Appendix A

Evaluating Pollutant Loadings from Construction Activities that Potentially Impact the Environment

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This appendix details aspects of the methodologies described in Section 3 to pollutant discharges that result from construction activities under two options. Specifically, it expands on the discussion presented in Section 3, providing additional information on the assumptions used by EPA in its assessment.

Estimates of Affected Area

The Phase II NPDES storm water rule economic analysis (USEPA, 1999) presented information on the size and nature of construction activities under the Phase I and II storm water programs. In addition, the Phase II economic analysis (EA) detailed an extensive analysis of pollutant loadings for a range of site sizes, soil types, land slopes, and locations. EPA's current evaluation uses the results presented in the Phase II report to update its overall estimate of national construction site loadings. EPA expects that new regulation of the construction and development (C&D) category will augment the existing state and Phase I NPDES storm water programs. In addition, new regulations will shape future development of construction programs expected under the Phase II NPDES storm water program.

EPA identified the array of potentially affected construction sites in the nation. EPA's assessment of construction site loadings is based on regulation of approximately 2.17 million acres per year. This regulated acreage estimate was calculated based on estimated national development rates from the 1997 National Resources Inventory (USDA, 2000), less the estimated acreage either occupied by sites less than 1 acre in size (not regulated) or sites which receive Phase II "R" waivers. "R" waivers are those applied for and granted under the construction general permit for sites with very low erosivity. The Phase II EA estimated the total acreage granted "R" waivers to be approximately 33 thousand acres (approximately 1.8 percent of the total constructed acreage). Based on its assessment of probable construction site size distribution, EPA estimates that another 1.7 percent of the annual constructed acreage will be on sites less than 1 acre. In addition, under Option 1, EPA is considering removing sites smaller than 5 acres. EPA estimates that approximately 18 percent of construction occurs on sites less than 5 acres in area.

EPA's Analysis of State Programs

Table A-1 presents the results of EPA's analysis of state construction programs. EPA focused on the states with the largest annual construction footprint to estimate the level of current control (i.e., not all state regulations were reviewed). As a result, the absence of a "Yes" value in Table A-1 may indicate that a construction program was not evaluated by EPA. Overall, the results in Table A-1 were converted into a ecoregion "score" or the percent of developed acreage that would gain greater management under EPA's options. Table A-2 indicates the resulting percentage of construction acreage affected by the potential effluent guidelines in each ecoregion. As expected, new BMPs required under the options (e.g., certification of sediment basins) were not found in existing state regulations, and overall, existing state requirements require option-level BMPs for approximately 30-35 percent of the acreage developed annually.

Table A-1. Assessment of State Construction Control Programs

State/Territory	Minimum of 3600 Cubic Feet per Acre Storage Requirement for Larger Sites	14-Day or More Inspection Frequency	14- Day Cover Required	States with Less than 20 Inches of Precipitation Per Year
Alabama				
Alaska	Yes	Yes	Yes	
Arizona	Yes	Yes	Yes	Yes
Arkansas				
California	Yes		Yes	Yes
Colorado				Yes
Connecticut	Yes		Yes	Yes
Delaware	Yes		Yes	Yes
District of Columbia				
Florida				
Georgia				
Hawaii				
Idaho				Yes
Illinois	Yes			
Indiana				
Iowa	Yes	Yes	Yes	
Kansas				
Kentucky				
Louisiana				
Maine				
Maryland				
Massachusetts	Yes	Yes	Yes	
Michigan				
Minnesota				

State/Territory	Minimum of 3600 Cubic Feet per Acre Storage Requirement for Larger Sites	14-Day or More Inspection Frequency	14- Day Cover Required	States with Less than 20 Inches of Precipitation Per Year
Mississippi				
Missouri				
Montana		Yes		Yes
Nebraska				
Nevada				Yes
New Hampshire	Yes	Yes	Yes	
New Jersey				
New Mexico	Yes	Yes	Yes	Yes
New York				
North Carolina				
North Dakota				Yes
Ohio		Yes	Yes	
Oklahoma	Yes			
Oregon				
Pennsylvania	Yes	Yes	Yes	
Rhode Island				
South Carolina	Yes	Yes	Yes	
South Dakota	Yes	Yes	Yes	Yes
Tennessee	Yes	Yes	Yes	
Texas	Yes	Yes	Yes	
Utah	Yes	Yes	Yes	Yes
Vermont				
Virginia	Yes	Yes	Yes	
Washington				
West Virginia	Yes		Yes	
Wisconsin				

