WATER QUALITY MANAGEMENT AND PROTECTION FOR WILD AND SCENIC RIVERS

A TECHNICAL REPORT OF THE INTERAGENCY WILD AND SCENIC RIVER COORDINATING COUNCIL

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FOREWORD

This document is designed to provide tools and strategies to address water quality issues on federally designated wild and scenic rivers (“WSRs” plural or “WSR” singular). The concepts explained in this paper will offer guidance to river managers on how to incorporate water quality protection and enhancement into the comprehensive river management plan (CRMP) required by the Wild and Scenic Rivers Act of 1968 (16 U.S.C. §1271 et seq.), and into other planning and management activities that affect water quality, including but not limited to construction projects; maintenance of facilities, roads and trails; restoration projects; and land use authorizations. Among the topics covered are both state and federal water quality regulations, water quality monitoring program design considerations, and water quality protection strategies.

DISCLAIMER: This paper does not represent agency or interagency policy, nor should it be construed as either legal advice or the legal opinion of the United States Government or any of its departments or agencies. If a federal or non-federal river manager has questions regarding the application of the information in this paper to a specific situation, it is recommended that they contact the appropriate federal agency or Interagency Wild and Scenic Rivers Coordinating Council representative to confirm that a proposed plan or action conforms with current agency and interagency guidance.

The intended audience of this paper is the range of professionals who manage and work on WSRs. These include both federal employees and non-federal river managers, including state, tribal, and local partnership river managers, who have responsibility for managing WSRs. Broadly speaking, these professionals will be referred to as “river managers” in this paper.

OVERARCHING PRINCIPLES

- Successful management of WSR water quality requires looking beyond the WSR corridor and instead taking a “watershed approach.” Such an approach entails an assessment of all sources of pollution within a watershed, identifying best management practices for protection and restoration, and the involvement and coordination of multiple stakeholders.

- The water quality protection policies outlined in the Wild and Scenic Rivers Act of 1968 (WSR Act) require river managers to actively engage with state water quality regulatory agencies, and often other tribal and local governments with water quality regulatory authority, to protect and enhance the water quality of WSRs.

- Creating a plan for both baseline and long-term water quality data collection and assessment is essential to water quality protection. Ideally, the water quality monitoring program should be specifically supported by the CRMP.

INTRODUCTION

Water quality protection is a fundamental reason for the establishment of the National Wild and Scenic Rivers System. River managers, state and federal water pollution control agencies, and other federal agencies or departments with jurisdiction over lands adjacent to or bordering a WSR, have a statutory responsibility to protect the water quality of WSRs. Water quality protection focuses on maintaining existing water quality, while enhancement includes water quality improvement or restoration to conditions better than those that existed at the time of designation, when and where feasible.

River managers require an understanding of the status and trends of water quality as a basis for making decisions and working with other local, state, tribal, and federal agencies for the long-term protection of the special values of WSRs. The overall purpose of monitoring water quality is to develop scientifically sound information to serve as a measure of river condition, and if necessary, to help river managers confront and mitigate threats to the water quality and water-dependent values of WSRs. The collection and analysis of water quality data provides a quantitative means to answer the question "Is water quality changing?"

Rivers are dynamic systems characterized by interactions among climate, flow, sediment, and biogeochemical processes. In addition, land use practices and other human activities in the watershed of a WSR will greatly affect its water quality. As a result, water quality is constantly changing, from season to season, year to year and from point to point along a river's course. Consistent and systematic data collection over the long-term is needed (1) to distinguish long-term trends from short-term fluctuations and to differentiate natural variations from the effects of human activities; (2) to evaluate whether water quality management practices and strategies are working; and (3) to choose the most cost-effective and sustainable resource protection strategies for the future.

WATER QUALITY REGULATORY FRAMEWORK

Water quality protection of WSRs requires an understanding of the statutory and regulatory requirements for addressing water pollution in the United States. The two main federal laws that guide water quality protection of WSRs are the Wild and Scenic Rivers Act of 1968 (16 U.S.C. § 1271 et seq.) and the Clean Water Act (33 U.S.C. § 1251 et seq.). Other federal laws that address certain aspects of water quality protection include the National Environmental Policy Act of 1969, as amended (42 U.S.C. § 4321 et seq.) and the Safe Drinking Water Act (42 U.S.C. § 300f et seq.). The Safe Drinking Water Act is not commonly encountered by river managers and will not be discussed further. Advice on drinking water regulations can be found from state, federal, and river managing agency water quality experts.

Wild and Scenic Rivers Act Provisions

The Wild and Scenic Rivers Act of 1968 (WSR Act) (16 U.S.C. § 1271 et seq.) identifies water quality protection as a fundamental purpose of designation. River managers are required to protect and enhance the water quality, free flowing condition, and the "outstandingly remarkable values" that led to a river's designation. Many outstandingly remarkable values (ORVs) rely on high quality water. For example, high quality water is essential in rivers where recreation (including swimming, boating, and fishing) has been identified as an ORV. In other instances, water quality is specifically identified as an ORV due to the significance of that value to the river environment (e.g., Wekiva WSR, White Clay WSR, Buffalo WSR, and Middle Fork of the Clearwater WSR). Specific provisions of the WSR Act that provide direction for river managers in the protection and enhancement of water quality are highlighted below.

Section 1(b) of the WSR Act (16 U.S.C § 1271(b)) describes the fundamental purpose of the WSR Act as follows:

> *"The Congress declares that the established national policy of dam and other construction at appropriate sections of the rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes."*

Section 2(b) of the WSR Act (16 U.S.C. § 1273(b) states that rivers or river segments classified as wild are rivers that have "waters unpolluted," which has been interpreted to mean that the water quality of a wild river will meet or exceed federal criteria or federally approved state water quality standards for aesthetics, propagation of fish and wildlife, and primary contact recreation, except where exceeded by natural conditions (1982 Interagency Guidelines). Water that exceeds federal criteria and/or state water quality standards is considered a high-quality water, and high-quality water receives additional antidegradation protections under the Clean Water Act.

Section 7 of the WSR Act (16 U.S.C § 1278(b)) prohibits federal assistance for water resources projects that would adversely affect WSR values, including water quality:

> *"…no department or agency of the United States shall assist by loan, grant, license, or otherwise in the construction of any water resources project that would have a direct and adverse effect on the values for which (a Wild and Scenic) river was established, as determined by the Secretary*

charged with its administration."

Section 10(a) (16 U.S.C § 1281(a)) includes direction for river managers to not only protect but also to enhance or improve WSR values, including water quality:

> "*Each component of the national wild and scenic rivers system shall be administered in such a manner as to protect and enhance the values which caused it to be included in said system…"*

Section 12(c) (16 U.S.C § 1283(c)) requires river managers to cooperate with the Environmental Protection Agency (EPA) and with state water quality agencies for the purpose of eliminating or diminishing the pollution of waters of the river:

> *"The head of any agency administering a component of the national wild and scenic rivers system shall cooperate with the Administrator, Environmental Protection Agency and with the appropriate State water pollution control agencies for the purpose of eliminating or diminishing the pollution of waters of the river."*

Clean Water Act Provisions

The Clean Water Act (CWA) (33 U.S.C. § 1251 et seq.) is the primary law regulating pollution of the nation's waterways. It applies to states and territories (collectively referred to as "states" in the CWA and herein)[1] and to authorized tribes. The objective of the CWA is "*to restore and maintain the chemical, physical, and biological integrity of the Nation's waters*" (33 U.S.C § 1251(a)).

The CWA establishes the basic framework for developing water quality standards and regulating discharges of pollutants into the waters of the United States. A national goal set forth in Section 101(a)(2) of the CWA is to achieve, wherever attainable, a level of water quality that provides for the protection and propagation of fish, shellfish, wildlife, and recreation in and on the water.

The CWA is administered and enforced by the EPA but implemented primarily through state and tribal water quality protection agencies and regulatory programs. Therefore, work to protect and enhance water quality requires a basic understanding of the CWA as well as state and tribal water pollution laws, and substantial engagement with state and sometimes tribal and local governments.

The CWA is extremely complex. A comprehensive explanation of each of the provisions included in the CWA is beyond the scope of this paper. Therefore, only portions of the CWA that are most relevant to WSRs are discussed in this paper. River managers should consult with water quality experts in their agencies, state water quality protection agencies, and the EPA to better understand the CWA and other applicable federal laws.

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[1] The CWA defines "State" as a State, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, the Commonwealth of the Northern Mariana Islands, and the Trust Territory of the Pacific Islands. 33 U.S.C. 1362(3).

Water Quality Standards

Water quality standards are provisions of law that define the water quality goals for a water body. Water quality standards are the foundation for a wide range of water quality management programs under the CWA. For example, they establish the water quality goals for a specific waterbody and provide the regulatory basis for establishing water quality-based effluent limits required by the CWA. Water quality standards also serve as a target for CWA restoration activities such as Total Maximum Daily Loads.

Under Section 303(c) of the CWA, states and authorized tribes are responsible for adopting water quality standards and submitting such standards to the EPA for review and approval or disapproval. Specifically, Section 303(c)(2)(A) of the CWA requires states and authorized tribes to adopt water quality standards that "…consist of the designated uses of the navigable waters involved and the water quality criteria for such waters based upon such uses." These standards shall "…protect the public health or welfare, enhance the quality of water and serve the purposes of this Act." States and tribes must submit new or revised standards for review by the EPA to determine whether they meet the requirements of the CWA and EPA's regulations.

As noted in Section 12(c) of the WSR Act, river managers are required to work cooperatively with state water pollution control agencies to eliminate pollution. As part of their responsibilities, river managers should work with states to ensure that water quality standards, including designated uses, water quality criteria, and antidegradation policies, are protective of WSR water quality including specific water quality-dependent ORVs of a WSR. Section 303(c)(1) of the CWA and EPA's implementing regulations at 40 CFR 131.20 require states and tribes to hold public hearings at least once every three years to review and, as appropriate, modify or adopt new water quality standards. This triennial review provides an opportunity for river managers to ensure there are adequate protections for the WSR of interest.

The EPA has prepared and maintains the Water Quality Standards Handbook (EPA, 2017) to provide detailed guidance on how water quality standards are developed and implemented, and to provide recommendations for states and authorized tribes in reviewing, revising, and implementing water quality standards. For additional information on the CWA and the development and implementation of water quality standards as they relate to WSRs, river managers should refer to the Water Quality Standards Handbook, additional guidance developed by state water quality agencies and the EPA, and/or seek advice from agency water quality experts.

