Methodology and Technical Approach of Study

To answer the questions posed in Chapter 1, this study has taken the following steps: compiled stream quality data from various sources, conducted limited baseline stream quality and stream habitat sampling, and estimated and evaluated impervious cover and land uses for the Paint Branch watershed within Eastern Montgomery County.

The assumption underlying the approach of looking at watershed imperviousness is that the higher the level of land development in a watershed, the greater the degradation in stream quality. As has been summarized in Chapter 2, this inverse relationship between stream quality and watershed imperviousness has been well-documented in several studies and is widely accepted in the water resources field. Factors such as stormwater management measures, improved sediment and erosion controls, and best management practices do help reduce the frequency and severity of impacts, but their effectiveness is limited. And in watersheds where stream systems are healthy and the biological communities in the streams contain pollution-intolerant, indicator species, the limited effectiveness of engineered measures may not be enough to maintain and protect the high quality and healthy conditions of these streams. The watershed's land cover and use, in and of itself, is still the overriding factor in predicting impacts to a stream system at the master planning level.

A. Defining Subwatersheds of Paint Branch

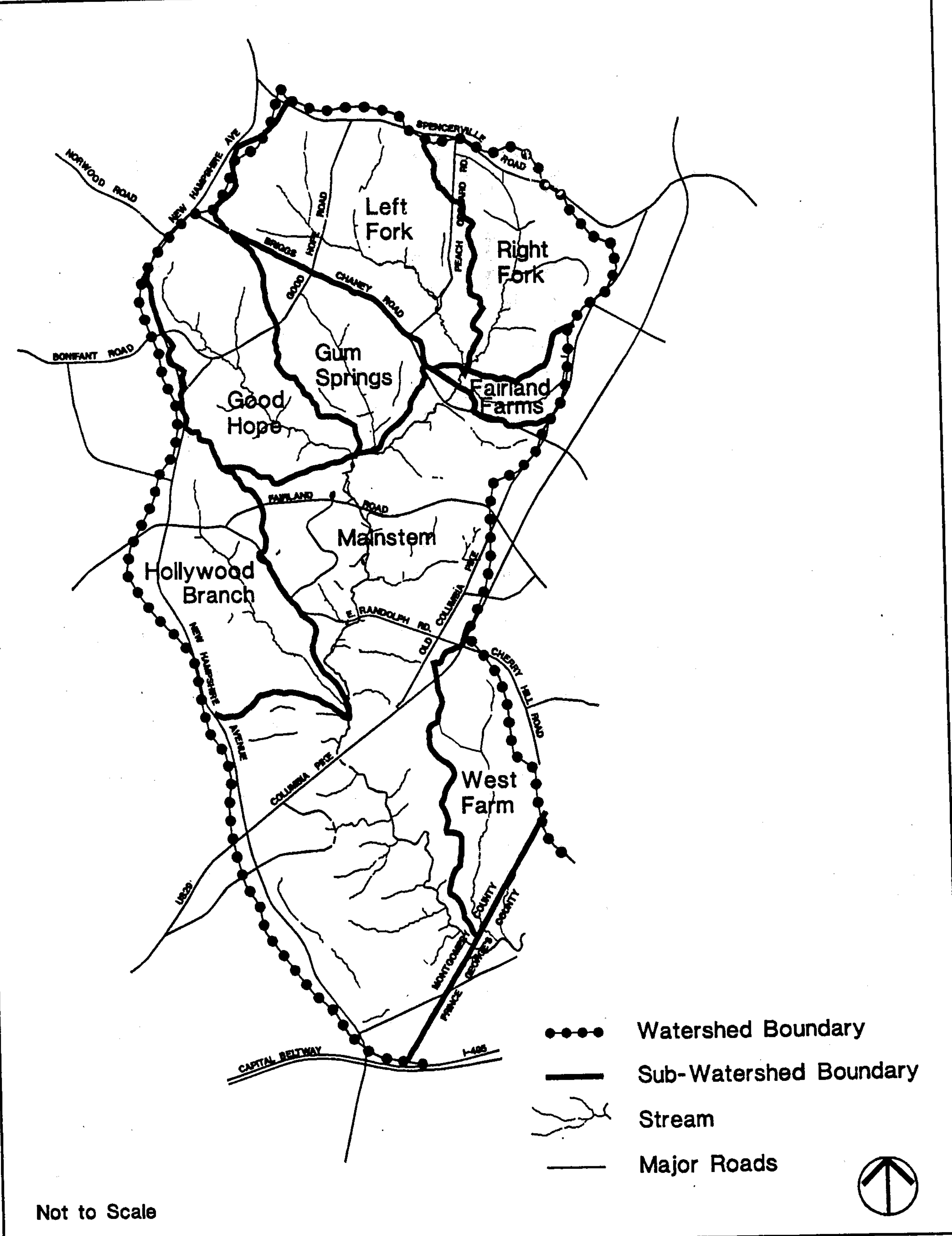
For the purposes of this study, Paint Branch within Eastern Montgomery County is divided up into eight subwatersheds. (See Figure 1, page 14.) A subwatershed is defined in such a way so that, in most cases, it contains at least one first- or second-order stream[9] and the land uses and/or potential for change in land use throughout the subwatershed are relatively similar.

