Water Quality Analyses for NEPA Documents: Selecting Appropriate Methodologies

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Executive Summary

As required by the National Environmental Policy Act (NEPA), federal agencies proposing, funding or approving transportation or other types of federal projects must consider, analyze, and document these projects' potential environmental impacts, and allow this information to be reviewed by other agencies and the public. Water quality impacts are an important environmental element covered under NEPA. These impacts include highway or urban stormwater runoff degrading the quality streams and rivers, wetlands encroachment, and the depletion or pollution of groundwater aquifers.

This research paper's objective is to identify water quality impact analysis methodologies that could be used for transportation projects undergoing agency and public review pursuant to NEPA. It focuses on methodologies currently being used by State Departments of Transportation (DOTs) and Federal Highway Administration (FHWA) division offices in preparing Environmental Impact Statements (EISs) or Environmental Assessments (EAs), or on methodologies required by environmental resource agencies.

Data collection involved a survey of all State DOTs and FHWA division offices, follow-up interviews with some of the offices that responded to a survey, and a literature research on the methodologies identified by survey respondents. Water quality methodologies are organized into four main categories:

- Stormwater runoff
- Stream quality
- Wetlands quality
- Groundwater quality

These methodologies are evaluated based on the following evaluation parameters. The goal is to help managers responsible for navigating transportation projects through the NEPA process make sound decisions in selecting appropriate water quality methodologies for their projects.

- Objectives and outputs
- Technical proficiency of practitioners
- Geographical or conditional applicability
- Data requirements
- Time and cost requirements
- Accuracy of results
- Agency involvement and acceptance
- Adaptability to cumulative impact assessments

The methodologies employed for a NEPA document can accomplish up to three main objectives:

1. Identify and characterize existing conditions in a project's study area
2. Assess or predict a project's potential impacts on existing conditions and expected future conditions
3. Identify and evaluate mitigation measures, if necessary.

A “complete” methodology is one that satisfies all of these main objectives. The results of this research paper demonstrate that most water quality methodologies satisfy only one or two of these objectives, but all three are relevant topics in a NEPA document. Therefore, a combination of multiple methodologies or other approaches would have to be used to make coverage of the water quality topic complete for NEPA purposes.

Most of the methodologies described in this research paper are qualitative in nature–especially those for stream quality, wetland quality, and groundwater quality categories, which in most cases can suffice for NEPA purposes. However, in some situations stakeholders may demand to know whether a project’s future activities (i.e., stormwater runoff) would cause a receiving water body to exceed federal and/or state water quality criteria. In this case, the NEPA manager would probably need to select a methodology that can quantify direct impacts on water bodies (e.g., in-stream pollutant concentrations) and quantify the effectiveness of mitigation measures, if necessary. NEPA managers should also consider the following factors in selecting appropriate water quality methodologies for projects:

- Environmental concerns
- Project scope and regulatory requirements
- Geographic or region-specific conditions
- Expected level of accuracy
- Appropriate agency coordination

1 Introduction

1.1 Study Purpose

This research paper was prepared for the National Cooperative Highway Research Program (NCHRP). Its goal is to identify appropriate water quality impact analysis methodologies that could be used for transportation projects undergoing environmental review pursuant to NEPA.

NEPA requires federal agencies proposing, funding, or approving transportation or other types of federal projects to consider, analyze, and document these projects' potential environmental impacts. These agencies must allow this information to be reviewed by other agencies and the public. NEPA is a process that is intended to lead to better decision making – a process that addresses an action's purpose and need while minimizing or avoiding unacceptably high environmental or social impacts or if necessary, mitigating the impacts of the action.

Water quality impacts are one of the environmental topics covered under NEPA. These impacts can include highway or urban stormwater runoff that degrades the quality of streams and rivers, wetlands encroachment, and depletion or pollution of groundwater aquifers. The construction (new or rehabilitation) and/or operation of highways can affect a surface water body's health through stormwater runoff that carries pollutants associated with various sources (e.g., vehicles, roadside fertilizers, de-icing agents, and transporting livestock or waste). Highway surfaces can also impact the health of nearby surface water bodies through the settling of airborne particulate matter. These water bodies can also be negatively affected by thermal changes caused by temperature differences between highway runoff and surface water.

The objective of this research is to identify appropriate water quality impact analysis methodologies that could be used for transportation projects undergoing agency and public review pursuant to NEPA. The methodologies examined do not include techniques used to identify water resources (e.g., wetland delineation and stream identification). Rather, they focus on issues of "water quality" and include methodologies used by practitioners to understand the functions and quality of the wetlands being studied. This research paper also includes methodologies that evaluate the health of surface water bodies based on how well they support fish, insects, plants, and other aquatic life.

This research paper focuses on "real-life" methodologies, or those currently being used by State Departments of Transportation (DOTs) and Federal Highway Administration (FHWA) division offices in preparing Environmental Impact Statements (EISs) or Environmental Assessments (EAs). It also focuses on methodologies required by environmental resource agencies. The research included taking a survey of all State DOTs and FHWA division offices, and performing follow-up interviews with respondents who identified their methodologies. The identified methodologies were then evaluated for their comparative advantages and disadvantages, based on situations or conditions where they would be appropriate or recommended.

1.2 Report Organization

This paper is designed to help NEPA practitioners or managers working on transportation projects become aware of available methodologies for evaluating these projects' impacts on water quality. Its intent is to provide guidance in selecting appropriate water quality methodologies for specific projects. Although this paper describes and evaluates methodologies in terms of appropriateness for certain situations or conditions, it does not provide guidance on how to use them. However, references are provided that do provide guidance on their use.

This research paper is organized in the following manner:

- Section 2 summarizes the NEPA process and documentation requirements, and explains how NEPA is integrated with other environmental regulations.
- Section 3 summarizes water quality regulations that are integrated with the NEPA process, and explains how they affect the level-of-impact analyses often found in NEPA documents.
- Section 4 outlines the data collection activities used for this research.
- Section 5 describes what a methodology is in the context of NEPA, and describes the evaluative parameters that differentiate between methodologies. These parameters are used to compare and contrast the methodologies identified in following sections.
- Sections 6 through 9 introduce the water quality methodologies identified through the data collection activities. They are organized by the following categories: stormwater runoff; stream quality; wetlands quality; and groundwater quality. With the exception of the last section, each includes an evaluation matrix that organizes the key parameters used to evaluate the methodologies. Sections 6 through 9 also contain narrative discussions of each methodology, which focus on their comparative advantages and disadvantages and on situations or conditions (e.g., size, project type and location, political factors, etc.) where use of the methodology would be appropriate or recommended. This evaluation is based on information obtained from the data collection activities described in Section 4, and on the technical knowledge and experience of the report's authors.
- Section 10 provides a summary and conclusions.
- Section 11 provides a recommendation for future research.

2 National Environmental Policy Act

The National Environmental Policy Act (NEPA) (Public Law 91-190) was signed by President Nixon in January 1970 and is intended to be the "national charter for protection of the environment" (40 Code of Federal Regulations (CFR) Part 1500.1). It was enacted to provide that information on the environmental impacts of any federal action is available to public officials and citizens before decisions are made and actions taken. NEPA applies to decisions made with a federal nexus, meaning any involvement by federal agencies (e.g., granting federal permits and using federal lands or funding). The NEPA process is intended to help public officials make decisions based on an understanding of environmental consequences, and to take actions that protect, restore, and enhance the environment.

NEPA requires federal agencies to work with a broad range of stakeholders (e.g., state and local governments, indigenous people, public and private organizations, and the public) to achieve and balance national social, economic, and environmental goals while still accomplishing their missions. Federal agencies are required to integrate the NEPA process with other planning requirements from the outset, to ensure that decisions reflect environmental values, avoid subsequent delays, and head off potential conflicts. The full text of NEPA can be found in 42 United States Code (USC) 4321-4347.

Regulations to implement NEPA were developed by the Council on Environmental Quality (CEQ) (*Regulations for Implementing the Procedural Provisions of NEPA*) and appear in 40 CFR 1500 – 1508. These regulations are applicable to almost all federal activities. Because one set of regulations would not be sufficiently detailed or appropriate to the actions of all federal agencies, each agency was required to develop their own NEPA regulations consistent with the regulations established by the CEQ. The Federal Highway Administration (FHWA) developed regulations applicable to its federal-aid highway projects. These appear in 23 CFR 771, *Environmental Impact and Related Procedures*. The FHWA has also prepared numerous guidance documents, including its *Technical Advisory, Guidance for Preparing and Processing Environmental and Section 4(f) Documents* (T6640.8A, October 30, 1987), to assist in preparing environmental documents for federal-aid highway projects.

All actions subject to NEPA are categorized as Class I, II, or III.

A Class I or major action is expected to cause a “significant” impact to the environment, and requires preparation of an EIS. A significant impact under NEPA is assessed in terms of an action’s context within the environment and its intensity impact. *Context* refers to the level or relative abundance of resources in a project area. *Intensity* refers to the specific impact, or how much of the resource(s) would be used or affected by the project.

The question of significance depends on the relationship between context and intensity. If a project’s intensity is anticipated to be large in the context of the environment, a significant impact can be expected and the action would probably require an EIS under NEPA. An EIS is a very detailed, comprehensive, and most often very lengthy document. It is not unusual for EISs to be thousands of pages long. EISs are required to describe the purpose and need of the action; the alternatives being considered for the action; the existing environmental and social conditions that may be affected by the action; the environmental and social consequences of the action; and a record of public and agency comments on the action. The EIS process is initiated by issuing a Notice of Intent (NOI) to prepare an EIS in the Federal Register. The Draft EIS, which includes a notice published in the Federal Register, is subject to agency and public review during a 45-day comment period. The federal sponsoring or lead agency is required to respond in writing to all substantive comments on the Draft EIS and to produce a Final EIS that reflects agency and public comments. The end of the public review process results in a Record of Decision (ROD), which identifies a preferred alternative; briefly describes other alternatives considered for the action; summarizes agency comments on the Final EIS; and identifies environmental mitigation and monitoring requirements.

A Class II or minor action is an action that, based on past experience with this type of action, will not cause a “significant” impact to the environment. These types of actions merit a Categorical Exclusion (CE). Only unusual circumstances would elevate a Class II to a Class I or III action, such as if it would affect properties protected by Section 4(f) of the Department of Transportation Act or Section 106 of the National Historic Preservation Act (NHPA). Certain types of FHWA Class II actions require documentation depending on whether the type of action is listed in 23 CFR 771.117(c) or 23 CFR 771.117(d). If a CE document is required for a Class II action, it is normally very brief (i.e., a few pages) because these actions tend to be very simple. Due to their relatively benign effects on the environment, the analytical benchmarks for CEs tend to be very low and are sometimes covered by simple checks using standardized forms, which can be used as CE document. CE documents are also not subject to external agency or public reviews. However, , Class II actions may still require external agency reviews under other pertinent federal regulations, and these reviews must be completed before a CE can be approved.

Under Class III, it is not yet known whether an action's environmental impacts would be significant, but the federal agency does not expect a significant impact. Class II actions require preparation of an EA, a document that contains the same basic information as an EIS, but is normally substantially shorter for two major reasons: (1) Class III actions tend to be smaller in size and scope than Class I actions; and (2) EAs do not have to be as comprehensive as EISs, because they can focus only on environmental issues that could rise to the level of significance.

The FHWA Technical Advisory has noted that CEQ recommends that EAs should be no more than 15 pages long. In reality, most FHWA EAs are usually substantially longer and it is not unusual for them to be over 100 pages. The EA review process does not formally begin until publication of the EA document. Similar to an EIS, an EA is subject to external agency and public review during a 30-day comment period. Also similar to the EIS process, the federal sponsoring or lead agency is required to review and respond to all substantive comments on the EA. Following this review, the federal agency may choose to:

- Revise the EA based on new substantive information provided by agency and public comments or resulting from other regulatory activities (given that this information still finds that the action would not result a significant impact);
- Not revise the EA because no new substantive information was provided, and the information included still finds that the action would not result a significant impact; or
- Abandon the EA process, because new substantive information was provided that the project would result in a significant impact, and proceed to an EIS process if the federal agency and other stakeholders want to continue development of the action.

Following the steps in the first two bullets above, the review process is completed by the issuance of a Finding of No Significant Impact (FONSI). This can be a simple statement attached to the Revised EA, or a full document containing the same type of information found in RODs. Revised EA/FONSI and FONSI documents are not subject to external agency or public review.

NEPA outlines processes for federal agencies to follow in considering their projects' environmental impacts, and how this should factor into decision making. NEPA does not provide guidance or regulations to federal agencies on how environmental impacts are determined, calculated, or assessed. For some environmental subjects, the U.S. Department of Transportation (or the FHWA) has developed regulations, guidance, and models to assist in NEPA environmental impact analyses. A good example is the impact analysis of highway-related noise where FHWA regulations contained in 23 CFR 772, *Procedures for Abatement of Highway Traffic Noise and Construction Noise*, were promulgated to address this issue. However, for other environmental subjects (e.g., air quality, historic resources, etc.), the NEPA process has traditionally relied on other environmental regulations to determine how impacts are assessed, because compliance with these other regulations is often conducted fully or partially within the NEPA process. Therefore, NEPA's environmental review processes have been integrated with other environmental regulatory requirements or processes such as Section 4(f), NHPA Section 106, Section 7 of the Endangered Species Act (ESA), Section 404 of the Clean

Water Act (CWA), and numerous others. NEPA documents, in particular EISs and EAs, record and provide the environmental analyses for more specialized environmental reviews such as impacts on parklands under Section 4(f).

3 Water Quality Regulations in the NEPA Process

For water quality impacts, major environmental regulations normally covered in the NEPA process include Sections 402 and 404 of the Clean Water Act and Section 1424(e) of the Safe Drinking Water Act. These regulations are summarized below.

3.1 Clean Water Act

The intent of the Clean Water Act of 1972 (CWA) (33 USC 1251 et. seq.), as amended in 1987, is to provide federal protection for the quality of the nation's waterways. The CWA's primary purpose is to stop pollutants from being discharged into waterways and maintain water quality for various uses. Two regulations stemming from the CWA are applied during the NEPA process: Section 404 and Section 402, or what is commonly known as the National Pollutant Discharge Elimination System (NPDES).

3.1.1 Section 404

Section 404 of the CWA establishes a permit program administered by the U.S. Army Corps of Engineers (USACE) for the discharge of dredged or fill materials into "waters of the U.S." A number of different types of surface waters are considered to be waters of the U.S., including ocean areas, rivers and streams, intermittent streams, wetlands, and isolated water bodies (see 33 CFR Part 328 for more detailed information). Waters of the U.S. do not include manmade surface waters such as irrigation ditches. For non-tidal waters, the waters of the U.S. (or the limits of the USACE jurisdiction) extend to the ordinary high water mark. However, if adjacent to wetlands or if the affected resource is a wetland, jurisdiction extends to the upland limit of the wetlands. For tidal waters, waters of the U.S. extend to the high tide line.

Other than conducting and documenting coordination with the USACE to identify the project classification (i.e., general or individual permit), very little of the Section 404 permitting process is conducted during the NEPA process if the USACE classifies the dredge or fill as a general permit, regardless of whether the action requires an EIS, EA or CE. However, if the USACE classifies the proposed dredged or fill material as an individual permit, more stringent coordination with the USACE and other agencies such as the U.S. Fish and Wildlife Service (USFWS) would be required during the NEPA process, and the analysis determining the Least Environmentally Damaging Practicable Alternative would be included in the NEPA document. However, regardless of the classification, formal application for a Department of Army permit is normally made after the NEPA process.

For a NEPA document to be in compliance with Section 404, it should provide an estimate of the amount of dredge or fill required by the proposed action. Conceptual or preliminary engineering would provide the information needed for the NEPA document. Some general permits include order-of-magnitude thresholds to determine qualification, and these estimates are important for the USACE in determining classification.

Wetlands are considered a special type of "waters of the U.S." due to the many and varied functions they perform. If an action has the potential to dredge or fill a wetland, the analytical requirements of Section 404 during the NEPA process include wetland delineation and functions assessments, and the results are provided in the NEPA document.

3.1.2 Section 402

Section 402 or the NPDES permit program was created from the 1977 amendments to the CWA. It regulates point sources of discharge, such as outfalls from sewage treatment plants and other easily identifiable point sources that contribute to the degradation of water quality. However, as pollution control measures were instituted it became evident that more diffuse sources, such as agricultural and urban stormwater runoff, were also contributing to the problem. In response to this concern, the 1987 amendments to the CWA added Section 402(p), which required the U.S. Environmental Protection Agency (USEPA) to establish a comprehensive two-phased approach to address stormwater discharges through the NPDES permit program. The new regulation required that discharges of stormwater from large and medium-sized municipal separate storm sewer systems (MS4s) become subject to NPDES permitting, including the drainage systems of highways owned by State DOTs. The NPDES permits require that stormwater discharges from MS4s reduce levels of pollutants to the maximum extent practicable.

Traditionally, the application of NPDES regulations to transportation development, which is usually not considered a point source, only involved construction (i.e., stormwater runoff, dewatering, and hydro-testing) under certain circumstances or thresholds. Depending on local requirements, NEPA documents may identify whether or not any construction activity would require an NPDES permit. Analytically, this NEPA document would contain an estimate of the construction area to determine NPDES applicability, which could be obtained through conceptual or preliminary engineering.

Once completed, the drainage systems of new or modified highway projects may become part of an MS4 subject to NPDES permitting. Pollutant discharges from highway projects have the potential to make compliance with the terms and conditions of the NPDES MS4 permit more difficult, which could force a more rigorous analysis in NEPA documents.

3.2 Safe Drinking Water Act

The Safe Drinking Water Act of 1974 (SDWA) is the main federal law that protects the quality of drinking water in the U.S. Under the SDWA, the USEPA is required to set standards for drinking water quality and oversee state and local water suppliers who implement these standards. Because surface transportation projects infrequently affect drinking water, application of the SDWA is rare during the NEPA process. The SDWA does, however, authorize the USEPA to designate an aquifer for special protection if it is the sole or principal drinking water resource for an area and if its contamination would create a significant hazard to public health. Such aquifers are called Sole Source Aquifers and Section 1424(e) of the SDWA allows the USEPA to prohibit federal funding for projects in areas that overlie a sole-source aquifer if a project threatens the aquifer. Under such circumstances the USEPA would conduct a Section 1424(e) review of the project, and this is normally conducted during the NEPA process.

For projects that trigger Section 1424(e) review, a water quality assessment (groundwater impact assessment) must be prepared during the NEPA process for submission to USEPA for review. At the end of the Section 1424(e) review, the USEPA makes one of the following determinations, or similar conclusions:

1. The risk of contamination of the aquifer through the recharge zone so as to create a significant hazard to public health is not sufficiently great so as to prevent commitment of Federal funding to the project; or
2. The project may contaminate the aquifer through the recharge zone so as to create a significant hazard to public health (40 CFR 149.109(b)(c)).

A USEPA #1 determination would be reported in the NEPA document, along with a copy of the water quality assessment and the USEPA's response. A USEPA #2 determination would lead to other activities, such as redesigning the project to justify the withdrawal of USEPA's objections.

4 Data Collection

Data collection involved three major activities: a brief questionnaire distributed to all State DOTs and FHWA division offices nationwide; follow-up interviews with some of the offices that responded to the questionnaire, and a literature research on the methodologies identified by the questionnaire respondents.

4.1 Questionnaire and Survey

To obtain information on the water quality impact methodologies being used nationwide in NEPA documents for highway projects, a brief questionnaire was developed. This questionnaire was specifically targeted to agencies that implement highway projects subject to NEPA, which include State DOTs and FHWA federal aid divisions nationwide. It contained only six questions, not including contact information (see Appendices), and was purposely made to be brief in order to encourage participation. The questionnaire asked about the agency's most pressing water quality concerns, and about what methodologies (if any) the agency believed to be most effective in addressing water quality concerns in NEPA documents. The questionnaire was reviewed by the study's advisory panel before distribution.

The questionnaire was distributed through e-mail by the study's NCHRP project manager. The e-mail message, as provided in the Appendices, asked that the responses be submitted directly to the study team. In order to reach all the State DOTs, the questionnaire was e-mailed to members of the Environmental Committee of the American Association of State Highway and Transportation Officials (AASHTO). Every state is represented on the committee. In order to reach the FHWA divisions, the FHWA Environmental Resource Center was contacted, who provided a listing of the environmental coordinators of the division offices nationwide.

Of the questionnaire recipients, 33 responded to the request for information. A few dozen different water quality methodologies were mentioned.

4.2 Interviews

Follow-up interviews were conducted by telephone. They focused on State DOTs and FHWA division office personnel who responded to the questionnaire and provided information on water quality methodologies they have used in their NEPA documents.

At the beginning of each interview, interviewees were told that the questions would focus on one or more methodologies, which were identified from his or her responses to the questionnaire. An interview guide was developed, with the goal of obtaining the following information:

- General information on how the methodology works;
- Any underlying assumptions associated with the methodology;
- The level of technical knowledge that practitioners need to properly use the methodology;
- Circumstances in which the methodology is not useful or is lacking;
- The level of effort required to acquire, collect, or obtain the data needed by the methodology, including whether or not fieldwork is required;
- The general expense and time needed to conduct the methodology;
- The type of information produced;
- The accuracy of results; and
- Opinions of resource or regulatory agencies on the methodology.

In general, these interviews focused on the evaluative parameters described in Section 5. The goal was to uncover information on logistical issues being faced in conducting the methodology; its appropriateness to certain types of projects and geographic areas; and special challenges it may present.

4.3 Literature Review

The main purpose of the literature research was to obtain technical information and details on the methodologies identified by State DOT and FHWA division offices. As a starting point and prior to implementing the questionnaire survey, the FHWA publication *Evaluation and Management of Highway Runoff Quality* (June 1996) was reviewed. Although this publication identified several methodologies for stormwater runoff, only two were identified by survey respondents: the FHWA (Driscoll) Method (see Section 6.2.2) and the Simple Method (see Section 6.2.3). The literature review effort was helped by survey respondents who provided references for the methodologies they use.

State DOT and relevant state environmental agency (e.g., State Departments of Natural Resources, Water Quality, and Environmental Protection) websites were consulted to obtain current and applicable water quality permits, regulations, and guidelines. Examples of state-level resources referenced in developing this technical paper include the following:

<u>Minnesota</u>

- Pollution Control Agency: *Stormwater Manual (2006)* (http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html)

- Department of Natural Resources: *Minnesota Water Statutes and Rules* (http://www.dnr.state.mn.us/waters/law.html);
- Minnesota Statutes: Chapter 114C-116I – *Environmental Protection* (https://www.revisor.leg.state.mn.us/revisor/pages/statute/statute_toc.php)

<u>Ohio</u>

- Department of Natural Resources, *Division of Water: Rainwater and Land Development Manual* (2006) (http://www.dnr.state.oh.us/water/rainwater/default/tabid/9186/Default.aspx)
- Ohio DOT: *Location and Design Manual*, Drainage Design (http://www.dot.state.oh.us/se/hy/ld2.htm)
- Ohio EPA: Technical Bulletin EAS/2006-06-1, *Methods for Assessing Habitat in Flowing Waters Using the Qualitative Habitat Index*. (http://www.epa.state.oh.us/dsw/documents/QHEIManualJune2006.pdf)
- Ohio Revised Code: Title 15 – *Conservation of Natural Resources*, Title 61 – *Water Supply, Sanitation, Ditches* (http://codes.ohio.gov/orc)

<u>Washington State</u>

- Department of Ecology (DE): *Stormwater Management Manual* (2005) (http://www.ecy.wa.gov/programs/wq/stormwater)
- Washington State DOT (WSDOT), *Stormwater Management Manual* (2006) (http://www.wsdot.wa.gov/Environment/WaterQuality/Runoff/HighwayRunoffManual.htm)
- Washington Administrative Code, Title 173 – Department of Ecology (http://apps.leg.wa.gov/wac)

In addition to FHWA, the USEPA and USACE websites were consulted to obtain relevant technical research papers and guidance on water quality methodologies. For example, USACE provides guidance on evaluating wetland functions and values, and USEPA describes methods for assessing watershed health, wetlands, and state source water. These references are listed in Section 11, References.

