Chapter 4.1 NONPOINT SOURCE ASSESSMENT, PRIORITIZATION, AND ACTIVITIES

This section of the Virginia Water Quality Assessment 305(b) Report includes an assessment of nonpoint source (NPS) pollution potential at the 6th order hydrologic units of the National Watershed Boundary Dataset (NWBD) level (hereafter referred to as either hydrologic units or just units). These units are smaller than the units assessed in previous NPS Assessment reports[1]. It also includes indicators for prioritizing NPS corrective actions at the hydrologic unit level and a summary of NPS reduction activities currently underway. It has been prepared by the Virginia Department of Conservation and Recreation (DCR) to provide a comparative evaluation of the state's waters, on a hydrologic unit basis for assisting in the targeting of limited resources and funds for NPS pollution protection activities to where they are most needed.

The 2008 NPS Assessment and Prioritization study summarizes information from DCR, the Virginia Department of Environmental Quality (DEQ), Virginia Department of Forestry (DOF), U.S. Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS), local Soil and Water Conservation Districts (SWCDs), the Department of Biological Systems Engineering (BSE) at Virginia Tech (VT), the Virginia Department of Health (VDH), the Virginia Department of Game and Inland Fisheries (DGIF), the Virginia Department of Mines, Minerals, and Energy (DMME), the Center for Environmental Studies (CES) at Virginia Commonwealth University (VCU), the US Environmental Protection Agency (EPA), the Chesapeake Bay Program (CBP), the U.S. Geological Survey (USGS), and other existing sources of information concerning nonpoint source impacts to Virginia waters.

There are four major components to the 2008 NPS Assessment and Prioritization study - potential pollutant loadings, water quality impairments, measures of biological health, and NPS reduction activities. The main focus is the determination of potential loadings of nitrogen, phosphorous, and sediment (hereafter referred to as NPS pollutants) by hydrologic unit by general land use categories. The evaluation of hydrologic units by impaired waters and aquatic species health represents water quality measures not necessarily related to the NPS pollutant loads. In order to prioritize clean-up and protection activities, hydrologic units of prime importance for the protection of public surface water supplies were also determined. Details on these components follow.

NPS POLLUTION LOADINGS

The NPS Assessment of pollutant loadings is a calculation of the estimated edge of stream (EOS) loadings of nitrogen, phosphorous, and sediment per hydrologic unit using a model whose input data sets had spatial resolutions that were usually much smaller than the hydrologic units themselves.

The calculation of loads of NPS pollutants as a basis for assessing water quality by hydrologic unit is consistent with Virginia's participation as a partner with the EPA's CBP in the calculations of NPS pollutant loads using the Chesapeake Bay Watershed Model (CBWM). Although Virginia uses CBWM results (particularly in CBP related activities), they have only been obtainable for that portion of Virginia that is in the Chesapeake Bay Watershed (James, York, Rappahannock, Potomac, and Bay Coastal basins). There are other state program needs that can benefit from having measures similar to the CBWM loads but for the non-Bay portion of the state. The current update to the CBWM, referred to as Phase 5, should correct this situation. In order to obtain statewide NPS pollution values, DCR contracted with the CBP and the USGS to add all of Virginia into the CBWM for Phase 5 of that model. This process has been underway for several years but has not yet produced approved NPS pollutant loads at the Phase 5 model segment level.

Therefore, as had been done for the 2002 NPS Assessment, DCR contracted with the BSE Department of VT to produce statewide NPS pollutant load results similar to those of the CBWM by using the Generalized Watershed Loading Functions (GWLF) model[2]. Assistance with the data requirements for GWLF

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[1] The development of these new units was completed in 2006. Previous NPS assessments were based on the smallest units of the 1995 hydrologic unit delineations for Virginia. More information about both of these systems can be found at the Hydrologic Unit Geography page at http://www.dcr.virginia.gov/soil_&_water/hu.shtml.

[2] GWLF was chosen because it was configured for continuous simulation and could produce EOS loads based on land-based loadings, fate, and the transport of pollutants as does the CBWM. Both models also simulate seasonal variations, include both surface and subsurface components, and can represent both dissolved and particulate forms of pollutants. The GWLF

was provided by DCR.

Before the GWLF model was used to develop NPS pollutant loadings for all hydrologic units in Virginia, it had to be calibrated. Calibration was done to the observed conditions at 133 monitoring sites across Virginia as assembled by the CBP Office primarily from the USGS and the DEQ for the CBWM. The BSE created calibration watersheds that corresponded to these monitoring station points and were as consistent as possible with existing NWBD unit boundaries. There are portions of Virginia that are downstream of these monitoring sites, however, that could not be calibrated in this manner. To calibrate the model for these portions of the state the BSE defined six physiographic regions covering Virginia. Regions consisted of aggregated 6^{th} order NWBD units and were adjusted to coincide with the aforementioned calibration points. Regionally developed parameter values were then modified during the calibration process of the upstream calibration watersheds until GWLF model output (load results) were sufficiently similar to what has been produced by the CBWM for the Chesapeake Bay drainage area of Virginia for this time period. Final parameter values per region were then assigned to the downstream portion of each region.