State/Territory	Minimum of 3600 Cubic Feet per Acre Storage Requirement for Larger Sites	14-Day or More Inspection Frequency	14- Day Cover Required	States with Less than 20 Inches of Precipitation Per Year
Wyoming		Yes		Yes

Table A-2. Percentage of Acreage Developed Without Option Equivalent Requirements

Ecoregion	3600 Cubic Feet per Acre Storage in Sedimentation Basins for Larger Sites (Criterion 1)	Certification of Sediment Basins (Criterion 2)	14-Day or more frequent inspection (Criterion 3)	14- Day Cover For Wet-States, or none required for dry states (Criterion 4)	Overall Weighted Percentage of Acres Without Coverage
ER 1	28.96%	0.00%	28.25%	30.72%	24.7%
ER 2	39.16%	0.00%	57.61%	57.61%	47.1%
ER 3	0.00%	0.00%	10.66%	10.66%	8.0%
ER 4	77.06%	0.00%	77.06%	77.06%	65.5%
ER 5	65.74%	0.00%	65.74%	65.74%	55.9%
ER 6	100.00%	0.00%	100.00%	100.00%	85.0%
ER 7	100.00%	0.00%	100.00%	100.00%	85.0%
ER 8	64.45%	0.00%	68.16%	64.45%	56.6%
ER 9	50.16%	0.00%	55.30%	42.80%	43.4%
ER 10	74.51%	0.00%	81.79%	81.79%	68.8%
ER 11	71.53%	0.00%	71.70%	71.70%	60.9%
ER 12	51.80%	0.00%	65.17%	65.17%	54.1%
ER 13	89.38%	0.00%	32.32%	89.38%	47.4%
ER 14	67.34%	0.00%	53.83%	71.01%	51.4%
ER 15	62.15%	0.00%	100.00%	100.00%	81.2%
ER 16	5.65%	0.00%	100.00%	100.00%	75.6%
ER 17	100.00%	0.00%	100.00%	100.00%	85.0%
ER 18	100.00%	0.00%	100.00%	100.00%	85.0%
ER 19	100.00%	0.00%	100.00%	100.00%	85.0%
National Average Weighted by Land Developed	64%	0%	70%	69%	58.9%

Information in Table A-2 was converted into an overall national “score,” to discount estimated TSS loadings reductions by accounting for acres covered by equivalent programs. To combine the four analyzed criteria, EPA assumed that the individual contributions to reductions were 10, 15, 50, 25 percent, respectively. For example, sedimentation basins based on 3,600 cubic feet contribute 10 percent of the estimated reduction between baseline and option loadings. On a national basis, EPA estimated that approximately 41 percent of land is served by equivalent programs, and would not be affected by Option 1 or 2 requirements.

Appendix B

Inventorying of Streams Potentially Impacted By Construction Activities

Appendix B Inventorying of Streams Potentially Impacted By Construction Activities

Overview

This appendix describes EPA's effort to inventory and assess environmental impacts of construction activities. Specifically, the appendix describes, in detail, the analytical steps performed to inventory the nation's stream system and provides general background information on the rationale used to develop the inventory approach. Delineation of impacted stream environments forms the basis for assessing the future benefits of regulatory controls on construction and activities.

The objectives of this appendix are as follows:

- To describe a method to characterize streams by their hydrologic function based on regional differences

- To establish the appropriate map scale for inventorying streams based on their size and geometry (e.g., length, slope, dimensions).

