ELECTRIC POWER RESEARCH INSTITUTE

TMDL Technical Evaluation Framework

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REPORT SUMMARY

Power generators may be significantly impacted by the Total Maximum Daily Load (TMDL) program. TMDLs are required by law to allow for public involvement and review. This report describes an approach to help guide electric power companies through the technical and strategic aspects of a TMDL review. The report will be valuable to electric power company environmental and planning staff.

Background

While the provision for TMDLs has existed in the Clean Water Act (CWA) since 1972, it was brought to the forefront through a series of citizen lawsuits in the 1980s and 1990s. The lawsuits forced states and the U.S. Environmental Protection Agency (U.S. EPA) to meet the CWA requirements. Specifically, they must list waterbodies that are not attaining designated uses (called the 303(d) list of impaired waterbodies) and develop maximum allowable loadings for those waterbodies necessary to meet designated uses. In many cases, aggressive schedules for development of TMDLs for those waterbodies also are required. Development of TMDLs is presently occurring on a widespread basis nationwide.

Objectives

- To identify concerns and needs of electric power companies with respect to the TMDL program.
- To illustrate how an electric power company may benefit from being involved in development and/or review of a TMDL.
- To develop a structured tool in the form of a step-by-step roadmap to help EPRI members navigate a TMDL review.
- To inform EPRI member companies on when and how to get involved with a TMDL development and/or review.
- To promote approaches for an objective TMDL review that focuses on the big picture, prioritizes efforts, and potentially saves time and money.
- To highlight lessons learned during development and review of previous TMDLs that are of interest to EPRI members.
- To direct EPRI members to references, reports, and guidance that may be useful to support a TMDL review.

Approach

Development of the TMDL technical evaluation framework presented in this report involved interviews with environmental staff of EPRI members, general TMDL guidelines research, creation of a TMDL review roadmap, and analysis of 30 existing TMDLs that are relevant to the electric power industry.

Results

A roadmap to technically review TMDLs is created and illustrated with analyses of existing TMDLs. The roadmap consists of six major steps that are divided into finer detailed activities. The six major steps address problem identification (defines nature of impairment); target selection (defines TMDL endpoints); source assessment (defines where loads are coming from); linkage analysis (relates loads to water quality targets); allocation (divides TMDL among sources); and implementation (proposes an action plan). The report identifies five emerging TMDL-related issues that are of significance to the electric power industry: air quality standards, nutrient criteria, climate variability, new contaminants of concern (for example, pharmaceuticals); and threatened or endangered species.

EPRI Perspective

TMDLs are playing an increasingly important role in establishing water-related regulations and policies. To date, regulators have concentrated on the easier TMDLs. In the future, it is anticipated that there will be a greater number of more difficult TMDLs, such as those where atmospheric deposition of nitrogen and mercury play a significant role. To maximize the likelihood that a TMDL outcome is based on sound science and is equitable for multiple parties, EPRI members should consider the following:

- Keep informed on upcoming TMDLs through regular review of the 305(b) and 303(d) lists.
- Become involved early. Waiting until the public comment period may result in missed opportunities to positively impact TMDL development.
- Know potential sources of pollutant within facility operations. Understand the challenges related to monitoring to verify impairment and characterize pollutant fate and transport through watershed and water quality models.
- Realize that although public participation is a TMDL requirement, it is not often encouraged. Be prepared to initiate participation with TMDL developers.
- Learn from other TMDLs. Seek out and/or join with other EPRI members to understand how best to positively influence the TMDL development process.
- Identify emerging issues and analyze their possible influence on current or potential TMDLs.

Keywords

TMDLs
Impairments
Stormwater
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Nitrogen
Thermal

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INTRODUCTION

Power generators are potentially impacted in significant ways by the Total Maximum Daily Load (TMDL) program. TMDLs are required by law to allow for public involvement and review. This report describes an approach to help guide electric utility companies through the technical and strategic aspects of a TMDL review.

1.1 Study Objectives

The research and recommendations described in this report were developed to address the following objectives:

- Identify the concerns and needs of electric utility companies with respect to the TMDL program;
- Illustrate how an electric utility may benefit from being involved in the development and/or review of a TMDL;
- Develop a structured tool in the form of a step-by-step roadmap to help EPRI members navigate a TMDL review;
- Inform EPRI member companies on when and how to get involved with a TMDL development and/or review;
- Promote approaches for an objective and focused TMDL review that focuses on the big picture, prioritizes efforts, and potentially saves time and money;
- Highlight lessons learned during the development and review of previous TMDLs, which are of interest to EPRI members; and
- Direct EPRI members to references, reports, and guidance that may be useful tools to support a TMDL review

1.2 Methods

Development of the TMDL technical evaluation framework presented in this report involved activities in the form of interviews, general TMDL guidelines research, development of a TMDL review roadmap, and case study research.

1.2.1 EPRI Member Interviews

Several members of EPRI's TMDL Program Steering Committee were interviewed to gain better understanding of the concerns and needs of electric utilities with respect to the TMDL program, identify any relevant case studies of past TMDLs and/or TMDL reviews, and solicit suggestions for useful elements of the final product presented here. These environmental compliance experts provided a balanced cross section of how concerns and challenges with respect to TMDLs may be similar or different across the country. Collectively the group represented electric utility operations within 23 states, primarily in the mid-West, southeast, and southwest regions of the country.

1.2.2 General TMDL Guidelines Research

A general research exercise was conducted to gather relevant reports and guidance documents related to TMDL development and review, which may serve as supplemental resources to this report. Materials reviewed include past EPRI reports and websites which relate to TMDL issues and TMDL pollutants of concern (e.g. mercury) as well as TMDL guidance documents, websites, and reports produced by U.S. EPA and the Water Environment Research Foundation (WERF). Also reviewed were TMDL review guidance or handbooks similar to this product which were developed for other industries who are considered to be TMDL stakeholders (e.g., drinking water utilities, wastewater utilities, home builders), and are also challenged to know how and when to get involved in TMDL development and/or review. A list of TMDL resources is provided at the end of this report (Appendix A).

1.2.3 TMDL Review Roadmap Development

A visual, decision-tree based roadmap was developed to inform electric utilities on the various steps of TMDL development and identify locations in the process where an electric utility stakeholder may benefit from involvement in the process. For each TMDL step, a set of key "questions to ask" was defined, along with potential courses of action that an electric utility may want to consider. The road map is visually presented within the report in three levels of detail ranging from a very high level figure, which provides an overview of the process, to more detailed decision tree flow charts of each step (Appendix B).

1.2.4 TMDL Case Study Research

Based on interviews and research, relevant case studies were identified. These case studies are intended to provide a cross section of examples that highlight aspects of the TMDL development and TMDL review process that may be of interest to the electric utility industry. Case studies were researched by reviewing TMDL reports and public comments, and where applicable, interviews were conducted with people familiar with the TMDL development and/or TMDL review. One or more unique aspects of how each TMDL or TMDL review are of interest to EPRI members in the context of the TMDL technical evaluation framework were identified (e.g., translation of narrative to numeric criteria, difficult quantification of background). Brief case study descriptions are included in appropriate report sections.

1.3 Overview of Report

Section 2 provides a general perspective of TMDLs and the electric power industry including background on the TMDL program, a discussion of the potential impacts of TMDLs on electric utilities, and the benefits, challenges, and methods for getting involved in TMDL development and review. Section 3 introduces the reader to a TMDL Review Roadmap, which is organized around the six major steps or components of a TMDL (problem identification, target selection, source assessment, linkage analysis, allocation, and implementation). Section 3 is then broken into six sub-sections, each highlighting a specific step of the TMDL development process and providing more detailed information in the form of questions to ask, suggested action alternatives, and supporting text. Figures that illustrate the process using a decision tree flow chart are also provided. A discussion of the issues to consider if a legal challenge to a TMDL is pursued is provided in Section 4, and Section 5 introduces the reader to the potential impacts of several emerging issues related to TMDLs and the electric power industry. Finally, Section 6 provides a summary and conclusions. Throughout the report, the reader will find a set of relevant TMDL case studies in shaded call out boxes.

2
TMDLS AND THE ELECTRIC POWER INDUSTRY

Total Maximum Daily Loads (TMDLs) are required under Section 303(d) of the Clean Water Act (CWA) for water bodies that do not attain water quality standards after technology-based pollution control requirements are applied. This chapter provides background on the TMDL program, including descriptions of the components of a TMDL, and a discussion of their relevance to the electric power industry.

2.1 History of TMDLs

While the provision for TMDLs has existed in the Clean Water Act (CWA) since 1972, it was brought to the forefront through a series of citizen lawsuits in the 1980s and 1990s. The lawsuits forced states and the U.S. Environmental Protection Agency (U.S. EPA) to meet the CWA requirements. Specifically, they must list water bodies that are not attaining water quality standards (called the 303(d) list of impaired water bodies), and develop maximum allowable loadings for those water bodies necessary to meet water quality objectives. In many cases, aggressive schedules for development of TMDLs for those water bodies are also required. The development of TMDLs is presently occurring on a widespread basis nationwide.

The TMDL program has come under considerable scrutiny and criticism. Some have argued that the program is long overdue, and demand aggressive schedules for TMDL development to conform with the law. Others have argued that the schedules are too aggressive, leading to poorly developed TMDLs based on insufficient data, poor science, and overly restrictive assumptions. Further, many have argued that the program fails to adequately address nonpoint source issues, and unrealistically focuses too heavily on point source controls; hence, ultimately the program will be ineffective in restoring designated uses. Overall, although the criticisms are many and diverse, most agree that significant improvements are needed in order to effectively use the TMDL program to help achieve the nation’s water quality goals.

Beyond U.S. EPA’s official regulatory functions, U.S. EPA has initiated numerous activities that support positive progress on TMDLs. These efforts have ranged from the issuance of guidance and protocols for the TMDL process, to convening a committee under the Federal Advisory Committee Act (FACA) to evaluate U.S. EPA and the states’ implementation of the TMDL program, to providing recommended improvements. The “FACA report” served as the basis for many of the provisions in U.S. EPA's new TMDL rules that were proposed in August 1999 and finalized in July 2000 [1]. Subsequent legislation prohibited U.S. EPA from spending funds in fiscal year 2000 or 2001 to implement the new rule, and the 2000 rules were ultimately rescinded in 2003. Therefore, the legal requirements for TMDL development that currently apply are those that were issued in 1985 and amended in 1992 (40 CFR Part 130, Section 130.7).

In 2002, U.S. EPA issued a report on research needs to improve the TMDL Process: "The Twenty Needs Report: How Research Can Improve the TMDL Program" [2]. The report focuses on science needs identified by the National Research Council, states and tribes, U.S. EPA National and Regional TMDL programs, and others. Several of the identified needs were addressed in part through a research project sponsored by the Water Environment Research Federation [3].

TMDL activities are now being conducted or planned in virtually all U.S. states and territories. According to the most recent U.S. EPA statistics, 35,647 TMDLs have been completed or are ongoing, addressing 38,318 causes of impairment [4]. The top three causes of impairment for 303(d) listed waters are pathogens, mercury, and metals (other than mercury).

2.2 Definition of a TMDL

The TMDL process establishes the allowable loading of pollutants for a waterbody based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL consists of wasteload allocations for point sources, and load allocations for nonpoint sources and natural background conditions. The TMDL also takes into account a margin of safety, which reflects the uncertainty in predicting how well pollutant reduction will result in meeting water quality standards. Therefore a TMDL is computed as follows:

$$TMDL = \Sigma WLA + \Sigma LA + MOS$$ **Equation 2-1**

Where

TMDL = Total Maximum Daily Load

WLA = Wasteload Allocation, given to each contributing point source

LA = Load Allocation, given to each contributing nonpoint source

MOS = Margin of Safety, to account for uncertainties in the analysis

The TMDL must also consider the effects of seasonal variation. By following the TMDL process, states can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality and designated uses of their water resources.

2.2.1 Overview of TMDL Components

TMDLs must be developed for all water bodies on the 303(d) list of impaired waters. TMDLs are typically developed by state agencies or U.S. EPA, and must ultimately be approved by U.S. EPA. In some cases, TMDLs, or portions of TMDLs, are developed by third parties under the oversight of the state agency or U.S. EPA. The TMDL development process typically includes the following distinct steps:

Problem Identification: This step is designed to provide a better understanding of the nature of the problem. Results from this step are used to verify that the water body of interest is impaired and that a TMDL is necessary. This is important to the electric power industry and others because it will prevent the investment of resources for TMDL development in a watershed that is not truly impaired.

Identification of Water Quality Indicators and Target Values: This step identifies specific measures that can be used to evaluate attainment of water quality standards and compliance with the TMDL. TMDL developers have wide latitude in selecting specific water quality conditions to represent the water quality standard, with potentially major ramifications on the degree of control needed. This step is of interest to the electric power industry because selection of an incorrect target may lead to overly restrictive permitting requirements.

Source Assessment: This step characterizes the types, magnitudes, and locations of sources of pollutant loading to the water body. The source assessment step is of interest to the electric power industry because it defines the magnitude of loading generated by all sources (including electric power plants), and ultimately affects the degree of controls that will be required.

Linkage between Water Quality Targets and Sources: This step defines the linkage between the selected water quality targets and the identified sources. It determines the maximum allowable loading (or total load reduction) needed to meet water quality targets. This step is of interest to the electric power industry because it defines the maximum allowable load that the water can receive. If the linkage analysis is not based on sound science, the outcome may be an incorrect and unrealistic allowable load.

Allocation: TMDLs are designed to consider all pollutant sources to a water body. The allocation step distributes total allowable loads among the various contributing point sources, nonpoint sources, and the Margin of Safety. The sum of the allowable point source loads in a TMDL is called the wasteload allocation; the sum of the allowable nonpoint source loads in a TMDL is called the load allocation. The allocation step is also required to account for uncertainties in the analyses through the use of a Margin of Safety. The allocation step is of interest to the electric power industry because it defines how much of the total allowable load is allocated to electric power-generating sources.

Implementation: Water quality standards cannot be attained without implementation of measures designed to attain them. Implementation plans are not a legal requirement, and many states do not require them. They are of interest to the electric power industry because they can provide clarity about what actions will be implemented, by whom, and in what time frame.

2.2.2 Eight Regulatory Requirements

TMDLs are based on analyses that range from simple to complex, depending on factors including the nature and severity of the impairment, data availability, and available resources. Some TMDLs rely on simple empirical methods to compute the allowable load, and others involve complex modeling and analysis. Regardless of the level of complexity of analysis, all TMDLs must address the following regulatory requirements:

1) Designed to result in compliance with applicable water quality standards;

2) Include a total allowable load as well as individual waste load allocations and load allocations;

3) Consider the impacts of background pollutant contributions;

4) Consider critical environmental conditions;

5) Consider seasonal environmental variations;

6) Include a margin of safety;

7) Provide reasonable assurance that the TMDLs can be met; and

8) Be subject to public participation.

These eight requirements typically serve as a "check list" for U.S. EPA when a TMDL is reviewed for approval. U.S. EPA's guidelines for reviewing TMDLs provide more information regarding these statutory and regulatory requirements, as well as other components of a TMDL [5]. Most of these eight U.S. EPA requirements fold into one or more of the typical TMDL steps which are described in Section 2.2.1 and further explored in the balance of this report. It is important to note, however, that the eighth requirement, public participation, could and ideally should occur throughout most of TMDL process. In reality, it usually doesn't occur until the end as a brief public comment period for a draft TMDL. The TMDL technical evaluation framework presented here is intended to help stakeholders, such as electric utilities, understand the benefits and challenges involved with an integrated approach for TMDL public participation.

2.3 Relevance of TMDLs to the Electric Power Industry

As described above, the TMDL program is a regulatory tool that has evolved over time. TMDLs will continue to be a major component of water quality management programs in the United States. Electric utilities are important members of the stakeholder community impacted by TMDLs. This section provides a discussion of why electric utilities should care about TMDLs in the context of pollutants of concern, potential pathways of pollutants from power generation facilities, and ways in which a TMDL may impact an electric utility.

2.3.1 Why Should Electric Utilities Care?

For an electric utility, the TMDL program may be thought of in terms of good news and bad news. The good news is that the TMDL program provides a rational method of setting discharge limits to meet water quality standards. The assimilative capacity of a waterbody is taken into consideration when deciding acceptable loading from point and nonpoint sources. It provides a potential mechanism for water quality improvement. However, the bad news is that a TMDL can often result in a tightening of discharge limits for point source dischargers, including electric utilities. Though TMDLs are intended to address both point and nonpoint loading, the Clean Water Act does not explicitly provide a regulatory control on nonpoint-source pollution. Therefore, in many watersheds, point sources continue to bear the burden of meeting revised standards in order to improve water quality in an impaired waterbody.

In 2002, EPRI conducted a review of the TMDL program [6]. This study summarized U.S. EPA's TMDL program, outlined potential impacts of TMDLs on the electric power industry, and identified research and other action needed to strengthen the TMDL program. TMDLs that considered atmospheric sources were identified as an evolving issue of particular interest to the electric power industry, and significant knowledge gaps about atmospheric deposition were noted. Mercury and nitrogen were identified as TMDL pollutants of high concern for electric utilities. Pollutant trading and phased TMDLs were noted to be viable (though not yet fully developed) approaches for TMDLs in many situations. The study also recognized that there is significant opportunity for stakeholders, such as electric utilities, to impact the TMDL process but that failure to get involved may result in a situation where utilities have little influence over resulting allocations.

EPRI has also recognized the relevance of TMDLs to electric utilities by providing its members with a web-based reference tool focused on watershed management and TMDLs [7]. The Electronic Watershed Assessment and Management Tool (eWAM) website (http://www.epri.com/ewam) provides a living resource to help electric utilities better understand and participate in these activities with information on the TMDL program, links to available guidance documents, and case studies of TMDLs that are relevant to electric power industry. The website also discusses modeling tools available for TMDL development, including those developed by EPRI (e.g. WARMF, D-MCM). The eWAM website also provides perspective on TMDL-related topics such as water quality trading, atmospheric deposition, surface water storage, and climate variability.

Since the 1990s U.S. EPA has encouraged the implementation of clean water programs (e.g., TMDL development, permitting) using a watershed approach rather than focusing on issues at an individual waterbody or discharger level. A watershed approach considers all sources impacting the watershed, provides the greatest level of flexibility in allocating loads, and encourages stakeholder participation. U.S. EPA has recently released a handbook for developing watershed TMDLs which discusses potential environmental, financial, and implementation benefits of watershed-based TMDLs [8]. It also describes a set of screening factors that can be used to determine the site-specific suitability of a watershed-based TMDL approach, taking into consideration pollutant type, waterbody type, and data quality. The Handbook highlights connections between watershed TMDLs and other water programs (e.g., watershed planning, permitting, and water quality trading), and identifies opportunities for integrating watershed TMDLs with other efforts.

TMDLs are being developed at an increasing pace. Figure 2-1 shows a plot of the number of TMDLs completed each year from 1996 to 2008. Note the numbers are not cumulative totals, rather discrete numbers for each year. The increasing trend illustrated in Figure 2-1 suggests that more TMDLs will be developed in future years. It is important for stakeholders, such as electric utilities, to be aware of TMDL development in their watersheds and get involved when appropriate. Supporting TMDL development by contributing reviews, data, and expertise can positively impact the TMDL outcome to be a water quality planning solution which provides benefits for multiple parties.

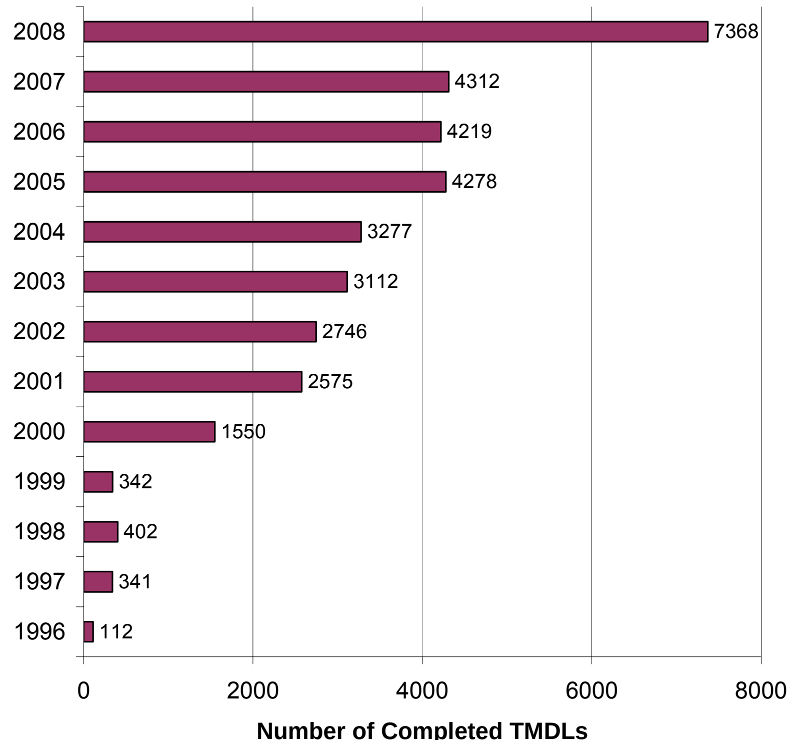


Figure 2-1
Number of completed TMDLs per year from 1996 to 2008. (information summarized from U.S. EPA [4])

2.3.2 What are the TMDL Pollutants of Concern for Electric Utilities?

U.S. EPA defines approximately 30 different TMDL pollutant groups and provides a ranking of the number of TMDLs developed for each group [9]. At the time of this writing, the top 12 pollutant groups with the most developed TMDLs are pathogens, mercury, metals (other than mercury), nutrients, sediment, organic enrichment/low dissolved oxygen, salinity/TDS/chlorides/sulfates, pH, temperature, and ammonia. Figure 2-2 provides a ranking of number of TMDLs for each pollutant group on a percentage basis.

Although a TMDL could potentially be developed for any pollutant which causes impairment, a subset of pollutants and related TMDLs are of most interest to electric power utilities. Interviews with members of EPRI's TMDL Program Advisory Committee identified a group of relevant TMDL pollutants, which are described below. For each pollutant, the impacts of the pollutant on the environment, sources of the pollutant from electric power utility operations, and specific challenges associated with the development TMDLs for that pollutant (e.g., criteria definition, monitoring, source characterization) are described.

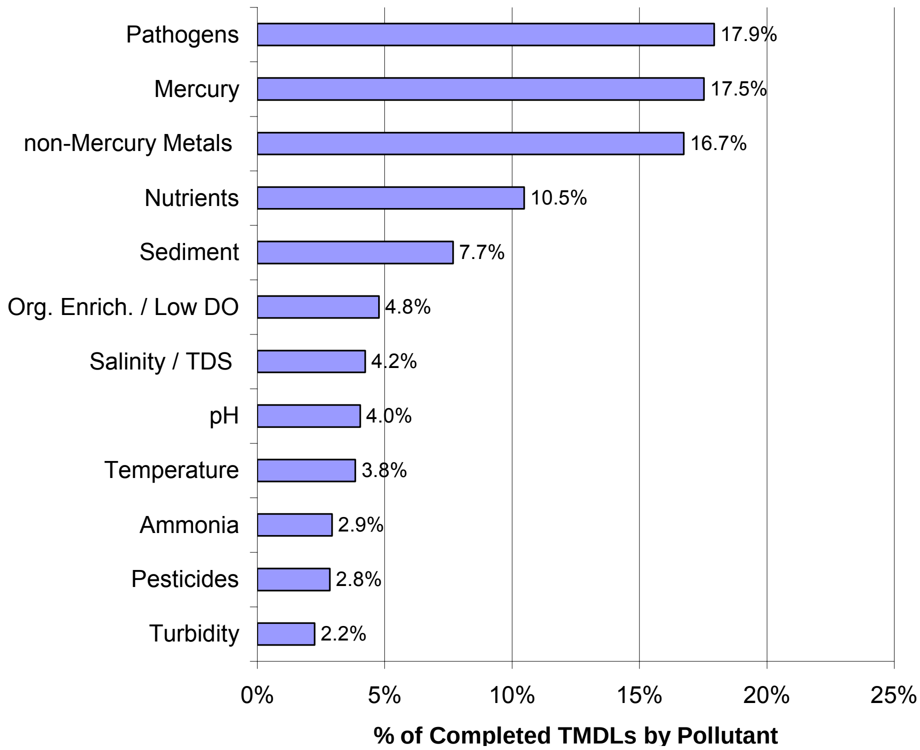


Figure 2-2
Percent of TMDLs developed for major pollutant groups. (information summarized from U.S. EPA [4])

2.3.2.1 Mercury

During the EPRI member interviews, the most commonly mentioned TMDL pollutant of concern was mercury. Mercury is a naturally occurring medium-weight metal found in a wide variety of rocks and minerals as either elemental or inorganic mercury. Inorganic mercury can be dissolved in waterways and converted by bacteria into an organic form called methylmercury. Methylmercury is bioavailable (i.e., easily taken up by organisms), can be consumed by aquatic and marine organisms, and has the potential to accumulate in fish and human tissues as it moves up the food chain [10]. The impact of mercury on the environment is typically noted as a public health concern. Methylmercury poisoning though consumption of contaminated food can impact the central nervous system (e.g;, vision, motor coordination) and creates a potential concern for development of young children and unborn babies [11]. Mercury contamination in a waterbody is typically noted through a fish consumption advisory, based on measurements of mercury of fish.

Mercury is of particular interest to electric utilities because the process of coal combustion creates the potential for mercury emissions to the atmosphere. U.S. EPA estimates that more than 40% of all domestic human-caused mercury emissions are due to coal-burning power plants [12]. However, only approximately 25% of these emissions are expected to deposit within the contiguous U.S., with the remainder entering the global cycle [12]. Global sources are significant; U.S. EPA estimates that U.S. sources of mercury emissions (power plants and others) account for less than half of the total deposition to the U.S. [12]. Science, data, and modeling are still emerging to help quantify the contribution of U.S. emissions relative to other global emissions, as well as mercury emitted by naturally occurring mercury deposits on the land masses and the ocean floor [10, 13]. Air-emitted mercury deposited on land can potentially be transported to adjacent waterways and lead to methylation and bioaccumulation, as described above. Electric power plants may also discharge mercury directly into surface waters through treated wastewater.

As a TMDL pollutant, mercury presents several challenges for electric utilities, including:

- More restrictive air regulations, potentially increasing mercury concentrations in wastewater discharges;
- Lower detection limits, resulting in more mercury TMDLs;
- Development of appropriate water quality standards for mercury;
- Difficulty in quantifying non-point sources of mercury; and
- Challenges in modeling the behavior of mercury in the aquatic environment.

The Clean Air Mercury Rule (CAMR), issued by U.S. EPA in 2005, was the first regulation in the world which intended to permanently cap and reduce mercury emissions from coal-fired power plants [14]. The target of CAMR was to reduce mercury emissions from coal-fired power plants by 70% by the year 2018. However, on February 8, 2008, a D.C. Circuit Court decision resulted in CAMR being vacated. The court determined that electric generating units (EGUs) must be regulated under Clean Air Act Section 112 standards, rather than the Section 111-based standards. As if this writing, EPA is reviewing the Court's decisions and evaluating its impacts. Until a federal regulation is promulgated, the reduction of mercury emissions from coal-fired EGUs will occur based on requirements put in place by individual states.

Removal of mercury from combustion gases through flue gas desulfurization (FGD) for sulfur emissions control, and selective catalytic reduction (SCR)/selective non-catalytic reduction (SNCR) for NO_x control leads to transfer of mercury contained in combustible coal into byproducts and solid wastes such as fly ash and FGD scrubber sludge [15]. Proper treatment of these materials through wastewater treatment systems, ash ponds, landfills, and sludge ponds is challenging, and creates potential for mercury loading to adjacent waterways [16,17]. As tighter air quality standards are enforced, more mercury will be removed from combustion gases, potentially leading to increased mercury loadings to wastewater treatment systems and surface water discharges.

A reduction in mercury detection limits since 1995 now allows for a total mercury detection as low as 0.5 ng/L (U.S. EPA Method 1631), whereas previously detection levels were 200 ng/L using U.S. EPA Method 245.1. These improved analytical capabilities have resulted in increased monitoring requirements for electric utilities and a greater likelihood of identified mercury impairment in water bodies, and therefore more TMDLs.

EPRI research has documented both the challenges of measuring mercury in the environment (fish tissue and water column), and the complexity of developing mercury water quality standards [15, 18]. Fish consumption advisories are often used to interpret narrative standards and waters may be listed as impaired even if there is no exceedance of a water column standard. The use of a bioaccumulation factors (BAF) and a methylation translator to “span the chasm” between total water column mercury and fish tissue concentrations is typically based on limited mercury observations [15]. This process introduces great uncertainty into a TMDL and often results in regulation that “misses the mark” [15].

Nonpoint sources of mercury (e.g., air deposition, watershed loads) are difficult to quantify due to limited data sets and mercury models which are still in a relatively young state of research as compared to models for other pollutants [15]. Specific modeling challenges include proper characterization of methylation and bioaccumulation as well as a lack of recognition that significant terrestrial mercury loads can originate from natural or older anthropogenic sources rather than solely from current emissions [15].

Because mercury is a pollutant of such great concern for electric utilities, EPRI has developed many products related to this topic. Many of these reports are listed in Appendix A.

2.3.2.2 Nitrogen

Nitrogen is another commonly identified TMDL pollutant of concern to electric utilities. Nitrogen can enter waterways through numerous pathways such as agricultural nonpoint sources, stormwater runoff, point source discharges from municipal and industrial facilities, and through air deposition. Nitrogen loading to waterways causes several water quality concerns including reduction of dissolved oxygen through nitrification, excessive algal growth which can lead to oxygen deficiencies, taste and odor issues, and aesthetics problems, as well as toxicity to aquatic species when nitrogen is present in the form of un-ionized ammonia.

Nitrogen is of particular interest to electric utilities because several different forms of nitrogen are released from facilities as NO_x emissions, byproducts of NO_x and SO_x reduction processes, treatment plant effluent, and stormwater runoff. Atmospheric deposition due to power plant coal combustion is the biggest source of nitrogen from electric utilities. Emissions of flue gas materials such as particulates (fly ash) and acidic gases (NO_x and SO_x) are controlled using devices that capture and transfer nitrogen from potential air sources to solid or water waste streams of a power plant. The performance of electrostatic precipitators (ESP), selective catalytic reduction units (SCR), and selective non-catalytic reduction (SNCR) units are typically improved with additional injection of ammonia. Ammonia slip, the presence of unreacted ammonia in the waste stream, contributes nitrogen to the particulate combustion byproduct, fly ash, through incomplete conversion of NO_x to N_2, catalyst degradation, and ammonia injection [16]. Fly ash can be sluiced to ash ponds where ammonia dissociates in the pond water, and can be discharged to adjacent waterways or leach to groundwater. Dry ash handling and wet scrubber facilities may also discharge ammonia to landfills or sludge ponds. Electric utilities may also discharge other forms of nitrogen via wastewater treatment plant effluent (e.g., nitrate) or stormwater runoff from electric utility facilities (e.g., adsorbed organic and inorganic nitrogen) [19].

Nitrogen, as a TMDL pollutant of concern, presents several challenges for electric utilities. Under the Clean Water and Clean Air Acts, electric utility plants are required to simultaneously comply with air emissions and water effluent permits for nitrogen. Though tightening of air pollution controls (e.g., a NO_x emissions cap goal of 31% of the 1980 value by 2015) reduces nitrogen loading to air, an indirect result is additional nitrogen discharge to ash ponds as described above [19]. Ammonia slip has been noted to result in elevated dissolved ammonia concentrations (up to 1000 times greater) in fly ash ponds as compared to natural [16]. Active fly ash pond ammonia treatment methods (e.g., chemical treatment, filtration) can be expensive and logistically impractical due to the high volumes of water, and innovative biological treatment methods are often unreliable due to inconsistent bacterial growth, incomplete nitrogen conversion, and the potential for an increase in dissolved metals concentrations (e.g., selenium) [17]. In addition to these waste treatment challenges, electric utilities continue to face the possibility of more stringent discharge limits due to new effluent guidelines, nutrient criteria, and whole effluent toxicity (WET) tests related to nitrogen [19].

2.3.2.3 Heat/Temperature

The discharge of heat to a waterway can relate to several types of TMDLs, focused on impairment due to elevated temperature and/or depleted dissolved oxygen concentrations. An increase in stream temperature can impact dissolved oxygen saturation, photosynthesis, and metabolic rates of aquatic organisms. Warmer water has a lower oxygen saturation level resulting in a less favorable environment for aquatic species with high oxygen requirements (e.g., trout, salmon). In nutrient-abundant environments, higher temperatures can increase the rate of photosynthesis, resulting in greater production of aquatic plants. The metabolic rates of stream organisms can also be impacted by increased temperature, leading to mortality or adverse impacts on reproduction or growth.

Thermoelectric power plants (e.g., coal-fired, nuclear) produce waste heat as a byproduct of useful energy production and must dissipate this heat, often through methods which consume water or alter its characteristics. Some power plants operate “once through” cooling systems, which withdraw large volumes of water from a lake or river and then discharge it at an elevated temperature. Many of these facilities are older and may be operating under a variance. Other facilities may use evaporative cooling technology, which produces a much smaller heat load discharge to a stream.

TMDLs that consider heat load as a contributing pollutant present several challenges for electric utilities. Hot summer conditions can result in elevated upstream withdrawal water temperatures and make it difficult for power plants to meet their permitted temperature limit and/or differential temperature between inlet and discharge. During drought conditions, receiving water flows are much lower and there is a higher sensitivity to heat loads. Both of these factors are serious considerations in the context of climate variability. An additional regulatory challenge related to heat loads is that many variances are due to expire, and electric utilities are forseeing the need to retrofit power plants during permit renewal. These requirements may be prompted by the development of a TMDL.