The 2008 assessment runs of GWLF followed the completion of the calibration process. Whereas the CBWM uses and produces data in CBWM-specific model segments (36 in Virginia), the assessment runs of GWLF used and produced data at the hydrologic unit level (1236 in Virginia; 11 other units that are all water were not modeled). Assessment runs of GWLF in 2008 differed from the calibration runs in that they used a land use / land cover data set developed by DCR from a number of sources[3] to represent 2002 conditions. It also took into consideration the model-relevant best management practice (BMP) installations and nutrient management planning occurring in Virginia over the previous five year period (1997-2002) by DCR, the NRCS, VDOF, VDMME, and private plan writers. Table 4.1-1 lists the land use classification system used in the assessment runs of the GWLF model and the equivalent generalized model output land use categories. Spatially attributed BMP and nutrient management plan effects are measured as both land use changes to the aforementioned 2002 land use / land cover data set and as fractional reductions to the loadings by land use. Output from the assessment runs of GWLF is in the form of annual loads (L) of each NPS pollutant (p: nitrogen, phosphorous, and sediment) per modeled land use[4] per unit. From this, two forms of unit area loads are calculated – per hectare (h) of output land use class (l: agriculture, urban, and forest) per unit (w) load (luUAL) and per hectare of modeled land per unit load (UAL).

The luUAL value is preferable to the load values themselves when comparing the loading impacts of the individual output land use classes between units. They are normalized in that the size of the unit does not impact this value. It is calculated as:

$$luUAL(plw) = L(plw) / h(lw)$$

While the above calculation does help identify those areas per output land use class that have the greatest loading rates, it does not necessarily identify those *units* in which NPS reduction activities should be focused[5]. Therefore the UAL was used for ranking hydrologic units in this assessment report. The UAL per output land use class per pollutant for each hydrologic unit is calculated as follows:

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model used in the 2008 assessment is an update of the model used for the 2002 assessment.

[3] The base imagery for the 2002 land use / land cover data set was developed by the Mid-Atlantic Regional Earth Science Applications Center (RESAC). It was developed for use in Phase 5 of the CBWM but was extended to all of Virginia with a grant from DCR. Agricultural uses were modified using the USDA 2002 Census of Agriculture and the National Crop Residue Management Survey from the Conservation Technology Information Center (CTIC). Barren classes were modified using data from the VDMME and VDOF. Additional classes were based on processes developed for DCR by The Academy of Natural Sciences of Philadelphia (1997) using data from DCR's confined animal databases.

[4] Not all land uses were modeled (see Table 4.1-1). The area of a particular unit as used in these calculations would not include the hectares of non-modeled land uses occurring in that unit.

[5] For instance, units with high loading rates for agricultural land may have only small this land use and therefore small total loads of pollutants from agricultural uses. Furthermore, any action (if possible) in any year could encompass all reasonable reduction activities, thus making this unit unworthy of further attention.

$$UAL(plw) = L(plw) / h(w)$$

The output loadings provide a statewide equivalent of the types of results that Virginia has been able to obtain from the CBWM for the Chesapeake Bay drainage area of the Commonwealth over the last nineteen years. Table 4.1-2 compares the final statewide loadings by pollutant by general land use class and the amount of land in Virginia by general land use class. Loading values in this table reflect the loads after the reductions are applied from BMP installations over the previous five years, and reflect a number of improvements to the model, in the input data, and to the calibration process.

There are a number of factors that can account for changes between loading estimations between the 2008 assessment and past calculations. This includes a revised calibration procedure, as previously described. In 2002 the model was calibrated to 10 large calibration regions of aggregated CBWM model segments. For the 2002 assessment, regional development was modified during the calibration process until the regions and their regional adjustment factors in the GWLF model sufficiently produced model output (load results) similar to that produced by the CBWM for the Chesapeake Bay drainage area of Virginia. Then non-Bay portions of the state were related to one of these calibration regions and assigned the relevant factors.

Other differences include model code and algorithm improvements, revised model parameters, new and updated data, calculation corrections, the distribution of data to the 6^{th} order NWBD units, and the determination of loads to these units. Data improvements per unit included updated weather (now for a 19 year period vs 10), updated population and septic use, more exact soil parameter distribution, new soil phosphorous content values, new dominant crop determinations, and new BMP pollutant reductions. Procedural differences included the addition of sediment build-up on impervious urban land, a new distribution method for groundwater nitrogen and phosphorous, the incorporation of water and wetland land cover for evapotranspiration calibration, and improved spatial distribution of model coefficients.

For consistency with other circulating NPS assessment reports and maps and with the manner in which this data is used, the ranking of hydrologic units for the NPS pollutant UAL components for the 2008 NPS Assessment study has maintained the same division of UALs into categories that has been used before - the top 20% of the values for each component being classified as high, the next 30% being classified as medium, and the remaining 50% classified as low. This ranking methodology applies to the NPS pollutant loads only. These range definitions are not absolute, since units with equal loading values would not be divided into different classes.

Information regarding the NPS pollutant loadings by general land use and as summations per pollutant is found within the following sections.

