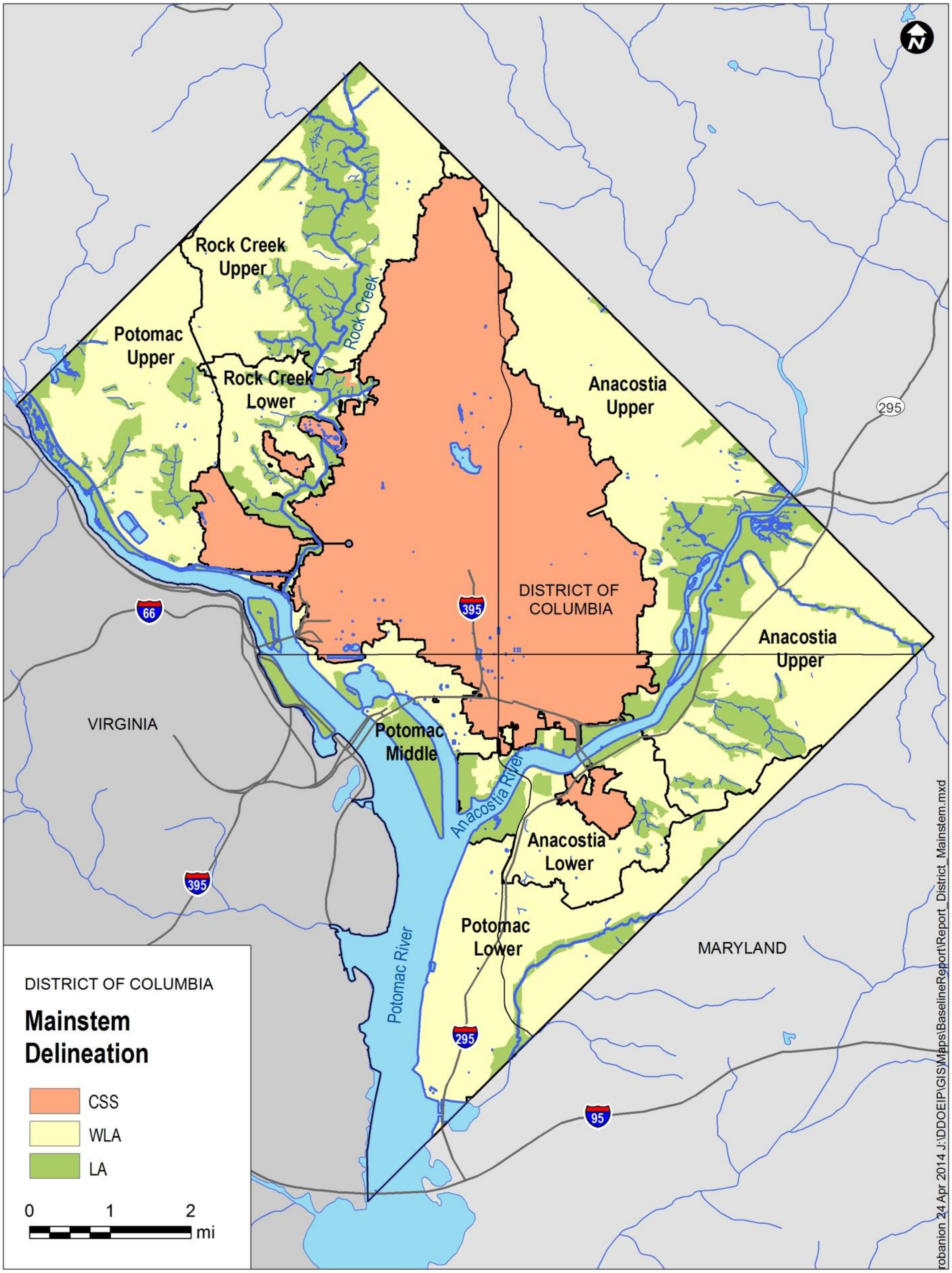

Figure 2: Mainstem Segment Delineation

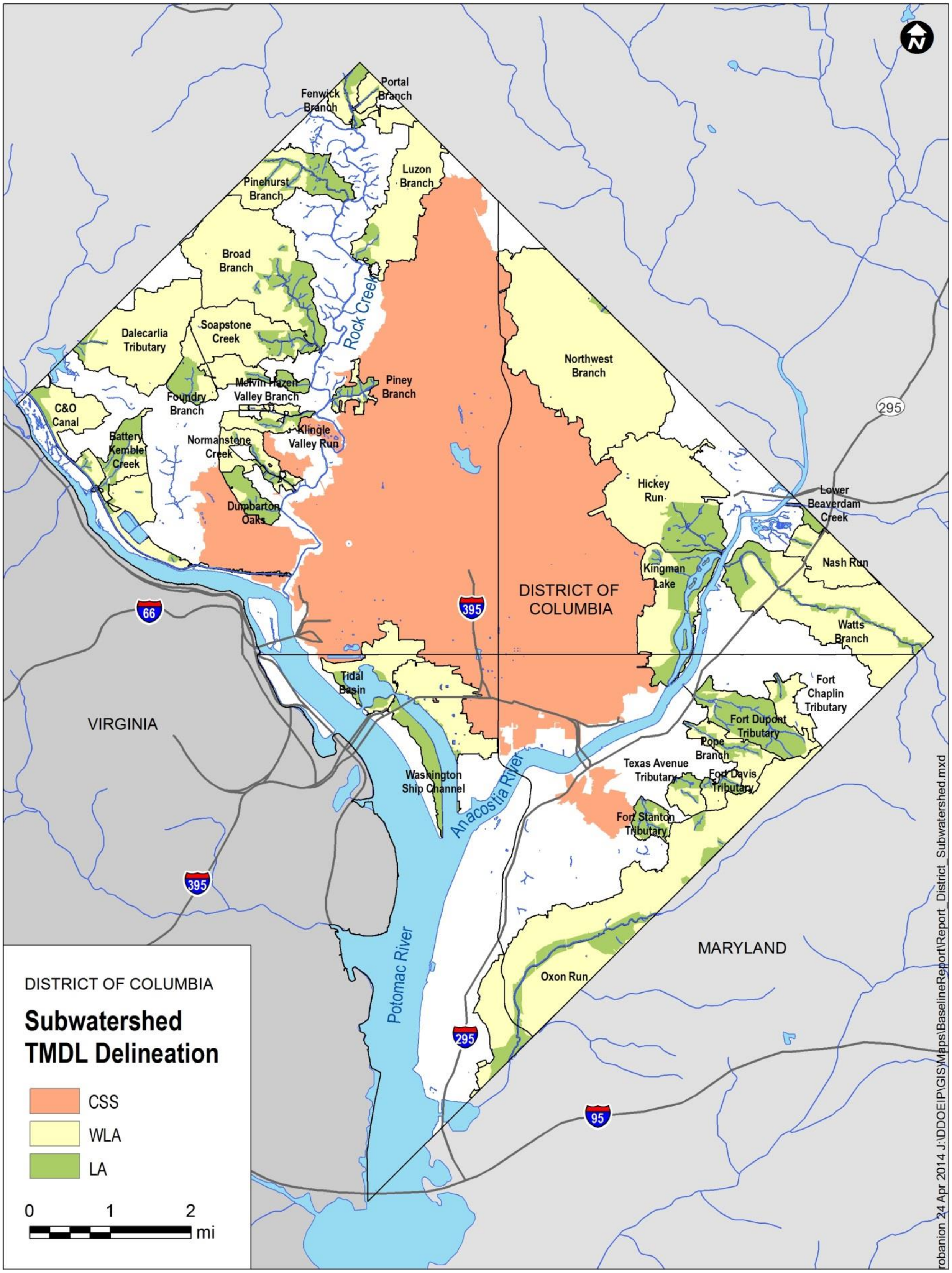

Figure 3: Subwatershed Delineation

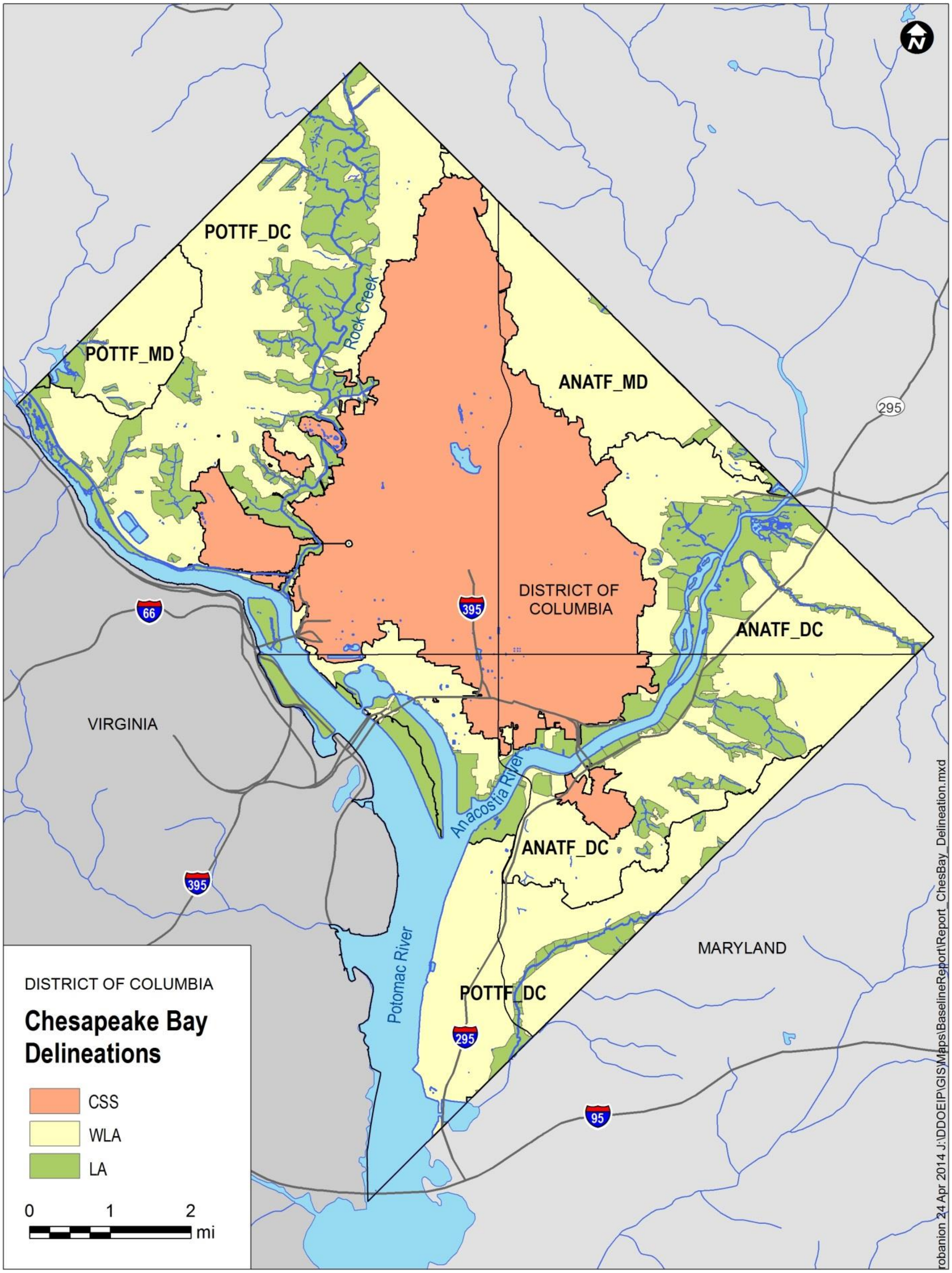

Figure 4: Chesapeake Bay Segment Delineation

3.3 Assigning WLAs and LAs to GIS Polygons

After finalizing the delineation, all MS4 WLAs and nonpoint source LAs were assigned to GIS polygons that represented where these WLAs and LAs actually applied on the ground. A hierarchical categorization of the GIS polygons was developed in order to make these assignments. This hierarchical categorization of GIS polygons was necessary because of the different scales at which the District's TMDLs assign WLAs and LAs. These "scales" included:

- Small tributaries and other minor waterbodies like Kingman Lake, the Washington Ship Channel and the C&O Canal
- Large mainstems that contain small tributary areas
- Chesapeake Bay TMDL segment-shed level, which represented a more "jurisdictional" approach rather than a strict watershed approach (i.e., polygons were assigned based on a combination of political and watershed boundaries rather than on solely watershed boundaries)

Thus, polygons representing tributary-scale areas needed to be "rolled up" and included as part of mainstem-scale areas. For example, the polygons representing the Anacostia small tributaries (e.g., Texas Avenue Tributary, Hickey Run, Fort Davis, Fort Chaplin, etc.) needed to be included when developing the polygons for the Anacostia (Figure 5).