Stream Characterization

Many of the impacts on streams are a function of drainage area and hydrologic regime. Producing a national summary of potentially impacted stream networks is challenging because the nature and size of streams vary significantly throughout the country. For example, watersheds that produce a minimum base flow of 1 cubic foot per second (cfs) occupy 1 square mile in the eastern United States but require 100 square miles in the arid southwest. To account for this variation, EPA divided the country into 19 large hydrologic regions and then further inventoried the streams in each region separately, based on approximate stream size categories (i.e., stream orders). Representative watersheds in each of the 19 large ecoregions in the contiguous U.S. (see Figure B-1) were inventoried to determine the average stream density for the stream orders that are the most likely impacted in each ecoregion.

EPA developed the boundaries for the 19 ecoregions based on a stream density assessment that used EPA's Reach File 1 (RF1) stream network and the 76 ecoregions developed by Omernik (1987). Figure B-2 shows the RF1 densities in terms of acres per stream mile for each of the 76 ecoregions. Combining the 76 ecoregions into the 19 ecoregions shown in Figure B-1 helps simplify the analysis while still capturing a reasonable number of regions with similar stream densities and accounts for gross changes in hydrology, land forms, soil types, and potential natural vegetation.

In general, the literature indicates that environmental sensitivity (e.g., geomorphologic changes, pollutant toxicity) is greater on smaller stream orders, from the intermittent headwater streams to small perennial streams. For most environmental impacts (except perhaps nutrient loadings), the impacts of the construction and land development industry tend to decrease with increased stream size, and the impacts tend to become confounded with other influences (e.g., other point and nonpoint source pollutant loads). For this reason, the inventory focused on relatively small watersheds (between 2 and 7 square miles) to better assess the impacts of hydrologic changes on small streams.