2.3.2.4 Non-Mercury Metals

Several types of non-mercury metals (e.g., arsenic, copper, selenium) are noted to be TMDL pollutants of concern for the electric power industry. Metals are naturally occurring and can enter surface waters as natural background sources, runoff from mines and mine tailings, and industrial facility air emissions and/or surface water discharges. Metals can dissolve and become bioavailable, depending on the physical and chemical properties of the surface water (e.g., pH, temperature, ionic strength). Though organisms require some trace metals for growth, excessive concentrations of these pollutants can be toxic. Metals can bioaccumulate through the foodweb as smaller organisms are consumed by larger. Metal toxicity for higher level organisms (e.g., fish, mammals) can result in impaired mental and neurological function. Arsenic is also a noted pollutant of particular concern for drinking water. When speciation changes and metals are adsorbed to organic solids or precipitate, they are less of a concern than the dissolved, bioavailable forms. However, because metals are conservative and are not broken down by mechanisms such as biodegradation or photolysis, they are persistent in the environment and have the potential to become bioavailable at a later time.

The process of coal combustion transforms naturally occurring metals contained in coal into fly ash particles, creating the potential for air deposition of metals. However, as a result of emissions control systems, many metals (e.g., arsenic, boron, cadmium, chromium, copper, lead, manganese, nickel, selenium, and zinc) can be captured in fly ash as waste products [16, 17]. Some fly ash metals can become soluble at certain pH levels (e.g., copper, selenium, and arsenic are most soluble at a pH of 7 to 9), making them more likely to leach from ponds [16].

Electric utilities face several challenges with metal-related TMDLs. Natural background sources of metals are significant for many watersheds, particularly in the western United States, Power plants that withdraw cooling water and later release it may simply be concentrating metals without contributing additional load. Without comprehensive monitoring of both influent and effluent metal concentrations, it may be difficult to demonstrate this during a source load assessment. As was noted for nitrogen, fly ash ponds can be difficult to manage. As air quality standards get stricter, there may be more metals in the fly ash waste stream, making control of these pollutants from entering surface or groundwater an even a greater challenge. Another potential challenge for metal TMDLs is that water quality standards for metals are typically written for dissolved content, but regulators may conservatively assume that 100% of effluent metals are dissolved, and set the limit in terms of total metals [17]. This can bias metals TMDLs toward excessive proposed load reductions.

2.3.2.5 PCBs

Polychlorinated Biphenyls (PCBs) are anthropogenic compounds that were manufactured and used commercially in the United States from 1929 to 1979 [20]. Prior to 1979, PCBs were directly discharged to the environment. Currently, sources of PCBs include poorly maintained hazardous waste sites, leaking electrical transformers, and incineration of municipal and industrial waste. PCBs are very persistent in the environment, can transport great distances, and cycle between air, water, and soil media. Much like metals, PCBs are taken up by aquatic organisms and move up through the food chain. PCBs are a probable human carcinogen and have also been shown to have non-cancerous effects on the immune, reproductive, nervous, and endocrine systems of animals [20]. Besides consumption of fish, another pathway for PCBs to enter humans is through accumulation in food crops.

Due to the 1979 ban on PCBs, electric utilities are not typically permitted dischargers of the pollutant, but there may be concern if a facility is operated near a PCB-impaired waterbody. Electric generation facilities have the potential to contribute PCB loads from coal combustion (air deposition), electrical equipment, legacy sources in sediments transported with stormwater runoff, and effluent discharge. Because most electric utilities are not permitted for PCBs, many potential sources are currently unquantified due to lack of data.

PCB TMDLs result in several unique concerns for electric utilities. Much like mercury, PCB impairment is typically based on fish consumption advisories. Development of a TMDL target criterion is complicated and often involves a translation between various media (e.g., fish tissue to water column) using limited data. Also, criteria can vary widely between various state, regional and national jurisdictions. It is difficult to quantify sources of PCBs from various potential sources (e.g., air deposition, legacy sediments, nonpoint sources) and therefore point source discharges tend to be reduced first in a TMDL, even though impacts from nonpoint sources such as legacy sediment contamination typically have much greater impacts. In the 1970s, detection limits for PCBs were approximately 1 ppm. Recent advancement in analytical chemistry now allows for detection limits in the 10 – 100 ppq range. Power plants may be faced with new monitoring requirements to demonstrate a zero or *di minimis* discharge.

2.3.2.6 Phosphorus

Many phosphorus TMDLs have been completed or are underway in the U.S. Sources of phosphorus to the environment include agricultural nonpoint sources, stormwater runoff, and point source discharges from municipal and industrial facilities. Much like nitrogen, phosphorus typically impairs waterways through excessive growth of algae, which can lead to issues with taste and odor, aesthetics, and low dissolved oxygen. Phosphorus strongly adsorbs to sediment and can be transported into waterways during high flow events.

Phosphorus loads from power generation facilities are typically less significant than nitrogen loads. Potential sources include treated wastewater and stormwater runoff. Cooling water discharges may also contain phosphorus. Even if concentrations are low, the contributing load could be considered to be significant due to the high volumes of water.

There are several potential concerns for electric utilities related to phosphorus TMDLs. Though a facility may be a minor discharger in terms of load, there can be ramifications because it is a pollutant of high concern from other sources (e.g., municipal wastewater, agricultural sources). If a phosphorus reduction is needed, TMDL developers may target all point source discharges first, rather than implementing nonpoint source reductions which are less enforceable. An electric utility may not even discharge phosphorus, but still be considered a responsible party for TMDL action simply by impounding water and creating the environment for nutrient enrichment and dissolved oxygen problems to occur. Additional challenges related to phosphorus TMDLs include the potential for nutrient standards to be developed at a state or national level. The concern is that uniform nutrient standards would not allow for consideration of site-specific variation in the effects of nutrients on waterbodies. A case study provided below illustrates another concern where an electric utility was indirectly impacted by a phosphorus TMDL through delay of a low level phosphorus permit requested for a new facility.

Case Study*: Upper Mississippi Phosphorus TMDL – Delayed Permit*

This TMDL provides an example of a situation where an electric utility has been indirectly impacted by the development of a TMDL through a delay of an NPDES permit. Under the Minnesota Pollution Control Agency's (MPCA) phosphorus strategy new and expanded NPDES permits for facilities that discharge phosphorus to 303(d) listed waters are closely scrutinized and there have been many third party challenges [21]. Great River Energy (GRE) was impacted while attempting to obtain an NPDES phosphorus permit for wastewater from the Cambridge Natural Gas Plant [22]. Though the phosphorus loads for this facility will be small, GRE has waited more than 2.5 years for a permit and is required by MPCA to collect additional data. Until a TMDL is completed and a discharge permit is approved, GRE will continue to truck wastewater elsewhere for treatment. A draft TMDL for the Upper Mississippi River is expected by December 2008.

2.3.2.7 Stormwater/Sediment

Concern for sediment and turbidity TMDLs was mentioned in interviews with several electric utilities, though generally at a lower priority than many pollutants described above. Sediment is typically transported to waterways during high flow storm events. Significant sediment loading to a river or lake can cause environmental problems such as aesthetic concerns, degradation of aquatic habitat, and sedimentation in reservoirs. Also, many pollutants adsorb strongly to sediment (e.g. phosphorus, metals, PCBs) and can be transported into waterways during storms and be released in dissolved and suspended form into the water column.

Electric power facilities often have large geographic footprints and therefore have great potential to contribute stormwater runoff. Older facilities may also have only limited stormwater management in place.

Specific concerns for electric utilities can include the need for facilities to comply with Municipal Separate Storm Sewer System (MS4) permit requirements and demonstrate pollution minimization through best management practices (BMPs). One utility noted that a sediment TMDL is under development where no power generation facilities are located, because the ownership of land for transmission lines makes the utility a potential source load contributor.

Table 2-1 provides a summary of many of the topics described above related to TMDL pollutants, potential pathways from electric generation facilities, and unique concerns in the context of electric utilities and the TMDL program.

Table 2-1
Summary of TMDL issues for the electric power industry

TMDL Issue	Pollutant Pathways	Unique Concerns
Mercury	Air deposition, blow down water, emissions removal systems, legacy sources	Complicated criteria, sources hard to identify, new monitoring requirements
Nutrients (e.g., NH_4)	Air deposition, emissions removal systems, WWTP, ash handling	Stricter air standards – shift from air waste stream to water, nutrients standards
Temperature	Plant cooling water	Time limits on variances, drought magnifies issues
Metals (e.g., As, Cu, Se)	Air deposition, ash handling	Concentrating effects of background/upstream sources
PCBs	Facilities near listed streams, legacy contamination	Complicated criteria, sources hard to quantify, new monitoring requirements
Dissolved Oxygen	Related to temperature, impoundments, nutrient inputs	Utilities responsible for creating impoundment, high temperature magnifies problem
Stormwater	Sediment, adsorbed pollutants	Large, older facilities with impervious surfaces, MS4 permitting

2.3.3 How could a TMDL Impact an Electric Utility?

In the context of pollutants and pathways described above, a TMDL could potentially impact an electric utility several ways: directly, indirectly, or in the future under changed watershed conditions.

If an electric utility discharges the TMDL pollutant of concern, the utility may be directly impacted through requirements to implement portions of a TMDL action plan. The TMDL allocation may specify a reduction of point source loads, likely to be realized as a change to discharge permit limits in the short term or during the next permit cycle. If a facility discharges a pollutant through nonpoint sources (e.g., air deposition, stormwater), load reductions from these sources may also be needed. There may be requirements to collect monitoring data for additional pollutants or at additional locations, or to expand an existing monitoring program. Development and demonstration of a pollutant minimization plan may also be required. Even if the utility's facility does not discharge the pollutant of concern, an electric utility may have to implement a water quality improvement solution (e.g. aeration system in a reservoir).

An electric utility could also be indirectly impacted by a TMDL, even if facilities do not discharge a pollutant of concern at significant levels. A TMDL developed for a watershed may result in a cap on additional loading from point and nonpoint sources which could translate into a growth curtailment for the region. For an electric utility, this could impact future sales and the prospect of a larger customer base. Also, a TMDL could put limits on opportunities for new NPDES permits, which may be required for new or expanding power plants.

A TMDL may not present an immediate concern for an electric utility, but changing watershed conditions may make it more important in the future. An increase in energy demand may result in an electric utility needing to expand operations, build new power plants, and apply for additional permits. As a stakeholder with a potentially increasing load to air and watersheds, electric utilities should be aware of the potential for degradation to water quality due to higher watershed loading and an eventual movement towards a TMDL. As air emissions standards become stricter, additional pollutants may be transferred from the air waste stream to the water waste stream, potentially resulting in an electric generation facility increasing their loads to waterways. Climate variability and drought conditions may potentially lead to waterways with lower flows and/or higher temperatures which are more susceptible to degraded water quality from heat or nutrient loads. The management of competing demands under these conditions (e.g., minimum water levels and flows, temperature) can present new challenges for beneficial use attainment. New or revised water quality standards (e.g., nutrients, emerging contaminants, threatened and endangered species) may result in additional waterbodies being identified as impaired and eventual development of a TMDL.

2.4 Electric Utility Involvement

When an electric utility first hears that a TMDL is planned or under development for their watershed, it may be unclear whether or not there is a need to be involved. This section outlines some of the potential benefits, challenges, and opportunities for TMDL public participation by an electric utility stakeholder. Interviews with several members of EPRI's TMDL Program Steering Committee provided many of the ideas discussed below.

2.4.1 Benefits of TMDL Involvement & Review

As described in Section 2.2, one of the eight regulatory requirements of a TMDL is public participation. Potentially, all watershed stakeholders could be impacted by a TMDL outcome and therefore, public participation should ideally occur throughout the TMDL development process. However, the reality is that for many TMDLs, public participation usually doesn't occur until the end of the process, typically in the form of a 30-day comment period for review of a draft TMDL. Comments received this late in the game may not carry much weight. They may simply be noted and recognized with a clarifying response, rather than having much influence to improve the TMDL outcome for multiple parties.

There are many potential benefits for an electric utility that gets involved in a TMDL development. Early involvement may help reduce the need to challenge the outcome through costly procedural or legal pathways. A stakeholder that is aware of how a TMDL development is progressing is less likely to be surprised by an outcome that may impact their operations. TMDL involvement may give an electric utility the opportunity to build relationships with regulators and other stakeholders in the community through meetings, sharing of data, and consensus building towards equitable solutions for water quality improvement. Improving these relationships may help reduce political and strategic barriers that can present additional challenges during a permitting process. A TMDL requires the identification of pollutant loads from all potential sources prior to setting acceptable limits. This exercise may help refocus attention to non-utility pollution sources, particularly if the impression is that all the blame should be placed on a handful of dischargers, when in reality the science shows that it is mix of point and nonpoint sources causing the impairment. The implementation of a TMDL may provide a mechanism to seek funding for water quality improvement through state grants, 319 programs, or water quality trading alternatives.

Case Study: *Ohio River PCB – Stakeholder Involvement*

The Ohio River PCB TMDL is an example of a situation where an electric utility has been an active stakeholder throughout the development of a TMDL. The Ohio River PCB TMDL is being developed by the Ohio River Valley Water Sanitation Commission (ORSANCO) for impaired segments downstream of the West Virginia/Kentucky border. ORSANCO is an interstate commission representing eight states and the federal government and has authority to develop the TMDL. The rejection of a draft TMDL by ORSANCO's technical committee (composed of water agencies and regulators) prompted the formation of a TMDL Task Force, charged with developing an equitable load reduction approach. The Task Force addresses the various sources of PCBs beyond the few quantified point sources, to include air deposition, contaminated sediments, polluted runoff, and other point sources. The Task Force is currently providing recommendations to ORSANCO's technical committee to better quantify loads and potential reductions.

Duke Energy is an interested stakeholder because their facilities potentially contribute sources of PCB loading from coal combustion (air deposition), electrical equipment, legacy sources in sediments, and effluent discharge. Loading contributions have not yet been quantified due to lack of data. Duke Energy has been an active participant in the TMDL Task Force and also serves on ORSANCO's Power Industry Advisory Committee to keep other electric utility stakeholders informed [23]. At the time of this writing, ORSANCO has set aside the development of the Lower Ohio River PCB TMDL until a bacteria TMDL for the entire Ohio River is complete.

2.4.2 Challenges of TMDL Involvement

Although it is ideal for an electric utility to be an involved and active stakeholder, there are many reasons this can be a very challenging undertaking. The TMDL process can be very unclear, and it is easy to get lost in the volumes of TMDL-related reports and guidance available from U.S. EPA and other sources. It is difficult for an electric utility to know whether they should be concerned, whether a TMDL outcome could affect them, and when to get involved. Most electric utilities have limited staff and resources and cannot afford to invest time and energy towards a TMDL if there is not a perceived risk related to the outcome. For some utilities, dealing with a TMDL may be viewed as a "hot potato" and responsibility may pass between departments without a strong sense of ownership. Even if an electric utility would like to get involved it can be difficult to do so because many TMDLs are developed by states or their contractors without extending an invitation for other watershed stakeholders to come to the table. TMDLs can also be confusing because of differences in procedures from state to state. An electric utility may have operations in multiple states, each of which follows a slightly different process for developing a TMDL. Some states are more organized than others and the quality of work reflected in the TMDL may depend on a state's available resources. Finally, although electric utilities around the country may have similar operations and face similar water quality challenges, there may be a lack of information sharing concerning the TMDL issues faced by other electric utilities and the lessons learned.

2.4.3 Opportunities for Involvement

There are many potential levels of TMDL involvement for an electric utility stakeholder ranging from minimal recognition of the development all the way up to being a defined third-party driving the funding and analysis behind a third-party TMDL. The level of involvement will likely depend on whether the TMDL is important to an electric utility, as well as available resources.

Many of the EPRI members interviewed have developed a 303(d)/305(b) tracking system and are signed up to receive public notices of planned TMDLs. At least one utility has developed a TMDL prioritization report, which helps ranks TMDLs of most concern. The report lists all waterbodies that the utility discharges to and cross references this with impaired waters and planned TMDLs. Each TMDL is given a ranking of low, medium, or high concern based on criteria such as:

- Low – irrelevant pollutant with respect to operations (e.g., fecal coliform);
- Medium – operations relevant to waterbody but not necessarily that pollutant (e.g., PCB TMDL near a hydropower facility); and
- High – the pollutant of concern is discharged from facility or cannot definitively say facility is not contributing to pollutant loads

There may be an opportunity for an electric utility to participate in water-quality-related committees (e.g., through trade organizations) prior to the development of a TMDL. As a TMDL is under development, TMDL-specific technical committees and working groups may form. Participation in these groups may pay off in terms of relationship building, as mentioned above. An electric utility may have the opportunity to supply data to help quantify loading sources or support model development through data collection, peer review, and contribution of local knowledge of the system. TMDL review by an electric utility may be done independently using in-house staff, or using outside consulting support. Alternatively, the review may be conducted using a collaborative approach with other watershed stakeholders.

Case Study: ***Minnesota Statewide Mercury TMDL – Public Participation***

This TMDL provides an example of a situation where electric utilities joined together with other stakeholders to publically participate in a TMDL development, and influenced the outcome by doing so. A regional Mercury TMDL was developed for the State of Minnesota and approved by U.S. EPA in 2008 [24]. The process was very open and regulators encouraged public participation from the start. Several electric utilities and other stakeholders banded together to pool resources and jointly review the TMDL [22]. Stakeholder involvement lasted more than 5 years.

One notable outcome of the review was that in response to public comments, Minnesota Pollution Control Agency (MPCA) decided to remove some impaired waters from coverage under the mercury TMDL. This was because MPCA could not be certain that all waterbodies included in the draft TMDL would meet the water quality standards when proposed reduction goals (93% load reduction) are achieved [25]. To be covered in the Mercury TMDL, fish data collected in the water bodies must meet several criteria including: 1) fish samples collected since 1990; 2) size class means containing more than one fish; 3) size classes < 30 inches for northern pike and < 20 inches for walleye; and 4) a maximum mercury concentration < 0.572 ppm for a size class mean. Of the mercury impaired waters on the 2006 list (870 lakes and 442 rivers), 334 lake impairments and 178 river impairments meet the requirements and are included in the final draft TMDL. Waterbodies not meeting these criteria remain on MPCA's 2006 list of impaired waters [25].

Section 3 of this report builds upon the ideas discussed above and provides greater detail about ways an electric utility can get involved in a TMDL development and review. These recommendations are framed within the typical steps taken during a TMDL development.

3

TMDL REVIEW ROADMAP

There are many facets of a TMDL that merit review, occurring throughout all aspects of the TMDL development process. This section describes the major steps of TMDL development, and provides key questions to guide the TMDL review process for each step (Figure 3-1). The TMDL review process is represented in the form of a decision tree flow chart. Potential pathways may be taken in response to each question, depending on whether the answer is "yes" or a "no." Figure B-1 (Appendix B) illustrates the TMDL Review Roadmap in this format. The reminder of this section is divided into subsections defining each step, and breaking the decision tree down piece-by-piece. Each subsection provides more defined information regarding specific questions to ask and possible actions. It should be noted that not all TMDLs are alike and not all will fit this roadmap exactly, but that the large majority should overlap significantly with the discussion provided here.

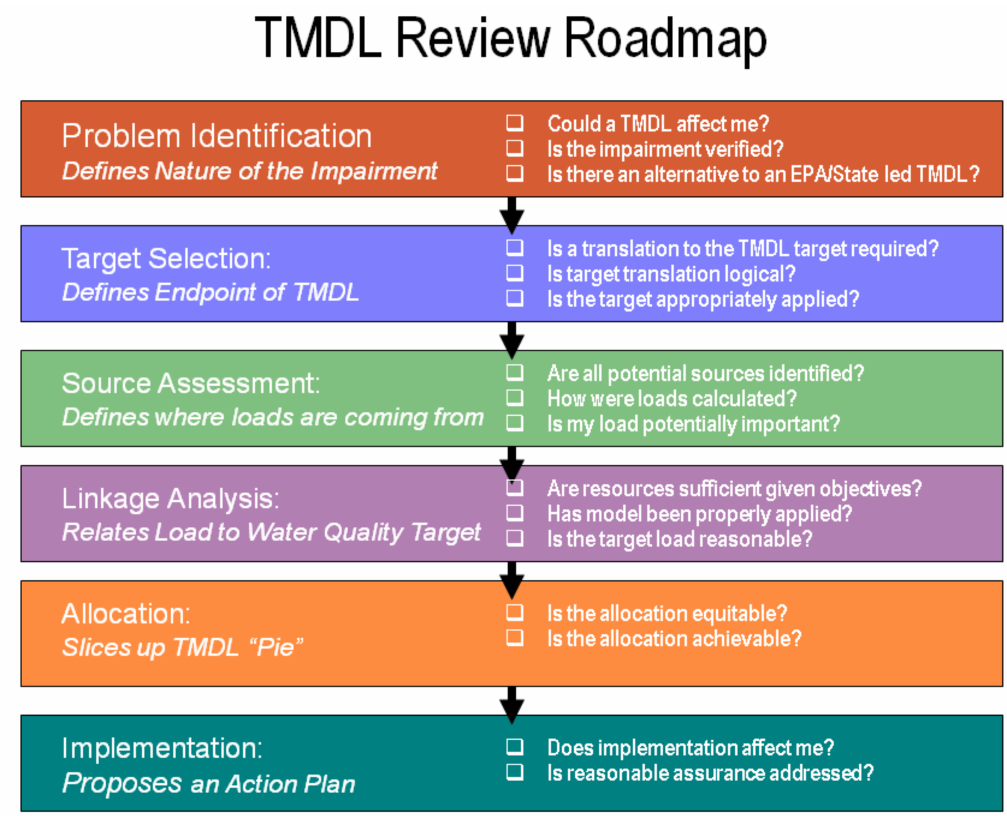


Figure 3-1
Overview of TMDL review roadmap

3.1 Problem Identification: is there a Problem and am I Potentially Contributing?

The problem identification portion of the TMDL is intended to provide general background on the waterbody and its associated watershed, and describe why the waterbody is identified as impaired. A review of the problem identification step is important to the electric power industry because it may help a utility decide whether to invest effort and resources on a particular TMDL. Early involvement may provide an opportunity to question whether a waterbody is truly impaired, or prevent the investment of resources for reviewing a TMDL for a waterbody which isn't impacted by an electric generation facility.

This section follows the decision tree flow chart presented in Figure 3-2 and describes how to determine if there is a problem and if you are potentially contributing. Subsections will address the following questions:

- Could a TMDL affect me?
- Is the impairment verified?
- Is there an alternative to an EPA or state-led TMDL?

A more detailed decision tree flow chart for this process is provided in Figure B-2 in Appendix B.

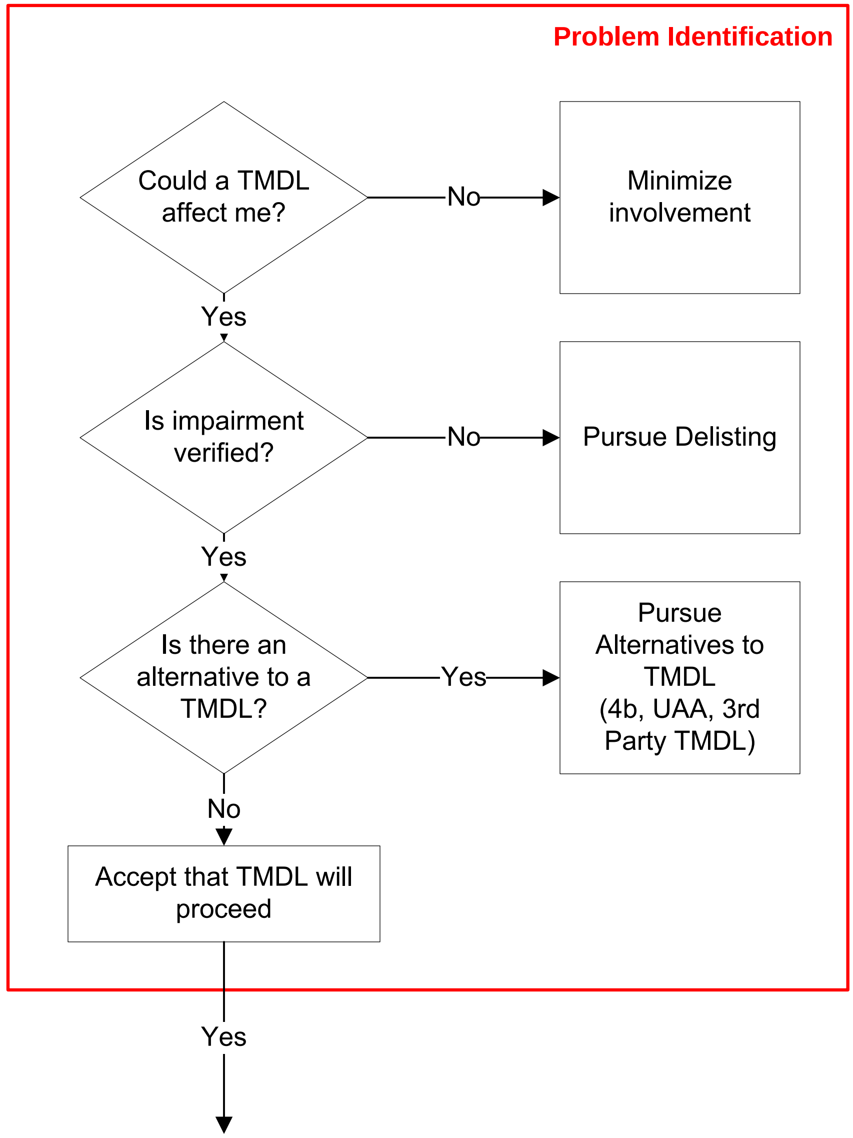


Figure 3-2
Problem identification flow chart

3.1.1 Could a TMDL Affect Me?

In order to determine if a TMDL could affect an electric utility, it is necessary to compile some basic facility information and assess the status of TMDLs within the state.

3.1.1.1 Compile Background Information

Information on impaired waterbodies and TMDLs is typically presented by the state on a watershed-specific basis. The first step in determining if a TMDL could affect an electric utility is to understand all of the water bodies potentially affected by power generation facilities, including those that are downstream of facilities. An assessment should also be made to determine whether any facility discharges, such as atmospheric emissions, have the potential to impact distant waterbodies. As illustrated in the case study below, some operations such as hydropower dams can be affected by a TMDL, even though no pollutants are discharged.

U.S. EPA's Surf Your Watershed (http://cfpub.epa.gov/surf/locate/index.cfm) and EnviroMapper for Water (http://map24.epa.gov/emr/) are on-line tools that are useful for mapping waterbodies and watershed boundaries.

Case Study: *A Northeastern Reservoir – Affected Utility Doesn't Discharge*[1]

This case study provides an example of a utility that was affected by a TMDL, even though they do not discharge pollutants that contribute to the identified impairment. A dissolved oxygen TMDL has been approved for a reservoir which impounds a river in the Northeastern United States. An electric utility owns the dam that creates the reservoir. The TMDL included a phased implementation involving pollutant reductions for upstream dischargers, and also required that the utility provide most of the funding for installation and operation of an oxygen diffuser. This requirement directly impacted the utility even though their facility does not discharge the pollutant of concern. The requirement will be implemented through NPDES permitting and a water quality certification for the dam hydropower licensing.

[1]Note: TMDL case study is written as confidential at the request of involved parties.

3.1.1.2 Determine Waterbody Listing Status

The next step in determining whether an electric generation facility may be affected by a TMDL is to determine which water bodies within the state are impaired. States are required to submit an assessment of waterbody conditions to U.S. EPA by April 1 of every even-numbered year. U.S. EPA encourages states to submit a single *Integrated Report* (http://www.epa.gov/owow/tmdl/2006IRG/) that combines many reporting requirements. Some states have not yet incorporated this approach and continue to submit the assessment information in separate 305(b) and 303(d) reports. The ATTAINS database displays information on these reports by state (http://www.epa.gov/waters/ir/).

Water Quality Standards

Water quality standards are the foundation of the water quality-based control program mandated by the Clean Water Act. Water Quality Standards define the goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants. A water quality standard consists of four basic elements [26].

Designated uses of the waterbody (e.g., recreation, water supply, aquatic life, agriculture): Some states have detailed categories or subcategories of designated uses that apply to specific waterbodies, although many have more general categories that apply to all waters.

Water quality criteria protect designated uses:, The criteria can be expressed numerically, as pollutant concentrations or as narrative requirements. Narrative criteria are qualitative statements that establish water quality goals. They can describe conditions that are not permissible (e.g., "waters shall be free from substances that may cause adverse effects to aquatic life") as well as conditions that are required (e.g., "maintain and improve all surface waters to a level that provides for the survival and propagation of a balanced indigenous aquatic community of fauna and flora").

Antidegradation policy maintains and protects existing uses and high quality waters.

General policies address implementation issues (e.g., low flows, variances, mixing zones).

The 305(b) report (or component of the Integrated Report) provides information on the method used to assess whether water quality standards are being met, and presents a comprehensive assessment of all waterbodies in the state. The 305(b) report also provides a description of the data used for this assessment, including: the types and age of data, as well as data quality and quantity. U.S. EPA guidance recommends that states place their waters into one of five reporting categories to classify the water quality standard attainment status for each segment. These categories are:

- **Category 1.** Waters attaining the water quality standard, and no use is threatened;
- **Category 2.** Waters attaining some designated uses ,and no use is threatened;
- **Category 3.** Waters for which there is insufficient data or information to determine whether any designated use is attained or threatened;
- **Category 4.** Waters impaired or threatened for one or more designated uses, but a TMDL is not required because:

    4a. A TMDL has already been completed, or

    4b. Other pollution control requirements are reasonably expected to result in attainment of standards within a reasonable period of time, or

    4c. The impairment is not caused by a pollutant;

- **Category 5.** Waters impaired or threatened for one or more pollutants, and for which a TMDL is required.

  5m. Waters impaired by atmospheric mercury and a statewide comprehensive reduction program is in place. This is an optional category approved by U.S. EPA (3/8/07).

The 303(d) list is comprised of those waterbodies in Category 5. These are waterbodies that do not meet water quality standards that states, territories and authorized tribes have set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. These are the waterbodies that require a TMDL to be developed.

A review of the most recent 303(d) list for a state will indicate whether a relevant waterbody has been identified as impaired and what pollutant is thought to be causing the impairment.

3.1.1.3 Determine the Status of TMDL Development

The goal of this step is to determine whether a TMDL is planned, underway or completed for a waterbody of interest. If so, then a TMDL could affect a local electric utility. If the waterbody is not identified as impaired, then a TMDL will not be needed. Because information on waterbody condition is continuously updated, the 303(d) list should be reviewed every two years to assess the listing status for the waterbody. Electric utilities should also contact the state to determine whether or not the waterbody will be monitored. If so, it may be beneficial to comment on the sampling plan, or consider contributing data. These actions may improve the quality of information used to determine whether or not it is attaining water quality standards.

3.1.1.4 TMDL is Underway or Completed

If a TMDL is underway or has been completed, it is important to contact the state to obtain a copy of the TMDL or any interim reports. These documents should be reviewed to determine whether any relevant power generation facilities are identified in the TMDL.

As part of this review or through an interview with the state, it is helpful to determine what is driving the TMDL and who is developing the TMDL. The answer to these questions may provide insight into the quality of the TMDL. For example, TMDLs driven by a court-ordered schedule may be more likely to have been developed quickly with available data, than those that were on a state-developed schedule that allowed time for additional data collection. Consultants are sometimes hired to develop the TMDLs under contract to the state. If the consultants are selected based on a lowest cost bid, then it may be more likely that the TMDL was developed using readily available data and simple models. TMDLs developed on a tight schedule or with very low cost should be examined very closely to make sure the approach selected is appropriate for the system and that the data were sufficient to characterize current conditions and calculate the TMDL. Section 3.4 provides information on assessing the linkage analysis (i.e., modeling) step of a TMDL.

Case Study: ***A Midwest Lake[1] – Insufficient Data***

This case study is an example of a TMDL that was developed using insufficient data, in part because it was done on a limited budget. A draft total phosphorus TMDL was developed for a heavily managed lake in the Midwest. The TMDL was developed by a consultant who was awarded the work, in part based on a low-cost bid. The TMDL identified internal phosphorus loading as the most significant source of phosphorus to the lake, but also calculated a wasteload allocation for a permitted discharge in the watershed. A financial impact assessment conducted by the facility showed it would cost the facility $20 million to implement the phosphorus reductions.

A review of the TMDL by a consultant (independent from the TMDL developers) found:

- The model applied was too simplistic for this system
- The TMDL was developed using available data, which were insufficient to characterize the system.

To date, the discharger has provided comments on the TMDL to the state and is willing to consider collecting data to support a use attainability analysis (UAA).

[1]Note: TMDL case study is written as confidential at the request of involved parties.

3.1.1.5 TMDL is Planned

If an impaired waterbody is included in Category 5, then this indicates that a TMDL is required. The targeted completion of the TMDL may be short or long term, depending on state resources and the level of priority the state has assigned to the TMDL. If a waterbody is impaired primarily by atmospheric mercury and listed under U.S. EPA subcategory “5m,” development of a TMDL will likely be deferred until later in the state’s TMDL development schedule. Whether the TMDL is planned for short or long term, there is an opportunity at this stage to assess whether any electric generation facilities are spatially relevant and should participate in the process to increase the odds of a favorable outcome.

Some states identify the extent of impaired waterbodies based on a set distance upstream and downstream of a sampling location. To determine if a facility is spatially relevant, the relationship between the facility’s discharges and the sampling locations used to identify the impairment should be examined. If the facility discharges to an impaired waterbody downstream of the location where the impairment was observed (i.e., the sampling location), then an argument could be made that the facility does not contribute to the impairment.