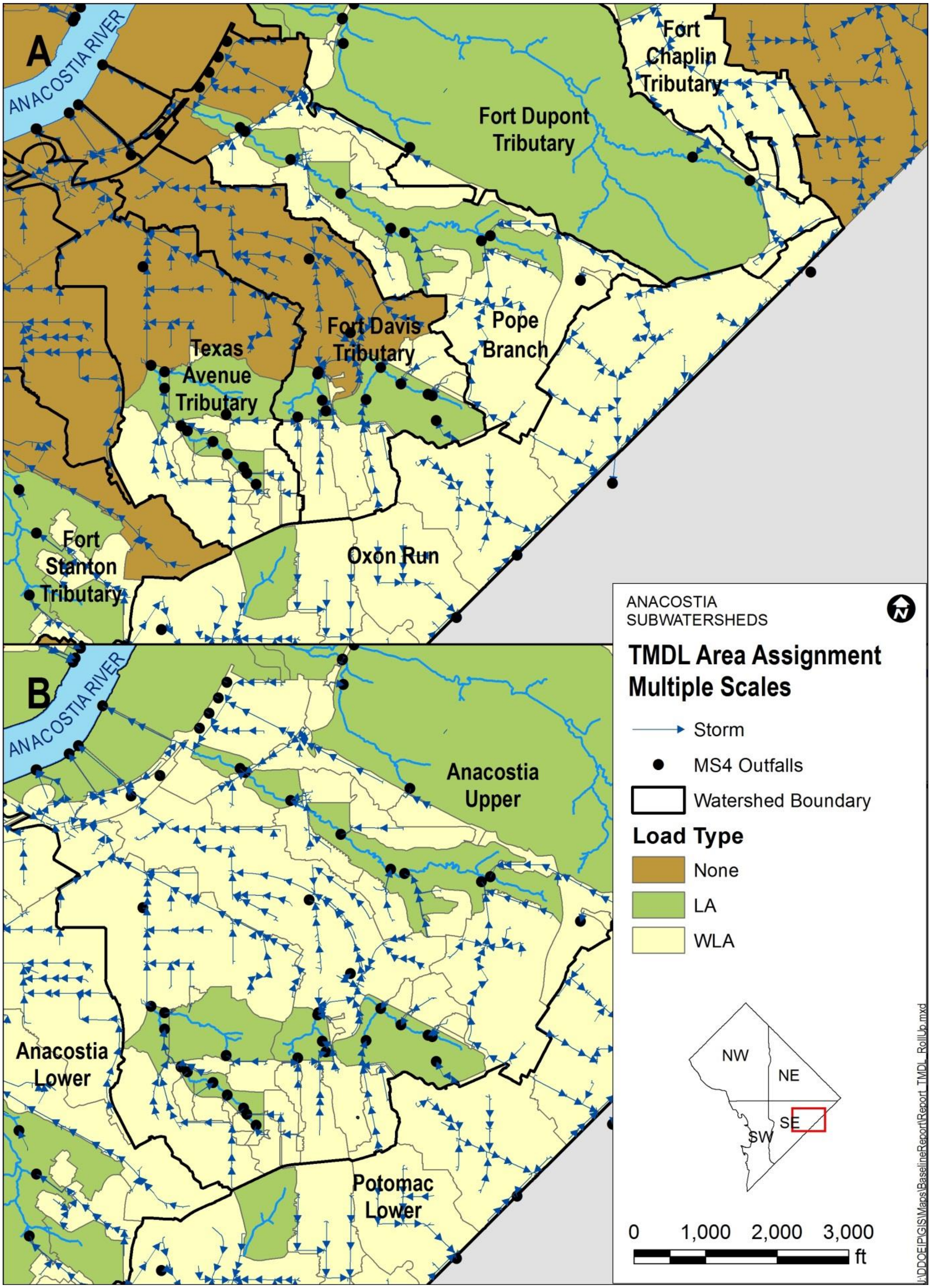

Figure 5: TMDL area assignment rollup. Map A is the subwatershed scale. Map B is the mainstem scale.

As described in the previous section, separate polygons were created for the open channel portion of tributary MS4 subsheds, the entirety (open and closed channel) of tributary MS4 subsheds, tributary direct drainage subsheds, mainstem MS4 subsheds, and mainstem direct drainage subsheds. MS4 WLAs and nonpoint source LAs were then assigned to various combinations of GIS polygons to represent where the various "scales" of MS4 WLAs and nonpoint source LAs applied on the ground. The finest scale TMDLs (TMDLs for small tributaries and other minor waterbodies) could be assigned to individual polygons (e.g., the Klingle Valley WLAs could be assigned to the Klingle Valley open channel MS4 polygon and the Klingle Valley LAs could be assigned to the Klingle Valley direct drainage polygon); but the larger scale TMDLs (e.g., TMDLs for the Upper and Lower Anacostia) needed to be assigned to a large polygon constructed from multiple smaller polygons consisting of tributary MS4 subsheds, tributary direct drainage subsheds, mainstem MS4 subsheds, and mainstem direct drainage subsheds in that watershed. In order to develop the correct larger polygon from multiple smaller polygons, a hierarchical categorization of polygons was utilized.

The hierarchical classification designed to assign the WLAs and LAs consisted of five "Watershed" and two "Sewer Type" classifications. These are described below:

WatershedL1

These are the three major basins in the District (Anacostia, Potomac, and Rock Creek). Every polygon was assigned to one of these three major basins.

WatershedL2

This classification consists of subdivisions of the three major basins in the District. The classification includes Upper and Lower Anacostia, Upper and Lower Rock Creek, and Upper, Middle and Lower Potomac. Every polygon in the District was assigned to one of these Watershed L2 classifications. This was the scale to which the District's mainstem TMDLs were assigned.

WatershedL3

This is the primary classification level for individual polygons, and it consists of MS4 sewersheds, small tributaries, and other delineated areas. There are 82 distinct classifications at this level.

WatershedL4

A fourth watershed level was necessary to address TMDLs in the Watts Branch subwatershed. In several TMDLs the watershed was broken into Upper and Lower components. However, other TMDLs assigned MS4 WLAs to Watts Branch as a whole at the Watershed L3 classification level. The WatershedL4 classification level allows for TMDLs to be assigned at both scales.

WatershedL5

The WatershedL5 level is used for further sub-classification of small waterbody (WatershedL3) polygons as being open channel or closed pipe. This allows the assignment of WLAs for small tributaries, because the DC Small Tributaries model (DCST) assigns WLAs to only the open channel areas of the small tributaries.