The Paint Branch mainstem in the area around Briggs Chaney Road downstream to the County line is defined as one large subwatershed with at least a third-order stream because there is very little potential for additional development or change in land use in this area.

[9] The size of a stream can be characterized in a relative manner according to where it fits in within the larger system of streams. A first-order stream is one in which no other stream drains to it. A second-order stream is a stream which is formed by the joining of at least two first-order streams.

Paint Branch Subwatersheds Defined for the Study

Figure 1



B. Compiling Stream Quality Data

Within the subwatersheds, the study has collected limited information on aquatic macroinvertebrate communities and stream habitat conditions in areas where no consistent monitoring has been done in the past in order to better characterize existing conditions. M-NCPPC Environmental Planning Division staff collected data on macroinvertebrates and stream habitat conditions at two stations using the Rapid Bioassessment Protocol II developed by the U.S. Environmental Protection Agency (Plafkin et al., 1989). A modified and more rigorous version of this methodology for assessing stream quality is being used by DEP in their stream monitoring program.

The original intent of this stream monitoring effort was to collect data for at least three seasons and, ideally, for a longer time period. However, because of staff time limitations, only one season, the 1993 summer season, could be sampled; therefore, the macroinvertebrate and stream habitat data collected by M-NCPPC staff is limited in nature and must be used with caution in characterizing existing stream quality conditions.

The stream sampling stations set up by the M-NCPPC Environmental Planning Division for the 1993 summer monitoring is shown in Figure 2, page 16. Stream sampling stations within the Eastern Montgomery County portion of Paint Branch that have been set up as part of past or present monitoring programs by other agencies are also shown in Figure 2.

Data on stream quality collected by other agencies have also been compiled to comprehensively characterize as well as possible the past and present conditions of the various streams and any changes in the quality and health of these streams since the adoption of the *1981 Eastern Montgomery County Master Plan*.

C. Calculating Existing Subwatershed Imperviousness

This study estimates subwatershed imperviousness for current conditions and projects the impervious cover assuming buildout conditions under the 1981 master plan zoning. The methodology in this study used Geographic Information System (GIS) data to estimate impervious cover for current conditions and added on estimated impervious cover by zoning category to project subwatershed imperviousness for future conditions.

The first step in estimating impervious cover was to define subwatershed boundaries. These boundaries were drawn on 1" = 200' topographic maps and clipped to each of the GIS planimetric layers (i.e, files) for buildings, roads, streets and parking lots, cultural features, and sidewalks. These planimetric layers form the foundation of the County's geographic information system. The information was entered into digital format from aerial photos by the Research and Information Systems Division of the M-NCPPC Montgomery County Planning Department.

