2.3 Hydrology and Water Quantity and Quality Modeling

Storm events are classified by the amount of rainfall, in inches, that occurs over the duration of a storm. The amount of rainfall depends on how frequently the storm will statistically occur and how long the storm lasts. Based on many years of rainfall data collected, storms of varying strength have been established based on the duration and probability of that event occurring within any given year. In general, smaller storms occur more frequently than larger storms of equal duration. Hence, a 2-year, 24hr storm (having a 50% chance of happening in a given year) has less rainfall than a 10-year, 24hr storm (having a 10% chance of happening in a given year). Stormwater runoff (which is related to the strength of the storm) is surplus rainfall that does not soak into the ground. This surplus rainfall flows (or 'runs off') from roof tops, parking lots and other impervious surfaces and is ultimately received by storm drainage systems, culverts and streams.

Modeling is a way to mathematically predict and spatially represent what will occur with a given rainfall event. There are two primary types of models that are used to achieve this goal; hydrologic and hydraulic:

- Hydrologic models take into account several factors; the particular rainfall event of interest, the physical nature of the land area where the rainfall occurs and how quickly the resulting stormwater runoff drains this given land area. Hydrologic models can describe both the quantity of stormwater runoff and resulting pollution, such as nutrients (nitrogen and phosphorus) and sediment that is transported by the runoff.

- Hydraulic models represent the effect the stormwater runoff from a particular rainfall event has on both man-made and natural systems. These models can both predict the ability man-made culverts/channels have in conveying stormwater runoff and the spatial extent of potential flooding.

Below shows three storm events and the rationale for being modeled:

Table 24: Storm Event

Storm Event	Rationale for being Modeled
2-year, 24hr	Represents the amount of runoff that defines the shape of the receiving streams.
10-year, 24hr	Used to determine which road culverts will have adequate capacity to convey this storm without overtopping the road.
100-year, 24hr	Used to define the limits of flood inundation zones

2.3.1 PRELIMINARY SWMM and STEPL Results

The Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) was first developed in the early 1970s. Over the past 30 years, the model has been updated and refined and is now used throughout the country as a design and planning tool for stormwater

runoff. Specifically, SWMM is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subwatershed areas (or in our case, areas which pertain to the various treatment types previously described) on which rain falls and runoff is generated. The routing portion of SWMM transports this runoff through a conveyance system of pipes, channels and storage/treatment devices. SWMM tracks the quantity and quality of runoff generated within each subwatershed, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps.

While the SWMM model can calculate pollutant loads, the Spreadsheet Tool for Estimating Pollutant Load (STEPL) was used to determine pollutant loads for Pohick Creek watershed. Also developed by EPA, the STEPL worksheet calculates nutrient and sediment loads from various land uses as well as calculating the load reductions that would result from the implementation of various BMPs. The nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. Sediment loads are calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using known BMP efficiencies.

A major cause for many streams' poor water quality and aquatic habitat loss is increased levels of two particular nutrients, nitrogen and phosphorous. While, these nutrients occur naturally in soil, animal waste, plant material, and even the atmosphere, the increase of nitrogen and phosphorus from manmade sources, can be detrimental to the overall heath of the streams. Increased phosphorus and nitrogen pollutants in urbanized areas primarily come from chemical lawn fertilizers, vehicle emissions, and discharges from municipal wastewater treatment plans.

The information presented in the following section is considered preliminary data results and will continue to be refined when a more accurate and calibrated SWMM model is finalized. The data below reflects current conditions only, in addition the model will be updated and results will be produced as the work progresses towards project identification/prioritization and the Draft Plan phases.

Preliminary SWMM results

Below, represents the results of the SWMM model at specific locations within the Pohick watershed. As shown below, flows were not captured at individual WMAs, therefore composite flows were used. See **Map 2.3.1-1** for specific point locations. The SWMM model will be further refined as additional information is captured in the Pohick Creek watershed planning effort.

Table 25: Preliminary SWMM Results

WMA Outlet Point[1]		Stormwater Runoff Peak Flow Values	
	Contributing Adjacent WMA(s)[2]	2-yr storm (cubic ft/sec)	10-yr storm (cubic ft/sec)
1 (41)	Rabbit Branch, Sideburn Branch,	552.000	11,411
2 (64)	Pohick Upper	1,295	16,101
3 (79)[3]	Middle Run, Pohick-Middle	2,177	14,324
4 (105)	Upper South Run	33	5,309
5 (119)	Middle Upper, Middle Run	2,747	22,252
WS Totals (181)	Middle Lower, Lower South Run	3,118	32,422

1. The "WMA Outlet Point" is a node that has the individual, cumulative peak flows (2 and 10 year) for the entire upstream drainage area. Example: The first confluence point with such a node is the "Upper" WMA
2. The "Contributing WMA(s)" are the upstream WMAs for which there is not a node that has the individual, cumulative peak flows (2 and 10 year) for the entire upstream drainage area. Example: The "Upper" WMA includes all the stormwater draining from the Cedar WMA and the Upper WMA
3. **This point does not include the contribution of the entire Pohick Middle WMA. This is captured in the downstream node (#6).**

Preliminary STEPL results

The data provided below represents the results from the STEPL model by WMA. The pollutant loads are heavily dependent on land use distribution within the watershed management areas. **Maps 2.3.1-2, 2.3.1-3**, and **2.3.1-4** illustrate the Total Nitrogen, Total Phosphorus, and Total Suspended Solids loads respectively throughout the watershed. As anticipated areas in the northern portion of the watershed experience higher levels of pollutant loading due to high urbanization while areas in the southern portions experience lower levels of pollutant loading. In addition, areas generally located downstream of the large lakes experience lower levels of nitrogen, phosphorus and total suspended solids loadings.

Table 26: Pollutant Loads - STEPL

WMA	Pollutant Loading			Pollutant Loading		
	Total Nitrogen (lbs/yr)	Total Phosphorus (lbs/yr)	Total Suspended Solids (tons/yr)	Total Nitrogen (lbs/ac/yr)	Total Phosphorus (lbs/ac/yr)	Total Suspended Solids (tons/ac/yr)
Rabbit Branch	14606.80	2254.41	395.86	5.7851	0.8929	0.1568
Sideburn Branch	16247.31	2425.25	392.12	7.0399	1.0509	0.1699
Upper South Run	6930.11	1136.01	202.94	3.3959	0.5567	0.0994

WMA	Pollutant Loading			Pollutant Loading		
	Total Nitrogen (lbs/yr)	**Total Phosphorus (lbs/yr)**	**Total Suspended Solids (tons/yr)**	**Total Nitrogen (lbs/ac/yr)**	**Total Phosphorus (lbs/ac/yr)**	**Total Suspended Solids (tons/ac/yr)**
Middle South Run	8,800.69	1,371.63	229.43	4.6586	0.7261	0.1214
Lower South Run	9,135.22	1,425.69	257.29	4.6903	0.7320	0.1321
Middle Run	17,170.58	2,620.80	401.41	6.7596	1.0317	0.1580
Upper	20,533.23	3,090.23	483.95	6.6135	0.9953	0.1559
Middle	18,919.12	2,891.53	466.47	12.3529	1.8846	0.3183
Lower	16,060.52	2,440.94	463.43	6.8445	1.0403	0.1975
Potomac	6425.03	1,338.11	464.77	4.1928	0.8732	0.3033
TOTALS	**134,828.61**	**20,994.60**	**3,757.67**			

2.3.2 PRELIMINARY HEC-RAS

The HEC-RAS hydraulic model was initially developed by the U.S. Army Corp of Engineers in the early 1990 as a tool to manage the rivers and harbors in their jurisdiction. HEC-RAS is a one dimensional program that provides no direct modeling of the hydraulic effect of cross section shape changes, bends, and other two- and three-dimensional aspects of flow. Aside from this limitation, the model has found wide acceptance in simulating the hydraulics of water flow through natural and/or manmade channels and rivers. HEC-RAS is commonly used for modeling water flowing through a system of open channels with the objective of computing water surface profiles. The data presented in the following section is considered preliminary and will continue to be refined as more accurate flow information is available from the SWMM model calibration effort. Updated results will be produced as the work progresses towards project identification/ prioritization and the Draft Plan phases.