5 Evaluative Parameters

According to the Merriam-Webster Dictionary, a methodology is: (1) A body of methods, rules, and postulates employed by a discipline: a particular procedure or set of procedures; and (2) The analysis of the principles or procedures of inquiry in a particular field. As noted in this definition, the methodologies employed for NEPA purposes involve methods, rules, procedures, and principles – regardless of whether the methodology requires many steps or just a few.

“Methods” can be either technological or non-technological. A good example of a technological method is the USEPA’s computer models (MOBILE 5A and the CAL3QHC) that are used for highway projects to evaluate micro-scale Carbon Monoxide impacts. Good examples of non-technological methods are the use of interviews and expert panels to evaluate potential impacts. These methods are most likely used for land use, social, and cultural topics – subjects that do not lend themselves to technological methods.

"Rules," from a NEPA perspective, refer to regulations, which often describe procedures that should be followed in addressing potential impacts on protected resources. The NHPA Section 106 regulations contained in 36 CFR 800 are a good example of rules that provide specific steps that federal agencies must follow to avoid or mitigate adverse impacts on historic properties.

"Procedures" are steps to be followed to achieve the methodology's objective. Steps can be processed oriented or, as noted above for "rules," they can be technical such as specific protocols for properly using a computer model.

For NEPA purposes, "principles" may refer to the methodology's underlying assumptions and also why it is being conducted. Many methodologies are built on the principles of science. For example, noise impact methodologies stem from the laws of physics. Other topics covered in the NEPA process, and by extension their methodologies, are based on past political decisions or considerations. Land use impacts are a good example, where the results of the analysis are predicated on local political preferences on the location and pace of land use development. Another good example is Environmental Justice, where a political decision was made by the President of the United States to direct federal agencies to make a good faith effort to avoid or minimize the impacts of federal actions on minority and low-income populations. Political-based principles also extend beyond human resources. Laws in place to protect species listed as threatened or endangered (T&E), migratory birds, and marine mammals are a good example.

All methodologies share common variables that determine or influence the type of information they produce and the quality of their results. Some of the variables or parameters used to compare and evaluate water quality methodologies are identified in this research paper. These parameters are as follows, and are described more fully in this section:

- Objectives and outputs
- Level of technical competency needed by practitioners
- Project type and geographic applicability
- Level of data requirements
- Time and cost
- Relative or comparative accuracy of results
- Agency involvement and acceptance
- Adaptability to cumulative impact analysis

5.1 Objectives and Outputs

In preparing a NEPA document, the employed methodologies are used to accomplish three main objectives:

1. Identify and understand the characteristics of the physical, natural and human resources that may be affected by the proposed action;
2. Predict how the identified resources would change or be altered as a result of the proposed action (i.e., impacts), including determining how the resources would be changed or altered if the proposed action were not implemented; and
3. If the proposed action's impact on the resource evaluated is considered adverse, help identify mitigation measures and evaluate their effectiveness.

These three objectives represent the basic elements that all NEPA documents must possess, in addition to information on the proposed action and public and agency comments. For the purposes of this research paper, a methodology that addresses all three objectives would be considered "complete." The best examples of complete methodologies are those that cover topics for which there is strong regulatory oversight prescribing how the resources should be identified. Complete methodologies also describe how impacts to those resources are derived, and if necessary, how mitigation measures are implemented to address adverse impacts.

Many methodologies only address one or two of the three objectives listed above. Therefore in order to be complete, many methodologies would have to partner with at least one other methodology in order to be complete. An exception is perhaps where the third objective (mitigation measures) is not required because the result of objective two (impacts) is not expected to be adverse.

The outputs of any methodology are quantitative, qualitative or a combination of the two. Certain environmental and social topics lend themselves to one of these choices. For instance, the evaluation of noise impacts are required for FHWA projects categorized as Type I as defined in 23 CFR 772. If applicable, the NEPA document would describe existing ambient noise conditions and predict the highway project's effects on these conditions. If a noise impact were identified, it would evaluate the effectiveness of noise mitigation (e.g., sound barriers). The results would be presented quantitatively to accomplish all three NEPA objectives for this subject (highway-related noise). On the other hand, the results of a methodology that attempts to address existing social conditions or activities, potential impacts on those activities, and the effectiveness of proposed mitigation would probably be qualitative. However, certain types of social conditions can be described quantitatively, such as those that can be obtained from U.S. Census Bureau information.

Quantitative results are generally perceived as being more accurate than qualitative results, which may not necessarily be true. Nevertheless, due to this perception NEPA practitioners generally choose to present results or outputs in a quantitative manner, and present information qualitatively only if the subject is difficult to present in a quantitative manner. Quantitative results are also usually easier to compare than qualitative results, which is useful, especially in NEPA documents that evaluate multiple alternatives. Practitioners may choose qualitative over quantitative outputs for subjects not deemed important in the context of the proposed action for NEPA purposes, if producing quantitative results is much more expensive than producing qualitative results.

The descriptions of all the methodologies evaluated in this research paper include their objectives and what type of output they produce in meeting these objectives.

5.2 Level of Technical Proficiency

NEPA documents, especially EAs and EISs, cover a wide range of topics where subject matter technical experts or specialists are often needed. In addition to NEPA practitioner(s), who may have technical skills or knowledge in a number of fields, preparation of a NEPA document for an FHWA project often requires civil and traffic engineers; air quality and noise analysts; and other topical experts such as economists, sociologists, biologists and archaeologists. Decisions to use any one of these technical experts or practitioners depend on the physical and operational characteristics of the proposed action and the surrounding environment.

Perhaps one of the most important factors affecting the level of technical proficiency needed to address particular topics or issues is the importance of that topic in the context of the proposed action. For instance, the federal regulation governing how impacts to Threatened and Endangered (T&E) species are addressed in NEPA documents (ESA Section 7) is contained in 50 CFR 402. If after initial consultation with the USFWS, no T&E species (plant or animal) are identified in the vicinity of the proposed action, completion of the Section 7 process would be a relatively simple exercise. As a Section 7 "methodology," the level of technical proficiency needed by the practitioner under such a situation would be a working knowledge of the Section 7 regulatory process. A trained biologist would not be needed. However, if USFWS were to identify at least one T&E species, a higher level of technical proficiency may be needed, depending on whether or not existing information is available on the identified species in the context of the project's study area. If good information were available, a practitioner with good analytical skills (not necessarily biological skills) could suffice in addressing Section 7 concerns. If good information was not available and a possible independent study required to address the issue, a biologist familiar with the identified species would likely be required.

The environmental topics covered in a NEPA document do not necessarily require the services of highly technical practitioners or specialists. The importance of a topic or issue in the NEPA document factors into the methodology selected to address the issue, and this in turn factors into the level of technical proficiency needed to implement the methodology. The selection of an appropriate water quality methodology also depends on the importance of the topic in the context of the project. As do methodologies employed for other topics, the level of technical proficiency needed varies.

5.3 Geographic or Conditional Applicability

A proposed action's geographic location often factors into the selection of methodologies used in the NEPA process. One of the most obvious examples of geographic bias in some methodologies is the application of the Farmland Protection Policy Act (FPPA), which requires that federal agencies identify and consider the effects of their actions on the preservation of farmland. Similar to Section 7, the FPPA regulations (7 CFR 658) stipulate a set of procedures that can be considered a methodology, to address potential impacts on certain kinds of farmlands. Obviously, an action in an urban area with no type of farmland protected by the Act would not trigger the requirements and methodology.

5.4 Data Requirements

All of the methodologies used during the NEPA process require information or data. In general, the information collected is used by practitioners to identify, understand, and characterize resources that may potentially be affected by a proposed action. This information is often contained in the "Existing Conditions" chapters or sections of the EA or EIS. Similar to studies or research papers, primary and secondary data are both used in EIS documents, depending on the methodology selected.

Primary data are information collected specifically for the objective at hand. For the NEPA process, primary data collection often involves field work by subject matter experts (e.g., biologists, archaeologists, etc.) using methods common to their scientific field (e.g., test pits in archaeology). Therefore, primary data collection is often associated with higher costs, and requires more time than secondary data collection and a high level of technical expertise.

However, there are situations for which primary data collection for NEPA purposes do not involve high costs or the need for a high level of technical expertise. For highway projects, traffic counts (a form of primary data) are often taken but may only cover single morning and afternoon peak periods. Although traffic counters need to be responsible, they do not necessarily have to know anything about traffic analysis. They do need, however, a brief training session and supervision by a traffic expert.

Secondary data are information that has been collected by others for other purposes, and are often in published format or available through public domains (e.g., public agency websites). Secondary data collection can require a high level of technical expertise, because specialists tend to know where and how to look for information. For example, archaeologists and architectural historians are highly adept in using archival information stored in libraries. A type of secondary information becoming increasingly available is environmental and social data in geographic information system (GIS) formats. Although practitioners with GIS skills and computer software are required to use this information, GIS has allowed project sponsors to identify affected resources relatively inexpensively and expediently – especially physical resources such as land use, floodplains, etc. The cost of developing and maintaining GIS information can be extremely high, so many owners of this information charge for their use.

5.5 Time and Cost

The time and cost parameter relates to the level of effort needed to conduct or implement the methodology. In general, methodologies that require extensive data collection, agency consultation and coordination, and other analytical work (e.g., computer programming and modeling) take longer to complete and are more costly. In recent years, however, GIS and Internet information have substantially reduced the time and cost of obtaining information on existing environmental conditions. GIS technologies are also being used for certain impact analyses.

5.6 Accuracy of Results

Most methodologies commonly used in the NEPA process to identify and characterize existing environmental and social resources tend to produce highly accurate results because practitioners are able to measure, record, or evaluate real-life conditions. Predicting future outcomes that may result from implementing a proposed action is less certain. The most accurate analyses focus on impacts that would occur immediately due to construction of the proposed action, such as any type of displacement impacts (e.g., residences, businesses, trees, etc.). Methodologies that identify displacement impacts normally rely on conceptual engineering.

Impact analyses that attempt to predict conditions many years in the future are less accurate mainly because it is almost impossible to anticipate all the other actions that could influence these predictions. For example, traffic impact assessments, which usually predict traffic conditions up to 25 and 30 years into the future, may assume a future major land use near the project site that results in certain traffic generation. If this land use does not materialize or its traffic generation is substantially different than assumed, actual traffic conditions may be very different than what was predicted.

5.7 Agency Involvement and Acceptance

Some methodologies used in the NEPA process require participation from resource agencies, because the methodologies are linked to environmental regulations. Resource or regulatory agencies are therefore highly influential in determining the scope of technical analyses, and in approving the results as they are reported in NEPA documents.

Projects that involve assessing impacts on historic properties are a good example of extensive resource/regulatory agency involvement during the NEPA process. For federal actions, methodologies that address this type of impact are governed by NHPA Section 106. Under Section 106, the federal agency is responsible for determining whether or not historic properties are within a project's Area of Potential Effect (APE). If historic properties are within the APE, the same federal agency is responsible for determining whether or not the project's affect on them would be adverse. This information is normally reported in the NEPA document, and State Historic Preservation Officers (SHPOs) are given the authority under Section 106 to either concur or not concur with these determinations. The federal agency is also responsible for making a "good faith" effort to identify historic properties in the APE, which often involves conducting archaeological or architectural historic studies. The Section 106 regulations, as provided in 36 CFR 800, require consultation with the SHPO to determine the scope of the study. In all likelihood, a SHPO would not concur with federal agency determinations if it does not agree with the methods, results and conclusions of the technical studies.

NEPA documents also cover topics that are not regulated by other federal or federally affiliated agencies. The methodologies used for these topics do not normally involve consultation with or approval from other agencies. This does not necessarily mean that agencies cannot comment on methodologies during NEPA-mandated comment periods (see Section 2.1), but these comments would unlikely carry as much weight as comments from agencies that have a regulatory oversight role.

5.8 Adaptability to Cumulative Impact Analysis

According to its Technical Advisory, FHWA requires that EISs discuss a proposed action's cumulative impacts. This requirement is normally not required for CEs, but may be applied to EAs on a case-by-case basis. A cumulative impact, according to 40 CFR 1580.7, is: "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions." FHWA further states that a cumulative impact includes the total effect on a natural resource, ecosystem, or human community and that cumulative impacts include the total of all impacts to a particular resource that have occurred, are occurring, and would likely occur as a result from past, present, and future activities or actions of federal, non-federal, public and private entities.

Each methodology identified in this research paper is evaluated based on it usefulness for determining potential cumulative impacts on the quality of water resources.

6 Stormwater Methodologies

6.1 Overview of Stormwater Runoff Impact Methodologies

The data collection described in Section 4 identified the following stormwater runoff impact methodologies:

- Stormwater Management Programs (SWMP)
- FHWA Method (Driscoll Method)
- 303(d) Listed Water Bodies, Total Maximum Daily Load (TMDL), and Waste Load Allocations (WLA)
- Simplified (Simple) Method
- Nonpoint Source (NPS) Pollution Load Model
- Washington State Department of Transportation Method
- Integrated Watershed and Water Quality Modeling Approach

Table 6-2 at the end of this section compares these methodologies.

6.2 Methodology Discussion

The stormwater runoff impact methodologies listed above in Section 6.1 are described in the following sections and evaluated based on the parameters explained previously in Section 5.

6.2.1 Stormwater Management Programs

Many states oversee stormwater management programs (SWMPs) to control stormwater water runoff and prevent water quality impacts to resources. An evaluation of the SWMP methodology is presented below.

6.2.1.1 Description

In NEPA documents, evaluations of potential impacts on water quality from highway stormwater runoff can be addressed through compliance with SWMPs administered in many states. Several survey respondents identified various SWMPs, and the study team is aware that similar programs exist in state DOTs and FHWA division offices that did not respond to the survey. Therefore, rather than identifying and describing each of these individual methodologies, they have been combined into a single generic methodology.

SWMPs can operate either internally within the State DOT or externally, usually through the state's primary environmental or water quality regulatory agency. Externally administered SWMPs are usually associated with NPDES permitting (see Section 3.1.2), which is normally administered at the state level. Internally administered SWMPs are often associated with the State DOT that holds an NPDES permit for its MS4 (municipal stormwater system).

Although specifics may vary from state to state, SWMPs typically require that projects meeting certain criteria consider alternatives that avoid stormwater discharges into water bodies, or include appropriate stormwater management measures. These criteria typically involve the introduction of a certain amount of new impervious surfaces or land disturbances of a certain amount, but may also include discharges into a certain type of water body, such as those classified as "impaired" or 303(d) by the USEPA. Using a SWMP as a methodology in a NEPA document assumes that a project meeting the program's criteria or thresholds would have an adverse impact on water quality if no mitigation were provided.

Stormwater management measures are usually physical elements incorporated into a project that are designed specifically to remove certain pollutants from runoff prior to discharge into an existing water body. These measures are also referred to as Best Management Practices (BMP). The definition of a BMP, as provided in 40 CFR 122 (*EPA Administered Permit Programs: The National Pollutant Discharge Elimination System*) in the context of stormwater management, is very broad, stating: "schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States." BMPs specifically used to treat highway stormwater runoff are often referred to as permanent BMPs or post-construction BMPs, to differentiate them from stormwater BMPs that are commonly used during construction and temporary in nature.

In the past, stormwater management focused on addressing runoff through various structural conveyance or storage-type systems. More recently, state SWMPs are emphasizing the importance of non-structural BMPs and site planning as the primary means of minimizing and preventing runoff-related water quality impacts. One such reoccurring concept among state SWMPs is known as *Low Impact Development* (LID), which involves careful site planning and an emphasis on non-structural measures, with structural BMPs as a secondary treatment option. For example, New Jersey's SWMP adopts a "prevent, minimize, mitigate" approach where LID and non-structural methods are required for new development projects, which can then be supplemented by structural BMPs as necessary to satisfy state stormwater requirements. As described in New Jersey's SWBMP Manual, the idea of LID is to mimic natural drainage systems and interact with the rainfall-runoff process at the site planning and design stage, using provisions such as minimizing proposed and disconnecting impervious cover, preserving and utilizing existing vegetation, and maintaining natural drainage systems.

The most common or popular post-construction BMP is detention basins. Detention basins, or similar forms of BMPs such as retention ponds, require relatively large areas but are effective in capturing and holding stormwater runoff, which allows pollutants to settle before the water is discharged offsite. Their advantages include relatively low construction and operational costs. The major disadvantage is that they are difficult to use in heavily urban areas, where obtaining right-of-way beyond what is needed for the transportation improvement can be difficult or very costly. If detention basins are not found to be practical or appropriate, a project may use structural types of post-construction BMPs. These are usually connected with the roadway's inlet catch basins, where stormwater is filtered by any number of means depending on the design of the structure before off-site discharge. The major advantage of structural post-construction BMPs is they are usually installed underground, and therefore require less space. Their major disadvantage is being more costly to construct and maintain than detention basins. Consistent with the notion of replicating natural systems, several state SWMPs are now advocating and in some cases requiring the use of vegetated conveyance systems such as grassed swales and/or treatment through infiltration including bioretention, infiltration trenches, and infiltration basins.

BMP performance and design is generally based on two factors: quantity control and pollutant removal capability. For quantity control, state regulations may specify certain runoff volumes or peak discharge conditions that must be controlled. For water quality, states may establish percent reductions in pollutant loadings associated with post-developed or average annual runoff that must be achieved. Percent removal requirements are most common for Total Suspended Solids (TSS) and are sometimes also specified for nutrients (i.e., Total Phosphorus [TP] and Total Nitrogen [TN]) depending on the classification/sensitivity of the receiving water body. Stormwater (SW) and BMP guidance manuals often provide estimated percent reductions in pollutants that certain BMPs can achieve based on various studies. Often, BMPs are presumed to satisfy water quality criteria if they are sized according to quantity control requirements, chosen from state-recommended lists or other reputable sources, and selected based on their capacity to remove pollutants to the maximum extent practicable.

Similar to how SWMP criteria or thresholds could vary from state to state, SWMP performance requirements for post-construction BMPs can also vary from state to state. BMP requirements for water quality are often watershed or water-body specific depending on the classification, status, sensitivity and/or use. Therefore, pollutant removal requirements are often not provided in state guidance. Many states claim that design/performance criteria are intended and presumed to meet state water quality standards. State guidance that does provide pollutant reduction goals often do so only for TSS, and sometimes presume that nutrient removal is accounted for in other performance-based criteria for TSS removal.

Table 6-1 summarizes some examples of state-specific BMP performance criteria related to quality (reduction of pollutants in post-development, average annual runoff) and quantity (depth and flow) control requirements. It is important to note that although the states listed in Table 6-1 administer regulations that require stormwater-related permits, many do not specify numerical criteria such as Montana and Utah. Instead, general guidance is provided, such as requiring that post-development conditions meet pre-development conditions or better, and that pollutants should be controlled to the maximum extent practicable based on current knowledge of the performance of various types of BMPs. Some states may even specify preferred methods of runoff treatment (e.g., infiltration techniques preferred by Eastern Washington and New Hampshire). Local municipalities are also tasked with enforcing regulations and may establish specific requirements as necessary to satisfy appropriate permits. For example, Colorado, Oregon, and Tennessee do not specify numerical criteria at the state level. However, stormwater management guidance and numerical criteria have been developed by their major cities (Denver, Portland, and Knoxville).

Instead of broad performance-based criteria, some State SWMPs adopt BMP-specific design criteria. For example, New Hampshire's Code of Administrative Rules (Chapter Env-Ws 400) includes the following BMP-specific criteria:

- Filter strip: discharge must not exceed 0.5 cubic feet per second (cfs) for 2-year storm
- Swale: discharge must not exceed 10 cfs for 10-year storm
- Detention: 24 hours of extended detention required for 2-year storm
- Infiltration Basin/Trench: must be designed for 2-year event

Local factors such as climatology may also be incorporated into SWMP guidelines. For example, the Minnesota Stormwater Manual emphasizes consideration of snowfall and snowmelt during BMP selection and design. Consideration of a 10-day event and including 25 percent of additional detention storage are two examples of recommendations provided. Minnesota's guidance also points out mosquito control as a factor in BMP selection and design.

Table 6-1
Comparison of State-Level Stormwater Quality and Quantity Control Criteria

State	QUALITY CONTROL Pollutant Removal			QUANTITY CONTROL Depth Control				Flow Control
	TSS	TP	TN	Control Minimum Percent of Average Annual Runoff	Control Runoff Generated by Specific Storm Event	Control Specific Runoff Depth (first-flush)	Multiple Choices	Control of Peak Discharge
PACIFIC								
Hawaii	-	-	-	-	-	-	1 inch or 0.4 inches/hr	-
WEST								
California	-	-	-	75-85%[5]	-	-	-	-
Oregon[1]	70%	-	-	90%	-	-	-	-
Washington (western)	80%	50%	-	-	-	-	6-mo, 24-hr OR 91% of 24-hr storm	No increase in 50% of 2-yr to full 50-yr
Washington (eastern)	80%	50%	-	90%	-	-	-	-
MOUNTAIN								
Colorado[2]	80%	-	-	-	80th % event (~ 2-yr)	-	-	2- to 10-yr
MIDWEST								
Ohio	80%[4]	-	-	-	-	0.75 inches	-	0.65 inches/hr
Minnesota	80-90%	50%	-	-	-	-	1-yr, 24-hr OR 0.5-2 inches	10-yr OR 10-yr and 25-yr
SOUTHEAST								
Florida	85-90%	85-90%	85-90%	-	-	-		2-yr, 24-hr
Georgia	80%	-	-	-	-	-	1.2 inches OR 85% of average storms/year	No increase in 25-yr/24-hr OR in 2- to 25-yr

Table 6-1 (Continued)
Comparison of State-Level Stormwater Quality and Quantity Control Criteria

State	QUALITY CONTROL Pollutant Removal			QUANTITY CONTROL Depth Control				Flow Control
	TSS	TP	TN	Control Minimum Percent of Average Annual Runoff	Control Runoff Generated by Specific Storm Event	Control Specific Runoff Depth (first-flush)	Multiple Choices	Control of Peak Discharge
Maryland	80%	40%	-	90%	-	-	-	-
North Carolina	85%	-	-	-	-	1-1.5 inches[6]	-	No increase in 1-yr, 24-hr
Tennessee[3]	75%	30-40%	30-40%	-	-	0.5 inches	-	-
NORTHEAST								
Connecticut	80%	-	-	-	-	1 inch	-	No increase in 10-,25-,100-yr
New Jersey	80%	-	-	-	1.25-inch/2-hr	-	-	No increase in 2-,10-,100-yr OR 50, 75, 80% of 2-,10-,100- yr, respectively
New York	80%	40%	-	90%	-	-	-	10-yr, 24-hr
Pennsylvania	85%	85%	50%	-			2-yr, 24-hr OR 2 inches[7]	No increase in 1- to 100-yr
Vermont	80%	40%	-	90%				10-yr, 24-hr

Notes:
TSS = Total Suspended Solids
TP = Total Phosphorus
TN = Total Nitrogen
In general, runoff and peak-flow criteria are based on post-developed conditions.
[1]Oregon State reference guidance is provided in Portland's SWM Manual
[2]Colorado State reference guidance is provided in Denver's Urban Storm Drainage Criteria Manual
[3]Stormwater treatment removal goals are presented in the Knoxville Best Management Practice Manual; a detention time of 24 hours is required
[4]Ohio state reference guidance provided for the Lake Erie Watershed
[5]Based on "the knee of the curve" of location-specific storm data
[6]Depends on state classification and sensitivity of receiving water body
[7]The 2-inch runoff criteria specify that 1 inch must be permanently removed and infiltration of 0.5 inches is encouraged

If using the applicable SWMP as a methodology, the NEPA document would disclose whether or not the project meets the criteria or thresholds specified by the SWMP. If it does meet them, the NEPA document should also disclose the proposed post-construction BMP that addresses water quality impacts or provides an alternative that avoids discharges into the water body of concern. Despite disclosure in the NEPA document, the SWMP's actual application and approval process typically would not occur until the project is in the design phase. Nevertheless, using the SWMP as a methodology during the NEPA process has the following benefits:

- The methodology is simple to apply. Application of the SWMP criteria or thresholds determines whether or not the project will have an adverse impact on water quality.
- Use of this methodology demonstrates to resource agencies and the public that the project will address its stormwater runoff impacts by proposing mitigation measures as part of the proposed action, rather than deferring the issue to the final design stage.
- Because some types of post-construction BMPs require right-of-way beyond what is needed for the transportation improvement (e.g., detention basins), applying the SWMP methodology during NEPA ensures that the concept design includes the additional right-of-way. The additional right-of-way would then be subject to impact analyses in other environmental topics of the NEPA document. Deferring application of the SWMP to the design stage may limit the options available to project engineers. This is because the concept design, which will have already cleared the NEPA process, may not have included enough right-of-way for less expensive but effective post-construction BMPs.