SewerTypeL1

Every polygon was classified as either "MS4," "CSS," or "None (direct drainage)." This classification was used to determine if the polygon should be assigned a WLA or an LA. Polygons classified as "MS4" were assigned MS4 WLAs; polygons classified as "None (direct drainage)" were assigned nonpoint source LAs; and polygons classified as "CSS" were not considered for further analysis because they represented combined sewer areas, which are not covered under DDOE's MS4 NPDES permit, and thus are not part of the Consolidated TMDL IP requirement.

SewerTypeL2

The SewerTypeL2 level is a further sub-classification of the polygons in the MS4. This classification assigns polygons in the MS4 area as either "MS4 direct drainage" or "MS4 closed pipe." This allows WatershedL5 areas to be assigned to WatershedL3 (mainstem) allocations. Areas with a WatershedL5 designation of "MS4 closed pipe" are assigned to WatershedL3 mainstem WLAs and areas with a WatershedL5 designation of "MS4 direct drainage" are assigned to WatershedL3 (mainstem) LAs.

These various classifications were used in a series of GIS queries to assign WLAs and LAs from the individual TMDLs to the GIS polygons. The GIS queries functioned as a type of "logical matrix" whereby individual conditions were set among the various classification categories to assign WLAs and LAs to various combinations of individual polygons (and thereby to mainstem and tributary waterbodies) according to the various rules under which the original TMDLs were done. Because the polygons were established at the scale of the smallest waterbody for which there are TMDLs (the WatershedL3 tributary/small waterbody scale), WLAs and LAs from individual TMDLs may be assigned to one or more polygons depending on the scale of the original TMDL (i.e., loads from the small tributary TMDLs would be assigned to less total polygons than would the loads from a mainstem waterbody TMDL). For example, the WLA for a mainstem TMDL would be assigned to all of the polygons representing the tributaries to that mainstem, whereas the WLA for a tributary TMDL would only be assigned to the one polygon that represents the MS4 area of that tributary. GIS can then be used to track progress in reducing loads, because load reductions achieved by BMPs implemented in any of the polygons which are assigned as part of a WLA or a LA can be applied to the WLA or LA.

Small Tributary Load Assignments

As described above, the WatershedL3 level is the classification level for tributary and other waterbody TMDLs. For each of the polygons with a WatershedL3 classification corresponding to one of the tributary or other waterbody TMDLs (e.g., Klingle Valley, Hickey Run, Foundry Branch, etc.), MS4 WLAs and LAs are assigned according to the following logic. First, all of the WatershedL3 tributary or other waterbody polygons are assigned as MS4 area under the SewerTypeL1 classification because all of these tributaries and other waterbodies are at least partially served by the MS4 system. Next, the WatershedL5 classification is reviewed. If the WatershedL5 classification is "Open," that means that the polygon is an open channel section of the waterbody, which is the area used for small tributaries modeled by the DCST. Subsequently, if the SewerTypeL2 classification for this open channel section of the waterbody is "MS4 closed pipe," that means that the open channel area is served by the MS4 system, and thus that the polygon should be assigned to the WLA for that TMDL. In contrast, if the SewerTypeL2 classification for this open channel section of the waterbody is "Direct Drainage," that means that the open channel area is <u>not</u> served by the MS4 system (i.e., it is overland flow direct drainage into the tributary), and thus that the polygon should be assigned to the LA for that TMDL. In contrast to polygons with WatershedL5 classifications of "Open," if the WatershedL5 classification of a polygon is "Closed," that means that the polygon represents a section of the waterbody that is completely piped (e.g., no open channel). By definition, the DCST, which defines all small tributary WLAs, does not include closed channel areas as part of the WLA. Therefore, this area is not included anywhere in the small tributary allocations.

This decision matrix is shown in Table 4 below:

Table 4: Decision Matrix for Assigning Polygons for WLAs and LAs for Small Tributaries				
WatershedL3	**SewerTypeL1**	**WatershedL5**	**SewertypeL2**	**Result**
All Sheds	MS4	Open	MS4 closed pipe	WLA
All Sheds	MS4	Open	Direct Drainage	LA
All Sheds	MS4	Closed	MS4 closed pipe	Null

Watts Branch Load Assignments

For several TMDLs (Anacostia and Tributaries Metals and Organics [2003]; Anacostia and Tributaries Bacteria [2003] and Watts Branch TSS [2003]), Watts Branch was broken into Upper and Lower components and different loads were assigned to Upper and Lower Watts Branch. Since the entire Watts Branch subwatershed was also assigned loads in other TMDLs, Watts Branch as a whole was classified at the WatershedL3 level. Therefore, in order to accommodate loads for Upper and Lower Watts Branch, these classifications were assigned to Watts Branch at the WatershedL4 level. Once that was accomplished, the load assignments for Upper and Lower Watts Branch were assigned following the same logic as described above for small tributaries.