Water quality standards are developed based on the following core elements:

- The designated uses of a water body;
- The numerical and narrative criteria necessary to protect those designated uses; and
- Antidegradation requirements that protect not only the existing uses of a water body, but also protect high-quality waters and waters of special ecological significance.

These core elements are described more fully in the next three sub-sections. Water quality standards may also include general policies that states and authorized tribes may include at their discretion (e.g., mixing zones, variances, and critical low-flow policies).

Designated Uses

A water quality standard defines the water quality goals of a water body or portion thereof, in part, by designating the use or uses to be made of the water body (40 CFR 131.10(a)). The designated use(s) of a water body are defined by each state and therefore vary in specificity and scope. Many water bodies have more than one designated use. Examples include recreation, propagation of fish and wildlife, industry, agriculture, and drinking water supply. The designated use of a water body determines the water quality criteria that must be met within a water body; for example, a water body designated for industrial use will include a different set of criteria than a water body designated for primary contact recreation. Because designated uses determine the water quality criteria that must be met for a water body, it is possible for one water body with a lower measured concentration of a given pollutant to fail in meeting its water quality criteria, while a neighboring water body with a higher measured concentration of the same pollutant could meet the water quality criteria set for the designated use for that water body. For waters with multiple designated uses relying on the same parameter, the most protective designated use and its associated criteria govern whether those waters are meeting water quality standards.

Numerical and Narrative Water Quality Criteria

Water quality criteria are defined as the elements of state water quality standards, expressed as constituent concentrations, levels, or narrative statements, that represent a quality of water necessary to support a particular use (40 CFR 131.3(b)). Water quality criteria must be based on sound scientific rationale and must contain sufficient parameters or constituents to protect the designated use (40 CFR 131.11). Water quality criteria can be numeric (e.g., the maximum pollutant concentration levels permitted in a water body) or narrative (e.g., a description of the desired conditions of a water body being “free from” certain negative conditions). Most water quality criteria are expressed as numeric—or quantitative—parameters. Numeric criteria are expected for toxic pollutants under most circumstances.

Narrative criteria may be used to express a parameter in a qualitative form when numeric criteria cannot be established, or to supplement numeric criteria. An example of a narrative water quality criteria is the following narrative cited in Pennsylvania’s administrative code (25 Pa. Code § 96.3) relating to water quality protection requirements:

> *§ 96.3 General water quality criteria*
> *(a) Water may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant, or aquatic life.*
> *(b) In addition to other substances listed within or addressed by this chapter, specific substances to be controlled include, but are not limited to, floating materials, oil, grease, scum, and substances that produce color, tastes, odors, turbidity, or settle to form deposits.*

Antidegradation Requirements

Antidegradation requirements provide a framework for maintaining and protecting existing water quality, and for protecting waters of special significance. Each State must develop, adopt, and retain an antidegradation policy and establish procedures for implementing the policy. Antidegradation requirements provide a framework for water quality protection based on a three-tiered approach:

- Tier 1 waters receive the most basic level of protection that includes the maintenance of water quality to support "existing uses" for all waters. Degradation of water quality is allowed, so long as the water still supports its existing uses;
- Tier 2 waters are high-quality waters where water quality exceeds the basic levels necessary to support recreation and the propagation of fish and wildlife. They must be managed to maintain their current, higher level of water quality. In such segments, limited water quality degradation may be allowed following an appropriate review that considers important economic and social development needs, and only after public participation has occurred; Tier 2 waters may be identified either waterbody by waterbody or parameter by parameter for a given waterbody.
- Tier 3 waters, or Outstanding National Resource Waters (ONRWs), include not only the highest quality waters that exceed their water quality criteria, but also waters of exceptional recreational or ecological significance. EPA's antidegradation regulation (40 CFR 131.12(a)(3)) states: "*Where high quality waters constitute an outstanding National resource, such as waters of National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.*" These can include water bodies that are important, unique, or sensitive ecologically, but whose water quality as measured by traditional parameters (e.g., dissolved oxygen, pH, or temperature) may not be considered a high-quality water. ONRWs receive the highest level of protection. No new or increased discharges to ONRWs are allowed and no lowering of water quality is permitted, except where states allow certain limited activities that result in short-term and temporary changes in water quality.
- Some states, e.g., Kentucky, designate some waters as Tier 2.5; in Kansas, those would be called Exceptional State Waters, waters of remarkable quality or waters of significant recreation or ecological value but are not at a scale or status to be considered "National." For Tier 2.5 waters, existing water quality must be maintained, unless the state determines there is an important social or economic need to lower water quality following an antidegradation review.

Because water quality protection is a fundamental purpose of the WSR Act, and WSRs by definition serve a vital national purpose and include river values of exceptional recreational and ecological significance, river managers should work with states and tribes to ensure that WSRs receive the highest level of protection consistent with the requirements for Tier 3 waters, or ONRWs.

There is wide variation in the programs and policies of states and how they identify ONRWs. Some states have prepared detailed guidance on how to apply for such designations (Arizona, for example) with clearly delineated criteria that the water body must meet to be designated as an ONRW. In other states, the statutes implementing the CWA may mention ONRW or their equivalent but provide no information on how they are to be implemented. River managers may work with state, tribal, and local agencies to seek ONRW designation for WSRs. Public participation processes associated with the triennial review of water quality standards provide an opportunity for river managers to propose ONRW status for WSRs.

General Policies

As specified in 40 CFR 131.13, states and authorized tribes may adopt certain policies into their water quality standards that affect how these standards are applied or implemented. Examples of such general policies include policies affecting mixing zones, critical low-flows, and water quality standard variances. For example, states may define a mixing zone where initial dilution of a discharge takes place and where certain numeric water quality criteria may be exceeded. By authorizing a mixing zone, states and tribes allow some portion of the waterbody to mix with and dilute particular wastewater discharges before evaluating whether the waterbody as a whole is meeting its criteria. If a state or tribe chooses to adopt a general policy, such policies are subject to EPA review and approval or disapproval if they constitute a new or revised standard. Because water quality protection is a fundamental purpose of WSR-designation, WSRs are of vital national importance, and most WSRs are of significant ecological and/or recreational value, most WSRs would meet the definition of an ONRW, and these general policies would not be applicable since no new or expanding discharges would be allowed.

Impaired Waters and Total Maximum Daily Loads

Under Section 303(d) of the CWA (33 U.S.C § 1313(d)) states and authorized tribes are required to assemble and evaluate water quality-related data and information for waters within the state to develop a list of impaired waters. Impaired waters are waters that do not meet state water quality standards and the list of impaired waters is known as the CWA Section 303(d) list. EPA regulations require states to submit the CWA Section 303(d) lists every two years.

Impaired waters must remain on the list until they achieve water quality standards, or the state develops a corresponding Total Maximum Daily Load (TMDL). Note that the mere development of a TMDL does not remove the impaired status of a water, it simply shifts it from a Category 5 list to a Category 4A list. A TMDL is the maximum amount of a pollutant allowed to enter a water body and serves as the starting point or planning tool for restoring water quality. The TMDL is calculated based on a pollutant reduction target for a water body and allocates pollutant reductions among all of the various point and nonpoint sources of the pollutant. Point sources are discrete points of discharge, such as a pipe, conduit, or ditch, while nonpoint sources are typically runoff processes associated with different land use activities that result in more diffuse sources of pollution.

Each pollutant causing or contributing to a water body's impairment must be identified, and typically a TMDL is developed for each water body/pollutant combination. For example, if one water body is impaired by three pollutants, three TMDLs might be developed for the water body. However, in other cases, a single TMDL document may be developed to address several water body/pollutant combinations. Neither the CWA nor EPA's regulations define or limit the scale of TMDLs. States develop TMDLs based on a water body, a watershed, multiple watersheds, or even the entire state.

State Reports on Water Quality

Under Section 305(b) of the CWA (33 U.S.C. § 1315(b)), states and authorized tribes are required to submit reports on the quality of their waters to the EPA every two years. Reports include a description of the water quality status of the state's waters; an analysis of the extent to which the waters of the state provide for the protection and propagation of shellfish, fish, and wildlife, and support recreational activities; and recommendations for additional actions necessary to achieve such objectives.

EPA provides program guidance on both the CWA Section 303(d) and Section 305(b) reporting process to help states prepare and submit their required reports. In 2002, the EPA began encouraging states to merge the CWA Section 303(d) list and the Section 305(b) report into one integrated report. Since then, the EPA has been issuing Integrated Report Guidance (IRG) on a biennial basis to support states in making listing decisions and reporting on the conditions of their waters. These reports provide the most up to date information from states on the water quality status of waters within a state.

Although states develop their own monitoring standards and protocols, the EPA has recommended a widely used numerical system to help states identify the condition of their waterbodies in a nationally consistent manner. The EPA recommends that states use five water quality categories (and four sub-categories) to report on the water quality status of all waters in their state (see Table 1). Category 5 waters comprise the traditional 303d impaired waters list.

The process described under Section 305(b) is the principal means by which EPA, Congress, and the public evaluate whether U.S. waters meet water quality standards. EPA compiles the data from state reports and transmits a summary of the data to Congress along with an analysis of the status of water quality nationwide. EPA encourages states to submit their water quality information in an online database known as the Assessment and TMDL Tracking and Implementation System (ATTAINS).

Table 1. Environmental Protection Agency recommended water quality categories for reporting water quality status (Source: https://www.epa.gov/sites/default/files/2018-09/documents/attains_calculations_of_epa_ir_categories_2018-08-31.pdf

Category	Description
1	All designated uses are supported, no use is threatened
2	Available data and/or information indicate that some, but not all, designated uses are supported
3	There is insufficient available data and/or information to make a designated use support determination
4	Available data and/or information indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed
4a	Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is established
4b	Available data and/or information indicate that at least one designated use is not being supported or is threatened, but other required control measures are expected to result in attainment of an applicable water quality standard in a reasonable period of time
4c	Available data and/or information indicate that at least one designated use is not being supported or is threatened, but non-attainment of any applicable water quality standard is not caused by a pollutant
5	Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed
5m	Non-attainment of any applicable water quality standard for mercury is the result of mainly atmospheric deposition sources and comprehensive mercury reduction programs are in place to address the impairment

Nonpoint Source Pollution Programs

Section 319 was added to the CWA in 1987 to establish a national program to address nonpoint sources of water pollution. Nonpoint source pollution originates from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification. NPS pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and ground waters. Agricultural, forested, and developed lands are some of the leading sources of nonpoint pollution, which may include the following:

- Runoff from excess fertilizers, herbicides, and insecticides from agricultural lands;
- Runoff of oil, grease, and toxic chemicals from urban runoff and energy production;
- Runoff of sediment from improperly managed drainage at construction sites, crop and forest lands, and eroding streambanks;
- Acid drainage from abandoned mines;
- Bacteria and nutrients from livestock and faulty septic systems; and
- Hydrologic alteration or hydromodification.