Preliminary HEC-RAS Development

Using HEC-RAS, hydraulic models were created for the major channels in the Pohick Creek watershed. These major channels extend from the basin outlet to the most upstream subwatershed in the watershed. Cross sections were aligned based on representative channel sections, and locations upstream and downstream of bridges/culvert structures. Structures such as these were identified along various stream reaches using county GIS road and stream spatial data along with the most recent aerial photography. All major structures that were considered likely to impact the water surface elevation were surveyed.

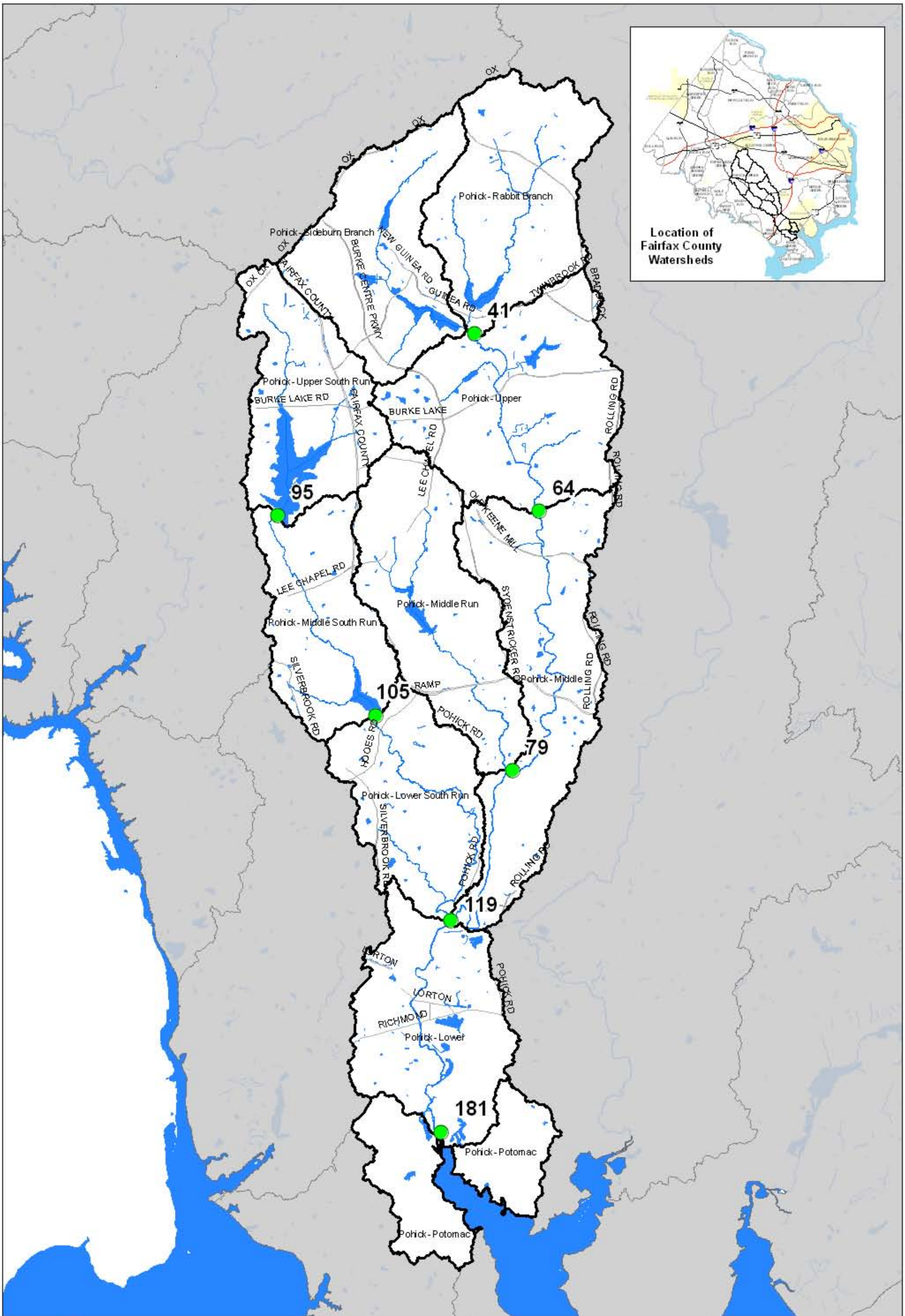
Once the HEC-RAS model was set up as described above, flow data was entered from the SWMM model. It should be noted that, the SWMM model did not account for reduced flows based on storage in the several large reservoirs in Pohick watershed and should therefore be considered preliminary until additional data is obtained. Once the model was run, water surface elevations were exported to GIS and the floodplain maps were then generated