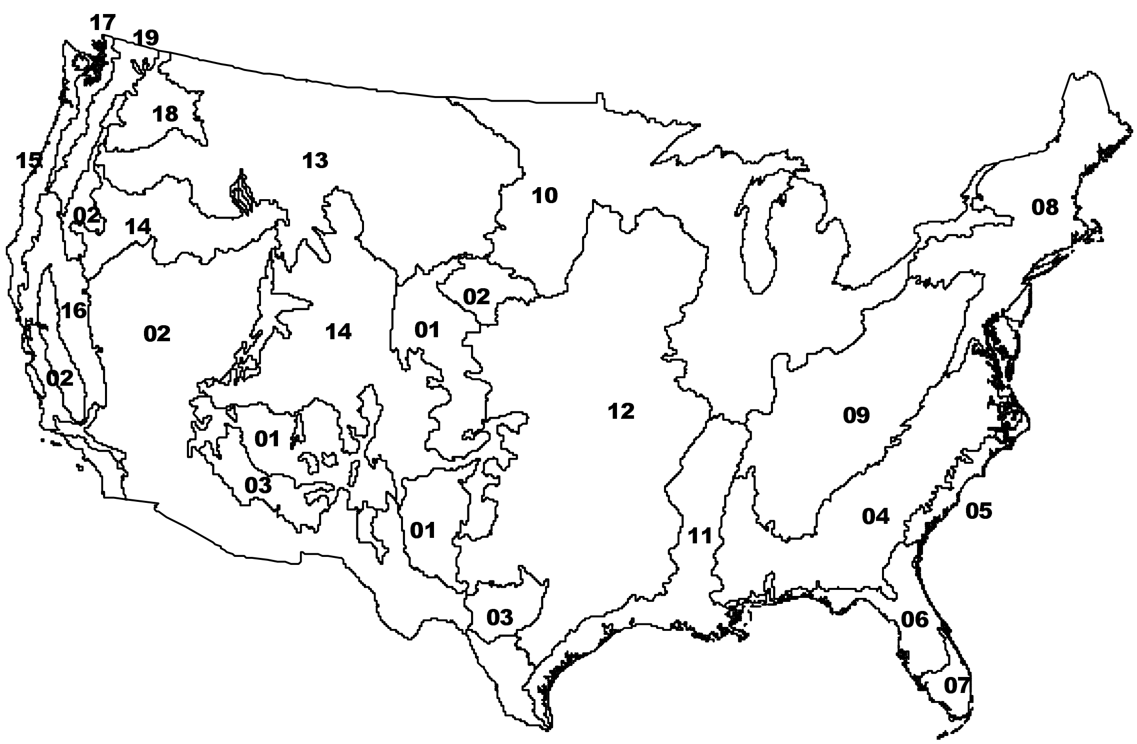

Figure B-1. Regions for Stream Inventorying

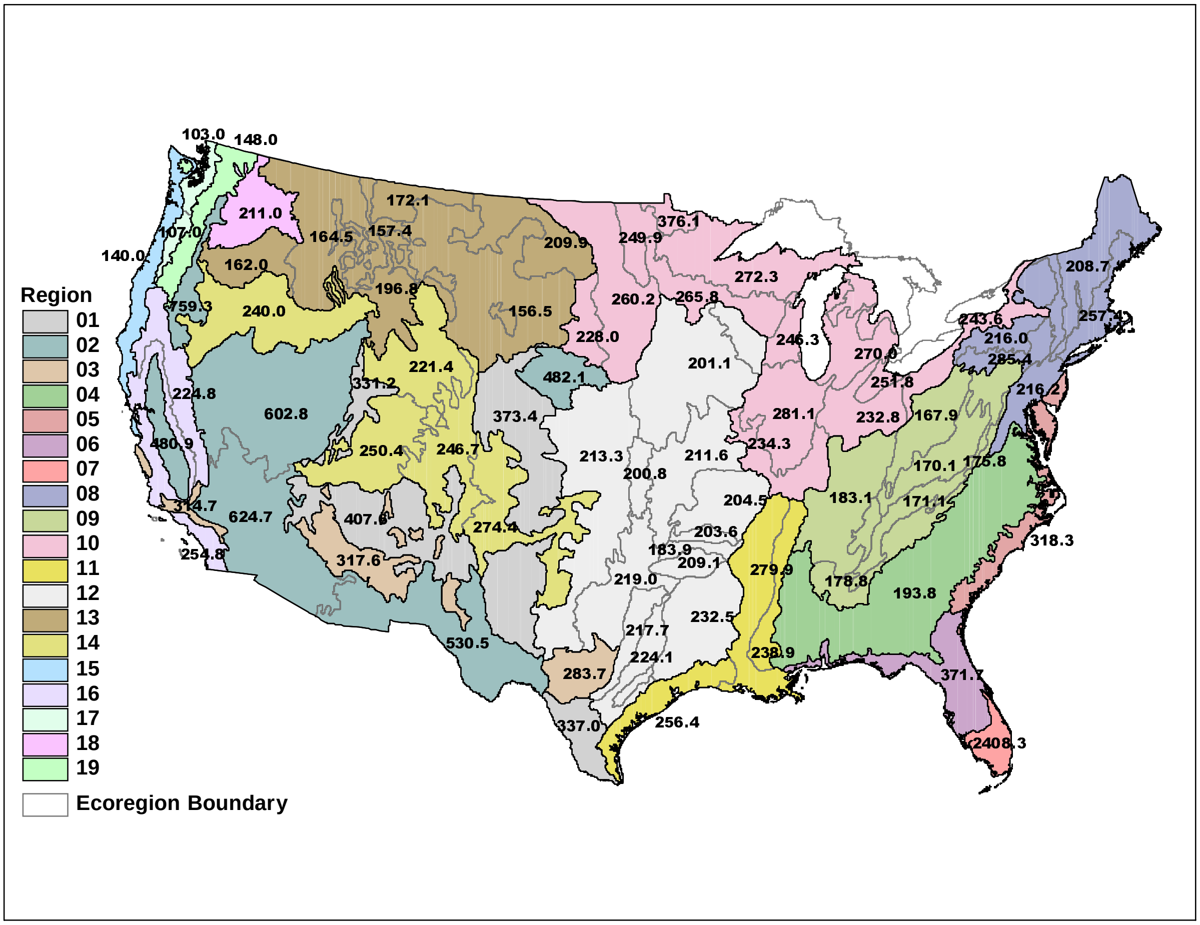

Figure B-2. Stream Densities for Omernik Ecoregions
(in units of acres per stream mile)

Because EPA focused on small streams, it was necessary to select a method by which to characterize streams by size. Historically, various schemes have been created to characterize and count streams within a drainage network, including the following:

- Stream order is determined by counting stream segments starting with the smallest stream channels found on a selected map scale.
- Stream level is determined by counting stream segments starting from the most downstream discharge point (ocean or estuary) on a selected map scale.