Mainstem Load Assignments

As described above, the WatershedL2 level is the classification level for mainstem waterbody TMDLs. For each unique WatershedL2 value (Upper and Lower Anacostia, Upper and Lower Rock Creek, and Upper, Middle and Lower Potomac), the combination of SewerTypeL1, WatershedL5, and SewerTypeL2 are queried. SewerTypeL1 data can be "MS4," "CSS," or "None (direct drainage)." If SewerType L1 is "None (direct drainage)," the polygon is not served by the MS4 system, and is assigned to the LA of the mainstem TMDL. If the SewerTypeL1 classification is "MS4", the polygon is in the MS4 area, and the data from the remainder of the query is used to help assign the load. If the WatershedL5 data shows that the area is "Closed" and the SewerTypeL2 indicates "MS4 closed pipe," that means that the polygon represents a section of the waterbody that is served by a completely piped MS4 system (e.g., the MS4 system does not first flow into an open channel tributary and then into the mainstem). Therefore, this area is assigned to the WLA for the mainstem. In contrast, if the WatershedL5 data indicates that the area is an open channel ("Open"), additional information from the SewerTypeL2 classification is required. If the SewerTypeL2 data shows that the areas is served by "MS4 closed pipe," then it is assigned to the WLA. If the SewerTypeL2 field shows that the area is MS4 direct drainage (i.e., it is direct overland flow to the waterbody), it is assigned to the LA. This is also how the assignments of these areas were made for the original Rock Creek and Potomac TMDLs. However, due to the differences in the way that the Potomac, Anacostia, and Rock Creek were modeled in the original TMDLs, this area was not included at all for the original Anacostia mainstem TMDLs (see Attachment 1 [*DC TMDL Modeling Approach for Mainstems and Tributaries*] to Appendix A, *Technical Memorandum: Model Selection and Justification*, for a discussion of the modeling of mainstem waterbodies and how this impacted the assignment of WLAs and LAs).

The logic behind these queries is shown in Table 5 below:

Table 5: Decision Matrix for Assigning Polygons for WLAs and LAs for Mainstems

WatershedL2	SewerTypeL1	WatershedL5	SewerTypeL2	Result
All Sheds	None (direct drainage)	N/A	N/A	LA
All Sheds	MS4	Closed	MS4 closed pipe	WLA
All Sheds	MS4	Open	MS4 direct drainage	LA
All Sheds	MS4	Open	MS4 closed pipe	WLA

3.4 QA/QC of Delineations and Assignment of WLAs and LAs

After initial delineations and assignments of WLAs and LAs to specific GIS polygons were completed, a series of QA/QC steps were taken to ensure that the delineations were both accurate relative to current information on the extent of the MS4 system, but that they were also able to reflect the sewer and watersheds as they were originally delineated in the TMDL studies. QA/QC included tabulation of areas from the original TMDLs (either through evaluation of model input files on sewer/watershed areas or tables of these areas in TMDL-related documents) and comparison of these areas to areas of the updated delineations from the geodatabase. QA/QC also included visual comparison of the watershed and sewershed boundaries between maps from the TMDL documents, GIS files from the original TMDL modeling, and current delineations. In several cases, discrepancies were found between the sewershed and watershed delineations completed for the original TMDLs and the delineations based on updated data. These discrepancies were resolved through further research into the original TMDL data, review of topography and other outside mapping data, and engineering judgment. Corrections to delineations were made where necessary. In general, delineations were made to conform to the most current data on MS4 drainage areas. By utilizing the most updated information on MS4 areas, the modeling will reflect current loads from MS4 areas and load reductions from implementation of BMPs that can help meet MS4 WLAs. However, in some cases (particularly in cases where it was unclear whether TMDLs were supposed to apply to an entire watershed or only parts of a watershed), delineations and/or polygon assignments were changed to reflect what was in the original TMDL. In all cases where changes were made to delineations, notes were made in the geodatabase to identify the changes. Keeping notes on the changes will help allow for flexibility in how the watershed and sewershed data can be used. For example, if there is a need to compare loads modeled with the IP modeling tool to loads from the original TMDLs, delineations can be changed to reflect the delineations in the original TMDL studies.

Another QA/QC check involved the comparison of areas from the current geodatabase with areas in the original TMDLs (see Table 6). In general, areas agreed within ± 20 percent, which was deemed to be acceptable for this type of exercise with multiple delineations. However, several subsheds, including seven (7) small tributaries and the ANATF-MD Chesapeake Bay segment shed, had discrepancies of more than 20 percent. These are summarized in Table 6 below, along with a discussion of how the discrepancies were resolved.