Preliminary HEC-RAS Results

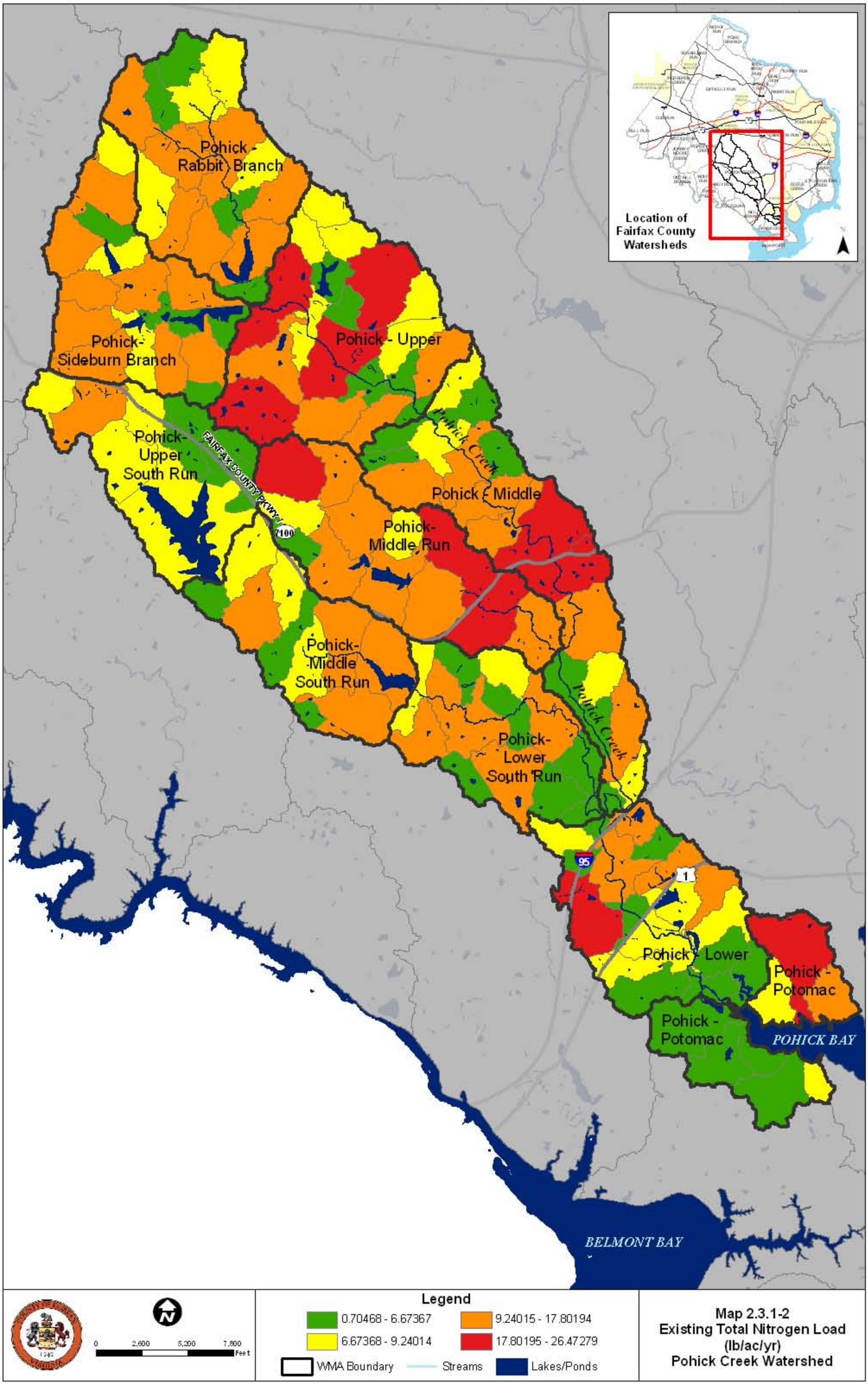
Since the flow results from the SWMM model are not final, these floodplain maps should be considered preliminary, rough estimates of the final floodplains. While results are preliminary and are likely to change with final flows and revised modeling, the new floodplains were compared to the effective Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) in the area, where available. FEMA FIRMs in the Pohick watershed are either Zone AE (detailed study) or Zone A (approximate study). Zone AE areas are studied with hydraulic models and surveyed cross sections and structures. Zone A areas require less detailed hydraulic computation and generally require less detailed survey data.

In general, the newly modeled floodplains compare well with the effective AE zones, and are similar or narrower than the effective A zones. There are some exceptions: in the Pohick Lower WMA, the Pohick Creek modeled floodplain is generally wider than the effective Zone AE. In Pohick Middle South Run WMA, the South Run modeled floodplain is wider than the effective Zone A at the downstream end of Lake Mercer. In Pohick Middle Run WMA, the short section of Middle Run modeled floodplain appears to be wider than the effective Zone A. In Pohick – Sideburn Branch WMA, the upper section of Sideburn Branch modeled floodplain varies in relation to the effective Zone AE, with some portions wider and some portions narrower. The Woodglen Lake modeled floodplain is wider than the effective Zone A. In Pohick – Rabbit Branch WMA, the modeled floodplain for Lake Royal is wider than the effective Zone A.

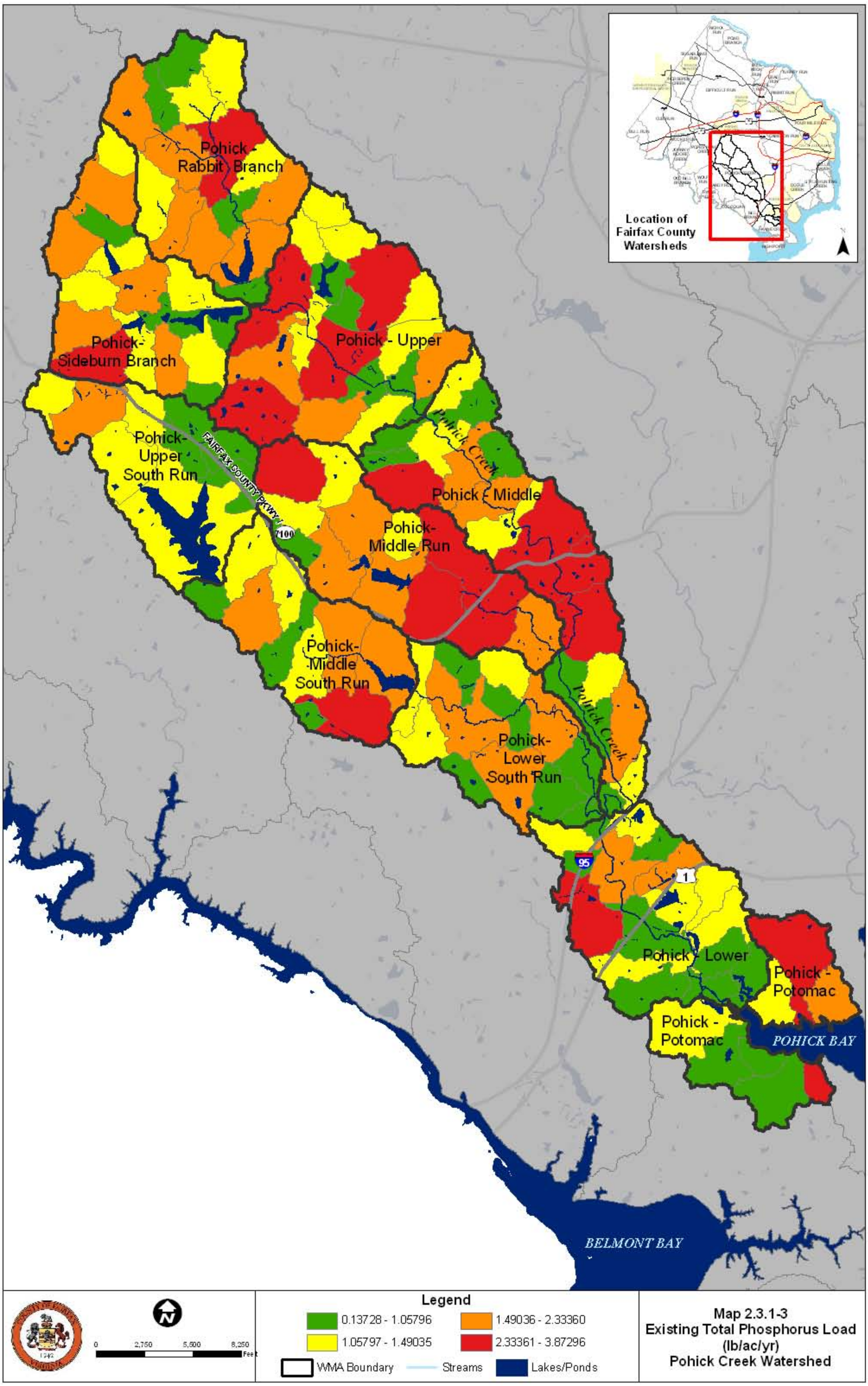
Refer to **Maps 2.3.2-1 through 2.3.2-6** for draft modeled 100-year floodplain results.