Section 319 addresses the need for greater federal leadership to help focus state and local nonpoint source efforts. Under Section 319, states and authorized tribes may receive grant money that supports a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific nonpoint source implementation projects. States and tribes may use these funds to develop and implement TMDLs; to develop watershed-based plans that target threatened waters, source waters, or high-priority unimpaired waters; and to conduct nonpoint source monitoring and program assessment activities.

Water Quality Certifications

Section 401 of the CWA provides states and authorized tribes with an important tool to help protect the water quality of federally regulated waters within their borders, in collaboration with federal agencies. Under Section 401 of the CWA, a federal agency may not grant a permit or license to conduct any activity that may result in any discharge into waters of the United States unless a Section 401 water quality certification is granted, or certification is waived. States and authorized tribes where the discharge would originate are generally responsible for issuing water quality certifications. In cases where a state or tribe does not have authority, EPA is responsible for acting on a request for certification.

National Pollutant Discharge Elimination System Permits

Section 402 of the CWA prohibits the discharge of pollutants into waters of the United States through a point source without a National Pollutant Discharge Elimination System (NPDES) permit. The NPDES permitting program controls water pollution by regulating point sources of pollutants. The term point source includes any confined or discrete conveyance, such as a pipe, ditch, channel, tunnel, conduit, discrete fissure, or container. A NPDES permit allows a facility to discharge a specified amount of a pollutant into a receiving water under certain conditions. Permits contain discharge limits, reporting and monitoring requirements, and other provisions to protect water quality and public health. Examples of operations requiring NPDES permits include, but are not limited to:

- Concentrated animal feeding operations (CAFOs);
- Municipal wastewater treatment facilities;
- Industrial and commercial wastewater discharges;
- Construction and industrial stormwater discharge (including transportation projects);
- Mining operations; and
- Pesticide applications.

Under the CWA, states and tribes may receive authorization to administer the NPDES program. The NPDES programs in states without program authorization (e.g., Massachusetts, New Hampshire, New Mexico, the District of Columbia, Guam, the Northern Mariana Islands, and Puerto Rico) are administered by the appropriate EPA regional office.[2]

Permitting Discharges of Dredge or Fill Material

Section 404 of the Clean Water Act (CWA) (33 U.S.C. § 1344) establishes a program to regulate the discharge of dredged or fill material into waters of the United States. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as bridges, highways, and airports), and mining projects. Section 404 requires a permit from the U.S. Army Corps of Engineers (USACE) before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulations (e.g., certain farming and forestry activities). Proposed activities are regulated through a permit review process.

There are two types of Section 404 permits: Individual Permits and General Permits. An Individual Permit is required for projects that pose potentially significant impacts, while General Permits apply to a category of activities defined by the USACE that are likely to have only minimal impacts. It is important to note that most water resources projects described under Section 7 of the WSR Act are also subject to the requirements under Section 404 of the CWA. Because of the overlap between Section 404 of the CWA and Section 7 of the WSR Act, coordination and communication between river managers and the USACE is essential.

Individual Permits are reviewed and authorized by the USACE, which evaluates applications based on public interest and environmental criteria set forth in the CWA Section 404(b)(1) Guidelines (40 CFR Part 230). General Permits differ from Individual Permits in that they are issued on a nationwide, regional, or statewide basis for certain categories of activities that are considered to have minimal adverse effects. Review of a project that falls under one of the categories of activities covered by the NWPs is not necessary, with some exceptions. General permits are usually valid for five years and may be re-authorized by the USACE after a public review and comment period.

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[2] EPA table and map showing the status of state authorizations are available from the EPA's National Pollutant Discharge Elimination System (NPDES) website. Retrieved 9/25/2023 from https://www.epa.gov/npdes/npdes-state-program-authority

There are three types of General Permits – Nationwide Permits (NWPs), Regional General Permits (RGPs), and Programmatic General Permits (PGPs). The NWPs are issued by the USACE on a national basis and are designed to streamline the authorization of a category of activities that are generally considered to produce minimal impacts. A RGP is a type of General Permit that authorizes activities in a particular state or states, or geographic region. In contrast, a PGP is based on existing state, local, or other federal agency programs and is designed to avoid duplication between these programs. For example, a State Programmatic General Permit (SPGP) is a type of permit that is issued by the USACE and is designed to reduce duplication of effort between USACE districts and state regulatory programs that provide similar protection to aquatic resources.

The most common type of General Permits that river managers are likely to encounter are NWPs. In 2021, there were 59 NWPs that covered a range of activities, including aids to navigation, fish and wildlife harvesting, scientific measurement devices, outfall structures, aquatic habitat restoration, and bank stabilization.[3] The NWPs are re-issued on a five-year basis following a public review period.

To qualify for NWP authorization, the prospective permittee must comply with all NWP General Conditions, in addition to any Regional Conditions imposed by the division engineer or district engineer. An example of a General Condition is a requirement for pre-construction notification (PCN) prior to initiation of an activity in a waterway. PCNs give the USACE the opportunity to further evaluate certain proposed NWP activities on a case-by-case basis to ensure that they will cause no more than minimal adverse environmental effects, individually and cumulatively. All NWPs are subject to General Condition 16, titled Wild and Scenic Rivers. General Condition 16 includes a PCN requirement for any activity proposed within a WSR. General Condition 16 states the following:

> *16. Wild and Scenic Rivers. (a) No NWP activity may occur in a component of the National Wild and Scenic River System, or in a river officially designated by Congress as a "study river" for possible inclusion in the system while the river is in an official study status, unless the appropriate Federal agency with direct management responsibility for such river, has determined in writing that the proposed activity will not adversely affect the Wild and Scenic River designation or study status. (b) If a proposed NWP activity will occur in a component of the National Wild and Scenic River System, or in a river officially designated by Congress as a "study river" for possible inclusion in the system while the river is in an official study status, the permittee must submit a pre-construction notification (see general condition 32). The district engineer will coordinate the PCN with the Federal agency with direct management responsibility for that river. Permittees shall not begin the NWP activity until notified by the district engineer that the Federal agency with direct management responsibility for that river has determined in writing that the proposed NWP activity will not adversely affect the Wild and Scenic River designation or study status. (c) Information on Wild and Scenic Rivers may be obtained from the appropriate Federal land management agency responsible for the*

[3] The 2021 Nationwide Permits, General Conditions, District Engineer's Decision, Further Information, and Definitions were published in the Federal Register on January 13, 2021 (86 FR 2744, and the correction at 86 FR 27274) and December 27, 2021 (86 FR 73522). Retrieved 6/5/2023 from https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/Nationwide-Permits/

designated Wild and Scenic River or study river (e.g., National Park Service, U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service). Information on these rivers is also available at: http://www.rivers.gov/.

National Environmental Policy Act Provisions

The National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. § 4321 et seq.), provides a national framework for protecting the environment by requiring that all branches of government consider impacts to the environment, including air and water quality, prior to undertaking any major federal action. Under NEPA, federal agencies are required to prepare environmental assessments or environmental impact statements on proposed major federal actions that may have significant environmental effects. River managers should ensure that projects with federal funding, permitting, or planning with potential to affect the water quality of WSRs receive appropriate NEPA review, and that the impacts to WSRs caused by these projects are included in NEPA documents. Examples include federal highway construction projects, urban and industrial stormwater runoff management projects, and federal resource management plans. In most instances, these projects will also require review under Section 7 of the WSR Act, and the assessments can be performed concurrently. Guidance on Section 7 reviews is available from the Interagency Wild and Scenic River Coordinating Council and appropriate federal agency representatives.

WILD AND SCENIC RIVER WATER QUALITY POLICY

The National Wild and Scenic Rivers System is a collection of nationally designated rivers managed by one of four federal agencies (the U.S. Forest Service (USFS), the National Park Service (NPS), the Bureau of Land Management (BLM), and the U.S. Fish and Wildlife Service (USFWS)), or by states, tribes, or local partners under cooperative agreements with a federal agency. Regardless of the administering agency, the water quality of WSRs receive the same legal protections. River managers should ensure that the water quality of WSRs is protected in a manner that is consistent with the purpose of the WSR Act and the goals of the CWA.

To provide a consistent approach to the management of WSRs across federal agencies, the Departments of the Interior and Agriculture established a set of management guidelines for designated rivers in 1982. In accordance with Section 12(c) of the WSR Act, the 1982 Final Revised Guidelines for Eligibility, Classification and Management of River Areas (47 FR 39453 Sept 7, 1982)[4] require river managers to work cooperatively with the EPA and state and local authorities to eliminate or reduce activities that degrade water quality. The federal management guidelines specifically state that the water quality of WSRs "*will be maintained or, where necessary, improved to levels which meet Federal criteria or federally approved State standards for aesthetics and fish and wildlife propagation. WSR managers will work with local authorities to abate activities within the river area which are degrading or would degrade existing water quality*." The federal management guidelines note that Section 10(a) of the WSR Act is interpreted as an anti-degradation and enhancement policy for all designated river areas.

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[4] Final Revised Guidelines for Eligibility, Classification and Management of River Areas, 47 Fed. Reg. 39453 (July 12, 1982). [Retrieved 6/5/2023 from https://www.rivers.gov/documents/guidelines.pdf](https://www.rivers.gov/documents/guidelines.pdf)

WATER QUALITY MONITORING PROGRAM DESIGN

Water quality may be thought of as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics. Water quality is determined through measurement or observation of the concentration and state (dissolved or particulate) of various chemical, biological, and physical parameters. The main elements of a water quality monitoring program are in situ (in-place) measurements, the collection and analysis of water samples, the study and interpretation of the analytical results, and the management of water quality data and reporting of findings. The results of analyses from a single water sample are valid for the location and time the sample was taken, but to fully characterize a water body it is necessary to gather sufficient data (by means of regular or intensive sampling and analysis) to assess spatial and/or temporal variations in water quality.