3.1.2 Is the Impairment Verified?

It is important to verify the original impairment determination that placed the watershed on the 303(d) list, to prevent investing resources on a waterbody that isn't truly impaired. A review of the 303(d) listing process found that many watersheds may have been improperly listed, due to issues such as improper judgment when interpreting narrative criteria, use of outdated data that no longer represent the system, and misinterpretation of data [27].

In order to verify impairment, it will be necessary to obtain a copy of the data used for the listing, including information on sample location, date and any quality assurance/quality control flags. The data should be assessed to determine if they reflect current conditions in the watershed. Although there is no universal guidance regarding a specific allowable data age, most states have established guidance listing the maximum age of data that are acceptable for basing impairment determinations. Data that are older than this must not be used for determining impairment. More recent data must also be disqualified if it can be demonstrated that they no longer reflect current conditions. Significant changes in land use or implementation of controls are examples of changes that could invalidate historical data.

Case Study: ***Upper Coosa River – Basis for Impairment***

This case study provides an example of a TMDL review where an electric utility questioned the basis of impairment. Georgia Environmental Protection Division (GAEPD) developed a dissolved oxygen TMDL for the Upper Coosa River under a tight, court-ordered schedule [28]. The final allocation included reductions of BOD loads by point source dischargers and a reduction of a heat load by a coal fired plant operated by Georgia Power. A group of several stakeholders, including Georgia Power, collectively challenged this TMDL by raising several issues, one being that the data used for listing did not indicate impairment [29].

The impairment was based on a Georgia water quality standard of "a daily average of 5.0 mg/L and no less than 4.0 mg/L at all times for waters supporting warm water species of fish" [28]. Stakeholders challenged the impairment because monitoring data did not indicate a violation of standards. Instead a critical conditions model (which assumed 7Q10 flows and point sources at permit limits) predicted a violation of DO standards and was the basis for the TMDL. By the time stakeholders questioned the listing, it was too late to remove the waterbody from the 303(d) list. Georgia Power indicated that if they had been better informed at the beginning of the process, there may have been a different outcome [29]. That said, recent drought conditions have resulted in critical low flows, observed DO violations, and a need for Georgia Power to address the situation with a temporary cooling system. Since the challenge, U.S. EPA has withdrawn the TMDL and a four-year study is underway to collect additional data and improve modeling. The revised TMDL is expected by 2009.

The data used to define impairment must also meet minimum quality requirements. Documentation must be available to determine whether appropriate procedures were used and Quality Assurance and Quality Control (QA/QC) measures were in place in the collection and analysis of the data [30]. Because mercury TMDLs were noted to be of high interest to electric utilities, some issues specific to mercury that were identified in EPRI are summarized below [15].

Data Issues Specific to Mercury[1]

Historically, ambient water column mercury measurements have been compared to the water quality standard, which may typically be 12 ng/l for fresh waters and 25 ng/l for marine waters (EPA's 1984 criterion) or 50 ng/l (EPA's 1998 criterion for consumption of water and organisms). Issues to consider with regard to such listings are the following:

- Prior to 1995, the detection limit for mercury was 200 ng/l and detections were infrequent. After the detection limit was lowered to 0.5 ng/l, detections became more frequent and sample contamination due to improper collection became a problem;
- If multiple laboratories have been used to analyze samples, interlaboratory differences in results can be an issue, especially when using low-level methods; and
- An adequate number of samples for proper comparison to standards is rarely available, given the variability of mercury measurements in the water column. In some cases, single samples have been used to list waterbodies.

[1]Condensed from EPRI [15].

The proper evaluation of data when comparing them to water quality standards depends highly on the nature of the standards. The evaluation is most straightforward when a numeric standard exists. For these situations, the primary consideration is whether the frequency that standards are exceeded is greater than the frequency allowed in state water quality standards. It should be recognized that states may designate a critical low flow below which numerical water quality criteria do not apply [31]. Data collected under extreme conditions, for which standards do not apply (e.g., the critical low flow), should not be used to define impairment. A discussion of Category 4c (i.e., impairment is not caused by a pollutant) is provided later in this section.

The comparison of data to water quality standards is less straightforward when narrative criteria are used. In cases where the state has developed specific protocols for determining impairment due to narrative criteria, the impairment decision must be consistent with these protocols. When protocols do not exist, the impairment decision must be based on best professional judgment. The quality of the impairment determination is only as good as the quality of the judgment used in these cases, so it is essential that the basis of the judgment be thoroughly explained. When the impairment decision is based strictly on biological or habitat targets, evidence must be provided that the identified pollutant is the cause of (or significant contributor to) the impairment.

If a review of the basis for impairment causes concern, it may be appropriate to meet with the state to present findings and propose a delisting (i.e., that the waterbody should be removed from the 303(d) list). Potential factors for delisting could include:

- the original basis for the waterbody listing is in error;
- the data and information show that the waterbody is meeting all applicable water quality standards; and
- the waterbody is listed as part of a state-wide advisory (e.g., for mercury), but there are either no site-specific data for the waterbody of interest, or the available water column data were collected using older sampling techniques.

If conditions in the watershed have improved the data used to list the waterbody do not reflect current conditions, then an electric utility should recommend additional data collection or offer to collect data. The case study below provides an example of a waterbody that was delisted following the collection of additional data.

Case Study: *Welsh Reservoir, Texas - Delisting*

Welsh Reservoir was listed on the Texas 303(d) list on the basis of a fish consumption advisory issued by the Texas Department of State Health Services, due to elevated selenium concentrations in fish tissue samples. Welsh Reservoir is a privately owned, 1,465-acre reservoir constructed to serve as a cooling pond for a steam-electric power plant. In addition, the reservoir serves as a popular recreational area. The electric utility believed that selenium contributions to the reservoir had been reduced, in part due to changes in ash handling at the facility. As a result of the 303(d) listing, the electric utility encouraged the Texas Commission on Environmental Quality (TCEQ) to reassess the status of Welsh Reservoir. The utility’s involvement led TCEQ to collect additional data which confirmed that selenium levels in fish tissue had decreased over time. TCEQ developed a new risk assessment, concluding that consumption of fish from Welsh Reservoir did not pose a threat to human health. The fish consumption advisory was rescinded, and Welsh Reservoir was subsequently removed from the 303(d) list [32].

3.1.3 Is there an Alternative to an U.S. EPA or State-Led TMDL?

If the data review confirms the impairment, then it is likely that a TMDL will proceed. However, there are several alternatives to an U.S. EPA or state-led TMDL that may be appropriate to consider, such as a use attainability analysis (UAA), reclassification from Category 5 to Category 4b or 4c, or a third-party TMDL.

3.1.3.1 Use Attainability Analysis

A Use Attainability Analysis (UAA) is a process to review and potentially modify a waterbody's designated uses, and can be considered when a designated use assigned to a waterbody is not an "existing use" (see 40 CFR 131.3(e)). During a UAA, a scientific assessment is conducted to determine if certain physical, chemical, biological, and/or economic factors prohibit the attainment of a designated use. As stated under 40 CFR 131.10(g), states may remove a designated use which is not an existing use, or establish subcategories of a use if the state can demonstrate that attaining the designated use is not feasible due to (in summary):

- Naturally occurring pollutants; or
- Intermittent or low flow conditions; or
- Human caused conditions or pollution sources which cannot be remedied or which would cause more environmental damage to correct; or
- Hydrologic modifications; or
- Physical conditions related to natural waterbody features; or
- Substantial economic and social impact.

Any one of these factors can justify a change in use, except that a designated use cannot be removed if it is an "existing" use, or a use that can be attained by implementing technology-based effluent limits required under the CWA. The outcome of a UAA can be any one of the following: no change; a revised use that provides greater protection; removal of a use; a refined use; partial uses or a temporary suspension or modification of a use; or site-specific criteria to protect a use [33].

UAA's can be a challenging alternative to a TMDL due extensive time and data requirements. A recent WERF report describes factors for success in developing UAAs and includes case studies and state UAA protocols [33]. This report is a useful resource to review when assessing whether a UAA is a viable TMDL alternative. Additional information on UAAs can be found on U.S. EPA's website on UAA's (www.epa.gov/waterscience/standards/uses/uaa/index.htm).

It should be noted that UAA's are presently an unlikely alternative to mercury TMDLs, because the conventional view is that mercury levels in fish tissue can be reduced through air emission controls (Section 3.3 discusses the importance of identifying legacy sources of mercury separate from current atmospheric sources). In the future, UAAs may become a more viable option, if fishing uses remain impaired in spite of implementation of Clean Air Act regulations for mercury.

3.1.3.2 Category 4b/4c

The Clean Water Act recognizes that TMDLs are not needed in all situations. If existing pollution control measures (e.g., best management practices or restoration) that are required or agreed to by local, state or federal authority are expected to result in the attainment of water quality standards in a reasonable period of time, then the state can categorize the waterbody as Category 4b, and a TMDL is not needed. If a waterbody is impaired entirely by something other than a pollutant (e.g., low stream flow or natural concentrations), then the state can categorize the waterbody as Category 4c, and a TMDL is not needed.

If an impaired waterbody could potentially be included in Category 4b or 4c, electric utilities may want to meet with the state to determine the information required to support this approach. It may also be appropriate to offer assistance in compiling the needed information. Information related to watershed controls (e.g., implementation schedule, assurance that planned controls will be implemented, and waterbody monitoring to assess improvements) may be useful for Category 4b. Historical flow data may demonstrate that the impairment listing was based on measurements collected during periods of unusually low flow, and may assist with inclusion in Category 4c. The case study that follows describes a situation where Category 4c may be appropriate.

Case Study: ***A Southeast Lake – TMDL Not Required?***[1]

This case study provides an example where Category 4c may be appropriate. The flow in a Southeastern U.S. river has decreased in response to a change in upstream dam operations and an extended drought. As a result, temporary temperature and dissolved oxygen issues have arisen in a downstream reservoir. The state regulatory agency listed the downstream reservoir on the most recent 303(d) list as impaired because of low dissolved oxygen and high temperature. A TMDL has not yet been developed.

An electric utility that discharges upstream of the 303(d)-listed reservoir would likely be required to install costly new controls at the facility if regulators were to proceed with a TMDL. The utility is working proactively to monitor the downstream reservoir and minimize thermal impacts from the facility, and is communicating regularly with regulators about these efforts, in hopes of addressing the issues outside the TMDL process.

[1]Note: TMDL case study is written as confidential at the request of involved parties.

3.1.3.3 Third-Party TMDL

A third-party TMDL is a TMDL in which some other organization (e.g., discharger, watershed group) takes the lead on TMDL development. The WEF Third-Party TMDL Development Toolkit is valuable resource for evaluating whether this approach should be considered [34]. Some of the advantages and disadvantages of leading a third-party TMDL are provided in the WEF document and are summarized below.

By leading a third-party TMDL, a stakeholder may be able to leverage state funds, as well as resources and expertise of other agencies and nongovernmental organizations. Greater funding may translate to improved data quality and analysis supporting the TMDLs. This in turn may lead to less uncertainty, a reduced margin of safety and subsequently, increased loads available to allocate. Furthermore, the third-party leading a TMDL development can be more closely involved in decisions on modeling approaches and allocation of allowable loads to different sources. Third-parties may be able to effectively involve other stakeholders, increasing the likelihood of effective implementation. Finally, third-parties are usually very familiar with local watershed issues and can provide valuable insight during the TMDL development process.

Third-party TMDL development can require significant resources. Before deciding if this is a viable approach, it is important to estimate the level of effort needed. Because third-parties typically fund the majority of third-party TMDL costs, it is important to assess whether there are adequate financial resources to pursue this approach. In addition to time and cost, a high level of expertise may be required to evaluate the data, conduct modeling, and develop the TMDL. Some other things to consider when deciding if this is the right approach are whether the TMDL can be completed within an appropriate timeframe, whether the third-party can support and facilitate an inclusive stakeholder group, and whether the TMDL can be developed objectively [34]. As described in Section 4, the development of a third-party TMDL may be an appropriate mechanism to challenge an existing TMDL, rather than pursuing a formal legal challenge.

Case Study: ***Truckee River – Third-Party TMDL***

This case study is an example of a TMDL that is being revised using a third-party approach. In 1993, a nutrient TMDL was developed for the Truckee River to protect aquatic life uses by controlling algal growth and improving oxygen [35]. Since that time a collection of local entities (City Reno, City of Sparks, Washoe County, Truckee Meadows Water Authority – TMWA) have initiated a TMDL revision through a third-party process. The motivation for the TMDL revision was based on regional growth and uncertainty that the tools (i.e., water quality model, data) used to develop the 1993 TMDL provided an accurate characterization of the river and its assimilative capacity for nutrients. In particular, managed flow operations and the quality of wastewater treatment plant effluent have improved over time. Since the late 1990s, the third-parties have collected additional water quality and river ecology data, and developed improved modeling tools to better characterize the system under contemporary conditions.

EPA Region 9 and Nevada Department of Environmental Protection (NDEP) have been engaged in discussions with the third parties on their proposal to revisit the 1994 TMDL. Regulatory expectations for an acceptable TMDL, as well as identification and potential approaches to address complex technical and political challenges have been defined through a third-party work plan. Initially, the third-party TMDL was wholly funded by the cities of Reno and Sparks. However, in 2008, the primary funding source for the effort was shifted to the Western Regional Water Commission (WRWC), a regional water entity developed under 2007 Nevada legislation, which includes the third parties and other stakeholders as member agencies.

In concert with a shift in funding source, the TMDL revision process has evolved to a broader, phased and multi-track process which includes basin-wide efforts to evaluate flow management, pollution control and restoration activities as a means to address the chemical, physical and biological conditions of watershed. To support this broader process, the third-party TMDL efforts now include comprehensive stakeholder education and facilitation components in addition to ongoing technical activities. At the time of this writing, the Truckee River third-party TMDL is still under development.

3.1.4 TMDL Development Proceeds

If a TMDL does proceed, it is recommended that an electric utility monitor TMDL development and consider being involved, at a minimum by reviewing interim reports and attending public meetings. In terms of monitoring TMDL development, it is useful to find out who will be developing the TMDL and when the TMDL will be developed. TMDLs are typically developed by state regulatory agencies (or contractors working directly for the state) or by U.S. EPA (or contractors working directly for U.S. EPA). It may also be beneficial to identify other potentially impacted parties in the watershed who share similar concerns, or consider getting outside help to review the TMDL as it is developed. By becoming involved in TMDL development at an early stage, an electric utility can prevent being blind-sided at a later stage, and minimize the possibly of pursuing a legal challenge with high costs (see Section 4).

3.2 Target Selection: has a Clean Water Goal Been Set Appropriately?

Once impairment is verified and a TMDL is scheduled to proceed, the next step of the TMDL process to evaluate is the target selection. Target selection is a critical component of a TMDL which involves is the selection of a numeric endpoint, also called the TMDL target. A numeric target establishes a goal used to evaluate the attainment of acceptable water quality to be achieved by the TMDL. The TMDL target specifies both the specific indicator to be assessed (e.g., phosphorus, mercury, etc.) and the allowable level (e.g., concentration). Where possible, the numeric endpoint should be represented by state water quality standards. When appropriate numeric standards do not exist, surrogate parameters must be selected to represent the designated use. Sometimes a water quality target must be developed from a criterion relevant to another medium (e.g., fish tissue) through a translation process.

This section is designed to follow the decision tree in Figure 3-3 to determine if a TMDL target has been set appropriately. Subsections will address the following additional questions:

- Is a translation to the TMDL target required?
- Is the target translation logical?
- Is the target appropriately applied?

A more detailed decision tree flow chart for this process is provided in Figure B-3 of Appendix B.

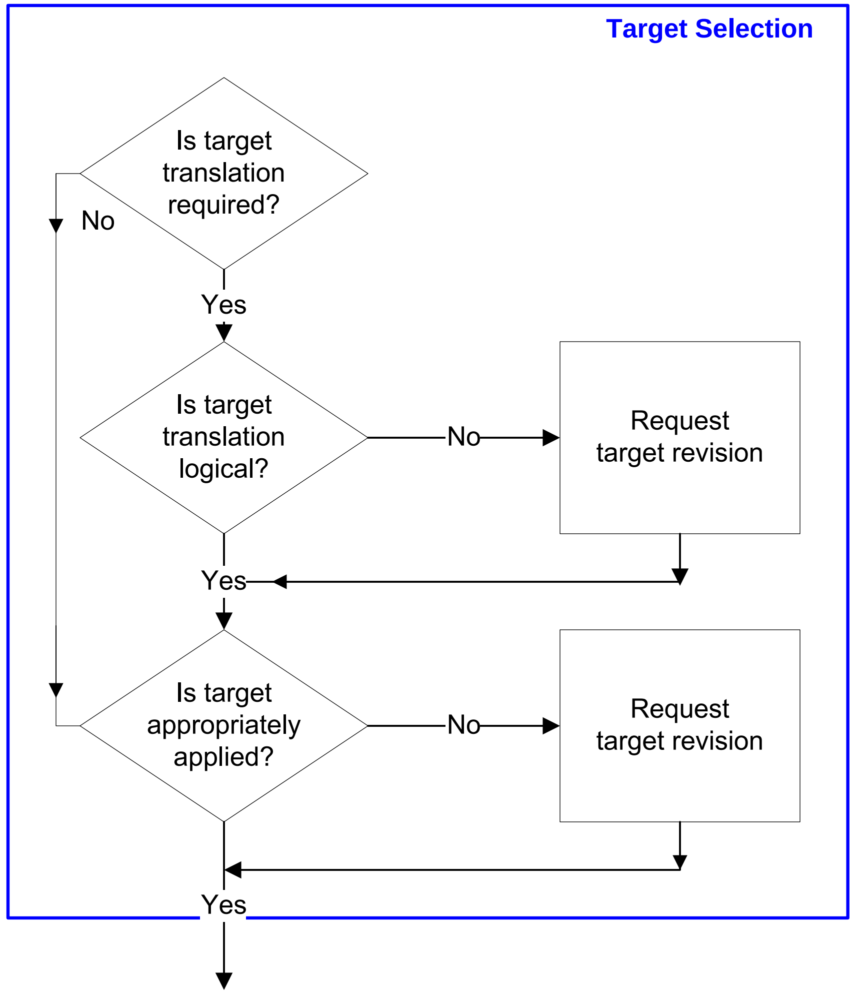


Figure 3-3
Target selection decision tree

3.2.1 Is a Translation to the TMDL Target Required?

The TMDL should indicate the water quality target that has been selected, as well as provide justification for the selection of the target constituent and allowable level. In some cases, target selection will be a simple matter of stating a numeric water quality criterion; in other cases, the analysis is more complicated. In either case, the TMDL should clearly identify the target and the basis for its selection. If this information is not provided, stakeholders (such as an electric utility) should request documentation of the target.

3.2.1.1 Promulgated Water Quality Criterion

Selection of a TMDL target is generally straightforward when a promulgated numeric water quality criterion exists for the constituent of concern, and where there is a directly defined relationship between the loading constituent (pollutant) and the water quality impairment. In such cases, the numeric water quality criterion may be directly used as the TMDL target. For example, if the waterbody is impaired for a particular metal, such as copper in the water column, and there is a numeric criterion for water column copper concentrations, the criterion is typically used as the TMDL target. In such cases, the criterion has undergone rulemaking and public comment, and the primary question becomes whether the criterion has been applied correctly (addressed in Section 3.2.3), versus whether it is the correct criterion. There are situations, however, where use of a promulgated numeric criterion is not entirely straightforward, such as when there are multiple jurisdictions and water quality criteria (see case study below). In such cases, the most stringent of the available criteria is often used.

Case Study: Lake Ontario PCB – Multiple Targets

The development of a PCB TMDL for Lake Ontario provides a good example of a flexible approach for recognizing and utilizing multiple water quality targets. Because Lake Ontario borders both New York and Ontario, and receives loading from the upper Great Lakes, three numeric PCB criteria designed to protect human health based on fish consumption are being considered in the development of the TMDL [36]:

1. The Great Lakes Protocol threshold for unrestricted consumption of lake trout = 0.05 ppm in side fillets;
2. The Great Lake Initiative standard for water column PCBs = 26 pg/l; and
3. The New York water quality standard for water column PCBs = 1 pg/L.

Each target was developed using different methodologies and risk factors [36]. The New York State water quality standard is the most restrictive of the three criteria and will likely be the basis for the final TMDL. The two remaining criteria will be used as intermediate targets for measuring progress toward the ultimate TMDL goal. New York State Department of Environmental Conservation (NYS DEC) will measure compliance with each of the numeric criteria on a lake-wide annual average basis, since both U.S. EPA and Environment Canada assess lake trout PCB concentrations on an annual basis. The proposed approach for TMDL development is to compute the total allowable PCB load to Lake Ontario to attain to each of the three targets. This calculation will provide three TMDL allocations which may be used sequentially through a phased TMDL implementation. TMDL is still under development and expected to move forward to completion by 2010.

3.2.1.2 Situations Requiring a Target Translation

Target selection is more complicated when promulgated numeric criteria do not exist for the constituent of concern (e.g., where the impairment is “toxicity” or loss of habitat), and/or where there is not a directly defined relationship between the loading constituent and the water quality constituent of concern (e.g., need to control phosphorus to meet dissolved oxygen criteria). In such cases, a translation is required to develop an appropriate target. It is important that stakeholders, such as electric utilities, have the opportunity to review and potentially contribute to this process to ensure that the target is not based on overly conservative assumptions or weak science. A poorly developed target could potentially lead to unrealistic or unfair load allocations.

Situations requiring a target translation include:

- **Surrogate Measure:** When the loading constituent to be controlled is different from the water quality constituent of concern; in this case, a surrogate measure may be selected;
- **Alternative Medium:** Where water quality criteria are specified for an alternative medium, such as fish tissue or sediment, but the TMDL must be developed for water column concentrations; or
- **Narrative Criteria:** Where the water body is listed on the 303(d) list based on violation of narrative water quality criteria and it is necessary to develop a numeric water quality objective in order to quantitatively define the numeric allowable loads.

In each of these cases, a translation is required to determine the TMDL target. Each of these situations is discussed in more detail in the next section.

3.2.2 Is the Target Translation Logical?

When a target translation is required (surrogate measure, alternative medium, or narrative criterion), the translation and its technical basis should be documented in the TMDL. The step of target translation provides TMDL developers wide latitude in selecting a target. Depending on the judgment of TMDL developers in this process, there could be major ramifications on the degree of control required by the TMDL. Therefore it is important for electric utilities to understand the target translation and be confident that it was done using adequate data and a strong scientific basis. Each of the situations requiring a translator is discussed below.

3.2.2.1 Surrogate Parameters

In many instances, an appropriate numeric water quality standard does not exist, or the impairment is different from the pollutant that must be controlled. In such cases, surrogate parameters may be required. For example, for a dissolved oxygen impairment, dissolved oxygen is not the pollutant that must be controlled, and a dissolved oxygen load is not allocated among sources. Nitrogen and phosphorus loadings to lakes can stimulate excess algal growth. When the algae die and decompose, they then settle to the lake bottom, where they contribute to low dissolved oxygen levels. There are two ways to develop a target for this situation:

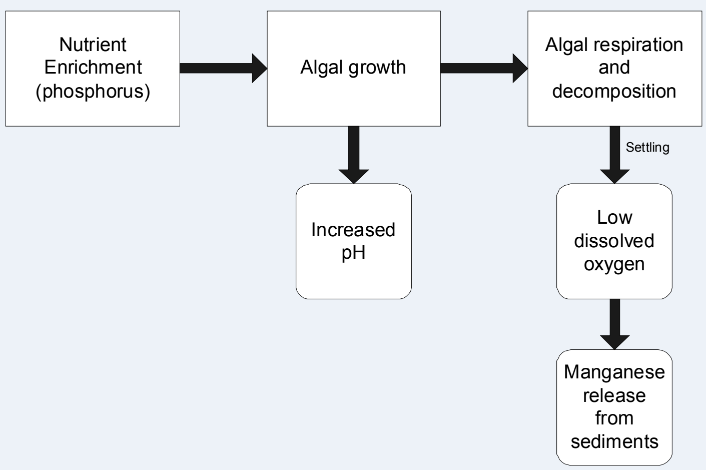
1) **Direct Linkage:** A water quality model provides a direct quantitative link between loadings of one parameter (e.g., phosphorus) and compliance with a TMDL target represented by a different parameter (e.g., dissolved oxygen). Section 3.4 provides more information on Linkage Analysis.

2) **Surrogate Parameter:** A surrogate parameter (e.g., nitrogen and/or phosphorus) is used as a surrogate parameter for the TMDL. The TMDL target is a specific nitrogen or phosphorus concentration that is expected to prevent excess algal growth and meet dissolved oxygen standards. An example of the use of surrogate measures is discussed in the case study below.

Case Study: ***Palymyra-Modesto Lake – Surrogate TMDL Target***

This case study provides an example of a TMDL where a surrogate parameter was used to develop a TMDL target. A surrogate parameter, total phosphorus concentration, was selected as the TMDL target for dissolved oxygen, manganese and pH TMDLs in Palmyra-Modesto Lake in Illinois [37]. Watershed characterization determined that there were no significant sources of oxygen-demanding or pH-altering materials to the lake, and that nutrient enrichment was the likely cause of both low dissolved oxygen and high pH. For manganese, the only controllable source was release from lake sediments during periods of low dissolved oxygen in lake bottom waters.

The linkage between the TMDL target (total phosphorus) and the other impairments can be explained as follows. Phosphorus loadings to lakes can stimulate excess algal growth. Excess algal growth can affect pH through the uptake of carbonic acid. When the algae die and decompose, they then settle to the lake bottom, where they contribute to low dissolved oxygen levels and anoxic conditions at depth. Under anoxic conditions, manganese is released from the lake sediments. Thus, it was determined that attainment of the total phosphorus target would result in attainment of the dissolved oxygen, pH, and manganese standards.



When a surrogate measure is used as the target, it is important for the surrogate to be appropriately linked to the impairment. As described in a WERF report a surrogate TMDL target measure must be [38]:

1. Quantitatively linked to source controls;
2. A significant causative factor determining impairment; and
3. Capable of having a target level established corresponding to designated use attainment.

For example, if a phosphorus concentration is used as a target for a dissolved oxygen TMDL, waterbody data should be used to demonstrate that phosphorus is the limiting nutrient (i.e., the controlling factor for algal growth). The TMDL should also document that phosphorus concentrations in the water body can be linked to source controls (e.g., point source reductions, BMPs, fertilizer reduction). Also, a well documented linkage analysis (water quality model) should demonstrate that a phosphorus target load reduction could result in attainment of the dissolved oxygen criterion.

For some pollutants, it can be difficult to establish the necessary relationships to support use of a surrogate measure. For example, methylmercury is the form of mercury that bioaccumulates in fish tissue, but methylmercury is difficult and expensive to measure. Some TMDLs, such as the Willamette River mercury TMDL, have used total mercury as a surrogate for methylmercury based on the ratio between total mercury and dissolved methylmercury in the water column [39]. However, research by both EPRI and independent parties has demonstrated a lack of correlation between total mercury and methylmercury [15]. This suggests that total mercury is not a good predictor of methylmercury concentrations in streams and lakes. It is important that the selected surrogate correlates well to the water quality impairment, to ensure that reducing loadings of the surrogate constituent will result in water quality improvement. If a review of the target translation indicates that there is not a well-defined relationship between the surrogate measure and the water quality impairment, a revision of the target should be requested.

3.2.2.2 Translation Between Media

Most TMDLs focus on water column concentrations of a pollutant. In some cases, however, a waterbody is listed as impaired based on pollutant concentrations in other media, such as fish tissue or sediment. For purposes of developing the TMDL and allocating loads, this often requires translation of the non-water column criterion to a water column target. For electric utilities, the most significant example of this situation is mercury in fish tissue. The following discussion focuses on fish-tissue-to-water-column translations, but the same general principles apply for sediment-based criteria.

A number of mercury TMDLs have been developed using a water column-based target derived from a fish tissue-based criterion [15]. Fish tissue-based criteria are often narrative (rather than promulgated and numeric) and are typically translated into a numeric water column target for either total mercury or methylmercury. Such targets can vary widely depending on assumptions such as bioaccumulation factors (BAF) and fish consumption rates. For example, EPRI research documents total mercury water column targets ranging from 0.52 ng/l to 41 ng/l nationwide [15]. This wide range highlights the importance of the underlying assumptions in the development of the target values.

BAFs are used to estimate the extent of bioaccumulation of pollutants in fish tissue. While the general concept of the BAF appears simple (BAF = fish tissue concentration/water column concentration), a variety of factors (e.g., spatial and temporal variability, fish species and size, environmental conditions) can affect the BAF [18]. Therefore, BAFs must be used carefully in the regulatory process. The preferred approach for translating a methylmercury fish tissue criterion into a water column criterion is to derive site-specific methylmercury BAFs, rather than relying on data from other watersheds. Scientifically defensible bioaccumulation models may also be used, however, the complexities of the biogeochemistry and food web make it difficult to reliably predict BAFs [15]. Several sampling and analytical issues (e.g., older data with high detection level, unapproved sampling method for methylmercury in water) must also be considered [18, 15].

The uncertainties associated with translating criteria between media can be substantial, and have a significant effect on the TMDL. If a criterion for one medium (e.g., fish tissue, sediment) is translated to a TMDL target for another medium (e.g., water), the translation must be documented, with sufficient technical basis and supporting data to justify the translation. One EPRI report notes that "the BAF (along with the methylation translator) is often used in TMDLs to span the chasm between total mercury in the water columns and mercury in fish tissue based on a handful of observations [15]. This will invariably result in regulation that misses the mark. Stakeholders should insist on, and probably assist with, the collection and analysis of sufficient data to reduce the uncertainties to reasonable levels." When reviewing a TMDL target translation, carefully evaluate BAFs and other factors used to translate criteria between media. If the translation is not supported by quality data, request revisions and consider providing additional data.

Case Study: ***Savannah River TMDL – Target Translation***

This TMDL illustrates how a target translation can significantly impact whether or not a TMDL is needed. The Savannah River TMDL (approved in 2001 and subsequently withdrawn) was developed for five contiguous segments of the Savannah River listed on Georgia's 2000 303(d) list as being impaired for mercury based on the State's fish consumption advisories. At the time, Georgia did not have a numeric criterion for mercury for the protection of human health.

U.S. EPA completed the mercury TMDL for the Savannah River under consent decree and selected a water quality target by translating the narrative standard into a watershed-specific human health criterion for total mercury, using different assumptions than used in the state fish consumption advisory [40]. U.S. EPA determined a water column concentration of 2.8 ng/L total mercury as the TMDL target [40]. Site-specific data were used to calculate the BAF and the percentage of methylmercury relative to total mercury.

Many comments were received during the public comment period, largely pertaining to the development of the water quality target. Subsequent to U. S. EPA finalizing and approving the TMDL, Georgia provided a numeric interpretation of their narrative standard, 0.3 mg/kg wet weight, based on the U.S. EPA methylmercury criterion for protection of human health published in January 2001 [41]. Comparison of available fish tissue data to this target yielded the conclusion that mercury levels in Savannah River fish did not exceed the criterion. Four of the five Savannah River segments included in the 2001 TMDL were removed from the 2002 303(d) list and U.S. EPA's TMDL was subsequently withdrawn [6]. This delisting demonstrates the importance of the target translation; U.S. EPA considered the segments impaired based on the water column target, but Georgia Environmental Protection Division's (GAEPD) fish tissue target allowed the segments to be delisted.

3.2.2.3 Narrative Criteria

Narrative criteria are qualitative descriptions of the condition of the water body necessary to support the designated uses, such as “no objectionable color, odor, taste, or turbidity” or “not toxic to humans, animals, or plants” [38]. These differ from numeric criteria, which quantitatively define the permissible level of a specific pollutant to maintain protection of a designated use. Many states have adopted narrative criteria to supplement numeric water quality criteria, and U.S. EPA considers that the narrative criteria apply to all designated uses at all flows and are necessary to meet the statutory requirements of section 303(C)(2)(A) of the CWA [31].

TMDLs are most easily developed when there is a known and quantifiable link between the causes/sources to be controlled and responses desired. Therefore, the absence of specific, quantitative water quality objectives poses a significant challenge in TMDL development. Setting a target based on narrative criteria can be difficult because narrative criteria are often related to biological endpoints (e.g., fish populations) that can vary widely over time and space and are impacted by more than one stressor [38].

Narrative criteria can be toxicological (“no toxics in toxic amounts”), ecological (“maintain the biological integrity of the waters of the state”), or aesthetic (“no nuisance amounts of…”) [38]. Each of these categories presents a challenge in setting TMDL targets. For toxicological criteria, it can be difficult to determine the specific cause of impairment. Translation of criteria across media may be required and presents numerous challenges due to complex chemical and biological interactions. For ecological criteria, surrogate measures are often used. Selecting target measures that are both reflective of the impairment and also able to be linked to controls can be difficult. Best professional judgment, which is subjective and requires substantial expertise, is commonly used to select targets for ecological impairments. For aesthetic criteria, it can be difficult to convert perceptions to quantitative target levels.

One WERF report discusses the challenges associated with addressing narrative criteria in the TMDL process and provides guiding principles which can serve as a “checklist” for evaluating TMDL targets [38]. If a TMDL involves target translation from narrative criteria, it may be helpful to compare the TMDL against the guiding principles for narrative criteria and request an alternative or revised target if principles are not followed.

A target translation may be developed under one or more of the conditions described above. Regulatory agencies should clearly explain the translation and its basis using sound science. Stakeholders should understand the science and data behind the translation. If an electric utility has concerns with the science, it could suggest additional scientific study, additional data collection (possibly contributing to this effort), and request a revision to the TMDL target.

