

**A Comparative Study of the Total Maximum Daily
Load (TMDL) Program and Process in Virginia and
Kansas: Possible Outcomes and Effects upon
Stakeholders**

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Abstract

As population increases, the number of water bodies meeting water quality standards tends to decrease. The 1972 Clean Water Act (CWA) addresses the issues of point and nonpoint source pollution by requiring states to compose lists of waters that do not meet water quality standards and develop Total Maximum Daily Loads (TMDL) for those waters. This requirement of the CWA remained inactive until EPA and states suffered lawsuits from environmental groups and concerned citizens. The result prompted a flurry to develop TMDLs in compliance with consent decrees.

A variety of methods and models serve as tools to calculate existing loads, load reductions and allocations. The purpose of this study is threefold 1) to examine two methods of TMDL development, Flow Duration (FD) used in Kansas and Hydrologic Simulation Program-Fortran (HSPF) used in Virginia; 2) to compare results of both methods in the same watershed of Virginia; and, 3) to evaluate stakeholder involvement in the TMDL process. A variety of stakeholders such as agencies, towns and industry, agribusiness, and concerned citizen/environmentalists are faced with meeting TMDL reductions and allocations. It is important that the TMDL process and implications are understood by all stakeholders.

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Acronyms

BAC: Basin Advisory Committee

BMP: Best Management Practices

BST: Bacterial Source Tracking

CAFO: Confined Animal Feeding Operations

CFR: Code of Federal Regulations

cfu: coliform forming units

CWA: Clean Water Act

DMME: Department of Mines Minerals and Energy

EPA: Environmental Protection Agency

FD: Flow Duration

HSPF: Hydrologic Simulation Program-FORTRAN

KDHE: Kansas Department of Health and Environment

LA: Load Allocation

MOS: Margin of Safety

TMDL: Total Maximum Daily Load

USDA: United States Department of Agriculture

VADCR: Virginia Department of Conservation and Recreation

VADCRSWCD: Virginia Department of Conservation and Recreation's Soil and Water Conservation Districts

VADEQ: Virginia Department of Environmental Quality

VDH: Virginia Department of Health

WLA: Waste Load Allocation

WQLS: Water Quality Limited Segments

1. Introduction

Clean water reigns as one of the most precious natural resources. As the global population increases, the protection of water resources becomes more critical and increasingly difficult. The degradation of water quality comes from point and nonpoint sources. Characteristically, point sources have an easily distinguished point of entry into the stream. Point source discharge can be readily measured (e.g. from an industrial discharge pipe) and therefore controlled. Nonpoint sources carried by water moving over and through the ground (e.g. runoff), disperse over a large area and are much harder to measure (EPA 2002).

The Total Maximum Daily Load (TMDL) program evolved from Section 303 (d) of the Clean Water Act (CWA 1972) provides protection of our nation's waters. According to the CWA, states must identify waters that are polluted and remain so after the implementation of technology (point source) standards, prioritize these waters according to the severity of pollution and develop total maximum daily loads taking into consideration seasonal variations and a margin of safety. The total maximum daily load is the maximum amount of a pollutant (from both point and nonpoint sources) that a waterbody can carry at any point in time and still meet water quality standards (EPA 2002). Since 1972, point source discharge regulation has occurred through a permitting system. However, any improvement from the reduction of point sources has been eradicated by the steady increase from nonpoint source pollution (Houck 1999).

The contribution of nonpoint sources and the development of TMDLs were largely ignored until lawsuits in the early 1980s (e.g., *Scott v. City of Hammond* and *Northwest Environmental Defense Center v. Thomas*) (Houck 1999). The EPA published guidelines for state implementation of §303(d) in 1991. In 1992 the EPA set a deadline for state submissions of water quality limited segments (WQLS). The litigation that began in the 1980s spread from state to state. To date there have been 40 legal actions in 38 states (EPA 2002). Lawsuits and consent decrees have forced the EPA and individual states to address the water quality problems from nonpoint sources. Therefore, the TMDL process is driven by lawsuits and consent decrees (Houck 1999).

The relatively new TMDL development process requires good science and good sense for making wise decisions to achieve water quality goals. The newness of this process and the urgency to meet consent decrees from the courts raises concerns about possible ramifications from the resulting TMDL. TMDL development affects many stakeholders, including government agencies, cities, towns (municipalities and industry), landowners/agribusiness, and citizens. Much is at stake in addition to meeting consent decrees. Stakeholders need to be well-informed and be active participants in the program.

The TMDL program forces institutions to make complicated policy decisions that ultimately affect stakeholders. There has been no standard development approach to computing a TMDL thus, the load allocations deliverable to a stream vary depending upon the modeling contractor and the state agency responsible for the TMDL (McClellan, personal communication, 2002). Assuming the TMDL survives legal challenge stakeholders will be forced to abide by the load allocations set forth in the TMDL calculation even though that load may vary significantly depending upon the method used for its calculation. Since there is no standard process for TMDL development, and the implementation of the program is in its infancy, it is difficult to get a complete picture of how stakeholders may be affected. Only after a study of this evolving process and the possible implications of its outcomes are taken into account can policy decisions be made in the best interest of all stakeholders.

This paper first gives an overview of the TMDL program and addresses program importance and the method of implementation, focusing mainly on the most difficult aspect of TMDL development: NPS pollution. Because of the magnitude of the program, this paper concentrates on fecal coliform impairments only and two methods of approaching TMDL development: Hydrological Simulation Program-Fortran (HSPF) and Flow Duration (FD).

An identification of stakeholders and their roles follows with a discussion regarding community involvement. It is important to briefly explore the different methods (FD and HSPF) for developing TMDLs so as to better understand the possible outcomes and effects on stakeholders. Since different states develop their own approaches to TMDL development, the discussion of the different methods is followed by case studies from

Virginia, which uses HSPF watershed modeling, and Kansas, which utilizes FD. Virginia historically has used HSPF for watershed modeling for TMDL development but currently considers changing to FD because of the method's simplicity. Kansas was chosen for this study because of the reputation for long term use of FD and the availability of records and data sources. Kansas developed the simple approach of using hydrologic records and water quality data to perform the analyses (Stiles 2002). This comparative study addresses the controlling agencies' methodology for soliciting stakeholder participation. Finally, the programs in both states are summarized, followed by possible outcomes and effects of the programs on stakeholders.

1.1. Methodology

Over the past three years my involvement in the TMDL program in Virginia included TMDL development for the North River and Big Otter Watersheds in Virginia. This experience included project coordination, data acquisition and stakeholder communication. Employment responsibilities and my personal interest in the program's effects on stakeholders led to my attendance at over a dozen stakeholder or focus group meetings and numerous field visits to stakeholder offices and residents. These meetings included TMDL public meetings for the North River, Big Otter River, Blackwater River, and Middle Fork Holsten and a presentation for state agencies on Flow Duration given in Charlottesville, Virginia.

Sources of background information on the Clean Water Act, initiation of the TMDL program and TMDL development methods included EPA and state websites and literature reviews.

The second phase in this research covered state responsibilities and program specifics for Kansas and Virginia. State information and specific TMDL development documents came from Kansas Department of Health and Environment (TMDL development for the Marais des Cygnes), and from MapTech, Inc*. (TMDL development for the Blackwater River Watershed in Virginia), which is a private company that develops TMDLs.

Kansas and Virginia utilize different development methods: Kansas uses FD while Virginia uses HSPF. These different methods of development coupled with

*Miller-McClellan is employed as a Computer Programmer/Analyst for MapTech and is espoused to Phillip McClellan, President and CEO.

Virginia's consideration of using FD warrants further study of the development methods and results. Once state methods were observed, the next phase of this research included a comparison of studies for both methods of development in the same watershed (Blackwater River), and a look at the purpose of Bacterial Source Tracking and its coupling with FD. Sources for this information include Virginia Department of Environmental Quality, and Virginia Department of Conservation and Recreation's Division of Soil and Water Conservation, and MapTech, Inc. This provided the relative information for analysis of possible affects on stakeholders.

Stakeholder involvement in the two states was evaluated using Arstein's ladder of participation (1969) as a basic framework. Points from a stakeholder case study by the Canaan Valley Institute, EPA, and Downstream Strategies are incorporated to add insight to improvement in stakeholder participation for the TMDL program. Methods of improving the process were drawn from these studies plus personal observation of TMDL public meetings (six meetings in 1999, four in 2000 and three in 2002).

1.2. TMDL Program

The Environmental Protection Agency (EPA) holds the delegated responsibility of protecting the nation's waters. Drawing its legal authority from the 1972 Clean Water Act (CWA), the EPA works with other state agencies "...to restore and maintain the chemical, physical, and biological integrity of the nation's waters" (CFR 1972). The Clean Water Act requires states to develop water quality standards for protecting and restoring water quality, and to develop a list of impaired waters and TMDLs to correct those impairments. States and tribal territories set their own water quality standards. However the standards must at a minimum meet the "fishable and swimmable" standard set forth in the CWA. Waterbodies are listed as impaired or threatened from one or more of the following: fecal coliform, nutrients, metals, organics, temperature, dissolved oxygen, pH, benthic, hydromodification and sediment.

Since 1972, the CWA has been applied to point sources such as wastewater treatment facilities, and industrial discharges, through discharge permitting. With the permitting system, industrial pollution levels took a dropped significantly and wetland losses slowed and in some cases, reversed (CEQ 1997) (Houck 1999).

However, regardless of the reduction of pollution from point sources, water quality is below standards (Houck 1999) (see Tables 1-1 and 1-2 below). Nonpoint source pollution over the years has been largely ignored by the regulating agencies and communities even though it is addressed in the CWA. According to the 1972 CWA, §303(d) states are required to identify waters that do not meet water quality standards and establish Total Maximum Daily Loads (33 USC §1313). Each state's water quality assessments are presented in a biennial Report to Congress required by §305(b) of the act. If states fail to uphold the CWA regulations the EPA is held responsible. Not until the late 1980s did agencies begin to take this responsibility seriously, and, then, only when prompted by lawsuits from various concerned citizens and environmental groups. Even though states bear responsibility for assessment, listing and TMDL development, EPA must approve the TMDL before it can be implemented.

Only about 33% of the nation's water bodies were assessed for the 2000 305(b) report. Of that, 40% of streams, 45% of lakes, and 50% of estuaries received impaired status. These impairments include approximately 270,000 miles of rivers and shorelines and approximately 7 million acres of lakes (Table 1-1).

Two hundred and eighteen million people live within 10 miles of impaired water. States report that the major causes of these impairments are nonpoint source pollution. Nonpoint source pollution contaminates drinking water sources, and alters stream habitat used for recreation, fishing, and wildlife. The importance of clean drinking water, fish as a safe reliable food source and the value of waterbodies for recreation increase the need to determine the possible sources of point and nonpoint source pollution, and develop plans to address these pollutants and while considering how the plans will affect the major stakeholders (EPA 2002).

Table 1-1. 2000 Summary of National Water Quality Assessments.

| Waterbody | Total Size | Amount Assessed | Good | Good but Threatened | Polluted |
|------------------------------|-------------------|------------------------|-------------|----------------------------|-----------------|
| Rivers (miles) | 3,692,830 | 699,946 | 367,129 | 59,504 | 269,258 |
| Lakes (acres) | 40,603,893 | 17,339,080 | 8,026,988 | 1,348,903 | 7,702,370 |
| Estuaries (sq. miles) | 87,379 | 31,072 | 13,850 | 1,023 | 15,676 |

Source: EPA 2002

Table 1-2. Causes and Sources of Impairments/waterbody.

| | Rivers and Streams | Lakes, Ponds, and Reservoirs | Estuaries |
|----------------|---------------------------|-------------------------------------|------------------------------|
| Causes | Pathogens (Bacteria) | Nutrients | Metals (primarily Mercury) |
| | Siltation (Sedimentation) | Metals (primarily Mercury) | Pesticides |
| | Habitat Alterations | Siltation (Sedimentation) | Oxygen- Depleting Substances |
| Sources | Agriculture | Agriculture | Municipal Point Sources |
| | Hydrologic Modifications | Hydrologic Modifications | Urban Runoff/Storm Sewers |
| | Habitat Modifications | Urban Runoff/Storm Sewers | Industrial Discharges |

Source: EPA 2002

Virginia encompasses approximately 50,145 miles of perennial streams and 2,500 square miles of estuaries. Of that, the Virginia Department of Environmental Quality (VADEQ) monitored approximately 9,800 miles finding that 44% of those rivers and streams do not fully support designated uses. Fecal coliform bacteria are the most commonly cited cause of impairment. Agriculture contributes much of the bacteria. Other causes of impairment include organic enrichment and acidity, and urban runoff (VADEQ 2000). Additional sources of nonpoint source pollution include mine drainage, leaky septic systems and wildlife.

In 2000, the Kansas Department of Health and Environment (KDHE) assessed water quality for 18,200 miles of rivers and streams. Of these, approximately 46% do not support aquatic life use. Major causes of impairment are fecal coliform bacteria, organic enrichment, sulfates, chlorides and metals. Pollutant sources include agriculture, natural sources, hydrologic modification, municipal point sources and groundwater withdrawal (KDHE 2000).