Table 4.1-1 Land Use Classification

Original Class	Derived Class	Modeled Class	General Output Class
Conifer Forest Deciduous Forest Mixed Forest Deciduous Wooded Wetlands Conifer Wooded Wetlands Mixed Wetlands (portion)		Forest	Forest
Barren (portion) * Extractive (portion) *	Disturbed Forest	Disturbed Forest	
Row Crop	Conventional Tillage Conservation Tillage	Conventional Tillage Conservation Tillage	Agriculture
Hay/Pasture Natural Grass	Pasture (unimproved) Pasture Cattle-Grazed ** Pasture Poultry Litter ** Manure Acres	Hay Pasture (unimproved) Pasture Cattle-Grazed Pasture Poultry Litter Manure Acres	
High Density Residential Medium Density Residential Low Density Residential Urban Residential Grasses Urban Residential Conifer Trees Urban Residential Deciduous Trees Urban Residential Mixed Trees Transportation Barren (portion) * Extractive (portion) *		Impervious Urban & Pervious Urban	Urban
Emergent Wetlands Mixed Wetlands (portion) Open Water Barren (portion) *		not modeled (no loadings)	

* The Extractive and Barren categories from the imagery were combined and apportioned out as Extraction, Disturbed Forest, and true Barren. This apportioning was done to intersected units of hydrologic units and jurisdictions based on where VDMME indicated extraction was occurring and where VDOF indicated forest-harvesting activities were occurring. Disturbed Forest was modeled whereas the apportioned Extraction was modeled as Pervious Urban and true Barren land was assigned no loads.

** Pasture Cattle Grazed and Pasture Poultry Litter are not mutually exclusive. Except for the Eastern Shore of Virginia, all Pasture Poultry Litter is also cattle grazed. Pasture Cattle Grazed is grazed pasture using other forms of fertilizer (typically commercial).

Table 4.1-2 Statewide NPS Pollutant Loads – Post BMP Reduction

	Agricultural Class	**Urban Class**	**Forestry Class**
Total VA Land Area *	6,322,108	1,931,178	16,588,940
%of VA Land *	25.4	7.8	66.8
Total Nitrogen **	31.2	9.1	2.9
%of all NPS N	72.3	21	6.7
Total Phosphorous **	4.5	0.8	0.4
% of all NPS P	78.8	14	7.2
Total Sediment **	2,569	310	857
% of all NPS S	68.8	8.3	22.9

* Units are acres. Does not include 2,506,889 acres of non-modeled uses (see Table 4.1-1).
** Units are millions of Kg/year.

Agricultural NPS Pollution Loads

Agriculture is a large and diverse industry in Virginia and accounts for approximately 25% of Virginia's land use. While this percentage is significantly lower than the national average and is declining in Virginia, agricultural activities continue to be the most significant source of nonpoint source pollution in the state. As shown in Table 4.1-2, the current and all past assessment model results suggest that despite accounting for about 25% of the land in Virginia agricultural land contributes significant NPS pollutant loads. Estimated loadings from agriculture in this assessment are from about 69% to 79% of the total statewide NPS pollutant loads.

Nonpoint source contamination from agriculture originates from several different sources with different associated impacts. Deposition of potential NPS pollutants to agricultural lands in the form of fertilizers and animal manures affect water quality when they reach groundwater reserves, are directly deposited to streams, or are washed into streams, lakes, etc during rain storms in either a dissolved state or with eroding soils. These pollutants include pathogens as well as nutrients.

This assessment measured the nutrient and sediment loads from agricultural areas but not the loading of pathogens. Factors in this assessment which affect the amount of nutrient loads reaching water from agricultural lands include the erodability of the soils, types of agricultural practices, types and numbers of farm animals, land cover, stream density, rainfall, seasonal variations in plant growth and nutrient applications, existence and type of agricultural BMPs, soil saturation, and slope.

The ranked UALs by hydrologic unit of nitrogen, phosphorus, and sediment from agricultural land uses are displayed in Figures 4.1-1, 4.1-2, and 4.1-3 respectively. The rankings are also listed in Table 4.1-3

There are a few factors that are specific to changes in loadings, and thus ranks, of the agricultural NPS pollutants between the current and past assessment products. An updated database on confined animals is invaluable in distributing farm animals spatially and allowing for better pollutant load estimations from animal sources. An improved calculation of pasture yield for the distribution of non-confined animals (usually beef) is also employed. Soybean continues to replace previous dominant crops in much of the coastal plain. There is also more transport of poultry litter than before, both as a fertilizer and as a means of disposal.

Urban NPS Pollution Loads

Although less than 8% of the land in Virginia is considered urban, urbanization of forest and agricultural land continues unabated in many parts of the Commonwealth. Urbanized land produces NPS pollutants as the result of precipitation washing nutrients, sediment, and other toxic substances from the impervious surfaces that make up these areas. The sources of these surface contaminants include: air and rain deposition of atmospheric pollution; littered and dirty streets; traffic by-products such as petroleum residues, exhaust products, heavy metals and tar residuals from the roads; chemicals applied for fertilization, control of ice, rodents and other pests; and sediment from construction sites. Illegal industrial, commercial and domestic hook-ups to storm sewers also contribute a number of specific pollutants to waterways, as do inadequate and/or improperly maintained sewage disposal systems both for municipalities and individual homes.

This assessment measured only the nutrient and sediment loads from urban areas as opposed to all urban NPS pollutants as described. As calibrated in this model, the urban land class includes some barren and resource extraction (mining) land. Factors in this assessment that affect the amount of loads reaching water from urban lands include the degree of imperviousness of the urban land use, impervious area NPS pollutant build-up rates, stream density, rainfall, septic system use, direct discharges, soil saturation, and slope.