- Streams are characterized by physical descriptions including flow frequency (perennial or intermittent streams), size (large, medium, or small), and/or terms such as swales, creeks, and rivers.

- Watershed size is based on the scale of the map on which the watersheds are just visible.

EPA selected the first method, stream order characterization, for use in this assessment.

Map Scale Selection

Because any network of "streams" identified at the outset of a hydrologic inventory is highly dependent on the scale of the map used, selecting the appropriate scale is a critical step. Rills and swales that are obvious and identifiable on a 1:2,400-scale map are completely absent on a 1:250,000-scale map. Figure B-3 shows the streams visible on the following three scales of maps for a typical watershed (10 square miles) in northeastern Maryland:

- U.S. Geological Survey (USGS) 1:250,000-scale map or streams found in EPA's RF1 stream network

- USGS 1:100,000-scale map or streams found in EPA's Reach File V. 3 (RF3) and National Hydrography Dataset (NHD) (USGS, 2000) stream networks

- USGS 1:24,000-scale map.

The three map scales, respectively, permit successively finer viewing of stream sizes: (1) large perennial streams, (2) medium perennial to intermittent streams, and (3) larger swales and intermittent streams. Although not shown in Figure B-3, an even finer detail stream network—one based on 1:2,400-scale maps (a scale commonly used by local governments) that includes the smallest swales—can be visualized by increasing the number of 1:24,000-scale streams threefold (i.e., delineation of watersheds as small as 2 acres). Figure B-3 illustrates the importance of map scale selection:

- Inventorying stream networks based on 1:24,000-scale will include many more streams than a 1:250,000-scale inventory;

- The stream order assigned to any stream will be different based on the map scale; and

- Direct evaluation using only EPA's RF1 and RF3 hydrologic stream coverages would grossly undercount the number of streams potentially impacted.