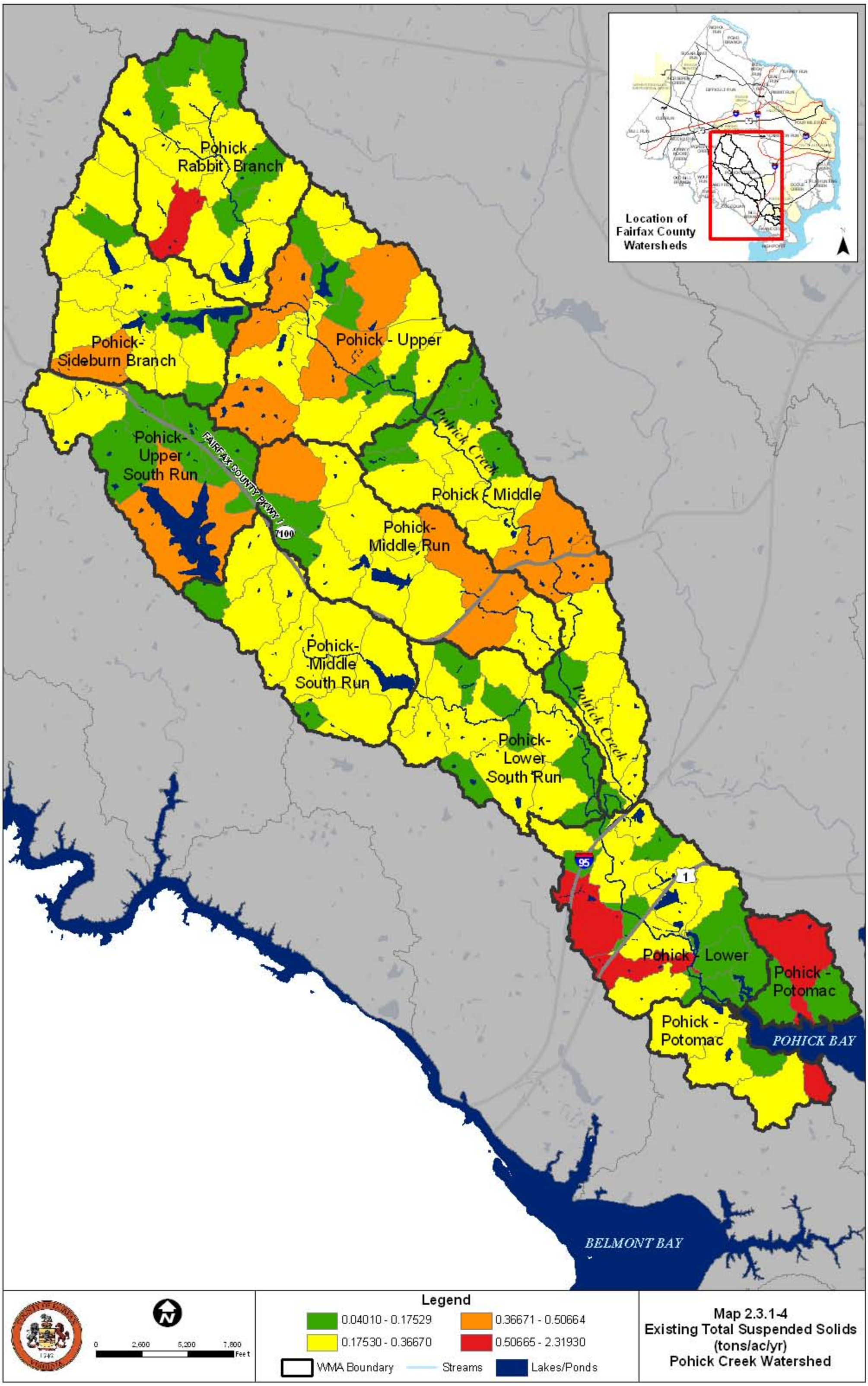
Map 2.3.1-1
Pohick Creek Watershed
SWMM Node Locations



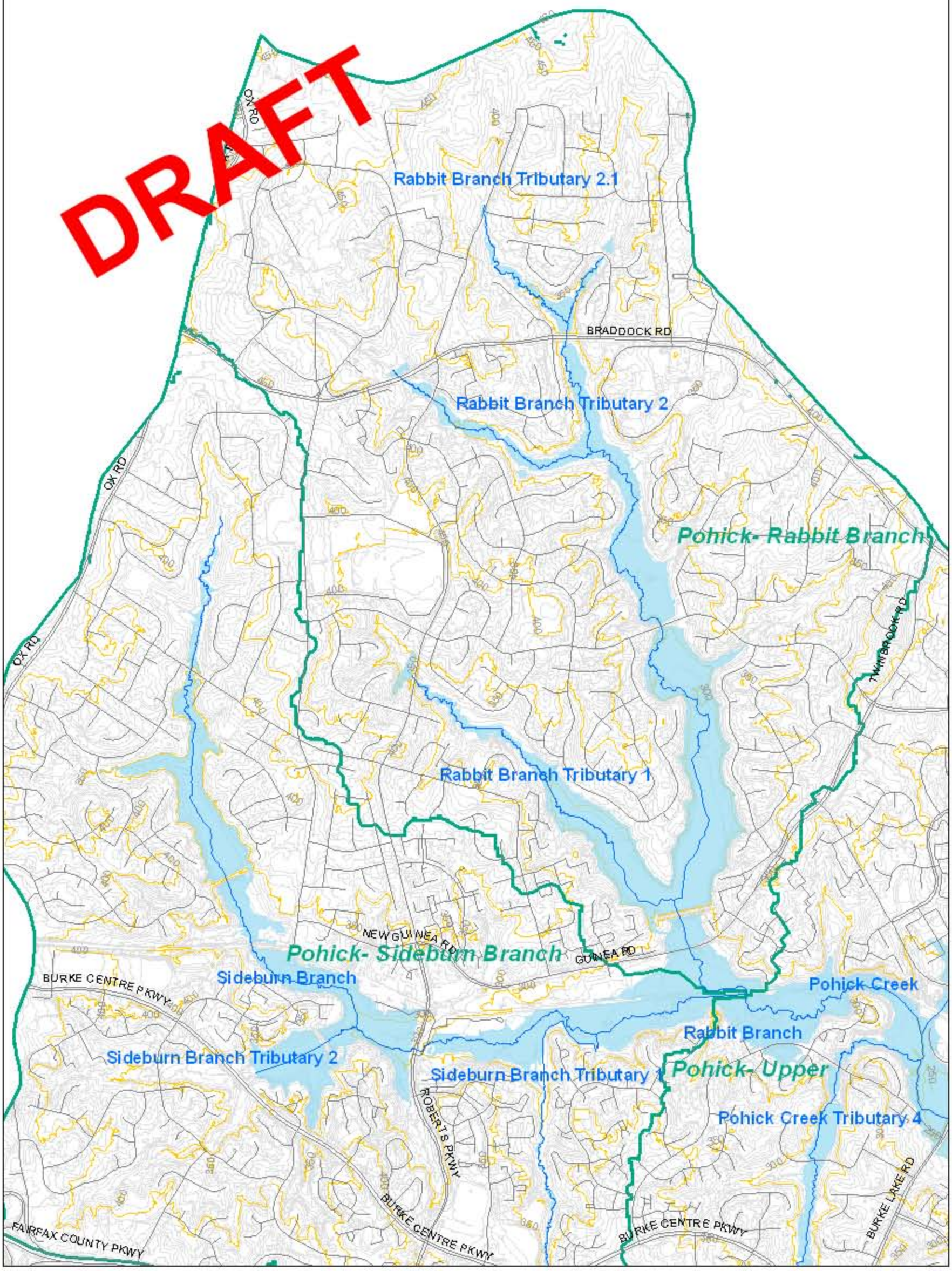
Map 2.3.1-2
Existing Total Nitrogen Load (lb/ac/yr)
Pohick Creek Watershed