The importance of clean water for consumption and the prevention of disease cannot be stressed enough. The development of TMDLs and the end product are law. Lead agencies scramble to meet consent decrees with limited funding and are driven to find cheaper and faster methods for TMDL development. In the midst of this flurry to meet consent decrees are the citizen stakeholders, who are affected most by the TMDL program. Ultimately farmers and other landowners are burdened with the greatest challenges and changes of the TMDL to meet the water quality standards. Without knowledge of the methods being used in the calculation of TMDLs and their potential outcomes, neither the agencies that run the program nor the other stakeholders understand the impacts. It is important that citizen stakeholders understand the difference in how TMDL calculations are made and the potential impact on their activities. Not only should they understand the processes but should have a voice in the criteria used to calculate loads. The purpose of this paper seeks to give stakeholders a better understanding of the TMDL modeling process and the various results obtained by different methods of load calculations.

2. TMDL Program Implementation

The TMDL program lay dormant for over 20 years after its initial passage, and similar to the upstart of any new program, the government agencies had to design a program process for achieving the water quality goals set forth by EPA and individual states. Even though states possess leeway to establish water quality standards and methods used for developing TMDLs, all TMDL programs have common basic elements in their implementation.

Implementation of the TMDL program involves:

- ❖ government agencies working together
- ❖ water quality standards development/modification
- ❖ water quality assessments
- ❖ beneficial use designations
- ❖ TMDL development
- ❖ public participation
- ❖ load allocations
- ❖ delisting

(McClellan, personal communication, 2002.)

Each of these components is discussed below.

2.1. *Government Agency Coordination*

The administration of the CWA ultimately falls upon the EPA. However, state agencies are required to monitor water quality, identify and submit a list of impairments, and develop a TMDL to restore water quality. For example Virginia's lead state agency is the Department of Environmental Quality (VADEQ). VADEQ entered into a memorandum of agreement with Virginia's Department of Conservation and Recreation (VADCR), the Department of Mines, Minerals and Energy (DMME), and the Virginia Department of Health (VDH) for oversight of TMDL development for specific types of impairments. (Responsible agencies in other states are similar to those in Virginia but

may have different titles such as Department of Environmental Protection, Natural Resource Conservation Commission, Department of Health and Environment, etc.) In Kansas, the responsible agency is the Kansas Department of Health and Environment. That agency works with the Bureau of Water, and the Bureau of Environmental Field Service. Kansas receives additional assistance from the U.S. Geological Survey agency. It is crucial for these agencies to work together in order to achieve successful implementation of the TMDL program.

2.2. Standard Development and Water Quality Assessment

According to the CWA, a state or territory sets water quality standards. Although the rigidity of these standards is determined by states, all navigable water must be fishable and swimmable as stated in the CWA. Water quality standards include three crucial parts: designated uses, criteria to develop to protect each use, and an antidegradation policy. From these standards stream quality can attempt to be measured. Monitoring waterbodies for conditions and various pollutants, and assessing stream health by observation of water communities and change over time make up an assessment. Organizations such as the U.S. Geological Survey, the EPA and citizens groups perform water monitoring and share data with state agencies. The state/tribes must list waters that are either impaired or threatened by pollutants and indicate the pollutant(s) suspected of causing the problem. These waters are then slated for TMDL development. Water assessments are done every two years: the latest being the year 2002, unless the EPA rules otherwise. Reports, including the list of impairments and the methodology for developing that list, are submitted simultaneously to the EPA.

2.3. Beneficial Use Designation

Beneficial uses are the uses that water quality should support. Based on the CWA, all water should support swimming and fishing. Other uses include drinking water, irrigation, industry, and navigation. A waterbody may be designated for multiple uses and each use includes a set of water quality criteria that must be met as dictated under the CWA and/or state standards. The criteria take both numerical and narrative forms. Numerical criteria establish thresholds for chemical, biological and physical conditions

required for aquatic life. Narrative criteria describe conditions. Antidegradation policies seek to protect waters from future degradation even if they currently meet water quality standards. These criteria used in conjunction with each other measure whether a waterbody meets its designated use. Recognized designated uses include: support of aquatic life, safe drinking water and fish consumption, shellfish harvesting, swimming, boating, fishing, agriculture, groundwater recharge, wildlife habitat, and cultural or ceremonial uses.

2.3.1. Designated uses and standards in Virginia

In Virginia, (Code of Virginia 2002, §62.144.15(3a)), a partial listing of surface water standards includes:

- All state waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.
- In designating uses of a water body and the appropriate criteria for those uses, the board shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters.
- The board may adopt subcategories of a use and set the appropriate criteria to reflect varying needs of such subcategories of uses, for instance, to differentiate between cold water (trout streams) and warm water fisheries.

(SWCB. 2003)

Virginia State Department of Health establishes fecal coliform criteria for shellfish in all ocean or estuarine waters. Since shellfish TMDLs are not relevant to this study, the criteria are not addressed in this paper.

General requirements for surface waters, excluding shellfish waters, state that fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per

100 ml of water for two or more samples over a 30-day period, or a fecal coliform bacteria level of 1,000 per 100 ml at any time (Table 2-1).

Table 2-1. Virginia Criteria for Fecal Coliform Bacteria.

| | |
|---|---|
| Primary and Secondary Contact Recreation/Fish consumption | Geometric mean of 200 colonies per 100 milliliters for 2 or more samples over a 30 day period or 1000 colonies/100 milliliters at any time. |
|---|---|

2.3.2. Designated uses and standards in Kansas

According to the Kansas Surface Water Register (1999) designated uses for unimpounded reaches of stream segments include: aquatic life use, special aquatic life use, restricted aquatic life use, recreational use (contact recreation is defined as recreation where the body is immersed in surface water to the extent that some inadvertent ingestion of water is probable such as boating or swimming (Table 2-2). Designation of surface water as secondary contact recreation is defined as recreation where ingestion of the surface water is not probable such as wading, fishing, or hunting, domestic water supply use, food procurement use, ground water recharge, industrial water supply use, irrigation use and livestock watering use (Kansas Register. 2003).

Table 2-2. Kansas Criteria for Fecal Coliform Bacteria (USGS 2002).

| | |
|--|--|
| Summer Primary Contact Recreation (April 1-Oct. 31) | Geometric mean of 200 colonies per 100 milliliters for five samples collected at least 24 hours apart in a 30 day period |
| Winter Primary Contact Recreation (Nov. 1- March 31) | 2,000 colonies per 100 milliliters |
| Secondary Contact Recreation | 2,000 colonies per 100 milliliters |

2.4. TMDL Development

A timeline for TMDL development is established for each impairment depending upon how severely it is polluted and its designated uses. A TMDL includes wasteload

allocations from point sources and nonpoint sources, as well as a margin of safety to allow for possible unknowns and takes seasonal variation into consideration. Applicable characteristics of each watershed such as rainfall, landuse, pollutant sources, industry, etc., are observed and accounted for in the modeling process when possible. One of the most detailed modeling software packages being used for TMDL development is Hydrologic Simulation Program-Fortran (e.g. as used in the Blackwater River TMDL in Virginia). Some states are using the simpler approach of Flow Duration Curves (e.g. as used in the Marais Des Cygnes Basin, Kansas).

Development of a TMDL includes (EPA 2001):

- ❖ Problem identification
- ❖ Identification of water quality indicators (e.g., pollutant) and targets (e.g., criteria)
- ❖ Source assessment
- ❖ Assessment of the linkage between sources and targets
- ❖ Allocation of loads and wasteloads

These items are discussed further in Section 6.

2.5. Public Participation

EPA guidelines suggest public involvement in all stages of TMDL development and subject all TMDL documents to public review. In 2001, the EPA held five TMDL listening sessions for the public throughout the nation, each on a different topic concerning TMDL development. Beyond that, the degree of public participation and the approach to solicitation for public involvement are left up to the individual states.

In Virginia, a series of meetings are held during TMDL development. The first is to inform the public about the impairment, discuss the TMDL process allowing time for stakeholder questions and comments. Approximately two other meetings (depending upon need) are held to discuss pollutant sources, modeling process, loads and allocations. Additional small-group stakeholder meetings may take place to acquire relevant information and assure data being used is of the best possible quality. These meetings

present the draft TMDL for public review and comments. Public meeting announcements are posted in local newspapers and the Virginia Register (VADEQ 2002).

Kansas uses processes already in place to create opportunities for coordination with other agencies, interest groups, and the public. The Kansas Department of Health and Environment takes the lead on convening interagency work groups to address specific TMDL issues. KDHE coordinate with agencies such as the Bureau of Water and the Bureau of Environmental Field Services. The Watershed Planning Section coordinates with other state agencies through the Kansas Water Office, the Kansas Water Authority, and the Kansas Water Plan. Basin Advisory Committees are present in all major river basins and advise the Water Authority on basin issues and concerns. After the initial six months of work on the TMDL, the first draft is available for public review. Comments are taken into consideration and any necessary revisions are made before the draft is presented to the Water Authority. Upon review by the Water Authority, the draft is released to the public for formal comments. Those comments are taken into consideration for redrafting before final approval of the Water Authority and submittal to EPA.

2.6. Load Allocation

The TMDL allocation process allocates allowable pollutant loads among nonpoint sources and point sources and includes a margin of safety. The load is calculated using the following equation:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$

Where:

Total Maximum Daily Load (TMDL) is the maximum amount of a pollutant loading a water body can receive and still maintain water quality standards.

Wasteload allocation (WLA) is the pollutant load allocated to existing and future point sources.

Load allocation (LA) is the pollutant load allocated to nonpoint sources and natural occurrences.

Margin of safety (MOS) is used to account for uncertainty in determining pollutant loads allowing for the unknown.

Although the TMDL, by law, must be developed, there are no strict guidelines by EPA on how to come up with the allocations. The method of modeling to use and how to use it is left up to the individual state. However, according to EPA, “states should use EPA’s technical support document and WLA technical guidance series when developing TMDLs. Alternative approaches can be used if they are technically defensible and approved by EPA” (EPA 2002).

2.7. Implementation

The 1972 Clean Water Act fails to require implementation plans for achieving the goals set forth in the TMDL plan. The EPA proposed revising the CWA to include the TMDL New Rule, which would require that implementation plans be developed along with the TMDL. The EPA later withdrew the New Rule. Some states require that implementation plans be developed to achieve the goals set forth in the TMDL plan. For example, in 1997 the Virginia General Assembly enacted the Water Quality Monitoring, Information and Restoration Act (§62.1-44.19:4 through 19:8 of the Code of Virginia). The act directs DEQ to develop implementation plans for the TMDLs (VADEQ 2002). Likewise, the state of Kansas requires the submission of plans for implementation with the TMDL document. “Such plans will fully recognize the existing efforts underway under the guise of water quality protection and improvement and will reference current agency programs and authorities, including those of the Kansas Water Plan. Realizing that resources for implementation are finite, a hierarchy of priority among TMDLs for implementation is recommended” (KDHE 2002).

EPA estimates that costs for attaining water quality standards through TMDL development could range between \$900 million and 4.3 billion dollars annually. Studies show that many states lack the data required to develop TMDLs for their impaired waters. To gather the necessary data, the estimated costs per state are \$17 million per year. After the data are acquired, states would need to spend an additional \$69 million annually over the next 15 years to develop the plans to clean up the 20,000 impaired

waters currently on the 303(d) list. State costs to develop implementation plans for each of these impairments are projected to average \$52,000 per plan. In Virginia, implementation plan development and implementation cost is estimated depending upon watershed size to range from \$400,000 to \$800,000 per watershed, not including shellfish areas (VADEQ, et. al 2000). Cost estimates for installing measures to reduce pollutant loads fall between \$900 million up to \$4.3 billion and would be borne by the dischargers (EPA 2001).

Implementation costs for TMDLs in Virginia are estimated at \$59,063,390 over ten years. State agency funds available for that time period total \$18,223,500 projecting a \$40,839,890 deficit through 2010. These costs are preliminary and are based on limited information (VADEQ 2002). The state of Kansas estimates its costs of program implementation to be approximately \$300,000 per year excluding salaries for three full time employees (Kozel 2000). However a more recent study/implementation plan developed for the Upper Wakarusa Watershed, Kansas alone found the cost of necessary BMPs to be slightly over \$12,124,347. Available funding with cost-share was \$1,490,000, leaving a \$10,634,347 shortfall for the river basin (KVHAP 2003).

2.8. Delisting

According to the 2002 Integrated Water Quality Monitoring and Assessment Report Guidance (EPA 2001), waters are removed from the listing once the standards are attained. Streams can also be delisted due to “Good Cause”, where it can be shown that the stream was improperly listed, resulting from recent or accurate data, more sophisticated or improved water quality modeling and data analyses (Gold 2002).

3. The Stakeholders

The stakeholders in the TMDL development process include federal and state governmental agencies, cities/towns (municipalities), industry, landowners and agribusiness, and concerned citizens. The key issue at stake, clean water quality, is in the best interest of all the stakeholders. However, issues of livelihood and implementability are equally crucial. It is sometimes difficult for a stakeholder to fathom that a change in one's lifestyle could help improve water quality for multitudes. Hastily made decisions of which measures utilized to achieve water quality goals can severely impact the livelihoods of stakeholders. Each of the key stakeholders is briefly discussed below.