6.2.1.2 Evaluation

Objectives and Outputs

The SWMP methodology would address one of the three major objectives of NEPA described in Section 5.1, and it would evaluate mitigation measures. SWMP requirements would compel project sponsors to propose mitigation as part of the proposed action. The effectiveness of mitigation or post-construction BMPs is already predetermined, because SWMPs typically include BMP performance measures. The output of using this methodology would be a conceptual description of the post-construction BMPs specifically designed to mitigate a project's stormwater pollution impacts. These BMPs would be made part of the proposed action.

SWMP methodology does not provide a way of identifying and describing elements of the environment that could be affected by stormwater pollution from a project, and does not identify project impacts. The Oregon DOT noted that a project may meet SWMP requirements but still have adverse impacts on water quality. For example, even with effective treatment (e.g., BMPs), discharges to surface waters may still exceed level of concerns established by National Marine Fishery Service (NFMS) for dissolved copper effects on salmon. In order to be a complete methodology, another methodology that addresses the first and second objectives (existing environmental conditions and project impacts) must be employed.

Technical Proficiency

The simplicity of the SWMP methodology means that a moderate level of technical proficiency would suffice to determine whether or not an adverse impact would be expected. However, a much higher level of technical knowledge is needed if post-construction BMPs are included as mitigation. The required skills include a professional water resource engineer familiar with highway drainage, pollutants, and post-construction BMPs. This includes an understanding of the circumstances in which certain post-construction BMPs are to be used. Detailed BMP plans are generally not required during the NEPA process, but the practitioner should still be capable of identifying the type of BMP (e.g., detention basin or structural measures) and should be able to calculate the general size of these measures so that enough right-of-way is covered in the overall NEPA process.

Geographic or Conditional Applicability

SWMP methodology could be used in any geographic condition or location, assuming the location has an active SWMP. However, the geographic location could factor into the selection of post-construction BMPs. For instance, the Florida DOT noted that using typical post-construction BMPs in South Florida can be problematic due to the low water table in many places. As noted in North Carolina's BMP manual, bioretention areas require a depth to groundwater of at least 2 feet – otherwise it will function as a wetland. As previously mentioned, the Minnesota Pollution Control Agency recognizes the importance of snowfall/snowmelt and mosquito control considerations. New Hampshire notes that modifications to BMPs may be required for cold climates, such as incorporating a movable diversion, like a gate, to re-direct snowmelt runoff and increase design capacity. Caltrans describes special considerations for projects in desert and low-rainfall areas such as the Mojave Desert, where receiving waters are few and typical storm events are of low frequency but high intensity. State-approved sediment control BMPs are not designed to handle these conditions, so Caltrans requires temporary sediment and erosion control measures on a site-specific basis (e.g., sediment barriers and de-silting basins) for the Mohave watershed and other arid regions of the state.

Data Requirements

Conceptual engineering or design of the project, which is typically available during the NEPA process, includes all the information needed to determine whether or not a project meets the threshold criteria – the test for determining which adverse impacts may result. To determine appropriate post-construction BMPs if necessary, additional data may be required such as site characteristics and constraints (e.g., precipitation data, site hydrology, climatological considerations). Fieldwork may also be required.

Time and Cost

The SWMP Method's simplicity means that the evaluation of potential impacts is not time consuming or costly. The most time-consuming, costly aspect of this methodology is developing the conceptual post-construction BMP plans.

Accuracy

Because the SWMP methodology does not directly evaluate stormwater pollution impacts on receiving water bodies, it may not be considered an accurate methodology. This methodology assumes that a project that meets certain threshold criteria would result in an adverse impact on the receiving water body without mitigation. The characteristics of the impact (e.g., the expected concentrations of certain pollutants) would not be known.

For post-construction BMPs, a certain level of the effectiveness can be reasonably estimated because their performance has been documented. For example, the International Stormwater BMP Database includes a web-accessible database of over 300 BMP studies, including performance summaries (*http://www.bmpdatabase.org/*). The Center for Watershed Protection (CWP) also maintains a National Pollutant Removal Performance Database, which includes 166 studies published through 2006 and a summary of BMP performance data (*www.cwp.org*).

Agency Involvement and Acceptance

The SWMP methodology requires very little outside (i.e., non-DOT) agency involvement, even if the SWMP itself is administered by an outside agency. Formal application and approval of SWMP requirements normally occurs during the design phase when detailed post-construction BMP plans are prepared. Plan reviews and approvals are normally conducted at that time.

This does not suggest that the SWMP administering agency cannot be involved during the NEPA process. This agency often releases or has post-construction BMP guidelines and manuals available, which can be used to prepare conceptual BMP plans. SWMP agency staff could also be available for consultation on appropriate post-construction BMPs. Also, if administration of the SWMP is conducted by an outside agency, that agency can be invited to be a cooperating or participating agency, and given the opportunity to review drafts of the NEPA document prior to public release. If the SWMP is administered internally within the DOT, program staff can also be given the opportunity to review drafts of the NEPA document. At a minimum, publicly released NEPA documents should be provided to SWMP staff for review. Early participation by SWMP staff increases the likelihood that final post-construction BMP plans will be approved with no or little delay or problems.

Adaptability to Cumulative Impacts

The SWMP methodology wouldnot be able to address cumulative impacts, because the threshold criteria typically only focus on the proposed action. They do not typically focus on adjacent land uses or other projects even though existing and future adjacent land uses may discharge their stormwater into the project's drainage system. None of the agencies responding to the survey or interviewed (see Section 4) noted inclusion of other land uses and projects in the threshold criteria. In addition, the authors of this research paper are not aware of any SWMP that includes these types of criteria.

6.2.2 FHWA Method (Driscoll Method)

FHWA developed a method to estimate pollutant loading resulting from highway runoff. An evaluation of the FHWA (Driscoll) methodology is presented below.

6.2.2.1 Description

The FHWA (Driscoll) Method focuses on pollutants from highway segments within a watershed (Driscoll et al. 1990). Site characteristics such as drainage area of total highway right-of-way, impervious area (area of highway pavement), and rainfall are used directly in the developed equations to estimate discharge and runoff volume. The FHWA Method includes data tables for input requirements, based on site location. The annual pollutant load is estimated after the runoff quantity at the site and the average pollutant concentration in the runoff are determined. The FHWA provides values for the site median concentrations of various pollutants expected for urban or rural highways. These values are based on field measurements, where an average daily traffic (ADT) of 30,000 demarcates between urban and rural settings. The pollutants covered by the Driscoll Method include: total suspended solids (TSS), volatile suspended solids, total organic carbon, chemical oxygen demand, nitrate + nitrite, total Kjeldahl nitrogen, phosphorus, total copper, total lead, and total zinc.

For highway discharges to flowing streams, the FHWA presents a probabilistic dilution model (PDM) that was developed and applied in the EPA Nationwide Urban Runoff Program (NURP) to evaluate stream water quality impacts. This model is intended to calculate the magnitude and frequency of in-stream concentrations of a pollutant produced by stormwater runoff. FHWA recommends calculating in-stream concentration corresponding to a three-year event (i.e., pollutant concentration in the receiving water body that would be expected to occur once every three years), to be able to compare with criteria and threshold values developed by USEPA (which are based on a three-year recurrence interval.) The receiving water concentration calculated using the PDM represents the average concentration after complete mixing of the runoff and stream flows just downstream of the discharge, and is calculated for individual stormwater runoff events. This procedure, which involves calculating a set of statistical input parameters related to upstream flow, upstream concentration, highway runoff flow, highway runoff concentration, and a series of transformations, can be repeated for various runoff events. The resulting set of concentrations can be evaluated statistically to determine the total percentage of runoff events during which expected stream concentrations would exceed specified target limits. The relative effectiveness of mitigation measures (i.e., post-construction BMPs) can also be described in terms of differences in the percentage of runoff events that cause the stream concentration to exceed target concentrations.

To evaluate lake impacts from highway runoff, FHWA recommends using the model developed by Vollenweider to evaluate the relationship between a load source and the expected trophic level of a lake (Driscoll et al 1990). The average lake's phosphorus concentration is estimated based on the annual mass loading, lake inflow rate, lake surface area, and settling velocity. The FHWA recommends using a typical settling velocity of 5 meters per year. The output is the average concentration of phosphorus expected in the lake. FHWA recommends a guideline of an average lake total phosphorus concentration of 10 milligrams per liter (mg/L) or less, to represent acceptable water quality conditions. It is important to note that concentrations above 20 mg/L are unfavorable, because this is associated with a high probability of eutrophic conditions. The FHWA also notes that these are empirically based estimates that reflect the trophic states of most lakes, and are not formal criteria. Therefore, lower or higher-target values may be established at the state level, depending on existing lake water quality and sensitivity.

In addition, the FHWA developed an iterative process for evaluating the effects of mitigation measures or post-construction BMPs (e.g., vegetative swales and detention basins) that can be followed if initial predicted concentrations exceed targeted amounts. The procedures estimate the reductions expected for various measures and the necessary adjustments to input parameters (e.g., reducing the site median concentration for swales or reducing the mean runoff flow rate for infiltration devices) for the receiving water impact analysis. The analysis can be repeated to test the effectiveness of various mitigation measures, with each revised result compared against the target levels until the target is achieved or reached.

6.2.2.2 Evaluation

Objectives and Outputs

The FHWA Method addresses impacts related to stormwater runoff from highway projects. As noted previously, it is used to determine pollutant loadings resulting from highway runoff and the corresponding impacts to the quality of receiving streams or lakes. This method can also evaluate the effectiveness of mitigation measures, by adjusting inputs into the model to represent the reductions in pollutant loadings and/or runoff volumes expected for proposed mitigation measures. The pollutant loading outputs are all quantitative, which allow for relatively simple comparisons between alternatives with or without mitigation measures. The receiving water quality computation methods generate an in-water concentration that can be compared against applicable water quality standards. This portion of the method can be used to determine receiving water concentrations for proposed and existing conditions. In addition, any sampling data can be substituted into the model, replacing default information. Therefore, the FHWA (Driscoll) Method is a complete methodology. However, it should be noted that the PDM recommended for determining in-stream concentrations accounts for ambient stream conditions as average upstream concentration and flow rate, rather than instantaneous values. In addition, the Vollenweider model for determining resulting lake concentrations does not consider ambient lake conditions.

Level of Technical Proficiency

A moderate level of technical proficiency is needed to use the FHWA (Driscoll) Method and the Vollenweider model. The practitioner should understand the nature and characteristics of the pollutants covered by the models in order to select the appropriate pollutants for analysis, and to be able to interpret the results. Because the PDM involves a series of equations and statistical analyses, the practitioner requires mathematical proficiency to implement the appropriate equations, which are available from FHWA and can be organized using a Microsoft Excel spreadsheet.

Geographic or Conditional Applicability

The Driscoll model works best for projects that convert existing pervious surfaces or undeveloped land into impervious roadway surfaces. It tends not to work as well for projects in urban environments where the proposed action would convert one type of impervious surface, (e.g., parking lots) to roadway surfaces. Some of the major model inputs are right-of-way width and the percent of impervious surfaces within the right-of-way. However, some impervious surfaces are not necessarily pollutant generating (e.g., sidewalks and building rooftops), and for this reason the model tends to overestimate the impacts of projects in urban environments.

The FHWA provides tables with recommended values for required input parameters related to rainfall characteristics, median pollutant concentrations, and settling velocity. These are general guidelines and may require site-specific measurements to accurately represent current or location-specific conditions. For example as noted above, the FHWA's information on site median pollutant concentrations in highway runoff is based on field measurements taken between 1975 and 1985.

Data Requirements

If only default data are used, the Driscoll Method's data requirements are very minimal. Site (project) data requirements such as site drainage area and percent imperviousness can easily be attained by examining the project's conceptual design or engineering plans, which are usually available during the NEPA stage. The default data covers rainfall information stream flow information and pollutant concentration in highway runoff. The FHWA provides values for the rainfall input data required (e.g., mean volume and interval between events) based on nine different U.S. regions and some statistics for major cities. Local rainfall data may also be used if available and needed for a better representation of site-specific conditions. The FHWA also provides values for site median concentrations for the various pollutants required to determine pollutant loading rates, which are based on whether a highway has more or less than 30,000 vehicles per day on average. As mentioned previously, these values are based on field measurements taken between 1975 and 1985, and may not reflect changes in highway practices or vehicle types.

If location-specific secondary or primary pollutant concentration, water quality (i.e., data from the affected water body), and other necessary data are available, they can be used as a substitute for the default data with relatively minimal effort. At times, primary data is preferable and can be crucial in properly addressing stormwater pollution concerns during the NEPA process. For example, a practitioner familiar with the Driscoll Method who works in the Pacific Northwest noted that dissolved metals, especially copper, are very toxic to salmonid species. In order to properly evaluate the risks to these species, the Driscoll Method needs real-life sampling data from the receiving water body.

Time and Cost

If default data or substitute secondary data are used, the Driscoll Method is a fast and inexpensive methodology. The use of primary water quality data increases the time and cost of this methodology, partially due to the required field and lab work. The research needed to obtain secondary data that are better than the default data also increases the time and cost of this methodology.

Accuracy

Like any quantitative model, the quality of the outputs or results depends heavily on the quality of the inputs. The default data can never duplicate real-world conditions, because water quality characteristics are site specific and influenced by many factors that simply cannot be reflected in any default data. The Colorado DOT noted that the FHWA water quality data is old and inappropriate in many instances. Indeed, more accurate input data results in more accurate results. For example, Driscoll Method practitioners have noted that even though the methodology addresses post-construction BMPs, the model accounts for these measures by decreasing the site median concentration of the pollutant being analyzed. However, this does not mirror real-world conditions because post-construction BMPs do not change the site median concentration, but do change the final pollutant concentration of the discharged stormwater. To compensate, practitioners have recommended calibrating the model by sampling water quality before and after implementation of post-construction BMPs.

As described previously, the equations developed for calculating concentrations in receiving lakes and streams are simplified, and represent single storm events or inflow rates. These results are useful for making general comparisons between alternatives, but more accurate representations of in-water concentrations resulting from highway runoff require more complex continuous simulations of precipitation events and pollutant loadings.

The Washington DOT also pointed out that the FHWA (Driscoll) Method does not consider the conversion of developed land to a different type of developed land. The example provided is replacing commercial land with highway, and how this could result in reduced stormwater pollutants.

Agency Involvement and Acceptance

Because this is a methodology developed by the FHWA, regulatory and resource agencies are not usually involved in implementing and overseeing how it is applied. Although they commented on this methodology in their review of NEPA documents, none of the DOT and FHWA survey respondents and interviewees who commented on the Driscoll Method spoke about extensive involvement by regulatory and resource agencies.

Adaptability to Cumulative Impacts

The Driscoll Method is not able to address cumulative impacts because the non-water quality inputs to the model only include project-specific information. The model does not allow for the analysis of other land uses, which may involve non-auto-related pollutants.

6.2.3 303(d) Listed Water Bodies, Total Maximum Daily Load and Waste Load Allocations

According to section 303(d) of the Clean Water Act, states, territories, and authorized tribes must develop lists of impaired waters that do not meet applicable water quality standards. Priority rankings and Total Maximum Daily Loads (TMDLs) must be established for these waters. An evaluation of this methodology is presented below.

6.2.3.1 Description

Section 303(d) of the 1972 Clean Water Act requires that appropriate jurisdictions (e.g., states) identify impaired waters, which are water bodies that no longer meet water quality standards even after implementation of minimum pollution control technology requirements. These jurisdictions prepare and periodically update a list of impaired waters, which are also referred to as 303(d) waters.

303(d)-listed waters must be assigned priority rankings, and Total Maximum Daily Loads (TMDLs) must be established for each water body to achieve water quality standards for the protection of human health and the environment. 303(d) lists and TMDLs must be approved by the USEPA. According to the USEPA, a TMDL represents the maximum amount of a certain pollutant that a receiving water body can accept and still meet water quality standards. The TMDL must support relevant aquatic and vegetation species and factors (e.g., tidal influences, stream flow, weather conditions, recreational uses) that influence the water body's capacity to handle pollutants of concern, which include sediment, metals, fecal coliform, nutrients (TN, TP), and pesticides. TMDLs can be developed for single pollutants or groups of pollutants, and identify the link between water use impairment, causes of the impairment, and the pollutant load reductions necessary to satisfy applicable water quality standards. Assuming that the affected water body (i.e., a water body subject to dredge, fill, or stormwater discharges from the proposed action) is listed as a 303(d) water, the existing quality of a water body may be characterized in the NEPA document through the TMDL development process.

TMDLs allocate pollutant loadings among current point and nonpoint pollutant sources, which are commonly referred to as Waste Load Allocations (WLA). These allocations do not account for proposed development, such as those undergoing NEPA review. If a project is proposed within a watershed of concern (i.e., a receiving water body on the 303(d) list), stricter requirements for water quality may apply. For water bodies with established TMDLs, the requirement may be no net increase in the pollutant load discharged into receiving waters as a result of the proposed action. For example, Oregon DOT guidance states that for projects where TMDL streams or designated water quality limited streams (i.e., 303(d) list) are involved, projects may be required to reduce or avoid causing a net increase in the pollutant load discharged to the receiving water body (ODOT 2006).

6.2.3.2 Evaluation

Objectives and Outputs

The existing quality of a water body can be characterized or described in the NEPA document using the applicable TMDL and/or the 303(d) listing. Therefore, this methodology relates to the first objective presented in Section 5.1: identify and understand the characteristics of the physical, natural, and human resources that may be affected by the proposed action.

The TMDL/WLA methodology does not provide assessment tools to determine the water quality impacts expected from proposed development or the effectiveness of mitigation, such as the FHWA or Simple Methods (see Sections 6.2.1 and 6.1.4). These other methods determine the pollutant loads that would be generated as a result of stormwater runoff from project activities. However, the estimated loads derived from the FHWA and Simple Methods cannot be directly compared with TMDLs established for the receiving water body, because TMDLs represent other pollutant sources and water body characteristics. A method used to understand how a water body would assimilate pollutant loads via dispersion, advection, and other processes would be needed. This method (the receiving water body model) is described in Section 6.2.7.

However, it should be noted that if a water body has an established TMDL for a highway pollutant, the use of TMDLs can be similar to what has been described for SWMP methodology. For example as the Oregon DOT noted, following establishment of a TMDL, a plan for meeting the TMDL is developed, which is often with the cooperation of the DOT that outlines the measures to be taken. The Oregon DOT also points out that if a project follows this type of plan, it is assumed that the highway system within that watershed is moving toward supporting the TMDL. However, this is not the case for 303(d) list pollutants where there is no overall plan.

Level of Technical Proficiency

The TMDL/WLA Method requires knowledge of where to find information on a state's 303(d) list of impaired water bodies, their TMDLs, and corresponding state regulations in order to determine whether or not special restrictions apply. This information can usually be obtained through a simple Internet search or by contacting local DOTs or environmental agencies. However, to quantify and directly characterize water quality impacts on a receiving water body from proposed activities, other methods are required and often require a higher level of technical proficiency, depending on the method employed.

Geographic or Conditional Applicability

The TMDL/WLA Method can only be used if the affected water body is 303(d) listed and has an established TMDL. Developing a TMDL can take several years, so many 303(d)-listed water bodies do not have TMDLs at this time.

Because TMDLs are established by individual states, state-specific requirements may apply. TMDLs are also water-body specific, and account for the support of relevant aquatic and vegetation species and factors that influence the water body's capacity to handle pollutants of concern (e.g., tidal influences, stream flow, weather conditions, and recreational uses).

Data Requirements

Because information on 303(d) waters and established TMDLs can be obtained relatively easily, data requirements are minimal. They include the state 303(d) list of impaired waters and corresponding state regulations. The affected receiving water body/bodies should be checked for applicable TMDLs and restrictions, if any.

Time and Cost

Time and cost requirements for this method are minimal due to the relative ease of obtaining information to support NEPA documents. However, if a complete methodology to satisfy all three objectives presented in Section 5.1 were required for a project, more time, effort, and cost would be required. The level of additional time and cost required would depend on which additional methodologies are employed.

Accuracy

TMDLs established for specific water bodies involve extensive data collection and analysis of the water body's properties and contributing point and nonpoint sources (NPS). Therefore, TMDL information is normally very accurate in characterizing current water body properties and waste load allocations. Because the process of establishing a TMDL is extensive (USEPA recommends from 8 to 13 years), states have not established TMDLs for many water bodies across the U.S.

Agency Involvement and Acceptance

303(d) lists and TMDLs are federally mandated by the Clean Water Act and regulations issued in 1985 and 1992. 303(d) lists and TMDLs are approved by USEPA on a two-year cycle basis. Following submittal, USEPA has 30 days to approve or disapprove 303(d) lists and TMDLs. Jurisdictional calculations of TMDLs are also subject to public review.

The Maryland DOT noted that TMDLs are understood by regulatory and resource agencies such as the USACE, USFWS, and state environmental protection agencies, which indicates that these agencies are likely to accept NEPA findings using TMDL information. However, the Maryland DOT also pointed out that updates of existing TMDLs may delay the decision-making process for current projects, which is the reason that some states do not use TMDL information for NEPA purposes. For example, the Maryland DOT claims that TMDLs are not analyzed and modeling is not conducted for NEPA process documents. The Maryland DOT generally follows the SWMP approach, but pays close attention to the 303(d) list and works with local jurisdictions to incorporate any available watershed plans to deal with water quality.

Adaptability to Cumulative Impacts

By describing the current state of the 303(d) water body, and its capacity to accommodate pollutant loads and pollutant sources subject to waste load allocations, the TMDL/WLA Method can support cumulative impact analysis in the same way that it can support project-specific impact analysis. However, because this is not a "complete" method, completion of the cumulative impact analysis would require using other methodologies that can evaluate cumulative impacts on the receiving water body.

6.2.4 Simple Method

Schueler (1987) developed an empirical equation to estimate pollutant loadings from an urban watershed. An evaluation of this methodology, the Simple Method, is presented below.

6.2.4.1 Description

The Simple Method is an empirically based model developed using data gathered during a National Urban Research Program (NURP) study conducted in Washington, D.C., and other NURP data-gathering activities. This method is termed "simple: because it requires a minimal amount of input information, and its output is limited to an estimate of the annual pollutant loading from an urban watershed.

Because the Simple Method is based on a simple governing equation, a practitioner could use a spreadsheet such as Microsoft Excel to set up the model and generate results from different input parameters as necessary. This method requires specific information on rainfall (typically the average annual rainfall depth and the percentage of rainfall that produces runoff), the site's area, and the percent of imperviousness. Pollutant concentrations in urban runoff are also required, which depend on general land uses including suburban, urban, business, forest, and highway areas. Appropriate concentration values can be obtained from various studies and subsequent statistical analyses performed on regional and national bases. If desired and available, the practitioner can easily substitute site-specific concentrations. Similar to the FHWA (Driscoll) Method, concentrations are generally available for phosphorus, nitrogen, chemical oxygen demand, biological oxygen demand, zinc, copper, and lead.