Map 2.3.1-3
Existing Total Phosphorus Load (lb/ac/yr)
Pohick Creek Watershed



Map 2.3.1-4
Existing Total Suspended Solids (tons/ac/yr)
Pohick Creek Watershed



COUNTY OF FAIRFAX 1742 VIRGINIA

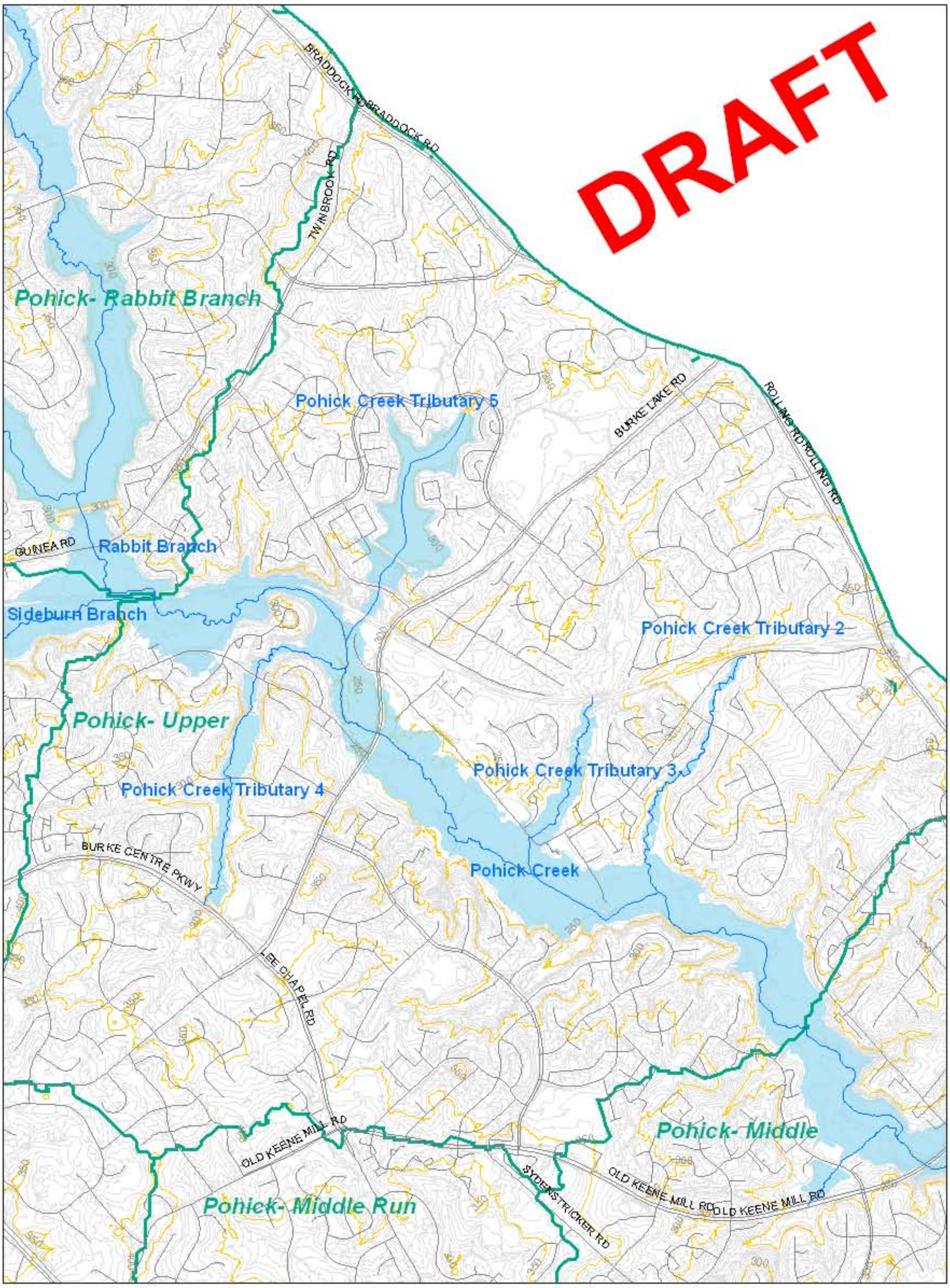
N

Legend

Streams
Streets
WMA
100 Year Floodplain
Contours
10-ft interval
50-ft interval

0 0.25 0.5 Miles

Map 2.3.2-1 - Pohick Creek Watershed Rabbit Branch and Sideburn Branch WMAs 100 Year Floodplains