Table 6: Comparison of Watershed Areas Between Original and Updated Watershed and Sewershed Delineations Geodatabase

	Area (acre)								
WATERBODY	MS4			Direct Drainage			All (MS4 + DD)		
	IPMT	TMDL	% Diff	IPMT	TMDL	% Diff	IPMT	TMDL	%Diff.
Anacostia Lower	1,567	Not found	-	632	110	476.44%	2,199	Not found	-
Anacostia Upper	7,112	Not found	-	2,195	215	922.68%	9,308	Not found	-
ANATF_DC	6,893	Not found	-	2,952	Not found	-	9,845	11,096	-11.27%
ANATF_MD	2,522	Not found	-	106	Not found	-	2,628	1,888	39.16%
Battery Kemble Creek	92	Not found	-	140	Not found	-	232	239	-3.03%
Broad Branch	900	Not found	-	245	Not found	-	1,145	1,129	1.37%
C&O Canal	490	426	15.03%	97	Not found	-	587	Not found	-
Dalecarlia Tributary	977	Not found	-	114	Not found	-	1,091	1,111	-1.83%
Dumbarton Oaks	12	Not found	-	124	Not found	-	136	168	-18.96%
Fenwick Branch	162	Not found	-	57	Not found	-	219	203	7.68%
Fort Chaplin Tributary	132	Not found	-	21	Not found	-	153	204	-24.98%
Fort Davis Tributary	60	Not found	-	44	Not found	-	104	72	44.84%
Fort Dupont Tributary	50	Not found	-	382	Not found	-	432	474	-8.94%
Fort Stanton Tributary	29	Not found	-	92	Not found	-	122	125	-2.50%
Foundry Branch	90	Not found	-	106	Not found	-	196	168	17.11%
Hickey Run	826	Not found	-	269	Not found	-	1,094	1,081	1.25%
Kingman Lake	296	Not found	-	296	Not found	-	591	Not found	-
Klingle Valley Run	125	Not found	-	46	Not found	-	172	354	-51.46%
Lower Beaverdam Creek	2	Not found	-	29	Not found	-	31	Not found	-
Luzon Branch	590	Not found	-	53	Not found	-	643	648	-0.78%
Melvin Hazen Valley Branch	109	Not found	-	65	Not found	-	174	184	-5.32%
Nash Run	297	Not found	-	12	Not found	-	309	286	8.02%
Normanstone Creek	166	Not found	-	51	Not found	-	217	249	-13.01%
Northwest Branch	1,976	Not found	-	12	Not found	-	1,988	Not found	-
Oxon Run	1,800	Not found	-	344	Not found	-	2,144	Not found	-
Pinehurst Branch	246	Not found	-	201	Not found	-	446	443	0.83%
Piney Branch	45	Not found	-	55	Not found	-	100	61	62.13%
Pope Branch	172	Not found	-	65	Not found	-	237	232	2.25%
Portal Branch	62	Not found	-	9	Not found	-	71	73	-2.98%
Potomac Lower	3,552	Not found	-	346	Not found	-	3,898	Not found	-
Potomac Middle	783	Not found	-	679	Not found	-	1,462	Not found	-
Potomac Upper	2,692	Not found	-	931	Not found	-	3,622	Not found	-
POTTF_DC	9,190	Not found	-	4,019	Not found	-	13,210	12,396	6.56%
POTTF_MD	1,133	Not found	-	150	Not found	-	1,283	1,311	-2.12%
Rock Creek Lower	1,010	826	22.32%	688	2,707	-9.70%	1,699	6,131	5.64%
Rock Creek Upper	3,022	2,598	16.32%	1,756			4,778		
Soapstone Creek	411	Not found	-	104	Not found	-	514	520	-1.09%
Texas Avenue Tributary	74	Not found	-	44	Not found	-	119	176	-32.54%
Tidal Basin	247	Not found	-	54	Not found	-	301	Not found	-

Table 6: Comparison of Watershed Areas Between Original and Updated Watershed and Sewershed Delineations Geodatabase

WATERBODY	Area (acre)								
	MS4			Direct Drainage			All (MS4 + DD)		
	IPMT	TMDL	% Diff	IPMT	TMDL	% Diff	IPMT	TMDL	%Diff.
Washington Ship Channel	440	Not found	-	176	Not found	-	616	Not found	-
Watts Branch	1,019	Not found	-	231	Not found	-	1,250	1,161	7.69%
Watts Branch - Lower	261	Not found	-	145	Not found	-	406	Not found	-
Watts Branch - Upper	758	Not found	-	86	Not found	-	844	Not found	-

Table 7: Review and Resolutions of Major Discrepancies in Watershed Area Between Small Tributary and Geodatabase

TMDL Watershed	Calculated Area (from Geodatabase) (acres)	Reference Area (from Input Files to DCST or Other Sources) (acres)	Percent Difference (%)	Discussion
Dalecarlia Tributary	270	1,111	-75.73	The reference area and GIS shapefiles for this watershed indicate that the DCST used the “Mill Creek” watershed, in addition to the Dalecarlia Tributary drainage area, to calculate loads for the Dalecarlia Tributary. Therefore, the current database was modified to include the Mill Creek drainage area within the Dalecarlia Tributary watershed.
Fort Chaplin Tributary	153	204	-24.98	The DCST included area that was “closed pipe” (and therefore should not have been included in the watershed area). The current geodatabase correctly excludes this area from the Fort Chaplin TMDLs.
Fort Davis Tributary	104	72	44.84	The DCST assigned a portion of the Fort Davis Tributary watershed to Texas Avenue, accounting for the discrepancy in areas. The current delineation correctly assigns this area to the Fort Davis Tributary.
Foundry Branch	539	168	221.65	DCST assigns MS4 WLA only to the upper part of the Foundry Branch watershed. Therefore, the delineation in the current database was modified to include only the upper part of the watershed for Foundry Branch TMDLs.