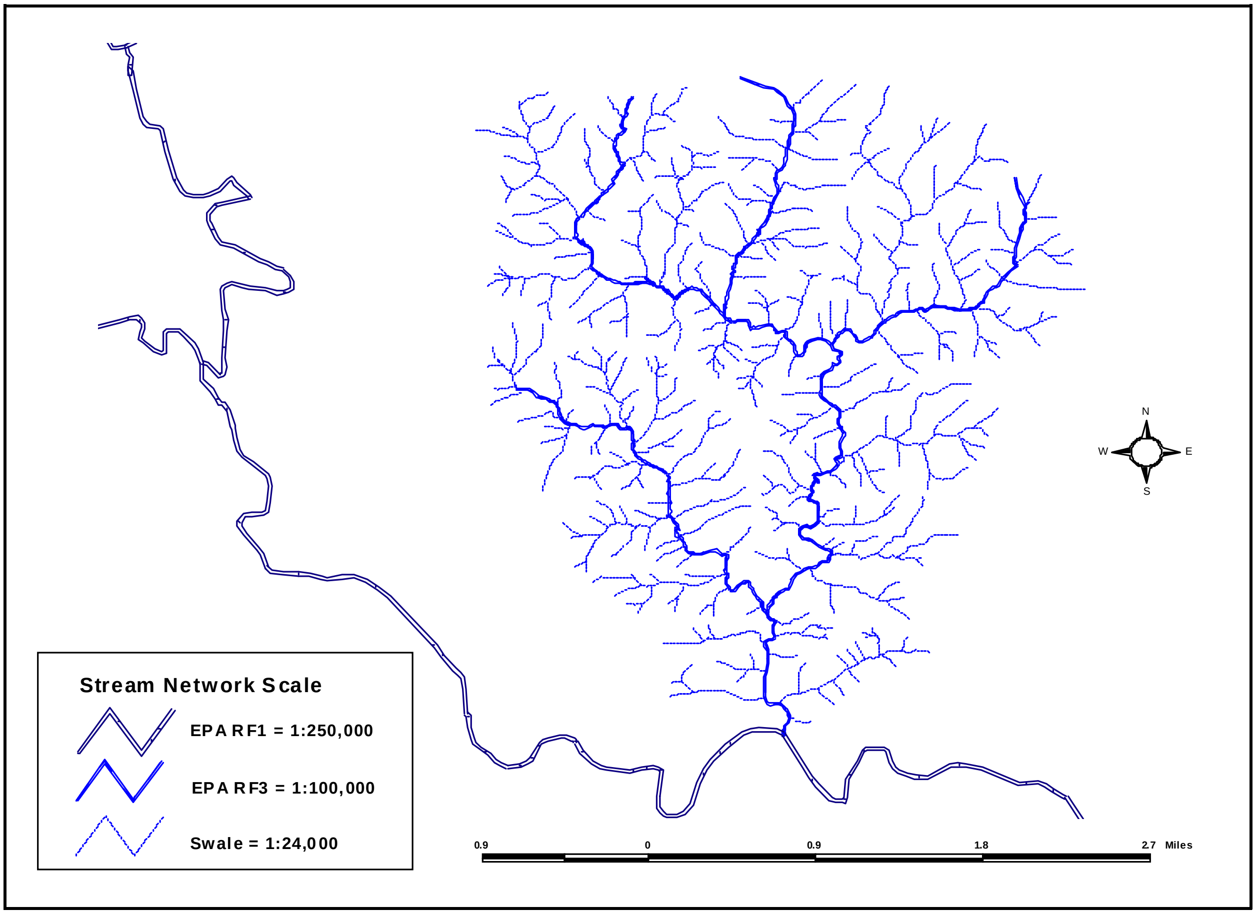

Figure B-3. Stream Networks for 1:250,000-, 1:100,000-, and 1:24,000-Scale Maps

Note: The 1:24,000-stream network shown contains more streams than the USGS identified on its 7.5-minute quadrangle maps using typical blue or dashed blue lines. This figure includes all swales that can be drawn based on contour lines given on the 1:24,000 map, resulting in an enhancement that shows two to three times more "streams" than are shown on the original map (down to watersheds approximately 10 acres in size).

Interpretation of contour lines defines a stream network based on land forms as the contours are present because streams/swales have created them. This contour-based enhancement defines a "stream" based on topography, regardless of whether or not the stream is actually drawn on the map.

Because using an increased detail of stream network (smaller map scale) requires increased effort levels, EPA developed a method that was both practical and depicted the appropriate stream level for this assessment. The amount of stream data available is extensive; the national coverage for RF1 contains 100 megabytes of data, while RF3 contains 7,400 megabytes. All of RF1 (data on just the largest rivers in the nation) can reside and be analyzed on a single microcomputer. However, the RF3 network and the similar, newer NHD are so large they can be analyzed in a microcomputer environment only when divided into 20 separate parts. Therefore, EPA assumed that a national dataset containing all streams and swales identifiable from 1:2,400-scale maps would be unworkable within the current limits of any microcomputer.

To maintain a relatively small map scale, EPA performed an inventory of streams and swales identifiable based on 1:24,000-scale maps (where swales are added manually) by first sampling representative watersheds or areas. (An actual inventory of individual swales and streams on a 1:24,000-scale for specific acreage developed in any given state in any given year is beyond current computational capabilities and the limits of available data, requiring some type of approximation or sampling technique). EPA used digital elevation maps (DEMs), which allowed EPA to process contour data, enhancing the original stream network to provide data on the larger intermittent streams (typically streams draining less than 30 acres). Because EPA's assessment of the construction industry indicates that a medium-sized construction start is approximately 20 acres, this approach is refined enough to inventory the number and size of streams potentially impacted by construction and land development activities. The number and length of streams in a larger area were then estimated by using the stream density found in the sampled watershed/area.

Appendix C

Impacts of Construction Activities on Hydrology

Appendix C Impacts of Construction Activities on Hydrology

Overview

This appendix describes hydrologic changes that result from construction and post-development activities, and focuses primarily on changes in runoff rates and soil infiltration. The general hydrologic changes caused by these industries have environmental and economic impacts.