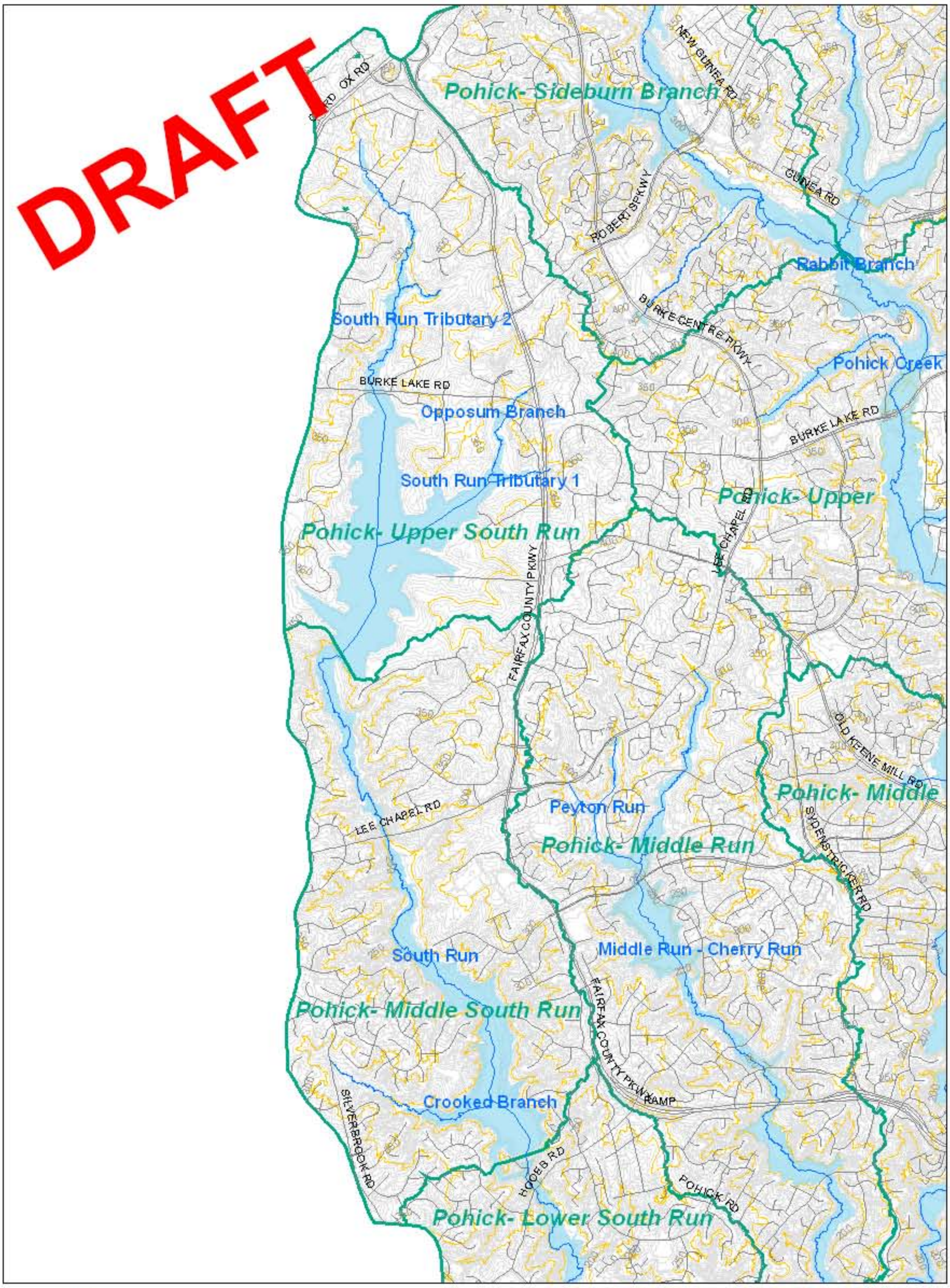
N

Legend

Streams
Streets
WMA
100 Year Floodplain
Contours
10-ft interval
50-ft interval

0 0.25 0.5 1 Miles

Map 2.3.2-2 Pohick Creek Watershed
Pohick - Upper WMA
100 Year Floodplains



Map 2.3.2-3 Pohick Creek Watershed
Pohick - Upper South Run and Middle South Run WMAs
100 Year Floodplains

Map 2.3.2-4 Pohick Creek Watershed
Pohick - Middle Run and Middle WMAs
100 Year Floodplains

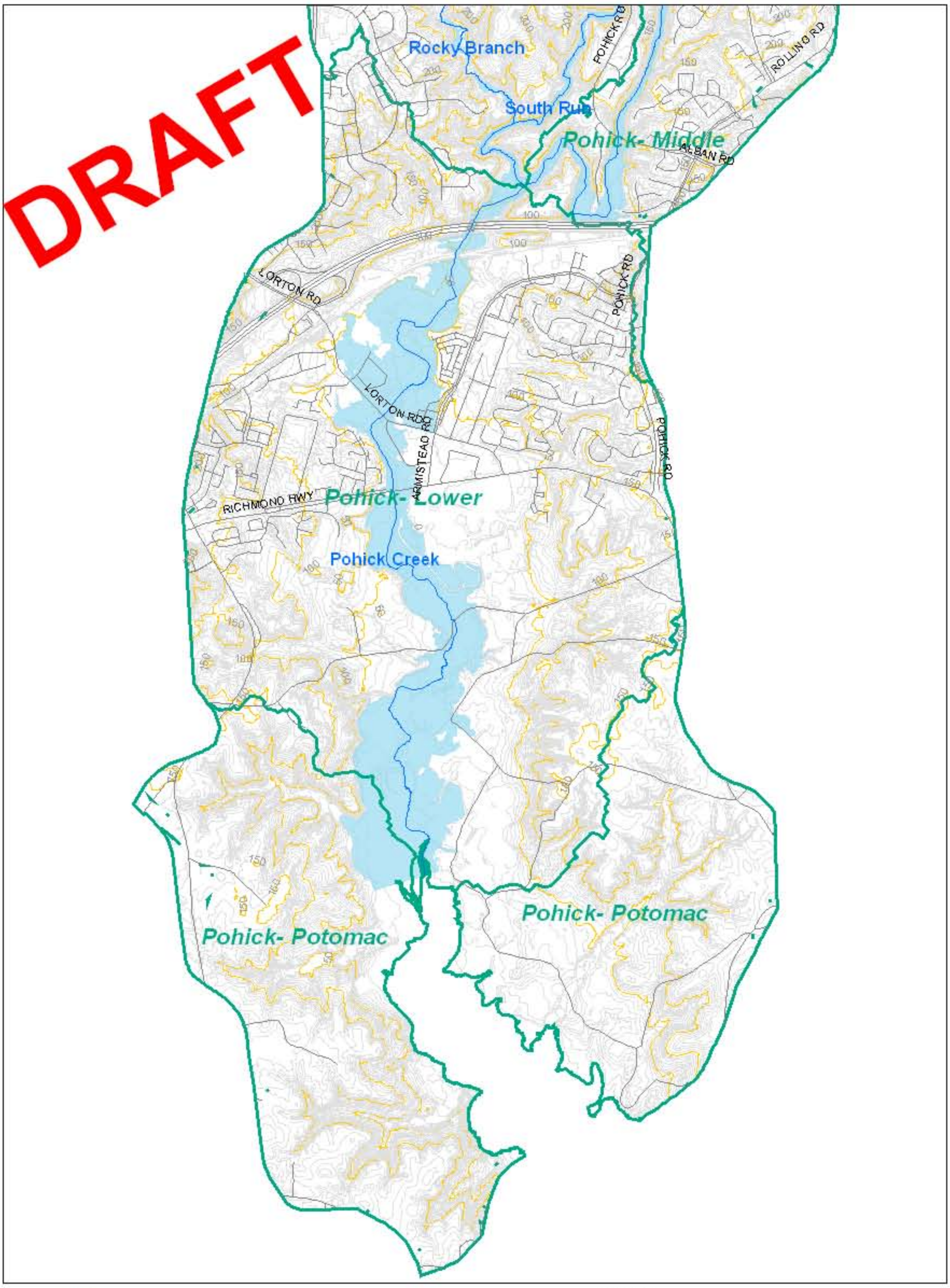
Legend

Streams
Streets
WMA
100 Year Floodplain
Contours
10-ft interval
50-ft interval

N

0 0.25 0.5 1 Miles

Map 2.3.2-5 Pohick Creek Watershed
Pohick - Lower South Run WMA
100 Year Floodplains



Legend

Streams
Streets
WMA
100 Year Floodplain
Contours
10-ft interval
50-ft interval

0 0.25 0.5 1 1.5 Miles

Map 2.3.2-6 - Pohick Creek Watershed Pohick - Lower and Potomac WMAs 100 Year Floodplains

2.4 Ranking of Subwatershed Areas

The County has developed goals and objectives to be applied to all watersheds during the workbook development process. The countywide goals and objectives allow recommendations to be linked to the countywide watershed assessment. The countywide watershed planning goals are to:

1. Improve and maintain watershed functions in Fairfax County, including water quality, habitat, and hydrology.
2. Protect human health, safety, and property by reducing stormwater impacts.
3. Involve stakeholders in the protection, maintenance and restoration of county watersheds.