The ranked UALs by hydrologic unit of nitrogen, phosphorus, and sediment from urban land uses (as described in Table 4.1-1) are displayed in Figures 4.1-4, 4.1-5, and 4.1-6 respectively. The rankings are also listed in Table 4.1-3. The highlighted units are reflective of the areas of Virginia that are undergoing significant urban development activity as well as those with significant amounts of marginal septic system use. Land use changes and the improved tracking of extraction activities (associated with urban uses in the model) by the VDMME are the primary factors in urban load and unit ranking changes.

Urban load measures are based on pollution potential and do not compensate for urban runoff control measures that may be in place in some areas. Such reduction measures are primarily installed by the private sector.

Forestry NPS Pollution Loads

About 67% of the land area of Virginia is forested. Forestland in general produces lower NPS pollutant loads[6] than other land uses. Certain forest disturbing activities such as tree harvesting, site preparation, and reforesting however do make a load contribution. As Table 4.1-2 shows, these activities contribute more to the sediment load than they do to other NPS pollutants.

The classification of land cover imagery can capture bare land and regrowth areas from the aforementioned forest activities. It captures forestland being cleared due to other land disturbing activities as well, such as surface mining and residential development. Due to the similar spectral signatures of these land activities as well as those of non-temporary land covers such as bare rock and beaches, it can be difficult to discern these activities and covers from one another without other associated data.

For this study the DCR staff endeavored to isolate forest disturbing activities found in the imagery from other barren-classified land so as to associate these (perhaps temporarily) barren lands with the most appropriate land use being used in the GWLF model runs. The VDOF, who has been tracking such activities of the forest industry to facilitate the proper management of Virginia's forest resources relative to water quality, supplied data useful for this purpose. In a similar fashion, data on the amounts of resource extraction by county from the VDMME helped isolate true extraction activities from reforesting sites. Whereas disturbed forestland is a component to the nutrient loads from forests, mine lands add to urban loads in this study.

Whereas agricultural activities operate on a yearly or seasonal cycle on agricultural lands, a single cycle of forest harvesting, site preparation, and reforestation occurs over many years. Where the next cycle

[6] Airborne nutrient pollution is accounted for as part of the load of the land use it falls upon. The majority of the airborne nutrient load falls on forestland in Virginia and is therefore associated more with forestland than with other uses.

begins amongst existing forested lands is undetectable from previous land cover images, making the measure of forest disturbance for these activities more of a snapshot than a trend.

Factors in this assessment that affect the amount of loads reaching water from forestlands include the erodability of the soils, existence of disturbed forestlands, stream density, rainfall, existence of forest (silviculture) BMPs, soil saturation, and slope.

The ranked UALs by hydrologic unit of nitrogen, phosphorus, and sediment from forestland uses are displayed in Figures 4.1-7, 4.1-8, and 4.1-9 respectively. The rankings are also listed in Table 4.1-3.

The factor most responsible for the changes in loadings, and thus ranks, of the forest NPS pollutant loads in this assessment is the improved disturbed forest determinations mentioned above, since land disturbance is the primary sediment loading activity. Data from the VDOF show a trend towards increased forest harvesting activities in the southwestern portion of the Commonwealth relative to the eastern portion in the past decade.

Total Loads Per NPS Pollutant

Calculated total nitrogen, total phosphorous, and total sediment unit area loads from all land uses combined are displayed in Figures 4.1-10, 4.1-11, and 4.1-12 respectively, and listed in Table 4.1-3. Total nitrogen is composed of septic nitrogen, groundwater nitrogen, dissolved nitrogen from various land uses, wash off of nitrogen from impervious surfaces, and sediment-attached nitrogen. Total phosphorous is composed of septic phosphorous, groundwater phosphorous, dissolved phosphorous from various land uses, wash off of phosphorous from impervious surfaces, and sediment attached phosphorous. Total sediment is the sediment yield from all land uses.

The summing of NPS pollutant loads by land use into total NPS pollutant loads in this NPS assessment is simply the addition of values with equivalent units (kg/ha/yr of nitrogen or phosphorous, Mg/ha/yr of sediment). Accordingly, the relative weight of the estimated NPS pollutants coming from one land use versus another is directly comparable. This comparison shows that NPS pollutants from agricultural lands dominate the total NPS pollutant loads.

IMPAIRED WATERS

In accordance with US EPA guidance and protocol, the DEQ assembled a list of the water quality limited riverine, lacustrine, and estuarine waters of Virginia in 2006 (303d report). That list of water quality limited waters is the basis for the impaired waters portion of the 2008 NPS Assessment study.

Waters listed in the 303(d) do not meet one or more of the EPAs five designated uses for water. Among the many defined attributes in the impaired waters database is the name of the impaired waters, the beginning and ending limits of the impaired portions, impairment causes, and impairment sources. Only waters listed by the DEQ staff as having NPS related sources or those waters not explicitly listed as having an NPS source but which (a) did not explicitly list any other sources, and either (b) listed possible agriculture related impairment causes[7] or (c) correlated with DCR's areas of nonpoint sources, were considered in this analysis.

Waters in the impaired waters layer that are suspected of being impaired due to nonpoint sources were divided by the hydrologic unit boundaries into segments by unit to allow for the summation of impaired water lengths or areas by these units. The same process performed on all waters in the state determined the total available miles of riverine, acres of lacustrine, and square miles of estuarine waters per hydrologic unit that occur for comparison against the impaired portions.