Case Study: ***McPhee and Narraguinnep Reservoirs – Narrative Standard***

The McPhee and Narraguinnep Reservoirs mercury TMDL provides an example of the use of a narrative standard in a TMDL. The Colorado Department of Public Health and the Environment (CDPHE) listed McPhee and Narraguinnep reservoirs on the 303(d) list, despite the fact that State ambient water quality criteria for mercury in water had not been exceeded in either reservoir. [42]. Mercury concentrations in the water column of McPhee and Narraguinnep reservoirs did not exceed Colorado's numeric criterion for mercury in the water column (0.01 ug/l). However, the State listed the reservoirs as not supporting their designated uses based on the presence of a fish consumption advisory. CDPHE determined that the presence of the fish consumption advisory violated the narrative water quality standard that prohibits concentrations that "are harmful to the beneficial uses or toxic to humans, animals, plants, or aquatic life." The numeric target for the TMDL was set to the fish consumption advisory action level (0.5 ug/g total mercury concentration in fish tissue).

3.2.3 Is the Target Appropriately Applied?

Whether the TMDL target is based directly on a numeric water quality criterion or requires a translation, TMDL development must also define the conditions that will be used when defining allowable loads based on that target. The final question to ask regarding the target is whether it has been appropriately applied. Aspects to consider include temporal and seasonal considerations, averaging, and environmental conditions.

3.2.3.1 Seasonal and Temporal Considerations

TMDLs must consider temporal and seasonal variations. Selection of appropriate conditions must consider the response time of the water quality impairment and the residence time of the pollutant in the water body. Acute toxicity impacts, for example, have a response time on the order of hours to a day because some metals can be lethal to aquatic organisms after a relatively short duration of exposure. The response time of eutrophication impacts, on the other hand, is generally quite slow and usually evaluated on a seasonal or annual basis. The duration of the environmental condition selected for the TMDL target should not greatly exceed the residence time of the pollutant in the water body, or the TMDL will consider loads that have little impact on water quality during the critical periods.

Selection of appropriate seasonal and temporal conditions can be particularly important in the case of nutrient TMDLs, because of variation in plant growth, fertilizer application, and seasonal weather patterns. A useful target for a low dissolved oxygen TMDL might be expressed on a daily basis, while a target related to nuisance algal growth might apply for the entire growing season [43].

Human health-based targets, such as fish tissue mercury levels, require a much longer time frame than short-term aquatic toxicity or seasonal dissolved oxygen and nutrient targets. Seasonal considerations also apply to temperature issues. The selected target should be applied at a temporal scale consistent with the impairment.

For TMDLs with a longer-than-daily target, it is still recommended to include an additional daily expression of the TMDL load. A 2006 District of Columbia (D.C.) Circuit Court of Appeals decision (*Friends of the Earth, Inc. v. U.S. EPA, et al., No. 05-5015*) found that two Anacostia River TMDLs did not comply with the Clean Water Act because allocations were not expressed in terms of daily loads. Though it is currently not a requirement in other jurisdictions, U.S. EPA recommends that all TMDL submissions with a longer-than-daily target include a supplemental daily allocation [44]. A more detailed discussion of the “daily-means-daily” topic is provided in Section 3.5.1.3 along with a summary of U.S. EPA guidance on how to derive daily loads for TMDLs with a non-daily target.

3.2.3.2 Averaging

While some water quality targets are expressed as instantaneous, never-to-be-exceeded values, many are more appropriately expressed as averages. Many water quality criteria are explicitly expressed as an average concentration over a particular time period; other criteria implicitly incorporate an averaging period. For example, dissolved oxygen criteria are often expressed as minimum daily average concentrations, and temperature criteria may be expressed as maximum daily averages. The U.S. EPA recommends an averaging period of one hour for acute aquatic life criteria for toxics (such as metals), and a four-day averaging period for chronic aquatic life criteria (i.e., the four-day average exposure should not exceed the criterion) [31]. Fish tissue-based criteria, such as the methylmercury criterion, are applied as average tissue concentrations, often weighted by species or trophic level. Use of an average concentration is appropriate, since the criteria represent an acceptable level of exposure over a lifetime [18]. The TMDL should indicate the duration of the target, which should be consistent with the impairment.

3.2.3.3 Environmental Conditions

Environmental conditions are a factor for some water quality criteria and may be considered in identifying the TMDL target. For example, water quality criteria for many trace metals (e.g., cadmium, copper, lead, zinc) vary with hardness, with less stringent criteria at higher ambient hardness. U.S. EPA’s recommended water quality criteria for copper apply the Biotic Ligand Model (BLM) to determine criteria based on temperature, pH, dissolved organic carbon (DOC), calcium, magnesium, sodium, potassium, sulfate, chloride, and alkalinity [45]. Also, ammonia criteria vary with pH and temperature. In such cases, the environmental conditions selected for the target should be consistent with the impairment, and with the appropriate critical conditions. For example, for impairments caused by metals toxicity, the highest metals concentrations are often observed under low flow conditions. In this case, a low-flow ambient hardness concentration should be used to calculate metals criteria and set the TMDL target. Similarly, dissolved oxygen problems typically occur under low flow, and high temperature conditions. Environmental conditions consistent with the impairment should be used in setting an appropriate TMDL target.

Target selection is a critical step in the TMDL process. Selection of an inappropriate target, or applying the target inappropriately can lead to a TMDL instead of a delisting, or to overly restrictive permitting requirements. Electric utilities should scrutinize both the TMDL target and how it is applied. If the target is not applied in a manner consistent with the impairment, stakeholders should comment and request revisions to the target.

3.3 Source Assessment: what Loads Contribute to the Problem?

If a target was appropriately selected and applied, the next TMDL component to review is the source assessment. A source assessment identifies and characterizes individual pollutant source(s), or categories of sources that are responsible for water body impairment, and quantifies the degree to which each source contributes to the problem [46]. The source assessment step is important to electric power utilities because it defines the contributing sources and quantifies the current pollutant load from these sources. The calculated load, will ultimately affect the degree of control that will be required to meet the TMDL.

Pollutant sources can be grouped into two categories: point and nonpoint sources. Point source loads are discharged from a pipe, ditch or other well-defined source and include National Pollutant Discharge Elimination System (NPDES) -permitted dischargers [27]. In certain instances described in this section, storm water runoff is covered by NPDES permits. Nonpoint source loads can be attributed to anthropogenic or non-anthropogenic origins and include runoff from different land uses (e.g., agriculture, residential), atmospheric deposition, legacy sources (e.g., lake sediments) and background sources [27]. Background sources are those which are typically natural in origin and which cannot be controlled.

This section is designed to follow the flow of Figure 3-4, to guide determination of what loads are contributing to the problem. Subsections will address the following questions:

- Are all potential sources identified?
- How were loads calculated?
- Is my load potentially important?

A more detailed decision tree flow chart for this process is provided in Figure B-4 of Appendix B.

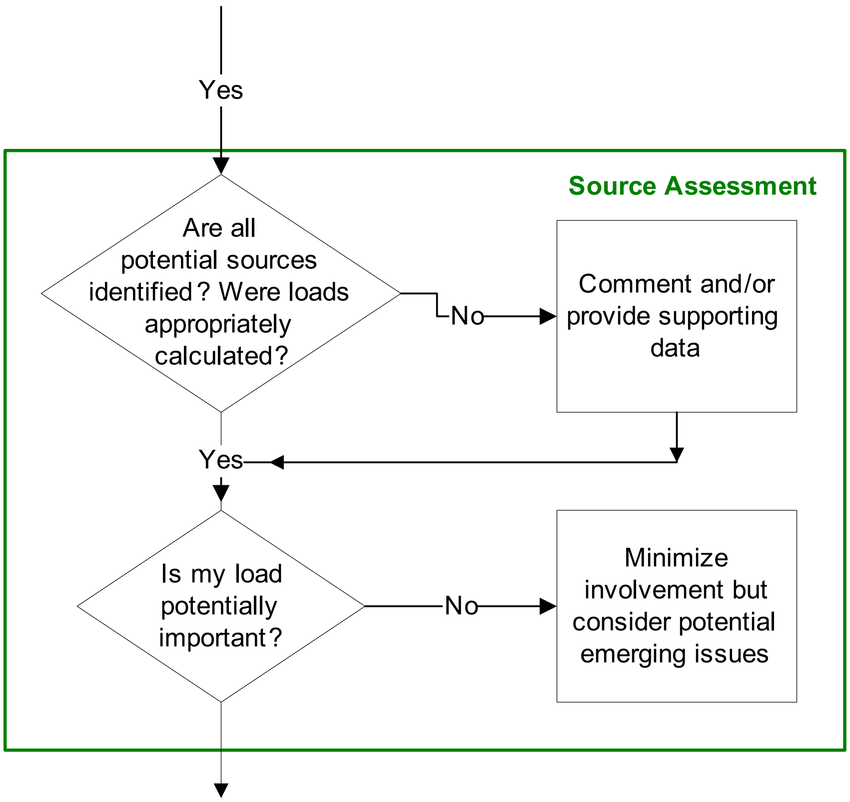


Figure 3-4
Source assessment decision tree

3.3.1 Are All Potential Sources Identified?

The TMDL should identify point and nonpoint sources contributing to the impairment. The TMDL should consider those sources that are located within the geographic area defined within the TMDL and should include those that have a potential to contribute to the problem. If a potentially important source or group of sources has been omitted or incorrectly located within the watershed, it may be useful to provide comments or additional information to the state.

The geographic area and specific waterbodies covered by the TMDL should be described in the TMDL report or identified on a map. For many TMDLs this area will consist of the watershed draining to the impaired waterbody. This watershed may include all upstream sources, even those far upstream of the impaired segment. Alternatively, the TMDL may only address sources that discharge directly to the impaired segment, and may combine all other upstream sources as a boundary or upstream tributary load. In some cases, the upstream boundary may be defined at a political boundary such as a state line.

For regional or state-wide TMDLs (e.g., mercury TMDLs), waterbodies with similar impairments may be grouped together. In such cases, the geographic area covered by the TMDL may be much larger. The TMDL should provide information on the factors used to group multiple waterbodies (e.g., do the waterbodies have similar fish mercury levels) and for multi-state TMDLs, should take into account differences across multiple states [47].

Throughout the process of identifying and assessing point and nonpoint sources, it is important to understand which pollutants are associated with each source or source category. It is also important to understand the conditions under which the impairment has been observed. The load duration approach (see Appendix C) is one method that can be applied to assess seasonal water quality effects and help differentiate between point and nonpoint source problems.

3.3.1.1 Point Sources

Information on currently permitted point source discharges is typically available from the state or through the U.S. EPA Permit Compliance System (PCS) database, which can be searched based on geography [48]. The list of permitted point sources should be reviewed to determine which facilities are currently active and where the facilities and their outfalls are located. This step is most easily conducted using a geographic information system (GIS), and location information in GIS format may be available from the state or U.S. EPA. The location of these sources and the effluent receiving water should be verified by TMDL developers through calls to the facilities or a site visit because the location information provided to the state is sometimes incorrect (e.g., location is for a billing address, and not the location of the permitted facility or outfall).

Three types of storm water discharges are currently covered under the NPDES program and as such, are also considered point sources. These are:

- Discharges from medium and large (Phase I) Municipal Separate Storm Sewer Systems (MS4s) and small (Phase II) MS4s located in “urbanized areas” as delineated by the Bureau of the Census;
- Discharge from industrial facilities in 11 categories that discharge to an MS4 or to waters of the United States (construction activity is one of these 11 categories, but because of the nature of its operations, it is addressed separately from the other 10 categories.); all categories of industrial activity (except construction) may certify to a condition of “no exposure” if their industrial materials and operations are not exposed to storm water, thus eliminating the need to obtain storm water permit coverage; and
- Discharges from construction activity that disturbs one or more acre of land; construction sites less than 1 acre are covered if part of a larger plan of development [49].

Information on MS4 and construction permits should be available from the state or U.S. EPA. Information on permitted storm water discharge from industrial facilities should be available in the U.S. EPA PCS database.

3.3.1.2 Nonpoint Sources

Nonpoint sources originating in the watershed are typically identified using land use or land cover maps. This information is often a good starting point, but because it can be outdated, it is best to conduct a site visit. The site visit can provide information on current conditions and inform how the land is being used (e.g., are there livestock grazing on the pasture land or is it solely used for grain crops).

Atmospheric deposition may or may not be identified as a nonpoint source. Its inclusion often depends on the pollutant of concern. For example, atmospheric deposition is likely to be identified as a source in mercury TMDLs, but not in bacteria TMDLs.

Natural background conditions can be an important consideration for some pollutants. Natural background conditions exist when there is no measurable difference between the quality of water now and the quality of water that would exist if there were no human-caused changes in the watershed.

Legacy pollutants are those that persist in the environment, after their use has been banned or severely restricted. Even though these pollutants are no longer generated, they may be a significant nonpoint source. Many pesticides such as DDT, toxaphene and chlordane are considered legacy pollutants, as well as PCBs and mercury. Legacy sources of mercury may originate from abandoned mines, past industrial discharges, or past atmospheric deposition. Legacy sources should be separated from current sources (e.g., current atmospheric deposition), so that the TMDL accurately reflects achievable reductions and the time required the achieve compliance.

Case Study: ***Upper Coosa River – Nonpoint Source Characterization***

This case study provides an example of a TMDL review where an electric utility questioned the nonpoint source characterization. Georgia Environmental Protection Division (GAEPD) developed a dissolved oxygen TMDL for the Upper Coosa River under a tight, court-ordered schedule [28].The final allocation included reductions of biochemical oxygen demand (BOD) loads by point source dischargers and a reduction of a heat load by a coal fired plant operated by Georgia Power. A group of several stakeholders, including Georgia Power, collectively challenged this TMDL. One challenge point was that only a minimal consideration was made for nonpoint sources [29].

Though the TMDL document notes nonpoint source runoff as a potential cause of impairment, the source assessment section of the TMDL did not provide a calculation or estimate of nonpoint source loading or loading from stormwater associated with MS4s 28]. Tributary inputs for the model were calculated from observed flow and water quality data. The final allocation focused only on point source reductions and listed a stormwater WLA of zero due to the TMDL being based on critical conditions with a 7Q10 flow. The nonpoint source load allocations reflect no reduction of loads and were set to equal the stream, tributary, and headwater model boundaries under critical conditions. TMDL recommendations discuss potential future watershed modeling to better predict nonpoint source loads, and the initial implementation plan includes a discussion of BMP demonstration projects. Since the challenge, EPA has withdrawn the TMDL and a four-year study is underway to collect additional data and improve modeling. The revised TMDL is expected by 2009.

3.3.2 How were Loads Calculated?

The TMDL should document data and methods used to calculate loads for identified sources. Documentation is important because it will allow others to properly review the calculations and any assumptions during the public comment period. The accuracy of these calculations directly depends on the accuracy of the data that are used. Data that reflect observed conditions in the watershed or measured discharge concentrations are greatly preferred over information obtained from literature or similar watersheds.

In reviewing the data and approach used to calculate point and nonpoint source loads, the TMDL reviewer should look for overly conservative assumptions. These assumptions will lead to an overestimate of the current load, and may ultimately result in a greater load reduction required by the TMDL. The reviewer should provide comments to the state that the assumptions are too conservative, or suggest that additional data collection or application of a more detailed model is appropriate.

3.3.2.1 Point Source Loads

Point sources may be continuous or intermittent. Continuous sources may include power generating facilities or permitted treatment plants that discharge year-round. Intermittent sources may only discharge under certain conditions (e.g., storm water runoff or combined sewer overflows that discharge during wet weather). When calculating loads for a discharger, it is important to understand when the discharge occurs and make sure that you have data that reflect any significant variations in effluent flow or concentrations.

NPDES permits frequently include monitoring requirements. Data collected by the dischargers are reported to the state on forms called Discharge Monitoring Reports (DMRs). Information reported may include flow, concentrations and/or loads for influent and/or effluent. Data may be reported for multiple intake and outfall locations and the monitoring requirements may vary by location. When reviewing monitoring data, it is important to understand where the sample was collected. In some cases, especially for facilities that intake water from the same river that they discharge to, credit (i.e., intake credit) should be given for background pollutant levels. In these cases, the load contributed by a facility should reflect the net load, or difference between the effluent and influent load. Evaporative losses of cooling water at a power generating facility may result in a pollutant becoming more concentrated in the effluent. In this case, it is important to look at the difference in influent and effluent loads, not concentrations, to assess whether a facility is adding a pollutant load to the receiving water beyond the background load.

Loads from permitted dischargers may be estimated a number of ways. The preferred approach is to use monitoring data that are representative of current conditions, if available. Because effluent volume and quality can vary seasonally due to plant operation or permit requirements, or annually (e.g., due to a change in plant operation), it is best to obtain the most recent monitoring data for a facility to characterize its current loads. If a discharger reports flows and concentrations as part of its permit requirements, then this information can be obtained from the DMRs. DMRs are available from the state and can also be found on-line in U.S. EPA's Permit Compliance System (PCS) database [48].

If monitoring data are not available, then loads may be calculated using a facility's permit limits or literature-based estimates. These approaches are not preferred and the uncertainty of information should be factored into the TMDL. If a facility's permit limits are used to estimate loads it should be recognized that facilities often discharge less than their permit allows. In the absence of data, literature-based estimates can be used to characterize effluent concentrations or effluent loads for similar types of facilities.

NPDES-permitted storm water loads may be calculated from monitoring data, if available. However, monitoring data may not be available for all NPDES-permitted storm water sources (e.g., Phase I storm water permits for medium and large MS4s have monitoring requirements, but Phase II storm water permits for small MS4s typically do not). If monitoring data are not available, then the contribution from these areas can be calculated using nonpoint source load estimation methods that are described in the following section.

If additional data are identified that should have been used to calculate loads, then it may be beneficial to provide comments to TMDL developers that these data should be used. This may include site-specific data for an electric generation facility which is more accurate than permit limits or literature values used for estimating loading.

3.3.2.2 Nonpoint Source Loads

Source assessment for nonpoint sources should differentiate between controllable nonpoint sources (e.g., runoff from developed or agricultural land, or atmospheric deposition) and natural background sources that cannot be controlled. If background sources are not estimated properly, unrealistic nonpoint loading reductions and load allocations could be specified in a TMDL [27]. If natural background conditions are not identified separately, then it may be appropriate to comment that they should be handled separately within the TMDL. TMDLs may also include load contributions from legacy sources (e.g., lake bottom sediments). These sources may contribute a significant pollutant load, and an effort should be made to characterize the contribution from these sources. If these sources are significant, but are not included in the load estimation, then the contribution from other sources may be overestimated.

This section provides an overview of several approaches, both simple and complex, that may be used to estimate the magnitude of both controllable and background nonpoint source loads. Reports by WERF and U.S. EPA provide additional information on nonpoint source estimation methods [27, 50]. The WERF report also contains an entire chapter dedicated to estimating background loads [27].

The decision of whether to apply a simple load estimation approach or more complex approach must balance competing demands. Management objectives typically call for a high degree of model reliability, although available resources are generally insufficient to provide the degree of reliability desired. Decisions are often required regarding whether to proceed with a higher-than-desired level of uncertainty, or to postpone modeling until additional resources can be obtained. There are no simple answers to these questions, and the decisions are often made using best professional judgment.

Simple Watershed Load Approaches

Simple watershed load approaches provide reasonable and adequate estimates of nonpoint source pollutant loads, although uncertainty may be higher than desired. They are often used when data limitations and budget and time constraints preclude the use of complex models [50]. With the exception of instream load calculations, these approaches are most useful where an annual load estimate or an estimate of relative loads from different sources is sufficient. These approaches can also provide a "reality check" against predictions from more complex models within an order of magnitude. Simple methods are typically applied using literature-based values (e.g., land-use specific runoff concentrations or loading rates), which introduce a high level of uncertainty. Furthermore, simple methods are not well suited for assessing seasonal or annual variability, or any pollutant decay, transformation or settling that may occur as the load travels to the listed waterbody. Finally, these methods do not consider pollutants associated with base flow conditions (e.g., dry weather sources) or ground water.

A number of simple approaches exist for estimating nonpoint source loads and some of the more common approaches are summarized in Table 3-1. These approaches generally apply to both controllable and non-controllable (background) sources. More detailed descriptions of these methods, including advantages and limitations, are provided in Appendix C.

Table 3-1
Simple approaches for estimating watershed loads

Approach	Data Needs	Output Timescale	Potential Accuracy	Calibration	Applicability for TMDL
Instream Load Calculations	High	Any	High	N/A	Good for defining existing total load; less applicable for defining individual contributions or future loads
Unit Area Loads	Low	Annual average	Low	None	Acceptable when limited resources prevent development of more detailed model
Simple Method	Low	Any	Low	None	Acceptable when limited resources prevent development of more detailed model. Applicable for urban areas.

Atmospheric Deposition

The contribution from atmospheric sources is important for some TMDL pollutants (e.g., mercury). The estimated atmospheric loading may be deposited directly to a waterbody or to the land. These depositions may be used as inputs to a watershed model to track transport of the pollutant. A simple approach for estimating atmospheric loads is to use areal deposition rates and the area of the waterbody and/or watershed of interest. Areal deposition rates are available in literature for some pollutants. Load estimates or loading rates may also be available through atmospheric monitoring networks such as the National Atmospheric Deposition Program (NADP) Mercury Deposition Network (MDN) (http://nadp.sws.uiuc.edu/mdn/) or the Integrated Atmospheric Deposition Network (IADN), which conducts air and precipitation monitoring in the Great Lakes basin (http://www.msc-smc.ec.gc.ca/iadn/index_e.html).

Case Study: ***McPhee and Narraguinnep Reservoirs – Atmospheric Deposition***

The McPhee and Narraguinnep Reservoirs mercury TMDL provides an example of a TMDL that incorporated atmospheric deposition [42]. This TMDL was phased, in part, because of uncertainty in the estimation of external loads, including watershed background, atmospheric deposition, and mining runoff.

Two large coal-fired power plants, located within 50 miles of the McPhee and Narraguinnep Reservoirs, and an additional 12 coal-fired plants within 200 miles of the reservoirs were identified as potential contributors to mercury deposition to the reservoirs. Direct atmospheric deposition to the reservoirs was estimated based on deposition rates from other sites, scaled by measures of atmospheric deposition of sulfate and nitrate in the vicinity of the reservoirs. Direct atmospheric deposition to the reservoir surface was identified as the primary source of mercury to Narraguinnep Reservoir, contributing approximately 47% of the existing load. Direct atmospheric deposition contributes a lesser proportion of the load to McPhee Reservoir, although the total load is higher due to the larger surface area of the reservoir. Mining operations contribute the majority (62%) of the mercury load to McPhee Reservoir, with watershed background loads representing 30% of the existing load, and direct atmospheric deposition to the reservoir surface accounting for only 8% of the mercury load.

Because of the lack of data, a "gross allotment" approach was taken, allocating loads to general classes of sources (atmospheric deposition, mining areas, background loadings, etc.), rather than to specific land areas within the watershed. Phase 1 of the TMDL included a preliminary allocation assessment and identified future data collection and analysis efforts to allow for a more refined allocation assessment in the future. These activities will be conducted in Phase 2 of the TMDL.

Watershed Models

More complex watershed loading models (e.g., WARMF, HSPF) can be useful tools for estimating nonpoint source loads. Watershed loading models simulate the generation and movement of pollutants from the point of origin to discharge into receiving waters in much greater detail than the simple methods listed above [50]. These models are able to describe current conditions and can also be applied to identify causes of problems and track instream loads back to a particular source. The application of more complex computer models to estimate nonpoint source loads can provide more accurate results if data and resources (e.g., modeling experts) are available to support model calibration. Additional detail on watershed modeling tools can be found in Section 3.4 (linkage analysis).

3.3.3 Is My Load Potentially Important?

Once the load from all sources has been quantified, it is important to determine the relative contribution from electric generation facilities as compared to other sources. If loads from electric generation facilities are significant, then it is likely a worthwhile investment of time and resources to continue with review of the Linkage Analysis step of TMDL development (Section 3.4). If electric utility loads are not potentially important, it may make sense to minimize your involvement in TMDL development. But it is still recommended that electric utilities monitor the progress of the TMDL. It may also be wise to consider whether any emerging issues (e.g., drought, climate variability) may affect the impact of a facility's loading in the future. It is important to monitor TMDL development within the state to see whether these issues are incorporated into other TMDLs.

Case Study: ***Middle Coosa River – Relative Load Contribution***

This case study provides an example of a situation where an electric utility may be impacted by a TMDL WLA though an initial assessment indicates their contributing load to be small relative to other sources. A draft TMDL for dissolved oxygen and nutrient enrichment in four reservoirs along the Middle Coosa River was released in 2008 [51]. The TMDL is focused on phosphorus because it was determined to be the limiting nutrient. Independent of the TMDL, Alabama Power quantified their phosphorus load from their Gaston Steam plant ash pond and found it to be minimal compared to loading coming from upstream [52]. Alabama Power is concerned that a point source reduction may still be required and it would be very difficult and expensive to treat their large volume of discharge (approximately 25 mgd) to remove a small portion of phosphorus. The WLA in the draft TMDL calls for a total phosphorus limit of 1.0 mg/L for "major" direct dischargers. The Gaston Steam plant is noted to be a "major" discharger.

Alabama Department of Environmental Management (ADEM) has discussed the situation with Alabama Power. The utility is looking at the potential of pollutant trading, however no formal trading program exists for Alabama [52]. Alabama Power would like to explore opportunities to get greater reduction from nonpoint dischargers for less cost. Most loading sources are from agricultural areas and cattle. At the time of this writing, the TMDL is open for public comment and review.

3.4 Linkage Analysis: what Science was used to Connect the Loads to the Water Quality Target?

After a TMDL target selection and source assessment are complete, a linkage analysis is performed to evaluate the receiving water's response to source loadings. The objective is to calculate the assimilative capacity of the waterbody to determine how much pollutant loading the system can handle and explore potential options to control the problem. This exercise is typically conducted using a model. The complexity of a model can range from a simple empirical data analysis to a complex mechanistic model. Electric utilities should evaluate this step to gain confidence in the scientific analysis that was conducted to link source loadings with a water quality target in order to calculate the overall target TMDL load.

This section follows the flow of Figure 3-5 to help determine if the linkage analysis was done appropriately by asking the following questions:

- Are resources sufficient given objectives?
- Is method properly applied?
- Is target load reasonable?

A more detailed decision tree flow chart for this process is provided in Figure B-5 of Appendix B.

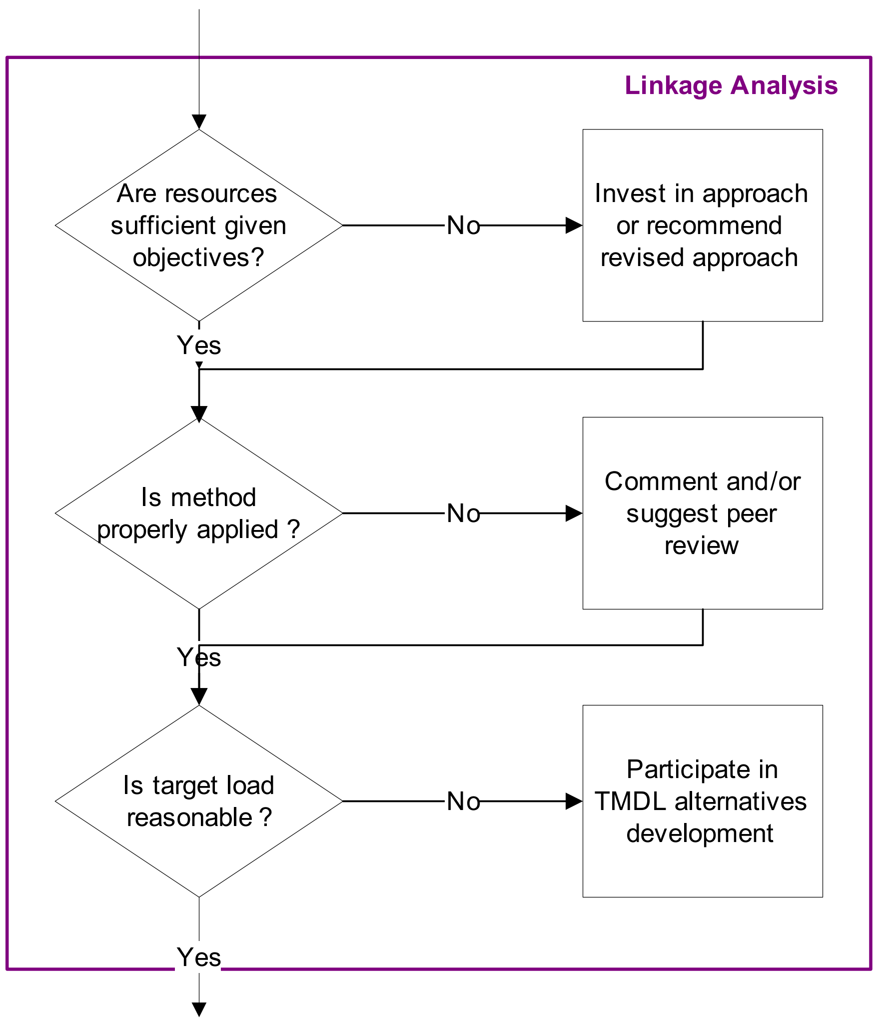


Figure 3-5
Linkage analysis decision tree

3.4.1 Are Resources Sufficient Given Objectives?

There is no one best model for TMDL development, and selection of the appropriate tool should be based on management objectives, site-specific characteristics, and resource constraints [53, 27]. Ideally, the TMDL development process should include a model selection step which considers these factors.

3.4.1.1 Management Objectives

The identification of management objectives includes defining what questions the model has to answer and at what levels of accuracy and precision. Obvious management objectives include defining the need to calculate the allowable loading of one or more TMDL pollutants in order to simulate a waterbody's ability to meet the defined water quality target. But objectives should also define the applicable spatial and temporal scales relevant to the target. For example, a dissolved oxygen TMDL criteria may be based on a daily minimum and it may be necessary to consider diurnal fluctuations throughout the day. Therefore a model with a daily or monthly time step may not be applicable. Another consideration is whether the waterbody is influenced by mostly point source, nonpoint, or a mixture of loads. Source assessment (Section 3.3) should define whether nonpoint sources are a significant. If nonpoint source loads are significant and control of these loads is likely to be an outcome of a TMDL, it may be appropriate to consider a watershed model with the ability to link watershed loads back to land use, rather than a simple empirical approach which does not distinguish between sources of loads. Other management objectives may include the selection of a model which is publically available, has been peer reviewed and/or is compatible with other watershed efforts.

3.4.1.2 Site Specific System Processes

Model selection should also consider the physical characteristics as well as the constituents and chemical/biological processes of interest, which are site specific for the TMDL watershed. The definition of which processes and characteristics are most important is best done through the development of a conceptual model, prior to the application of a computational model [53]. A conceptual model can simply be "back of the envelope" calculations which define the potentially important processes linking watershed causes (loads) to receiving waterbody effects. An examination of this conceptual model can help TMDL developers decide which processes are less significant and need not be represented in detail in the TMDL model. This will guide the model selection process so that the chosen model is only as complex as necessary without devoting computational complexity or data needs towards processes with minimal importance.

Case Study: ***Upper Coosa River – Model Selection***

This case study provides an example of a TMDL review where an electric utility questioned the model selection. Georgia Environmental Protection Division (GAEPD) developed a dissolved oxygen TMDL for the Upper Coosa River under a tight, court-ordered schedule [28]. The final allocation included reductions of BOD loads by point source dischargers and a reduction of a heat load by a coal fired plant operated by Georgia Power. A group of several stakeholders, including Georgia Power, collectively challenged this TMDL on several issues including an argument that the applied model did not adequately characterize the system [29].

The TMDL was based on a 1-dimensional river model (EPD RIV-1) that was previously applied by GAEPD to the Chattahoochee River. The Coosa River system is more complex than the Chattahoochee and the stakeholders questioned the model's applicability 29]. Recommendations in the TMDL document recognize the limitations of the 1-D modeling approach used and propose additional modeling activity to handle the hydrodynamic backwater impacts of Lake Weiss [28]. Since the challenge, EPA has recognized the flaws and withdrawn the TMDL. A four-year study is underway to collect additional data and improve modeling. The revised TMDL is expected by 2009.

3.4.1.3 Resources

Another consideration during model selection is the availability of resources such as data, time and expertise. Models must be based on an appropriate data set. Complex models generally require more data than simple models and typically include 1) physical data to characterize the system (e.g., channel geometry, meteorology, land use), 2) external loading/environmental data to drive model processes (e.g., point source loadings, air deposition), 3) process-related data to govern pollutant fate and transport (e.g., reaction and settling rates), and 4) ambient system response data to compare with model output (e.g., in-stream flow or concentrations) [53]. Data availability should be considered during model selection so that improper model application does not occur due to insufficient data.

Time is another resource important to consider during TMDL model application. The timeline of many TMDLs are driven by court-ordered deadlines. In these situations, there may simply not be enough time to properly apply a complex modeling tool. If it seems that a model application was rushed and inadequate time was available for data collection or proper calibration, it may be appropriate to evaluate and possibly question the model application.

Successful TMDL model application should involved technical experts with proper training and experience. The process requires a large number of judgment-based decisions. Insufficient funds to support qualified in-house staff or contracted experts to perform model application and calibration, may result in a poor model application. In this situation, it is possible that a more simple approach should be considered or TMDL developers should seek outside help.

There may be a discrepancy between available resources and the proposed model and management objectives. TMDL developers may be proposing to take on model application for which there is simply not enough data, time or expertise to support. Moving forward without considering resources could result in a poorly applied model based on insufficient data which was not adequately calibrated and therefore provides a weak scientific basis for making sound management decisions. It may be more appropriate for TMDL developers to consider a simple, yet robust approach for the TMDL and propose an adaptive or phased solution. As more time is available, more data are collected, and more knowledge of the system and processes are gained, a complex model can be developed to improve upon the preliminary, simple approach. If stakeholders are involved in the model selection process and it becomes evident that resources are limited, there may be an opportunity for an electric utility or group of stakeholders to contribute resources to better the TMDL development. Resource contributions may include the collection of data near your facility or elsewhere in the watershed to support a model application. It may also include stakeholders collectively funding model application and calibration to be performed by an outside expert (e.g., consultant or academic).