3.1. The Agencies

The EPA is under court order or has agreed to establish TMDLs if individual states fail to do so. Depending upon the litigation, specific TMDL development completion deadlines were set. For example, Virginia was to have 1 TMDL submitted to EPA by May of 1999, 12 more TMDLs by May of 2000, etc. (see Table 3-1). Following the consent decree, Virginia TMDLs for the listed impairments must be completed by May, 2010; Kansas is working on a timeline to have TMDLs completed by June of 2006 (see Table 3-2). The Kansas schedule is set up by river basin rather than impaired stream segment. To develop TMDLs by river basin rather than by stream segment requires less work because of less detail (Petraskus, personal communication 2003). The state of Kansas is also taking the initiative to attempt an accelerated schedule to allow for additional work to be done. Therefore, EPA and the states race against time to meet the decrees. Responsible state agencies face hiring contractors for TMDL development, informing stakeholders, overseeing the TMDL development process and documentation, completing the TMDL on time, and submitting the document for EPA approval.

Table 3-1. Virginia Consent Decree TMDL Schedule per Impairment.

| TMDL Submittal Dates | EPA Action Dates | Consent Decree for Impaired Waters |
|-----------------------------|-------------------------|---|
| 5/1/99 | 5/1/00 | 1 |
| 5/1/00 | 5/1/01 | 12 |
| 5/1/02 | 5/1/03 | 30 |
| 5/1/04 | 5/1/05 | 74 |
| 5/1/06 | 5/1/07 | 213 |
| 5/1/08 | 5/1/09 | 127 |
| 5/1/10 | 5/1/11 | 179 |
| Total impairments | | 636 |

Table 3-2. Kansas Consent Decree TMDL Schedule per River Basin.

| TMDL Submittal Dates | Decree Schedule/River Basin | Accelerated Schedule |
|-----------------------------|------------------------------------|-----------------------------|
| 6/30/99 | 1 | 1 |
| 6/30/00 | 2 | 3 |
| 6/30/01 | 1 | 2 |
| 6/30/02 | 2 | 3 |
| 6/30/03 | 1 | 3 |
| 6/30/04 | 2 | Follow-up |
| 6/30/05 | 1 | Follow-up |
| 6/30/06 | 2 | Follow-up |
| Total river basins | 12 | 12 |

3.2. Cities, Towns, and Industry

Cities and Towns contribute to NPS pollution through numerous means including stormwater runoff from parking lots and lawns, straight pipes (raw sewage directly to the stream) and leaky septic systems from businesses and private residences. Elected city officials volley between taking responsible actions to promote clean water quality and satisfying state regulations, and understanding the needs, and financial burdens these regulations may impose on the voting population.

Industry is also affected by water quality regulations. Those with a permitted discharge are concerned not only with meeting their permit limits but also with being restricted from expansion because of the allocations set forth in the TMDL.

3.3. Landowners/ Agribusiness

Landowners have property that either borders a stream or, due to its location in a watershed, the surface runoff from rain events carries pollutants from land to a stream. Agribusiness usually brings to mind large commercial operations. However, according to the U.S. Department of Agriculture, small farms (incomes of \$250,000 or less) account for 94% of total farms. Small farms vary by region and commodity. While \$250,000 in gross receipts may sound high, the average farm with annual gross sales between \$50,000 and \$250,000 yielded a *net* cash income of only \$23,159. Over 80 percent of a farmer's gross sales are absorbed by farming expenses. Farms with gross sales between \$100,000 and \$250,000, vary in gross sales based on the value of the commodities grown and the mix of commodities, fixed and variable expenses, and ultimately, in net farm income. A bushel of corn today sells for the same price now as it did in 1953 (Brinkman, personal communication, 2003). The farmer makes approximately 4 cents per loaf of bread whether the loaf sells for \$1.50 a loaf or \$2.50 a loaf. A typical wheat farm in 1996 received *gross* cash income of \$149,020 but after cash and fixed expenses, depreciation and labor were paid, the *net* farm income totaled \$28,842 (ERS 2003.) Yearly income for U.S. wheat farmers reveals no significant increase (Table 3-3.) In 1980, the farmer received 37 cents for every consumer dollar spent on food. Today the farmer receives 23 cents of every dollar (USDA 1998.)

Table 3-3. Farm income for U.S. wheat farmers (ERS 2003.)

| Income (dollars) | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|-------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Crop | 100,636 | 91,917 | 74,462 | 61,735 | 68,847 | 79,085 |
| Gross Cash | 149,020 | 143,683 | 137,413 | 123,216 | 154,809 | 144,236 |
| Net | 28,842 | 35,126 | 32,216 | 27,048 | 34,501 | 18,467 |

In 1996, cattle producers did not fair much better. A typical beef operation received gross cash income of \$70,774. After cash and fixed expenses, depreciation and labor were paid, the *net* farm income for a typical beef operation was \$5,264 (ERS 2003.)

(Small farmers own 75% of the total productive assets in agriculture and 72% of all land in agricultural production and account for only 41 % of all agricultural receipts (Glickman1999).

Table 3-4. Farm income for U.S. cattle farmers (ERS 2003.)

| Income (dollars) | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|-------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Livestock | 57,380 | 83,475 | 76,927 | 72,879 | 81,307 | 98,338 |
| Gross Cash | 70,774 | 114,636 | 105,001 | 101,661 | 105,459 | 98,338 |
| Net | 5,264 | 24,326 | 16,526 | 17,461 | 13,870 | 9,915 |

In order for landowners to reduce their contribution to water pollution, they must institute Best Management Practices (BMPs). BMPs conserve water and prevent water pollution. Agriculture is America’s greatest water quality challenge of the 21st Century (Libby, et.al, 2001.) Years of non-regulation for nonpoint source pollution have taken their toll. Historically, the EPA’s approach toward agricultural regulation was permitting confined animal feeding operations (CAFOs) that house over 1000 animal units. Regulation currently applies to approximately 39,000 CAFOs. These large operations are required to have a national pollution discharge elimination system (NPDES) permit. EPA was successful in developing a new rule regulating CAFOs. This new rule decreases the number of animal units defining a CAFO to 300 in one instance and 500 under another. In addition to a stricter definition of animal unit, the new rule more closely monitors manure spreading and eliminate the exemption for a catastrophic storm event (25 year, 24 hour storm). Estimated compliance cost for CAFO farmers falls between \$850 million and \$950 million dollars per year (Libby et.al, 2001).

In Virginia, approximately 41,095 farms cover over 8 million acres (USDA 1997). Estimates project a cost of approximately \$20 million to implement all the existing water quality goals and objectives (Miller 2000). To encourage farmers to use BMPs, the state set up a BMP cost-share program. The program offers financial assistance to farmers who voluntarily install BMPs. With the cost-share program, the government may provide up

to 75% of funding for BMPs. Depending upon state financial resources, a farm may or may not receive cost-share assistance.

The majority of Kansas' 52.5 million acres are used for agriculture and 97% of those reside in private ownership. Kansas estimates that installing BMPs for six of its 12 river basins will exceed \$280 million. Like Virginia's cost-share program Kansas provides an environmental incentives program that will contribute up to 75% of the funding for BMP installation. In 2001, 885 landowners applied for cost-share assistance which totaled 6.2 million dollars. The 2001 allocation for cost-share totaled \$3.9 million leaving the state \$2.3 million short in helping their farmers (NRCS 2001.) Many of the BMPs needed to address water quality problems remain cost-prohibitive for the landowner/land manager to bear alone. In the current economic climate, even the landowner's share of the costs can be cost-prohibitive (Streeter 2002). For example, a BMP such as an animal waste storage facility can cost \$120,000 to \$150,000 (VFB 2001.) Even if a farmer can get cost-share assistance, whatever percent of the total cost the farmer must provide can cause financial hardship. Upon BMP establishment, the farmer must see to its upkeep. Since funding in Kansas and in Virginia runs in short supply, some who apply for funding may get little to nothing.

3.4. Concerned Citizens/Environmentalists

U.S. citizens, regardless of where they live or their occupation, need good water quality and experience the affects of the TMDL program. Pets, straight pipes, malfunctioning sewer systems, and lawn fertilization, just to name a few, are ways citizen practices change water quality. These stakeholders ultimately help shoulder the cost burdens of installing new septic systems, water and wastewater treatment, etc. Stakeholder attendance at local TMDL public and focus group meetings holds great importance.

Separation of environmentalists from citizen stakeholders seems unnecessary. Environmentalists are citizen stakeholders and oft times, vice versa. Those concerned with the environment desire clean water for recreational activities and future water usage. Most stakeholders want good water quality for future generations to enjoy.

Contaminated streams harbor disease for plants, animals and humans. Environmentalists as all stakeholders have a right to voice concern for clean water.

4. Different Approaches to TMDL Development

One of the most crucial steps in TMDL development for the stakeholders involves selecting a method of modeling that will most accurately represent their watershed. To help government agencies and contractors decide which model(s) is most appropriate for use in simulating pollutant transport to receiving waters and ecosystems, the EPA has published a handbook called “Compendium of Tools for Watershed Assessment and TMDL Development” (1997). According to the EPA “the most challenging tasks of understanding the cause-effect relationships within a watershed include selecting the most appropriate mix of assessment tools, developing the most cost-effective procedures to use these tools, and generating the needed information to support the decisions made using the tools” (Shoemaker, et al, 1997, p.61). The key to watershed modeling is selecting the right model. Models differ in capability, detail and accuracy. Poorly adapted models produce misleading results and lead to further complications and controversial decisions (Nix 1990). Model selection should meet the most application requirements and historically demonstrate application and continuous support from developers and communities (Nix 1990). Several models and methods meet specific analyses. The two most widely used models—the Hydrological Simulation Program-FORTRAN model and the Flow Duration Method—are discussed here.

4.1. *Hydrological Simulation Program-Fortran (HSPF)*

The EPA Compendium (1997) includes three rankings for model capabilities: simple, mid-range, and detailed. “Detailed models best represent the current understanding of watershed processes affecting pollution generation” and, “are best able to identify causes of problems rather than simply describing overall conditions” (Shoemaker, et al. 1997, p. 13). HSPF is a detailed watershed model developed by EPA in cooperation with Aqua Terra (Aqua Terra 2002) and ranks highest in model capabilities of any models evaluated in the Compendium (1997). HSPF requires extensive data. However, model capabilities include simulating water quantity and quality for many organic and inorganic pollutants.

The model generates simulations for runoff flow rate, sediment, and pollutant concentrations in the watershed. In addition, HSPF includes components for nutrient fate and transport, biochemical oxygen demand, pH, and concentrations of dissolved oxygen, phytoplankton, zooplankton and benthic algae. Within the modeling framework exists a statistical package that allows for frequency-duration analysis of specific output parameters. This model has been used extensively for detailed analyses of watersheds.

4.2. Flow Duration

Kansas derived a simple TMDL development method based on a frequency analysis of the historic hydrologic record, resulting in a cumulative frequency of daily flows (flow duration curve) on the water quality limited stream. A water quality standard load or "allowable load" is calculated by multiplying the numeric water quality criteria by the flows from the frequency analysis (Stiles 2002). Multiplying the water quality data by the daily flow calculates actual pollutant loads. The critical flow and allocation are determined by a comparison of the pollutant loads with the allowable loads. In essence, the FD method is considerably simpler than the HSPF model. The advantage of simple methods being quick, easy to compute (do not require a computer model program) and require less data than more advanced models. However, "Simple methods provide only rough estimates of sediment and pollutant loadings and have very limited predictive capability" and "limited transferability to other regions....Because they often neglect temporal variability, simple methods might not be adequate to model water quality problems for which loadings of shorter duration are important" (Shoemaker, et al. 1997, p. 10-11).

When it comes to linking load reduction estimates, hydrologic conditions, contributing areas and delivery mechanisms the FD method needs much improvement. TMDL development requires using several tools such as monitoring, modeling, screening, and BST. Duration curves supplement as another tool for the toolbox. Sometimes accurate watershed representation requires other tools such as HSPF modeling. The flow duration method makes a useful screening device (Cleland 2002). The KDHE intends to address modeling in the implementation phase instead of the TMDL development stage because of the time constraints of meeting consent decrees (Stiles 2003).

4.3. *Selecting a Model*

Several criteria need evaluated when selecting a model. One must have the appropriate modeling software and hardware. To save costs, agencies must consider whether in-house modeling expertise exists or if personnel will need additional training. Since modeling can be expensive, it is wise to select a model that can be used repetitively for various projects rather than change models from project to project. Model credibility is easier established for a model that is widely used rather than one that is not. Finally, the stakeholders must be willing to accept the results of the model as a decision-making tool (Nix 1990).

Most models designs address a specific problem and therefore, a single model may not always be enough. In a complex watershed with multiple stressors, more than one model may be required. However, more sophisticated models such as HSPF and SWMM are used for multiple applications. “No one model is ideal, although most simple and midrange models can provide valuable information for screening and planning level decisions, they are of little use for advanced phases in the development of TMDLs or siting and designing of management plans” (Shoemaker, et al. 1997. p62).

In summary, models/techniques should be matched with the project phase. Since most watershed studies, such as TMDLs, are done in phases, the preliminary phases of priority and ranking can be accomplished using simple modeling approaches. However, the TMDL development phase or design of management measures to meet water quality goals requires a higher degree of accuracy. During these phases, model selection and configuration needs to be defensible and results verified (Shoemaker, et al 1997. p 62).

Advantages and disadvantages exist with different development methods depending on the task to be completed (see Table 4-1). The Flow Duration method does not require a computer program but a simple spreadsheet and minimal data. The method is quick, uncomplicated and inexpensive. This simple method uses large simulation time steps to provide long term estimates. However the inability of simple methods of modeling to simulate the fluctuations in pollutant loading or concentrations found in using smaller time steps decreases accuracy.