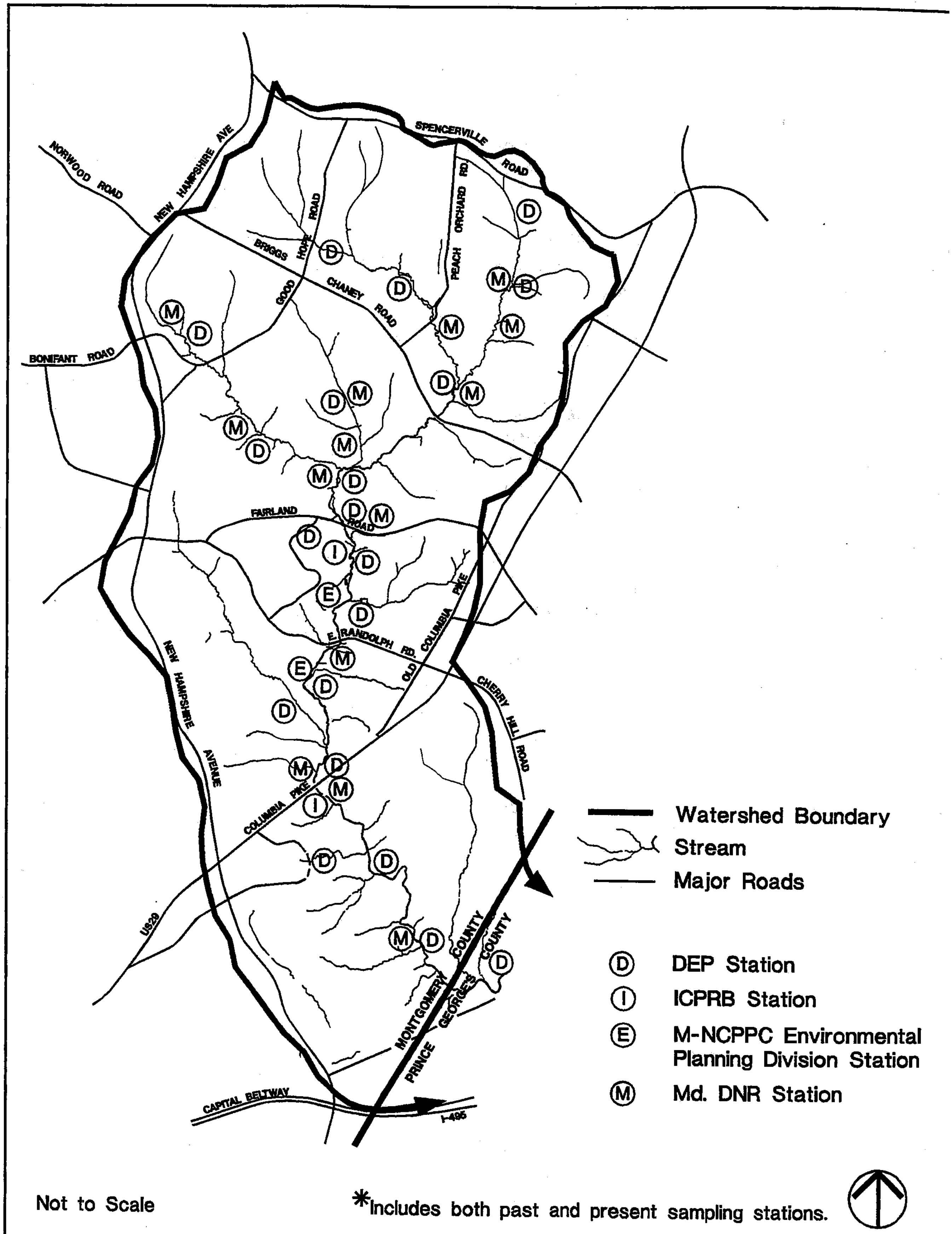
For the study, the layers that represented current conditions reflected 1990 conditions. There has been a relatively small amount of development in the Eastern Montgomery County area since 1990 due to traffic moratorium conditions, so that land use conditions reflected by the 1990 planimetric data were assumed to closely represent present existing conditions. That is, 1990 planimetric data were used to characterize existing conditions with respect to land uses and land cover.