In remote areas where river access is difficult, other innovative approaches may be necessary, such as remote sensing technologies and community-based water quality monitoring programs. For example, the United States Geological Survey (USGS) and the Yukon River Inter-Tribal Watershed Council (YRITWC) have been partnering to collect water-quality samples from the Yukon River and its tributaries with the assistance of trained community members. The program has allowed the USGS to create and maintain a baseline record of water-quality in the river basin that would not otherwise be available.

Water quality monitoring is necessary to ensure that WSRs continue to support the water quality and water quality-dependent ORVs that led to their designation. Creating a plan for collection and evaluation of water quality data should be one of the earliest steps taken toward protecting and enhancing water quality. The plan should be based on clear objectives that are practical and achievable in terms of available staff and budgetary resources. At a minimum, river managers should use monitoring efforts to document baseline conditions, determine compliance with the appropriate CWA standards, and monitor the most significant threats to water quality from existing land uses within the basin. River managers may work with state and tribal agencies in developing the monitoring program to ensure that monitoring is accomplished in an efficient and useful manner.

Baseline information representing the condition of the river at the time of designation is necessary to establish a scientific foundation for future water quality protection. Long-term data collection is necessary for trend detection, and additional data collection may be needed to evaluate the effects of certain land use activities or to ensure compliance with water quality standards. Ideally, the water quality monitoring plan should be specifically outlined and implemented as part of a Comprehensive River Management Plan (CRMP) to ensure that river management is based on the data gathered through the monitoring program.

Baseline Information

Every WSR—even those with no apparent water quality-related issues or conflicts—should have a description of the baseline condition that existed at the time of designation. Baseline condition is the collection of measurements against which future conditions are compared. In the context of WSRs, baseline condition is the characterization of the status and trends in water quality that existed at the time the river is designated. The baseline condition may include the effects of past or present land-use or water-use activities on the river and may reflect changing climatic or other environmental conditions. A description of the baseline condition may rely on existing water quality data but will likely require additional data collection. Historical water quality data may have been collected by the USGS, the U.S. Bureau of Reclamation, state water quality management agencies, units of local governments, tribes, and researchers. But in many cases, these data may rely on outdated methods, may not be readily available or simply may not exist, especially for WSRs in remote locations. If no historic data exists or historic data are not sufficient or useable, data collection on water quality should begin as soon as possible after designation.

Water quality data tend to be collected by various entities according to different methods and protocols. The result is that not all data is comparable or appropriate for use in establishing baseline conditions. Detailed research should be conducted to inventory and assess the available water quality data from different resources. Research may include literature reviews, scoping workshops, and communication with researchers and other subject matter experts that are familiar with the river and the data that has been collected. If sufficient and well-documented baseline data does not already exist, then a baseline monitoring program should be developed and implemented for an appropriate duration and frequency to establish a scientifically defensible baseline dataset.

Elements of a Water Quality Monitoring Program

The principal elements of a water quality monitoring program are as follows:

- a clear statement of the purpose of monitoring;
- a description of the study area (e.g., drainage or watershed);
- a description of the sampling locations including geographic location;
- a listing of the water quality (and other) variables that will be measured;
- how measurements will be taken (multi-parameter probes, grab samples) and the cost-benefit of each sampling method;
- the proposed frequency and duration of sampling;
- an estimate of the resources (staff and funding) necessary to fulfill the program;
- a quality control and quality assurance plan; and
- a plan for managing and disseminating data.

An example of a water quality monitoring program that includes these principal elements was developed by NPS for continuous monitoring of the Upper Delaware WSR and Middle Delaware WSR as part of the NPS Inventory and Monitoring Program (Tzilkowski et al., 2018). A second example was developed for discrete water quality monitoring (Hughes, 2018). River managers should discuss the requirements of a water quality monitoring program with water quality experts, including those within their federal river managing agency responsible for the WSR, as well as experts from the USGS, the EPA, state agencies and universities.

Purpose of Monitoring

The first and most important step in the design of a water quality monitoring program is to clearly identify and articulate the purpose of the monitoring program. In other words, what are the goals and objectives of monitoring? A monitoring program that clearly describes the objectives of monitoring will be useful in ensuring that the plan is carried out in a purposeful manner, and that the objectives of the plan are achievable and useful. If the monitoring program objectives are too vague, it will likely fail to produce useful data. In addition, it is important to keep in mind the intended use of the information. There is little point in generating monitoring data unless it is intended to meet a particular need or purpose.

Monitoring objectives will determine what water quality parameters will be monitored, as well as where and how frequently measurements are taken. This step includes evaluating the ORVs of the WSR and determining which values are dependent on water quality and may be vulnerable to changing conditions, and what water quality parameters are representative of those values. Regardless of the unique ORVs of a WSR, the monitoring program should be designed to help river managers protect the water quality of WSRs and identify and eliminate sources of pollution.

Monitoring can be conducted for many purposes, including the following:

- To characterize water quality status and identify changes or trends in water quality over time;
- To identify existing or emerging water quality problems;
- To gather information to design specific pollution prevention or remediation programs;
- To determine whether program goals -- such as compliance with pollution regulations or implementation of effective pollution control actions -- are being met;
- To respond to emergencies, such as harmful algal blooms, spills, and floods; and
- To evaluate cause and effect relations on water quality in the WSR, resulting from directed or inadvertent cross-program decisions and actions regarding the water or its watershed.

Some types of data collection and monitoring activities meet several of these purposes at once; others are specifically designed for one reason. Once the water quality needs have been identified, they can be used to develop a statement of purpose and design an effective monitoring program.

Description of the Monitoring Area

The water quality of a WSR will be dependent on land uses and water quality of the river upstream of the designated segment, as well as land uses and water quality associated with any tributaries that flow into the designated segment. Therefore, the geographic extent of a water quality monitoring program may include the watershed or area that drains to the designated segment, including its tributaries. Depending on the length of the designated segment or segments, the extent of the monitoring area may be quite large. In this case, it may be helpful to divide the watershed into smaller drainage areas or sub-basins.

The description of the monitoring area should include the following:

- The geographic location of the river and its watershed, including the hydrologic unit code (HUC) as determined by the USGS;
- a description of the range in elevation and extent of the contributing area (e.g., the watershed or drainage basin);
- a description of the existing land cover and land uses within the watershed that may affect water quality;

- the meteorological and hydrological information for the watershed including existing flow information; and
- a summary of the existing and potential uses of water within the watershed.

Sampling Site Selection

A sampling site is a location along a river where measurements will be made and where samples will be collected. Site selection is a critical part of the monitoring program design. It requires careful consideration of the monitoring objectives, as well as knowledge of water uses, and the location of any potential or known sources of contaminants. Because staff and budgets are limited, there will be tradeoffs between the number of sampling sites, the number of samples collected, and the different types of analyses that are performed. River managers should consult with water quality experts to ensure that the sampling site locations will satisfy the objectives of the monitoring program, are achievable in the long term, and are scientifically and statistically valid.

In general, the goal in site selection is to be able to establish sampling sites that are representative of the WSR segment and the specific objectives of the monitoring program. Two commonly used approaches for selecting sampling site locations are probabilistic and targeted sampling designs. In a probabilistic approach, monitoring sites are selected randomly using a statistically representative approach to provide an unbiased assessment of the river. In a targeted approach, monitoring sites are chosen individually to answer specific questions or address existing or foreseeable problems. Regardless, the exact location of the sampling sites should be described and the geographic coordinates noted.

Sampling locations on rivers should be established where the water is sufficiently well-mixed. For example, it is best to not locate a sampling site immediately below the confluence of a tributary since mixing may not occur for some distance downstream of the confluence. Sampling sites should be marked on a map and georeferenced with specific coordinates.

Ideally, river managers should select a combination of monitoring designs (e.g., fixed station, targeted, or probabilistic designs) that will yield credible data to support multiple resource protection programs and inform management decisions. However, at a minimum, it is recommended that at least one fixed station is established on each WSR that includes both flow and water quality parameters to characterize the WSR and identify changes or trends in water quality over time. Additional sampling locations may be included in the monitoring program as needed to meet monitoring objectives. Monitoring designs should also consider whether there is opportunity to cooperate with other agencies (e.g., state, tribal or local agencies) in the implementation of monitoring programs and data collection to avoid duplication of effort.

The U.S. Geological Survey (USGS) has developed the "National Field Manual for the Collection of Water-Quality Data" to provide general guidelines and procedures for USGS personnel who collect water quality data (USGS, 2018). Chapter 1, titled "Preparations for Water Sampling," provides an overview of basic field sampling measures and considerations, which includes site reconnaissance, project work plans, quality-assurance plans, basic equipment and supplies needed for fieldwork, safety precautions, and planning for data management. Recommendations for water quality sample site selection include the following:

- At or near a stream gaging station to obtain concurrent surface water discharge data necessary to compute constituent transport loads and determine discharge/constituent concentration relations. If a stream gaging station is not available and discharge cannot be rated or estimated with sufficient accuracy, then discharge must be measured at the time of sampling;
- In straight reaches having uniform flow and a stable bottom contour;
- Where constituents are well mixed along the cross-section;
- Far enough above or below confluences or point sources of contamination to avoid sampling where flows are poorly mixed or not unidirectional;
- At a stream reach where representative samples can be collected safely during all flow conditions
- In stream reaches upstream from bridges or other structures to avoid contamination from the structure or road surface; and
- In unidirectional flow that does not include eddies. (If eddies are present within the channel, make note of the condition and sample only the unidirectional flow.)

Water Quality Parameters

Water quality parameters include chemical, physical, and biological characteristics or properties that are used to assess the health of aquatic ecosystems and to provide an indication of undesirable conditions. Chemical characteristics include parameters such as pH, dissolved oxygen, organic matter, metals, and nutrients like nitrogen and phosphorus. Physical properties of water quality may include flow, temperature, and turbidity, and biological indicators may include algae, macroinvertebrates, and phytoplankton. River managers should consult with water quality experts to select water quality parameters that meet the objectives of the monitoring program and that are consistent with state water quality standards.

Combining measurements of flow with water quality monitoring regardless of the parameters being sampled is highly recommended, since many parameters are correlated (either directly or inversely) with streamflow. Natural fluctuations in streamflow due to daily, seasonal, and annual weather patterns may cause noise or variability in the water-quality data that can confuse the detection of a trend in water quality (Hirsch et al., 2010). In such cases, the variability in the concentration of a water quality parameter due to the variability of streamflow needs to be removed to correctly identify a trend in water quality.