Detailed models such as HSPF best represent the watershed processes and are used to identify problems and causes as opposed to just describing overall conditions. This

model was developed in the 1960's. Improved versions were released in the 1970s and 1980s (USGS 2002). Commonly recognized as the most complete and defensible process-based watershed model for quantifying runoff and addressing water quality impairments from both point and nonpoint source pollution. HSPF is used not only in the United States but other countries as well to model small and large watersheds: for example, Santa Monica Bay, CA and the Chesapeake Bay in VA (Aqua Terra 2002). The disadvantages of using HSPF include: a requirement of extensive data, trained personnel and it is time.

Table 4-1. Evaluation of TMDL development Method/Model Capabilities

| Criteria | | Capability of FD Method* | Capability of HSPF model |
|--------------------------|------------------------|---------------------------------|---------------------------------|
| Land uses | <i>Urban</i> | Low to medium | High |
| | <i>Rural</i> | Low to medium | High |
| | <i>Point Sources</i> | Low to medium | High |
| Time Scale | <i>Annual</i> | Low to medium | - |
| | <i>Single event</i> | Low | High |
| | <i>Continuous</i> | Low to medium | High |
| Hydrology | <i>Runoff</i> | Low to medium | High |
| | <i>Baseflow</i> | Low to medium | High |
| Pollutant Loading | <i>Sediment</i> | Low to medium | High |
| | <i>Nutrients</i> | Low to medium | High |
| | <i>Others</i> | Low to medium | High |
| Pollutant Routing | <i>Transport</i> | n.a. | High |
| | <i>Transformation</i> | n.a. | High |
| Model Output | <i>Statistics</i> | Low to medium | High |
| | <i>Graphics</i> | Low to medium | ◇ |
| | <i>Format Options</i> | n.a. | High |
| Input Data | <i>Requirements</i> | Medium | High |
| | <i>Calibration</i> | n.a. | High |
| | <i>Default data</i> | n.a. | Medium |
| | <i>User Interface</i> | n.a. | - |
| BMPs | <i>Evaluation</i> | Low to medium | High |
| | <i>Design criteria</i> | Not incorporated | High |
| Documentation | | Low | High |

◆ High ■ Medium ◇ Low - not incorporated

*Flow duration data provided by Bruce Cleland 2003.

Source: Shoemaker et al., 1997

Due to time constraints and lack of resources to meet the consent decrees that states such as Kansas are using Flow Duration. Virginia began using HSPF but because of the time and immediate cost is considering changing to the Flow Duration method. However, Virginia proposes the use of Bacterial Source Tracking (BST) in conjunction with Flow

Duration. The scientific analysis called BST identifies sources of fecal bacteria (human, wildlife or livestock.) BST provides another tool to help identify problem sources in a watershed and has been used to verify the reliability of HSPF modeling results. Examples of the applicability of BST in TMDL development are provided in Section 6.

5. Approaches to TMDL Development in Virginia and Kansas

The TMDL program addressed in the Clean Water Act (1972) lay dormant from 1972 until the mid 1990s. Since the mid 1990s, states from New York to Washington have been contending with litigation involving the CWA and the NPS pollution component. Driven by lawsuits, the state of Virginia schedule for TMDL development totals 636 impaired waters by May 1, 2010. Likewise, Kansas, pursuant to consent decree, schedule for TMDL development includes 770 impaired streams and 130 lakes by June 30, 2006. Even though states face the same problem each state may opt to address this problem with a different approach as long as that approach is approved by the EPA. For the purpose of this paper it is impractical to discuss approaches for every state. The following TMDL development study examines one case in Kansas and one in Virginia; these cases cover both the FD and HSPF approaches to development. It is important to compare different methods of TMDL development that may produce vastly different results. Virginia was chosen for the study because it has consistently used HSPF modeling for TMDL development but desires to change to FD. Kansas was chosen for the comparison because it developed the FD approach for TMDL development and has TMDLs approved by EPA. A TMDL is a legal document and one must assume stakeholders will have to abide by the resulting allocations and reductions. Section 6 compares the results of both methods used in the same Virginia watershed. It is the potential impact that the method of development may have on stakeholders that needs to be addressed by the comparison.

Reviewing the minimal TMDL requirements established by EPA (2001), a TMDL must include problem identification, identification of water quality indicators and targets, source assessment, linkage between water quality targets and sources, and allocations. TMDL calculation and allocation are required by law. Although not required by law, follow-up monitoring and implementation are recommended.

5.1. Case Study: TMDL Development for the Marais des Cygnes

The following consists of a brief overview of the Marais des Cygnes River TMDL submitted to EPA by the state of Kansas and how each of the criteria under EPA guidelines was met by the TMDL. The TMDL received EPA approval on August 28, 2001.

5.1.1. Problem Identification

The Marais des Cygnes River watershed is located in Franklin and Miami Counties, Kansas. The watershed drainage area includes 147,424 acres. Its tributary is Rock Creek, and the watershed includes grassland (47%), cropland (38%), woodland (10%), and urban land (2.5%). Designated uses for the Marais des Cygnes River include special aquatic life support, primary contact recreation, domestic water supply, food procurement, groundwater recharge, industrial water supply, irrigation, and livestock watering. The impaired use is contact recreation and is attributed to violation of the Kansas standard for fecal coliform colonies for primary and secondary contact uses (Table 2-1). The flow duration method was used to develop the TMDL (KDHE 2001).

5.1.2. Identification of Water Quality Indicators and Target Values

Water quality data collection from Monitoring Station 270 covered the period of 1986-1999. U.S.G.S. gaging station 06913500 served as the source for flow data (1971-1999) for each of the three defined seasons: Spring (April-July), Summer-Fall (August-October), and Winter (November-March) (Figure 5-1). The averaged daily flow records were computed and a frequency analysis performed (Table 5-1). Load duration curves for colonies of bacteria per day were developed for both primary and secondary contact recreation criteria by multiplying the flow values along the curve by the water quality criterion. The load curves function as the TMDL since any point along the curve represents water quality at the standard at that flow. Water quality standards are achieved when the data points fall below the load duration curve. This endpoint is expected to be met through unspecified reductions in loading from the various sources in the watershed through implementation of corrective actions and best management practices (KDHE 2001).

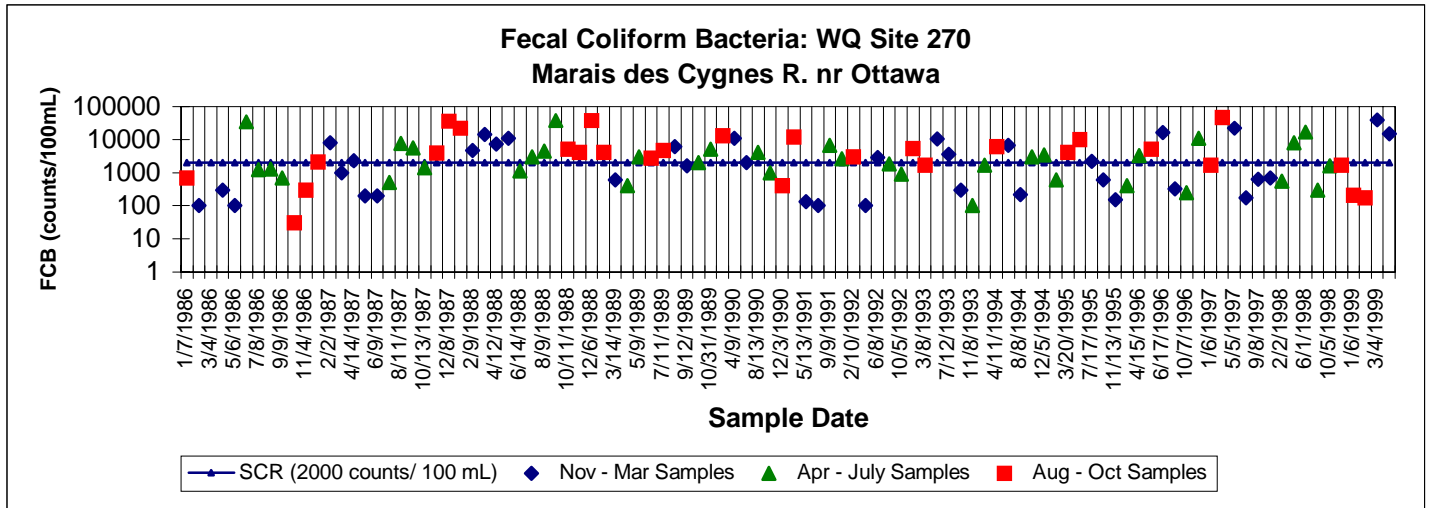


Figure 5-1. Bacterial data above and below the state standard (KDHE 2001).

Table 5-1. Number of samples over bacterial standard of 2000 by season.

| Station | Season | % of Samples | | | | | | Cum Freq. |
|---|--------|--------------|-----------|-----------|-----------|-----------|------------|-------------|
| | | 0 to 10% | 10 to 25% | 25 to 50% | 50 to 75% | 75 to 90% | 90 to 100% | |
| Marais des Cygnes River near Ottawa (270) | Spring | 4 | 2 | 4 | 3 | 3 | 2 | 18/38 = 47% |
| | Summer | 2 | 0 | 1 | 4 | 5 | 7 | 19/30 = 63% |
| | Winter | 1 | 3 | 1 | 5 | 4 | 4 | 18/40 = 45% |

*Kansas Department of Health (2001).

Water quality monitoring results for station 270 shows that in the spring sampling period 47% of the samples violated Kansas water quality standards. Summer sampling had the highest percentage of violations at 63% followed by the winter sampling at 45%.

5.1.3. Source Assessment

Sources located in the watershed include two wastewater treatment facilities (point sources). One facility is located a substantial distance below monitoring site 270 and therefore cannot be a contributor to the impairment. The second facility operates in

Ottawa. Projected future growth for Ottawa to the year 2020 indicates a 50% growth. Water use and wastewater treatment appear to be within the current facility's treatment capacity. The violations of water quality standards seem to occur under a variety of flow conditions but particularly under flow extremes (i.e. both high and low flow conditions). Nonpoint sources include failing septic systems. Livestock operations (27 registered, certified, or permitted) include beef, swine and dairy. One third of these operations lay upstream from site 270. Background levels may be attributed to wildlife. Deer are dispersed across the watershed and considered not a problem to water quality. The rural human population for Franklin and Miami counties through 2020 is anticipated to grow substantially at 37% and 95% respectively (KDHE 2001).

5.1.4. Allocations and Responsibility

Flow duration does not identify specific sources (human, livestock, or wildlife) of fecal coliform but makes assumptions from the flow duration curves on whether sources are attributed to point or nonpoint source pollution therefore the load and wasteload allocations cannot be numerically addressed. Allocations are established by the expected reduction of loads for the corresponding flow condition. Seasonal curves were developed. The allocations are expected to be met through implementation of corrective actions and best management practices in order to meet water quality standards (KDHE 2001).

Point sources in this watershed include two wastewater treatment plants. Due to the size and location of the Ottawa facility, it will be required to disinfect its wastewater discharge. The responsibility to maintain proper working conditions of these operations falls upon each facility.

The wasteload allocation corresponds with the flow condition where the total of the design flows represent more than 10% of the flow or the 7Q10 (the lowest consecutive 7 day streamflow that is likely to occur in a 10 year period), whichever is greater (Kearns 2002). Since the flow in the Marais des Cygnes River is modified by releases from Melvern and Pomona Lakes, which has increased the lower flows in the river, the Wasteload Allocation is more realistically defined as the flow regime between 75 and 100% exceedence. At this location in the Kansas River, that flow condition ranges from

flows of 0-53 cfs. In the future, permits of these discharge facilities will be adjusted so that the facilities will not cause violations of the standards at this flow.

Nonpoint sources are assessed as being a significant cause of violations of the fecal coliform bacteria standards. Measures to reduce the contribution from livestock should be directed at smaller unpermitted livestock operations, rural homesteads and farmsteads along the river and urban runoff from the city of Ottawa. The implementation of Best Management Practices will be used to address this problem (KDHE. 2001).

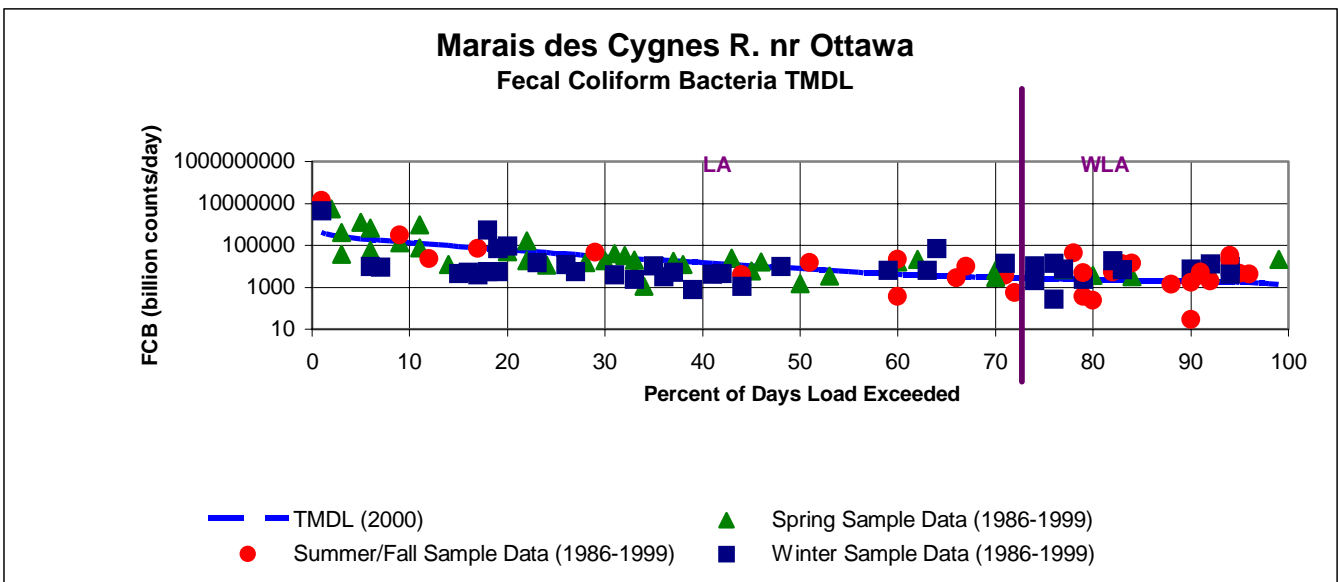


Figure 5-2. Flow duration curve for Fecal Coliform TMDL.