6.2.4.2 Evaluation

Objectives and Outputs

The Simple Method addresses impacts and mitigation measures (Objectives 2 and 3 described in Section 5.1), but not to the extent that the FHWA (Driscoll) model does. The Simple Method does not provide the tools to identify or characterize existing surface water resources.

Unlike the FHWA (Driscoll) Method, the Simple Method does not include an algorithm to determine pollutant concentrations in the receiving water body that result from stormwater runoff. The Simple Method's main output is the pollutant loading associated with stormwater runoff based on rainfall, pollutant, and development characteristics. The impact on the quality of the receiving water body (i.e., pollutant concentrations) would require using an additional method to convert the pollutant loading calculated by the Simple Method into pollutant concentrations in the affected water body. If this step were conducted, the results could be compared with state and/or national water quality standards to evaluate direct water quality impacts, similar to how the FHWA (Driscoll) Method evaluates impacts. Nevertheless, the Simple Method's pollutant loading output is still quantitative, and could therefore be used for comparisons between alternatives and baseline (existing and no build) conditions.

The effectiveness of mitigation measures could be evaluated by changing model inputs to reflect mitigation measures, similar to the FHWA (Driscoll) Method. However, direct impacts on water quality would still require an additional methodology, as described previously.

Level of Technical Proficiency

As noted previously, the Simple Method is easy to use, so the required technical skills are relatively low. However, similar to the technical requirements needed to use the FHWA (Driscoll) model, the practitioner should understand the nature and characteristics of the pollutants covered by the model. The practitioner should also be able to understand rainfall data and information relating to drainage and impervious areas in order to generate trustworthy and realistic results.

Geographic or Conditional Applicability

The Simple Method can be used anywhere, but is best for small watersheds with drainage areas of no more than 2.5 square kilometers (approximately 618 acres). The analysis of larger and more complex urban watersheds requires more advanced modeling.

For the Simple Method, rainfall data and stormwater runoff pollutant concentrations can be adjusted to represent specific locations, depending on available information.

Data Requirements

The Simple Method requires minimal data, limited to annual rainfall, the percentage of rainfall that produces runoff, pollutant concentration in urban runoff, the area of the development site, and the percent of imperviousness. Rainfall data is generally available at most locales throughout the U.S. from nationally based weather centers such as National Oceanic and Atmospheric Administration (NOAA) and National Climatic Data Center (NCDC). The percentage of rainfall that contributes to runoff is generally based on past experience and engineering judgment. Information on pollutant concentrations in runoff is available from various national and regional studies, and information on the area of development and percent of imperviousness can be easily obtained from conceptual design or engineering plans typically prepared during the NEPA stage. If available, site-specific sampling data can be substituted into the model.

Time and Cost

Conducting the Simple Method is fast and inexpensive, but its application is limited to simple comparisons of potential pollutant loading among alternatives and their mitigation measures. . If necessary, more time-consuming and expensive methods can be used to evaluate how pollutant loadings would affect the quality of the receiving water bodies. Incorporation of site-specific sampling data may also require more time and money if field work is required.

Accuracy

With any equation or model, the accuracy of the output is largely affected by the quality or reliability of the inputs. Assuming that the inputs are reliable, the Simple Method is capable of providing reasonable estimates of pollutant loadings resulting from different alternative scenarios on a small scale (see the previous "Geographic or Conditional Applicability" section). For NEPA purposes, this level of accuracy may suffice, depending on the importance of the issue with respect to the proposed action. As noted previously, the Simple Method is best used to compare the relative stormwater runoff pollutant loads of different alternatives and stormwater management measures. This method provides general estimates, so the precision of the results should not be overly emphasized. Also, similar to the FHWA (Driscoll) Method, the Simple Method tends to overestimate project impacts because it assumes that all impervious surfaces generate pollutants, which is often not the case because sidewalks and rooftops are considered impervious surfaces but are not used for auto traffic.

It should also be noted that the Simple Method evaluates pollutant loads generated during storm events and does not consider pollutants associated with baseflow volume. As reported by the Center for Watershed Protection (CWP), baseflow pollutant loads typically contribute a small (or perhaps negligible) percentage of the total load from an urban area. However it is important to consider, depending on the development density. For example, CWP has noted that approximately 75 percent of annual runoff may occur as baseflow for a large low-density residential sub-watershed (i.e., impervious cover less than 5 percent), in which case the annual baseflow load may equal the annual storm flow load. For this situation, the Simple Method would substantially underestimate pollutant loads.

Agency Involvement and Acceptance

The Simple Method is well established and widely used for planning purposes, such as environmental review under NEPA. Several national (e.g., NURP data analysis) and regional studies have also been conducted to define pollutant concentrations associated with stormwater runoff for different land uses, for use in the Simple Method equation. This method is also referenced in several state stormwater management manuals. Therefore, agencies generally accept the methodology for planning purposes, such as in NEPA documents. However, practitioners should be prepared to respond to comments regarding how the estimated pollutant loading results would affect the quality of receiving water bodies.

Adaptability to Cumulative Impacts

The Simple Method can be used for cumulative impact analyses, but in most cases would not be ideal. This methodology is based on the fraction of the overall impervious area in the study area and the classification of land use, which is very general (e.g., suburban, urban, business, forest, and highway). Because this method generalizes variations in existing land uses and development, it would be unlikely to produce realistic or relatively accurate results. For the Simple Method to work in a typical urban area, a watershed would have to be subdivided into smaller areas by homogeneous land uses that are evaluated separately, and a composite (i.e., weighted) runoff concentration would need to be developed based on fractions of different types of areas. The input parameters could be adjusted to evaluate present, proposed, and future conditions separately. However, these scenarios would have to be generalized by an overall impervious fraction and land use type.

6.2.5 Maryland SHA Nonpoint Source Pollutant Load Model

The Maryland State Highway Administration (SHA) developed a nonpoint source (NPS) pollutant load model to estimate and compare annual pollutant loads for a state highway project. An evaluation of this methodology is presented below.

6.2.5.1 Description

The Maryland State Highway Administration (SHA) developed a spreadsheet-based nonpoint source (NPS) pollutant load model in 2005 to estimate and compare annual pollutant loads associated with pre and post-conditions of the Inter-County Connecter (ICC) project. The ICC is a highway that would link Interstates 270 and 95 in Montgomery and Prince George's Counties. SHA used two methods to calculate pollutant loads: one for urban or developed areas and the other for rural or undeveloped areas. The Simple Method (see Section 6.2.4) was employed to evaluate urban areas. For rural or undeveloped areas (e.g., agriculture, pasture, and forest) along the ICC corridor, export coefficients were used to estimate NPS loads. This method is similar to the one used by the Washington State DOT (see Section 6.2.6), where export coefficients represent the mass of NPS pollutant exported from a unit area based on certain land uses, and are not based on imperviousness. Pollutant loads are calculated by multiplying the NPS pollutant load coefficient with the area of land use. The pollutants covered by the rural method include fecal coliform, TSS, TN, TP, copper, and zinc. The Maryland SHA noted that the rural method does not evaluate pollutant loads associated with existing or potential future stream bank erosion.

Similar to the Simple Method or the Maryland SHA Method for urban areas, a practitioner could use a spreadsheet (e.g., Microsoft Excel) with equations from nationally recognized modeling approaches and pollutant load rates associated with different land uses, to generate results from different input parameters as necessary. As described in the following section, the information requirements are relatively minimal.

6.2.5.2 Evaluation

<u>Objectives and Outputs</u>

Like the Simple Method, the Maryland SHA NPS Method addresses impacts and mitigation measures (Objectives 2 and 3 described in Section 5.1). This method does not provide the tools to identify or characterize existing surface water resources.

The Maryland SHA NPS Method produces the same kind of information as the Simple Method–annual pollutant loading–but includes both urban and rural watersheds. The quantitative results allow for comparisons between alternatives and baseline (existing and no build) conditions. The effectiveness of mitigation measures can also be evaluated by applying practice efficiency to the treatable load, and then adjusting the total load accordingly to represent implementation of a BMP (Caraco 2002). However, according to the ICC Pollutant Load Study (MDSHA 2005), the analysis did not account for existing BMPs within the corridors due to lack of reliable data (e.g., type, location, area served). Therefore, comparisons between the alternatives and existing conditions were not conducted.

Like the Simple Method, this methodology's major deficiency is that an additional method would be needed to evaluate impacts on the quality of the receiving water body–one that would convert the pollutant loading output into pollutant concentrations of the affected water body.

Level of Technical Proficiency

Similar to the Simple Method, the required technical skills to use the Maryland SHA NPS Method are relatively low. The export coefficients are based on a simple governing equation and spreadsheets are easily producible. Depending on the study area's complexity, subdividing land use types should be relatively straightforward using spatial data software currently available (e.g., GIS).

Geographic or Conditional Applicability

The Maryland SHA NPS Method is applicable throughout the U.S. for urban areas. As discussed in Section 6.2.4 for the Simple Method, rainfall data and stormwater runoff pollutant concentrations can be adjusted to represent specific locations, depending on available information. Since this method is based on the Simple Method, it is best for small urban watersheds, and recommended for drainage areas no greater than 2.5 square kilometers (approximately 618 acres). Similar to the FHWA and Simple Method evaluations, this method may overestimate project impacts in urban areas since some impervious surfaces may not generate pollutants (e.g., sidewalks and rooftops).

For rural areas, the Maryland SHA NPS Method can be used anywhere if export coefficients for different rural land use types in the study area are available. The export coefficients used for the ICC were extracted from the Watershed Treatment Model developed by the CWP (Caraco 2002). The ICC coefficients were based on storm and non-storm loads from rural and forest basins in the Potomac River, and therefore were relevant to the ICC project. These coefficients would not be transferable to others areas in the U.S. Coefficients can be developed if accurate regional, local or site-specific data is available.

Data Requirements

Data requirements for urban areas are minimal and the same as those described in Section 6.2.4, which include the annual rainfall amount, percentage of rainfall producing runoff, pollutant concentration in urban runoff, area of the development site, and percent of imperviousness to estimate annual pollutant loading. Rainfall data is generally available for most locations via local weather gages (e.g., airports) or from nationally based weather centers such as NOAA and NCDC. The percentage of rainfall contributing runoff is generally based on past experience and engineering judgment. Pollutant concentrations are available from various national and regional studies. Site-specific sampling data can also be substituted.

The Maryland SHA NPS Method requires export coefficients for each pollutant and area associated with the rural land use types found in the study area. In addition to proposed urban/developed area characteristics, the model requires information about the type of rural land uses found in the study area and their corresponding areas. This kind of information should be readily available from spatial data available through GIS.

Time and Cost

If export coefficients are available or easily attainable for rural land uses, the Maryland SHA NPS Method would be fast and inexpensive. Developing the export coefficients would substantially increase the time and cost needed to conduct this method. Furthermore, similar to the problems associated with Simple Method, if the project is tasked to evaluate how pollutant loadings would affect the quality of the receiving water bodies, more costly and time-consuming methods would be required.

Accuracy

The Maryland SHA NPS Method provides reasonable planning-level estimates of changes in pollutant loadings resulting from urban development scenarios on a small scale (e.g., development site, single catchment, or subwatershed). With any equation or model, output is a function of input reliability. The level of accuracy of the Maryland SHA NPS Method also depends on the accuracy of the export coefficients. Assuming that the coefficients are reliable, this method is capable of providing reasonable estimates of pollutant loadings from different types of rural land uses. Similar to the Simple Method, the Maryland SHA NPS Method would suffice for NEPA purposes if used to compare the relative stormwater runoff pollutant loads of different alternatives and stormwater management measures. The precision of the results should not be overly emphasized.

Mitigation effectiveness can also be modeled, for example by using removal efficiencies in the National Pollutant Removal Performance Database. For the ICC NPS model, an order-of-magnitude perspective was recommended between future and proposed conditions, because the existing conditions model did not include the same extent of detail for BMPs as the proposed conditions model.

Agency Involvement and Acceptance

The resource agencies generally accepted use of the Maryland SHA NPS Method for the ICC Project’s EIS. Whether agency acceptance of this method would extend to other states is unknown. However, the NPS model employs the Simple Method, a well established and widely used model, as noted in Section 6.2.4. The NPS model also applies pollutant-related data from several national databases for default input parameters. Therefore, it is likely that agencies would generally accept implementation of this methodology for NEPA purposes, if used to evaluate the relative affects of different alternatives. However, regional and site-specific data should be employed first if available. Regardless, practitioners should be prepared to respond to comments on how the estimated pollutant loading results would affect the quality of receiving water bodies.

Adaptability to Cumulative Impacts

The Maryland SHA NPS Method is capable of conducting cumulative impact analyses, assuming that the export coefficients are available for all possible existing and future land uses in the study area expected under cumulative conditions. The method would allow for order-of-magnitude comparisons between cumulative scenarios (i.e., with project and without project).

6.2.6 Washington State Department of Transportation (WSDOT) Method

The Washington State DOT (WSDOT) is currently using this guidance to compare stormwater impacts of NEPA project alternatives. It is important to note that over the next year, WSDOT will be reevaluating this approach with the intent of incorporating a more holistic methodology that integrates both site-scale effects and landscape-scale conditions. When completed in 2009, the new guidance will be posted on the WSDOT website.

6.2.6.1 Description

To assess the surface water impacts of projects in Washington State during the NEPA process, WSDOT recommends calculating annual loads among different alternatives being evaluated. As discussed in Section 6.2.5, export coefficients were employed, representing the annual mass of pollutant exported from a unit area based on certain land uses. WSDOT's export coefficients for highway runoff (which are available for TSS, total phosphorus, total copper, dissolved copper, total zinc, and dissolved zinc) are based on highway runoff data collected in Western Washington since 2003. For other land uses including commercial, single-family low and high-density residential, multi-family residential, forest, grass, and pasture, WSDOT uses export coefficients derived from literature, which used data collected mainly in the Pacific Northwest in the 1980s (Horner 1992). The data used to develop the other land use export coefficients are therefore much older. Annual pollutant loading rates for the different land uses are provided for the following pollutants: TSS, TP, TN, lead, zinc, copper, fecal coliform, and chemical oxygen demand.

Pollutant loads are calculated by multiplying the NPS pollutant load coefficient with the area representing the land use. If different land use types are involved for a single alternative, calculations of individual annual pollutant loads are conducted for each land use type and the total annual pollutant load is determined as their sum.

6.2.6.2 Evaluation

Objectives and Outputs

The objectives and outputs of the WSDOT Method are the same as the NPS Method, as described in Section 6.2.5. As such, Objectives 2 and 3 described in Section 5.1 are addressed. Similar to the NPS Method, the WSDOT Method does not provide the tools to identify or characterize existing surface water resources.

Quantitative estimates of annual pollutant loadings are generated, which allow for comparisons between alternatives and baseline conditions. As discussed in Section 6.2.5, the effectiveness of mitigation measures can also be evaluated by applying practice efficiency to the treatable load and then adjusting the total load accordingly to represent implementation of a BMP (Caraco 2002). Similar to the Simple and NPS methods, an additional method would be needed to evaluate water quality impacts to the receiving water body.

Level of Technical Proficiency

The level of technical proficiency needed to conduct the WSDOT Method is the same as what is needed for the NPS Method, described in Section 6.2.5, where the technical skills required are relatively low. Export coefficients are provided by WSDOT, and spreadsheets are easily producible to consider multiple land use types and/or pollutants to perform calculations. The drainage area and areas associated with land types should be clearly defined. Depending on the complexity of the study area, subdividing land use types should be relatively straightforward using the spatial data software currently available (e.g., GIS).

Geographic or Conditional Applicability

As discussed previously, export coefficients were specifically developed for conditions found in Washington state and the Pacific Northwest. WSDOT noted that highway runoff data was compiled from a wide range of highways where annual daily traffic (ADT) volumes varied substantially, but most data was obtained from higher-volume ADT highways. Therefore, using the highway export coefficients for a lower ADT highway may represent a worst-case scenario. WSDOT recommends limiting the use of these coefficients to calculate loads from highway runoff (from treated and untreated highways) and for projects that do not include significant conversions of previously developed lands to highways.

Data Requirements

The WSDOT Method requires export coefficients for each pollutant and area associated with the type of land uses found in the study area. Export coefficients are provided by WSDOT. Land types and areas associated with each alternative should be readily available from spatial GIS data.

Time and Cost

The WSDOT Method is fast and inexpensive. Similar to the Simple and NPS methods, more costly and time-consuming methods would be required to evaluate the impacts of pollutant loadings to the receiving water body. If additional sampling is desired to incorporate more recent information, this may also require more time and money.

Accuracy

Assuming that the coefficients provided by WSDOT are reliable, this method can provide reasonable estimates of pollutant loadings from different types land uses. Similar to the Simple and NPS methods, the WSDOT Method would suffice for NEPA purposes if used to compare the relative stormwater runoff pollutant loads of different alternatives and stormwater management measures. The precision of the results should not be overly emphasized.

Agency Involvement and Acceptance

This pollutant loading estimation procedure was developed and is recommended by WSDOT, and should therefore be accepted for the State of Washington and perhaps other states in the Pacific Northwest, such as Oregon and Northern California. Practitioners should be prepared to respond to comments on how the estimated pollutant loading results would affect the quality of receiving water bodies. Comments may also be made on the relevance of measured pollutant loadings and the need for more recent sampling data.

Adaptability to Cumulative Impacts

This method is generally adaptive to cumulative impacts, because different land use types can be incorporated for a single scenario. However, future and current conditions may not be accurately represented, since most of the pollutant concentration data is from specific time periods. However, order-of-magnitude comparisons can be made between cumulative scenarios.

6.2.7 Integrated Watershed and Receiving Water Modeling Approach

An Integrated Watershed and Receiving Water Modeling Approach (Integrated Modeling Approach) involves using a watershed model to estimate pollutant loadings from a watershed to a water body followed by the use of a receiving water model to determine a water body's response to these pollutant loadings. An evaluation of this methodology is presented below.

6.2.7.1 Description

An Integrated Watershed and Receiving Water Modeling Approach (Integrated Modeling Approach) provides the most comprehensive methodology to analyze or evaluate the potential water quality impacts of transportation projects or other kinds of development. Use of this approach requires an understanding of existing and potential hydrologic/hydraulic and water quality conditions in the study area. Unlike the other individual stormwater methodologies described previously, the Integrated Modeling Approach assesses the pollutant loadings associated with development scenarios (e.g., a transportation project's physical characteristics) and the responses (i.e., water quality) of corresponding receiving water bodies. This approach may use a combination of models that together are able to simulate watershed hydrology and water quality impacts to receiving waters. Because individual models often do not account for all processes involved during rainfall runoff and pollutant fate/transport phenomena, an integrated approach is often warranted.

Watershed models are necessary to link pollutant sources to receiving water bodies as nonpoint and source loads. The following group of commonly used models focuses on describing watershed hydrology and NPS pollution, and simulating water and pollutant runoff as a function of precipitation, land use, impervious area, slope, soil types, and drainage area:

- *HSPF (Hydrologic Simulation Program – FORTRAN):* HSPF simulates (1-D) watershed hydrology, land and soil contaminant runoff, and sediment-chemical interactions, generating results as user-defined time series. Land processes are simulated through water budget, sediment generation and transport, and water quality constituents' generation and transport.

- *SWMM (Stormwater Management Model):* SWMM is a rainfall-runoff simulation model (1-D flow and pollutant routing) developed by USEPA and applied primarily to urban areas for single-event or continuous time steps. Pollutant loadings are simulated via buildup and washoff functions, as well as rating curves and regression techniques.

- *PSRM-QUAL (Penn State Runoff Model)*: PSRM-QUAL was developed by the Civil and Environmental Engineering Department at Penn State University. The watershed model portion, PSRM, is a single-event deterministic model that includes overland runoff, stream/pipe flow, surcharging, and channel and reservoir routing. The quality modeling portion, OUAL, calculates buildup and washoff of sediments from upland surfaces.

Receiving water models focus on the hydrology and water quality of water conveyance systems (e.g., rivers, lakes, estuaries, etc.). In-stream or water body response to watershed runoff and pollutant loadings from the watershed model involves simulation of sediment and pollutant transport and transformation. This requires input information related to various physical (e.g., flow rates, water body geometry, dispersion coefficients, mixing lengths) and chemical properties (e.g., decay rates, partitioning coefficients). Some commonly used receiving water models include:

- *SYMPTOX3 (Simplified Method Program – Variable Complexity Stream Toxics Model):* SYMPTOX3 is an USEPA-supported model for calculating water column and stream bed sediment concentrations and TSS expected from point source discharges into streams and rivers. Pollutant concentrations are estimated in dissolved and particulate phases as a function of user-specified hydraulic properties and physical/chemical coefficients.

- *WASP (Water Quality Analysis Simulation Program)*: WASP is a finite-difference model developed by USEPA for quantifying the fate and transport of water quality variables in surface waters. This model assumes well-mixed control volumes and applies conservation of mass, accounting for advection and dispersion processes. WASP analyzes steady-state or time variable one, two or three-dimensional scenarios.

- *QUAL2E (Enhanced Stream Water Quality Model):* QUAL2E simulates 15 time-variable water quality parameters under steady, non-uniform flow and can be applied to steady state and diurnal time variable situations. This one-dimensional model assumes trapezoidal sections and solves advection-dispersion reaction equations for control volumes.

Some models are available that incorporate both watershed- and water quality-based routines. Examples include the following:

- *SWAT (Soil Water and Assessment Tool):* SWAT was developed for the U.S. Department of Agriculture (USDA) Agricultural Research Service to predict land management impacts on water, sediment, and agricultural chemical yields in large, complex watersheds. SWAT is a continuous time model that simulates watershed hydrology and routing of water, nutrients, pollutants, and sediment to the watershed outlet

- *BASINS (Better Assessment Science Integrating Point and Nonpoint Sources):* Basins combines GIS, national watershed data, and EA modeling tools. It was developed by the USEPA for use on a regional, state, or local scale to support watershed studies, develop TMDLs, evaluate point and nonpoint pollutant sources, and test different watershed management options. BASINS includes QUAL2E for modeling in-stream water quality, HSPF and SWAT for watershed loading and transport modeling, and PLOAD (a GIS-based tool to calculate pollutant loads for watersheds developed by CH2M HILL) for estimated nonpoint pollutant loads..

Additional models and descriptions can be found in USEPA's review of models, which is currently available for simulation of watershed and receiving water conditions as part of the TMDL program entitled TMDL Model Evaluation and Research Needs (Shoemaker et al 2005).

6.2.7.2 Evaluation

Objectives and Outputs

The Integrated Modeling Approach is a "complete" methodology, as described in Section 5.1. Both existing and future (with and without the project) conditions can be modeled, to understand existing hydrologic/hydraulic and water quality characteristics and determine or quantify impacts on ambient water quality concentrations. The evaluation of current conditions would require existing or real-life input parameters, such as existing land uses and point sources. The water quality analysis or evaluation of future conditions, which may include different build and no build scenarios, would require modification of input parameters to reflect changed conditions due to the project as well as changed land uses as a result of each scenario. In addition, input parameters can be adjusted to incorporate mitigation measures and reflect appropriate attenuation in runoff volume and/or pollutant loadings.

Level of Technical Proficiency

The Integrated Model Approach requires a higher level of technical proficiency than required for the other methods discussed. Although the models discussed vary in complexity, the practitioner must consider how to best represent the watershed system to produce realistic results, by selecting the most appropriate model or combination of watershed and water quality models. To do this, the practitioner must be able to understand model theory, assumptions and limitations. He or she must also accurately represent site conditions by understanding the roles and influences of input parameters, and be able to calibrate and interpret results. Even if a relatively simple model were employed, such as a one-dimensional spatial representation as opposed to more complicated two or three-dimensional representations, the practitioner must be able to accurately represent general site conditions through appropriate spatial and temporal input parameters. Complex watersheds, such as those with multiple land and water features, may require use of and linkage with two or more models to represent the entire system, which would require a knowledge of file transfer or common database-sharing protocols.