Table 7: Review and Resolutions of Major Discrepancies in Watershed Area Between Small Tributary and Geodatabase

TMDL Watershed	Calculated Area (from Geodatabase) (acres)	Reference Area (from Input Files to DCST or Other Sources) (acres)	Percent Difference (%)	Discussion
Klingle Valley Run	172	354	-51.46	The DCST included several areas that actually discharge directly to Upper Rock Creek (and not into the Klingle Valley Tributary) in the Klingle Valley shapefile. Therefore, the DCST was incorrect and there is no need to change the delineations.
Piney Branch	114	61	85.63	Updated delineation of this watershed had assigned some area as MS4 that was potentially in the CSS. Additional review concluded that this area should be re-classified from MS4 to CSS area, thereby resolving the discrepancy.
Texas Avenue Tributary	119	176	-32.54	See note for Fort Davis Tributary
ANATF_MD	2,628	1,888	39.16	Chesapeake Bay Program incorrectly assigned a large area of Northeast DC (~740 acres) to ANATF_DC that should have been assigned to ANATF_MD. This error was corrected in the updated delineation. No reciprocal error flag occurred in ANATF_DC because ANATF_DC is a much larger area, and so this discrepancy was less than 20% of the total ANATF_DC area

4 Results and Discussion

The delineation of TMDL watersheds and sewersheds using the most current data on the MS4 system, including the sewer geodatabase, resulted in several changes to watersheds and sewersheds relative to those used to develop the original TMDLs. Some of these changes were due to an updated understanding of the sewer system and of where flows discharge (for example, see the discussions of Fort Davis, Klingle Valley Run, Piney Branch and Texas Avenue in Table 7 above). In other cases, errors in the original assignment of areas to watersheds and sewersheds were corrected (for example, see discussion of Fort Chaplin in Table 7 above). Finally, in several cases, the logic for assigning WLAs and LAs to specific polygons was modified to accommodate the way that WLAs and LAs were assigned in the original TMDLs (for example, see the discussion of Dalecarlia and Foundry Branch in Table 7 above).

As described in the **Purpose** section above, the delineation of watersheds and sewersheds is critical to identifying where MS4 WLAs and nonpoint source LAs apply on the ground. Because of the complexity of the original TMDL modeling, different TMDL studies used different logic for determining the areas to which that TMDL's MS4 WLAs, and nonpoint source LAs apply. The differences in modeling and consequent identification of MS4 and nonpoint source areas included in the TMDLs are particularly important with respect to mainstems versus small tributaries and other waterbodies. Therefore, understanding the delineation and extent of watersheds and sewersheds from the original TMDLs is of critical importance. It is also important to understand the most updated information on the MS4 sewersheds, because the current MS4 delineations do not always match up exactly with the delineations used in the original TMDLs. One reason for this is that the writers of the original TMDLs did not have access to the sewers geodatabase that has subsequently been developed to help track the MS4 and CSS areas in the District. The sewers geodatabase has been critical in the development of updated MS4 and unsewered areas delineations.

One ramification of the differences between the watershed and sewershed delineations in the original TMDLs and the updated watershed and sewershed delineations is that loads calculated from these updated areas will not match the loads calculated for the original TMDLs. Because load is a function of runoff, which in turn is dependent on the contributing drainage area, changes in area inherently impact loads. However, any changes in loads due to changes in land areas delineated for the TMDLs reflect the actual current conditions in that watershed/sewershed using the most updated data. This greatly increases confidence in the IP and its ability to affect changes in the watersheds and sewersheds that will lead to meeting applicable MS4s and improving water quality in District waterbodies. Any changes that are made to the sewersheds and watersheds relative to what was used in the original TMDLs will be documented and tracked so that comparisons can be made to the original data. For example, if boundaries of a specific sewershed have been updated from the original TMDL boundaries, these original boundaries will be documented so that current loads based on the updated load calculation methodology (See Appendix A, *Model Selection, Justification and Validation*, for a discussion of the load calculation methodology used in the IP) can be calculated for the old sewershed boundaries, and compared to the original TMDL loads to determine the similarity of the loads. This can serve as a method for validating the load calculation methodology.

In conclusion, the updated watershed and sewershed delineations and the assignment of WLAs and LAs to appropriate GIS polygons will be instrumental in the development of a defensible Consolidated TMDL IP that is based on the most up-to-date understanding of MS4 areas, but also considers the intent of the original TMDLs.

References

U.S. EPA. 2011. *Authorization to Discharge under the National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System Permit*. NPDES Permit No. DC0000221.

U.S. EPA. 2012. *Authorization to Discharge under the National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System Permit*. NPDES Permit No. DC0000221. Modification #1.