5.2. Case Study: TMDL Development in the Blackwater River Watershed in Virginia

The Blackwater River basin is in Franklin County VA and includes six impairments. The basin contains an area of 108,000 acres with forest and agriculture as the primary landuse. In order to model the watershed, it was divided into five subwatersheds and a TMDL developed for each one. The six subwatersheds include: Upper Blackwater, Middle Blackwater, Lower Blackwater, Magodee Creek, North Fork Blackwater and South Fork Blackwater. VADEQ identified causes of impairments in the Blackwater

River basin as violation of the fecal coliform standard. TMDL development for the impairments occurred in 2000 using HSPF modeling. The TMDLs were submitted and approved by EPA in 2001 (VADEQ 2003).

The initial modeling for the Blackwater River TMDL development used HSPF for modeling current watershed conditions and pollutant loads in 1999. In 2001, Virginia's VADEQ and VADCRDSWC decided to perform independent studies developing a TMDL for the same watershed using flow duration to compare the outcome of both methods. Section 6 provides data from that comparison.

5.2.1. Problem Identification

Six segments of the Blackwater River appear on the Commonwealth of Virginia's 303(d) list of impaired waters because of consistent violations of the water quality standards for fecal coliform for primary contact recreation (MapTech 1999). The map below provides the location of DEQ monitoring stations in the North Fork Blackwater River. For results of that monitoring see Table 5-2. The Virginia water quality standard limits fecal coliform concentrations to no more than 1000 colonies/100mL at any time.



Figure 5-3. DEQ monitoring stations in the North Fork Blackwater River Watershed (MapTech 2000).

Table 5-2. Summary of Water Quality Sampling in the North Fork Blackwater River Watershed by DEQ.

| Impairment and Station Number | Count (#) | Minimum (cfu/100 ml) | Maximum (cfu/100 ml) | Mean (cfu/100 ml) | Median (cfu/100 ml) | Violations (%) |
|-------------------------------|-----------|----------------------|----------------------|-------------------|---------------------|----------------|
| <i>North Fork</i> | | | | | | |
| 4ABNR009.36 | 120 | 100 | 8,000 | 808 | 300 | 23% |
| 4ABNR004.56 | 120 | 100 | 6,700 | 761 | 500 | 20% |
| 4ABNR000.40 | 116 | 100 | 8,000 | 5,130 | 5,700 | 89% |

Source: MapTech 2000.

Fecal coliform violations within the North Fork Blackwater watershed result from both nonpoint and point sources. Critical conditions for waters impacted by nonpoint sources generally occur during periods of wet weather and high surface runoff. Critical conditions for point source-dominated systems usually occur during low flow and low dilution conditions. Fecal coliform concentrations and discharge showed that there was no obvious critical flow level (Figure 5-4). The analysis showed no obvious dominance of either nonpoint sources or point sources. High concentrations occurred in all flow conditions (MapTech 2000).

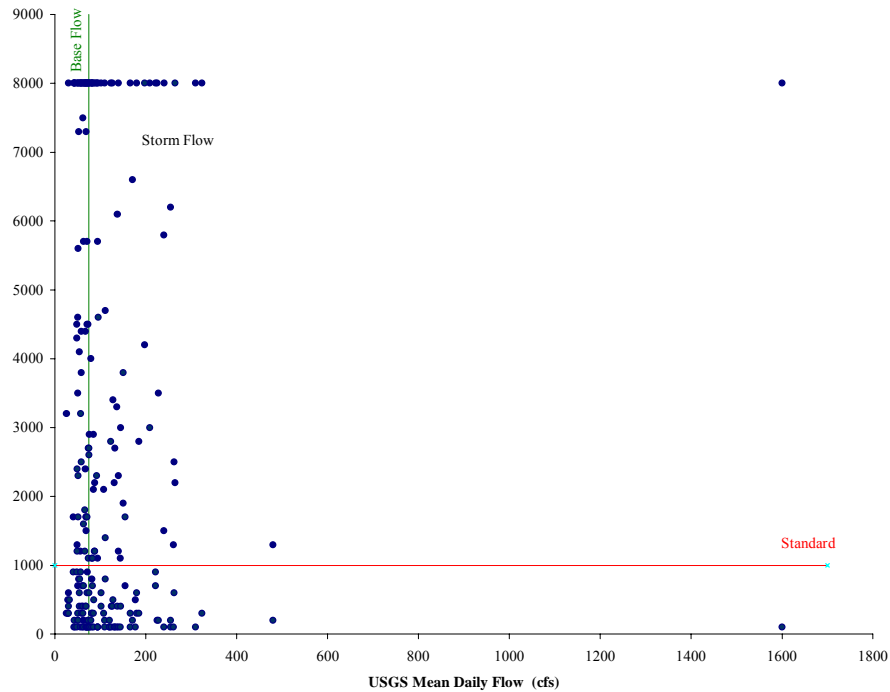


Figure 5-4. Existing Conditions in the North Fork Blackwater River Watershed (MapTech 2000).

5.2.2. Identification of Water Quality Indicators and Target Values

Virginia state law specifies no more than 1000 colony forming units (cfu) per 100 milliliters (mL) or a thirty day geometric mean of 200 cfu/100 mL as the maximum allowable level. Monitoring data for the study area indicates frequent violation of the allowable level. The HSPF model was used in the development of the Blackwater TMDL to characterize the linkage between measured in-stream water quality and hydrology, upstream landuse, land management practices, landcover, and pollutant sources. The model takes into consideration the seasonal variations in precipitation, hydrology, land practices and pollutant contributions. HSPF has a reputation of being one of the few models capable of integrating point and nonpoint source loads and determining their fate and transport. BASINS (Better Assessment Science Integrating Point and Nonpoint Sources) was also used. BASINS is an interface to HSPF, developed by EPA to support watershed studies with particular emphasis on TMDL development.

BASINS software consists of a comprehensive database of maps and tabular datasets compatible with ARCVIEW Geographic Information Systems (GIS) software package (MapTech 1999).

5.2.3. Source Assessment

Data collected for the project included: hydrography, topography, land use, point source loads, farm management plans, soil types and characteristics, sources of fecal coliform, and load fecal coliform from each source, waste production rates and fecal coliform content of feces, stream flow history, data from water quality monitoring stations within the impairment, weather history, expected growth in agricultural and urban areas, areas with and without wastewater treatment, maps of impervious areas, and census data. Statistical analyses were performed to characterize land areas being modeled, and used to identify trends and relationships useful in modeling and development of achievable wasteload allocations. Seasonal trends were identified and taken into consideration in the TMDL development. In addition, performance of statistical analyses explored the relationships between monitored variables. These analyses aided in evaluating pollution control strategies (MapTech 1999).

Bacterial Source Tracking (BST) results identified specific pollutant sources in the basin such as human, livestock and wildlife. Six point sources in the Blackwater River watershed include discharges from public wastewater treatment facilities, nursing homes, car dealerships, etc. Nonpoint sources include wildlife, grazing livestock, and land application of manure, urban runoff, failed septic systems, and uncontrolled discharges such as dairy parlor waste. Information from the BST provides insight into the likely sources of fecal contamination, and improves the chances of success in implementing solutions (MapTech 1999). Sampling results are presented as the percentage of isolates (colonies taken from membrane filtration plates) acquired from the sample that were identified as originating from either human, livestock, or wildlife sources (Figure 5-5) (Maptech 2000). The dotted line down the center of the figure is the 1000 cfu/100 mL instantaneous standard. The representative symbols to the right of the line are the isolates above the standard identified by source.

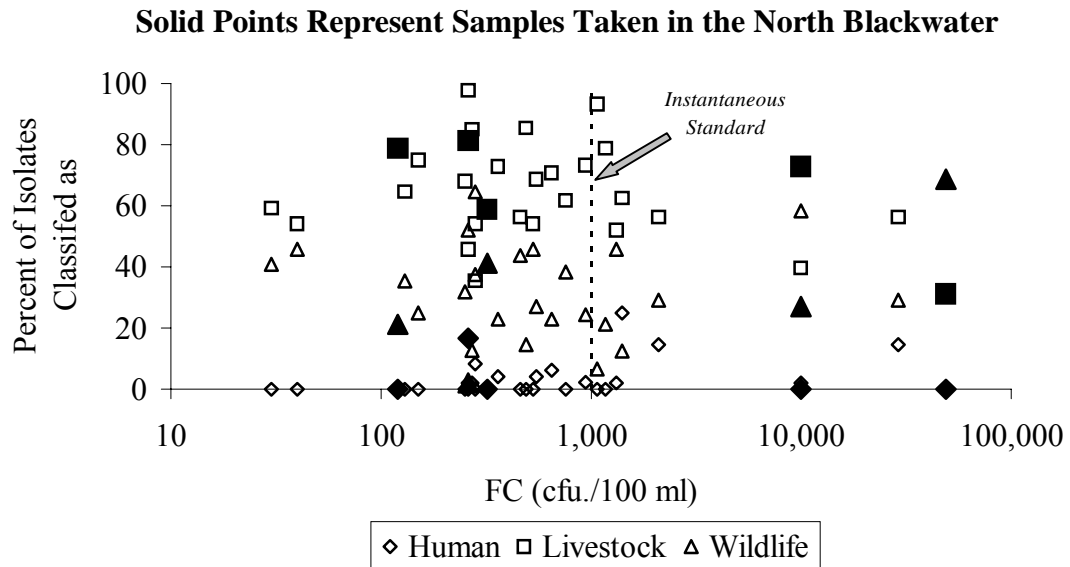


Figure 5-5. Results of Fecal Coliform Concentrations and BST analysis from for impairments within the Blackwater River Basin (MapTech 2000).

5.2.4. Allocations

Upon determination of the watershed’s existing conditions, several scenarios were developed to address reduction in loads from the various sources to achieve the water quality standard. The commonwealth of Virginia allows 0% exceedance of the standard. Using the Upper Blackwater for example, the final load allocation scenario required 100% reduction in uncontrolled discharges (i.e. straight pipes), a 100% reduction in direct deposition to the stream by livestock, and 75% reduction of direct deposition by wildlife (MapTech 1999). Further data for the Blackwater subbasins can be found in Section 6.

The TMDL provides a starting point for water pollution reduction. To meet the allocations, the state of Virginia allows for a phased implementation. It is of the utmost

importance to first rally local support and input from stakeholders in the development of an implementation plan. Again using the Upper Blackwater as an example, the scenario developed for the first phase of implementation included a 50% reduction in failed septic systems, a conversion of 50% of poor pasture to good pasture, a 100% reduction in uncontrolled discharges, a 90% reduction in direct deposition to streams by livestock, and a 20% reduction in direct deposition by wildlife. Continual water quality monitoring remains necessary to gage the effectiveness of the implementation plan, to make amendments to the plan if necessary to meet the standards and to gain removal of the waterbody from the 303(d) list (MapTech 1999).

5.2.5. Summary of Approaches

Virginia and Kansas are both racing against time in order to meet the consent decrees. In both states, finding funding for TMDL development and implementation is a challenge, they face similar sources of pollution, and both serve a variety of stakeholders whose lives are affected by the development outcome.

EPA requires problem identification of water quality indicators and targets, source assessment, linkage between water quality and sources and allocations (EPA 2001). Both states use whatever water quality data found available from monitoring agencies. However, Kansas uses the simpler spreadsheet method of Flow Duration Curves for the TMDL. The method considers flow and water quality data. Development of load curves for bacteria per day is achieved through multiplying the flow values along the curve by the water quality criterion. Wherever bacteria data points fall below the load curve, water quality standards are met. Specific sources of bacterial contamination cannot be identified by FD. It is assumed that wasteload allocations correspond with the flow condition. Therefore, nonpoint sources were determined to be a significant problem in the Marais des Cygnes River Basin.

Contractors modeled the Blackwater River Watershed using HSPF. The model characterized linkages between measured in-stream water quality and hydrology, upstream landuse, land management practices, landcover and pollutant loadings. The model also accounts for seasonal variation, landcover, and pollutant contributions. With the modeling package, GIS datalayers and tabular datasets compatible with Arc View

were generated. Statistical analyses characterized land areas, and identified trends and relationships useful for modeling. Seasonal trends were identified and taken into consideration. Bacterial Source Tracking analysis identified specific pollutant sources. Upon completion of the modeling for existing conditions, several different load allocation scenarios were developed to meet the water quality standards.