Geographic or Conditional Applicability

Each of the models identified has certain assumptions and limitations that should be taken into account during model selection and determining how the practitioner would interpret the results. For example, SWMM is conducive to urban areas where most of the drainage area is impervious. As another example, QUAL2E is limited to one-dimensional, steady-flow scenarios, and therefore cannot handle tidal impact or variable flow conditions. Despite these particular limitations, the identified models were developed to address a broad range of situations and are able to incorporate input parameters from a wide variety of specific site conditions, such as rainfall and land use, which can vary substantially from place to place.

Data Requirements

The Integrated Model Approach requires a significant amount of data collection and input parameters, especially compared to the other stormwater methods identified previously. Watershed models generally require input information related to area, soils, imperviousness, slope, roughness, width, depression storage, infiltration, land use, precipitation, and evaporation. Receiving water body models typically require information related to spatial characteristics of the water body (e.g., depth, cross-section shape), water temperature, flow rate, dispersion coefficients, and various chemical specific parameters such as decay rates.

Time and Cost

The time and cost to needed to implement an Integrated Model Approach generally depends on the project's overall scale. For larger projects with larger study areas, which typically would affect a higher number of water bodies, lengthy schedules and relatively high costs can be expected. Because many of the models are publicly available, obtaining use of them may be free or at a nominal cost. However, some information may have to be bought from the owners of this data, such as precipitation records and GIS layers. The time and labor-consuming aspects of the methodology are compiling and inputting the required information, calibrating the model, and validating the results. To generate reliable results, the latter two activities often require multiple iterations.

Accuracy

The accuracy of the Integrated Model Approach depends on the selected models' assumptions and limitations. The practitioner should consider these factors when selecting the models and interpreting the results. For example, most watershed hydrologic models rely on empirically based relationships to represent physical processes. Results can be calibrated using field measured data, but may require significant effort to do so. Compared to other methods discussed previously, the Integrated Model Approach usually produces a time series of results as opposed to single events and output values, and therefore is probably more accurate in representing site conditions and evaluating water quality impacts.

Agency Involvement and Acceptance

The models used in the Integrated Model Approach were developed by or with support from federal agencies, including the USEPA and USACE. Universities are also common sources of model development. In general, widely used and verified models are readily accepted by resource and permitting agencies if the practitioner properly uses and validates each model.

Adaptability to Cumulative Impacts

The Integrated Model Approach is very adaptable to conducting cumulative impact analysis, assuming the availability and accuracy of input parameters representing "other past, present, and reasonably foreseeable future actions." As noted previously, this approach has been used to develop TMDLs, which take a comprehensive view of affected watersheds.

Table 6-2
Comparison of Stormwater Runoff Impact Methodologies

Evaluative Parameters	Methodology						
	SWMP	**FHWA**	**303(d), TMDL, WLA**	**Simple**	**Maryland SHA NPS**	**WSDOT**	**Integrated Model**
Objectives 1: Existing Conditions 2: Impacts 3: Mitigation	3	1,2,3	1	2,3	2,3	2,3	1,2,3
Outputs Qualitative Quantitative Combination	Combination	Quantitative	Combination	Quantitative	Quantitative	Quantitative	Quantitative
Technical Proficiency Low Medium High	Medium	Medium	Medium	Low	Low	Low	High
Geographic and Conditional Applicability	Active state-administered SWMP	Undeveloped or pervious area	Available TMDL/WLA for affected water body	Small watersheds (< 2.5 km^2)	Maryland State (transferable if export coefficients available)	Washington State and Pacific Northwest (transferable if export coefficients available)	No geographic limitations; consider specific model assumptions
Data Requirements Primary Secondary	Primary or Secondary	Primary or Secondary	Secondary	Primary or Secondary	Primary or Secondary	Primary or Secondary	Primary or Secondary
Time and Cost Low Moderate High	Low	Low	Low	Low	Low	Low	High
Accuracy Low Moderate High	Low	Moderate	Moderate-High	Moderate	Moderate	Moderate	Moderate-High
Agency Involvement Low High	Low	Low	High	Low	Low	Low	High
Agency Acceptance Low High	High	High	High	High	High	High	High
Adaptable to Cumulative Impacts No Yes Maybe	No	No	No	Maybe	Maybe	Maybe	Maybe

Notes:
Data Requirements:
Primary – Site-specific sampling data
Secondary – Published values from available studies

7 Stream Quality Assessment Methodologies

7.1 Overview of Stream Quality Assessment Methodologies

The data collection described in Section 4 identified the following stream quality assessment impact methodologies:

- Index of Biotic Integrity
- Aquatic Macroinvertebrate Index
- Qualitative Habitat Evaluation Index
- Field Evaluation Manual for Ohio's Primary Headwater Habitat Streams (PHWH)
- Maryland SHA Physical Stream Assessment

Table 7-1 at the end of this section compares these stream quality assessment methodologies.

7.2 Methodology Discussion

The stream quality assessment methodologies listed above in Section 7.1 are described in the following sections and evaluated based on the parameters explained previously in Section 5.

7.2.1 Index of Biotic Integrity

The presence, condition, numbers, and types of aquatic life convey information about a water body's quality. The Index of Biotic Integrity (IBI), for example, uses numerical measures of fish population and characteristics as indicators to assess a water body's health. An evaluation of the IBI methodology is presented below.

7.2.1.1 Description

According to the USEPA, the Index of Biotic Integrity (IBI) was first developed by Dr. James Karr in 1981 for use in small warm water streams in central Illinois and Indiana. It was designed to include a range of attributes or metrics that can measure fish assemblages. By combining or integrating information on individual, population, community, zoo-geographic, and ecosystem levels into a single ecologically based index, the quality of the water resource can be evaluated (Karr 1986).

The original IBI version had 12 metrics grouped in the following five categories:

- Species Richness and Composition Metrics: (1) total number of fish species; (2) number of catostomidae species; (3) number of darter species; and (4) number of sunfish species

- Indicator Species Metrics: (5) number of intolerant/sensitive species; and (6) percent of individuals that are lepomis cyanellus

- Trophic Function Metrics: (7) percent of individuals that are omnivores; (8) percent that are insectivorous cyprinidae; and (9) percent that are top carnivores or piscivores

- Reproductive Function Metrics: (10) percent of individuals that are hybrids

- Abundance and Condition Metrics: (11) abundance or catch per effort of fish; and (12) percent that are diseased, deformed, or have eroded fins, lesions or tumors

Current applications of the IBI, such as the Biological Stream Characterization Methodology used by the Illinois Department of Transportation, also use these 12 metrics.

Metrics are rated according to a standardized scale to evaluate the overall quality of a stream. In evaluating a stream using the original IBI that may be subject to project impacts, each metric is given a score of five, three or one. The data obtained from the stream is evaluated in comparison to what might be expected in a similar type of stream in a similar geographical region, but with little human influence. A metric is assigned a score of five if the stream compares well against what would be considered pristine conditions or those conditions with little or no disturbance. Conversely, a score of one represents the worst case where conditions depart significantly from the “five” score or reference condition. A three represents an intermediate condition.

The total IBI score is a summation of all 12 metric scores, which can range from the best possible score of 60 to the worst possible score of 12. The USEPA noted that some IBI practitioners have reduced the lowest possible score to zero. Letter grades (A, B, C, D and E) are given depending on certain ranges of scores. For instance, the Illinois IBI methodology assigns an “A” grade for scores that range from 51 to 60, which means that the stream is classified as Unique Aquatic Resource. Other Illinois grades are as follows: a “B” grade (41 to 50) is classified as Highly Valued Resource; a “C” grade (31 to 40) is classified as a Moderate Aquatic Resource; a “D” grade (21 to 30) means that the stream is classified as a Limited Aquatic Resource; and streams with scores less than 21 are given an “E” grade which signifies a Restricted Aquatic Resource.

More recent IBI approaches start with a list of several potential metrics, then use a systematic approach to filter out metrics that do not meet certain criteria. According to the USEPA, bio-related criteria are derived from biological assessments of the composition, diversity, and functional organization of a reference aquatic community. The reference conditions are the basis of biocriteria, representing unimpaired or minimally impaired conditions and the "high end" of a state's designated aquatic life use classification system. Therefore, classification systems and corresponding metrics can be regional specific (e.g., Ohio's "excellent warm water habitat" or Maine's "Class A, as naturally occurs"). Because IBI values depend on characteristics such as geology, topography, and climate, it is also necessary to evaluate IBI in an eco-regional context.

7.2.1.2 Evaluation

Objectives and Outputs

The IBI methodology addresses the first of the three objectives described in Section 5.1: identify and characterize the affected resources. As noted previously, the IBI is used to evaluate the quality of affected water bodies by studying how well they support fish communities. Since rating systems are used, water quality can usually be described by both quantitative and narrative means. Other methodologies would have to be used to determine the project’s impacts on the water body, and to evaluate any necessary mitigation measures.

Level of Technical Proficiency

The IBI Method requires a high level of technical knowledge. The Illinois DOT uses a version of the IBI called the Biological Stream Characterization Methodology, and has a contract with the University of Illinois at Urbana-Champaign to conduct this methodology for its projects. Practitioners who conduct these assessments have PhDs or are university researchers. Although a high technical proficiency required, services from trained biologists are generally available.

Geographic or Conditional Applicability

The IBI Method can be used anywhere in the U.S., assuming that usable data from reference streams (display conditions with little human influence) are available in the geographical region where the project is located. Over time, different versions of the IBI methodology have been developed for different regions and ecosystems. Some still incorporate a multi-metric system but vary in number, identity, and scoring of metrics. Newer versions developed for water bodies in the central U.S. contain metrics similar to the original IBI, with modifications to those metrics that turned out to be unaffected by environmental degradation in certain geographic areas or stream types. Versions developed for eastern and western U.S. regions tend to have different metric sets, indicating significant differences in fish species compared to the central U.S. Different metrics have also been developed based on types of ecosystems, such as estuaries and natural lakes.

To date, most IBI versions are based on small (i.e., wadable for sampling) warm water streams in the central U.S. Some are being developed for coldwater streams, larger rivers, and other regions and water body types.

In Illinois where a version of the IBI Method is used, the Illinois DOT noted that the IBI Method assumes a normal annual stream flow. Over the past few years they have not had normal flows. The streams were either in drought conditions or had excess water. Illinois DOT observes that under low or drought conditions, the IBI tends to overestimate the amount of fish and macroinvertebrates (i.e., reflecting conditions better than they are). For example, under low flow, fish tend to congregate more than they would otherwise under normal flow conditions. The opposite is true for high or above-average stream flow, where conditions are underestimated and worse than actual conditions. Therefore, the IBI Method is sensitive to stream flow.

Data Requirements

Data requirements for IBI investigations are intensive and depend on the metrics selected for evaluation. For example if the original IBI version were followed, the data requirements would be considerable, as discussed previously. In general, because the IBI Method requires a spatial distribution of the magnitude and types of fish species and characteristics of interests, extensive fieldwork is necessary.

Time and Cost

The most costly and time-consuming aspect of the IBI Method is data collection. The IBI Method could require a data collection program that spans over a year. For example, the Biological Stream Characterization Methodology that the Illinois DOT uses collects data in late spring, late summer, and early fall, and each data collection effort takes approximately two days per site for a medium-sized stream. Fish can be identified in the field, so lab work is not required for collected samples. In some cases, data may be available from other state agencies. For example, Illinois DOT uses fishery data from the Illinois DNR collected on a five-year basis and supplements data gaps with direct collection of chemical and biological data.

Accuracy

Assessment of fish communities leads to an accurate evaluation of water resource quality because fish living in affected streams:

- Incorporate the water's chemical, physical and biological histories;
- Are useful for assessing regional and macrohabitat differences;
- Can be a sign of long and short-term quality as a result of long life spans;
- Represent a wide range of tolerances;
- Respond to impacts in characteristic response patterns; and
- Are persistent and generally remain in the same areas.

The IBI Method's accuracy is highly dependent on inputs (i.e., selection of proper metrics and proper metric application by biologists) and reference conditions to accurately represent water resource quality. If the right metrics are used and input data are properly collected and analyzed, the IBI Method is relatively accurate. In terms of accuracy, the major drawback of the IBI method is that it does not identify pollutants or their sources.

Agency Involvement and Acceptance

Fish are obvious and valuable component of the aquatic community. Biological integrity criteria based on fish communities (the IBI Method) have been developed by various state and federal agencies. Therefore, the IBI Method is among the most commonly used and effective approaches for evaluating the biological integrity and health of streams and thus water quality. USEPA's support of this methodology is grounded in the language in the Clean Water Act, which describes aquatic life in terms of fish (e.g., fishable and swimmable goals in the CWA). Life histories and responses to environmental factors for several North American fish species are also well documented in literature. The Illinois DOT noted that agencies and the public seem to have a better understanding of biological-related assessments, as opposed to the mathematics associated with methodologies such as the stormwater assessment methods described in Section 6.

Adaptability to Cumulative Impacts

By evaluating the quality of affected streams through studying their aquatic life, the IBI Method can support cumulative impact analysis the same way that it can support project-specific impact analysis. However, because the IBI Method is not a "complete" methodology, completion of the cumulative impact analysis would require other methodologies that can evaluate the cumulative impacts on receiving water bodies. Also, because this approach focuses on the current state of water bodies with respect to reference or pristine conditions, it cannot account for or address past or future conditions. If data is available from previous time periods, relative comparisons can be made regarding cumulative impacts to date, but a comparison of future effects would not be possible.

7.2.2 Aquatic Macroinvertebrate Indices

Macroinvertebrates can also be used as indicators to assess water quality. An evaluation of the Aquatic Macroinvertebrate Indices (AMI) methodology is presented below.

7.2.2.1 Description

Similar to IBI Method, the Aquatic Macroinvertebrate Indices (AMI) methodology uses a biotic index based on the presence of macroinvertebrate species (e.g., insects, worms, snails, etc.) to help assess water quality. The USEPA has noted that macroinvertebrate assemblages are good indicators of localized water quality conditions because such species have limited migration patterns. Therefore, an AMI Method may be more appropriate for site or project-specific impact assessments than the IBI Method. Macroinvertebrates possess general characteristics that make them useful for assessing the health of the watershed. An abundance and extended presence of macroinvertebrates is a strong indicator of healthy water body, because of their limited mobility compared to other aquatic life such as fish. These species reside in the water most of their life, remain in areas suitable for their survival, are relatively easy to collect, vary with respect to pollutant tolerance, are easily identifiable especially in a laboratory, have life spans that often exceed one year, have limited mobility and integrate with environmental conditions. In addition, several small streams that may only support a limited fish fauna will naturally support a diverse macroinvertebrate fauna.

Some macroinvertebrate-related assessments involve a pollution tolerance rating (i.e., relating to levels of oxygen in water). It is typically assumed that a lack of oxygen signifies poor water quality. Scientists have found that some macroinvertebrates rely on dissolved oxygen content and only survive in water with high levels of oxygen, whereas others can survive in water with less oxygen. This means that water bodies containing mostly pollutant-tolerant organisms generally have poorer water quality than those with more pollutant-sensitive species.

A healthy water body should also have many different types of organisms, including pollutant-tolerant and pollutant–sensitive species. The assigned biotic index value for a water body depends on how many types of organisms are present in a sample, and the tolerance category associated with those organisms. For example, the Water Action Volunteer (WAV) citizen monitoring program in Wisconsin employs a biotic index where macroinvertebrate species are separated into four categories based on pollution tolerance for scoring purposes: tolerant (4), semi-tolerant (3), semi-sensitive (2), and sensitive (1). Once a sample is collected, organisms are separated in these categories using a field key developed by the University of Wisconsin that identifies the types of macroinvertebrates that fall within each category. A score is assigned to each category, which is equivalent to the number of macroinvertebrate types found in that group multiplied by the corresponding category score (e.g., 4 for pollutant-tolerant species). The overall index score is equal to the sum of the four individual category scores divided by the total number of macroinvertebrate types found in the entire sample. Stream health ratings are then assigned based on biotic index values ranging from poor (1.0 to 2.0) to excellent (3.6 or higher).

Another methodology is the Family Biotic Index (FBI) (Hilsenhoff 1988), which identifies macroinvertebrates at the family level, which is less specific than organisms by genus or species as required by the original Hilsenhoff Biotic Index (HBI). This is a statistically based method that uses stream sampling. Similar to the IBI Method, FBI provides a number score or index from “0” to “10”, with “0” representing excellent conditions and “10” representing very poor conditions. The score indicates the “degree of organic pollution” in the studied water body.

7.2.2.2 Evaluation

Objectives and Outputs

Similar to the IBI methodology, AMI (e.g., FBI, HMI and WAV) methods address the first of the three objectives described in Section 5.1: identify and characterize the affected resources. These indices are used to evaluate the quality of the affected water body by studying the different types and characteristics (e.g., pollutant–tolerant) of macroinvertebrate species present. Similar to the IBI Method, rating systems are used, which means that water quality can usually be described by both quantitative and narrative means. Other methodologies would have to be used to determine the project’s impacts to the water body, and if necessary, to evaluate mitigation measures.

Level of Technical Proficiency

Many state water quality agencies employ trained and experienced biologists for invertebrate-related assessments. Similar to the IBI methodology, people trained to conduct these assessments have PhDs and/or are university-level researchers. Although the level of technical proficiency is high, services from trained biologists are generally available.

The level of technical proficiency required also depends on the complexity of the index system implemented. The identification of organisms involved in conventional indices usually requires knowledge of aquatic biology, in order to determine family types for FBI or species for HBI. However, the WAV citizen monitoring program was developed by scientists from Wisconsin DNR and the University of Wisconsin to allow citizens to participate in stream health assessments based on biotic indices specific to streams in Wisconsin. This method follows closely with the original Hilsenhoff (HBI) Method but with less scientific detail, and therefore requires less training or technical proficiency.

Geographic or Conditional Applicability

Except for regional-specific sub-methods such as the WAV, the AMI Method can be used anywhere in the U.S. In order to use the AMI Method, a normal annual stream flow is preferred. Low or high-flow conditions may misrepresent typical water resource quality. Also, data collection may be difficult in smaller streams where flow is intermittent.

Data Requirements

The AMI Method’s data requirements depend on the specific method selected for the evaluation (e.g., FBI, HBI, etc.). In general, samples of organisms are collected to identify the species (or family for FBI) found, their quantities, and their pollutant tolerances. Similar to the IBI Method, the AMI Method requires a spatial distribution of the magnitude and types of organisms and characteristics of interests. Also, multiple sampling periods might have to be used to accommodate seasonal variations, if necessary (see below).

Time and Cost

The AMI Method's time and cost requirements depend on the index system selected. For example, a more sophisticated system such as the HBI requires substantial laboratory work to distinguish organisms to a detailed level.

According to the USEPA, sampling for macroinvertebrate species is relatively easy, requires relatively few people, does not need expensive equipment, and creates minimal disturbance to the resident biota. Per USEPA, the ideal sampling procedure involves surveying the biological community with each change of season. However, stress effects are typically integrated over the course of a year and several studies have determined that a single index period can provide a sufficient database. If understanding seasonal variability is important, it may be necessary to index sampling periods during multiple seasons, in which case the entire process would take approximately one year (similar to what was described for the IBI Method in Section 7.2.1.2).

Accuracy

Although it is relatively accurate for assessing water body conditions and providing indications of any water quality issues (e.g., lack of oxygen) due to the science associated with macroinvertebrate species, the AMI Method (similar to the IBI Method) does not identify pollutants or their sources. This type of information would require other types of monitoring and methodologies.

Agency Involvement and Acceptance

Many water quality state agencies routinely collect biosurvey data that focus on macroinvertebrates, and may have extensive background macroinvertebrate information. In addition, they may have more staff with expertise in invertebrates than fish. Therefore, agency involvement regarding the scope of an AMI study may prove useful in obtaining agency acceptance of study results.

Adaptability to Cumulative Impacts

Similar to the IBI Method, the AMI Method can support cumulative impact analysis, but because it is not a "complete" methodology, completion of the cumulative impact analysis would require other methodologies that can evaluate the cumulative impacts to receiving water bodies. Also like the IBI Method, the AMI Method focuses on the current state of water bodies. Evaluation of the future state of affected water bodies is not possible.

7.2.3 Qualitative Habitat Evaluation Index (QHEI)

Macro-habitat characteristics are another group of indicators that can be used to assess water quality. An evaluation of the Qualitative Habitat Evaluation Index (QHEI) methodology is presented below.

7.2.3.1 Description

The Qualitative Habitat Evaluation Index (QHEI) is intended to provide a quantified approach to evaluating the general macro-habitat characteristics of a water body, which are important indicators of overall aquatic life. This method focuses on key physical characteristics of the water body and the surrounding area. As described in the Ohio EPA's technical bulletin entitled *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)*, the QHEI consists of the following six primary metrics (Ohio EPA 2006):

- Substrate (1): substrate type and quality;
- Instream Cover (2): presence of types and amount of overall cover;
- Channel Morphology (3): sinuousity, development, channelization, and stability of the stream channel;
- Riparian Zone and Bank Erosion (4): riparian zone width, floodplain quality, and extent of bank erosion;
- Pool/Glide and Riffle-Run Quality (5): pool depth, velocities, pool morphology, riffle-run depth, riffle-run substrate, and riffle-run substrate quality;
- Map Gradient (6): elevation drop through the sampling area using USGS 7.5-minute topographic maps

A score is assigned to each individual metric using a state-specific rating system and the sum represents the total QHEI site score. Ohio EPA's, for example, has a maximum possible score of 100, which indicates the best-case scenario for a sampling site. Excellent QHEI scores range from 70 to 100, and poor QHEI scores range from 30 or less. Physical characteristics are evaluated based on a water body's ability to support aquatic life and biodiversity. A higher score indicates that physical features are conducive to supporting aquatic life and encourage biodiversity, which signifies high water quality.

Minimal human disturbance and natural conditions are ideal characteristics of habitats that support aquatic life and indicate high water quality. For example, streams with a diversity of high-quality substrates such as boulders, sand and gravel are awarded higher points than those with hardpan, silt, and/or artificial substrates (e.g., trash, bricks, concrete).

In-stream cover includes various types such as roots, woody debris, and vegetation (in-water and overhanging). Diverse and extensive cover indicates a higher potential for habitat that supports various life forms, the ability to support vegetation, and high dissolved oxygen content, which is needed for vegetation to thrive. An extensive but single type of cover may provide habitat potential, but its diversity and habitat type would be limited. A diverse and extensive cover suggests higher water quality, and therefore would be awarded higher points than sites with single or no cover, which suggest moderate and poor water quality, respectively.

Channel morphology, the third metric, relates to the creation and stability of the stream channel. The fourth metric relates to the quality of the riparian buffer zone and floodplain. Severely eroding banks indicate an unstable habitat and may result in sediment disturbance and shallower water depths than under normal circumstances. Because these factors can contribute to a reduction in water quality, severely eroded banks would be given a low score. The floodplain quality is represented and evaluated in terms of the predominant land use types (e.g., forest, residential, pasture, etc.) adjacent to the water body that can have direct runoff and erosion effects. Land uses that may deliver harmful runoff to a receiving water body would be given lower scores. The final metric addresses the quality of habitat types found in the channel. For example, pools should have sufficient depth to provide refuge for aquatic life during dry weather periods.

7.2.3.2 Evaluation

Objectives and Outputs

Similar to IBI and AMI methods, the QHEI Method addresses the first objective in Section 5.1, because it increases the understanding of the quality of potentially affected water bodies by examining their habitat-related features. The QHEI Method provides the means to describe the state of habitat of a water body and its capacity to support aquatic life in both quantitatively and narrative ways. Other methodologies would have to be used to determine the project's impacts and to evaluate any necessary mitigation measures.

Level of Technical Proficiency

Depending on the level of detail required by the state resource or regulatory agency, the QHEI process can be relatively simple because it is based on visual observation of specific physical features. The Ohio EPA, for example, provides a checklist of features and scores that correspond to specific characteristics. As an example, extensive cover is defined as an area having 75 percent or more of the total in-stream area and should be assigned a score of 11. To assist practitioners, the Ohio EPA provides example photos that correspond to different ratings.