Water quality can be assessed using a variety of methods with a multitude of parameters. The selected parameters should reflect the monitoring objectives and include parameters or indicators that are linked to the ORVs, the designated uses of the WSR, and any perceived threats to water quality. Because limited resources affect the design of water quality monitoring programs, a tiered approach to water quality monitoring is often recommended. A tiered approach includes a core set of water quality parameters that are supplemented by additional parameters according to site-specific or project-specific decision criteria. A tiered approach should help river managers make the best use of available resources to meet water quality objectives, including characterizing water quality status, assessing water quality trends, and identifying causes and sources of impairments.

The core set of water quality parameters is a suite of parameters that are used routinely to provide information on the fundamental attributes of the aquatic environment. Supplemental parameters are added to the monitoring program when there is a reasonable expectation that a specific pollutant may be present in a watershed, when core parameters or biologic indicators indicate impairment, or to support a special study. Supplemental parameters may include water quality criteria based on state or tribal water quality standards, any pollutants controlled by NPDES permits or identified in a TMDL, and any other constituents or indicators of concern.

For nonpoint source assessments, supplemental parameters might be selected depending on the land use activities in the watershed. In agricultural areas, it may be appropriate to analyze pesticides, nutrients, and biochemical oxygen demand (BOD), while mining activities may lead to higher levels of heavy metal concentrations. Areas with one use, but not the other, would have different data collection strategies.

Core water quality parameters that typically would be measured include pH, conductivity, dissolved solids, suspended solids, dissolved oxygen, fecal coliform, turbidity, and temperature. Additional monitoring may include nutrients, metals, pesticides and other organic contaminants, and biological indicators (for example, fish communities and benthic macroinvertebrates).

Frequency, Duration and Spatial Considerations

The monitoring objectives will determine the frequency, duration, and spatial distribution of data collection. Samples must be collected repeatedly at sufficient intervals and over a sufficient length of time at selected locations to establish a time series of data that lends itself to scientific analysis and interpretation. Use of real time or continuous monitoring sensors that measure temperature, pH, conductivity, turbidity, dissolved oxygen, and in some cases, nitrate and other nutrients, can be invaluable in providing temporal resolution of basic water quality conditions on the WSR.

The frequency and duration of sample collection affects how well the data represents actual water quality conditions and affects the ability to detect changes in water quality conditions over time (Hirsh and others, 1982). Statistical methods must be considered in the design of a water quality monitoring program to ensure that data is collected at appropriate intervals and locations and for a sufficient length of time to meet monitoring objectives and to provide certainty in data interpretation.

A comprehensive discussion of statistical approaches used in water quality study design and data analysis is beyond the scope of this paper. Therefore, river managers should consult with water quality experts familiar with statistical methods to develop an appropriate sampling design and to perform appropriate analyses of water quality data. Guidance on statistical methods used in water quality analysis can be found in “Statistical Methods in Water Resources” (Helsel et al., 2020).

The objectives of the water quality monitoring program will influence the appropriate sampling frequency (USDA, 2003; EPA, 1997). One of the main purposes of water quality monitoring is to establish baseline conditions and to evaluate long-term trends in the condition of the WSR. The statistical methods used to establish baseline condition or to detect trend have minimum data requirements that are important to consider in the design of a monitoring program.

Commonly used methods to establish baseline condition in water quality data include measures of central tendency such as the mean or median, measures of variability such as the sample variance, standard deviation or coefficient of variation, and measures of the distribution symmetry of a population, such as the coefficient of skewness (Helsel et al., 2020).

Effective trend analysis requires a long sequence of data collected at a fixed location, by consistent methods, with few long gaps. Common methods of trend analysis include the seasonal Kendall test for trend and the seasonal Kendall slope estimator (Hirsch and others, 1982). Hirsch (1988) recommends at least five years of monthly data as the minimum time frame to determine a monotonic trend (a continuous rate of either increasing or decreasing change). In contrast, a step trend (an abrupt shift up or down) associated with a particular action requires two years of monthly data before and after treatment (Hirsch 1988). These time frames are only guidelines and longer periods of record and/or more intensive sampling frequency may provide greater sensitivity to detect smaller changes.

Monitoring to determine the effectiveness of a management action will likely require a greater sampling frequency than does trend monitoring. Trend monitoring, however, is typically carried out over a far longer period, bringing total sample counts near to those collected to monitor whether management actions are achieving their purpose. In addition, individual states may have established minimum frequency sampling requirements to determine whether numeric water quality criteria have been attained. Guidance and examples of sample size calculations are available in the literature (Clausen and Spooner, 1993; USDA, 2003).

Quality Assurance and Quality Control Plans

Valid and reliable water quality data is the foundation for effective water quality management and is essential to the development of successful water quality protection strategies. A quality assurance and quality control (QA/QC) plan outlines minimum requirements for data collection, analysis, and reporting and ensures that the data generated are of known and suitable quality to meet monitoring goals and objectives. The goals and objectives should be stated in the QA/QC plan at the forefront as the reason these data need to be collected.

A key aspect of a QA/QC plan is the proper documentation of methods and procedures for sample collection and analysis. Standard Operating Procedures (SOPs) or monitoring protocols describe in detail the methods an organization uses to collect, handle, process, and analyze its environmental data. The use of SOPs ensures data comparability, defensibility, and accuracy. Quality assurance activities include training staff, developing data quality objectives, validating data, and performing laboratory audits. Quality control procedures include the collection and analysis of blank, duplicate, and spiked samples and standard reference materials to ensure the integrity of analyses and regular inspection of equipment to ensure proper operation.

The process of preparing a QA/QC plan promotes consistent data collection procedures and a data set of known and acceptable quality (EPA, 2001). State and tribal water quality agencies often require QA/QC plans as part of their water quality management programs. River managers should ensure that the data being collected for a WSR is consistent with the requirements of a state QA/QC plan so that data is comparable to other water quality data that is being collected in the state.

Data Records and National Databases

The EPA has developed various databases and tools to provide access to water quality data and information systems that help support water quality decision-makers and better inform the public, including:

- The water quality monitoring repository that includes the Water Quality Exchange (WQX), and the Water Quality Portal (WQP)[5];
- The Assessment TMDL Tracking and Implementation System known as ATTAINS[6]; and
- The Watershed Assessment, Tracking & Environmental Results System (WATERS)[7], which unites water quality information with a geospatial stream network known as the National Hydrography Dataset Plus (NHDPlus).[8]

The WQX is the mechanism for data partners to submit water monitoring data to EPA, while the WQP is the mechanism for anyone, including the public, to retrieve water monitoring data from EPA. The WQP includes publicly available water-quality data from the EPA WQX, USGS National Water Information System (NWIS), and the USDA Watersheds, Agricultural Research Data System (STEWARDS).

ATTAINS contains information on water quality assessments, impaired waters, and total maximum daily loads (TMDLs) reported by states under Clean Water Act Sections 303(d) and 305(b). The information reported by states is made available via ATTAINS web services, ATTAINS geospatial services, as well as through other EPA tools. The ATTAINS system allows registered EPA users to provide comments about assessment decisions, and to review Clean Water Act Section 303(d) lists of impaired waters.

WATERS integrates information from various EPA water programs by linking it to the national surface water network based on the NHDPlus dataset. NHDPlus incorporates features from the National Hydrography Dataset (NHD), the National Elevation Dataset (NED), and the Watershed Boundary Dataset (WBD). The integration of water program data using NHDPlus improves communication and efficiency that allows EPA to meet its goals under the Clean Water Act. Using WATERS, environmental professionals and interested citizens can access comprehensive information about the quality of the nation's surface water.

Data acquired from monitoring the WSR should be submitted to the applicable state environmental agency in accordance with its biennial call for data to develop its 303d list of impaired waters. States are to evaluate “all existing and readily available data” in developing those lists.

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[5] Retrieved 6/5/2023 from https://www.epa.gov/waterdata/water-quality-data

[6] Retrieved 6/5/2023 from https://www.epa.gov/waterdata/attains

[7] Retrieved 6/5/2023 from https://www.epa.gov/waterdata/waters-watershed-assessment-tracking-environmental-results-system

[8] The EPA developed and maintains NHDPlus in partnership with the USGS. The geospatial datasets included in WATERS are periodically updated by EPA based on state-submitted data and may not reflect the most current high resolution geospatial datasets available from the USGS.

WATER QUALITY CHALLENGES

A 2018 review of the water quality of WSRs reported by states in their integrated reports found that the main causes of impairments for WSRs (based on assessed river miles) were: temperature, mercury (in fish tissue), metals, sediment, polychlorinated biphenyls (PCBs), and pathogens (IWSRCC, 2018). It is important to note that some river and stream segments are impaired by more than one cause or source. In many cases, states and tribes were not always able to identify the source of pollution when making their assessment decisions; as a result, sources are often reported as unknown or unspecified. However, the most common causes of water pollution reported by states and tribes come from a variety of human activities, including agriculture, forestry, urban runoff, and mining. Wastewater treatment plant effluent may also contribute to water pollution mainly through increased water temperature, nutrients, and concentrations of trace organic contaminants, but also via decreased dissolved oxygen levels.

Agricultural Uses

Agricultural operations can have significant effects on water quality due to soil erosion, nutrient loss, and runoff of pesticides and other contaminants.[9] Nonpoint source pollution from agricultural runoff is the leading cause of water quality impacts to rivers and streams in the United States (EPA, 2003a). Agricultural activities that cause nonpoint source pollution include poorly located or managed concentrated animal feeding operations; overgrazing; plowing too often or at the wrong time; livestock access to rivers, and improper, excessive, or poorly timed application of pesticides, irrigation water, and fertilizer. Pollutants that result from farming and ranching include sediment due to soil erosion, nutrients, pathogens from livestock manure, pesticides, metals, and salts. For example, increased nutrient loading from animal waste can lead to eutrophication of water bodies and damage to aquatic ecosystems.

Forestry Practices

Sources of pollution associated with forestry activities include removal of streamside vegetation, road construction and use, timber harvesting, and mechanical preparation for the planting of trees. Road construction and road use are the primary sources of NPS pollution on forested lands, contributing up to 90 percent of the total sediment from forestry operations[10] . In addition to other water quality impacts, an excessive quantity of sediment in a water body can reduce the ability of aquatic organisms to successfully live, forage, and spawn. Harvesting trees in the area beside a stream can affect water quality by reducing the streambank shading that regulates water temperature and by removing vegetation that stabilizes the streambanks. These changes can harm aquatic life by limiting sources of food, shade, and shelter, as well as decreasing areas suitable for species intolerant of warmer temperatures.