Clearly the FD method of TMDL development is cheaper and faster to complete. It saves states time, money and serves as a way to meet the consent decrees. However, the method does not model the watershed conditions or pollutant transport mechanisms. Landuse, specific sources, hydrology, soils, topography, or expected growth for an area are not considered in the method.

Modeling with HSPF incorporates flow, water quality data, landuse, hydrology, soils, typography, etc. The model has a long record of use and respect. HSPF provides for detailed representation of a watershed and allows for consideration of seasonality and pollutant transport mechanisms. The modeling method appears unattractive because it requires experienced modelers and varying time constraints in collecting the data, model calibration and running the allocations. However if HSPF modeling is done in place of FD for the TMDL development then the modeling process during the implementation phase is greatly reduced and therefore the overall cost will also be reduced (McClellan, personal communication, 2003).

Common practice for the agencies involved in the TMDL development program involve water monitoring, impairment list preparation, contractor solicitation or modeling in-house then after the initial modeling, contact the citizen stakeholders. The evaluation of public participation for both states falls somewhere within the rungs of consultation and placation. Rather than the primary stakeholders being involved from the beginning of the process they are separated from the issue by the administrators and process. See Section 9 for recommendations concerning the participatory process.

Now that Flow Duration and HSPF modeling in the role of TMDL development has been addressed, questions remain. The previous sections introduced the programs in two different states, using two different methods of development in two different, albeit similar watersheds. The following section examines results of the two methods in the same watershed.

6. Comparison of Results of the HSPF modeling and the Flow Duration method in the Blackwater River watershed.

In order to find a “cheaper, better, faster” (FD/BST) method of developing TMDLs, Virginia’s Department of Environmental Quality set in motion the utilization of Flow Duration coupled with Bacterial Source Tracking (VADEQ 2002). Calculation of BST distribution for the target station (the percentage contributed by livestock, human, and wildlife), provides greater specificity for current conditions and allocations. The two methods, FD/BST and HSPF yielded different allocations and load reductions required to meet the state’s water quality standard. Sections 6.1 through 6.5 show the comparative results.

6.1. Comparative Results for the Blackwater River

At first glance, results using both methods seem comparable. For example in the North Fork of the Blackwater River the existing HSPF model requires on average a 99% reduction in specific sources and FD/BST requires a 98% reduction. Upon closer examination, however, the current HSPF model requires on average a 99% reduction of 6.66×10^{11} cfu’s however FD/BST requires a 98% reduction of 8.55×10^{12} for the North Fork. In other words, the FD/BST calculation for reductions needed to meet the standard reach an order of magnitude greater than those required by the HSPF model (Tables 6-1, 6-2).

Table 6-1 Allocated total load in cfu/day for each method.

| Impairment | HSPF | FD/BST |
|------------------------------------|-------------|---------------|
| South Fork Blackwater River | 1.05E+12 | 2.69E+11 |
| North Fork Blackwater River | 2.54E+12 | 1.79E+11 |
| Upper Blackwater River | 5.23E+12 | 8.08E+11 |
| Middle Blackwater River | 6.08E+12 | 1.64E+12 |

Source: VADCRDSWCS 2001

Table 6-2. Reductions required in cfu/day for each method.

| Segment | HSPF | FD/BST |
|------------------------------------|-------------|---------------|
| South Fork Blackwater River | 4.82E+11 | 4.84E+12 |
| North Fork Blackwater River | 6.66E+11 | 8.55E+12 |
| Upper Blackwater River | 1.07E+12 | 1.92E+13 |
| Middle Blackwater River | 2.03E+12 | 1.15E+13 |

Source: VADCRDSWCS 2001

South Fork Blackwater River

According to the comparison, the HSPF model identifies the critical conditions as occurring June through September. However the FD/BST method identifies the critical condition as October. Results indicate that the FD/BST TMDL requires about 10 times more reductions to meet the water quality standard than the HSPF method requires (Figure 6-1).

North Fork Blackwater River

For the North Fork impairment, the HSPF model identifies the critical conditions as occurring June through September. However the FD/BST method identifies the critical condition as September. Results show that the FD/BST TMDL requires approximately 13 times more reductions to meet the water quality standard than the HSPF model requires (Figure 6-2).

Upper Blackwater River

According to the HSPF model critical conditions for the Upper Blackwater River occur June through September, however the FD/BST method identifies the critical condition as occurring in September. Results indicate that the FD/BST TMDL requires about 18 times more reductions to meet the water quality standard than the HSPF method requires (Figure 6-3).

Middle Blackwater River

For the Middle Blackwater impairment, the HSPF model identified critical conditions as occurring June through September, however the FD/BST method identifies the critical condition as occurring in July. Results show that the FD/BST TMDL requires about 6 times more reductions to meet the water quality standard than the HSPF method requires (Figure 6-4).

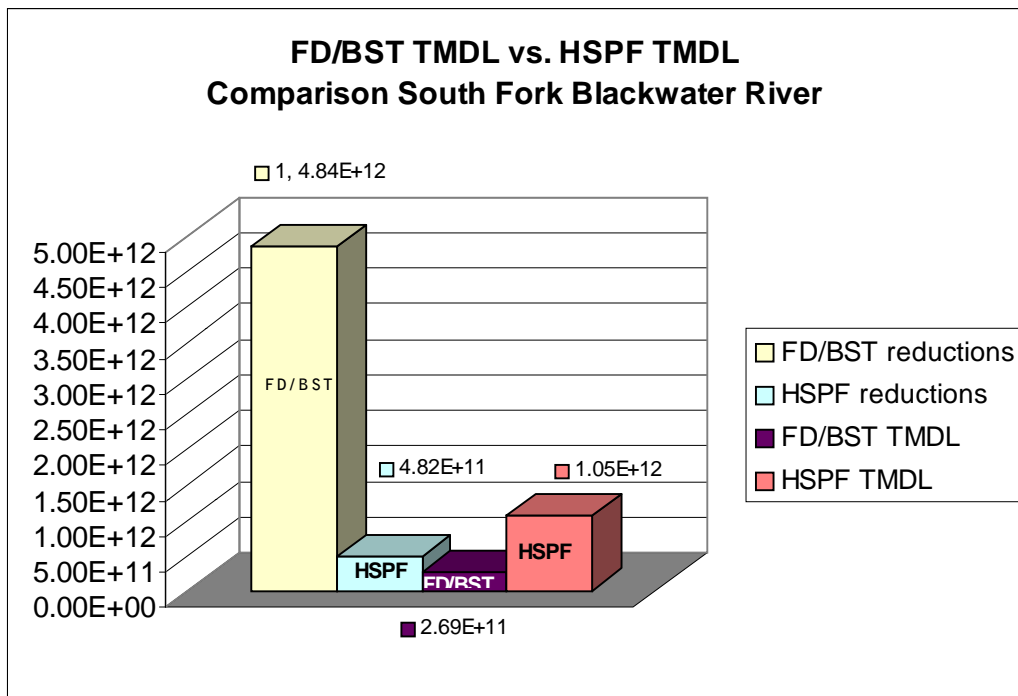


Figure 6-1. Comparison of the FD and HSPF method in the South Fork Blackwater (VADCRDSWCS 2001).

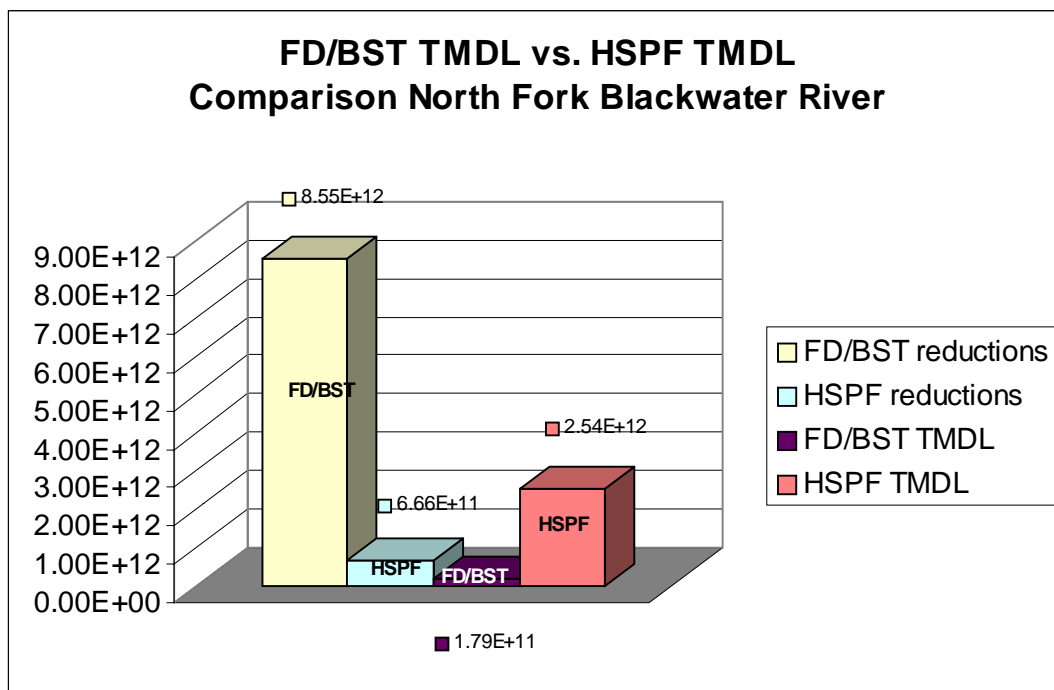


Figure 6-2. Comparison of the FD and HSPF method in the North Fork Blackwater (VADCRDSWCS 2001).

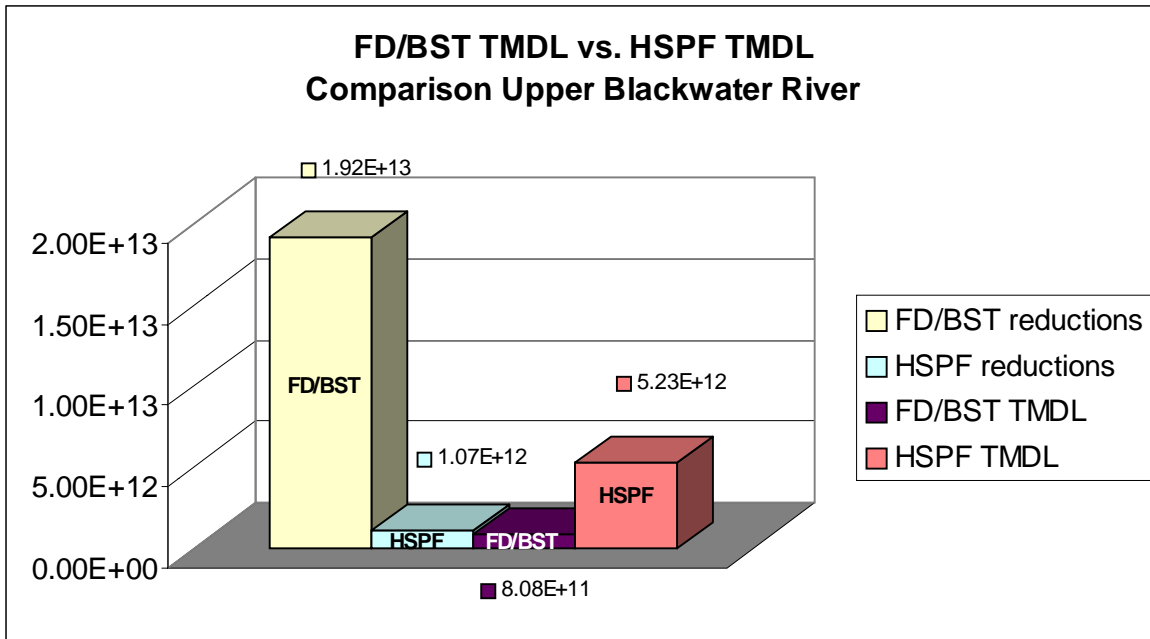


Figure 6-3. Comparison of the FD and HSPF method in the Upper Blackwater River (VADCRDSWCS 2001).

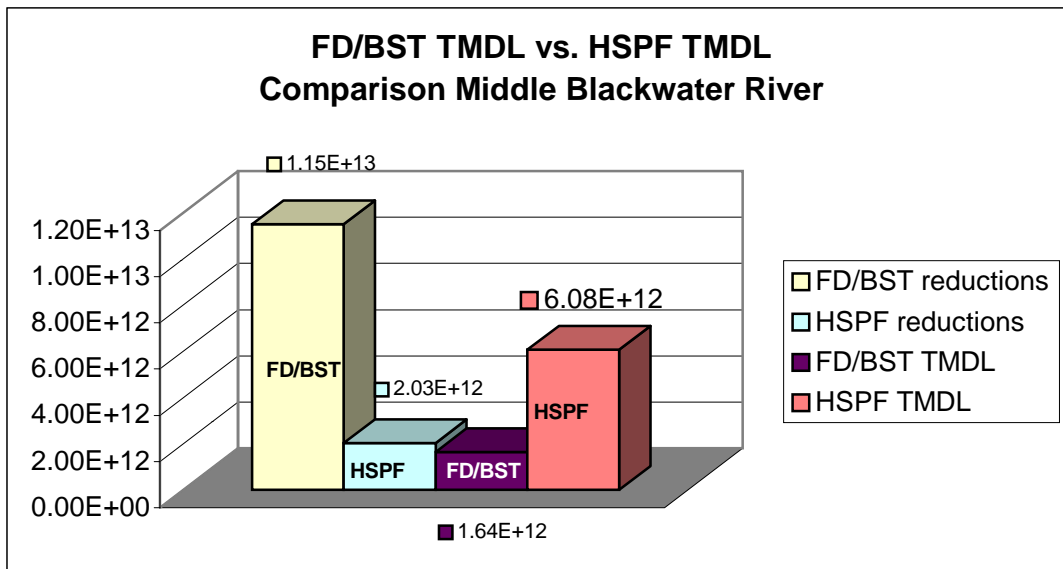


Figure 6-4. Comparison of the FD and HSPF method in the Middle Blackwater River (VADCRDSWCS 2001).