Geographic or Conditional Applicability

The QHEI Method can be used anywhere in the U.S. because prevailing metrics or index categories can generally be applied to various geographic regions. Modifications may be made to the features within a category and to the rating scheme, to accommodate regional variations due to unique habitats that may support aquatic life that is characteristic of a specific water body type or location.

Similar to the IBI and AMI methods, the QHEI Method is dependent on flow conditions. Assessments should be made during representative normal flow periods and if possible during low and high low conditions to note any significant changes. For example, as mentioned previously, it is important to note whether pool depth is sufficient to provide habitat during low flow conditions. During high flows, it is important to observe riparian buffer zones and the stability of banks to protect habitat and water quality from higher flow velocities, which can increase runoff and erosion.

Data Requirements

Field observations and recordation are required to perform a QHEI evaluation (assigning scores to each metric), and to be able to assign an overall rating for the water body. As noted previously, the Ohio EPA provides a field checklist to assist with the evaluation. Because data collection is based on visual observations and not sampling and corresponding lab testing, the effort is generally not extensive. A complete inventory of the entire reach of the water body that could be affected by the project is usually not necessary. A single sampling area could be appropriate, but it should be generally representative of the entire length of the water body and should incorporate the typical physical features observed.

Time and Cost

In general, the time and costs associated with using the QHEI Method are not high because data collection is not extensive (see above) and overall ratings can be assigned shortly after field observations. If additional measurements of water quality parameters are desired to supplement visual observation (e.g., temperature and turbidity), collecting this kind of information would involve more time and cost because they require monitoring equipment.

Accuracy

The QHEI Method provides a relatively fast and inexpensive means of evaluating water quality in terms of a water body's macro-habitat characteristics, but its accuracy is limited. Depending on the level of detail and guidelines provided for evaluation, descriptions and ratings are largely based on the practitioner's judgment. If selected to be used for NEPA purposes and if water quality is an important issue of the project, one or more of the other methods described in this research paper should be used in conjunction with the QHEI Method, or the QHEI Method should be supplemented with monitoring of physical and chemical water quality parameters to build a more complete evaluation of water resource quality. A greater level of accuracy using only the QHEI Method would involve clearly identifying the reference conditions and properties (via quantifiable measures, if possible) and showing how analyzed conditions compare with them.

Agency Involvement and Acceptance

The USEPA provides general guidance on the concept of bio-assessments involving habitat quality, and therefore would be supportive of a QHEI Method if it is consistent with this guidance. Some state regulatory agencies such as the Ohio EPA require a habitat assessment, such as the QHEI as part of an overall survey of watershed health. According to the Ohio DOT, the QHEI Method is also accepted by the Ohio Department of Natural Resources and the U.S. Fish and Wildlife Service.

Adaptability to Cumulative Impacts

Similar to the IBI and AMI methods, the QHEI Method can support cumulative impact analysis, but because it is not a "complete" methodology, completion of the cumulative impact analysis would require other methodologies that can evaluate the cumulative impacts to receiving water bodies. Like the other methods, the QHEI Method focuses on the current state of water bodies, and cannot evaluate the future state of affected water bodies. Unless past survey information is available to evaluate changes in morphology and other characteristics over time, the QHEI may not be as useful as the IBI and AMI methods in evaluating long-term water quality.

7.2.4 Maryland SHA Physical Stream Assessment

Maryland SHA developed a method to evaluate potential impacts to stream due to SHA projects. An evaluation of this methodology is presented below.

7.2.4.1 Description

Maryland SHA Environmental Programs Division developed a stream assessment protocol in 2001 to evaluate potential impacts to streams as result of SHA projects. The data collected are intended for qualitative comparison and use by the Maryland Department of the Environment (MDE) and Maryland Department of Natural Resources (MDNR) Biological Stream Survey (MBSS). The method can be used in the NEPA process for impact assessment, but also may be applied during and after construction to monitor actual project-related impacts to water quality and resources.

7.2.4.2 Evaluation

Objectives and Outputs

During the NEPA process, the Maryland SHA Method can be used to assess various biological, physical, and chemical parameters before construction, both upstream and downstream of the proposed limits of disturbance. Similar to the IBI, AMI, and QHEI methods, the Maryland SHA Method addresses the first objective in Section 5.1: identify and characterize the affected resources. Water quality parameters are measured before construction to establish the baseline conditions of a stream's health. Since some physical measurements are collected, water quality can usually be described by both quantitative and narrative means.

Level of Technical Proficiency

The data collection specified by SHA (see the following Data Requirements section) requires the practitioner to be familiar with water quality measurement devices. A practitioner must also be familiar with state guidelines in order to determine stream classification, and with stream characteristics to identify different aquatic and vegetation species. SHA recommends using the MBSS manual provided by MDNR. Reports must be generated to document baseline (yearly basis) and post-construction (final report) conditions. Shorter memorandums are also required for each, during construction monitoring events.

Geographic or Conditional Applicability

Similar to the IBI, AMI, and QHEI methods, the Maryland SHA Method is intended for streams with perennial flow and a well-formed channel. Monitoring may not be applicable to streams with significant vegetation, unless they have sensitive habitat or are specified by MDE/MDNR. Monitoring schedules are limited, to reduce impacts to fish spawning activities and sustain biological communities depending on the use classification. Seasonal monitoring should occur in the spring (between March 1 and April 30), summer (between June 1 and September 30), and fall (between November 1 and December 31) of each year.

Data Requirements

The Maryland SHA Method involves the following components (on a seasonal or annual basis): water quality, habitat, photographic documentation, watershed analysis, benthic macroinvertebrates, and physical properties. Water quality parameters include pH, dissolved oxygen, temperature, conductivity, TSS, and turbidity. If rare, threatened, endangered (RTE) or pollutant-intolerant species are present that may be negatively impacted by construction activities, additional monitoring may be required (e.g., fish species, submerged aquatic vegetation, shellfish, reptiles/amphibians, wetlands).

Maryland SHA recommends that monitoring be conducted at one station upstream and one station downstream of proposed construction activities. The presence of multiple upstream tributaries may warrant additional stations. Station locations should be selected to represent typical/consistent-reach substrate, vegetation, and channel geometry.

Time and Cost

The time and effort required for monitoring activities are project-specific and depend on the stream use classification, sensitivity of surrounding environmental (e.g., endangered species), and extent of disturbance expected for construction.

Accuracy

This is a comprehensive assessment of several parameters for defining stream characteristics that may be impacted by construction activities. Similar to the QHEI Method, descriptions and ratings are largely based on the judgment of the practitioner and depend on the level of detail and guidelines provided for evaluation. Similar to the IBI, AMI and QHEI methods, the Maryland SHA Method does not identify pollutants or their sources. This type of information would require other types of monitoring and methodologies.

Agency Involvement and Acceptance

This method was developed by SHA and is consistent with DNR/MDE protocols for stream assessments. Each monitoring stage requires a report detailing results, to be reviewed by applicable agencies.

Adaptability to Cumulative Impacts

Similar to the IBI, AMI and QHEI methods, the Maryland SHA Method can support cumulative impact analysis, but because it is not a "complete" methodology, completion of the cumulative impact analysis would require other methodologies that can evaluate the cumulative impacts to receiving water bodies. Like these other methods, the Maryland SHA Method focuses on the current state of water bodies and cannot evaluate the future state of affected water bodies for NEPA purposes. Like the QHEI Method, unless past survey information is available to evaluate changes in morphology and other characteristics over time, the Maryland SHA Method may not be as useful as the IBI and AMI methods in evaluating long-term water quality.

Table 7-1
Comparison of Stream Quality Assessment Methodologies

Evaluative Parameters	Methodology			
	IBI	AMI	QHEI	MD SHA
Objectives 1: Existing Conditions 2: Impacts 3: Mitigation Outputs Qualitative Quantitative Combination	1 Qualitative	1 Qualitative	1 Qualitative	1 Combination
Technical Proficiency Low Medium High	High	Medium-High	Medium	Medium-High
Geographic and Conditional Applicability	No geographic or conditional limitations, but a normal annual stream flow is desired; Small, warm water streams; Consider regional variations	No geographic or conditional limitations, but a normal annual stream flow is desired; Consider seasonal and regional variations	No geographic or conditional limitations, but a normal annual stream flow is desired; Consider regional variations	No geographic or conditional limitations, but a normal annual stream flow and well-formed channel is desired; Consider seasonal variations and stream sensitivity
Data Requirements Primary Secondary	Primary	Primary	Primary	Primary
Time and Cost Low Moderate High	Moderate-High	Moderate-High	Moderate	Moderate-High
Accuracy Low Moderate High	Moderate-High	Moderate-High	Low-Moderate	Moderate-High
Agency Involvement Low High	High	High	High	High
Agency Acceptance Low High	High	High	High	High
Adaptable to Cumulative Impacts No Yes Maybe	No	No	No	No

Notes:
Data Requirements:
Primary – Site-specific sampling data
Secondary – Published values from available studies

8 Wetlands Quality Assessment Methodologies

8.1 Overview of Wetlands Quality Assessment Methodologies

The data collection described in Section 4 identified the following wetlands quality assessment methodologies:

- Wetland Evaluation Technique
- Hydrogeomorphic Approach for Assessing Wetland Functions
- Florida Uniform Mitigation Assessment Method
- Rapid Functional Assessment Methodology
- MDT Montana Wetland Assessment Method

The purpose of these methodologies is to evaluate the functions of wetlands subject to CWA Section 404 permitting. As explained in Smith et al. (1995), wetland functions are activities that occur in wetland ecosystems as a result of their physical, chemical, and biological characteristics. An example of a simple function is the reduction of nitrate to gaseous nitrogen, when aerobic and anaerobic conditions exist in the presence of denitrifying bacteria (Smith et al. 1995). More complex wetland functions include nitrogen and nutrient cycling, which involve more components and processes.

As described in Section 3.1.1, assessments of wetlands functions are typically covered during the NEPA process, even though the actual CWA Section 404 permitting (nationwide or individual) by the USACE normally occurs after the NEPA process. CWA Section 404 permitting is considered a NEPA action. For federal-aid or federal-land highway projects, which are already subject to NEPA requirements, the USACE typically adopts the NEPA document prepared for the project for its NEPA regulatory responsibilities under CWA Section 404. If a project involves wetland displacements that would trigger CWA Section 404 permitting, FHWA often asks that the USACE participate in the NEPA process as a cooperating agency, even if the displacement is considered small or minor.

Table 8-1 at the end of this section compares these wetland quality assessment methodologies.

8.2 Methodology Discussion

The wetland quality assessment methodologies listed above in Section 8.1 are described in the following sections and evaluated based on the parameters explained previously in Section 5.

8.2.1 Wetland Evaluation Technique

The Wetland Evaluation Technique (WET) was developed to assess wetland functions in the 404 Regulatory Program and considers characteristics that are valuable to society. An evaluation of the WET method is presented below.

8.2.1.1 Description

The Wetland Evaluation Technique (WET) is a comprehensive approach for evaluating individual wetlands according to Section 404 functions and values and other applicable regulatory situations. The WET Method was developed in 1983 for the FHWA and later revised in 1987 with support from the USACE. According to WET, wetland functions include the following physical, chemical, and biological characteristics that can be found in a wetland:

1. Ground water recharge
2. Ground water discharge
3. Flood flow alteration
4. Sediment stabilization
5. Sediment/toxicant retention
6. Nutrient removal/transformation
7. Production export
8. Wildlife diversity/abundance
9. Aquatic diversity/abundance
10. Recreation
11. Uniqueness/Heritage

The WET Method can also evaluate habitat suitability for 14 waterfowl species groups, 4 freshwater fish species groups, 120 species of wetland-dependent birds, and 133 species of saltwater fish and invertebrates.

Values are assigned to the functions listed previously in terms of effectiveness, opportunity, social significance, and habitat suitability. *Effectiveness* means the wetland's ability to perform a certain function. For example, for water quality, a wetland with no outlet would be given a high value for sediment retention. *Opportunity* is a measure of the wetlands' potential to perform a certain function, and is based on flood flow alteration, sediment/toxicant retention, and nutrient removal/transformation. A low value for opportunity would be given to a wetland in a forest type area, because such a site would have no potential sediment sources. *Social significance* is a non-statistical measure of importance to society in terms of economic value (e.g. recreational uses), strategic location and other factors, such as protecting endangered species. *Habitat suitability* is the wetland's ability to support wetland-dependent species such as waterfowl, fish, birds, and invertebrates.

The practitioner starts by assembling available information on the wetland and its surrounding and downstream areas. Sources of this information include soil surveys, topographic maps, and aerial photos. The practitioner then selects the type of evaluation and delineates assessment areas using techniques approved by the USACE, such as its Wetlands Delineation Manual. Evaluation types include social significance, effectiveness/opportunity, and habitat suitability. Based on available data and/or site visits, the practitioner answers a series of yes-no questions about the watershed, topography, vegetation, and other features. Responses to these questions are analyzed in a series of interpretation keys that assign a probability rating of high, moderate, or low to each of the functions listed previously. This rating indicates the probability that the function will occur in the wetland with respect to effectiveness, opportunity and/or social significance.

According to Smith et al. (1995), several methods have been developed to assign economic value to wetland functions, such as assigning dollars or other economic value units to the benefits, goods, and services resulting from wetland functions. Smith et al. (1995) suggest that this method works well in the open market, where a market price is established that encompasses the factors that motivate people to pay for benefits, goods, and services. An example provided is timber products harvested from forested wetlands, which can be assigned an economic value based on its market price.

The WET Method has been adapted to provide numeric values indicating the degree to which wetlands perform various functions, or groups of functions (Hruby, Cesanek and Miller, 1995). Called the Indicator Value Assessment (IVA) Method, it is based on the assumption that certain wetlands have specific environmental indicators of performing certain functions better than wetlands that do not have these indicators. The IVA Method allows for local adaptation of the WET Method to a particular study area or watershed, by allowing a team of professionals to select a subset of WET questions that describe locally important wetland characteristics and functions relating to the characteristics described by those questions. Numeric additive or multiplicative values are then assigned to each question as it relates to each function. Performance scores are calculated for each function, which are normalized on a scale of 0-100, relative to the wetland having the highest performance score in the planning region. These performance scores are then multiplied by the area of the site and a rank score, representing the relative social importance of that function. The end result is a value score for the wetland.

The IVA Method was first developed for use in several watershed planning management planning initiatives. It has since been adopted for use by the USACE and New Jersey Department of Environmental Protection, to calculate the magnitude of wetland impacts due to specific projects, calculate gains in wetland values due to proposed and implemented wetland replacement and banking projects, and calculate compensatory mitigation ratios necessary for each project and mitigation proposal. It is also currently being used by the New York City Metropolitan Transit Authority to help prioritize sustainability measures within their network of facilities.

8.2.1.2 Evaluation

<u>Objectives and Outputs</u>

During the NEPA process, the WET Method, as with other wetland quality assessment methodologies, is used in conjunction with wetland delineation methods if the project proposes to dredge or fill a wetland to meet its objective. The information provided by the WET Method is used to understand the characteristics of the subject wetland (i.e., the wetland's function and how well it performs this function), and therefore addresses the first objective in Section 5.1: identify and understand the characteristics of the physical, natural and human resources that may be affected by the proposed action.

Without wetland delineation, the WET Method would not provide a complete approach for "existing conditions." The most common delineation methodology is the USACE's Wetland Delineation Manual. Other methodologies would also have to be used to determine a project's impacts on wetlands. Typically, an overlay of the project's conceptual design on a USACE-approved delineation of the wetland would suffice to determine direct impacts. Indirect impacts such as stormwater pollution can be covered by using the methodologies described in Section 6. However, the Oregon DOT noted that the WET Method is being used to assess a project's impacts on wetland functions that are lost as a result of removal or fill in qualitative terms. Therefore, it partially satisfies the second objective in Section 5.1.

Information from the WET Method can support the third objective in Section 5.1: "help identify mitigation measures and evaluate their effectiveness." Although the method does not evaluate the effectiveness of mitigation measures, its results can be used for discussions between project sponsors and USACE in determining the amount of compensatory mitigation (e.g., wetland replacement, wetland banking, etc.), if any. This may be a condition for obtaining Section 404 general/nationwide permit coverage or an individual permit. However, some DOTs choose not to use this method for Section 404 permitting purposes.

The WET Method produces probability ratings based on the evaluation of relevant functions, such as its capacity for sediment and nutrient removal and presence of aquatic wildlife. These ratings are basically qualitative assessments, or general descriptions of the current state of water resources in a wetland. If desired or required, quantitative measures would require using another methodology, such as the IVA Method and/or field sampling. The Pennsylvania DOT noted that districts use this method for informational purposes but not for Section 404 permitting. USACE also suggests that WET should not be used as a design guide, but to provide useful information on individual questions.

Level of Technical Proficiency

The WET Method is intended for use by environmental professionals. At a minimum, the USACE states that practitioners should have an undergraduate degree in biology, wildlife management, environmental science, or several years of experience in one of these areas.

Geographic or Conditional Applicability

The WET Method is applicable to all wetland types in the U.S. However, modifications may be necessary to focus on regional variations or local characteristics. USACE has noted that the WET Method has been mostly used for large projects such as highways, some regulatory actions, and for restoration and creation of wetlands.

Data Requirements

The data requirements are extensive but not necessarily difficult to obtain. As discussed previously, the WET Method requires general site information on the wetland and its surrounding and downstream areas, and this information can be obtained from topographic and soils maps (including GIS layers) and aerial photos. Fieldwork is required to obtain information regarding on and off-site characteristics with respect to the functions and values described previously. These characteristics involve the larger watershed and the vegetation, aquatic life, and wildlife species found at the site.

Time and Cost

The WET Method can require a substantial amount of time to complete. According to USACE, the estimated time to assess a 1-acre site is between 14 and 42 hours. Preparation and data collection may take about 8 hours. The social significance evaluation should take between 4 and 5 hours; and evaluating effectiveness and opportunity can take anywhere from 2 to 29 hours.

Accuracy

The WET Method can provide reasonably accurate results, because the relationships between wetland functions and characteristics are well documented in the literature. However due to the qualitative nature of the results, this methodology's level of accuracy is subject to the professional judgments of the practitioner. As noted previously, the WET Method can be modified to an IVA Method, which yields predictive and quantitative comparative wetland functional values that are more adaptable to calculating compensatory wetland mitigation ratios.

Agency Involvement and Acceptance

As the developer of the WET Method, the USACE would likely accept the results of the method, assuming that it was properly conducted, including consultation with USACE. This method is widely used for various types and locations of wetlands throughout the U.S.

Adaptability to Cumulative Impacts

The WET Method can support cumulative impact analysis, assuming that the wetlands being studied are the only wetlands that would potentially be affected by cumulative impacts. In most situations under NEPA, this assumption would not be valid. The WET Method is not a "complete" methodology, and completion of the cumulative impact analysis would require other methodologies or activities that can evaluate the cumulative impacts to wetlands.

8.2.2 Hydrogeomorphic Approach

The Hydrogeomorphic (HGM) approach is a wetland quality assessment method supported by multiple agencies including USACE, the EPA, the FHWA, the Natural Resource Conservation Service (NRCS), and the US Fish and Wildlife Service. An evaluation of the HGM approach is presented below.

8.2.2.1 Description

The hydrogeomorphic (HGM) approach evaluates the characteristics or functions of the affected wetland by comparing it to reference wetlands (i.e., undisturbed or least-disturbed wetlands and landscapes in the reference area) established for the region in which the project is located. In other words, the HGM approach cannot be used if the study area is not already set up to use this methodology. This assessment approach is based on the hydrogeomorphic classification developed by Brinson (1993) to identify groups of wetlands that have similar functions (Smith et al. 1995). This classification is based on three main factors that affect wetland functions: geomorphic setting, water source, and hydrodynamics. The development of the methodology for a region, and for a particular type (i.e., subclass) of wetland in that region, must be completed before the HGM approach can be used. A sample of some of the regions and types of wetlands in the U.S. for which the HGM approach can be applied include:

- Riverine wetlands in Western Kentucky
- Northwest Gulf of Mexico tidal fringe wetlands

- Intermontane prairie pothole wetlands in the Northern Rocky Mountains
- Wet pine flats on mineral soils in the Atlantic and Gulf Coastal Plains
- Flats wetlands in the Everglades
- Depressional wetlands in Nebraska

The HGM approach's overall objective is to identify regional wetland subclasses, based on the HGM and other factors of regional importance that are relatively homogeneous in structure, process, and function. The hydrogeomorphic classification is based on geomorphic setting, water source, and hydrodynamics, which are the three fundamental factors that influence how wetlands function (Smith 1995). For each wetland subclass, a particular procedure is developed that can be used for CWA Section 404 purposes. By reducing variability through classification, this assessment is simplified by focusing on the functions a wetland is most likely to perform and the characteristics most likely to influence those functions (Smith 1995).

Guidebooks for developing an HGM approach for regional wetland subclasses are available from the USACE. The guidebooks provide instruction for identifying regional wetland subclasses, developing functional profiles, identifying reference wetlands and reference standards, and developing calibrating and testing assessment models.

After classification of wetlands, each wetland subclass is provided a narrative profile that describes its physical, chemical, and biological attributes, and also includes its likely functions. This functional profile defines the variables related to each function and illustrates relationships between functions and variables (Clairain 2002).

The end result of developing an HGM methodology for a region and its wetland subclass is an HGM assessment procedure or model. Assessment models represent the relationship between the wetland's physical, chemical, and biological attributes and the surrounding landscape, and the functional capacity of the wetland (Clairain 2002). The models should be simple and efficient, but at the same time should be accurate and precise enough to detect any functional changes or differences between wetlands of the subclass (Smith 1995).

The assessment model consists of a number of functional indices that, when applied to a subject wetland (i.e., a wetland potentially affected by a project), results in a single functional index that estimates the wetland's capacity to perform the functions of the regional subclass relative to other wetlands from that regional subclass. The reference wetlands or standards represent the highest sustainable level that can be achieved across the suite of functions performed by wetlands within the regional subclass (Smith 1995), and are therefore used to calibrate the assessment model.

According to Smith (1995), the HGM approach is a compromise between the large amounts of information needed to properly evaluate wetlands and the reality that it can be difficult to obtain extensive information for many projects due limited time and resources. The HGM approach provides a relatively simple method, while retaining the essence of the information needed for wetland evaluations. By developing and using functional indices calibrated from reference wetlands, it is possible to achieve an acceptable level of accuracy and precision even though minimal data collection and analysis are needed for each project.

A NEPA or CWA Section 404-level assessment using the HGM approach would estimate the functional capacity of the wetland assessment area, which is defined as wetland area within the project area that is physically continuous and meet the criteria used to define regional wetland subclass. *Functional capacity* means the degree to which a wetland assessment area performs the specific function of the reference wetlands of the regional subclass. The application of the assessment model for NEPA/Section 404 purposes would result in a Functional Capacity Index (FCI) rating that can range from 0.0 to 1.0. A 1.0 score indicates that the wetland assessment area is equal in terms of functional capacity to the referenced wetlands. The amount of functional deviation from the referenced wetlands would correspond to lower FCI scores. By itself, the FCI does not consider the size of the wetland assessment areas. The affect of size is incorporated into the calculation of functional capacity by multiplying the FCI of a wetland assessment area by the size of that wetland. The total functional capacity of a wetland assessment area is equal to the sum of the FCIs.

8.2.2.2 Evaluation

<u>Objectives and Outputs</u>

Similar to the WET Method and the other wetland quality assessment methods described in this section, the HGM approach addresses the first of the three objectives described in Section 5.1: identify and characterize the affected resources. Without delineation through an acceptable methodology (e.g., USACE's Wetland Delineation Manual), the HGM approach would not be a complete "existing conditions" methodology. Also, the functional capacity derived of the subject wetland cannot be determined without a USACE-approved delineation. Similar to the WET and other wetland quality assessment methods, other methodologies would have to be used to determine the project's direct (i.e., displacement) and indirect (i.e., runoff) impacts to wetlands. Typically, an overlay of the conceptual design of the project on a USACE-approved delineation of the wetland would suffice to determine direct impacts. Indirect impacts such as stormwater pollution can be covered by using the methodologies described in Section 6. However, the Oregon DOT noted that similar to the WET Method, the HGM Method is being used to assess a project's impacts on functions that are lost as a result of removal or fill in qualitative terms. Therefore, this methodology partially satisfies the second objective in Section 5.1.