Urban Runoff

In urban and suburban areas, much of the land surface is covered by buildings and paved or impermeable surfaces, which do not allow rain and snowmelt to soak into the ground. Instead, most

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[9] Retrieved 9/26/2023 from https://www.epa.gov/nps/nonpoint-source-agriculture

[10] Retrieved 2/12/2024 from https://www.epa.gov/nps/national-management-measures-control-nonpoint-source-pollution-forestry

developed areas rely on storm drains to carry large amounts of runoff from roofs and paved areas to nearby waterways. Stormwater runoff carries pollutants directly to streams and rivers, where they degrade water quality (EPA, 2003b). Urbanization increases the amount and type of pollutants carried into streams, rivers, and lakes.[11] Pollutants may include sediment; oil, grease, and toxic chemicals from motor vehicles; pesticides and nutrients from lawns and gardens; viruses, bacteria, and nutrients from pet waste and failing septic systems; road salts; heavy metals from roof shingles, motor vehicles, and other sources; thermal pollution from dark impervious surfaces such as streets and rooftops. These pollutants can harm fish and wildlife populations, kill native vegetation, foul drinking water supplies, and make recreational areas unsafe and unpleasant.

Mining

Mining activities can be responsible for both chemical contamination and physical alteration of riverine ecosystems. Mining may cause a range of impacts to WSR water quality and ORVs depending on the type of operation, proximity to the river, and whether it is active, in remediation, or abandoned. Mining activities may cause extensive impacts to aquatic and riparian habitats long after mining has ceased (EPA, 2004; USFS and BLM, 2007; USFWS, 2007).[12]

Mining may have a range of impacts on water quality, but the most common types of pollution are acid mine drainage, heavy metal pollution, and sedimentation. Acid mine drainage occurs when sulfur-bearing minerals are exposed to air and water through mining activities that cause the formation of sulfuric acid. The resulting acidic drainage further leaches heavy metals such as copper, lead, and mercury into groundwater or surface water. Guidance on addressing abandoned mines with acid mine drainage can be found in the Abandoned Mine Site Characterization and Cleanup Handbook (EPA, 2000).

Heavy metal pollution occurs when metals like arsenic, cobalt, copper, cadmium, lead, silver, and zinc that are contained in excavated waste rock or tailing deposits come into contact with water, like the process that occurs during acid mine drainage. The difference is that heavy metal pollution may occur under neutral pH conditions. Excavated tailing materials that have been processed and crushed may make metals that were formerly bound up in solid rock more accessible to water, increasing the potential for heavy metal contamination.

Another common water quality issue related to mining is the increased erosion and transport of sediment into rivers causing increased sediment loads, changes in sediment characteristics such as grain size, and elevated levels of both dissolved and suspended sediments. When suspended solids are transported to rivers, they can increase temperature and decrease dissolved oxygen and light penetration, degrading habitat.

Mining operations are regulated under the CWA, including discharges of pollutants to streams from point sources (CWA Section 402) and the placement of rock and dirt in streams and wetlands (CWA Section 404). The CWA requires point source discharges from mining operations, including discharges from mining-related impoundments, to be authorized under an NPDES permit.

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[11] Retrieved 9/26/2023 from https://www.epa.gov/nps/nonpoint-source-urban-areas

[12] Retrieved 9/26/2023 from https://www.epa.gov/nps/abandoned-mine-drainage

Climate Change

The water quality of WSRs may be affected by climate change through changes in air temperature, the frequency of heavy precipitation or droughts, associated changes in dilution and concentration, and through physical processes such as runoff, bank scour, and erosion. Increased occurrence and/or intensity of wildfires may lead to elevated stream temperatures, sediment delivery, and reductions in dissolved oxygen. Increased precipitation intensity and frequency influence nonpoint source pollution (e.g., pollutants washed from agricultural fields, roads, and other land surfaces by runoff). Warming air temperature may lead to increased water temperature, which can affect habitat suitability and the chemical properties of water and may lead to worsening water quality conditions. For example, altered water temperature influences the potential for algal blooms, which can further reduce oxygen levels. In areas with melting permafrost, thawed carbon can be released to aquatic ecosystems as dissolved or particulate organic matter affecting water clarity, acidity, and trace metal transport (such as mercury) to streams.

Hydrologic Alteration and Depletion

The natural flow regime, defined as the characteristic pattern of flow magnitude, timing, duration, frequency, and rate of change, plays a critical role in supporting the chemical, physical, and biological integrity of streams and rivers (Novak et. al., 2016). Human-induced alteration of the natural flow regime can lead to loss of aquatic life and reduced aquatic biodiversity. Protecting aquatic life from the effects of flow alteration involves maintaining multiple components of the flow regime within their typical range of variation. While not specifically an introduction of pollutants as regulated by the CWA, flow alteration is certainly a form of pollution with consequences of impairment. These situations would be examples of Category 4C waters under the EPA's 305b hierarchy of assessed waters.
Effects of hydrologic alteration on the physical properties of rivers may include altered channel geomorphology (channel incision, widening, and bed armoring), reduced riparian and flood-plain connectivity, and reduced longitudinal (upstream-downstream) and vertical (surface water/groundwater) connectivity. Effects on water quality can also result from altered flow magnitudes. For example, salinity, sedimentation, and water temperature can increase when flow volumes are reduced, whereas erosion and sediment transport can increase with increased or amplified flow volumes.

Addressing flow conditions on designated WSRs may contribute to a comprehensive approach to maintaining the state determined designated uses of a river, including aquatic life, cold-water or warm-water fisheries, and economically or recreationally important aquatic species. Flow protection strategies for WSRs can be found in the 2022 technical guidance document titled "Instream Flow Protection Strategies for Wild and Scenic Rivers" prepared by the IWSRCC (2022).

Critical low-flow conditions present special challenges to the water quality of WSRs, the integrity of the aquatic community, and the protection of human health. Salinity, sedimentation, and water temperature can all increase when flows are reduced. Low-flow conditions may also aggravate the effects of effluent discharges because there is less water available for dilution, resulting in higher instream concentrations of pollutants.

DEVELOPMENT OF WATER QUALITY PROTECTION AND ENHANCEMENT STRATEGIES

The development of a water quality protection and enhancement strategy for a WSR requires an understanding of the status and trends in water quality that existed on the date of river designation, the water quality regulations of the state or states in which the river is located, potential threats to water quality within the watershed of the WSR, and any existing water quality management programs or initiatives that are applicable to the watershed or sub-basins through which the WSR flows. The protection and enhancement of water quality requires key types of information about the chemical, physical, and biologic condition of the river. These include water quality parameters, biologic indicators, flow measurements, and information on land cover and land uses in the WSR watershed. Preventing negative impacts to water quality is more effective and more efficient than trying to restore degraded water quality. Therefore, water quality protection and enhancement strategies should consider not only restoration of impaired or degraded waters but also protection of high-quality waters.

Watershed Management Frameworks

Watershed management refers to the process of implementing both land use and water management practices in a comprehensive manner to protect and improve water quality and other natural resources within a watershed. The EPA encourages the use of watershed management frameworks to protect the quality of our nation's waters. The watershed management approach helps address water quality problems in a comprehensive and holistic manner by evaluating potential sources of pollution within a watershed and then prioritizing restoration and protection strategies to address these problems. The EPA has developed guidance on the development and implementation of watershed management plans to meet water quality standards and to protect water resources (EPA, 1996; EPA, 2008; and EPA, 2013).

This document provides guidance to states, authorized tribes, local governments, watershed organizations, and the public regarding technical tools and sources of information for developing watershed-based plans to improve and protect water quality. Where WSRs do not include federally administered lands in the river's designation, a watershed approach may be more difficult to implement unless there is already state or local interest in doing so. In these circumstances, the key elements and conservation practices that are part of a watershed approach may still provide tools and resources that can be shared with stakeholders to address water quality issues.

Common elements found in watershed approaches include the following:

- Stakeholder involvement that includes federal, state, tribe, local, and private entities;
- Management focused on hydrologically defined management units (watershed or sub-basin);
- Inventory and assessment of existing and potential threats (both point and nonpoint sources) within the watershed;
- Prioritization of water quality issues based on severity of the issue and the resources available to address the issue; and

- Development and implementation of monitoring and management activities in a unified and coordinated approach.

The watershed approach places emphasis on all aspects of water resource quality, including physical properties (e.g., temperature, flow, mixing, habitat); chemical properties (e.g., conventional and toxic pollutants such as nutrients and pesticides); and biological properties (e.g., health and integrity of biotic communities and biodiversity) of the resource.

Assessment of Potential Threats to Water Quality

Water quality is affected by both point sources that discharge pollutants directly to water bodies and nonpoint sources of pollution associated with different land use and land management activities. Monitoring a range of water quality parameters and biologic indicators can help identify water quality issues. But depending on the parameters being monitored, additional and more targeted monitoring may be necessary to identify specific sources of pollutants or causes of impairments.

An inventory of the watershed and an assessment of potential contaminants will help identify possible sources of water quality degradation and help determine what monitoring is necessary to address any issues. A watershed inventory begins with a delineation of the watershed or sub-basin area, an evaluation of existing water quality conditions, and identification of potential water quality threats or stressors in the watershed. A complete inventory includes information on natural land cover, human activities, and other factors that can affect water quality.

Important categories of land cover include forests, open spaces, bodies of water, agricultural cover (e.g., pastures, row crops), and impervious surfaces (e.g., roads, parking lots and roofed structures). Human activities within watersheds can affect water quality by producing contaminants from discrete point sources or from diffuse nonpoint sources. Human-caused sources of pollutants include industrial and municipal wastewater treatment plants, individual sewage disposal systems, permitted stormwater discharges, agricultural activities, forestry, mineral extraction, and the generation, storage, and disposal of hazardous materials. Recreational activities, both within watersheds and on bodies of water, can also affect water quality.

Geographic information system (GIS) data that include information on the locations of permitted discharges (including wastewater treatment facilities and the location of NPDES permitted facilities), as well as information on land uses like road density, population density, feedlots, septic system density, abandoned mines, and a variety of other land use categories can be very useful in identifying and quantifying potential sources of pollution. Both federal and state agencies often have GIS land coverage information that can assist in identifying potential threats.