[7] This included all fecal causes of unknown sources since approximately 90% of non-urban fecal problems are surmised to be due to agricultural or natural animal loadings. Similarly, because about 85% of benthic impairments are believed to be sediment related, and because DEQ personnel are more likely to know and document point sources of benthic impairments, all benthic impairments of unknown sources are considered to be NPS related. Impairments with nutrient sources were also included.

Whereas the NPS pollutant loads of the 2008 NPS Assessment are estimated measures of nutrients and sediment, most of the NPS impaired waters from the 2006 303d report are listed due to the existence of pathogens. Total Maximum Daily Load (TMDL) studies have shown that pet wastes can have a role in high pathogen counts in some urban streams. Concentrations of wildlife can have a similar affect in various land use / land cover settings. Likewise human wastes arising from the existence of straight pipe disposal, failing septic systems, or malfunctioning water treatment plants can all contribute to the impairment of waters due to high levels of pathogens. A significant number of the waters impaired due to the existence of pathogens however are believed to be impaired because of farm animal wastes.

The number of farm animals by type and by unit is part of the nutrient load calculation, since most farm animal wastes are recycled back to the ground by the animals or in a more controlled mode by farmers who want to fertilize fields and/or remove wastes from confined animal sites. The controlled dispersal of wastes is a goal of Nutrient Management planning and a practice that DCR cost-shares with farmers to implement. The fencing off of stream banks and construction of alternative water sources are two such practices, in this case designed to keep cattle out of and away from streams so as to avoid the sediment loading from eroded stream banks and also avoid the high pathogen counts of direct deposition of manure.

The rankings of hydrologic units by water regime that follow consider all and only NPS-associated impairments.

Riverine Impairments

Summed lengths of NPS impaired riverine water features in 2006 as miles per hydrologic unit were compared to the total miles of riverine systems available per unit at the same scale[8] to determine the percentage of the available riverine water miles per unit that were NPS impaired. Unlike previous NPS Assessments, the ranking of this value is based on the value itself and not on a pre-set distribution of the range of calculated percentage values. The rankings of hydrologic units for impaired riverine waters are displayed in Figure 4.1-13 and listed in Table 4.1-3.

Estuarine Impairments

Most of the impaired main stem estuarine water bodies in Virginia have listed impairment causes that are not considered to be due to (with any significance) practices occurring in the immediate units that the main-stems flow through. There may be, in fact, very little land associated with some of these units. Estuarine waters are also tidal and may show pollution effects from multiple areas, even if they are not main-stem estuarine water bodies. For these reasons the estuarine waters are not being used to rank the hydrologic units in which they pass in this assessment. In short, although there are NPS impaired estuarine waters it is difficult to associate them with specific upland NPS pollutant sources.

Lacustrine Impairments

Summed areas of impaired lacustrine waters in 2006 as acres per hydrologic unit were compared to the total acres of lacustrine waters available per unit to determine the percentage of lake waters in a unit that were impaired. Although the land area of these units can be a source of the NPS pollutants, so too can the incoming streams.

Unlike previous NPS Assessments, the ranking of this value is based on the value itself and not on a pre-set distribution of the range of calculated percentage values. The vast majority of the hydrologic units in

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[8] The calculation of miles or acres of water within any unit will vary by the scale of the hydrography layer from which it is calculated because of both line generalization and network simplification at lower scales. Therefore the calculation of available miles or acres had to be done using the same scale of hydrography as was used to calculate miles or acres of impaired waters. In 2008 that scale was 1:100,000, augmented by the inclusion of smaller streams designated as impaired. That scale will improve to 1:24,000 by the 2010 assessment, at which time these calculations must be redone.

Virginia contained no impaired lake or reservoir waters in 2006. The majority of the rest however had very high percentages of impaired lacustrine waters. This distribution is in part due to the decreased unit sizes of the 6th order NWBD units. The rankings of hydrologic units for impaired lacustrine waters are displayed in Figure 4.1-14 and listed in Table 4.1-3.

BIOLOGICAL HEALTH

Also included in the 2008 NPS Assessment and Prioritization study is information from VDH on public surface water sources and their protection zones, and an evaluation of the health of aquatic species in the state's waters by the CES at VCU. These components provide an additional means to prioritize water quality protection - the protection of the sources of public drinking water and of natural aquatic communities respectively.

Public Source Water Protection

As part of their Source Water Area Protection (SWAP) Program, the VDH determined the area upstream of public surface water intakes that must be investigated for threats to water quality. The most immediate area of their concern is referred to as the Zone 1 for each intake. Zone 1 areas extend out to a 5 mile radius upstream from a water supply intake or 5 miles around a lake containing an intake, without crossing watershed boundaries except those upstream. The population served by an intake, provided by VDH, and the portion of a hydrologic unit that is within a Zone 1 area has been used by DCR to calculate the concentration of persons served per unit by these public surface water supplies. The concentration values serve as a measure of the importance of high water quality by hydrologic unit for public drinking water supply protection.