Case Study: *Delaware River Estuary PCB – Phased Modeling Approach*

A staged approach was taken for the development of the Delaware River Estuary PCB TMDL [54, 55]. The approach was identified as necessary due to several factors such as court ordered deadlines, difficulty in establishing applicable water quality criteria for a shared waterbody, emerging knowledge on system processes, and lack of data to quantify loadings. The Stage 1 TMDL met all required elements and was based on a water quality model for only one PCB homolog (penta-PCB). A final Stage 1 TMDL for total PCB was derived by extrapolation from the allocations developed for penta-PCB [56]. The model (modified from WASP5/TOXI5) avoids complexities of sediment transport, primary production, and sediment diagenesis but accounts for the influence of PCB sorption to organic carbon and interactions between the water column and bedded sediments. Model review by a panel of experts stated that the model reflects the current state of the art and is acceptable for a Stage 1 PCB TMDL. A Stage 2 TMDL is currently under development and will make use of additional data and modeling since the 2003 TMDL. The final allocation will be derived from the summation of the PCB homolog groups without extrapolation. The Stage 2 TMDL is targeted for development by December 2008 [57].

3.4.1.4 Model Selection

Consideration of management objectives, important system processes, and available resources should result in the selection of a linkage method or model appropriate for TMDL development. It is important to note that a more complex model is not necessarily more reliable than a less complex model, especially when resources (data, time, and/or staff expertise) are limited. This concept is shown in Figure 3-6. Usually with increased resources, additional data could be collected to support a more complex model. But, even if resources are unlimited, there becomes a point when utility and reliability (e.g., accuracy) do not increase, and may even decrease, with increased model complexity. This point occurs where additional processes are included in the model that are not clearly understood and/or described by the available data.

The key in balancing model reliability and model complexity is to select the simplest model that can answer the management questions at hand. If the relevant management questions being asked require a degree of reliability indicated as point A (Figure 3-6), it does not make sense to use more resources and increase model complexity in order to reach the complexity and reliability of point B. For either situation, the optimum point is the point on the curve where increasing model complexity does not add any additional reliability. The appropriate level of model complexity can be difficult to quantify and it is always best to begin with a simple model and increase complexity only if driven by management objectives and supported by project resources.

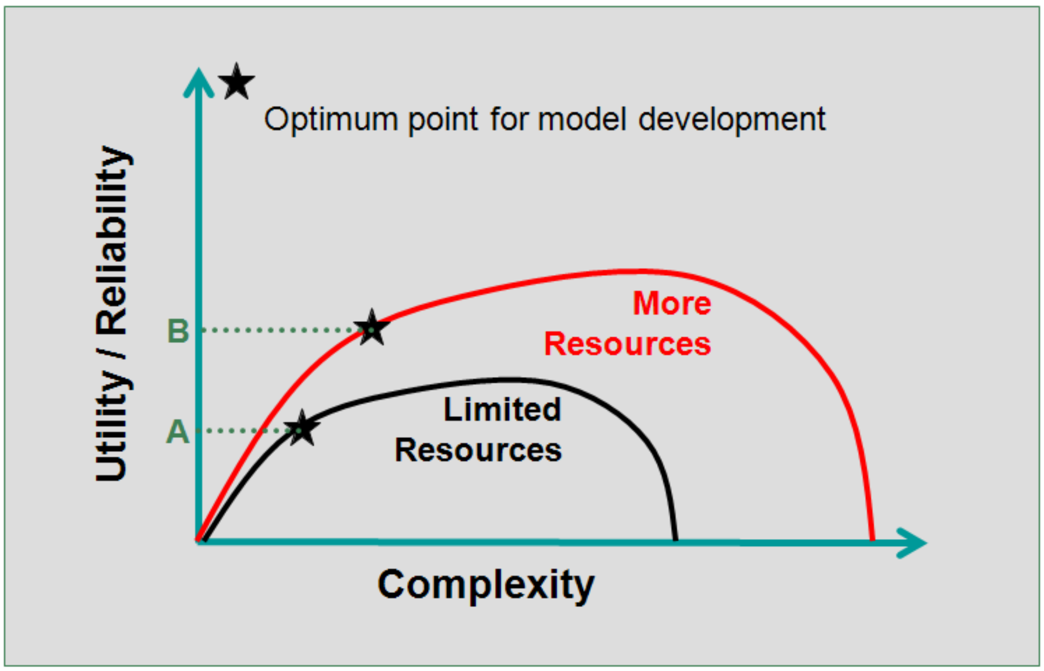


Figure 3-6
Relationship between model reliability and model complexity and available resources/data [52]

3.4.2 Is the Method Properly Applied?

After an appropriate model is selected, it can then be applied to estimate existing source loads as well as allowable loads to meet water quality standards. Whether the chosen approach for linkage analysis is simple or complex, it is important to consider whether or not the method was properly applied. The sections below describe relevant questions to ask and factors to consider when determining whether the selected approach properly documented the source of model inputs (with most inputs based upon site-specific data), and demonstrated that the model can accurately describe conditions in the watershed without arbitrary adjustment of model inputs.

3.4.2.1 Simple Linkage Methods

There may be several reasons for choosing a simple linkage method over a complex model. Sufficient data may be available to characterize the necessary loadings to meet water quality standards, therefore a model is not required. Or, limited data and/or resources may preclude a more complex model development. A few possible simple methods (e.g., reference watershed, pre-impairment historical data from the watershed, or an empirical model) are described below and for each method particular areas of concern are highlighted.

A reference watershed approach involves identifying a non-impaired watershed with similar characteristics and determining the current loading for the pollutants of interest through nonpoint source estimation methods as listed in Table 3-1 and described in Appendix C (e.g., instream load calculations, simple method, unit area loads). Pollutant loadings for the non-impaired watershed are used as a target for loading reductions and can be compared with the loadings of the impaired watershed determined during the source assessment to estimate the percent reduction required to meet water quality standards. If this approach is taken it is important that watershed characteristics such as area, slope, soils, and meteorology are as similar as possible to the impaired watershed. Differences between watersheds may include land use (e.g., urban development, agricultural) or point sources loadings.

A second simple linkage approach may be used if historical data provide information on loadings at a time when the waterbody was not impaired. If so, then the linkage analysis becomes a very straight forward method of comparing current impaired loadings to previously un-impaired loadings. From this difference a required load reduction can be calculated. Shortcomings of this approach include difficulty in obtaining quality data collected prior to anthropogenic impacts. For some parameters (e.g., mercury, PCBs, nutrients) it is important to note the associated detection limit differs between datasets. Also, TMDL developers and reviewers must consider the feasibility of returning the watershed to pre-impairment conditions due to irreversible changes to landscape or development, when projecting required load reductions.

There are several empirical approaches that can be used for TMDL source assessment and subsequently for linkage analysis, as described in Section 3.3.2.2. An empirical model consists of a mathematical function that passes through the site-specific data points to approximate the system. Although an empirical model cannot be used to explain a system, it can be used to predict behavior where data do not exist. Dilution calculations may be applicable with empirical data when the impairment needs to be evaluated at a single, discrete river location (e.g., attainment of standards is evaluated only at the outlet of a watershed) for a specified flow condition. The relationship between loading and resulting concentration is described by the simple dilution equation:

Concentration = Load/ Flow **Equation 3-1**

Where:

Concentration = Pollutant concentration in the river (mass/volume)

Load = Pollutant loads delivered to the river from all sources (mass/time)

Flow = Flow in the river (volume/time)

To calculate the TMDL when a dilution model is used, Equation 1 is rearranged to define the pollutant load that will result a specified pollutant concentration for a given flow condition:

Load = Concentration x Flow **Equation 3-2**

For TMDL purposes, the concentration used in Equation 2 corresponds to the numeric water quality target. The flow used in Equation 2 depends upon the duration and frequency specified by the water quality standard; specifically, the averaging period used for calculating flow must match the averaging period (duration) of the standard. For example, daily average flows must be used when defining the allowable load necessary to meet a daily average target, while annual average flows must be used when defining the allowable load necessary to meet an annual average target. Some water quality standards do not explicitly specify duration, and the TMDL developer must use judgment in selecting values for the environmental inputs used in the model. The load duration approach can be used to identify current and target TMDL loading under a range of flow conditions, as described in Appendix C and further in [27]. If empirical approaches such as these are employed to calculate a TMDL and required loading reductions, it is important that adequate data sets are available to support the development of curves under flow conditions of interest.

If a simple linkage method was chosen and it seems inadequate to answer management objectives (e.g., need to consider nonpoint source reduction on land use basis), it may be appropriate to suggest building upon the simple method to develop a more complex model to characterize the system. This process could involve additional data collection, investment of resources (e.g., time, funding, expertise). If movement towards a more complex modeling approach occurs during the TMDL process, the deadline for TMDL completion may be extended. However, if issues are raised after a TMDL is complete, a phased or adaptive TMDL may be considered. For watershed stakeholders, there may be opportunities to comment on the approach, collect more data, invest more resources into the process and/or assist in reviewing potential models for applicability.

Case Study: *Florida Statewide Mercury TMDL – Empirical Linkage Approach*

The Florida statewide TMDL for mercury is an example of a TMDL where linking pollutants to the waterbody endpoint is complicated due to regional differences in pollutant loading and response, and an empirical approach was chosen. A statewide approach to the mercury TMDL was chosen by the Florida Department of Environmental Protection (FDEP), rather than a waterbody or watershed-specific approach for two major reasons:

1. The primary source of mercury in Florida waterbodies is atmospheric deposition, which is fairly uniform throughout the State and is transported across watershed boundaries.
2. The number of waterbodies impacted by mercury is large (approximately 1,300), making development of a single statewide TMDL more cost-effective [58].

FDEP recognizes that many aquatic ecosystems (e.g., the Everglades, softwater seepage lakes, and upper stream reaches with high dissolved organic carbon) have heightened sensitivity to mercury loadings [58]. FDEP is planning an empirical linkage approach to describe mercury impact based on both the magnitude of loading and the waterbody's biogeochemistry using data from the state's large Status and Trends monitoring database. This database includes parameters that have been identified to be predictors of mercury levels in largemouth bass. The planned approach involves the following major steps:

- Defining various regions or lake districts within the states based on "bins" of waterbodies with similar biogeochemistry;
- Sampling a subset of waterbodies from each bin for mercury, methylmercury, water chemistry, and fish tissue mercury in largemouth bass;
- Analyzing the data from each subset within the various regions to develop multivariate relationships between the most-descriptive parameters and largemouth bass fish tissue concentrations;
- Verifying the model with an additional subset of waterbodies; and
- Using the Status and Trends database to develop cumulative frequency distributions of mercury concentrations in each region and using the distributions to calculate required loading reductions with a margin of safety included [58, 59].

3.4.2.2 Complex Linkage Methods

For TMDLs where multiple sources of pollutants contribute to the impairment, more detailed fate and transport models may be beneficial to better define the relationship between pollutant load and resulting water quality. A complex model is typically more challenging and resource intensive to set up but can offer more flexibility when tracking loads back to individual sources.

Two basic types of models, watershed and receiving water, are typically used in TMDL linkage analysis. Watershed models use inputs such as meteorology, topography, and land use to calculate rainfall-runoff and associated nonpoint source loadings from the watershed, as illustrated in Figure 3-7. A watershed model can be used for source assessment in place of a simple approach (as discussed in Section 3.3.2.2) and can also be used to project nonpoint loadings with revised land management or best management practices. Outputs from watershed models are then transferred to receiving water quality models to compute the response of the river or lake to loading sources. Some models contain both watershed and receiving water components so the modeling is done within a single framework. In other cases, output from a watershed model may be linked to a downstream receiving water model. Or, a simple source assessment method may be used to develop tributary inputs for a receiving water model. Many receiving water models are focused only on water quality and therefore require hydrology and/or hydrodynamic flow inputs. For steady state analysis, a pre-defined critical flow (e.g., 7Q10) may be used. For a dynamic analysis, a separate hydrodynamic model may be developed and coupled with a water quality model.

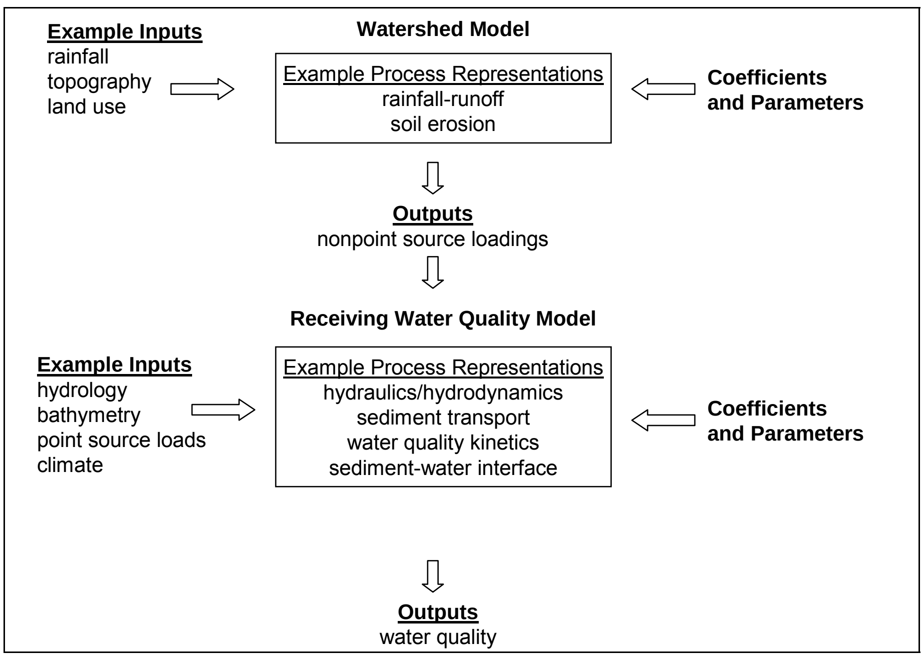


Figure 3-7
Conceptual modeling framework for the TMDL process [27]

There are a wide range of watershed and/or receiving water models that may be applied for a TMDL linkage analysis. Table 3-2 summarizes some important characteristics of a few models relative to TMDL application. Appendix C provides more detailed information related to each model's methodologies and suitability for defining water quality for TMDL development. Many of these models function in a similar way, but have different capabilities and requirements with respect to input data, scale, and applicability. All models described require ambient flow and concentration data for model calibration. The use of potential TMDL models is not limited to this list. Additional model descriptions and comparisons may be found in several reports [50, 60, 27]. A comprehensive summary of models suitable for use in mercury TMDLs has been developed by EPRI [15]. Also, the EPRI eWAM website (http://www.epri.com/ewam) provides additional model summaries along with links to download models and documentation [7].

Table 3-2
Moderate to complex approaches for calculating watershed loads and linkage analysis

Approach	Waterbody Type	Data Needs	Output Timescale	Complexity	Applicability for TMDL
GWLF	Watershed	Moderate	Monthly Average	Moderate; loading functions	Compromise between simple and more complex models
WARMF	Watershed/ River/Lake (1-D)	High	Daily/ Sub-daily	High; physically-based	Mixed Land Use; highly applicable if sufficient resources
HSPF	Watershed/ River (1-D)	High	Sub-daily	High; physically-based	Mixed Land Use; highly applicable if sufficient resources
SWAT	Watershed/ River (1-D)	High	Daily	High; physically-based	Strongest in agricultural watersheds; highly applicable if sufficient resources
QUAL2E	River (1-D)	Moderate	Steady State	Moderate	Good for low-flow assessments of conventional pollutants in rivers
BATHTUB	Lake (1-D)	Moderate	Steady State	Moderate	Good for screening-level assessments
WASP	River or Lake (1-D to 3-D)	High	Dynamic	High	Excellent water quality capability; simple hydraulics

For any of the models described above, similar questions can be asked to determine if the model was appropriately applied by considering the underlying conceptual model, outcomes of a formal peer review, and assessment of model inputs, assumptions, and calibration output.

Conceptual model

The foundation of any complex model should be a sound conceptual model which is ideally developed before model selection. Development of a conceptual model may include a list or box-and-arrow process diagram which describes state variables, potential processes and linkages which influence the waterbody (e.g., atmospheric deposition loading, nitrification). An order of magnitude calculation should be developed for each cause and effect process which is considered significant. These estimations can be done using data or simple “back-of-the-envelope” calculations. When evaluating the applicability of complex model for TMDL linkage analysis, a comparison between model output and estimations from a conceptual model can be used as a reality check. If loads from a specific source predicted by a complex watershed model (e.g., point sources relative to nonpoint sources) are significantly different than would be expected based on a conceptual model, additional investigation is warranted.

Model peer review

If a complex watershed and/or receiving water model is used for a TMDL, it may be beneficial for stakeholders to recommend a peer review, particularly if the TMDL involves complex, emerging science (e.g., mercury or PCBs), involves a unique application of a previously reviewed and accepted model, or involves a heavily controversial or politically charged situation where extensive stakeholder buy-in is needed for a successful TMDL process. U.S. EPA has developed guidance for implementing the peer review process for environmental regulatory models focusing on the review of models during the model development and pilot application phases [61]. The guidance recommends that the peer review be well documented and consider the following elements:

- Model purpose and objectives
- Major defining and limiting considerations
- Theoretical basis for the model
- Parameter estimation
- Data quality and quantity
- Key assumptions
- Model performance measures
- Model documentation and users guide

U.S. EPA recommends several options for conducting a peer review such as 1) using an ad hoc technical panel of at least three scientists, 2) using an established external peer review mechanism such as the Science Advisory Board or Scientific Advisory Panel, or 3) holding a technical workshop [61]. Alternatively, stakeholders may chose to independently contract with outside consultants or academic experts to conduct a model review, partially removed from the TMDL development process. If a model peer review is to be conducted, an electric utility may consider contributing to the process through expertise (by participating as a member of a peer review panel), or through shared financially responsibility to compensate external scientific experts to conduct and perform the review.

Case Study: *Lake Ontario PCB TMDL – Peer Review*

The Lake Ontario PCB TMDL provides a good example of a model peer review effort which helped reassure the involved agencies (U.S. EPA, Environment Canada, NYDEC, Ontario Ministry of Environment) and other stakeholders of the science behind the TMDL model development and analysis. A technical model peer review of LOTOX2 was proposed and paid for by EPA-Region 2. A panel of 11 model peer reviewers was selected by EPA-Region 2 and included a cross-section of experts from involved federal and state/provincial agencies, academia, and research organizations. Both U.S. and Canadian experts were represented on the panel.

Prior to gathering for a workshop, model reviewers were given model documentation and asked to evaluate details as thoroughly as possible by responding to a set of questions developed by U.S. EPA [62]. Questions focused: on overall performance of hydrodynamics, transport and transformation processes, and food chain bioaccumulation mechanisms; adequacy and quality of model input data; model assumptions; model applicability and performance measures; and general topics such as model strengths and weaknesses, and the consistency of model predictions compared to data and best-available understanding of Lake Ontario's internal processes and functions.

Reviewers were asked to consider two approaches during evaluation: 1) a purely objective and scientific evaluation, and 2) a practical evaluation of model success in the context of resources spent while considering costs and results of similar Great Lakes modeling efforts. During a two-day technical workshop, model developers presented model history, development, application, calibration, and confirmation. A model demonstration was provided and future model modifications were discussed. The agenda allowed for designated "questions and open discussion" blocks of time interspersed between technical presentations. Reviewers were given one month to supply written comments to the peer review facilitator (from U.S. EPA) for compilation.

The outcome of the peer review was positive. A LOTOX2 Peer Review summarizes comments of support by the majority of reviewers, the reviewers' recognition of budgetary and data constraints, and a set of specific recommendations for further development organized in terms of priority [63]. Since the LOTOX2 peer review, the model was enhanced to include a Niagara River component, expanded to include recent data sets, and confirmed against new data sets. At the time of this writing, the Lake Ontario PCB TMDL is still under development and expected to move forward to completion by 2010.

Model Application and Calibration

Whether or not a formal peer review is conducted, an evaluation of model application and calibration is typically warranted. If possible, TMDL stakeholders should review model results and assumptions to determine if output is reasonable. The model application process should thoroughly document the source of all model inputs. These inputs may include physical data to set up the model, external loading/environmental data to drive the model, and process-related data to govern pollutant fate and transport. In addition, model documentation should describe any assumptions made to characterize the system. The accuracy of model predictions directly depends on the accuracy of the model inputs. Site-specific model inputs based on observed watershed conditions are greatly preferred over model inputs based upon values obtained from the scientific literature or other watersheds. In particular, data that characterize watershed properties (e.g., land use), watershed inputs (e.g., point loads, meteorology) and watershed outputs (e.g., stream flow and quality) should be site-specific. Model applications that obtain the majority of their inputs from other sites should be carefully scrutinized. However, data used to parameterize watershed processes (e.g., soil physical and chemical properties, deposition velocities) are typically less available, and it is generally acceptable for these inputs to be defined based on scientific literature.

Model calibration involves a comparison of model predictions to observed data, and the adjustment of model coefficients, within a reasonable range, to improve model predictions as compared to observed conditions. This process requires at least one additional data set, typically consisting of ambient flow and water quality data. Ideally, an independent data set is used for model confirmation where the calibrated model is applied without adjusting model coefficients. Both subjective and objective approaches should be used to assess model calibration and confirmation. A subjective visual comparison can be made of model results to observed data (e.g., temporal or spatial plots, or calculated vs. observed scatter plots). Statistical comparisons (e.g., relative error, root mean square error) are typically used for an objective comparison. There are no rules defining what constitutes an acceptable comparison. At a minimum, the TMDL must discuss the magnitude of the differences between predictions and observations and justify that the level of error will still result in a credible TMDL. A model application that does not provide some demonstration of its ability to describe actual conditions should not be used to develop TMDLs. If review of model application and calibration indicates a problem, stakeholders should provide comments which suggest a recalibration of the model or an effort to collect more data to provide better model inputs or a basis for calibration. These additional efforts may require an adaptive approach for the TMDL.

Case Study: *A Northeastern Reservoir*[1] *– Model Calibration*

This dissolved oxygen TMDL provides an example of how a utility challenged a TMDL based on shortcomings related to modeling. An electric utility owns the dam that creates an impoundment in the Northeastern United States. In 2005, the State issued a TMDL for the reservoir. The TMDL phased implementation plan required pollutant reductions for upstream dischargers. In a later phase of implementation, the electric utility will be required to install and operate an oxygen diffuser.

The electric utility identified several questions related to the modeling that the State used to support the need for a diffuser. The utility hired a consultant to review the model, and they identified serious errors in the model calibration. The consultant subsequently provided expert testimony on behalf of the utility, and the State was directed to redo the TMDL scenarios with the corrected model. The scenarios are not yet finalized, but it is expected that the resulting TMDL will be more favorable to the electric utility than the initial TMDL.

[1]Note: TMDL case study is written as confidential at the request of involved parties.

3.4.2.3 Uncertainty

Whether the TMDL linkage analysis is based on a simple method or a complex model, there should be consideration of uncertainty. At a minimum, uncertainty is accounted for in the Margin of Safety (MOS) component of a TMDL allocation (see Section 3.5). However, uncertainty estimates related to pollutant source loads may provide insight when considering potential source reduction strategies such as BMPs.

For simple source assessment and linkage approaches uncertainty analysis is typically performed using a statistical method (e.g., first order error analysis, modified Latin Hypercube approach, or modified Chebyshev inequality) or a computationally intensive error analysis (e.g., Monte Carlo simulations, or regional sensitivity analysis) [27].

For more complex, deterministic models, the approaches mentioned above may or may not be practical depending on the number of model inputs and computation time. For most models, a sensitivity analysis is performed to better understand uncertainty. This exercise involves performing a set of simulations which varies by systematic adjustment model inputs such as reaction coefficients, loads, or fluxes. These model inputs should be adjusted within a reasonable range as specified in literature or based on local system knowledge. By understanding how much resulting water quality varies within a range of inputs, TMDL developers will have a sense for how much confidence can be placed on model predicted loads in the context of decision making.

3.4.2.4 Critical Conditions

Another important consideration during the calculation of a TMDL is the selection of critical conditions. A critical condition is defined by U.S. EPA to be:

> "... the 'worst case' scenario of environmental conditions in the water body in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence." [64, 43].

For most TMDLs, streamflow is typically the basis for the critical conditions, whether it is low flow or high flow conditions. For systems impaired for low dissolved oxygen and influenced by point source loads of oxygen consuming pollutants (e.g., BOD), the critical condition is usually defined as a low flow condition (e.g., 7Q10 flow). For systems dominated by nonpoint sources under high flow events (e.g., suspended sediment) a critical condition may be associated with a percent exceedance flow calculated from historical records. For some bioaccumulative pollutants (e.g., mercury or PCBs) harmonic mean flows may be selected to reflect long term averages. For some pollutants, the critical conditions may depend on factors other than flow such as pH (for metals or ammonia toxicity) or hardness (for metals). For any TMDL, the critical conditions used as the basis for the TMDL load calculation should be clearly documented. As a TMDL reviewer, stakeholders should consider whether the approach was appropriate. A WERF report provides additional guidance on the selection of critical conditions [27].

3.4.3 Is the Loading Capacity Reasonable?

The final step of a linkage analysis is the calculation of the loading capacity. This is the total allowable load that a water body can receive and still meet water quality standards. From this total, an allocation will be developed to divide the load between point and nonpoint source contributions and a MOS (see Section 3.5). If a simple linkage approach was used, the TMDL target load calculation is typically straightforward and represents a general percent reduction as compared to estimated existing loads. More complex linkage approaches, which use models to differentiate between point and nonpoint loading contributions, allow the flexibility to test various options of potential TMDL solutions. Not one single solution, but a matrix of potential solutions, can define an acceptable TMDL load which allows the waterbody to support beneficial uses.

When calculating TMDL loading capacity, models are run in an iterative fashion, with different test loading scenarios to determine which will result in compliance with the water quality target (Figure 3-8). First, the watershed model is run using inputs describing point source loads, land use and land management practices to produce pollutant loads for input to the water quality model. Depending on the modeling framework, the watershed and water quality model may be united or represented separately. The water quality model output is then compared to the TMDL target to determine if acceptable quality is predicted. Assuming that the initial simulation does not result in acceptable water quality, point source loads and watershed model inputs on land management practices are adjusted to reflect pollution control activities, and the models are re-run. This cycle continues until a scenario is defined that results in acceptable water quality, defining the TMDL pollutant loads.

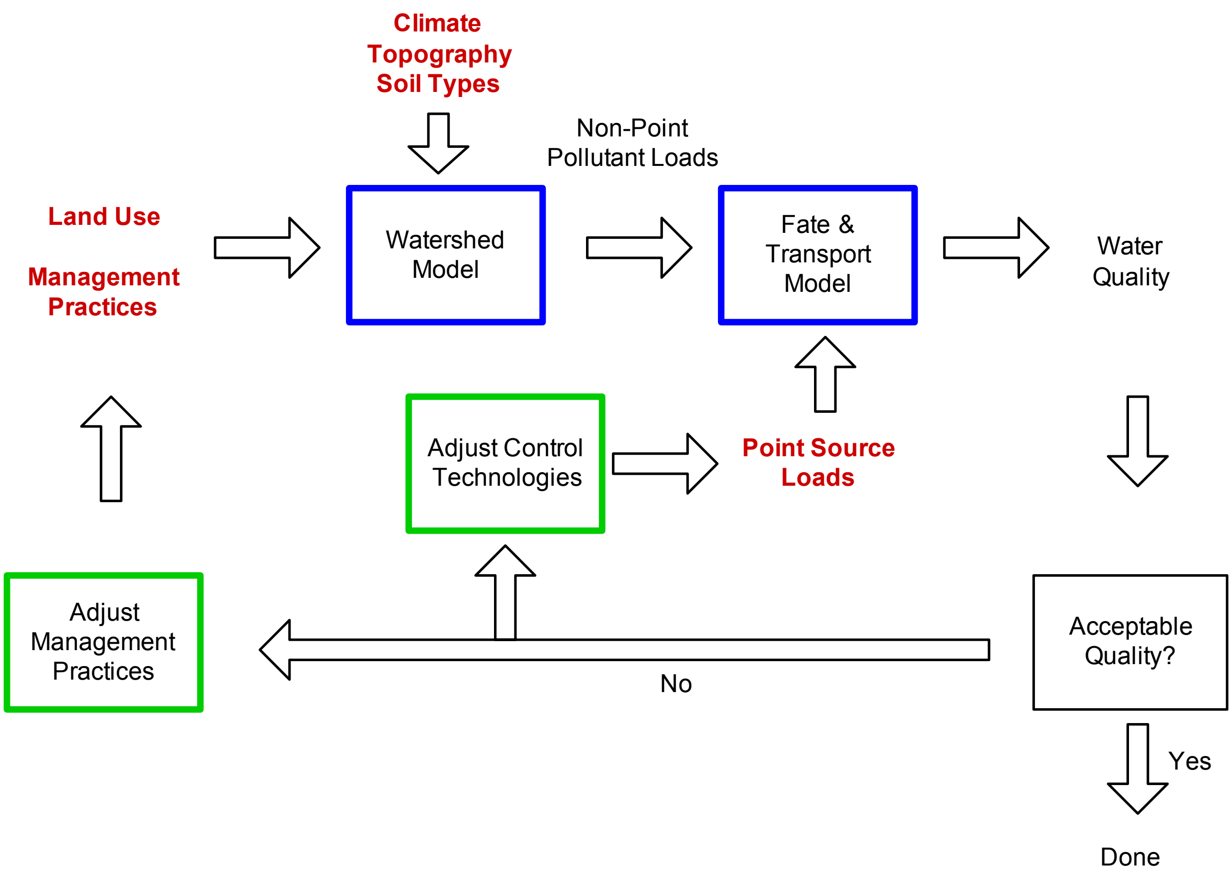


Figure 3-8
Calculating maximum allowable load with a fate and transport model using iterative approach

For many watersheds, a matrix of possible TMDL loading capacities can be developed, which represent different combinations of point and nonpoint source loads, that allow for beneficial use attainment. Ideally, the iterative process of developing this matrix of possibilities should be an open, stakeholder driven process. There may be opportunity for stakeholders, such as electric utilities, to get involved and provide valuable input to help screen out unrealistic or undesirable solutions which focus only on point source reduction without considering reduction to other sources. Though this step does not define individual allocations, proportions of allowable loads explored during the linkage analysis modeling often provide the basis for more detailed allocations as described in the next section.

3.5 Allocation: How was the Allowable Load Divided?

The objective of the allocation step is to define how much of the total allowable load is given to the various contributing point and nonpoint sources, as well as a Margin of Safety. This step is very important because it defines how much of the total allowable load will be allocated to utility industry sources.

The standard TMDL equation is written as:

$$TMDL = \Sigma WLA + \Sigma LA + MOS$$ **Equation 3-3**

Where

TMDL = Total Maximum Daily Load

WLA = Wasteload Allocation, given to each contributing point source

LA = Load Allocation, given to each contributing nonpoint source

MOS = Margin of Safety, to account for uncertainties in the analysis

No explicit guidance exists defining how allocations are to be made, although it is understood that equity in burden among affected parties and cost-effectiveness of controls must be considered in defining allocations. These two objectives can conflict in some TMDLs where the most cost-effective controls require reduction in only a subset of the contributing source categories. The most cost-effective solutions are not the most equitable in these cases, as the sources that are most easily controlled would bear the majority of the burden for control. U.S. EPA states that allocation determinations are policy decisions and should reflect public perceptions about acceptable tradeoffs between overall costs and equity in reductions among sources [65]. Because allocation is a policy decision designed to reflect public input, it is important that the utility industry provide input to this step to ensure that the controls required are cost-effective and equitably determined.

This section is designed to answer the question: “How are the loads allocated?” As illustrated in Figure 3-9, subsections address the following additional questions:

- Is the allocation equitable?
- Is the allocation achievable?

Each of these questions is addressed below. A more detailed decision tree flow chart for this process is provided in Figure B-6 of Appendix B.

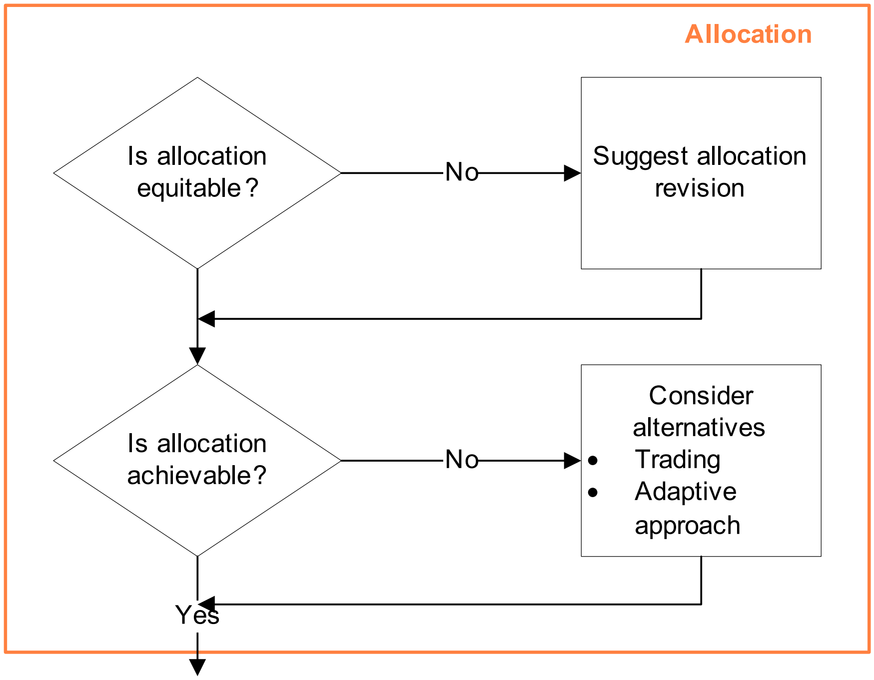


Figure 3-9
Allocation decision tree

3.5.1 Is the Allocation Equitable?

A wide variety of approaches may be taken in allocating the allowable load. In some TMDLs, all sources are required to reduce their contributions by the same percentage; in others, the level of reduction varies between point and nonpoint sources, and among individual sources. There is no "one size fits all" approach to allocating loads among sources.