In summary, the FD/BST method derived different critical condition dates in half of these segments (South Fork and Upper Black Water River). The HSPF model reviewed approximately 20 years of weather and flow data to determine the critical condition as low flows between the months of June and September.

FD/BST requires between five to eighteen times greater reductions in loadings to the in-stream fecal coliform load than the current HSPF method for all 4 impaired segments compared in the Blackwater River Basin. In-stream loadings include directly deposited and NPS land load contributions. Table 6-3 presents comparison data for the existing and allowable loading (LA) from a single source (livestock direct deposition) and does not reflect the actual loadings or reductions required by the EPA approved TMDLs to the existing in-stream fecal bacteria load. Table 6-4 presents the actual loadings and reductions from the approved TMDLs. The overall daily reduction to the existing in-stream bacteria load as determined for these four river segments by the HSPF model and EPA approved TMDL average 24 percent. The overall average daily reduction that would have been determined for these four river segments using the VADEQ FD/BST method is 94 percent or 71 percent greater reductions (VADCRSWCD 2001).

Table 6-3. VADEQ livestock loadings and reductions (VADEQ 2002).

| | Total Actual Load | Total LA | % reduced |
|----------------|--------------------------|-----------------|------------------|
| | cfu/day | cfu/day | |
| S. Fork | 4.71E+11 | 3.67E+09 | 99% |
| N. Fork | 7.15E+11 | 2.55E+09 | 99% |
| Upper | 1.05E+12 | 3.12E+09 | 99% |
| Middle | 1.98E+12 | 1.67E+10 | 99% |

Table 6-4. Actual total Loadings and reductions from approved TMDLs (VADEQ 2002).

| | Total Actual Load | Total LA | % reduced |
|----------------|--------------------------|-----------------|------------------|
| | cfu/day | cfu/day | |
| S. Fork | 1.53E+12 | 1.05E+12 | 31.4% |
| N. Fork | 3.21E+12 | 2.54E+12 | 20.9% |
| Upper | 6.30E+12 | 5.23E+12 | 16.9% |
| Middle | 8.11E+12 | 6.08E+12 | 25.0% |

6.2. Where would the required reductions come from?

Allocations and reductions generated by different methods forecast dire effects for stakeholders. Take for instance the agricultural community for the North Fork Black Water River impairment. The actual calculated directly deposited load from livestock (cattle defecating in a stream) accounts for only 19 % of the FD/BST livestock in stream loadings for the North Fork Black Water River. Therefore the remaining approximate 79% of the loading from livestock would have to come from other livestock sources (total NPS land load). In other words, meeting the standard would prohibit spreading of animal waste on crops and possibly eliminate grazing animals from pastures. The HSPF loading accounts for only 0.47% of the FD/BST in stream load attributed to human sources. The remaining 98% reductions would have to come from all other human sources (total NPS land load) such as the land application of class B biosolids. The FD/BST method fails to provide sufficient evidence for initiating the measures needed to meet the load reductions considering that the majority of the loadings cannot be accounted for by direct deposition from this source. As far as the Blackwater River, the reductions required by the FD/BST TMDL method could be achieved through regulatory action only, enforced by state regulatory agencies.

The implications of the FD/BST TMDL method and resulting reduction requirements on any permits issued by Virginia regulatory agencies (e.g. state Water Control Board) appear potentially very significant. EPA's current position on storm water discharge limits requires point source permits be reviewed in context of the TMDL loading reductions which could potentially result in dramatic effects on permit holders. For example, an industry or wastewater treatment plant would not be granted an expansion if the allowable load was already met.

Wildlife sources in stream loadings from FD/BST is $3.09E+12$ cfu/day, whereas the HSPF method determined on average that the direct load from this source was $6.36E+09$ cfu/day (MapTech 2000) or 0.21% of the FD/BST load from this source. The remaining approximate 98% of the wildlife load reduction would have to come from sources other than direct deposition from wildlife (VADCRSWCD 2001). These reductions from the land loadings require virtually all land based loadings be eliminated in order to meet the FD/BST TMDL requirements.

Additional comparison of the two methods by VADCRSWCD encompassed 38 EPA approved TMDLs developed through the 2002 cycle in Virginia. The study revealed on average 38% reduction requirement from the HSPF model as opposed to 88% by the FD method.

Allocation corresponds to reduction. Therefore considerably greater reductions in the load allow for much smaller allocations per source (VADSWC, personal communication, 2003).

Even though the FD/BST method of TMDL development appears cheaper and faster, additional modeling will most likely have to be done during the development of implementation plans (Stiles 2003). In this case, the TMDL development and implementation total cost rises. Projected cost for implementation of the modeled reductions for the North Fork Blackwater River Watershed total \$1.43 million over 10 years. Preliminary estimates suggest that at least 12 times that amount or approximately \$18 million would be required to implement the FD/BST reductions (VADCRSWCD 2001).

6.3. The Application of Bacterial Source Tracking

Advantage to using Bacterial Source Tracking exists in targeting specific sources in specific areas. When used with HSPF modeling BST serves as a validation for the modeling results. Bacterial Source Tracking allows agencies to target sources and direct funding to the most serious problems. The amount that BST enhances the FD method of TMDL development remains to be seen. Seasonality cannot be addressed reliably with only monthly sampling over a 1-year period. Pollutant loadings and flow regimes are determined with long term monitoring (5 to 10 years) and/or simulation with modeling such as HSPF. Consideration should also be given to the monitoring program itself. What about the proximity effect that nearby sources of a pollutant has on the monitoring results? The number of stream miles any single BST monitoring station can describe remain unknown. The masking effect from nearby sources could give a false indication of what is occurring in a watershed. Relatively new to the TMDL process, BST best provides verification for modeling assumptions or to direct appropriate BMP installation (VADCRSWCD 2001).

7. Citizen Involvement

“Participation is a categorical term for citizen power. It is the redistribution of power that enables the have-not citizens, presently excluded from the political and economic processes, to be deliberately included in the future” (Arnstein 1969. p. 216).

Arnstein describes degrees of citizen involvement in terms of rungs on a ladder (Figure 7-1) Levels one and two have no real plan to allow stakeholder participation in planning or conducting the program. These participation methods allow the powerholders to “educate” or “cure” the participants. Levels three, four and five represent levels of tokenism as informing, consultation and placation. Modes of informing and consultation involve stakeholders being informed in which citizens are allowed to express themselves. However citizens do not possess the power to ensure that their views are heeded by agencies in power. The level placation allows citizen stakeholders to advise but leaves the agencies the power of final decision. The rungs of the ladder represent degrees of citizen power. These topmost rungs include partnership, delegated power, and citizen control. Citizen power allows public participation in which citizens negotiate with the agencies to make decisions. Rung six, partnership, empowers the stakeholders with the ability to negotiate with the powerholders. The two top rungs of the Arnstein’s ladder delegated power and citizen control place citizens in full managerial power.

Citizen involvement in the TMDL process can be described using Arnstein’s (1969) ladder of citizen participation. According to VADEQ’s policy on public participation, a notice of the beginning of TMDL development is placed in the Virginia Registrar and local newspapers. A variety of political agencies and stakeholder groups may be notified and at least two public meetings are held. Initially, VADEQ monitors the water, puts impaired waters on the list, prioritizes the list, and schedules the TMDL to be developed as required. Selection of a contractor, acquisition of the necessary data, and public notification follow.

During the development phase there is a series of public meetings for public input. The VADEQ describes public participation as “crucial” and beginning shortly after the project starts (VADEQ 2001). Citizens may be allowed to express themselves but there is no guarantee that the government agency will make any changes based on citizen input. On Arnstein’s ladder

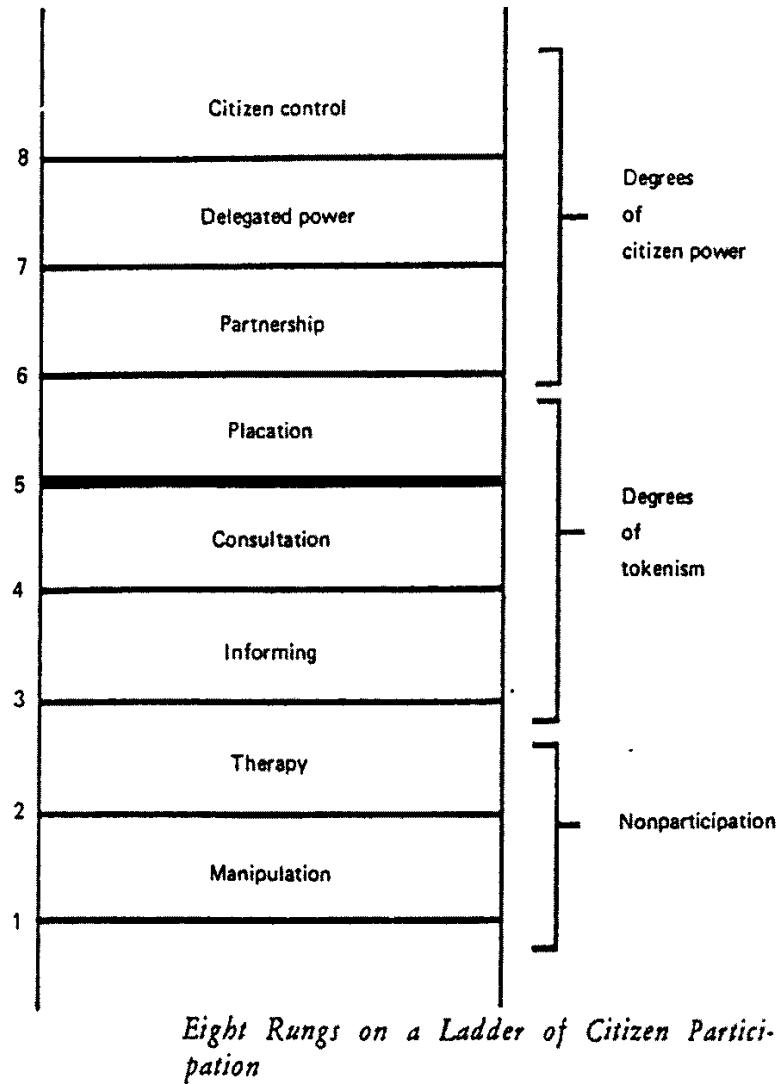


Figure 7-1. Arnstein's Ladder of Citizen Participation (Arnstein 1969).

of participation, Virginia's public participation policy would fall between consultation and placation (Figure 7-1).

The Kansas process of participation incorporates the meeting and input of several agencies such as the Bureau of Water , Bureau of Environmental Field services, Kansas Water Office, Kansas Water Authority and the Kansas Water Plan. Relying significantly on the Kansas Water Planning process KDHE engineers opportunities for agency, interest group, and public input. Public meetings are held and citizen comments are taken under consideration. Each river basin has a Basin Advisory Committee (BAC) to assess the needs for each river basin. The BAC passes its recommendations to the Kansas Water Authority which are considered in the implementation of the TMDL. If approved by the Authority, it becomes a part of the Kansas Water Plan. As with the TMDL development process in Virginia, Kansas citizens do not possess a great amount of power in the decision making process. Again, using Arstein's ladder (1969), the level of citizen participatory power would fall within the degrees of tokenism (Figure 7-1) somewhere between consultation and placation. Their voices are heard but the ultimate decision is left in the hands of the agencies in power.

Giving citizen stakeholders full managerial control in the TMDL program would be unfair to all other stakeholders. However citizen stakeholder participation in the TMDL program can be improved. In a case study to improve stakeholder participation in the TMDL process, Downstream Strategies, the Canaan Valley Institute, EPA and others formed a stakeholder group for the development of the Cheat River TMDL to better understand ways to communicate with and motivate stakeholders. In addition to EPA's required public meetings, stakeholders held twelve other meetings. The stakeholder group involvement started from the beginning of the process with collecting local data for contractors. It is unrealistic to expect most citizens to be trained in modeling watershed processes but the contractor/agency should be able to present the modeling in a manner that can be understood by others. Stakeholders of the Cheat River watershed observed the modeling process and were able to assess the model and make suggestions for improvement (Hansen, 2001). Watershed residents show capability of understanding the modeling process and should be included in model selection.

Though most people possess little or no experience with models, citizens understand what modeling results can mean for each individual. The Cheat River study found communication to be one of the major problems between contractors/agencies and stakeholders. Citizens realize

that the modeling results may cause stricter rules and regulations from these agencies and thus express skepticism of models (Cleland, 2003). This citizen mistrust, in turn, makes it difficult for modelers to get accurate data in a timely fashion for the modeling work. For example, a farmer does not want to disclose livestock numbers for fear of stricter regulation from the government. Refusal to give accurate numbers forces TMDL developers to use estimates. Typically state estimated numbers in Virginia range tend to exceed actual or are inaccurate. For example, according to state agency estimates the number of dairy cattle in the Dry River impairment of the North River Watershed totaled 15,578 head, upon consultation with stakeholders that number was dropped to 6,970 (BSE et al. 2000). The reason for inaccuracy lies in the initial agricultural surveys and the time lapse wherein the data is compiled and published.