GIS was used to measure all paved surfaces and building rooftops that are shown in the planimetric layers for each subwatershed. These layers include all features that are considered to be impervious surfaces except for sidewalks and driveways for single-family detached houses (see below for the method used in estimating impervious surface area attributable to sidewalks and residential driveways). This method of measuring impervious surfaces differs from past studies (i.e., M-NCPPC staff analysis of imperviousness in upper Paint Branch for the *1981 Eastern Montgomery County Master Plan* [M-NCPPC 1981] work, staff analysis of imperviousness in Paint Branch due to proposed development in 1979 (Gresh, 1979), and the "Anacostia: Technical Watershed Study" [CH2M Hill, 1982]) in that previous methods relied largely on imperviousness factors by land use or development category to estimate subwatershed imperviousness under "current" or "existing" conditions; to calculate imperviousness within a given subwatershed, the factor would be multiplied by the amount of corresponding land use or development category occurring in the subwatershed, and the estimated impervious surfaces for the various land use or development categories would be summed.

The actual measure of impervious surface on the land, which has only recently become possible due to the development of GIS technology, pro-

Paint Branch Stream Sampling Stations

Figure 7



vides a more accurate measure of imperviousness for "current" or "existing" conditions. It can also provide a reference against which to evaluate past and present methods of estimating imperviousness by land use category.

As part of this study, the GIS layers were compared to 1993 aerial photographs to check and verify the accuracy of the data. This comparison revealed that substantial paved area exists in the form of driveways on single-family detached residential lots which are not included in the planimetric database. To calculate the area of driveways not already accounted for, the building, road/street, and parking layers were evaluated and an approximate count obtained of the number of buildings (primarily residential single-family detached units in subdivisions; rear yard structures assumed to be sheds and the like were not counted) for which a driveway existed but did not appear in the planimetric layer. This number was then multiplied by an estimated average area for a driveway in each subwatershed, which was obtained from the required front-yard setback for the predominant residential zones within the watershed multiplied by an assumed width of 15 feet.

Sidewalks are a feature in the GIS data that are shown as lines and not as polygons. The area of sidewalks was determined by multiplying the length (taken from the planimetric layer) by an assumed width of 4 feet.

In addition to the GIS layers for paved features (buildings, driveways, roads, streets and parking, cultural, and sidewalks) the "impervious" contribution of non-paved land cover was calculated, based on the assumption that these surfaces also contribute to surface water runoff for some precipitation events. Remaining non-paved land was categorized as either forested or nonforest-nonpaved. Non-forest, non-paved land includes lawn, pasture, and crop fields and is referred to as meadow. Forest cover is assigned an imperviousness factor of 1 percent; non-forest green cover is assigned a factor of 3 percent. A 1 percent imperviousness factor for forest cover has been used in other studies that focus on land use imperviousness (Northern Virginia Planning District Commission, 1980; Galli, 1983; CH2M Hill, 1982). For non-forested green cover, a wider range of imperviousness factors have been used (i.e., 0 to 7 percent). This study uses 3 percent imperviousness factor for non-forested green cover because it is roughly the middle of the range of values that have been used in other studies, it is the factor used in the Paint Branch compendium (Galli, 1983), and it reflects the greater benefits of forest cover compared to meadow or grass cover on streams.

The study's methodology may underestimate imperviousness at some development sites because it does not account for compacted urban soils. However, there are currently no imperviousness factors that are generally accepted to accurately represent the "impervious" nature of such soils.

Figure 3 summarizes the study's assumptions in calculating subwatershed imperviousness under 1990 conditions.

D. Projecting Subwatershed Imperviousness

To estimate the effects of the 1981 master plan zoning recommendations on the ultimate subwatershed imperviousness levels, the study projected imperviousness by zoning.