Management Practices

Water quality protection is achieved through a combination of water quality monitoring, identification of potential threats from the contributing watershed, and implementation of BMPs[13] that can reduce or eliminate the risk. BMPs provide methods for protecting the water quality of various water bodies from nonpoint sources of pollution associated with agriculture, forestry, mining, construction, and urban areas. Any management practices that are implemented within a designated WSR corridor or on a tributary to a designated WSR that involves construction or development which could affect the free-flowing characteristics of a WSR must be approved through the WSR Act Section 7 review process (IWSRCC, 2004).

The EPA has prepared a technical guidance document for use by state, local, and tribal resource managers in the implementation of nonpoint source pollution management practices on agricultural lands (EPA, 2005b). Examples of management practices include soil conservation measures that promote soil health, reduce erosion, and lessen nutrient runoff. Examples of agricultural management practices that are associated with improved water quality include filter strips, cover crops, reduced tillage, and manure management. These practices not only benefit natural resources but enhance agricultural productivity and profitability by improving soil health and optimizing the efficacy of agricultural inputs.

Additional financial and technical assistance is available to landowners through various Natural Resources Conservation Service (NRCS) programs and initiatives. Among these are the Environmental Quality Incentives Grant program and the National Water Quality Initiative program, which was created as a partnership between NRCS, state water quality agencies, and the EPA to identify and address impaired water bodies through voluntary conservation measures.

The USFS has developed technical guidance on BMPs for water quality management on national forest system lands (USDA, 2012). In addition, state forestry agencies have developed and adapted forestry BMPs for state forest lands.[14] Forestry BMPs address timber harvest, road construction and maintenance, revegetation of disturbed areas, management of chemicals and fire hazard, and maintenance of streamside buffer zones. BMPs for agriculture generally address erosion control and sediment transport in disturbed areas including the use of riparian buffer zones, and management of significant activities such as grazing and irrigation, with special emphasis on controlling sediment, nutrients, pesticides, and herbicides.

The EPA also provides technical and managerial guidance to protect bodies of water from polluted runoff associated with various activities in urban areas (EPA, 2003b). The guidance document can help states implement nonpoint source control programs in urban areas. It also provides examples of practices that can be used to minimize pollution from roads and bridges, parking lots, construction activities, and urban stormwater. BMPs for urban areas include practices like vegetated swales and filter

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[13] Best management practices (BMPs) are defined here as any management practice or measure based on sound science that is economically achievable, geographically appropriate, and representative of the best available practices, technologies, processes, and siting for the control of nonpoint sources of pollutants.

[14] Retrieved 2/12/2024 from https://www.stateforesters.org/bmps/

strips, stormwater infiltration and percolation, extended detention (dry) basins, retention ponds (wet), and constructed wetlands.

Coordination With States, Tribes, and Local Water Quality Agencies

Water quality regulation generally falls under the jurisdiction of state governments. In some cases, authorized tribes may regulate water quality. Each state or tribe will have different water quality standards and requirements for water quality management and enforcement. Understanding water quality criteria, designated uses and the antidegradation requirements of the states or authorized tribes with jurisdiction over water quality is essential for river managers.

River managers are encouraged to engage with state, tribal, and local water quality and land management agencies to protect and enhance the water quality of WSRs. Coordination with state and tribal water quality agencies is extremely helpful to ensure that WSRs are protected by state-based water quality standards and included in state water quality assessments. Education and outreach with various stakeholders are essential for meeting water quality protection and enhancement goals.

In some states, memorandums of understanding (MOUs) have been established to outline state/federal partnerships for managing and controlling point and nonpoint water pollution. For example, the Oregon Department of Environmental Quality and the BLM have established a MOU to define the process by which the BLM and DEQ will cooperatively meet state and federal water quality rules and regulations on BLM-administered lands in the State of Oregon.

In addition, communication between river managers, state agencies, and tribes may provide opportunities for collaboration and sharing of information and resources. Coordination with local governments and local entities such as water treatment and wastewater agencies, municipal water suppliers and other local water users within a watershed may also be necessary for successful protection.

Federal Land Use Regulations

Section 12(a) of the WSR Act states that the Secretary of the Interior and the Secretary of Agriculture, and the head of any other federal department with jurisdiction over lands bordering or adjacent to a WSR, shall take necessary action regarding management policies, regulations, plans, and contracts to protect WSRs in accordance with the purposes of the WSR Act. If a river-related project requires federal permitting, funding, or assistance, the relevant federal agency should consider permitting conditions that help avoid water quality impacts. NEPA requires that all potential impacts associated with a proposed project must be fully analyzed and disclosed. Regardless of the federal agency that is providing authorization for a new project, the NEPA analysis should fully analyze and disclose any potential impacts to water quality and water quality related attributes of ORVs in both designated and study rivers. The NEPA process can be used to identify alternative approaches and mitigation measures that would avoid long-term impacts to water quality.

Section 505 of the Federal Land Policy and Management Act (FLPMA) provides that federal right-of-way authorizations shall include terms and conditions which will “minimize damage to scenic and aesthetic values, fish and wildlife habitat, and otherwise protect the environment.” Numerous water-related facilities are authorized by the USFS under Special Use Permits and by the BLM under Right-of-Way Grants. In addition, the USFS and BLM authorize water-related facilities under their range, minerals, and forestry programs. These authorizations can include terms and conditions that ensure water quality protection. When proposed facilities are located upstream from a designated WSR, federal agencies are required to ensure that such land use authorizations do not degrade the water quality or ORVs of the WSR. In addition, when existing land use authorizations for dams and diversions come up for reauthorization, the WSR Act requires the river managing agency to consider appropriate terms and conditions to protect and enhance water quality and ORVs.

FINAL REMARKS

Protection and enhancement of WSR water quality is a fundamental purpose of river designation. Water quality issues often arise outside the boundary of WSRs and addressing these issues requires working cooperatively with states, tribes, and other local stakeholders. Section 12(c) of the WSR Act requires the head of any agency administering a component of the national WSR system to cooperate with the EPA and with the appropriate state water pollution control agencies for the purpose of eliminating or diminishing pollution of waters of the river. Under the CWA, both states and authorized tribes are required to prioritize and develop restoration and pollution management plans, or TMDLs, for impaired waters. Waters can be impaired for any of their designated uses and by a variety of contaminants. River managers should work closely with state and tribal agencies to ensure that impaired segments of WSRs receive high priority in a state's water quality restoration program, and that the pollution of a WSR is eliminated or diminished. In addition, because WSRs meet the definition of ONRW as described in EPA's Water Quality Standards Handbook, eg., WSRs are of vital national importance, WSRs have both ecological and recreational significance, and water quality protection is a fundamental purpose of designation, state water quality protection policies for WSRs should be consistent with EPA's antidegradation regulation (40 CFR 131.12(a)(3)) for ONRWs and/or Tier 3 waters.

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ABBREVIATIONS

AMD	Acid mine drainage
ATTAINS	Assessment and TMDL Tracking and Implementation System
BLM	Bureau of Land Management
BMP	Best Management Practices
GIS	Geographic Information Systems
CAFO	Concentrated Animal Feeding Operation
CRMP	Comprehensive River Management Plan
CWA	Clean Water Act (and amendments)
EPA	Environmental Protection Agency
MCL	Maximum contaminant level
NRCS	Natural Resources Conservation Service
NEPA	National Environmental Policy Act
NWP	Nationwide Permits
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NWQMC	National Water Quality Monitoring Council
ONRW	Outstanding National Resource Waters
ORV	Outstandingly Remarkable Values
QA/QC	Quality Assurance/Quality Control
PCN	Pre-construction notification
SOP	Standard Operating Procedures
SDWA	Safe Drinking Water Act
TMDL	Total Maximum Daily Load
USACE	United States Corps of Engineers
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WSR	Wild and Scenic River
WSR Act	Wild and Scenic Rivers Act (and amendments)
WSRs	Wild and Scenic Rivers
WQP	Water Quality Portal

GLOSSARY OF TERMS

Term	Definition
Criteria	Elements of state water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use.
Designated use	Those uses specified in water quality standards for each water body or segment whether or not they are being attained.
Nonpoint source	Diffuse sources of pollution where pollutants are released to the environment from runoff over land surfaces including runoff from parking lots, roadways, or agricultural land. As the runoff flows across the land or through storm drains, it picks up and carries away natural and human-made pollutants, depositing them into lakes, rivers, wetlands, coastal waters, and groundwater.
National Pollutant Discharge Elimination System	The NPDES permit program addresses water pollution by regulating point sources that discharge pollutants to waters of the United States.
Point source	Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, concentrated animal feeding operation, or vessel from which pollutants are or may be discharged.
Pollution	The human-made or human-induced alteration of the chemical, physical, biological, and radiological integrity of water.
Total Maximum Daily Load	The calculated maximum amount of a pollutant allowed to enter a waterbody without the waterbody exceeding the water quality standards for that pollutant.
Watershed	An area of land bounded by a topographic divide where all precipitation and surface water runoff drains (i.e., “sheds”) to the same place – toward the same body of water or the same topographic low point.
Watershed Approach	A framework for addressing natural resource management within a watershed.

Appendix A – COMMON WATER-QUALITY PARAMETERS

Chemical Parameters

Alkalinity - The alkalinity, or the buffering capacity, of water refers to how well it can neutralize acidic pollution and resist changes in pH. Alkalinity measures the concentration of alkaline compounds such as carbonates, bicarbonates, and hydroxides, in a sample of water.

BOD - Biochemical oxygen demand (BOD) is related to dissolved oxygen. While there are many factors that influence dissolved oxygen, the most important is the amount of organic matter decomposing in the water. Oxygen in the surrounding water is consumed as microorganisms decompose this organic matter. In other words, BOD is a measure of the use of dissolved oxygen by life forms, particularly during decomposition.

Conductivity - Electrical conductivity is the ability of a substance to conduct an electrical current, measured in microsiemens per centimeter (µS/cm). Ions such as sodium, potassium, and chloride give water its ability to conduct electricity. Conductivity is an indicator of the amount of dissolved salts in a stream. Conductivity often is used to estimate the amount of total dissolved solids (TDS) rather than measuring each dissolved constituent separately.

DO - Dissolved oxygen (DO) is needed by fish and other stream organisms. In unaltered streams, dissolved oxygen levels usually determine the ability for the stream to support aquatic oxygen-dependent life, as defined by temperature and elevation. Cold water can hold more dissolved oxygen than warmer water. Dissolved oxygen measurements can be expressed as a concentration, milligrams per liter (mg/L), or as percent saturation (the amount of oxygen the water holds compared to what it could absorb at that temperature).