The HGM approach can be used to assist in the mitigation identification process that is part of CWA Section 404 permitting requirements. The amount of functional capacity (a quantitative measure) that a project would eliminate can be used to determine the size and quality of replacement wetlands. At a minimum, the USACE is likely to require that the numerical functional capacity of the replacement wetlands match the numerical functional capacity of displaced wetlands. The USACE notes that assessments may be conducted under a set of conditions expected in the future or conditions assumed to have existed in the past, in order to provide an estimate of function capacity for past and/or future conditions (Smith et. al 1995). However, although the numerical functional capacity can be useful to compare impacts between alternatives, this method lacks the more detailed information required to make specific recommendations for mitigation measures.

<u>Level of Technical Proficiency</u>

A high level of technical proficiency is needed to use the HGM Method. The Alaska DOT reports that significant training is required to become familiar with HGM terminology. Practitioners should have knowledge of and field experience with the regional wetland subclass under consideration.

Geographic or Conditional Applicability

The HGM approach can only be used if the type and regional location of the wetland studied has an existing HGM model and its functional indices. These functional indices can be used to compare wetlands within the same regional subclass, but cannot be used to compare wetlands from different subclasses within a region or similar wetlands in different regions (Smith et. al 1995). For example, the Alaska DOT notes that guidebooks are available for assessments of wetlands functions for three locally based areas within Alaska (Interior, Cook Inlet Basin, and Southeast/South Central) using the HGM approach.

Similar to the WET Method, indices developed during the HGM approach are not intended to assign actual values (e.g., dollars in terms of economic functions). The USACE (Smith et. al 1995) notes that indices can be used to determine the loss or gain of wetland functions, but values can not be assigned to that loss or gain. The change in a wetland's capacity to perform a certain function is measured in terms of the extent to which an area of wetland performs that single function. For example, a wetland's ability for floodwater storage can be measured in terms of cubic or acre feet per year or as high or low. This concept is also true for nutrient or sediment removal capacity.

Data Requirements

The HGM Method requires a narrative description of the project area, which should include the classification of the subject wetlands, climate description, surrounding landscape, hydrology, vegetation, soils, land use, groundwater features, geology, and other significant characteristics. Maps are also needed to determine property boundaries, topography, watershed boundaries, wetland assessment areas, infrastructure and utilities, and red flags (i.e., special recognition or protected areas).

A field visit may be required to fully understand the wetland and surrounding landscape characteristics. At a minimum, walking the perimeter and interior of the subject wetland is recommended to determine sources of water; surface water connections; the composition, structure, extent, and variability of plant and animal communities; soil types; disturbance; and other factors that influence how a wetland functions (Smith et. al 1995).

Time and Cost

Developing a regional HGM methodology requires a considerable investment of time and resources. Major activities include identifying regional wetland subclasses; developing functional profiles; identifying reference wetlands and reference standards; and developing, calibrating, and testing assessment models. Once a regional wetland subclass HGM Method is developed, the time and resources required to apply the method are relatively minimal.

Accuracy

The HGM Method's accuracy depends on the quality of the applicable HGM assessment model, the practitioner's level of knowledge on the wetland's regional subclass, and his or her ability to obtain the information necessary to use the model. Higher-quality HGM assessment models classify wetlands into regional subclasses, allowing for development of simplified model versions that reduce variability. A general comparison of overall impacts and existing conditions is provided by this method. More detailed information and analyses are required to determine the quantifiable characteristics of impacts.

Agency Involvement and Acceptance

Like the WET Method, the USACE developed the HGM approach through research administered by its Waterways Experiment Station. The original report (Smith et. al 1995) was generated by a collaboration of agencies including the USACE, Natural Resources Conservation Service, Environmental Concern, Inc., and East Carolina University. The USACE would likely accept the results of the HGM approach, assuming that the method was properly conducted.

Adaptability to Cumulative Impacts

Similar to the WET Method, the HGM approach is not conducive to cumulative impact assessments. Although the HGM Method takes surrounding landscape into account in terms of how it influences the wetland's capacity to perform functions, in order to evaluate cumulative impacts the practitioner must consider functions on a larger scale (i.e., larger landscape or watershed), not just within the wetland ecosystem.

8.2.3 Rapid Functional Assessment Methodology

The Rapid Functional Assessment Methodology (Rapid Method) can also be used to assess wetland functions in accordance with CWA Section 404. An evaluation of the Rapid Method is presented below.

8.2.3.1 Description

Similar to the WET and HGM methods, the Rapid Function Assessment Method (Rapid Method) can be used to support CWA Section 404 coordination that occurs during the NEPA process. Although specifics can vary between states that use the Rapid Method, it basically uses qualitative or general ratings that allow for relative comparisons between wetlands. In general, wetlands are categorized in order to identify functions and values of public interest that may be affected by a project. As noted below, these qualitative ratings can be supplemented with quantitative measures, but neither should be used to determine absolute values with intrinsic meaning.

Two examples of the Rapid Method are described below: the Ohio Rapid Assessment Method for Wetlands (ORAM) and the Rapid Assessment Method for Southeast Alaska (Juneau Method).

ORAM was developed using a method developed by the Washington State Department of Ecology to provide a fast and easy method for categorizing particular types of wetlands. A qualitative or narrative rating system was developed, which assigns wetlands into one of the three following categories:

- Category 1 or low quality: wetlands that support minimum wildlife habitat, recreational, and hydrological functions
- Category 2 or medium quality: wetlands that provide moderate function support; can also include wetlands that are degraded but restorable

- Category 3 or high quality: wetlands that have superior habitat, vegetation and species diversity, hydrology, and functional values

Once a wetland's category is determined, the practitioner can refer to regulations for avoidance, minimization, and mitigation that apply to the project-related impacts expected for that resource. For example, Category 2 and 3 wetlands require installation of stormwater and water quality controls, so that peak post-development runoff rates do not exceed pre-development rates and water quality is controlled to the maximum extent practicable.

ORAM also includes a numerical rating system similar to the QHEI Method described in Section 7.2.3. Similar to the QHEI Method, six metrics are used to evaluate wetlands: wetland size; upland buffers and surrounding land use; hydrology; habitat alteration and development; special wetland communities; and vegetation interspersion. These metrics are weighted unequally. For example, the maximum score for wetland size is 6, but for hydrology it is 30. The sum of all metric scores represents the quantitative rating, which can range from 0 to 100. If a narrative rating is absent, the numerical scores (which are still somewhat qualitative due to the weighting) can be used as follows: Category 1 (0 to 34.9), Category 2 (35.0 to 59.9), and Category 3 (60.0 to 100).

The Juneau Method is used to evaluate Juneau wetlands in Alaska. This method uses the following wetland functions, which are similar to those used in the WET Method with the addition of regionally specific factors:

- Groundwater recharge and discharge
- Surface hydrologic control
- Sediment/toxicant retention
- Nutrient transformation and export
- Riparian support
- Salmonid habitat
- Disturbance-sensitive wildlife
- Regional ecological diversity
- Erosion sensitivity
- Ecological replacement cost
- Recreational use (actual and potential)
- Downslope beneficiary sites

Based on criteria established for each function, each is assigned one of the following qualitative ratings: very high, high, moderate-high, moderate, moderate-low, low, and very low. For example, for salmonid habitat a very low rating represents a wetland with no salmonid access in any part of the wetland, and a very high rating is assigned to a wetland with excellent habitat for anadromous salmonid rearing and/or major spawning, with documented use in both winter and summer. Examples of criteria for other salmonid habitat-related ratings include low for access-restricted and poor rearing salmonid habitat, and high for good habitat for rearing and/or spawning and documented use in winter and/or spring. The criteria often include quantitative footnotes to distinguish between qualifiers, such as “poor” and ”good”. For example, a “poor” rearing habitat would have less than 2 percent of area occupied by woody debris and less than 20 percent by deep pools.

8.2.3.2 Evaluation

Objectives and Outputs

Like the other wetland quality assessment methods described in this section, the Rapid Method addresses the first of the three objectives described in Section 5.1. Also like the other methods, it would not provide a complete “existing condition” description of potentially affected wetlands without delineation using an acceptable methodology, and other methodologies would have to be used to determine a project’s impacts on wetlands.

The Rapid Method usually produces qualitative descriptions of the overall wetland quality based on ratings scales. The ORAM supplements its qualitative method with numerical ratings, which are still somewhat qualitative due to the unequal weights distributed among the metrics.

Level of Technical Proficiency

Practitioners who use the Rapid Method should have basic knowledge of wetland functions and related characteristics, such as vegetation and wildlife species. Regional specific knowledge of the unique features of wetlands found in specific regions would also be required, as well as the ability to conduct literature research.

ORAM can be used by people with a wide range of training and experience, who are not necessarily experts in botany. The Ohio EPA does specify that practitioners should be able to identify dominant plant and wildlife species, have basic knowledge of vegetation sampling techniques, be able to recognize high quality or unique wetlands, and be familiar with wetland types and quality relevant to Ohio. In general, the Ohio EPA states that a person trained to delineate wetlands according to the Wetland Delineation Manual should have the necessary skills to use the ORAM.

The Alaska DOT claims that substantial training is needed to properly use the Juneau Method because it is very comprehensive and was developed by wetland specialists with support from a technical committee comprised of various agency and industry representatives (e.g., Alaska Fish and Game, USACE, USDA, USGS, Alaska DEC).

Geographic or Conditional Applicability

The Rapid Method can be applied to a wide variety of wetlands through the U.S. (USEPA 2004). However, it needs to be tailored for regional variations to produce reliable indicators of conditions.

The Ohio EPA recommends accounting for seasonal variations, since the time of year that assessments are made may affect metric and overall scores. The most reliable scores using ORAM are generated during the growing season (April through October, depending on location). Examples given by Ohio EPA include underscoring due to snowfall, flood events, and droughts.

Data Requirements

The Rapid Method requires information similar to other wetland quality assessment methodologies. This normally involves a field visit to note landscape and wetland features, collecting available information (e.g., maps, topography surveys), and a literature review of existing data s(e.g., native and endangered species). The ORAM assists data collection by providing a series of questions on various topics.

Time and Cost

According to the USEPA, the Rapid Method should take two people no more than four hours of field time and a half-day of office preparation and data analysis to generate a condition score (USEPA 2006). This opinion was supported by the Michigan DOT, who reported that in general the Rapid Method requires minimal data collection and is generally inexpensive. The Ohio DOT also noted that the ORAM is quick and easy to use.

Accuracy

Because the Rapid Method is intended to apply to a wide range of sites in “rapid” manner, reaching a level of accuracy for CWA Section 404 purposes can be challenging because of the diversity and uniqueness of wetland communities in different geographic regions. This method’s accuracy depends on the consistency of field protocols employed during assessments and the modifications to address wetland diversity. The USEPA reports that misidentification of a wetland area can lead to over or under-scoring. The Ohio EPA noted that although attempts have been made to reduce the inherent errors associated with ORAM (or any Rapid Method), practitioners should be aware of possibly over or under-scoring a wetland, especially if the site does not exactly match method assumptions. The Ohio EPA provides worksheets and specific rating guidance for applying the ORAM, in order to limit subjectivity and variability between users.

Agency Involvement and Acceptance

The Ohio DOT reported that the ORAM is required by regulatory agencies in Ohio, including the Ohio EPA. They also reported that the USACE has accepted the method for CWA Section 404 permitting. The Juneau Method is based on a method published by FHWA in 1983 for the 48 contiguous states, and was adapted by the original author for Juneau at the request of the City-Borough Department of Community Development (Adamus 1987). This concept was supported by the Alaska directors of most major federal and state resource agencies.

Adaptability to Cumulative Impacts

The Rapid Method is not conducive to cumulative impact assessments, similar to the other wetland quality assessment methodologies. This is because a cumulative analysis would be set at a larger scale than what is normally conducted using a Rapid Method.

8.2.4 Florida Uniform Mitigation Assessment Method

The Florida Uniform Mitigation Assessment Method (Florida Method) is used to assess wetland functions that may be impacted by a project in order to determine mitigation for CWA Section 404 permitting. An evaluation of the Florida Method is presented below.

8.2.4.1 Description

Through a joint process involving the USACE and Florida Department of Environmental Protection (DEP), the Florida Uniform Mitigation Assessment Method (Florida Method) is used to determine mitigation under CWA Section 404 permitting. This method assesses the size and function of a wetland that would be affected (displaced) by a project, and assigns a score to that wetland. The permitting process involves both the applicant (e.g., the Florida DOT) and the Florida DEP preparing this assessment independently. Any discrepancy between the scores assigned to the subject wetland is negotiated during the permitting process. Once a score is agreed upon by both parties, the replacement wetland must match that score. Theoretically, replacement wetlands do not have to be the same size or greater than displaced wetlands. A replacement wetland that is smaller, but has greater functions may suffice. This permitting process normally occurs after the NEPA process, but evaluation of affected wetlands using the Florida Method could (and should) occur during the NEPA process.

This method evaluates wetlands in two parts. The first part is a qualitative characterization of the assessment area, including native community type and the functions it supports with respect to fish and wildlife and habitat. The information established in Part I is used for the Part II assessment, to determine the degree to which the assessment area provides the functions identified during Part I. Part II is a quantitative assessment of the impact or mitigation, where numerical scores are used to compare the reduction or gain in ecological value due to proposed impacts and mitigation. Scoring guidance is provided in Chapter 62-345 of the Florida Administrative Code (FAC). The scoring on a number of indicators is based on what would be suitable for the type of wetland or surface water evaluated. Scoring options for each indicator include the following (the score value is indicated in parentheses):

- Optimal (10): optimal condition and wetland/surface water functions fully supported
- Moderate (7): less than optimal condition but sufficient to support most functions
- Minimal (4): minimal support of wetland/surface water functions
- Not Present (0): insufficient conditions to support functions

The three main indicators include location and landscape support, water environment, and community structure (vegetation and/or benthic community). Each assessment area is assessed for two conditions: current (or without mitigation) and with impact or mitigation (assuming the project adheres to applicable regulations). The Part II scores for an assessment area are calculated by summing the scores for each indicator and dividing by 30 (the maximum possible score), which yields a composite score between 0 and 1.

8.2.4.2 Evaluation

<u>Objectives and Outputs</u>

The Florida Method is intended “to determine the amount of mitigation needed to offset adverse impacts to wetlands and other surface waters…” and provides a standardized method for assessing wetland/surface water functions that may be reduced by project-related impacts. This method satisfies the first and third objectives in Section 5.1. Conceptual project design or engineering information would be needed to assess direct (i.e., displacement) impacts, and stormwater pollution methodologies (as described in Section 6) would be needed to assess indirect (i.e., runoff) impacts.

The Florida Method addresses the third objective (identify mitigation measures and evaluate their effectiveness) because as noted previously, mitigation determination formulas are provided in Part II to translate wetland function scores into numbers that quantify functional gains and losses related to wetlands/surface waters (e.g., the area of mitigation required). Because a wetland is translated through a mathematical equation into a number, this method is useful in making general comparisons of results. For example, because the Florida DEP also conducts a wetland assessment, achieving a middle ground can be relatively straightforward.

Level of Technical Proficiency

According to the Florida DOT, at least a moderate level of technical knowledge is needed to properly delineate a wetland, identify factors that may contribute to the wetland's function, and properly score the wetland.

Geographic or Conditional Applicability

According to the FAC, this method may be used in any type of wetland in the State of Florida.

Data Requirements

Like the other wetland quality assessment methodologies, the Florida Method requires fieldwork to complete the assessment. Part I involves a qualitative description of the following: area; watershed; affected water body; water/wetland classification; geographic relation and hydrologic connection to surrounding land and water; surrounding land uses; unique features with respect to regional landscape; significant nearby features, anticipated wildlife use, and list of species found. Other information such as aerial photographs, topographic maps, GIS data, and previous site reports may also be required to complete Part I.

Time and Cost

According to the Florida DOT, the Florida Method can be extremely time consuming because it involves visiting the site, collecting all the factors that determine the function of the wetland, scoring the wetland, and comparing the assessment. In general, the level of effort is commensurate with the size of the site (i.e., the larger the wetland, the larger the effort.).

Accuracy

The Florida Method's accuracy is contingent upon the consistency of the assessment protocol. Although the Florida DOT finds that this method is fairly accurate, they noted that wetland descriptions and scores are subjective and based on "reasonable scientific judgment". Therefore, the practitioner's experience and skills can make a difference. However, any potential lack of experience among Florida DOT practitioners could be offset by the fact that the Florida DEP also prepares an assessment.

Agency Involvement and Acceptance

As reported by the Florida DOT, the Florida Method is accepted by all Florida State agencies and the USACE. This method is also endorsed jointly by the USACE and Florida DEP.

Adaptability to Cumulative Impacts

The Florida Method can be used for cumulative impact assessments because it is more of a "complete" methodology than the other wetland quality assessment methodologies. However, because it is time consuming to conduct even for a single project and because detailed information about other past, present, and future projects is needed, project sponsors would be unlikely to use this method for assessing cumulative impacts.

8.2.5 Montana Department of Transportation (MDT) Wetland Assessment Method

The Montana Department of Transportation Wetland Assessment Method (MDT Method) is used to assess wetland functions that may be impacted by transportation projects in Montana. An evaluation of the MDT Method is presented below.

8.2.5.1 Description

The Montana DOT developed a wetland assessment method (the MDT Method) in 1989 as a standardized approach for functional assessments of wetlands affected by transportation projects. It has been revised and tested for several field seasons in 1994, 1996, and 1999, all of which have been approved by the Montana Interagency Wetland Group. The MDT Method is basically a Rapid Method with the incorporation of some hydrogeomorphic (HGM) principles. The MDT Method includes an assessment of the following 12 primary wetland functions and values, some of which are similar to the WET Method described previously:

1. Threatened and endangered species habitat
2. Montana Natural Heritage Program (MTNHP) sensitive species habitat
3. General wildlife habitat (e.g., evidence of use, vegetative density and distribution, surface water, disturbance)
4. General fish habitat (e.g., surface water, cover, vegetated banks, species)
5. Flood attenuation
6. Surface water storage
7. Sediment/nutrient/toxicant retention and removal
8. Sediment/shoreline stabilization (potential to dissipate stream or wave energy)
9. Production export/food chain support
10. Groundwater discharge/recharge
11. Uniqueness (replacement potential)
12. Recreation/education potential

Each parameter is assigned a rating of low, moderate, high, or exceptional and functional scores are provided on a scale of 0 to 1 using a matrix format. The overall score is expressed as a percentage of the total possible score. This percentage is used to assign an overall ranking, starting from Category I (high quality) all the way to Category IV (high disturbance). The results of the MDT Method include an identification of probable stressors and an overall assessment of wetland quality.

8.2.5.2 Evaluation

Objectives and Outputs

The MDT Method addresses the first of the three objectives described in Section 5.1. This is the same as the Rapid and HGM methods, which are the two wetland quality assessment methodologies most similar to the MDT Method. Wetland delineation and the use of other methodologies to assess project impacts would be needed to make the MDT approach complete. As with the other wetland methodologies, information from the MDT Method can support the third objective in Section 5.1: help identify mitigation measures and evaluate their effectiveness. The MDT Method addresses these objectives through qualitative rankings of a wetland.

Level of Technical Proficiency

According to the Montana Department of Environmental Quality (Montana DEQ), the MDT Method requires practitioners who are professionals or trained in the field of wetland assessments.

Geographic or Conditional Applicability

Although the MDT Method was developed specifically for wetlands found in the State of Montana, there is no reason why its general methodology–one that combines elements of the Rapid, WET and HGM methods–cannot be adapted to other states.

Data Requirements

The MDT Method's data requirements are similar to the Rapid Method and other wetland quality assessment methodologies described in this section. For example, a field visit to identify the general characterization of vegetation communities is required, as well as obtaining information for each of the 12 functions described previously. Higher-quality or unique wetlands, as designated by MTNHP, would require more detailed information.

Time and Cost

According to the Montana DOT the MDT Method is intended to be rapid, economical, and repeatable. The Montana DOT noted that this method generally requires only one field person with a wetland science background and proper training. They also noted that several similar sites can be grouped together under one assessment. As a reference, a 20-acre site should take one person approximately one hour in the office and one to two hours in the field, assuming that wetlands have been previously delineated.

Accuracy

Because the MDT Method was specifically developed for wetlands in the state of Montana and field-tested several times, it should provide relatively accurate assessments of current wetland characteristics and general comparisons with other sites in the state, notwithstanding the subjectivity and variability among evaluators.

Agency Involvement and Acceptance

According to the Montana DOT, the MDT Method is accepted by the USACE for CWA Section 404 permitting.

Adaptability to Cumulative Impacts

Like the other wetland quality assessment methods, the MDT Method is not conducive to cumulative impact assessments, because a cumulative analysis would be set at a larger scale that what would normally be conducted under a MDT Method.

Table 8-1
Comparison of Wetland Quality Assessment Methodologies

Evaluative Parameters	Methodology				
	WET	HGM	Rapid	Florida	MDT
Objectives 1: Existing Conditions 2: Impacts 3: Mitigation Outputs Qualitative Quantitative Combination	1 (partial) 2 (partial) 3 (partial) Qualitative	1 (partial) 2 (partial) 3 (partial) Qualitative	1 (partial) 3 (partial) Qualitative	1, 3 Qualitative	1 (partial) 3 (partial) Qualitative
Technical Proficiency Low Medium High	Moderate-High	High	Moderate	Moderate-High	Moderate-High
Geographic and Conditional Applicability	No geographic or conditional limitations; Consider local characteristics	HGM model already in place for project region and wetland subclass	Version already in place for state or regional where project is located	Florida State, but concept can be applied to other states	Montana Transportation projects, but concept can be applied to other states
Data Requirements Primary Secondary	Primary	Primary	Primary	Primary	Primary
Time and Cost Low Moderate High	High	Moderate	Low-Moderate	High	Low-Moderate
Accuracy Low Moderate High	Moderate	Moderate	Moderate	Moderate	Moderate
Agency Involvement Low High	High	High	High	High	High
Agency Acceptance Low High	High	High	High	High	High
Adaptable to Cumulative Impacts No Yes Maybe	No	No	No	No	No

Notes:
Data Requirements:
Primary – Site-specific sampling data
Secondary – Published values from available studies

9 Groundwater Methodology

Unlike the methodologies covering stormwater runoff, stream quality assessments and wetland quality assessments, only one general methodology for groundwater was identified: USEPA Source Water Assessment Steps.

9.1 Description

The USEPA Source Water Assessment and Protection Program was developed as a result of the SDWA 1996 Amendments (see Section 3.2). According to the USEPA, a source water assessment (SWA) consists of a minimum of three steps:

1. Delineate the source water assessment area
2. Inventory potential sources of contamination
3. Determine the water supply's susceptibility to contamination

Water sources include ground water wells or surface water intakes that draw from streams, rivers, lakes, and/or reservoirs. Potential contamination sources include landfills, underground fuel storage tanks, septic systems, stormwater runoff, farms (pesticides, fertilizers), and sludge disposal sites. Often, an inventory of potential sources is obtained from databases that include facilities that have environmental permits, such as industries and sewage treatment plants that discharge wastewater, hazardous waste sites, and mining operations. However, this approach disregards unregulated sources such as small livestock areas, auto salvage yards, and abandoned dump sites (USEPA 1997).

SWAs are normally conducted by states to generate basic information on drinking water in public water systems. As a first step, maps are generated showing land areas where pollutants could filter through soil to specific ground water wells. Maps of watershed boundaries are generated for surface water sources (e.g., lakes, rivers, streams, reservoirs) to show land areas where rain or snow flows over or through the ground, and where it could potentially enter the water source upstream of a system's intake.