For each subwatershed, properties were identified according to their development status as of 1990: already developed, developable, committed or pipeline (i.e., properties that have an approved development plan, preliminary plan, or site plan, or are recorded lots, but were not constructed as of 1990). Developable and committed/pipeline properties were further characterized by zoning. For land in each category of zoning and development status, the amounts of forest and non-forest cover and associated impervious surfaces under 1990 conditions were calculated through the use of M-NCPPC Montgomery County Planning Department Arc/Info layers and databases. The projected impervious cover on a category of land if or when it develops under either the master plan zoning or an approved plan was calculated using imperviousness factors by zones. To estimate the total subwatershed impervious cover assuming 1981 master plan buildout, the projected impervious covers for all categories of land were added to the 1990 calculated impervious coverage and 1990 impervious surfaces for developable and committed/pipeline land were subtracted out (as shown in box below):

$$\text{Projected subwatershed imperviousness for given land use scenario} = \left(\text{1990 subwatershed imperviousness}\right) - \Sigma\left(\text{1990 calculated imperviousness for developable or committed/pipeline property}\right) + \Sigma\left[\left(\text{size of developable or committed/pipeline property}\right) \times \left(\text{imperviousness factor of the zone proposed or existing for the property}\right)\right]$$

Assumptions Used in Calculating Subwatershed Imperviousness for Existing Conditions

Figure 3

1. Use 1990 planimetric data (most current data available on GIS at this time) to represent existing conditions.

2. Driveways for single-family detached lots are not included in the GIS data bases. Assume the following average dimension for a driveway:

   30 ft. x 15 ft. in Paint Branch

3. Imperviousness due to forest cover = 1%

4. Imperviousness due to non-forest, non-paved cover (i.e., meadow, pasture, lawn, field, shrub-shrub) = 3%

5. Imperviousness due to buildings and pavement = 100%

6. Sidewalks appear in the GIS data as linear features, not polygons. Assume sidewalks have an average width of 4 feet.

7. Percent subwatershed imperviousness in 1990 =

$$100\%\ \text{X}\ \frac{\left(\begin{array}{c}\text{Acres of}\\ \text{roads +}\\ \text{buildings}\end{array}\right) + \left(\begin{array}{c}\text{Estimated}\\ \text{acres of}\\ \text{driveways}\end{array}\right) + \left(\begin{array}{c}\text{Estimated}\\ \text{acres of}\\ \text{sidewalks}\end{array}\right) + \left[(.01)\left(\begin{array}{c}\text{Acres}\\ \text{of forest}\\ \text{cover}\end{array}\right)\right] + \left[(.03)\left(\begin{array}{c}\text{Acres of non-}\\ \text{forest, non-}\\ \text{paved cover}\end{array}\right)\right]}{\text{Subwatershed size in acres}}$$

Imperviousness Factors by Zone

Table 1

Zoning Category	Imperviousness Factor (percent)
RC	6
RE-2	9
RE-2C	9
RE-1	11
R-200	19
R-90	20
R-200/TDR5	35
R-150/TDR5	35
R-90/TDR 5 to 8	37
R-60/TDR 8 to 9	40
R-20	60
PD-2	20
C-1, C-2, C-3	90
O-M	90
I-1	60
I-2	80
I-3	60
I-4 in West Farm	60

Imperviousness factors by zone were primarily derived from and are comparable to estimates of percent impervious cover by land use type that were compiled as part of a study of nonpoint pollution from uncontrolled urban and rural-agricultural land uses in northern Virginia (Northern Virginia Planning District Commission, 1980). These land use types are comparable to the zones found in Montgomery County. In addition, the Eastern Montgomery County watershed study calculated impervious cover for selected residential subdivisions that have been constructed in Eastern Montgomery County using data on the GIS system.

Table 1 presents the imperviousness factors by zones that have been used to project the total subwatershed imperviousness under the 1981 master plan buildout. These imperviousness factors by zone have also been used to project subwatershed imperviousness under various buildout scenarios that deviate from the 1981 master plan zoning recommendations for specific subwatersheds to determine how changes to the 1981 master plan may affect impervious cover.