Some of the questions to be addressed with regard to the allocation scheme include:

- Are the allocations specific?
- Are required reductions equitable among sources?
- Is a daily load expression required?
- Is the margin of safety documented, quantified, and reasonable?
- Are future growth assumptions appropriate?

Each of these questions is discussed briefly below.

3.5.1.1 Are the Allocations Specific?

Some TMDLs do not include specific allocations for individual sources; rather, they allocate allowable loads broadly to source categories. An example of this is provided in the case study below. If the allocations are not specific, a phased TMDL should be expected. Phasing allows initial reduction efforts to move forward while additional data is collected to refine the TMDL and allocations.

Case Study: ***McPhee and Narraguinnep Reservoirs – Non-Specific Allocation***

The McPhee and Narraguinnep Reservoirs mercury TMDL provides an example of phased TMDLs with non-specific allocations [42]. The Colorado Department of Public Health and the Environment (CDPHE) prepared TMDLs for McPhee and Narraguinnep reservoirs to address impairment due to mercury fish consumption advisories. Because of the uncertainties associated with watershed and reservoir modeling, and a need for additional data, phased TMDLs were prepared. One of the primary sources of uncertainty was uncertainty in the estimation of external loads, including watershed background, atmospheric deposition, and mining runoff.

Because of the lack of data regarding specific mercury loadings from various sources within the McPhee and Narraguinnep watersheds, a 'gross allotment' approach was taken, and loads were allocated to general classes of sources (e.g., atmospheric deposition, mining areas, background loadings) rather than to specific land areas within the watershed. A 75% reduction in atmospheric deposition loads to both reservoirs was proposed to meet the TMDL targets. The TMDL suggested that reduction in atmospheric loads might be achieved in part through reduced emissions at the major coal-fired power plants located within several hundred miles of the reservoirs, as well as through reduction of long-range background atmospheric load from more distant sources. Phase 1 of the TMDL identified additional data collection and analysis efforts needed to provide a more accurate identification and quantification of mercury loadings and develop more specific allocations. These activities will be conducted in Phase 2 of the TMDL, and the TMDL will be modified after sufficient data are available to refine the preliminary modeling and assessment.

3.5.1.2 Are the Required Reductions Equitable Among Sources?

A key decision in all TMDLs is a determination of how much of the available load should be allocated to each of the contributing sources. There is little guidance available related to these allocation decisions. U.S. EPA "encourages authorities to consider a range of allocation options that are technically feasible and demonstrate programmatic consistency," and notes that "allocation determinations are policy decisions and should reflect public perceptions about acceptable tradeoffs" between cost effectiveness and equity 65]. As an example, allocation strategies that minimize costs may be deemed unfair if particular sources are burdened with most of the cost, while allocations based on equal load reductions may be more costly [65]. These decisions apply to both allocation between point and nonpoint sources and allocation among individual point or nonpoint sources.

Examples of allocation schemes that can be applied to point and nonpoint sources include the following:

- Equal Percent Overall Removal;
- Equal Percent Incremental Removal;

- Equal Overall Reduction of Raw Load;
- Equal Incremental Reduction of Raw Load;
- Equal Cost per Pound of Pollutant Removed;
- Percent Removal Proportional to Raw Load per Day;
- Seasonal Limits based on Cost-effectiveness; and
- Minimum Total Compliance Cost [65].

Each of these allocation schemes has its benefits and drawbacks, and the best approach for a particular TMDL will vary based on site-specific factors. The allocation process must avoid using “regulatory convenience” as a means for setting allocations. Research conducted for WERF showed that a primary concern among TMDL stakeholders was that disproportionately large reductions would be required of NPDES permit holders, because point source limits are easier to enforce than nonpoint source controls [27].

Equity issues are particularly difficult when allocating between point and nonpoint sources because of the differences in the economic resources, available treatment options, and pollutant concentrations of point and nonpoint sources. The State of Florida has identified other factors that merit consideration in making allocations [66]. The factors below should be given consideration as appropriate, but must not replace consideration of equity and cost-effectiveness:

- **Existing treatment levels and management practices**: Sources that have already invested in pollution control efforts may be expected to have less reduction required under the TMDL than sources that have not implemented any controls. The case study below provides an example of an inequitable allocation in this regard.
- **Environmental and technological feasibility of achieving the allocation**: Control actions that are more certain to provide the expected reduction in pollutant load are preferred over controls with a higher degree of uncertainty.
- **Reasonable timeframes for implementation**: Control actions that will achieve benefits quickly are preferred over controls that will take longer to achieve benefits.

Case Study: *Limekiln Lake Phosphorus: Point-Nonpoint Source Allocations*

An example of an inequitable allocation between point and nonpoint sources is the Limekiln Lake draft phosphorus TMDL in Michigan. The draft TMDL proposed an across-the-board 47% reduction in phosphorus loads from both point and nonpoint sources. The point sources argued, however, that this was inequitable, given that they had already reduced their phosphorus loads by 65% over the previous two decades. During that same time period, nonpoint source loads had increased significantly. As the result of significant deficiencies in the draft TMDL identified by the point source dischargers, the TMDL was withdrawn, and Limekiln Lake was later delisted based on additional data collection [67].

3.5.1.3 Is a Daily Load Expression Required?

Many TMDLs are expressed with averaging periods longer than daily (e.g., monthly or annual) to be compatible with the time scale of the impairment (e.g., mercury TMDLs are developed based on long-term bioaccumulation in fish tissue). The results of recent litigation now require that, in some jurisdictions, load allocations include additional daily load expressions with the final TMDL submission. A 2006 District of Columbia (D.C.) Circuit Court of Appeals decision (Friends of the Earth, Inc. v. U.S. EPA, et al., No. 05-5015) held that two Anacostia River TMDLs did not comply with the Clean Water Act because they were not expressed as daily loads. In a subsequent memorandum,U.S. EPA stated that it is uncertain whether courts across the country will follow the reasoning of the D.C. Circuit [44]. Therefore, U.S. EPA recommends that all TMDL submissions include a supplemental daily time increment allocation. It is still acceptable for TMDLs to include non-daily pollutant load expressions, particularly to better address water quality standards and to account for seasonal variation and margin of safety.

In response to the 2006 *Friends of the Earth v. EPA* court decision, EPA developed a draft guidance document “to provide technically sound options for developing *daily load expressions* as a routine process in TMDLs calculated using allocation time frames greater than daily” [68]. This guidance presents a step-by-step process for deriving daily loads for TMDLs typically based on non-daily allocations, and summarizes the process into a flow chart with the following steps:

- Evaluate the current TMDL approach;
- Develop a daily dataset from non-daily output if needed;
- Select the appropriate daily load expression in the context of level of resolution (e.g., variability with respect to flow and/or time); and
- Select the appropriate daily load expression in the context of probability level (e.g., central tendency, 90^{th} percentile).

The inclusion of a daily load expression to supplement a longer-term loading capacity and allocation benefits the TMDL process by providing a tool for gauging whether load reductions are on track with meeting long-term TMDL allocations [68]. A monthly, seasonal, or annual allocation is useful for guiding management measures and implementation plans by considering the overall loading capacity of the waterbody. In contrast, a daily allocation represents a day-to-day snapshot of the loading capacity under ambient conditions.

Caution should be taken if regulators intend to use a daily expression of a TMDL load for the basis of a NPDES permit. NPDES permits are commonly written to specify daily maximum loads. This time frame is inconsistent with the time frames used in many TMDLs (e.g., seasonal, annual), requiring some degree of processing to convert TMDL allocations into permit limits. TMDL allocations expressed as daily loads have the same time scale as many NPDES permits, making it convenient for permit writers to incorporate TMDL results directly into a permit limit. While the direct incorporation of daily TMDL limitations into permit limits is not necessarily wrong, it must be done with extreme caution to make sure that the TMDL and permit numbers are directly comparable. The potential for incompatibility exists because the TMDL allocation is a planning tool and the NPDES permit is a compliance tool. The relationship between wasteload allocations and permit limits is explained in detail in U.S. EPA's Technical Support Document for Water Quality-based Toxics Control [69]. Prior to being used in a permit, wasteload allocations should be statistically converted into permit limits which represent the maximum effluent level that can occur before concluding with statistical certainty that a discharge is out of compliance with the desired long-term average.

Daily expressions of a longer-term load allocation should only be directly included in permits in cases where it has been demonstrated that the relationship between wasteload allocations and permits has been explicitly incorporated. For example, a TMDL with a non-daily allocation may result in a maximum average load of 365 lbs/year. One way to convert that to daily is to assume equal loading every day, and divide by 365 to get 1 lb/day. What the permit writer needs to define in terms of a daily maximum, is the highest daily load one would expect see in a system that is in compliance with the 365 lbs/year target. Given natural variability, it is not possible to achieve 365 straight days of 1 lb /day. Permit calculations should adjust the 1 lb/day to something slightly higher (e.g., 2 or 3 lbs/day) to factor in the natural variability. If a TMDL results in an expression of daily loads in addition to a more suitable longer-than-daily time frame, it is critical to pay close attention to how the permit writers translate daily and non-daily load allocations into permit limits.

Case Study: Anacostia River TMDL – Daily Load Expression

The Anacostia River total suspended solids TMDL was originally written to define allocations on a seasonal basis. As a result of a District Court ruling, the TMDL had to be revised in order to specify allocations on a daily basis. The original TMDL contained wasteload allocations for continuous point source discharges which were technology-based and represented average conditions. The desire of the permitting agency was to directly use the daily allocations specified in the TMDL as permit limits. In order to convert the long-term average allocations into daily allocations (and limits), the statistical permit derivation procedures described in EPA's Technical Support Document for Water Quality-based Toxics Control were used. Daily allocations were developed based on the long-term-average allocations, and calculated to be directly translated in to daily maximum permit limits [69]. Rather than simply performing a units conversion (e.g., 365 lb/year converted to 1 lb/day), the daily allocation and subsequent permit limits were set to reflect natural variability in day to day concentrations. Statistical calculations were used to establish the highest daily concentration that would be expected to occur in an annual time series of concentrations which achieved the long term average. These calculations produced daily allocations and permit limits much higher than 1/365th of the annual load, yet still expected to result in compliance with the long-term loading target [70].

3.5.1.4 Is the Margin of Safety Documented, Quantified, and Reasonable?

TMDLs are required to include a Margin of Safety (MOS) to account for uncertainty in predicting how well pollutant reduction will result in meeting water quality standards. The MOS is of interest to utilities because every pound of loading that is allocated to the MOS is one less pound that can be allocated to the contributing sources. No guidance exists on how large the MOS should be. Ideally, the magnitude of the MOS would be directly related to the uncertainty in the calculations, but in practice it largely a policy decision.

The MOS can be included in the TMDL using two different approaches, termed *explicit* and *implicit*. Explicit approaches directly allocate a portion of the TMDL to the MOS, typically identified as a percentage of the total allowable load. The explicit MOS used for most TMDLs is often arbitrary and often ranges from 10-25% of the total allowable load. An implicit MOS approach accounts for uncertainty by using conservative assumptions during the TMDL development process rather than setting aside a direct MOS allocation. Specifically, numerical values for TMDL inputs (e.g., water quality target, watershed model input coefficient) are chosen conservatively to represent inherent uncertainty. The outcome of these conservative input values will be a smaller WLA and/or LA for the TMDL. The primary drawback of the implicit approach is that the magnitude of the MOS is not explicitly defined. This results in an uncertain degree of protection, which can be problematic when numerous conservative assumptions are used in the same TMDL. Ideally, an implicit approach should include an estimate of the degree of protection to ensure that an overly large MOS has not been provided.

An EPRI report provides an extensive discussion of approaches for estimating the MOS including the sources of uncertainty in TMDL calculations, theoretical and practical considerations with regard to the MOS, and a recommended strategy for assessing uncertainty and developing an appropriate MOS [71]. WERF also addresses MOS in research related to improving the TMDL process and indicated that existing MOS practices were “varied, arbitrary and unscientific [27].” For example, six of the eight states surveyed had no standardized procedure for defining the MOS, and a review of 176 individual TMDLs showed that 58% specified an explicit MOS. Of the 103 TMDLs that specified an explicit MOS, 102 arbitrarily selected the MOS. None of the 56 implicit MOS TMDLs indicated the degree of protection provided by the MOS. Also, a review of 17 TMDLs found that explicit MOS ranged from 5% to 90% [27]. An improved approach for calculating an MOS, along with examples for application for real-world TMDLs, is provided by WERF [27]. The improved MOS approach is based on the following steps:

1. Specify desired level of protection
2. Choose method
3. Calculate MOS
4. Consider Implementation Feasibility [27].

Electric utility stakeholders should review the basis for the MOS and consider proposing an alternative strategy, as needed, to provide more equitable allocations.

3.5.1.5 Are Future Growth Assumptions Appropriate?

The TMDL allocation process should also consider the potential future growth in the watershed. This is typically accomplished by setting aside a portion of the TMDL loading capacity in reserve for future sources. This component of the allocation can be important to utilities in two regards. First, any portion of the TMDL that is allocated to future growth is no longer available for existing sources. For this reason, specification of too large of a future growth allocation can lead to overly-restrictive TMDL controls on existing sources. The second consideration is that some capacity for future growth may be needed to allow additional future development activities in the watershed, which would lead to increased demand for electric power. Guidance is still evolving on the exact means to consider future growth in all types of TMDLs, although a commonly accepted guideline is to account for “reasonably foreseeable” increases in pollutant loads when considering future growth. It is important to consider the nature of the pollutant in evaluating future growth. For example, a future growth set aside might be appropriate for a dissolved oxygen TMDL, where there may be a reasonable likelihood that future development will result in increased loads. However, for a PCB TMDL, it is unlikely that new or expanded sources would be permitted. In this case, a future growth allowance essentially increases the MOS and unnecessarily decreases the load allocated to existing sources.

3.5.2 Is the Allocation Achievable?

The TMDL allocation process must take equity and cost-effectiveness into consideration, although the balance between these considerations will vary on a case-by-case basis. Achievability has two components: technical achievability and economic feasibility.

Technical achievability is a significant factor to consider in evaluating the TMDL allocation. For some pollutants, adequate treatment technology does not exist for dischargers to meet very stringent effluent limitations. For example, a reduction of effluent mercury concentrations from 10 ng/l to 5 ng/l is not technically feasible [15] Also, power plant cooling water may contain very low pollutant concentrations but a high flow. Treating this high volume water to a lower concentration may be very difficult and/or expensive. Many point sources already employ the best available treatment technology, and further reductions may not be technically achievable. Also, electric utilities must constantly balance tradeoffs between reductions of air vs. water emissions.

Required reductions for nonpoint sources are difficult to evaluate, and can also be difficult to achieve. Information about best management practice (BMP) effectiveness is often not readily available, and many TMDLs do not provide support that selected BMPs will be effective in reducing loads [27] A significant concern for point sources is that if nonpoint sources are not reduced sufficiently, the waterbody will remain impaired, possibly requiring further reductions from point sources in the future. In addition, nonpoint source controls are more difficult to implement and achieve because there are fewer enforceable mechanisms to control nonpoint sources. For some TMDLs, there are also cross-jurisdictional issues, such as highlighted in the case study below.

Case Study: ***Lake Ontario PCB – Multiple Jurisdictions***

The development of a PCB TMDL for Lake Ontario provides a good example of an approach for allocating loads from a variety of source categories, many of which are outside the jurisdiction of the regulatory authority responsible for the TMDL.

Because of the challenges of doing a TMDL for a legacy contaminant like PCBs in a system that is bounded by two countries and has significant in-place and upstream/out-of-the watershed sources, a unique approach to allocating the TMDL among source categories was applied [35]. Each source category (e.g., upstream Lake Erie, atmospheric deposition, Canadian tributaries, etc.) that was outside the governing influence of the State of New York was assumed to be meeting its fraction of the target based on its fraction of the total load for 2005. For example, a source category that contributed 10% of the 2005 load was considered to be meeting 10% of the TMDL target load. Also, the TMDL calculation was made for steady-state conditions to remove the influence of sediment feedback of historical PCB loads on the target levels. At the time of this writing, the Lake Ontario PCB TMDL is still under development and expected to move forward to completion by 2010.

In addition to technical achievability ("Can the loads be reduced the required amount?"), economic feasibility must also be considered. From an economic standpoint, the optimal allocation strategy is one that achieves the necessary load reductions at the lowest overall cost. This can be achieved by evaluating the costs of all load reduction options from all contributing sources and focusing the allocation reductions on those sources that can be reduced most cost-effectively. This approach may require some type of cost-sharing to achieve an equitable distribution of burden among the contributing sources. This cost-sharing can be addressed through what is called water quality trading, where stakeholders with sources that are expensive to control contribute to the cost of load reductions from other more economically controlled sources [63]. Trading has been successfully implemented in a number of watersheds (see case study below). EPRI has also examined pollutant trading, specifically focusing on cross-pollutant trading, in which dischargers earn credits for reducing loads to the watershed of complementary pollutants that contribute to the same common water quality impairment [72]. This report reviews existing trading programs, with an emphasis on trade in discharges of interest to thermoelectric power generators, summarizes common features of successful programs, and makes recommendations for maximizing the likelihood of successful trading.

Stakeholders should carefully review TMDL allocations and consider a variety of options to identify and implement cost-effective, equitable, and achievable allocations as part of the TMDL. Water quality trading holds great promise to accomplish cost-effective water quality improvements, and should be explored as an option in TMDL allocation and implementation.

Case Study: ***Tualatin River - TMDL Trading***

Clean Water Services (CWS), a public utility located in the Tualatin River watershed in Oregon, discharges its treated wastewater and stormwater into the Tualatin River, which is listed by the state of Oregon as impaired by temperature, DO, bacteria, pH, and chlorophyll a. Loads of oxygen-demanding pollutants and heat from CWS facilities contribute to those impairments. Consequently, the 2001 Subbasin TMDL wasteload allocations require CWS to reduce its pollutant loads to the Tualatin River [73].

In 2004, the Oregon Department of Environmental Quality (ORDEQ) issued CWS a watershed-based NPDES permit, which consolidated seven individual permits (for wastewater treatment facilities, industrial stormwater, and municipal separate storm sewers) into a single, integrated municipal permit [74]. The CWS watershed-based permit allows trading of oxygen-demanding parameters, 5-day carbonaceous biochemical oxygen demand (CBOD5) and ammonia (NH3), within a single wastewater treatment facility or between two wastewater treatment facilities [75].The permit also allows two of the wastewater treatment facilities to offset thermal loads through riparian restoration, flow augmentation, and effluent reuse for irrigation [75].

CWS sought to develop a cross-pollutant trading program for CBOD5 and ammonia, in addition to thermal load offsetting, because trading provided CWS with a less expensive and more flexible approach to meeting water quality standards. This integrated and innovative method to watershed management will likely result in watershed benefits on a much larger scale, as well as the ability to handle an increase in water demand as population continues to grow in this area.

Temperature trading has been implemented and is currently underway. It is estimated that CWS will incur a cost savings of $42 million over a period of five years through temperature offsets as opposed to implementing more traditional approach, such as wastewater treatment technology upgrades [76].

3.6 Implementation: How will the Water Quality Goal be Achieved?

Once the TMDL has been calculated and loads allocated, the remaining step is implementation. Implementation planning is a common element of a TMDL (though not a requirement in all states) which provides clarity on what actions (e.g., pollution minimization, monitoring, water quality trading, permit limit changes) will be implemented, by whom, and in what time in order to achieve the TMDL. It is a critical part of the TMDL process, since water quality improvements are unlikely to be achieved without implementation of control measures. As shown in Figure 3-10, two primary questions for utilities to address with regard to implementation are:

- Does implementation affect me?
- Is reasonable assurance addressed?

Each of these questions is discussed below. A more detailed decision tree flow chart for this process is provided in Figure B-7 in Appendix B.

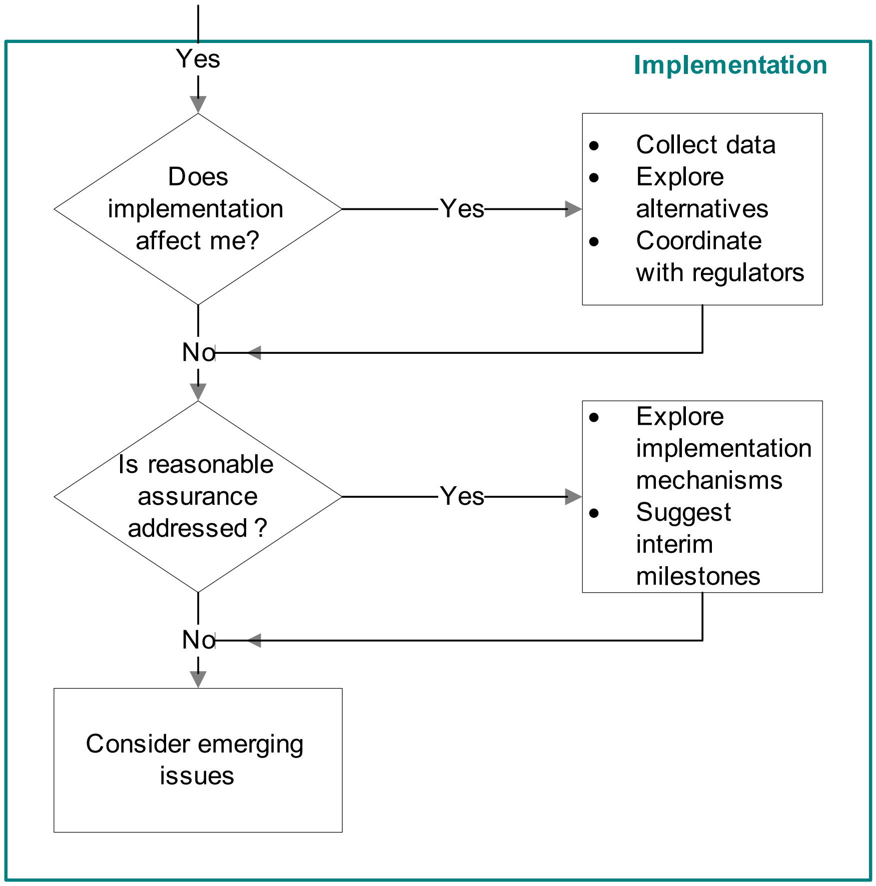


Figure 3-10
Implementation decision tree

3.6.1 Does Implementation Affect Me?

In some cases, the effect of TMDL implementation will be minimal for permittees. In many cases, the TMDL does not include an implementation plan. Research conducted for the Water Environment Research Foundation reviewed 176 TMDLs and found that 43% did not include implementation plans [27]. For those TMDLs that had implementation plans, less than half were detailed plans that included specific actions, a schedule, and a monitoring plan, and fewer than one-third had contingencies in place in case the TMDL target is not achieved [27].

In other cases, even if an implementation plan is developed, point sources may be only minor contributors to the impairment, and no change in NPDES permit limits may be proposed. For example, in a number of dissolved oxygen TMDLs in Illinois, phosphorus loads from agricultural runoff were the primary cause of the impairment. Point source discharges had little effect, and thus were included in the allocation at the existing discharge level.

The first question for a utility to ask is whether there is an implementation plan. If no implementation plan exists, the utility need only stay abreast of developments to ensure that its facility will not be adversely affected. If an implementation plan exists, the utility should review any wasteload allocations, to determine whether the permit for the facility will be affected. If no change in permit conditions is anticipated, the utility does not need to be actively involved in implementation, but should consider emerging issues, as described in Section 5.

3.6.1.1 Alternatives to Permit Limits

If the implementation plan proposes a reduction in permit limits for the utility, the utility should consider whether there are alternatives to a reduced permit limit (e.g., variance, pollutant minimization plan, increased monitoring). A variance is a tempory relaxation of a water quality standard that is typically used instead of removal of a designated use when a state believes the water quality standard can ultimately be attained [31]. Examples relevant to electric utilities include regional variances for mercury or a heat variance for cooling water discharge. A variance may specify an interim water quality criterion that is applicable for the duration of the variance. Variances can help to assure that further progress toward improving water quality is achieved, while providing some compliance relief to the discharger. Variances are temporary, subject to review every 3 years, and may be extended upon expiration.

Pollutant minimization plans are often required in conjunction with variances. For example, statewide mercury variances in Michigan and Ohio require mercury minimization plans to ensure that progress is made toward meeting the water quality standard. Michigan's mercury strategy includes a "level currently achievable" (LCA) that the state has determined that most dischargers can meet, based on data for a number of dischargers [77]. A permittee is considered to be in compliance with the mercury limit if they do not exceed the LCA and are implementing a pollutant minimization plan to identify and eliminate sources of mercury in the discharge [77]. The case study below highlights how pollutant minimization plans can be a requirement for a non-numeric approach to pollutant reduction.

Another alternative to numeric effluent limits is additional effluent monitoring. In determining the need for permit limits, the permitting authority must determine whether a discharge "causes, has the reasonable potential to cause, or contributes to an excursion of numeric or narrative water quality criteria" [69]. Guidance on conducting such reasonable potential evaluations is provided by U.S. EPA and many states incorporate specific reasonable potential procedures in their permitting rules [69]. In many cases, the available effluent data do not demonstrate reasonable potential, and a limit is not needed. Often a monitoring requirement will be included in the permit, to assess whether the facility may be discharging the pollutant at a level that raises water quality concerns. Data may show that influent loads are equal to or higher than effluent loads, releasing the responsibility away from the discharger. Depending on the amount of data available and site-specific considerations, a utility may be able to avoid an effluent limitation by proposing additional monitoring in the permit.

Case Study: ***Delaware River Estuary PCB - Pollutant Minimization Plans***

As part of the Delaware River Estuary PCB TMDL, the Delaware River Basin Commission (DRBC) established a TMDL Implementation Advisory Committee (IAC) charged with developing creative and cost-effective strategies for reducing loadings of PCBs and achieving the TMDLs. Members of the IAC include state officials from Delaware, New Jersey, and Pennsylvania; municipal and industrial dischargers; and fishery, wildlife, and environmental organizations [57]. The IAC has provided extensive public input regarding reducing PCB contamination in the Delaware River and Bay.

The DRBC adopted a rule in May 2005 requiring pollutant minimization plans (PMPs) for point and nonpoint source discharges of PCBs in the Delaware Estuary. "A non-numeric approach to implementing the Stage 1 TMDLs was taken, in part because it was understood that dischargers could not reduce their PCB loadings quickly enough to comply with numeric limits. The PMP rule embodies the principle of adaptive management, which encourages experimentation, measurement, and readjustment depending on the results of the actions taken. It reflects an awareness that while dramatic reductions in loadings from all source categories will be required to achieve the TMDLs over several decades, uncertainty as to the effectiveness of any particular reduction activity currently persists." [57]. The rule provides the commission with the regulatory authority to require PMPs before permits are reissued by the states, thus ensuring that steps to improve the estuary's water quality begin sooner. Stakeholders have been very supportive of this non-numeric approach to reduce PCB levels in the watershed.

As discussed in Section 3.5, water quality trading or pollutant offsets might also assist an electric utility in complying with the TMDL and should be investigated. A pollutant offset program for mercury is being evaluated in California (http://www.bemercuryfree.net/offsets.html). For stormwater related pollutants, BMPs may be used in lieu of final numeric effluent limits if such limits are infeasible (40 C.F.R. §122.44(k)(3)). This approach has not been commonly adopted and utilities may encounter some reluctance on the part of regulators because it is not the traditional numeric limit approach, but it is worth investigating as an alternative to numeric limits.

3.6.1.2 Monitoring Requirements

Whether or not an effluent limit is imposed through a revised permit, a TMDL implementation plan may include new or expanding monitoring requirements for an electric utility. The utility should carefully consider whether the monitoring is overly burdensome, and if so, attempt to negotiate a more reasonable plan. Issues to consider include frequency of monitoring, reliability of methods, special equipment and techniques needed, and cost. In some cases, ultra-clean sampling or other labor-intensive techniques may be needed (e.g., mercury, PCBs). Low-level monitoring for many constituents can be very costly. Sometimes approved analytical methods are not available for the constituent of concern at the levels required by the TMDL. Regulatory agencies may not be fully aware of some of these issues and may not consider them in developing permit requirements. The proposed monitoring should be carefully reviewed in light of the objectives, to cost-effectively obtain a reasonable data set.

Case Study: ***Ohio River PCB TMDL – Monitoring Requirements***

This TMDL provides an example of a situation where an electric utility will likely be required to collect additional data as part of a TMDL implementation plan. The Ohio River PCB TMDL is being developed by the Ohio River Valley Water Sanitation Commission (ORSANCO) for impaired segments downstream of the West Virginia/Kentucky border. The TMDL involves an extensive data collection effort (air, water, sediment, and fish) to quantify current PCB levels. An ultra low level PCB sampling method, not yet approved by EPA, has been used to quantify PCB concentrations in major tributaries and discharges. An approved PCB TMDL for upper sections of the Ohio River stated that significant load reductions (85% to 99%) will be required for each stream segment and major tributary in order to meet water quality standards [78]. This TMDL recognizes many potential sources of PCBs (e.g., municipal and industrial point sources, sediment, atmospheric deposition), however, insufficient data were available to positively identify actual sources and loads. Only two facilities were directly identified as point sources of PCBs based on available effluent data and only one facility was given a WLA. All other load allocations were lumped as "other sources" and specified on a tributary basis.

For the TMDL under development, a TMDL Task Force is recommending that additional efforts be made to quantify and address other PCB sources in an equitable manner. Upon acceptance of these recommendations by ORSANCO's technical committee, many dischargers in the basin (including electric utilities) will likely be required to sample their effluent using the ultra low level method (1668A) and will incur considerable expense (up to ~$1000 per sample) [23]. Other potential impacts to electric utilities may be requirements for pollutant minimization plans and PCB permit limits. At the time of this writing, ORSANCO has set aside the development of the Lower River PCB TMDL until a bacteria TMDL for the entire Ohio River is complete.

3.6.1.3 Implementation Schedule

In addition to specific requirements such as permit limits and monitoring, utilities should consider the implementation schedule. If the implementation plan has a long-term schedule, no immediate action is required, although the utility may want to plan for future monitoring or load reduction activities. If the facility will need to comply with new requirements soon, the utility might want to consider negotiating a compliance schedule to allow time to implement actions. The implementation plan should indicate whether NPDES permits will be reopened, or whether the TMDL will be implemented during permit renewals.

3.6.2 Is Reasonable Assurance Addressed?

The second key question regarding implementation relates to reasonable assurance. One of the eight regulatory requirements of the TMDL program is reasonable assurance that the TMDLs can be met. This is particularly important given the lack of regulatory authority over nonpoint sources. Reasonable assurances provide evidence that nonpoint source participants in the implementation plan are committed to full and timely implementation. Examples provided by WERF include:

- Signed agreements by which land owners and managers have committed to the plan;
- Signed commitments from agencies, local governments, and other watershed stakeholders;
- Signed contracts, licenses, or permits that include stipulations related to implementation;
- Evidence that funding for implementation has been committed;
- Evidence that financial incentives such as cost-sharing funds, grants, etc. are in place;
- Identification of how and by whom implementation of management measures will be enforced; and
- Evidence that similar approaches have succeeded elsewhere [27].

Enforceable mechanisms to address nonpoint sources are important for successful TMDL implementation, but most states rely primarily on a voluntary approach to nonpoint source control [27]. Utilities should evaluate whether mechanisms are in place to implement nonpoint source controls, and may want to explore or suggest specific mechanisms for implementation. These might include an implementation action committee of stakeholders, funding for implementation, or other alternatives to ensure that the TMDL load reductions are achieved. Electric utilities should also review whether the proposed implementation schedule is realistic, particularly given the challenges of implementing controls. Interim milestones or implementation phasing can provide for load reduction at a reasonable pace (see case study below). With input from stakeholders such as electric utilities, a reasonable implementation plan can be developed which includes appropriate mechanisms and schedules for improving water quality without unnecessarily burdensome requirements.

Case Study: *Minnesota Statewide Mercury TMDL – Implementation Planning*

Minnesota's Statewide Mercury TMDL was approved by U.S. EPA in 2008 and provides an example of a TMDL with implementation planning and interim milestones [24]. The source assessment identified that >99% of the mercury in fish originated from air sources, with 90% from sources "upwind" of Minnesota. The TMDL required a 93% reduction in mercury emissions (10% in MN, and 90% federal) along with monitoring and minimization plans for permitted facilities greater than 0.2 MGD. A one-year stakeholder process was convened to develop specific recommendations for an implementation plan. The outcome of the stakeholder process is a Strategy Framework, with elements that include:

- Strategies and timelines for reducing air emissions from all sources that will meet the goal of 789 lb per year by 2025;
- Guidelines for water point sources discharges to ensure that total statewide mercury discharges remain below 24.2 lb per year; and
- A process for addressing new and expanding sources of air emissions [79].

The strategy to reduce air emissions specifically from coal-fired electric power generation incorporates an emission goal of 235 pounds to be achieved by 2025, with an interim goal of 294 pounds by 2018. Mercury emissions reduction plans are to be prepared by the utilities, and filed with MPCA under a specified schedule. The strategy also establishes a Mercury TMDL Implementation Oversight Group, which includes representatives from the electric power sector.