The second step involves identifying and mapping facilities and activities within the delineated assessment area that could release contaminants into wells or surface water drinking sources. Information from Steps 1 and 2 are combined during the susceptibility analysis, to determine the likelihood of a specific water supply source being contaminated by the potential pollutant sources. Ultimately, states use these results to prioritize the potential for drinking water contamination, and may represent this by assigning susceptibility rankings (e.g., high, medium, low) to specific drinking water sources. The overall objective is to provide information for communities to use in developing any necessary contamination protection programs for targeted water sources.

Two examples of the SWA are the District of Columbia's SWA and the Washington State Groundwater Assessment Program (a pilot study).

The SWA program for the District of Columbia (DC) includes two additional steps beyond the minimum required components discussed previously (ICPRB 2002):

1. Incorporation of a GIS search and query tool that shows watershed delineations, a contaminant inventory, and a susceptibility analysis that allows practitioners to sort and rank potential contaminant sources by type, location, and travel time; and
2. Adaptation of the Chesapeake Bay Program's Watershed Model to evaluate DC source water's susceptibility to contamination from sediment, nutrients, pathogens, and pesticides.

DC's SWA program focuses on assessing and protecting the quality of source water from the Potomac River, where USACE operates two intakes (at Great Falls and Little Falls) through the Washington Aqueduct (WAD) to supply water to DC. Through DC's SWA process, an inventory and analysis of potential contaminant sources within the Potomac River watershed above the WAD intakes was generated to determine potential pollutants that could impact public water systems at the intakes. This susceptibility analysis involved a delineation of time of travel boundaries upriver from the Great Falls intake. These boundaries were used in the GIS tool to spatially analyze data, and to rank sources for potential threats to the public water supply and water resources. DC's current model includes approximately 5,000 sites or permitted facilities that have been ranked for contamination potential. During the susceptibility analysis, a list of sites was created that represents potential pollutant sources for DC's source water. These sites are separated into three categories: sources of fecal contamination, petroleum contamination, and accidental spill (entering a receiving water in a short period of time).

The Washington State Department of Ecology (DE) conducted a hydrogeologic assessment of the Centralia-Chehalis area surficial aquifer, to pilot test a standardized technical approach for a new state groundwater assessment program (DE 2005). This study's objectives included characterizing the hydrogeologic setting, describing local groundwater/surface water interactions, and determining current ambient groundwater quality and water level conditions. This required developing a well inventory and database, a dry-season seepage evaluation of the Chehalis and Newaukum Rivers, and monitoring well and in-stream piezometers. As a result of this study, current groundwater quality conditions were determined as well as interactions with primary surface waters (Chehalis and Newaukum Rivers).

If available, information generated by SWAs can be used in NEPA documents. Generating a SWA for a specific project is unlikely, mainly because if potential contamination of groundwater drinking sources is a key issue, the affected jurisdiction would already have an SWA or SWA-like information on these sources. For instance, if a project has the potential to affect a sole source aquifer, the owner or manager of the aquifer would already know the location, characteristics, and potential threats to the resource. The water quality assessment under Section 1424(e) review (see Section 3.2) would include this information.

9.2 Evaluation

9.2.1 Objectives and Outputs

If available and used for NEPA purposes, SWAs would satisfy the first of the three methodology objectives described in Section 5.1: identify and understand the characteristics of the physical, natural and human resources that may be affected by the proposed action. Information from SWA Step 1 can be used to identify groundwater supply sources that could be affected by a project. Combined with Steps 2 and 3, each identified groundwater source is prioritized based on the potential for contamination, which is valuable information in characterizing these sources.

An SWA does not provide a “complete” methodology, because it does not support methodology Objectives 2 and 3: assess impacts of the project and evaluate mitigation measures. However, this methodology may provide valuable information to help practitioners assess groundwater impacts and determine whether or not mitigation is needed. For instance, if a local government demarcates groundwater protection areas, a project inside this area may require mitigation to prevent highway runoff from infiltrating into the groundwater.

9.2.2 Level of Technical Proficiency

In general, using an SWA for NEPA purposes does not require a high level of technical proficiency, other than being able to interpret the assessment’s results and consult with environmental science, geology, and engineering professionals to complete impact and mitigation assessments, if necessary. Water resource information and assistance is readily available from agencies, including NRCS, USGS, and a state’s Cooperative Extension Service.

The same skills and assistance from agencies would be required if a project has to prepare a project-specific SWA. According to USEPA, community groups (e.g., watershed organizations and scout troops) and public water systems are often involved in the Step 2 of the EPA SWA Method (i.e., inventory of potential contamination sources).

9.2.3 Geographic or Conditional Applicability

SWA programs differ between states, but each should at least identify municipal drinking water resources, including groundwater, and potential threats to these sources. Two examples of state SWA programs were described previously. The Washington State studies accounted for seasonal variations (e.g., water level fluctuations) that affect groundwater quality.

9.2.4 Data Requirements

A USEPA-accepted SWA is needed to identify groundwater drinking sources that could be affected by a project. Some SWAs also identify potential groundwater contaminant sources. For example, DC’s SWA gathered information from federal databases and fieldwork to inventory hazardous waste sites, landfills, storage tanks, and other activities that could affect water resources. Washington State’s pilot study includes a well inventory that includes aquifer hydraulic properties, groundwater level measurements, groundwater/surface water interactions, hydrogeology, and groundwater quality. Additional geological and design/conceptual engineering information would be needed to conduct impact and mitigation assessments.

If a project is required to prepare a SWA, the practitioner during Step 1 would delineate or map the land area that could contribute water and pollutants to the water supply for each ground water well or surface water intake. He or she must then identify potential contamination sources within each delineated area. For groundwater supply, groundwater flow information is typically used to delineate assessment boundaries. Surface water supplies require topographic maps in order to delineate watershed boundaries. Once the watershed up to the state’s boundaries is delineated, an inventory of pollution sources is required and may involve a more detailed analysis in segments closer to the intake. Some states request assistance from community groups or public water systems. Others focus on currently mapped or regulated land uses that are readily available from GIS databases, such as land uses and activities.

9.2.5 Time and Cost

If available, using an existing SWA to help evaluate groundwater impacts is relatively fast and inexpensive. On the other hand, preparing a SWA would be time consuming and expensive for a single project. For a state or government, this cost may be relatively inexpensive because the information is used for state or regional purposes. As noted previously, most data should be readily available from existing databases or field visits, and assistance from community groups or public water systems is often sought.

9.2.6 Accuracy

There is a chance that a SWA used for a specific project would not identify all groundwater drinking sources or the susceptibility of groundwater supplies to contamination. However, an SWA generally contains a relatively thorough review that provides accurate information on the location and current quality of groundwater resources in a project's study area.

9.2.7 Agency Involvement and Acceptance

This method was developed by the USEPA to satisfy SDWA requirements for state source water assessment programs. Therefore, a groundwater impact assessment that uses SWA information would likely be approved by the USEPA, such as in a Section 1424(e) review, assuming that the information was properly interpreted and used.

9.2.8 Adaptability to Cumulative Impacts

SWAs can support cumulative impact analysis, mainly because its information comprehensively covers groundwater and surface drinking water sources. By identifying pollution sources, SWAs also comprehensively address past and present threats to water sources in a cumulative manner. Practitioners still have to obtain information on other planned future development and assess their potential for threatening water sources, but information in an SWA could greatly help with this analysis.

10 Summary and Conclusions

The purpose of this research paper is to identify appropriate water quality impact analysis methodologies that can be used for transportation projects undergoing the NEPA environmental review process. As required by NEPA, the potential environmental impacts of proposed projects must be considered, analyzed, and documented for agency and public review. The ultimate purpose of the NEPA process is to facilitate better decision making, by addressing a project's purpose and need and preventing, avoiding, and mitigating unacceptable environmental impacts.

The methodologies presented in this report are currently being used by State DOTs and FHWA division offices in preparing EISs and EAs, or were recommended by these DOTs and FHWA offices and environmental resource agencies via agency interviews, surveys, and literature research. The methodologies were organized into four main categories, and descriptions of each were provided:

- Stormwater runoff impacts
- Stream quality assessments

- Wetlands quality assessments
- Groundwater quality assessments

These methodologies were also evaluated based on the following parameters:

- Objectives and outputs
- Technical proficiency of practitioners
- Geographical and conditional applicability
- Data requirements
- Time and cost requirements
- Accuracy of results
- Agency involvement and acceptance
- Adaptability to cumulative impact assessments

With the exception of the groundwater methodology, each of these sections contains an evaluation matrix that compares methodologies and uses these parameters.

These evaluation parameters are meant to help private and public agency managers tasked with navigating transportation projects through the NEPA process make sound decisions and select appropriate water quality methodologies for projects. The following sections describe how each parameter can affect a NEPA manager's decision making.

Objectives and Outputs

The methodologies used for a NEPA document can accomplish up to three main objectives: (1) identify and characterize existing conditions in a project's study area; (2) assess or predict potential project impacts on existing conditions and conditions expected in the future; and (3) identify and evaluate mitigation measures, if necessary. A "complete" methodology is one that satisfies all three main objectives.

As presented in Table 10-1, most water quality methodologies satisfy only one or two of these objectives for relevant topics in a NEPA document. The NEPA manager should be aware that many of the approaches covered in this report are not complete methodologies. Either multiple methodologies need to be combined, or other approaches would have to be used for complete coverage of the water quality topic for NEPA purposes. For instance, many methodologies would satisfy Objective 1 either fully or partially, so other methodologies presented in this report would have to be used to evaluate impacts and mitigation, if necessary. As another example, some stormwater runoff methodologies use annual runoff pollutant loadings as their outputs. Pollutant loadings can be used for relative comparisons between project alternatives. However, to assess the impact on the quality of a receiving water body, an additional method would be required to convert the pollutant loading into pollutant concentrations in the affected water body while also accounting for ambient conditions. The resulting pollutant concentrations in the affected water body could then be compared with state and/or national water quality standards to evaluate direct water quality impacts.

Because the issues of water quality, as covered under the NEPA process, do not have a single definition of what constitutes an "adverse" impact, selection of a methodology often defines or influences the definition of an "adverse" impact. Using the previous example, a methodology that outputs annual runoff pollutant loadings could be used to define an “adverse" impact as any increase, no matter how small, over existing loadings. If further refinement is needed, as noted in the previous example, an “adverse” impact could be defined as any in-water pollutant concentration exceeding accepted water quality standards or anything above existing concentrations.

Methodology outputs can be quantitative, qualitative, or a combination of the two. Not only are quantitative results perceived to be more accurate, their major advantage over qualitative results is that they provide an easier way to compare different alternatives and define what constitutes an “adverse” impact. Most of the methods described in this report are qualitative in nature, especially those for the stream quality, wetland quality, and groundwater categories. These methods provide useful tools for understanding the quality of existing water resources, even though their results are presented in a qualitative manner.

In most cases, presenting water quality information in a qualitative manner can suffice for NEPA purposes. However, sometimes stakeholders demand to know whether or not a project’s future activities (i.e., stormwater runoff) would cause a receiving water body to exceed federal and/or state water quality criteria. In this case, the NEPA manager would probably have to select a methodology that can quantify direct impacts to the water body (e.g., in-stream pollutant concentrations) and quantify the effectiveness of any necessary mitigation measures.

Technical Proficiency of Practitioners

The technical proficiency needed to use a methodology is a strong indicator of the methodology’s complexity. Selection of a particular methodology to address a specific issue often depends on the importance of the topic in the context of the project. Important topics often influence selection of rigorous methodologies, which usually require a high skill level among its practitioners. However, highly skilled practitioners may not always be available, in which case, selection of less rigorous or simpler methodologies may be appropriate alternatives, depending on the issue’s importance with respect to the project.

The methodologies in the stormwater category (presented in Section 6) require the widest range of technical skills among all the categories. Although these stormwater methodologies all require a general understanding and knowledge of water quality and the characteristics of stormwater pollutants, a practitioner using the SWMP Method (see Section 6.2.1) does not need to have specialized water quality modeling skills. In contrast, the Integrated Modeling Approach (see Section 6.2.7) requires water quality professionals who have a thorough understanding of water pollution and are familiar and able to work with many of the mathematical models available in this field.

Geographical and Conditional Applicability

Certain methodologies can be used anywhere under any or most conditions, whereas others can only be used in certain geographical areas or conditions. Depending on a project’s location and the study area’s characteristics (i.e., existing conditions), the NEPA manager can face a limited choice of methodologies. Wetland quality assessments are a good example of this. Due to the variations and uniqueness of many types of wetlands found throughout the U.S., stakeholders (e.g., local water resource agencies and organizations and the USACE) were motivated to develop wetland quality assessment methods unique to certain types of wetlands located in certain geographic regions. These organizations benefited from developing wetland assessment methods that must be tailored to conditions on the ground, such as the HGM and Rapid Methods (see Sections 8.2.2 and 8.2.3). However, if a project is located in a region not covered by a tailored HGM or Rapid Method, NEPA managers would be faced with limited options if a wetland quality assessment is needed—perhaps only one, the WET Method (see Section 8.2.1).

<u>Data Requirements</u>

All methodologies require data or information to meet their objectives and produce usable outputs. Data requirements can involve information already developed by others (e.g., existing mapping and GIS layers) or can involve practitioners collecting primary data themselves. A methodology that requires mostly primary data collection is often associated with higher costs, duration, and technical expertise than methodologies that rely mostly on secondary data collection. This may not be true in all cases, so NEPA managers should not overly rely on this parameter even if he or she is faced with limited time and budget.

<u>Time and Cost</u>

Similar to the technical proficiency parameter, the time and cost parameter is an indicator of methodology complexity. This parameter often relates to the level of effort needed to conduct or implement the methodology, and complex methods often require a lot of time and effort, which translates into higher costs. Therefore, similar to the technical proficiency parameter, it is advisable for the NEPA manager to select a complex (higher-cost) methodology (e.g., the Integrated Modeling Approach) if the situation warrants, such as if water quality is a major issue of the project that could make or break a successful conclusion to the NEPA process.

It should be noted that when a long duration is needed to complete a methodology, this does not necessarily mean high cost. For example, a stream quality assessment may require data points spread throughout a year. Between these points the methodology would be inactive, so even though the time duration would be long, the costs may be relatively low.

<u>Accuracy</u>

The accuracy of a specific methodology's results, compared to other methodologies of the same classification, often correlates with complexity – and complexity often requires high technical proficiency, extensive data collection, and high costs. However, there is often a diminishing rate of return in using complex and costly methodologies. A highly charged issue may necessitate using a costly and complex methodology that produces very accurate results and may be money well spent. However, using the same methodology in a situation where the issue is not important may not be money well spent, and if a far less expensive methodology could be used that would produce marginally less accurate but acceptable results, this would often be "good enough" for the situation.

<u>Agency Acceptance</u>

The NEPA process is highly participatory, especially for agencies that have regulatory oversight over natural and environmental resources that could be affected by a project. Because of this, methodologies used in the NEPA process often play a dual role in satisfying other regulatory requirements. Using a methodology that satisfies NEPA but does not satisfy other pertinent regulations would not be advisable or financially prudent, because two assessments would have to be conducted – one for NEPA and the other to satisfy another regulatory requirement.

For this reason, all of the methodologies presented in the report have shown to be acceptable to NEPA as well as resource and regulatory agencies, if they are properly conducted and appropriate agency coordination is conducted.

Cumulative Impacts

A methodology that can address both project-level and cumulative impact assessments can provide efficiencies that result in time and cost savings when preparing NEPA documents. Many of the methodologies described in this report, especially those that address Objective 1 (existing conditions) can be used to address cumulative impacts. However to be "complete" as defined in this report, other methodologies would still have to be used.

Similar to conducting a project-level impact analysis, a cumulative impact analysis requires the identification of environmental and social resources and activities that could be affected by "past, present, and reasonably foreseeable future actions" by others. One of the main reasons why a methodology typically used for project-level analysis is often not used for cumulative impact assessments is that the study (impact) area, for purposes of analyzing cumulative impacts, is usually much larger than the project-level study area. A NEPA manager would generally be unwilling to pay to evaluate a much larger area using the same methods applied to the project study area, and this evaluation would also have to include non-water quality methods (air quality, noise, historic properties, etc.) for the sake of consistency. For these reasons, methods used for cumulative impact assessments are typically far less rigorous than methods used for project-level impacts.

In conclusion, the following guidance is offered to NEPA managers responsible for selecting appropriate water quality methodologies for their projects:

- Do not overlook the importance of scoping in the NEPA process. Through consultation with resource and regulatory agencies and the public, scoping allows you to identify potential environmental concerns or controversies early in project development. A highly charged issue will require an appropriate response, and selection of a water quality methodology should address this, perhaps even if the perception of the issue is incorrect. Conversely, it may not be wise to spend limited project funds on a complex and expensive methodology if water quality is not an important issue, especially considering that less expensive methods are available.

- It is important to understand what a water quality methodology seeks to address and how it presents results, including how it can be used to define an "adverse" impact. Very few of the methodologies described in this report are "complete". Although a particular water quality method can provide accurate and useful information, if it does not address a particular scoping or a regulatory requirement, an additional method(s) would need to be employed.

- Be aware of what tailored water quality methodologies are available in your geographic area or region, especially for stream and wetland quality assessments. General methodologies have been developed for these topics, but must be tailored to specific types of water bodies and/or regions.

- Do not be overly concerned about data requirements. A particular methodology may require primary data gathered through fieldwork, but this does not necessarily mean it will be costly and time-consuming.

- A methodology's expected level of accuracy should be commensurate with what is required, as determined by applicable regulations, the views of resource agencies, and scoping. A level of accuracy that is too low can risk rejection from resource or regulatory agencies, and one that is too high can be a waste of money. Because the ramifications of risking rejection are greatest, a good NEPA manager should lean more toward doing more than what is required.

- Be sure to coordinate with appropriate agencies, even if using a methodology that they favor. Obtaining their buy-in at key points during your research is a good opportunity for coordination and consultation with these agencies.

Table 10-1
Comparison of Water Quality Methodologies and NEPA Objectives

Category	Methodology	Objective 1	Objective 2	Objective 3
Stormwater Runoff	SWMP			X
	FHWA	X	X	X
	303(d),TMDL, WLA	X		
	Simple		X	X
	Maryland SHA NPS		X	X
	WSDOT		X	X
	Integrated Model	X	X	X
Stream Quality	IBI	X		
	AMI	X		
	QHEI	X		
	MD SHA	X		
Wetland Quality	WET	X	X	X
	HGM	X	X	X
	Rapid	X		X
	Florida	X		X
	MDT	X		X
Groundwater	EPA SWA	X		

11 Future Research

The main focus of this research paper was to evaluate water quality impact analysis methodologies individually, on the basis of the following parameters:

- Objectives and outputs
- Technical proficiency of practitioners
- Geographical and conditional applicability
- Data requirements
- Time and cost requirements
- Accuracy of results
- Agency involvement and acceptance
- Adaptability to cumulative impact assessments

The applicability of available methodologies depends on various factors, such as state requirements and a project's location and size. A relevant topic for future evaluation would include comparisons between methodologies, and a discussion of situations for which a particular methodology would be appropriate.

As discussed previously and presented in Table 10-1, most water quality methodologies employed for NEPA documents satisfy only one or two of three main objectives, or partially satisfy all three objectives. Because of this, many of the approaches covered in this report are not "complete" methodologies and would require additional approaches to complete the water quality topic for NEPA purposes.

In some cases, a methodology may be complete for its particular category (i.e., stormwater runoff impacts, stream quality assessments, wetlands quality assessments, or groundwater quality assessments) and may contribute to the analysis of other water resources. For example, the Oregon DOT noted that stream quality methods include factors such as invertebrate and fish counts, which are indicators of ambient water quality. These indicators are important because other water quality parameters (e.g., concentrations and pollutant loads) may not provide a complete picture. Therefore, although a methodology may be complete with respect to a specific topic, a comprehensive water resource evaluation would involve consideration of stormwater runoff, stream quality, wetlands, and groundwater. The concept of a comprehensive water resource evaluation is another potential topic for future research, which could include making relative comparisons of available methodologies, evaluating applicability for different situations, and discussing how to best link methods that cover different categories.

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Appendix A: Survey Questionnaire

NCHRP 25-25 (035)
Water Quality Analysis Methodologies for NEPA
Questionnaire

Name:

Agency/Organization:

E-mail:

Telephone number:

1. Which of the following water quality issues most affect your projects during the NEPA stage (please pick no more than two)?

   a. Wetland impacts

   b. Stormwater runoff affecting the quality of streams, rivers or other surface waters

   c. Contamination of water resources

   d. Water supply reduction (ground and surface)

   e. Other, please specify:

2. When conducting environmental review during the NEPA stage, what impact assessment methodologies have you found to be effective in addressing the issues you identified above? (Note: Two well-known examples of methodologies include the Army Corps' wetland delineation manual developed in 1987, FHWA's stormwater pollution model developed in 1990 by Driscoll et. al, and other "first flush" stormwater pollution estimation methods.)

3. What are the advantages in using these methodologies? For example: Does it require minimal data collection or field work? Is the methodology relatively inexpensive? Is it readily accepted by resource or regulatory agencies? If so, please list these agencies.

4. What are the disadvantages, if any, in using these methodologies?

5. Have you used in the past or considered but rejected other methodologies to address the water quality issues identified above? If so, why did you drop or reject the methodology?

6. During the NEPA stage, do you use standards or criteria to address stormwater pollution impacts of your projects? For instance, do you require that conceptual or preliminary plans include stormwater treatment if the project meets certain numerical or non-numerical thresholds? If so, what are these standards or criteria?

7. Name, telephone number and e-mail address of someone who could be available to answer follow-up questions if different from person identified above.

Please return this form to:

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THANK YOU

Appendix B: List of Questionnaire Recipients

E-Mail to AASHTO Environment Committee

Subject: NCHRP 25-25 (035), Water Quality Analysis Methodologies for NEPA, Questionnaire

Dear Member of AASHTO Standing Committee on the Environment:

The National Cooperative Highway Research Program is conducting research to identify water quality analysis methodologies that are best suited for project-level impact assessments contained in NEPA EAs and EISs. We have contracted the services of PB Americas, Inc. (Parsons Brinckerhoff) to assist us in this research.

We would very much appreciate if you could complete the attached questionnaire. This should only take a few minutes of your time. If you feel others in your agency could better respond to these questions, please forward this e-mail and attached questionnaire to those persons.

Please e-mail, fax or deliver the completed questionnaire to:

Jason Yazawa, AICP
Project Researcher, NCHRP 25-25 (035)

PB Americas, Inc.
465 Spring Park Place
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Yazawa@pbworld.com
Ph: 703-742-5820
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If you have any questions, please feel free to contact Jason or Chin Lien, the Principal Investigator, at (410) 385-4186 or LienC@pbworld.com.

Thank you,

Chris Hedges
National Cooperative Highway Research Program

NCHRP 25-25 (035)
Water Quality Analysis Methodologies for NEPA
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Water Quality Analysis Methodologies for NEPA
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Appendix C: Agency Interview Guide

NCHRP 25-25 (035)
Agency Interview Guide

Agency Name:

Name of Interviewee/telephone number:

Date of Interview/time:

Main subject methodology for interview:

Questions
Please review the "Methodologies Working Spreadsheet" before conducting the interview because the interviewee may have already answered some of these questions.

1. Can you please elaborate how this methodology works?
2. What has been your role in your agency's use of this methodology?
3. Are there any underlying assumptions associated with this methodology?
4. How much or what level of technical knowledge do practitioners need to properly use this methodology?
5. Are there certain types or size of projects or geographic conditions that are not conducive to using this methodology? Is so, what are they?
6. How much time or effort does it take to acquire, collect or obtain the data needed by this methodology? Does this require fieldwork?
7. What kinds of information does this methodology produce? Or, what is the end result? Is the result quantitative or descriptive?
8. Does this methodology have a definition of an "adverse impact"? If so, what is it? Does the impact tie specifically to certain resources?
9. How expensive or time-consuming is it to conduct this methodology?
10. In your opinion, how accurate do you consider the results?
11. Are you generally satisfied with the results of the methodology?
12. In what circumstances did you find the methodology to be lacking?
13. [If interviewing a DOT] What do the resource or regulatory agencies have to say about the methodology?