The countywide objectives identified are linked to the above County goals. The list of objectives allows for a countywide evaluation that addresses stakeholder concerns while providing an efficient and effective means of assessment. In addition, watershed-specific goals and objectives that are recommended by local stakeholders may also be incorporated into the watershed workbook development process. The objectives listed under Category 5 (Stewardship) will be considered during countywide watershed assessment but are not addressed in the subwatershed ranking approach.

Table 27: Fairfax County Watershed Planning Final Objectives

Objective		Linked to Goal(s)
CATEGORY 1. HYDROLOGY		
1A.	Minimize impacts of stormwater runoff on stream hydrology to promote stable stream morphology, protect habitat, and support biota.	1
1B.	Minimize flooding to protect property and human health and safety.	2
CATEGORY 2. HABITAT		
2A.	Provide for healthy habitat through protecting, restoring, and maintaining riparian buffers, wetlands, and instream habitat.	1
2B.	Improve and maintain diversity of native plants and animals in the county.	1
CATEGORY 3. STREAM WATER QUALITY		
3A.	Minimize impacts to stream water quality from pollutants in stormwater runoff.	1, 2
CATEGORY 4. DRINKING WATER QUALITY		
4A.	Minimize impacts to drinking water sources from pathogens, nutrients, and toxics in stormwater runoff.	2
4B.	Minimize impacts to drinking water storage capacity from sediment in stormwater runoff.	2
CATEGORY 5 STEWARDSHIP		
5A.	Encourage the public to participate in watershed stewardship.	3
5B.	Coordinate with regional jurisdictions on watershed management and restoration efforts such as Chesapeake Bay initiatives.	3
5C.	Improve watershed aesthetics in Fairfax County.	1, 3

The purpose of the subwatershed ranking approach is to provide a systematic means of compiling available water quality and natural resources information. Ranking subwatersheds based on watershed characterization and modeling results provides a tool for planners and managers to use as they consider which subwatersheds should undergo further study and/or set priorities. The ranking will be updated based on issues and problem areas identified during the introductory and issues scoping forum and advisory group meetings. The resultant data is then utilized to identify key issues and proceed with projects that will achieve the county's watershed management goals and objectives.

Three basic indicator categories identified below are used to rank subwatershed conditions:

Table 28: Subwatershed Ranking Indicators

Indicator Type	Description
Watershed Impact	Diagnostic measures of environmental condition (e.g. water quality, habitat health, biotic integrity) which are linked to the county's goals and objectives
Programmatic	Reports the existence, location or benefits of stormwater management facilities or programs
Source	Quantifies the presence of stressors and/or pollutant sources

These scores are rolled up into composite scores which are used in the prioritization and subwatershed ranking process. In the process of compiling the draft ranking for Pohick Creek, surrogate metric values were assigned to a subwatershed when a particular indicator or actual data was missing. The approach followed in assigning surrogate values was based on the current Fairfax County Watershed Management Plan Subwatershed Ranking Approach document. This guidance document provided several factors in priority which should be considered when assigning surrogate metric values.

2.4.1 Pohick Creek Results

The Pohick Watershed Impact Composite Score is shown in **Map 2.4.1-1**. This map displays an overall composite score that itself is a weighted average of composite scores of the individual impact indicator scores for each subwatershed. The scale on the map ranks the subwatersheds within the watershed from high (green) to low (red) quality.

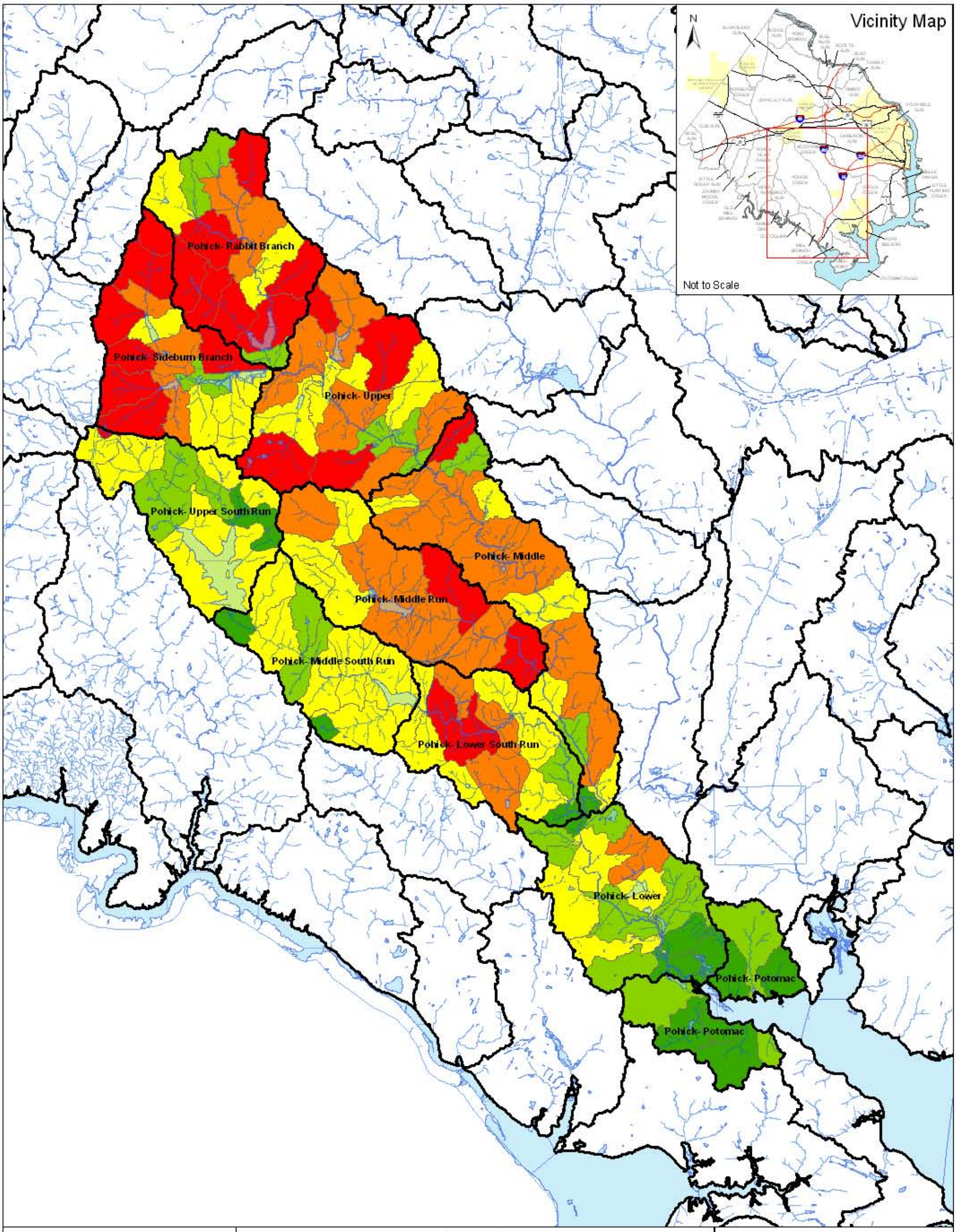
In the Pohick Creek watershed, various portions of the watershed differ considerably in terms of watershed quality as measured by the overall watershed impact indicator composite score. The watershed's southern portion (Potomac and Lower WMAs), including its discharge to the Potomac, show generally above average watershed quality. A few of the subwatersheds in the I-95 corridor of this southern section show poorer watershed quality. The entire southwestern edge of the watershed (Upper South Run, Middle South Run and Lower South Run WMAs) also shows generally good watershed quality. Areas in the vicinity of Burke Lake in the Upper South Run WMA show very high quality, but the Lower South Run has some areas of lower quality. The more developed eastern portion of the watershed (Middle Run and Middle WMAs) shows a generally average watershed quality, but also a great deal of variation between individual subwatersheds. The heavily developed headwaters of the Pohick Creek watershed (Rabbit Branch, Sideburn Branch, and Upper Pohick WMAs) show the poorest watershed quality in