The objectives of this appendix are:

- To demonstrate the variation in runoff rate for a 10-acre site as it changes from a forested condition into a construction condition.
- To describe the environmental benefits of current BMPs primarily designed to limit discharge from construction sites.

Methodology

A simple hydrologic model was developed to depict the hydrologic changes that result from construction and land development activities on a (10-acre) site. The size of 10-acres was chosen because it represents the typical size for a construction site. In addition, the hydrologic changes are believed to be similar to changes that result on larger sites such as 100-acre sites and 1000-acre sites.

Investigation of hydrologic changes was performed by using two hydrologic models: TR-55 and TR-20. These models use data developed over many years by USDA/Natural Resources Conservation Service (NRCS), and are among the most often employed models for the hydrologic design of hydraulic structures, such as storm drainage systems (USDA, 2002).

The 10-acre watershed was assumed to have a 50/50 mix of soils in the type B and C hydrologic soil classification, with an average ground slope of 7 percent. Time of concentration was derived based on standard TR-55 worksheets that analyze sheet flow, shallow concentrated flow, and pipe flow. For the analysis, the 2-year 24-hour SCS[1] type II rainfall event, totaling 3.2 inches of rainfall, was used to conservatively estimate the runoff hydrographs.

Multiple land use conditions (Table C-1) were evaluated to help assess the hydrologic impacts for the small 10-acre site. EPA notes that most construction sites occupying 10 acres are

[1] The Soil Conservation Service (SCS) is the former name of the Natural Resources Conservation Service (NRCS).

equipped with a sedimentation pond, intended to minimize sediment discharge from the site. Although sediment ponds are not designed specifically shave the peak runoff rate (i.e., limit the construction site peak discharge rate to be equal to or less than the peak runoff from the forested site), these structures inherently have some capability of peak-shaving depending on the site conditions. In addition, sedimentation ponds can be built to increase its peak-shaving capability. For the purposes of this assessment, EPA assumed that a sedimentation pond (Condition 3) shaves the peak completely, as shown in Figure C-1.

Table C-1. Evaluated Hydrologic Conditions for a Typical 10-Acre Site

Land Use Condition	Description
1	Pre-development: a forested land use
2	Construction: cleared and grubbed soil surface with no vegetation and without construction runoff BMPs (No sedimentation ponds)
3	Construction: cleared and grubbed soil surface with no vegetation with storm water BMPs (a sedimentation pond that also shaves the peak runoff to match the pre-development peak flow)

The results of the analysis are presented below for each of these land use conditions.

Discussion of Runoff Results for Modeled Land Use Conditions

Figure C-1 compares the predicted runoff hydrographs for Land Use Conditions 1 through 3. The hydrographs in the figure show the large increase in runoff volume and peak runoff rate that occurs for construction sites with or without storm water BMPs that limit the peak runoff rates. This increase is caused by the removal of existing vegetation and compaction of site soils with earth moving equipment, which greatly diminishes the site’s ability to absorb rainfall and limit discharge. In fact, NRCS data strongly suggest that a fully-constructed site (e.g., a residential neighborhood) produces less runoff than a denuded site under construction, even though impervious surfaces (e.g., driveways, roofs) have not yet been installed.