Ideally, a TMDL review will have allowed for stakeholders, such as electric utilities, to publicly participate in the TMDL process and resulted in a tolerable outcome, if not favorable, for multiple parties. However, the outcome of a TMDL review may instead reveal specific concerns not addressed through the public participation process. In this situation, an electric utility may want to consider potential options for challenging the TMDL (Section 4). Alternatively, the review may indicate that the current TMDL will likely cause little impact to an electric utility. In this situation it may still be beneficial for an electric utility to monitor the TMDL or any potential future TMDLs in the context of emerging issues (Section 5).

4
CHALLENGING THE TMDL

Utilities can be most effective in challenging a TMDL by getting involved early in the development process, as discussed earlier in this report. In situations where the water quality standard and/or the 303(d) listing is considered inappropriate, challenges should be made before the TMDL is developed. The chances of a favorable outcome are far less if the TMDL that is being challenged has been completed and approved by U.S. EPA. In some cases, however, utilities may find that a TMDL is unacceptable, and consider a legal challenge or a review/revision through a Third Party TMDL process.

4.1 Legal Challenges

To date, few TMDLs have faced legal challenges by regulated parties. This is because many of the more difficult TMDLs, with the potential to have a significant impact on point source dischargers, have not yet been developed. Also, States are still working on how to implement TMDLs through NPDES permits, and in some cases TMDLs have been ignored when discharge permits were issued. This is particularly true in situations where the TMDL lacked an implementation plan and therefore it is unclear how the pollutant load reductions will be achieved and water quality standards will be attained.

U.S. EPA regulations require that states prepare TMDLs for all water bodies that do not meet water quality standards; however, U.S. EPA has not established a time frame for submittal of TMDLs. In *Scott v. City of Hammond*, the Seventh Circuit found that lack of action by either the state or U.S. EPA should not continue indefinitely [80]. As a result of this decision and numerous lawsuits filed by citizen groups, many consent decrees have been signed requiring states to develop TMDLs or U.S. EPA to develop them if states fail to do so under schedules ranging from 8 to 13 years [81]. Whether the TMDL is developed by the state or U.S. EPA, all TMDLs must be approved by the regional office of U.S. EPA assigned to that state. A TMDL may therefore be challenged in the U.S. EPA regional office to convince U.S. EPA to not approve the TMDL; in federal court if U.S. EPA has developed or approved the TMDL; or in state court after the state has developed the TMDL. Considerations related to these various options are discussed below.

A utility may seek U.S. EPA disapproval after the TMDL has been finalized by the state and before U.S. EPA approval. The utility will need to present the regional office with a case for rejecting the state's TMDL. The basis for this type of challenge may include failure on the part of the state to follow the Clean Water Act or specific administrative procedures, shortcomings in the science, or failure to consider the utility's comments.

Challenging the TMDL

After a TMDL has been approved or developed by U.S. EPA, a utility may challenge it in federal district court under the federal Administrative Procedures Act. The statute of limitations is six years, but immediate action would likely be needed to precede issuance of a potentially overly restrictive permit based on the TMDL. Courts generally grant wide discretion to U.S. EPA and states in such cases, and the utility would need to demonstrate that U.S. EPA's approval was "arbitrary and capricious, an abuse of discretion, or not in accordance with law" [82].

In some cases, regulated parties may also seek a concurrent review of a state TMDL decision under the state's Administrative Procedures Act. Typically, a hearing must be requested within 30 days after the TMDL is approved. In such cases, a hearing before an administrative law judge may be granted. The utility would need to demonstrate that the TMDL will cause injury-in-fact. If successful, the administrative law judge would remand the TMDL back to the state agency for revision [82]. Another option is to seek a legal declaration regarding the "applicability of a statute or rule or order" from a state agency [82]. For example, a utility may seek a declaration regarding data (or lack thereof) supporting the 303(d) listing. If the utility receives an unfavorable opinion from an administrative review or an attempt to obtain a declaratory judgment, it may seek judicial review of that action in state court.

Legal challenge at the state level is not always an option, and in some states it is unclear if TMDLs can be challenged. This is because courts have not yet settled the question of whether a regulated party must wait to challenge a TMDL until a new limit is included in the NPDES permit [82]. Some states argue that TMDLs may not be challenged until they have been approved by U.S. EPA. One state has determined that TMDLs can only be challenged at the federal level, because U.S. EPA approval is what makes TMDLs effective [82]. Other states prohibit challenges to 303(d) listings. If the situation is unclear, it is best to engage legal counsel, and consider filing a challenge at the both the state and federal level, and as early as possible, rather than wait until the permit is issued [82].

Case Study: *Northeastern Reservoir*[1] *– Legal Challenge*

A dissolved oxygen TMDL developed for an impoundment in the Northeastern United States provides an example of an electric utility legally challenging a TMDL based on model calibration. An electric utility owns the dam that creates the impoundment, and in 2005, the State issued a dissolved oxygen TMDL for the reservoir that was subsequently approved by U.S. EPA. The TMDL required that the electric utility provide the majority of the funding for installation and operation of an oxygen diffuser with implementation of this solution driven by NPDES permitting and a water quality certification for the dam hydropower licensing.

A consultant hired by the electric utility determined that the modeling may have been questionable through a review of interim and final modeling results. Expert testimony was submitted on behalf of the electric utility at a formal hearing for the State board of environmental protection as part of an appeal of the permits. The testimony was accepted by the board, and the board directed the model be corrected and the TMDL be recalculated. Revised scenarios are expected to result in a TMDL more favorable for the electric utility. The utility's challenge of the TMDL involved both consultant and legal expenses. Earlier involvement, including commenting during the public review process, may have reduced the need for legal involvement.

[1]Note: TMDL case study is written as confidential at the request of involved parties.

4.2 Third-Party TMDLs

A third-party TMDL can be an alternative approach to a state or U.S. EPA led TMDL. This is an effort where a "third party" organization such as a watershed group, nonpoint source organization, municipality, or industrial discharger assumes primary responsibility for a TMDL. A third-party TMDL can be developed for either a first-time TMDL or during a TMDL review and revision, in place of a formal legal challenge. These types of TMDLs differ from those prepared by the lead water quality agency only in terms of the party that assumes the lead role. The state must still review and concur with the TMDL, and submit it to U.S. EPA for approval. Some potential advantages of third party TMDLs is that they can leverage state funds with resources from other entities, they may enable stakeholders to directly decide how the TMDL will be conducted (pending state approval), and the process may increase stakeholder awareness and support. There can also be disadvantages, including the resource and time-intensive nature of the process, and the potential for others to view the outcome as biased [34].

Third parties may also be actively involved in a TMDL but not assume the lead role. For example, they may assume responsibility for data collection, source assessment, or modeling. Third parties may also limit their involvement to review and comment.

The Water Environment Federation's "Toolkit" on Third Party TMDLs provides four case studies that describe lessons learned, challenges, outcomes, and other aspects of third-party TMDLs [34]. It is clear from the case studies that the success of third party TMDLs depends on many factors. One challenge can be a lack of technical expertise, particularly for complex TMDLs. Where many stakeholders are involved, coordination and communication can present logistical challenges. A third-party approach may not provide the responsible agency with flexibility in the schedule to meet court-imposed deadlines. A key factor for success is having the active involvement and guidance of the state or federal agency responsible for their enforcement [34].

5
EMERGING ISSUES FOR POWER GENERATORS

A review of a proposed TMDL by an electric utility stakeholder may result in a determination that the electric utility will face minimal impact with respect to operations, permitting, or potential for future growth. In some cases, there may be no TMDLs under development or planned for the near future that cause concern for an electric utility. But, even under these conditions, it is important to understand how emerging issues may change this sense of comfort, and suddenly one or more TMDLs become a concern. For example, a watershed which was previously not considered impaired may suddenly show up on a 303(d) list due to new criteria defined for nutrients, emerging contaminants, or to protect a threatened or endangered species. Furthermore, the operations of an electric generation facility may change due to factors such as increased energy demand associated with regional growth, compliance with stricter air quality standards, or a reduction in receiving water assimilative capacity resulting from natural (e.g., drought) or anthropogenic (e.g., increased upstream loads) stressors, or a combination.

A few potential emerging issues that electric utilities may want to consider in the context of the TMDL program are summarized below:

5.1 Air Quality Standards

Electric utilities are required to simultaneously comply with Clean Water and Clean Air regulations for pollutants such as nitrogen, mercury and other metals. As tighter air quality standards are enforced, more mercury will be removed from combustion gases, potentially leading to increased pollutant loadings to wastewater treatment systems and surface water discharges. The transfer of these pollutants into power generation facility waste products (e.g., fly ash, sludge) will continue to increase and electric utilities will be faced with wastewater treatment challenges in order to comply with permit limits and TMDLs. Active fly ash pond treatment methods can be expensive and logistically impractical due to the high volumes of water, and innovative biological treatment methods are often unreliable [17]. Many of these challenges are discussed in Section 2.3.2 of this report.

5.2 Nutrient Criteria

TMDLs involving reduction of nutrient loadings are typically motivated by a dissolved oxygen waterbody impairment that impacts fish habitat. Nutrient loading can lead to excessive growth of algae and ultimately a depletion of dissolved oxygen, as described in Section 3.2. In most cases, the waterbody is listed based on a promulgated state water quality criterion for dissolved oxygen, rather than numeric criteria for nutrients. In many states and also on a national level, the prospect of statewide nutrient criteria that are not waterbody specific is becoming a reality (http://www.epa.gov/waterscience/criteria/nutrient/). This is potentially of great concern as nutrient impairments are typically waterbody specific, and other factors (such as sediment, flow) can affect whether excess nitrogen and phosphorus result in aquatic life impairments. The TMDL could then be conducted regardless of the actual response of the waterbody to reductions in nutrient loads and therefore the TMDL may be overly conservative or not address the aquatic life impairment. The outcome may be unnecessarily restrictive permit limits that result in little or no water quality benefit.

5.3 Climate Variability

Managing the potential risk associated with climate variability is a focus of water and watershed management, and may affect the TMDL program in the coming years.

U.S. EPA intends to promote the use of BASINS 4.0 Climate Assessment Tool (CAT) as part of the National Water Program Strategy [83]. BASINS CAT is a preprocessing tool which allows modelers to use externally generated precipitation and temperature data, which reflect hypothesized climate variation, to serve as input to the HSPF watershed model. Also, as part of ZeroNet Water-Energy Initiative, the watershed model WARMF was enhanced to evaluate the hydrological influences of climate variation including extended drought and increasing temperature [84, 85]. Simulations showed that drought and increased temperature impact availability in for all economic sections (agriculture, energy, municipal, industry, etc.) and lead to increased critical water shortages.

In the future, tools such as WARMF or BASINS CAT may be used to project watershed impacts due to climate variability. This modeling could be useful for long range planning, power plant siting, and assessment of source water availability. However, if climate variability modeling is used during TMDL development (e.g., target selection, linkage analysis) it could result in a prediction of lower flows and/or higher temperatures, which may result in lower TMDL load allocations. Watershed modeling that considers potential climate impacts must be performed with caution to fully recognize the uncertainties associated with climate variability. EPRI's eWAM website provides useful information on climate variability and water sustainability.

5.4 Emerging Contaminants of Concern

Emerging contaminants of concern are synthetic or naturally occurring compounds (e.g., pharmaceuticals, personal care products) which are not commonly monitored in the environment but have the potential to enter the environment and cause known or suspected adverse ecological and(or) human health effects. Although these compounds are not currently considered to be common TMDL pollutants, they could be of concern as the risks of low-level exposure for humans and aquatic life are better defined. Emerging contaminants are unique in that they are typically produced industrially yet are dispersed to the environment from domestic, commercial, and industrial uses. These chemicals are also unique in that significant reproductive effects may occur at very low levels of exposure and the effects of exposure to aquatic organisms during the early stages of life may not be observed until adulthood. In that regard, US EPA is currently evaluating the most appropriate methods for establishing aquatic life criteria for these contaminants [86]. As additional research on emerging contaminants is conducted, it is possible that states might choose to address these contaminants through the use of narrative criteria (see Section 3.2.2.3). A USGS website provides a resource for further investigating this topic and understanding how emerging contaminants may intersect with the TMDL program (http://toxics.usgs.gov/regional/emc/).

5.5 Threatened or Endangered Species

Waterbodies protected for aquatic life are generally compared to promulgated state standards for dissolved oxygen and/or temperature. However, if a threatened or endangered species is newly identified, more restrictive criteria set on a federal level may apply. In this case, the waterbody may be noted as impaired during the next development of a 303(3) list and a TMDL may follow.

6
SUMMARY AND CONCLUSIONS

The TMDL program is a requirement of Section 303(d) of the Clean Water Act, which strives to improve water quality though establishment of pollution budgets and management plans for impaired watersheds. The TMDL program has evolved over time and will continue to be a major component of national water quality management programs. In many TMDLs, power generators are identified as relevant stakeholders who potentially contribute to impairments through point source discharges, nonpoint source discharges (e.g., air deposition, storm water), or impoundments created for hydropower operations. One legal component of a TMDL is public participation. Ideally, this should occur though a consensus-building process among stakeholders, though typically it involves a brief opportunity for public comment as a draft TMDL is released. The TMDL Technical Evaluation Framework presented in this report describes potential pathways for TMDL review and opportunities for active participation from electric utility stakeholders. It is important to remember that a TMDL is a planning tool, but depending on TMDL outcomes, it can have significant impact as a regulatory tool.

To maximize the likelihood that a TMDL outcome is based on sound science and is equitable for multiple parties, electric utility stakeholders should consider the following recommendations:

- Get involved early. Waiting until the public comment period may result in missed opportunities to positively impact the TMDL development;
- Keep up to speed on upcoming TMDLs through regular review of the states integrated report (i.e., 305(b) and 303(d) lists);
- Prioritize efforts for the TMDLs of most concern but keep an eye on those with less potential impact;
- Recognize that each TMDL is different. Tremendous variation among the states TMDL programs results in a need to be informed as to how the program is developing both nationally and by state;
- Know the potential sources of pollutant within facility operations. Understand the challenges related to monitoring to verify impairment and characterizing pollutant fate and transport through watershed and water quality models;
- Realize that though public participation is a TMDL requirement, it is not often encouraged. Be prepared to initiate participation with TMDL developers. Consider contributing in-house resources (e.g., time, funds to support data collection and consultant assistance) when needed;
- Build relationships with regulators and other stakeholders though public participation in a TMDL. Use this experience to improve public image and leverage options during the permitting process;

- Consider lessons learned from other TMDLs. Seek out and/or join with other EPRI members to understand how best to positively influence the TMDL development process; and
- Consider emerging issues and their possible influence on current or potential TMDLs.

If time and resources are limited for a comprehensive TMDL review, focus on review of these key TMDL components:

- Verify the impairment;
- Determine if your facility loading is significant relative to other loads;
- Examine linkage analysis modeling for major flaws (e.g., inappropriate model selected, inadequate data set); and
- Consider if allocation is generally equitable (e.g., considerations for both point and nonpoint sources).

Finally, if conducting a TMDL review seems necessary, but conducting an independent review would be difficult, explore the idea of collaboration with other utilities or other concerned stakeholders, or consider seeking outside help from TMDL experts in consulting or academic fields.

7
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A
LIST OF TMDL RESOURCES

EPA Impaired Waters and Total Maximum Daily Loads website:
www.epa.gov/owow/tmdl

This website provides links to TMDL regulations and guidance documents, technical resources, example TMDLs, and information on air deposition, water quality trading, and other relevant topics.

EPA *DRAFT* Handbook for Developing Watershed TMDLs:
http://www.epa.gov/owow/tmdl/pdf/draft_handbook.pdf

This document discusses the potential environmental, financial, and implementation benefits of developing TMDLs on a watershed scale, and provides practitioners with a series of screening factors that should help determine, based on pollutant type, waterbody type, data quality, and other considerations, the site specific suitability of the TMDL watershed approach. Additionally, the Draft Handbook highlights the connections between watershed TMDLs and other water programs, identifying opportunities for integrating watershed TMDLs into other similar water quality management efforts, such as watershed planning, permitting, and water quality trading.

EPA Section 303(d) Program Guidance:
http://www.epa.gov/owow/tmdl/guidance.html

This website provides links to EPA guidance related to assessment and listing of waters under Sections 305(b) and 303(d) of the Clean Water Act. It includes guidance on reviewing TMDLs, preparing integrated water quality reports, listing waters impaired by atmospheric mercury, use of fish and shellfish advisories in listing decisions, and establishing TMDL daily loads.

EPA guidance related to mercury TMDLs and atmospheric deposition:
http://www.epa.gov/owow/tmdl/pdf/cover_memo_mercury_tmdl_elements.pdf
http://www.epa.gov/owow/tmdl/pdf/document_mercury_tmdl_elements.pdf

EPA recently released a document that describes considerations when developing TMDLs for waters where atmospheric deposition is the primary source of mercury. The document (also referred to as a mercury TMDL "checklist") includes factors to consider when addressing TMDL elements on different geographic scales, such as waterbody, regional, and multi-state. The "checklist" builds on approaches in approved mercury TMDLs.

EPA memo regarding Listing Waters Impaired by Atmospheric Mercury Under Clean Water Act Section 303(d):
http://www.epa.gov/owow/tmdl/mercury5m/

This site provides information to states, territories, and tribes regarding a voluntary approach for listing waters impaired by mercury mainly from atmospheric sources. EPA recommends this approach for states that have in place a comprehensive mercury reduction program with elements recommended by EPA. These states may separate their waters impaired by mercury primarily from atmospheric sources in a specific subcategory ("5m") of their Clean Water Act section 303(d) lists and may defer development of TMDLs for mercury-impaired waters as a result of having implemented mercury reduction programs.

EPA Air Pollution and Water Quality website:
http://www.epa.gov/owow/airdeposition/index.html

This website includes a downloadable atmospheric deposition handbook and links to TMDLs addressing atmospheric deposition, including Northeast Regional Mercury TMDL, Minnesota Statewide Mercury TMDL, Ochlockonee Watershed Mercury TMDL, and Everglades Mercury TMDL Pilot Study.

EPA Assessment Total Maximum Daily Load (TMDL) Tracking and Implementation System (ATTAINS) website:
http://www.epa.gov/waters/ir

This website provides water quality assessment and impairment information reported by the states under Sections 305(b) and 303(d) of the Clean Water Act. ATTAINS shows which waters have been assessed, which are impaired, and which are being (or have been) restored. This website allows the user to view dynamic tables and charts that summarize state-reported information for the entire nation, for individual states and waters, and for the 10 EPA Regions.

Allocating Loads and Wasteloads:
http://www.epa.gov/waterscience/models/allocation/

This website provides information on watershed modeling frameworks which may be used to help evaluate the tradeoffs associated with different allocations. These frameworks are capable of identifying cost minimizing allocations and comparing cost distributions across stakeholders under different allocation scenarios. This web site demonstrates a cost-minimization framework and provides examples of load allocations and cost distributions for a case study watershed.

EPRI's Watershed Management and TMDL website, eWAM:
http://www.epri.com/ewam/.

This website contains links to many EPRI reports related to the TMDL program, as well as other resources related to TMDLs, watershed assessment, management, and modeling. Links to key guidance documents and case studies of particular interest to utilities are included.

The Center for TMDL and Watershed Studies at Virginia Tech:
http://www.tmdl.bse.vt.edu/.

This website includes links to TMDL studies, implementation case studies, and a TMDL Knowledgebase Clearinghouse that includes literature reviews, guidance documents, and state summaries.

TMDL Knowledgebase Clearinghouse:
http://www.ext.vt.edu/cgi-bin/WebObjects/TMDL.woa

The TMDL Knowledgebase Clearinghouse is a searchable database that will contain TMDL resource materials including literature reviews, links to national and state TMDL guidance documents, and summaries of TMDL programs from around the nation.

TMDL Implementation – Characteristics of Successful Projects:
http://www.tmdl.bse.vt.edu/research/C58/

This research discusses factors that positively and negatively affect TMDL implementation efforts, with case studies provided for watersheds undergoing successful implementation.

EPA Water Quality Trading website:
http://www.epa.gov/owow/watershed/trading.htm

This website includes trading background and policy, a trading assessment handbook, and a water quality trading toolkit.

EPA Use Attainability website:
http://www.epa.gov/waterscience/standards/uses/uaa/index.htm

Provides an overview of UAAs, a memorandum on improving the UAA process, and several UAA case studies.

Water Environment Research Foundation Use Attainability Analysis website:
www.werf.org/AM/Template.cfm?Section=Use_Attainability_Analysis&Template=/TaggedPage/TaggedPageDisplay.cfm&TPLID=23&ContentID=5427

This site includes links to a Use Attainability Analysis Handbook, Peer Review of the City of Lincoln, NE: Salt Creek Site-Specific Ammonia Water Quality Criterion, and a Study on Factors for Success in Developing Use Attainability Analyses.

EPA Guidelines for Reviewing TMDLs Under Existing Regulations Issued in 1992:
http://www.epa.gov/owow/tmdl/guidance/final52002.html

This document summarizes and provides guidance regarding effective statutory and regulatory requirements relating to TMDLs, to assist states in determining if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations.

EPA mercury website:
http://www.epa.gov/mercury/

This website provides a broad range of information, targeted largely to the general public. It also include information about the health effects of mercury, fish consumption advisories, and a mercury Report to Congress. There are also sections regarding regulation of mercury emissions.

Water Environment Research Foundation (WERF) research:
http://www.werf.org/AM/Template.cfm?Section=Search_Research_and_Knowledge_Areas&Template=/CustomSource/knowledgeareas/Search.cfm

WERF sponsors independent, peer –reviewed research on wastewater and stormwater issues. This website can be searched by knowledge areas (including climate change and use attainability analyses) or interest areas (including TMDLs, water quality criteria, watershed trading, etc.)