Concentration values are the summation by hydrologic unit of all Zone 1 areas or combinations of Zone 1 areas in that unit times one one-thousandth of the effective population each serves. In cases where a municipality owned several intakes, the single recording of population served was divided amongst each intake to create an effective population served. In cases of overlapping intake reaches the effective population of each reach was summed for the portion of overlap.

The categorized values and rankings for indicating concentration by unit are displayed in Figure 4.1-15 and listed in Table 4.1-3. Unlike the NPS loading variables in this assessment, where units that are ranked high represent units of concern, high ranking public source water units are just units with a high need for water quality protection. A significant amount of their area lies immediately upstream from surface water intakes that are used extensively for public drinking use by many people.

The vast majority of hydrologic units contained no Zone 1 protection zones or portions of Zone 1 protection zones. Of those with some Zone 1 content, the majority had low levels (< 10) of the calculated measure for concentrations of people served within a watershed. Of the remaining units, a few had significantly higher value measures (> 100) and were therefore classified as having a "Very High" need for source water protection. The rest were divided amongst a moderate category (10-30) and a high category (30-100).

Aquatic Species Measures

The presence or absence of certain aquatic species can serve as an indication of the overall quality of a particular waterway. They can also indicate where the most biological damage can occur from water quality degradation. Accordingly, the NPS Assessment and Prioritization study provides a ranking of hydrologic units for stream-dependent living resources (including fish, mollusks, and crayfish) using a multi-metric index calculated by the CES at VCU as part of their Interactive Stream Assessment Resource (INSTAR).

These indexes (referred to as the mIBI - a modified version of the Index of Biological Integrity) are calculated by the CES using databases originally developed by DCR, the VDGIF, and VCU[9]. Since INSTAR's conception, the more than 150,000 original database records of information have been augmented by VCU's

[9] More information about the mIBI and the other components of INSTAR can be found at http://instar.vcu.edu.

stream assessment team. As a result it was possible for this assessment to calculate a mIBI value for more than 92% of the 6th order units of the NWBD. An equally beneficial result from having more records available for any unit is the decreased likelihood of a false prioritization indication based on minimal information.

By associating a hydrologic unit code to each of the stream segments for which aquatic species information was available in the various databases, metric scores by unit were developed for each of 6 metrics. These metrics are as follows:

Metric 1 – Number of Intolerant Species: refers to the total number of unique water quality intolerant species found in a unit.
Metric 2 - Native Species Richness: refers to the number of indigenous (local) species present in a unit.
Metric 3 - Number of Rare, Threatened and Endangered Species: refers to the number of species that are considered rare, threatened or endangered due to their low population levels that are present in a unit.
Metric 4 - Number of Non-indigenous Species: refers to the number of non-native species present in a unit. These are introduced species that would not normally be found in this particular location.
Metric 5 - Number of Critical Species: refers to the number of species found in a unit that are considered critical because of some important role that they play, such as being a food source or major recreational fishery.
Metric 6 - Number of Tolerant Species: refers to the number of species found in a unit that are tolerant to degraded stream conditions and can survive even in these sub-optimal conditions.

A score for each metric per hydrologic unit was assigned by the CES. In general a high metric score is indicative of high stream health. A score of zero was given if insufficient data was available. Metrics 4 and 6 were reversed in the scoring, since a low value for either of these metrics would indicate high stream health. Lower values are more desirable in metrics 4 and 6 because a high number of non-native species and/or a high number of species that are tolerant to stream degradation are less desirable characteristics for a stream. The final form of the scores for each metric for each unit were totaled to give an overall total mIBI score per hydrologic unit. Summed scores per hydrologic unit were then tiered relative to the summed scores of the other units in the same basin by assigning a category value of High (score of 5), Medium (score of 3), or Low (score of 1) on a per metric per basin basis. The resulting total mIBI scores are used to place each hydrologic unit into ranked categories reflecting biotic integrity and resource importance.

Since there were 6 metrics and a maximum score of 5 could be obtained for each metric, the overall maximum score a unit could receive was 30 (6 x 5). About 9% of the units (114) are considered to have very high biodiversity, with total mIBI scores of 20 or more. Another 199 units have total mIBI scores of at least 18. At the other end of the spectrum, about 22% of the units (275) have low biodiversity. These units may contain waters with some degree of degradation, but their mIBI values may also reflect waters where insufficient studies and inventories have yet to occur.

Figure 4.1-16 displays, and Table 4.1-3 lists, the categorization of the mIBI scores by hydrologic unit. In this figure and table, high mIBI scores equate to areas of high biotic integrity, and vice versa. Whereas low mIBI rank represent units of concern in regards to low water quality based on aquatic species measures, high ranked units represent areas of importance for the protection of the state's streams of exceptional biodiversity.

While the maintenance or enhancement of water quality for the protection of all native aquatic life is the preferred goal, these aquatic species priorities should help direct NPS pollution mitigation efforts and other water quality improvement projects toward hydrologic units with the most important aquatic resources.

COLLECTIVE USE OF RANKINGS

The 12 rankings assigned to hydrologic units for NPS pollutants by land use, the 2 rankings of units for impaired waters, and the 2 rankings of units for biological health can be used in various combinations to evaluate statewide conditions and prioritize NPS reduction activities. Which measures are included in each prioritization process, and how one weighs in comparison to another, is dependant on the activity to be prioritized. For instance, DCR uses the agricultural NPS pollution rankings as variables in the targeting of agricultural best management practices (see Agricultural Cost Share Program below) and rankings of NPS pollutant loads and biological health were part of the TMDL implementation prioritization (see Total Maximum Daily Loads below).