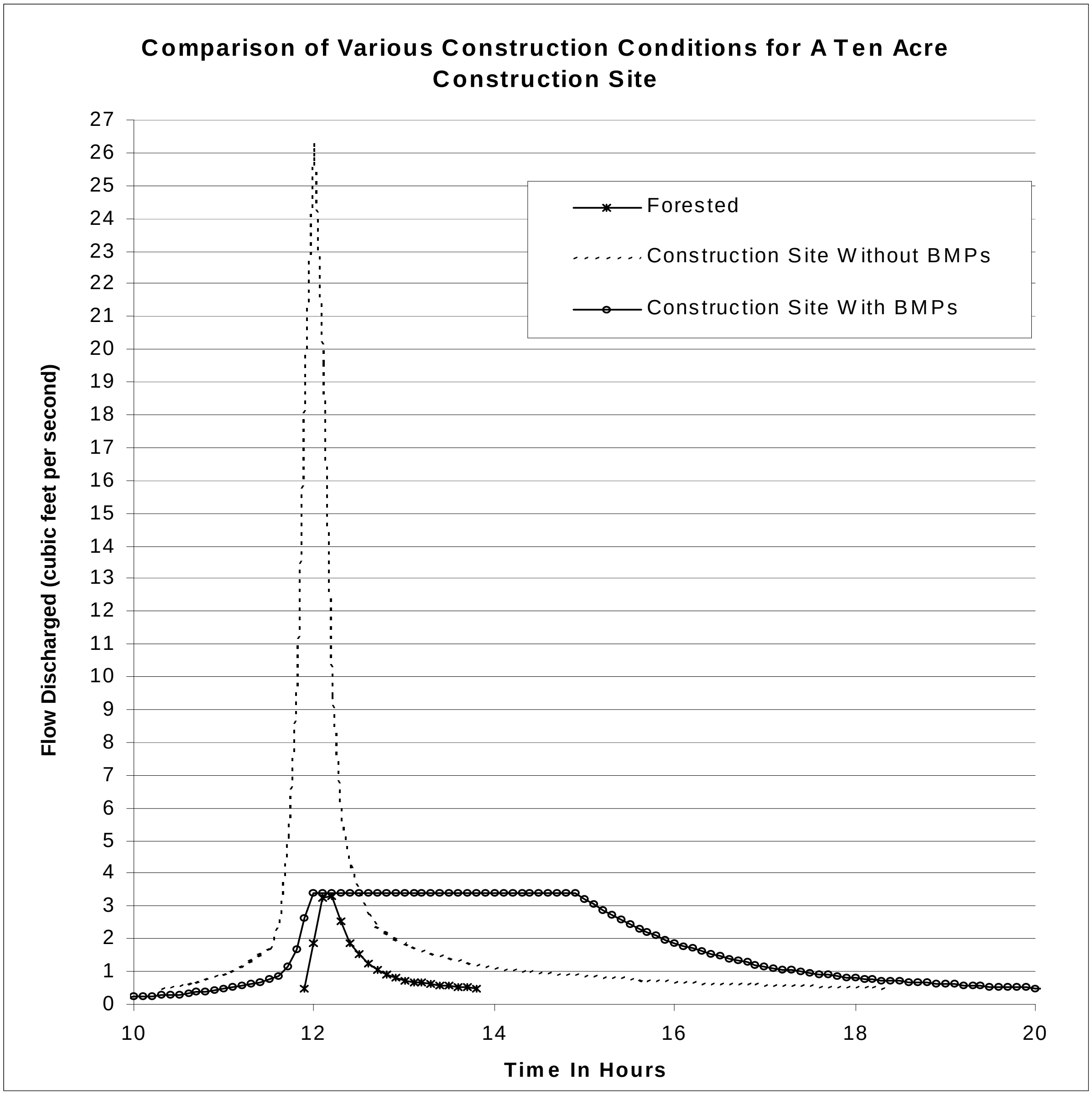

Figure C-1. Runoff Hydrographs for a 10-Acre Construction Site

Although the implementation of peak-shaving BMPs minimizes some of the flooding downstream of a construction site due to high peak flows, it does not eliminate the potential for enhanced flooding that is caused by longer durations of high-flow discharges. Table C-2 indicates that the construction site produces high flows for a much greater duration than flows originally released from the forested site. In fact, the 10-acre site that once produced a flow rate equal to or greater than 3 cubic feet per second (cfs) for only 0.2 hours will produce more than 3 cfs for 3.2 hours when peak-shaving BMPs are employed during construction. Should a 2-year storm occur during the construction period, the longer flow duration increases the chances that the discharge will be combined with downstream peak flows from other developing/developed locations to produce a flooding condition.

Table C-2. Comparison of Durations of High Flow Rates for Different Land Use Conditions

Land Use Condition	Hours of flow equal to or greater than:		
	3 cfs	2 cfs	1 cfs
Forested	0.2	0.3	0.8
Construction site without peak shaving BMPs	0.9	1.4	3.3
Construction site with peak shaving BMPs	3.2	4	5.7

cfs = cubic feet per second