Communication builds a trusting relationship between all the stakeholders and the success of the TMDL program hinges on trust. The stakeholders of the Cheat study also recommended that agency staff should (Hansen, 2001):

- Calm stakeholder concerns about the model calibration process by clear communication. Stakeholders, excluded from the calibration information expressed suspicion that parameters may have been adjusted so that model validity might have been compromised. The modeler should explain in the TMDL report why the model is believed to be the most appropriate for the job and why the model was believed calibrated accurately.
- Show the existing load and reduction requirements in the TMDL document in order for stakeholders to assess the load allocations and understand the resulting implications. Without this information stakeholders cannot participate meaningfully.
- Use well thought out graphs and tables to communicate existing loads and necessary reductions with stakeholders rather than using complicated model output.
- Document and justify the use of non-local data.
- Clearly explain point source concentration output and how these apply to permit limits.
- Address trading programs if applicable.
- Promote transparency in models and make a greater effort to communicate assumptions and results.

The Cheat River study served to improve stakeholder participation/communication in the TMDL process in West Virginia. Some argue that soliciting public participation is too time consuming and expensive and that some groups cannot handle the responsibility. However there is an array of benefits such as increase in efficiency and effectiveness, capacity building and promotion of ownership (Carmin 2001). In addition public agencies that actively solicit public participation foster positive public relations, public trust and support, greater ability to deal with contingencies and angry citizens, and heightened citizen interest. This approach avoids costly delays and impending lawsuits while increasing overall success (Lindstrom and Nie 2000).

Although evolution of citizen involvement in the TMDL process may not reach the level of total partnership, the program already possesses some partnership qualities by the presentation of data from agencies to the stakeholder for stakeholder comments. By initiating the recommendations from the Cheat River Study, the program graduates beyond just consultation/placation progressing toward partnership. Constraints of the program include cost, expertise and time. Building trust by open and honest communication will promote accurate, timely data acquisition. Accurate data from the beginning saves time and money for the contractor and the state agencies by avoiding remodeling a watershed. A re-appropriation of time spent may save time and money in the overall process. For example, a good effort to convene stakeholders for a meeting explaining the modeling process before the modeling is done will foster trust between stakeholders and give citizen stakeholders a greater feeling of ownership for the project. Trust will also help in obtaining accurate data, which will improve the validity and efficiency of the TMDL modeling process have greater validation, progress quicker and thus save money. Upon this accomplishment, official public meetings could possibly be fewer and less combative. With this relationship already in place, implementation of the TMDL should be much smoother which would again, save time and money.

8. Conclusions

Provisions of the Clean Water Act concerning nonpoint source pollution have been for the most part ignored since its inception. Decline in water quality threatens communities throughout the world. Approximately 33% of the nation's water bodies were assessed for the 2002 305(b) report. Of that, results showed 40% of streams, 45% of lakes, and 50% of estuaries impaired. Citizen and small interest group litigation prompting the EPA and the states to address the statutes of the CWA serves as the driving force behind the TMDL development program. However, with states setting their own water quality standards (beyond the minimum required in the CWA), including evaluation criteria, monitoring, recordkeeping, and TMDL development methods, the future water quality of the nation remains uncertain. Certainly the accuracy of watershed/river basin representation and stakeholder involvement remain of major importance to the success of the TMDL program.

Responsibility for TMDL development in Kansas falls upon the Kansas Department of Health and Environment. In the search for a cheaper, faster method of developing TMDLs, Kansas pioneered the Flow Duration (FD). The simple, quick and inexpensive method provides an attractive option for calculating TMDLs. Graphics from FD and the steps of the process are easier for individuals with modeling skills to comprehend. Flow duration provides a suitable method of screening (Cleland 2002).

Flow Duration meets criteria for a simple method of analysis. A simple method, according to EPA provides "only rough estimates of pollutant loadings and has very limited predictive capability" and "limited transferability to other regions" (Shoemaker et al. 1997. p 10). KDHE intends to utilize FD for TMDL development, meet the consent decrees and then perform whatever modeling necessary to meet water quality standard. To meet water quality standards empirical data will have to be collected and either intensive sampling to try and trace where the major sources of pollution are coming from or more detailed. FD serves well as an instrument for screening, offering an economical, quick picture of overall watershed conditions. Screening methods provide assessments from rough estimates and limited detail. This method could be well used in initial watershed assessments for water quality and general pollutant sources. However,

because of the greater requirements of FD in load reductions, the method may not be a good tool to use alone in TMDL development. The key differences in the methods hinges on the capability of the HSPF method to allocate loads to specific sources and consider pollutant transport mechanisms, whereas, the FD/BST method does not accurately address either. The consequence of the resulting TMDL analyses revolves around how the TMDL will be used. Assuming the TMDL loads and reductions have legal grounds, the calculated load reductions will have to be adhered to and subject to regulation. If the TMDL, for example, requires reductions 10 times greater than necessary, will the total reductions be enforced or just the reductions necessary to meet the standard? Most stakeholders express uncertainty. If the FD/BST inflated reductions and allocations are enforced, some stakeholders may even be forced out of business. This magnifies the importance of stakeholder awareness of the methodology, and possible ramifications of a TMDL.

Stakeholder participation in Kansas falls between consultation and placation. Watershed and agency groups join together to make decisions as watershed representatives but the citizen public review comes later in the process. Citizen stakeholders take part in consultation however, the final say remains with the government agencies.

Virginia's TMDL program began with VADEQ as the lead agency initiated by VADCRSWCD in conjunction with, DMME and VDH. These agencies hired contractors who used HSPF modeling for TMDL Development. With the push of consent decrees and program expense VADEQ currently considers changing the TMDL development method from modeling with HSPF to using FD/BST (see Table 7-1 for a summary of the models). Unlike Kansas plans for modeling load allocations for the implementation phase, no modeling currently appears in the plan for Virginia's program.

With the Controversy over modeling methods for the TMDL program in Virginia VADCR and the VADEQ dissolved their partnership. VADEQ controls the decisions to develop fecal coliform TMDLs in-house or hire contractors. Stakeholders should be aware that with this change, Virginia's TMDL program is completely in the hands of regulatory agencies. Comparison studies of the FD method and modeling with HSPF show a magnitude of difference in the load reduction requirements. VADCR remains

concerned for stakeholders due to the escalating cost of implementation from using the FD method and the staggering affect the increase in load reductions may have on citizen stakeholders. After TMDL acceptance by EPA in order for the implementation plan to be developed for accurate load reduction distribution, the watershed if not “modeled” during the TMDL development, will have to be modeled during the implementation phase (McClellan, personal communication 2002).

Table 8-1. Comparison of Flow Duration and HSPF modeling.

| Criteria | Flow Duration | Flow Duration/BST | HSPF |
|--|-----------------------------|--|--|
| Type | Simple Spreadsheet | Simple Spreadsheet | Detailed Modeling |
| Cost of TMDL development | Low | Low to Medium | Medium to High |
| TMDL application | Screening | Screening | Complex modeling |
| Watershed representation | Low | Low to medium | High |
| Comprehension of steps of analyses by stakeholders | High | High | Low to Medium |
| Primary Function | Describe overall conditions | Describe overall conditions and source identification (human, wildlife, livestock) | Model existing conditions and identify problems and causes |
| Modeling capabilities | Low | Low | High |
| Historic usage and reliability for watershed representation | Low | Low | High |
| Reductions | High | Low | Low |
| Allocations | Low | Low | High |
| Cost to stakeholders | High | Medium | Medium to Low |
| Possibility of meeting the TMDL requirements | Low | Low | Medium to High |

Even though the FD method appears simpler, cheaper and easier to use for TMDL development the magnitude of difference in TMDL reductions will have a greater impact on stakeholders, may be much more difficult to implement, make water quality goals more difficult to attain and in the end, more costly to everyone. At a minimum, stakeholders should be made aware of the TMDL development methods and the consequences of each before a decision on a modeling approach is reached.

It cannot be stressed enough the need for more in-depth comparisons of the modeling methods currently considered by each state. Program responsibility for meeting the consent decrees resides with the agencies levying serious time restrictions for completing the TMDLs. Agencies have approached the participatory process by forming focus groups of other state agencies, and watershed groups.

To view the shortcomings of the participatory process as failure only on the part of the agencies constitutes unfairness. The participatory process proves as complex as the TMDL development itself. The process of public meetings with the administrator having control and the citizen functioning as the client stands as the norm.

Virginia records instances where attendees of the public meetings consisted mostly of agency persons and fewer than five actual watershed residents. Experience of program agency personnel should include getting to know the watershed before setting meeting dates and times. Care should be taken not to schedule meetings on nights of religious services, and avoid farming hours. In other words if the watershed consist mostly of dairy farmers, scheduling meetings during the time for evening milking reflects bad policy. Putting the announcement in the federal register and local paper serves a purpose of meeting agency requirements but falls short of encouraging citizen participation. Non-agency people seldom access the federal register and many do not get a local paper. Greater effort must be made, and in some instances has been made, to get meeting information in more accessible places such a grocery store and farm store bulletin boards, public service announcements, etc.

Stakeholders in Kansas and Virginia face the same issues of those in the Cheat River Watershed. Communication between all stakeholders reigns extremely important. Without that communication, and inclusion of citizens in choosing TMDL development methods, citizens hold no influence on the outcome and affects on their lives. Agencies are aware of the possible consequences (greater load reductions and greater expense to stakeholders) for watershed residents by changing TMDL development methods. However, the time constraint in meeting consent decrees outweighs the need to take the sensible approach to clean water and individual financial welfare. The administrating agencies need to step back, think about the TMDL development process, the results and implementation and the program affects for the future.

Concerned citizens need be informed and network their neighborhoods to assure everyone else is informed as well and have a voice in their futures. Good, solid information is important before taking a stand for or against the TMDL process and program. Stakeholder action without knowledge in some instances can make matters worse for themselves. For example, one of the most common complaints from non-

agency stakeholders revolved around use of fecal coliform for the water quality standard. Although not all fecal coliform bacteria are harmful, the bacteria have historically been used as an indicator of the presence of harmful pathogens. *E. coli* exist as a subset of fecal coliform. Virginia stakeholders argued and wrote letters to public officials complaining that the state of Virginia should be using *E. coli* bacteria as a water quality indicator instead of using fecal coliform bacteria. Studies indicate that most fecal coliform bacteria are *e. coli* (EPA 2000). In the Virginia study, all TMDLs through the 2002 cycle computed using *e. coli* with FD resulted in greater reductions than HSPF or FD with the old fecal coliform standard. Those opposed to the fecal coliform standard had little knowledge of pathogens and stood unaware that the promoted change in regulation would result in a stricter water quality standard. As of January 2003, the water quality standard required by Virginia changed from a fecal coliform standard to *e. coli*. That new standard states that *e.coli* bacteria shall not exceed a geometric mean of 126 bacteria per 100 mL of water for two or more samples over a calendar month nor shall a single sample taken in a month exceed 235 bacteria per 100 mL of water (VRR 2003).

Apparent from the Blackwater River comparison and other studies is that a change in TMDL development methods could have a huge impact on stakeholders' lives. Even though the collaborative efforts among some agency stakeholders are well organized, the inclusion of citizen stakeholders remains insufficient. In order for the TMDL program to be a success and provide good water quality for all, much work needs done. Program needs for a win-win situation include greater stakeholder involvement, sound decisions based on good science, and a better relationship between those administering the program. Studies show HSPF is more detailed and has better accuracy in watershed representation. Using HSPF for TMDL development will save from extensive modeling during implementation. The results from HSPF as an implementation guide are much less restrictive on stakeholders and less expensive for all stakeholders. It makes sense to utilize a method that will meet water quality goals with less impact on stakeholders. Given the information from Table 7-1 and the ability to choose a method for TMDL development, it is doubtful stakeholders other than a few agency people would choose FD method for TMDL development in their watershed.

9. Recommendations:

- Use flow duration as a screening method of analysis for obtaining rough estimates of watershed pollutants.
- Use more complex modeling such as HSPF in TMDL development to better represent watershed processes and yield more accurate allocations.
- Use detailed modeling such as HSPF for TMDL development to save time and money overall for TMDL development and implementation.
- Explain development methods to citizen stakeholders and seek their input.
- Establish honest, open communication between agencies and farmers to foster a trusting relationship which is crucial for successful implementation.
- Know the relevant customs/schedules of watershed residents for scheduling public meetings to make them more accessible.
- Exert greater effort to involve citizen stakeholders.

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- TMDL development for fecal coliform impairments in the North River, Rockingham County, Big Otter Creek, Bedford County, and Naked Creek, Augusta County, Virginia. Provided GIS analysis and public participation support for the development of nine fecal coliform TMDLs in these areas.
- Co-author of agricultural research surveys and research publications involving non-point source pollution.

- Project manager for the identification of confined animal sites for impaired watersheds in Virginia using GIS and remote sensing (priority given to units slated for TMDL development).
- Performed water quality monitoring.
- Created and implemented environmental education programs.
- Evaluated Richlands Regional wastewater treatment plant and lab to certify that plant operations remained in compliance with state and federal regulations.
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