There are a number of considerations to keep in mind when constructing prioritization processes from these rankings. Perhaps the most important is that some factors are measures potentially being produced at the hydrologic unit of interest, such as the NPS pollutant loadings. Other measures reflect existing conditions at the unit of interest, such as the impaired waters and aquatic species health, and may in part be due to activities occurring in upstream units. The source water concentration values directly account for the upstream affect by virtue of their being based on a designated upstream zone.

Another consideration is the possible incorrect inference of cause and effect. Waters in a unit may be impaired due to nonpoint sources, and subsequently ranked high, but the cause of these waters being listed as impaired is usually not related to the nitrogen, phosphorous, and sediment that is potentially being loaded to these waters in either the unit of concern or upstream of it. Likewise point source loadings can be the reason for the streams in a unit to collectively produce a low mIBI score / high aquatic species rank.

In the 2008 NPS Assessment and Prioritization some units have been flagged for a number of conditions that can be determined by comparing the rankings for all measures in this report. The flags have been entered into Table 4.1-3. The conditions are:

1> Exceptional aquatic biodiversity.
  Units (10) with mIBI scores of 24 or greater.

2> High aquatic biodiversity with potentially high NPS pollutant loads.
  Units (16) with mIBI scores of 18 or greater and all high ranked NPS pollutant loads.

3> High public water supply protection need with potentially high NPS pollutant loads.
  Units (6) with source water concentration values greater than 30 and any high ranked NPS pollutant load.

4> NPS impaired waters within high public water supply protection need zones.
  Units (11) with source water concentration values greater than 30 with NPS impaired riverine or lacustrine waters within the source water protection zone.

As per the considerations noted above, the flagging of units for conditions 2-4 could be expanded to include upstream units. For instance, units above the high aquatic biodiversity units of condition 2 could have a negative affect on that biodiversity, especially units immediately upstream or upstream units with very large NPS pollutant loads.

NPS REDUCTION ACTIVITIES

Efforts to reduce NPS pollution in Virginia have been undertaken by a full range of government agencies - federal, state, regional, and local, as well as by citizen action. In many cases the activities are cooperatively performed and funded. The 2004 Virginia Nonpoint Source Pollution Program Report, found at http://www.dcr.virginia.gov/soil_&_water/ss319.shtml, contains descriptions of the cooperative NPS reduction activities. Most of these efforts target particular watersheds. Among them, and elaborated on here, are the TMDL studies and implementation, Tributary Strategies, Agricultural Cost Share incentive programs for BMP installations, and incentives for the set aside of agricultural land.

Total Maximum Daily Loads

TMDLs, described elsewhere in this 305(b) report, are performed for waters that have been determined to be impaired and are so listed in the State's 303(d) report. Waters are not listed as impaired however due to high concentrations of nitrogen, phosphorous, or sediment, but rather because they cannot support, or can only partially support, one or more of the five designated uses. This is because water quality standards do not exist for concentrations of these NPS pollutants. Nevertheless, certain impairment causes are primarily due to nonpoint source pollutants (see Impaired Waters in this chapter) and DEQ staff has often determined that there are nonpoint sources for these impairments.

Using the logic of the impaired waters rankings of the NPS Assessment study, all impairments for which one or more of the stages of a TMDL have begun were divided between those with and those without a nonpoint source. Most of the waters declared impaired in Virginia are, or are believed to be, impaired due to, or partially due to, nonpoint source pollution. Consequently, most of the TMDLs that are being undertaken have a nonpoint source component. These studies are focusing on identifying the sources of the impairment causes, quantifying the loadings of these sources to the water, and determining the reduction in loads needed in order to meet the use criteria. The development of an implementation plan is expected following the completion of a TMDL study for a particular watershed. Implementation of the plan's course of action then follows.

The number of TMDLs underway or completed is continually increasing. Table 4.1-4 lists the NPS TMDLs as of Feb 2008 by their status, which is a temporal condition. There are now 68 completed NPS dominated TMDL Implementation Plans with another 15 underway. In addition there are 157 NPS dominated TMDL Studies that have been approved by the EPA and are awaiting implementation plans, with another 116 under development.

Whereas it is streams or water bodies that are listed as impaired, it is the watershed of those impaired stream segments and water bodies that are the focus of nonpoint source pollutant reduction activities. The hydrologic units listed in Table 4.1-4 are those in which some portion of the unit contains the listed impaired stream segment. Sometimes the entire area of the listed hydrologic unit is the watershed of the impaired stream segment, but often only a portion of that unit must be studied for a TMDL. Figure 4.1-17 shows the true TMDL study areas and thus gives a better indication of the geographic extent of where the work is being performed. One difficulty in geographically representing the extent of multiple TMDL areas is that they often overlap – the watershed of a TMDL for a headwaters stream becomes part of the watershed of a TMDL for a larger water feature downstream. In Figure 4.1-17 the status of the latest TMDL work is assigned visual priority.