general. Some pockets of green and light-green subwatersheds still exist where there are suburban parks and undeveloped portions of institutional land.

As a caveat, the watershed impact scores contain some degree of uncertainty because the weighted composite score is derived from surrogate metric values, which are currently being refined.

The Source Composite Score rankings are shown in **Map 2.4.1-2**. Unlike the watershed impact score, it is computed as a simple average of approximately a dozen individual source indicator scores. The scale again establishes the bounds on the gradation from generally good quality (green) to comparatively poor quality (red) on the map. Since the source composite score is computed with a distinct set of indicators from the overall watershed impact score, the subwatersheds with good quality or poor quality may be very different than for the overall watershed impact map.

The sparsely developed area near the Pohick watershed's discharge generally has the best source quality in the watershed. The subwatersheds just to the East of I-95 in Pohick-Lower WMA, however, have generally low source quality. The western portion of the middle reaches of the watershed (along South Run) is characterized by above average to good source quality, with significant zones of average source quality. The more developed eastern portion of the middle of the watershed (Middle Run and Middle WMAs) is dominated by subwatersheds with below average watershed quality. The northern headwaters of the watershed have generally poor source quality as shown by the large regions of red and orange on the map. The source composite score has considerably less uncertainty than the overall watershed impact score because a much smaller percentage of the indicator scores (< 5%) were calculated based on surrogate metrics



N

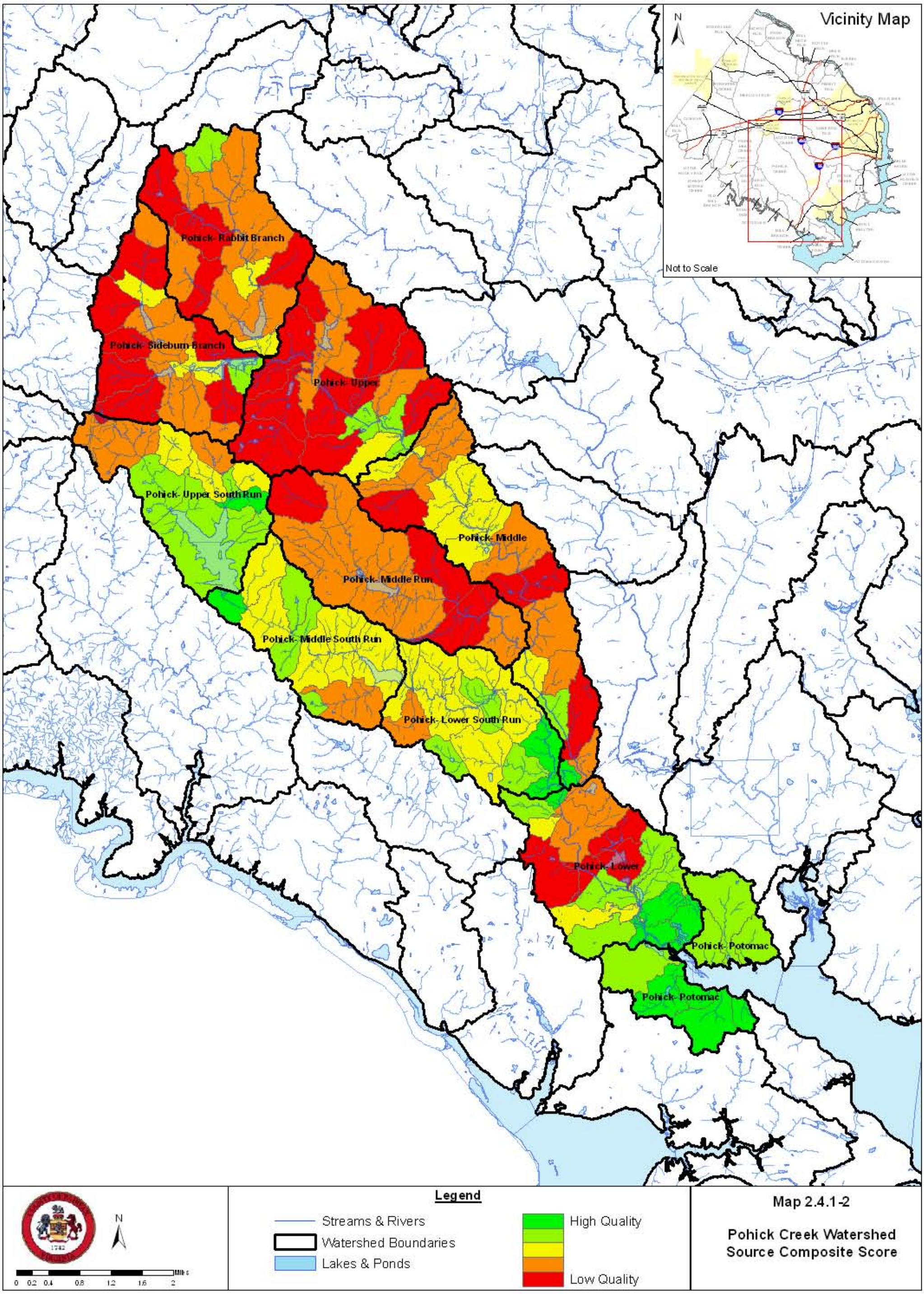
0 0.2 0.4 0.8 1.2 1.6 2 Miles

Legend

- Streams & Rivers
- Watershed Boundaries
- Lakes & Ponds
- High Quality
- Low Quality

Map 2.4.1-1

Pohick Creek Watershed Impact Composite Score



Map 2.4.1-2

Pohick Creek Watershed
Source Composite Score