B

TMDL REVIEW ROAD MAP DECISION TREES

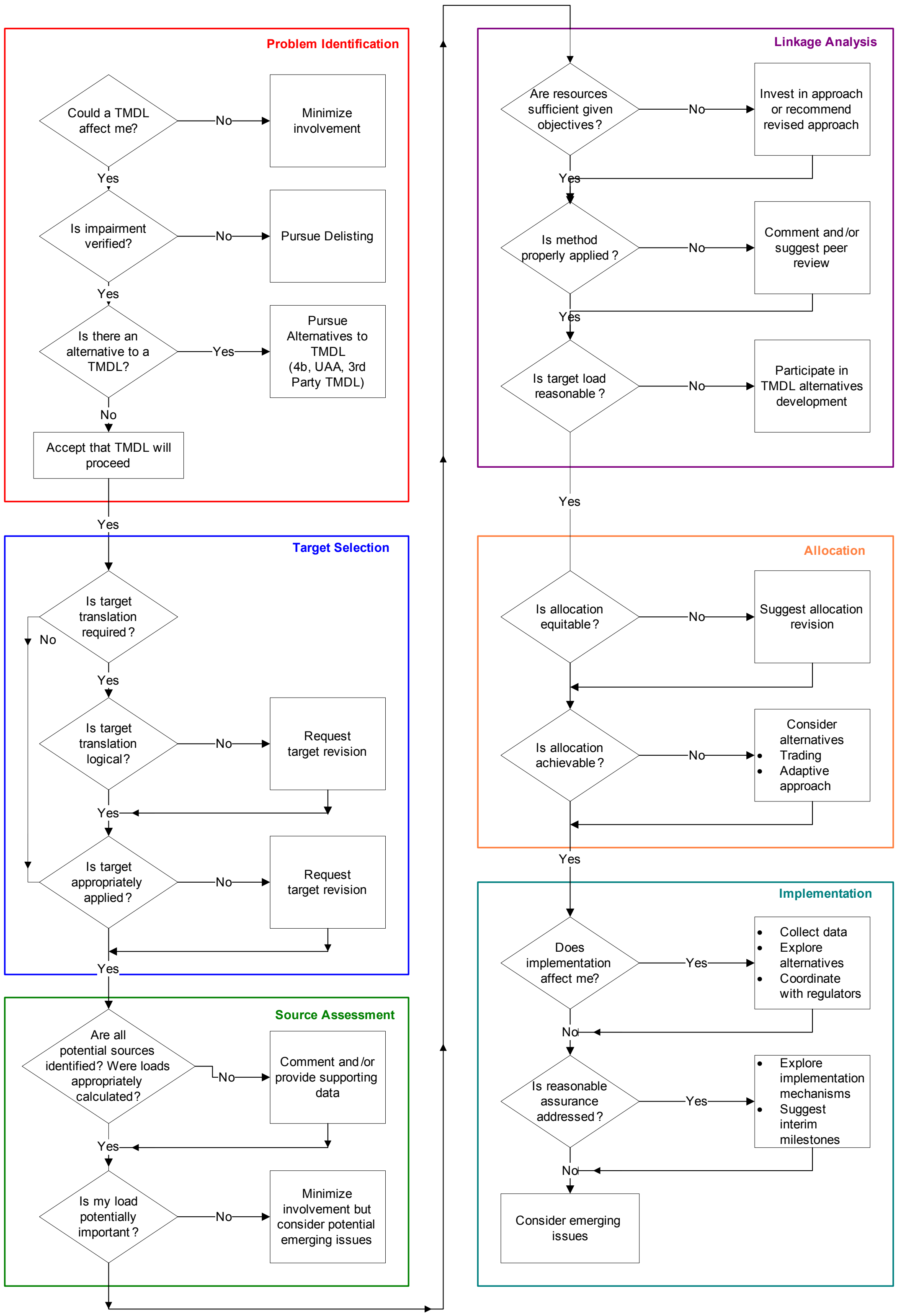

Figure B-1
Combined decision tree of TMDL review roadmap

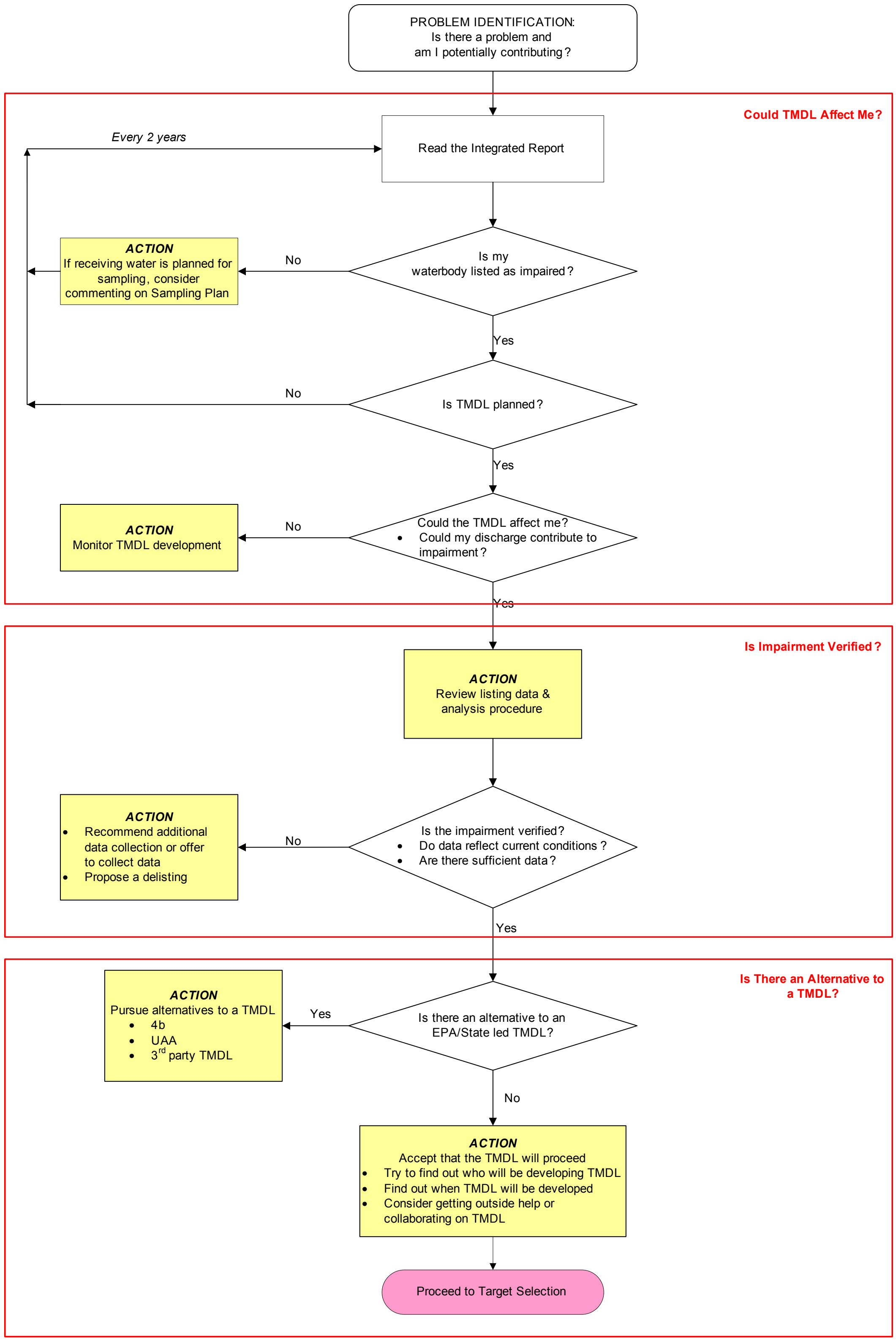

Figure B-2
Detailed problem identification decision tree

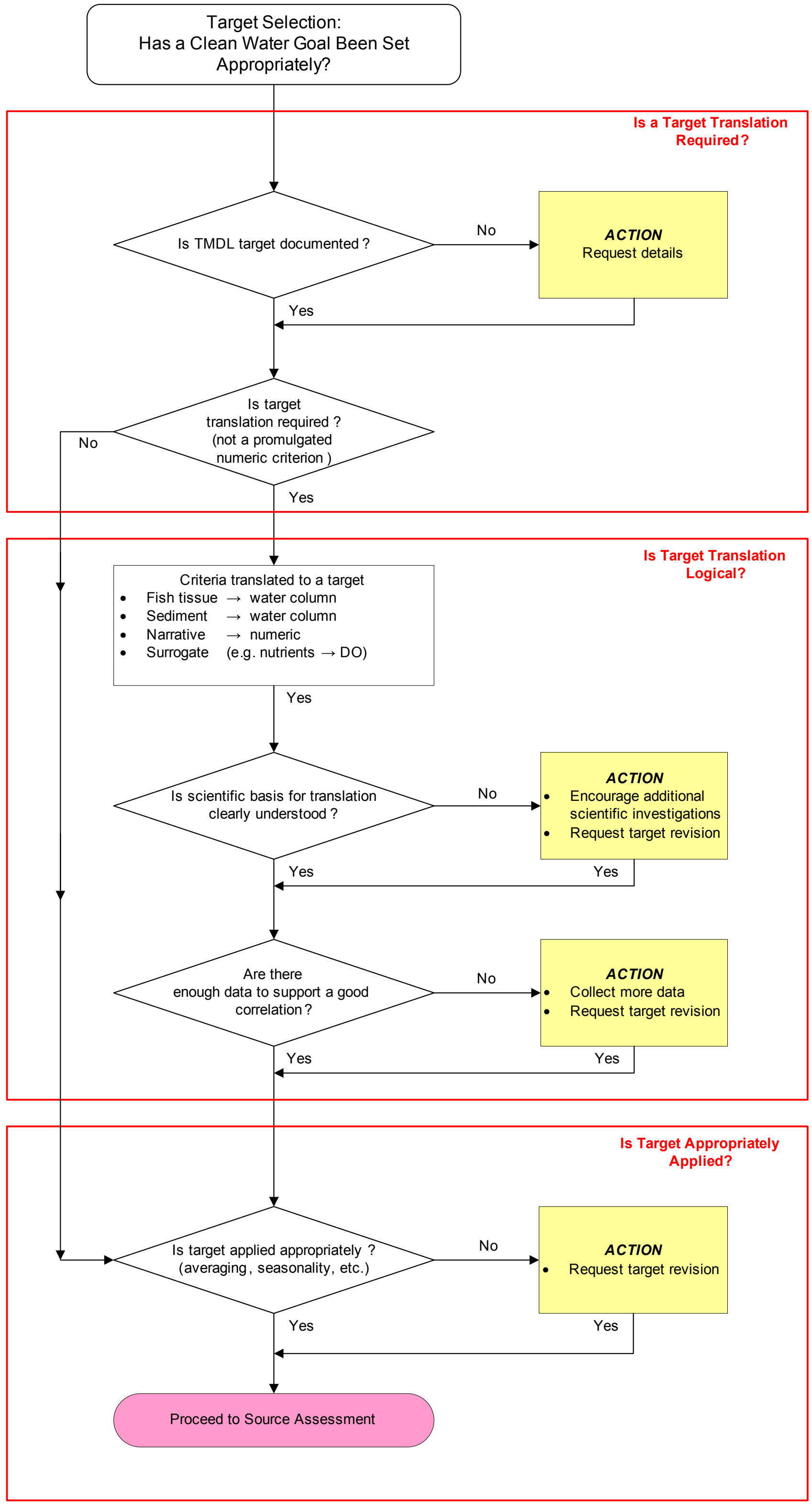

Figure B-3
Detailed target selection decision tree

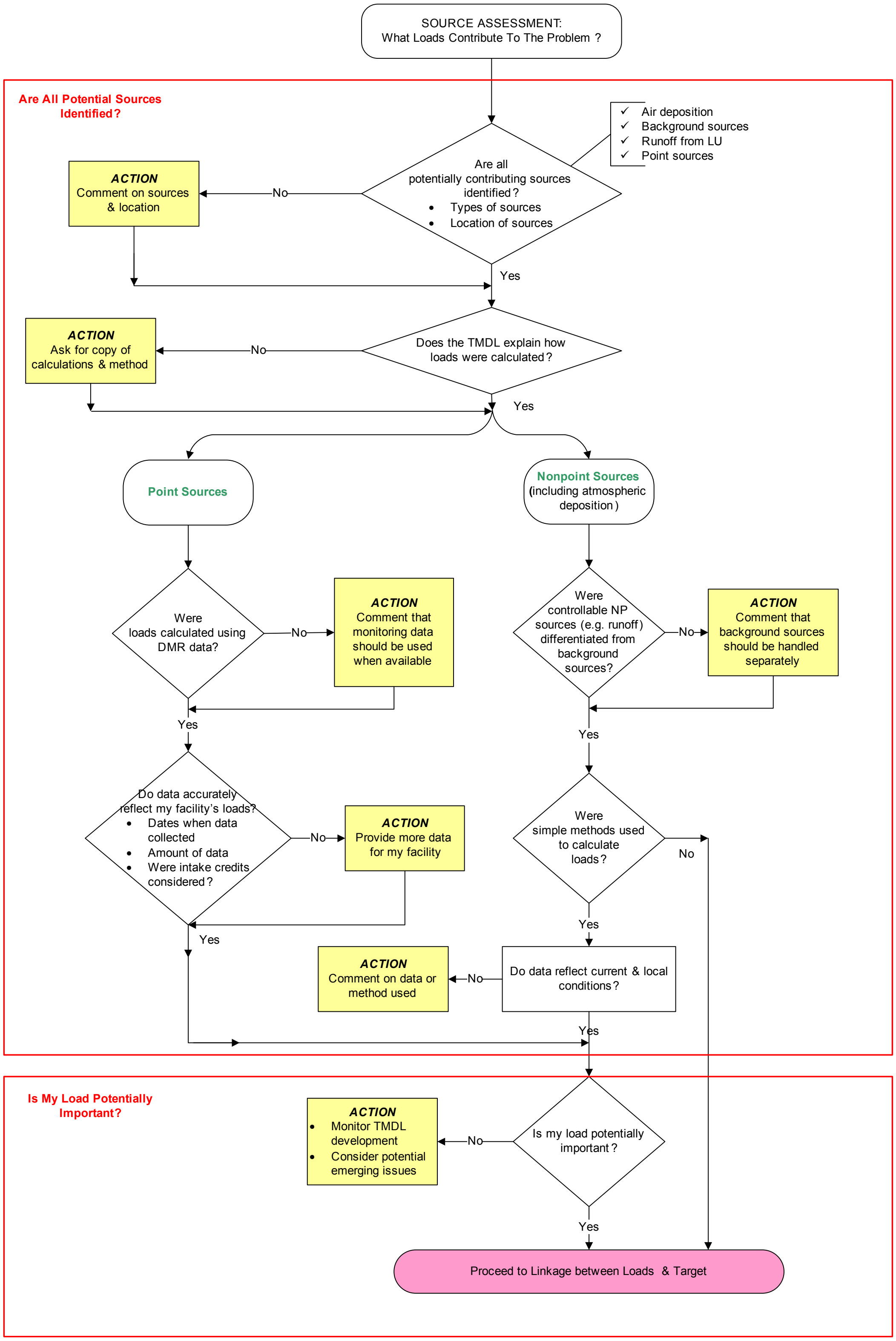

Figure B-4
Detailed source assessment decision tree

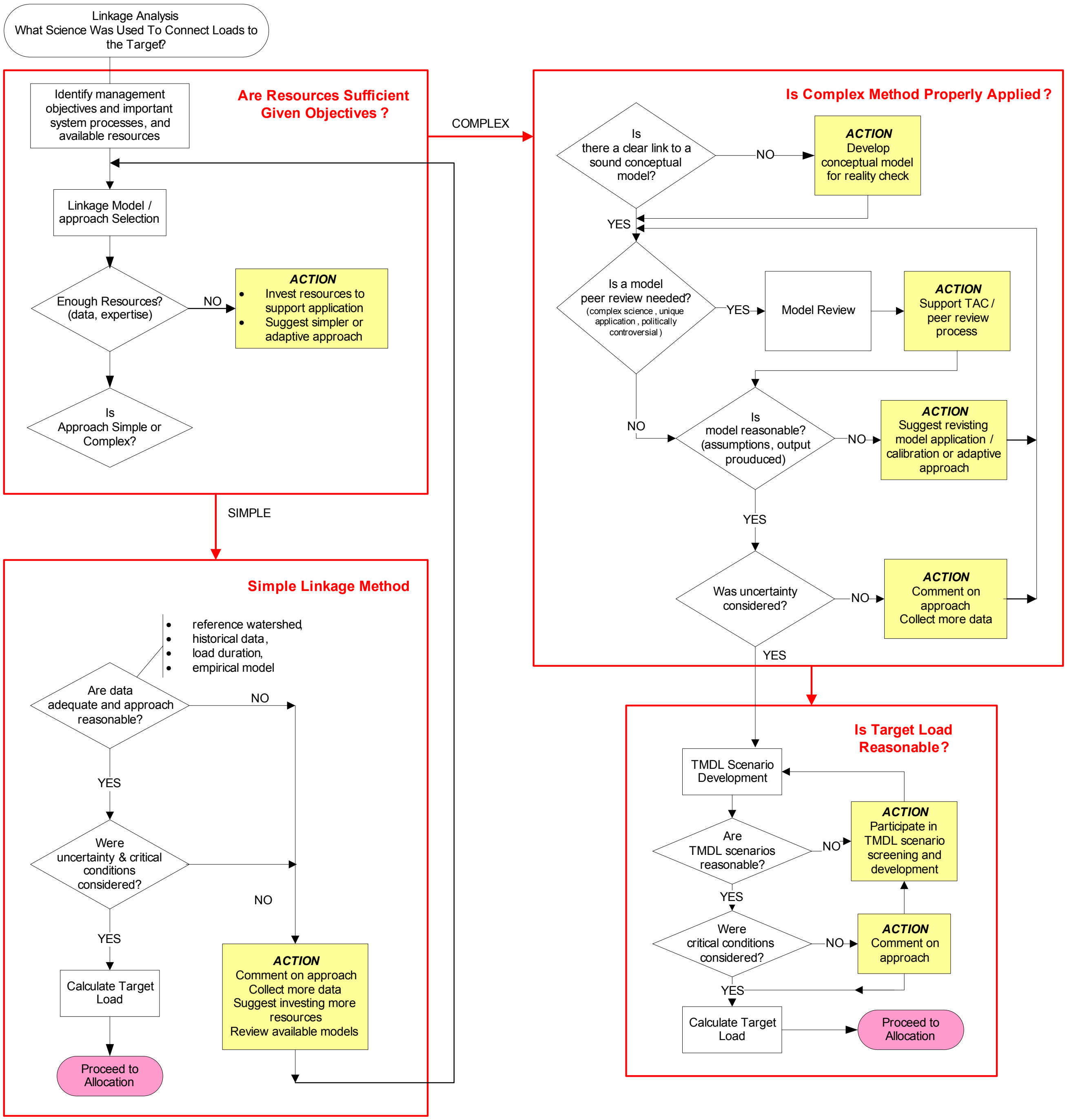

Figure B-5
Detailed linkage analysis decision tree

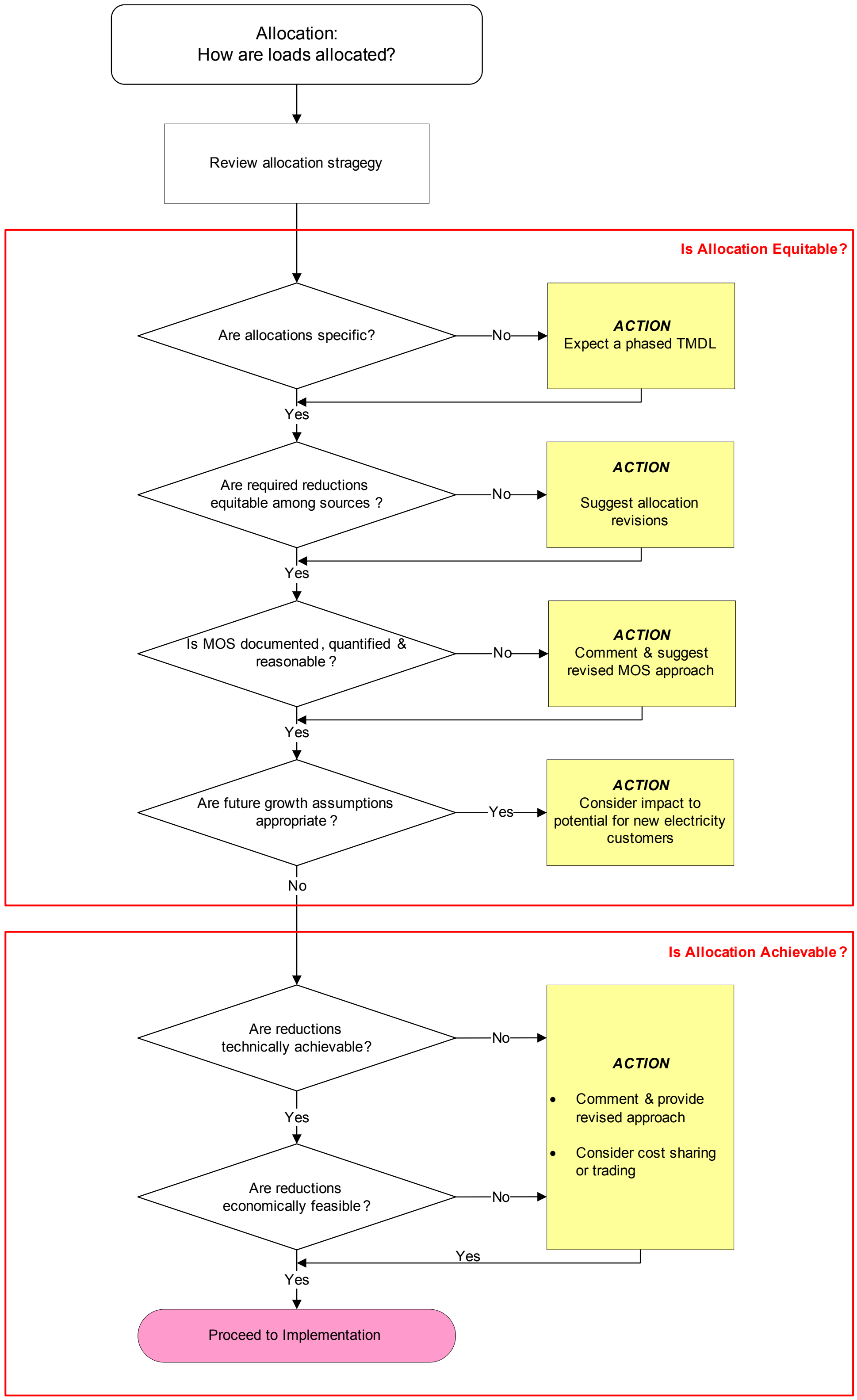

Figure B-6
Detailed allocation decision tree

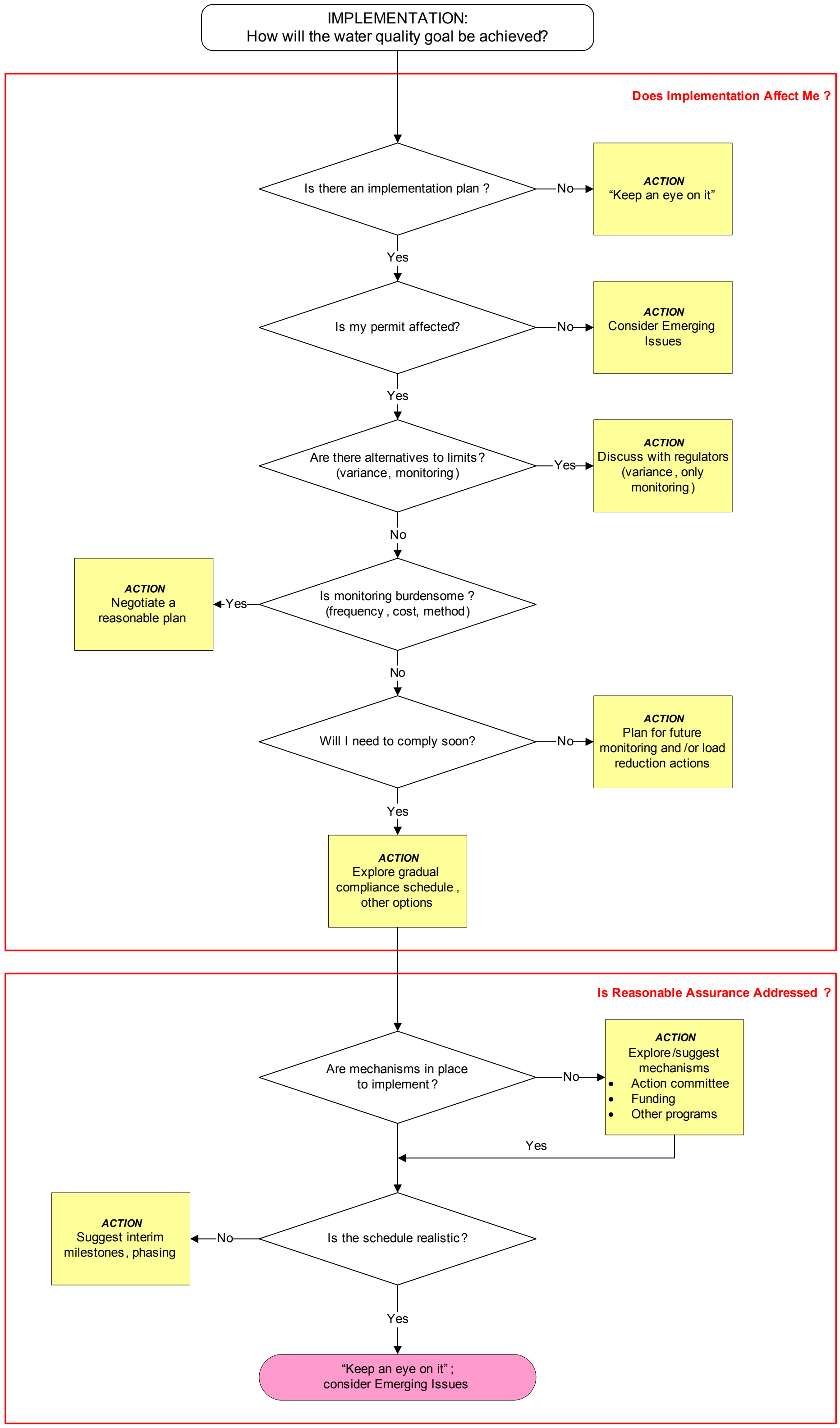

Figure B-7
Detailed implementation decision tree

C
SOURCE ASSESSMENT AND LINKAGE ANALYSIS METHODS

C.1 Load Duration Curve

The load duration curve approach uses stream flows and observed concentrations for the period of record to gain insight into the flow conditions under which exceedances of the water quality standard occur. A load-duration curve is developed by:

1. Ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results in what is called a flow duration curve (Figure C-1);
2. Translating the flow duration curve into a load duration curve by multiplying the flows by the water quality standard; and
3. Plotting observed pollutant loads (measured concentrations times stream flow) on the load duration curve graph (Figure C-2).

Observed loads that fall above the load duration curve exceed the maximum allowable load, while those that fall on or below the line do not exceed the maximum allowable load. An analysis of the observed loads relative to the load duration curve provides information on whether the pollutant source is point or nonpoint in nature. For example, Figure C-2 shows the pollutant exceedences of the target load are infrequent and occur during dry weather conditions. This suggests that particular emphasis should be placed on evaluating potential point source issues. If exceedences were more prevalent along the left (wet weather) end of the curve, nonpoint source issues would likely be of highest concern. A distribution of exceedences along the middle of the curve may indicate a mix of point and nonpoint issues.

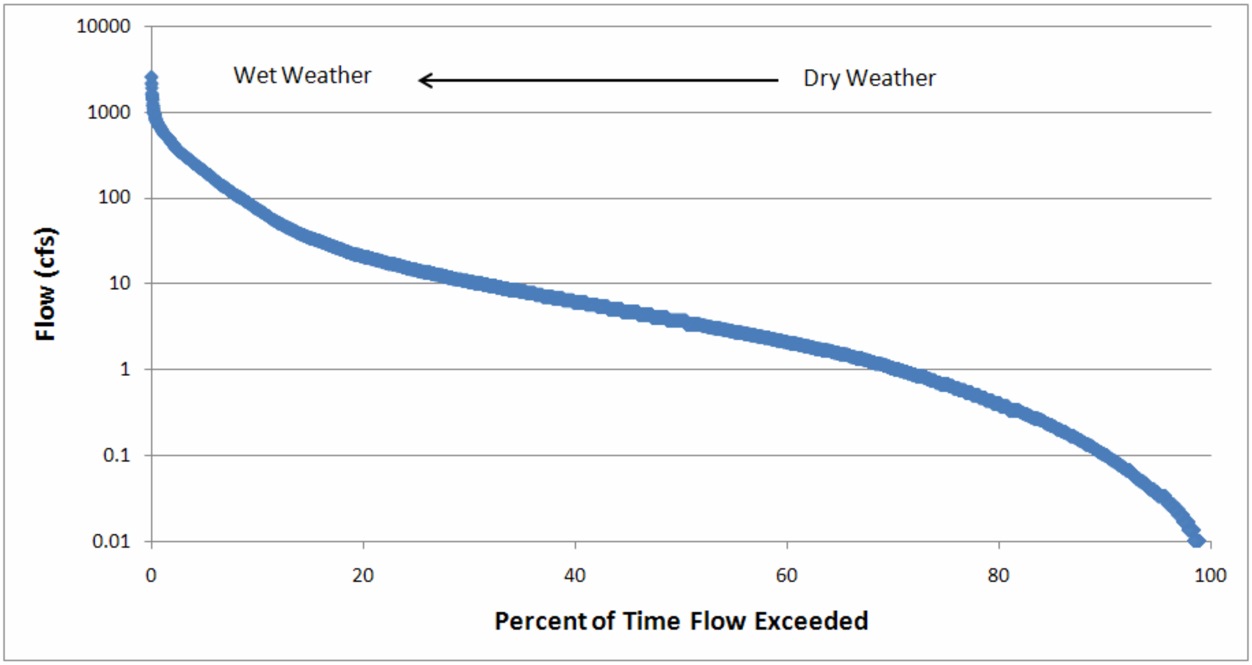

Figure C-1
Example flow-duration curve

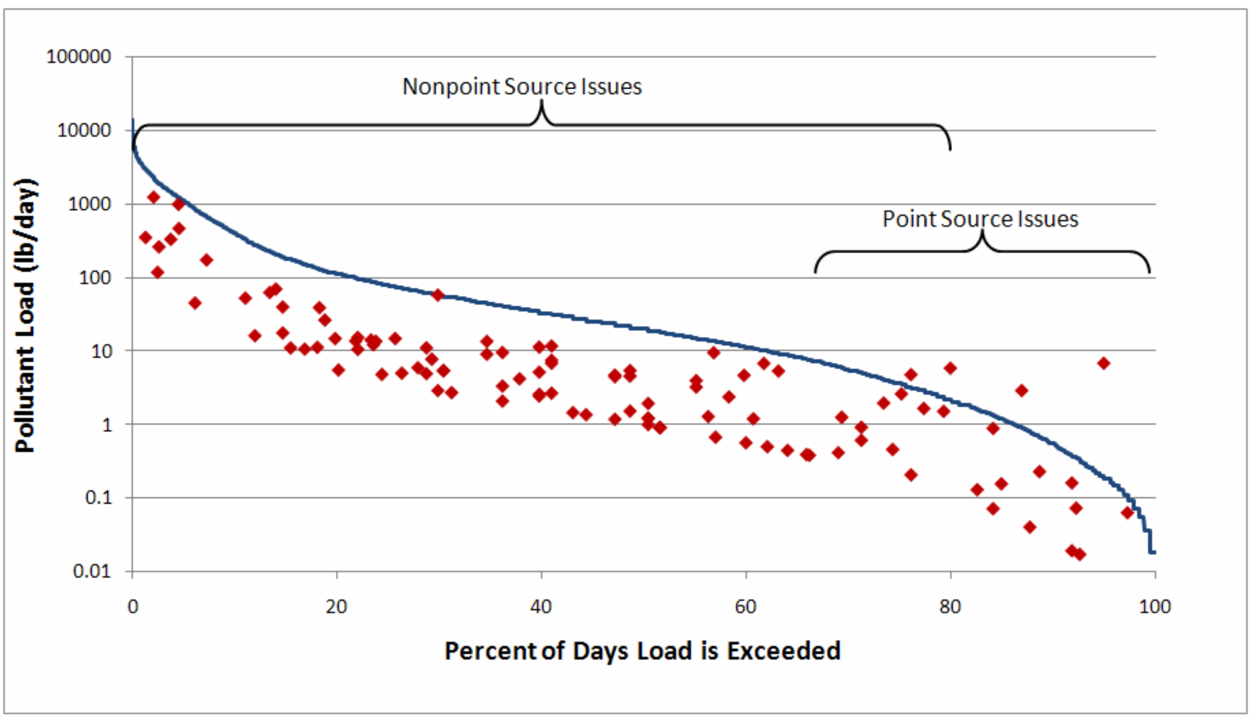

Figure C-2
Example load-duration curve

C.2 Instream Load Calculations

This approach estimates pollutant loads based upon site-specific measurements, without using a model to describe specific cause-effect relationships. It involves multiplying measured flow times a concentration to get a load. Time series information is required for both stream flow and pollutant concentration. These loads may reflect a combination of point and nonpoint sources, depending on upstream sources. Stream flow is most commonly available from the USGS (http://water.usgs.gov/). Water quality data can be obtained from the U.S. EPA STORET database, which serves as a data repository for multiple agencies (http://www.epa.gov/storet/dbtop.html). More recent data may be available by contacting the states or USGS directly.

This approach may be used to estimate loads from a specific land use if the monitoring data are available for a watershed with a homogeneous land use. This approach can also be applied using data from regional reference streams to represent natural background conditions, although data from minimally impacted watersheds may also be used to estimate background loads in TMDLs.

An advantage to this approach is that direct measurement of a pollutant will generally be far more accurate than any model-based estimate. This approach, however, has several disadvantages. It often neglects seasonal variability because it provides information specific to the storms that are monitored, but does not provide direct information on conditions for events that were not monitored. Load estimation methods, such as regression analysis or ratio estimators, can be used to integrate discrete concentration measurements with continuous flow records to provide load estimates over a range of conditions.

The primary limitation of this approach is its inability to separate individual contributions from multiple sources. This problem can be addressed by collecting samples from tributaries draining single land uses, but most tributary monitoring stations reflect multiple land uses and/or contributions from point sources. This approach requires more data than the other simple approaches discussed in this section.

C.3 Unit Area Loads/Export Coefficients

Unit area loads (also called export coefficients) are a routinely-used method to estimate nonpoint source pollutant loads. Pollutant loads are calculated by multiplying a pollutant export coefficient (e.g., kg/m^2*yr) that defines the expected load from a particular land use for the region, by the land area. The accuracy of these estimates is dependent on accurate land use data and appropriate pollutant export coefficients for the region. This approach may require expertise in GIS to calculate the area of different land uses in the watershed.

The Unit Area Load approach can account for differences in pollutant load generation from different land uses. One benefit of this approach is that it can be applied to estimate loads for a wide range of pollutants in watersheds where data are not available. Furthermore, this approach provides estimates of existing loading and can be used to assess the contribution of loads from different land uses. Finally, this approach can be used to estimate uncertainty in load calculations by applying a range of expected export coefficients (e.g., low and high literature values for the region).

There are several limitations to this approach. The approach provides an estimate of average annual pollutant load that may have a high level of uncertainty. Furthermore, this approach does not capture seasonal or annual variability (e.g., due to rainfall variations), or any pollutant decay, transformation or settling that may occur as the load travels to the listed waterbody. Finally, this approach does not consider pollutants associated with base flow conditions (e.g., dry weather sources) or ground water.

C.4 Simple Method

The simple method estimates annual storm water pollutant loads using annual runoff volume and literature-based pollutant concentration data. Data needs for this approach include annual rainfall, runoff coefficients, land use area and flow-weighted mean pollutant concentration. This approach can be applied for multiple land uses and the loads can be summed to estimate watershed pollutant loads. Runoff concentrations are typically available by land use in the literature, but site-specific data are preferred. The National Stormwater Quality Database is a good place to look for runoff concentration data (http://rpitt.eng.ua.edu/Research/ms4/Paper/Mainms4paper.html).

The Simple method accounts for annual variability in rainfall, and if runoff concentration data are available, can reflect site-specific conditions. This approach can also be applied to estimate loads for a wide range of pollutants in watersheds where data are not available, and can be used to assess the load contribution from different land uses.

This method estimates load at a site, catchment or subwatershed scale, but more complex models may be needed for larger watersheds. A disadvantage is that it provides an annual estimate of pollutant load and may have a high level of uncertainty. Furthermore, this approach does not consider pollutants associated with base flow conditions or ground water.

C.5 Generalized Watershed Loading Functions Model (GWLF)

http://www.avgwlf.psu.edu/

GWLF is a watershed model that simulates runoff and sediment loadings from mixed-use watersheds. It is a continuous simulation model (i.e., predicts how concentrations change over time) that uses daily time steps for weather data and water balance calculations. Pollutant loads are provided on a monthly basis. GWLF requires the user to divide the watershed into any number of distinct groups, each of which is labeled as rural or urban. The model does not spatially distribute the source areas, but simply aggregates the loads from each area into a watershed total; in other words, there is no spatial routing. Erosion and sediment yield for rural areas are estimated using monthly erosion calculations based on the Universal Soil Loss Equation (USLE), with monthly rainfall-runoff coefficients. A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff are then applied to the calculated erosion to determine how much of the sediment eroded from each source area is delivered to the watershed outlet. Erosion from urban areas is considered negligible. GWLF provides more detailed temporal results than the USLE, but also requires more input data. Specifically, daily climate data are required as well as data on processes related to the hydrologic cycle (e.g., evapotranspiration rates, groundwater recession constants). By performing a water balance, it has the ability to predict concentrations at a watershed outlet as opposed to just loads.

C.6 Watershed Analysis Risk Management Framework (WARMF)

http://www.epa.gov/athens/wwqtsc/html/warmf.html

WARMF, a watershed and receiving water model, was developed under sponsorship from EPRI as a decision support system for watershed management and TMDL development (EPRI, 2001a; EPRI, 2001b). Pollutants of interest include conventional pollutants (e.g., pathogens, suspended sediment, BOD, nutrients) as well as metals (including mercury). WARMF is GIS-based and calculates daily runoff, shallow ground water flow, hydrology and water quality of a river basin. The river basin is divided into a network of land catchments (including canopy and soil layers), stream segments, and lake layers for hydrologic and water quality simulations. Land surface is characterized by land use/land cover and precipitation is deposited on the land catchments to calculate snow and soil hydrology, and resulting surface runoff and groundwater accretion to river segments. Instead of using export coefficients, a complete mass balance is performed starting with atmospheric deposition and land application as boundary conditions. Nonpoint loads are routed through the system with the mass so the source of nonpoint loading can be tracked back to land use and location. Point and nonpoint loads are routed to downstream receiving waters (e.g., rivers and lakes) where fate and transport is modeled. The algorithms of WARMF were derived from many well established codes such as ILWAS, SWMM, ANSWERS, and WASP. WARMF also includes unique decision support tools for consensus building and TMDL development. The scientific basis of WARMF and the consensus building tools have undergone several peer reviews by independent experts under U.S. EPA guidelines (EPRI, 2000; EPRI, 2002). Capabilities added to WARMF over recent years include the ability to address problems related to mercury loadings, acid mine drainage, and decentralized sewage treatment (EPRI, 2001c; EPRI, 2006; Siegrist et al., 2005). WARMF is now compatible with the data extraction and watershed delineation tools of U.S. EPA BASINS and is available under public domain at U.S. EPA's Watershed/Water Quality Modeling Technical Support Center.

C.7 Hydrologic Simulation Program – Fortran (HSPF)

http://www.epa.gov/ceampubl/swater/hspf/index.htm

HSPF is a watershed and receiving water model which uses information on the time history of rainfall, temperature, evaporation, and parameters related to land use patterns, soil characteristics, and agricultural practices to simulate the processes that occur in a watershed. The initial result of an HSPF simulation is a time series simulation of the quantity and quality of water transported over the land surface and through various soil zones down to the groundwater aquifers. Runoff flow rate, sediment loads, nutrients, pesticides, toxic chemicals, and other quality constituent concentrations can also be predicted. The model uses these results and stream channel information to simulate instream processes. From this information, HSPF produces a time series simulation of water quantity and quality at any point in the watershed. HSPF is well suited for mixed-use (i.e., containing both urban and rural land uses) watersheds, as it contains separate sediment routines for pervious and impervious surfaces. HSPF is an integrated watershed/stream/reservoir model, and simulates sediment routing and deposition for different classes of particle size. HSPF was integrated with a geographical information system (GIS) environment with the development of Better Assessment Science Integrating point and Nonpoint Sources (BASINS). HSPF provides a more detailed description of urban areas than some agriculturally based models (e.g., AGNPS) and contains direct linkage to a receiving water model. This additional computational ability carries with it the cost of requiring more detailed model inputs, as well as requiring more time to set up and apply the model. BASINS software can automatically incorporate existing environmental databases (e.g., land use, water quality data) into HSPF, although it is important to verify the accuracy of these sources before using them in the model.

C.8 Soil & Water Assessment Tool (SWAT)

http://www.brc.tamus.edu/swat/

The Soil & Water Assessment Tool (SWAT) is a basin-scale, continuous-time watershed model designed for agricultural watersheds. It operates on a daily time step. Sediment yield is calculated with the Modified Universal Soil Loss Equation. It contains a sediment routing model that considers deposition and channel erosion for various sediment particle sizes. SWAT is also contained as part of U.S. EPA's BASINS software. SWAT is a continuous time model, i.e., a long-term yield model. The model is not designed to simulate detailed, single-event flood routing. SWAT was originally developed strictly for application to agricultural watersheds, but it has been modified to include consideration of urban areas.

C.9 QUAL2K

http://www.epa.gov/athens/wwqtsc/html/qual2k.html

QUAL2K (a modernized version of QUAL2E) is a one-dimensional receiving water quality model that assumes steady-state flow, but allows simulation of diurnal variations in dissolved oxygen and temperature. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model simulates the following state variables: temperature, dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, inorganic phosphorus, organic phosphorus, algae, and conservative and non-conservative substances. QUAL2K also includes components that allow implementation of uncertainty analyses using sensitivity analysis, first-order error analysis, or Monte Carlo simulation. QUAL2K has been used for wasteload allocation purposes throughout the United States. QUAL2K is also linked into U.S. EPA's BASINS modeling system. The primary advantages of using QUAL2K include its widespread use and acceptance, and ability to simulate all of the conventional pollutants of concern. Its disadvantage is that it is restricted to one-dimensional, steady-state analyses.

C.10 BATHTUB

http://el.erdc.usace.army.mil/products.cfm?Topic=model&Type=watqual

BATHTUB is a receiving water model for estimating nutrient loading to lakes and reservoirs, summarizing information on in-lake water quality data, and predicting the lake/reservoir response to nutrient loading (Walker, 1986). It was developed, and is distributed, by the U.S. Army Corps of Engineers. BATHTUB consists of three modules: FLUX, PROFILE, and

BATHTUB (Walker 1986). The FLUX module estimates nutrient loads or fluxes to the lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified. PROFILE is an analysis module that permits the user to display lake water quality data. PROFILE algorithms can be used to estimate hypolimnetic oxygen depletion rates, area-weighted or mixed layer average constitutent concentrations, and similar trophic state indicators. BATHTUB is the module that predicts lake/reservoir responses to nutrient fluxes. Because reservoir ecosystems typically have different characteristics than many natural lakes, BATHTUB was developed to specifically account for some of these differences, including the effects of non-algal turbidity on transparency and algae responses to phosphorus. BATHTUB contains a number of regression equations that have been calibrated using a wide range of lake and reservoir data sets. It can treat the lake or reservoir as a continuously stirred, mixed reactor, or it can predict longitudinal gradients in trophic state variables in a reservoir or narrow lake. These trophic state variables include in-lake total and ortho-phosphorus, organic nitrogen, hypolimnetic dissolved oxygen, metalimnetic dissolved oxygen, and chlorophyll concentrations, and Secchi depth (transparency). Uncertainty estimates are provided with predicted trophic state variables. There are several options for estimating uncertainty based on the distribution of the input and inlake data. Both tabular and graphical displays are available from the program.

C.11 WASP5

http://www.epa.gov/athens/wwqtsc/html/wasp.html

WASP5, a receiving water model, is U.S. EPA's general-purpose surface water quality modeling system. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model can be applied in one, two, or three dimensions and is designed for linkage with the hydrodynamic model DYNHYD5. WASP5 has also been successfully linked with other one, two, and three dimensional hydrodynamic models such as RIVMOD, RMA-2V and EFDC. WASP5 can also accept user-specified advective and dispersive flows. WASP5 provides separate submodels for conventional and toxic pollutants. The EUTRO5 submodel describes up to eight state variables in the water column and bed sediments: dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, organic phosphorus, and phytoplankton. The TOXI5 submodel simulates the transformation of up to three different chemicals and three different solids classes. The primary advantage of using WASP5 is that it provides the flexibility to describe almost any water quality constituent of concern, along with its widespread use and acceptance. Its primary disadvantage is that it is designed to read hydrodynamic results only from the one-dimensional RIVMOD-H and DYNHYD5 models. Coupling of WASP5 with multi-dimensional hydrodynamic model results will require extensive site-specific linkage efforts.

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