Agricultural Cost Share Program

The Virginia Agricultural Cost Share Program (VACS) offers incentives to farmers and agricultural land- owners to encourage the installation and use of a number of approved techniques (BMPs) for reducing agricultural related nonpoint source runoff. While the program aims to address nonpoint source pollutants statewide, specific hydrologic units are targeted based on the agricultural loads estimated from the NPS Assessment study (see Agricultural NPS Pollution Loads). Soil and Water Conservation Districts further target the practices to individual needs within their district within these load priority areas.

Funding for the implementation of these practices has been borne by the state and the federal government since the program's inception in 1985. The number of installations per year has varied widely over the years, correlating with the variation of funding from the Water Quality Improvement Fund (WQIF) of the Commonwealth's Water Quality Improvement Act (WQIA). A consistent funding source for this program is needed to achieve and maintain maximum nutrient reductions.

Table 4.1-5 contains the estimated NPS reductions by basin for program years 2005 and 2006, as well as the state's costs to attain these reductions, from the VACS and the Virginia Conservation Reserve Enhancement Program (CREP). The $5,510,781 of total VACS costs for this program in this table is a 14% reduction in expenditures from the 24-month period reported in the 2006 305(b) Report. As might be expected, there is a similar reduction in the reported estimated loads of NPS pollutants as well.

Additional information on agricultural best management practices and the cost-share program can be found at http://www.dcr.virginia.gov/soil_&_water/costshar.shtml. Other efforts to reduce NPS pollutants include local and state stormwater controls, BMP installations by the USDA, and silviculture BMP installations by the VDOF. These and other pro-active efforts increase the reductions reported and negate estimated loads as calculated in the NPS pollution loadings of this assessment.

Conservation Reserve Enhancement Program

The USDA's Conservation Reserve Program (CRP) provides incentives for the removal of agricultural land from production to protect environmentally sensitive land alongside rivers and streams. The Virginia Conservation Reserve Enhancement Program (CREP) augments CRP by providing for state enhanced cost-share and rental payments for conservation practices focused on the restoration of riparian buffers and wetlands. The Virginia CREP also funds the purchase of conservation easements on the restored riparian buffers.

Most areas of the state qualify for CREP assistance. Table 4.1-5 contains the estimated reduction of nonpoint source pollutants by basin for program years 2005 and 2006 from the Virginia CREP, as well as the state's costs to attain these reductions. The $1,054,408 of total state costs for this program in this table is a 63% reduction in expenditures from the 24-month period reported in the 2006 305(b) Report. CREP funding reductions are primarily due to cost-share payment structure changes by federal program management for the CRP. As with the VACS funding reductions, there is a similar reduction in the reported estimated loads of NPS pollutants from CREP installations as well.

The USDA's CRP increases the reported reductions. Information about CRP can be found at http://www.nrcs.usda.gov/programs/crp/. Additional information on the Conservation Reserve Enhancement Program can be found at http://www.dcr.virginia.gov/soil_&_water/crep.shtml.

Tributary Strategies

Tributary Strategies are basin wide water quality plans designed to meet the pollution reduction goals of the Chesapeake Bay Program. They are part of the State's CBP commitment, and thus are described in that chapter of this 305(b) report. The goals of these plans directly specify both nonpoint source nutrient load reductions needed for water quality attainment and attainment measures that will require nonpoint source pollutant reductions. Consequently, significant amounts of nonpoint source pollutants must be reduced to achieve these plans, at considerable cost.

Implementation Plans have been written for the Eastern Shore, York River, James River, Potomac-Shenandoah Rivers, and the Rappahannock River. These plans are available at http://www.naturalresources.virginia.gov/Initiatives/WaterQuality/index.cfm. Addressing agricultural sources through cost-share and other programs is a priority in these plans. In addition, water quality initiatives that achieve measurable reductions will be funded in the urban and suburban arenas and competitive grants are being offered to local governments and nonprofits through Cooperative Nonpoint Source Local Programs for local water quality implementation projects that meet tributary strategy goals.

Table 4.1-5 NPS BMP Pollutant Reductions and Costs, Program Years 2005 & 2006
1 July 2004 through 30 June 2006

	Ag Cost Share Totals				CREP Totals			
BASIN	Tons SL Reduced	Lbs N Reduced	Lbs P Reduced	State Cost ($)	Tons SL Reduced	Lbs N Reduced	Lbs P Reduced	State Cost ($)
POTOMAC	19021	103477	16643	465120	416	2263	332	46200
SHENANDOAH	18162	98800	22093	1480279	1750	9522	1850	132064
RAPPAHANNOCK	12234	66551	12239	539184	1829	9949	1556	104258
YORK	5035	27392	4946	136437	355	1928	301	39244
JAMES	16228	88279	16697	747199	730	3973	675	124686
BAY COASTAL	53206	289443	71976	214739	226	1230	293	7595
OCEAN COASTAL	10396	56557	10735	919616	33	178	48	3717
ALBEMARLE SOUND	26476	144029	35958	35795	66	362	88	40104
CHOWAN	11714	63722	17259	64760	1210	6580	1774	221278
ROANOKE	65933	358677	72943	360979	3252	17693	3969	97962
YADKIN	345	1878	345	28430	80	434	80	3520
NEW	37548	204261	36720	138223	1167	6351	1152	70853
CLINCH/POWELL	29207	158888	32175	361694	1397	7602	1422	104936
HOLSTON	433	2358	433	4165	667	3631	724	56994
BIG SANDY	1814	9865	1830	14161	0	0	0	0