Metals - Metals are elements present in all waterbodies with natural concentrations corresponding to local geology. Types of metals found in waterbodies may include aluminum, arsenic, copper, manganese, mercury, nickel, selenium, and zinc. In a waterbody, metals are either dissolved or in particulate form. Over time, dissolved and particulate metals in the water can build up in the tissue of fish and other aquatic organisms. Dissolved metals are typically expressed as micrograms of the dissolved metal per liter of water (µg/L).

Nitrogen - Nitrogen is a critical nutrient required for all life. Nitrogen enters water in numerous forms, including both inorganic and organic forms. The primary inorganic forms of N in rivers and streams are ammonia (NH3), ammonium (NH4), nitrate (NO3), and nitrite (NO2). Organic-nitrogen (organic-N) is usually determined from the laboratory method called total Kjeldahl nitrogen (TKN), which measures a combination of organic-N and ammonia + ammonium. Since nitrogen can transform from one form to another, it is often considered in its totality as total nitrogen (TN).

Nutrients - Nutrients are chemical elements that are essential to plant and animal life and growth including nitrogen and phosphorus. At high levels, they are considered contaminants. Commonly measured nutrient parameters include nitrate, ammonia, orthophosphate, and total phosphorus. Nutrients are commonly reported as milligrams per liter (mg/L) or micrograms per liter (µg/L) of water.

pH - pH is a measure of the level of activity of hydrogen ions in a solution, resulting in its acidic or basic quality. pH is measured on a logarithmic scale that commonly ranges from 0 (acidic) to 14 (basic), with 7 being neutral. Each stream organism is adapted to a specific pH range.

Phosphorus – Phosphorus, like nitrogen, is a critical nutrient required for all life. Phosphorus in aquatic systems can occur as both organic and inorganic phosphate and can be either dissolved in the water or suspended (attached to particles in the water column). Total phosphorus (TP) is a measure of all phosphorus found in a sample, whether that phosphorus is dissolved or particulate. The concentration of total phosphorus is typically reported in micrograms per liter (µg/L).

TDS - Total dissolved solids (TDS) is a measure, in milligrams per liter (mg/L), of the concentration of dissolved materials in the water. Ions such as potassium, sodium, chloride, carbonate, sulfate, calcium, and magnesium all contribute to the dissolved solids in the water. In many instances resource agencies use the terms TDS and salinity interchangeably since these ions are typically in the form of salts.

Physical Parameters

Flow - Stream flow (discharge) is the volume of water discharged or moving through a stream at any given time. Stream flow often is expressed in cubic feet per second (cfs) or sometimes as gallons per minute (gpm). Stream flow is particularly important in interpreting dissolved oxygen readings.

Temperature - Water temperature is a crucial aspect of aquatic habitat for two reasons. First, water temperature affects nearly all other water quality parameters. Second, aquatic organisms are adapted to certain temperature ranges.

TSS – Total suspended solids (TSS) are particles of sand, silt, clay, and organic material moving with the water or along the bed of the stream. Suspended solids usually are measured as a concentration in milligrams per liter (mg/L).

Turbidity is a measure of the amount of particulate matter and dissolved color that is suspended in water. Turbidity measures water clarity or the ability of light to pass through water. Water that has high turbidity appears cloudy or opaque. Turbidity is measured in Nephelometric Turbidity Units (NTUs) or with a Secchi disk.

Biological Parameters

Benthic macroinvertebrates - Benthic (meaning “bottom-dwelling”) macroinvertebrates are small aquatic animals and the aquatic larval stages of insects. They include dragonfly and stonefly larvae, snails, worms, and beetles. Evaluating the abundance and variety of benthic macroinvertebrates in a waterbody gives an indication of the biological condition of that waterbody.

Chlorophyll a - Chlorophyll a is the predominant type of chlorophyll found in green plants and algae and provides a measure of the amount of algae growing in a waterbody.

Cyanobacteria - Cyanobacteria, also referred to as blue-green algae, occur naturally in freshwater ecosystems. However, too many nutrients such as phosphorus and nitrogen in a waterway can result in conditions that lead to cyanobacterial blooms. When cyanobacteria degrade, they may release algal toxins that can be harmful to aquatic and human life.

Enterococci - Enterococci are bacteria that live in the intestinal tracts of warm-blooded animals, including humans, and are indicators of possible contamination of streams and rivers by fecal waste.

E. coli - Escherichia coli (E. coli) and fecal coliform are measured as indicators of more harmful bacteria. High numbers might indicate the presence of other bacteria that cause illness. E. coli criteria are expressed as the number of colony-forming units (cfu) per 100 milliliters (mL).

Total coliform - Total coliform bacteria are commonly found in the environment and are generally harmless. If only total coliform bacteria are detected in drinking water, the source is probably environmental. Fecal coliform bacteria are a sub-group of total coliform bacteria. The presence of fecal coliform in a drinking water sample often indicates recent fecal contamination, meaning that there is a greater risk that pathogens are present than if only total coliform bacteria is detected. E. coli is a sub-group of the fecal coliform group. The presence of E. coli in a drinking water sample almost always indicates recent fecal contamination, meaning there is a greater risk that pathogens are present.

Appendix B –WATER QUALITY PROTECTION AND MANAGEMENT CASE STUDIES

Case Study 1 – Managing Turbidity on Birch Creek (Ikheenjik) Wild and Scenic River, AK

Introduction

One hundred twenty-six miles of upper Birch Creek[15] were added to the National Wild and Scenic Rivers System (PL 90-542) and classified as "wild" as part of the 1980 Alaska National Interest Lands Conservation Act (ANILCA). Approximately 77 miles of the Birch Creek Wild and Scenic River (WSR) flows through the Steese National Conservation Area (Figure 1), which was also designated under ANILCA. Congress directed the Bureau of Land Management (BLM) to protect two identified special values within the Steese National Conservation Area: caribou habitat and the Birch Creek WSR.

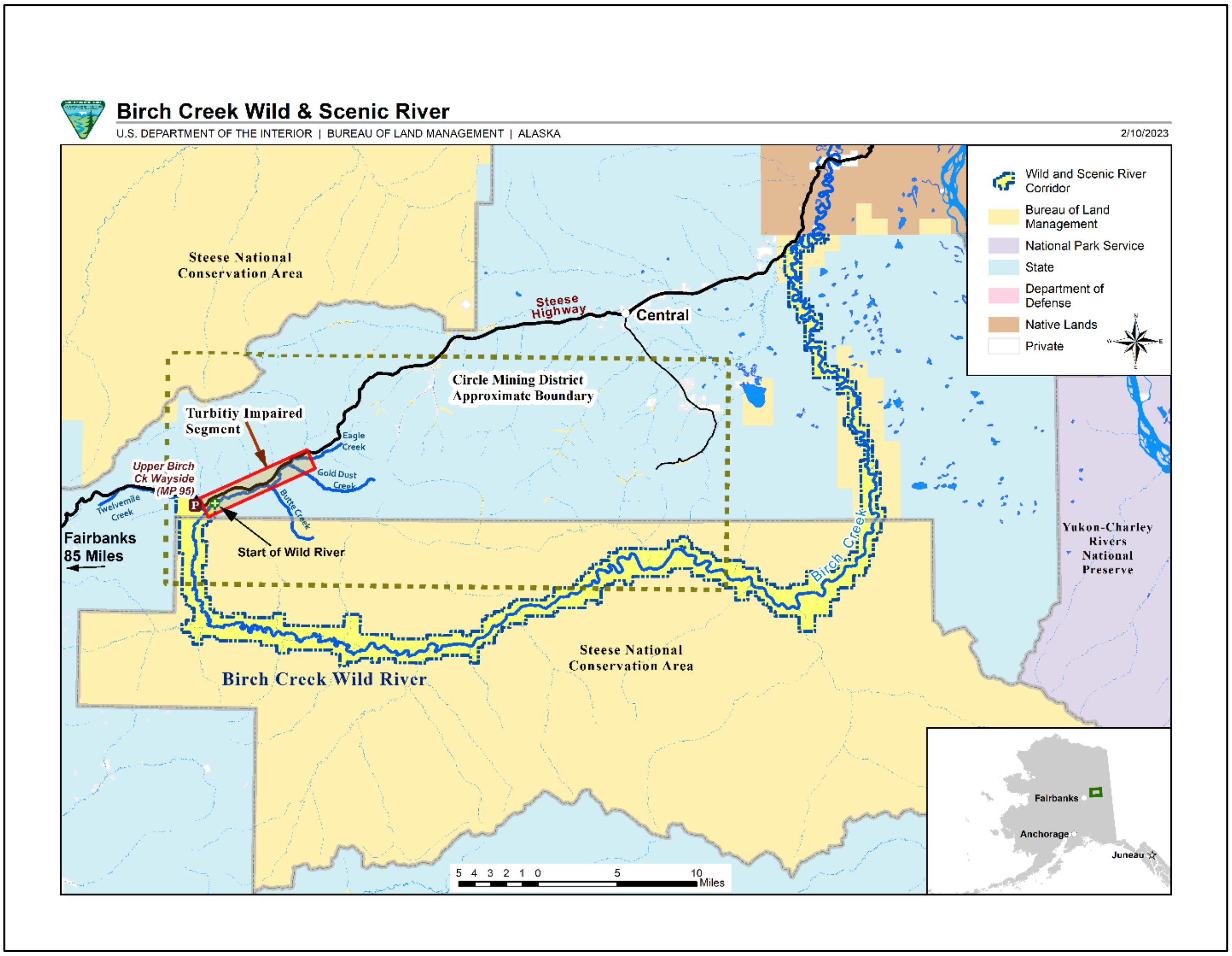

Figure 1. Birch Creek Wild and Scenic River location map.

The entire length of the Birch Creek WSR is classified as "wild". Under Section 2(b) of the WSR Act, Congress has directed all river managing agencies to administer wild rivers in a manner that preserves

[15] Retrieved 6/05/2023 from https://www.rivers.gov/rivers/birch.php

the river corridor and water quality in an unspoiled condition. At the time that the river was designated, water quality related to placer mining had not yet been identified as a resource management issue. Since the river's designation, however, it has become apparent that more than a century of placer gold mining has adversely affected water quality and geomorphic conditions in the upper Birch Creek watershed. This case study provides a summary of upper Birch Creek water quality-related activities and cooperative efforts by the BLM and the Alaska Department of Environmental Conservation (ADEC) to monitor and reduce elevated turbidity levels associated with stormwater runoff from placer mined areas in the upper Birch Creek WSR watershed.

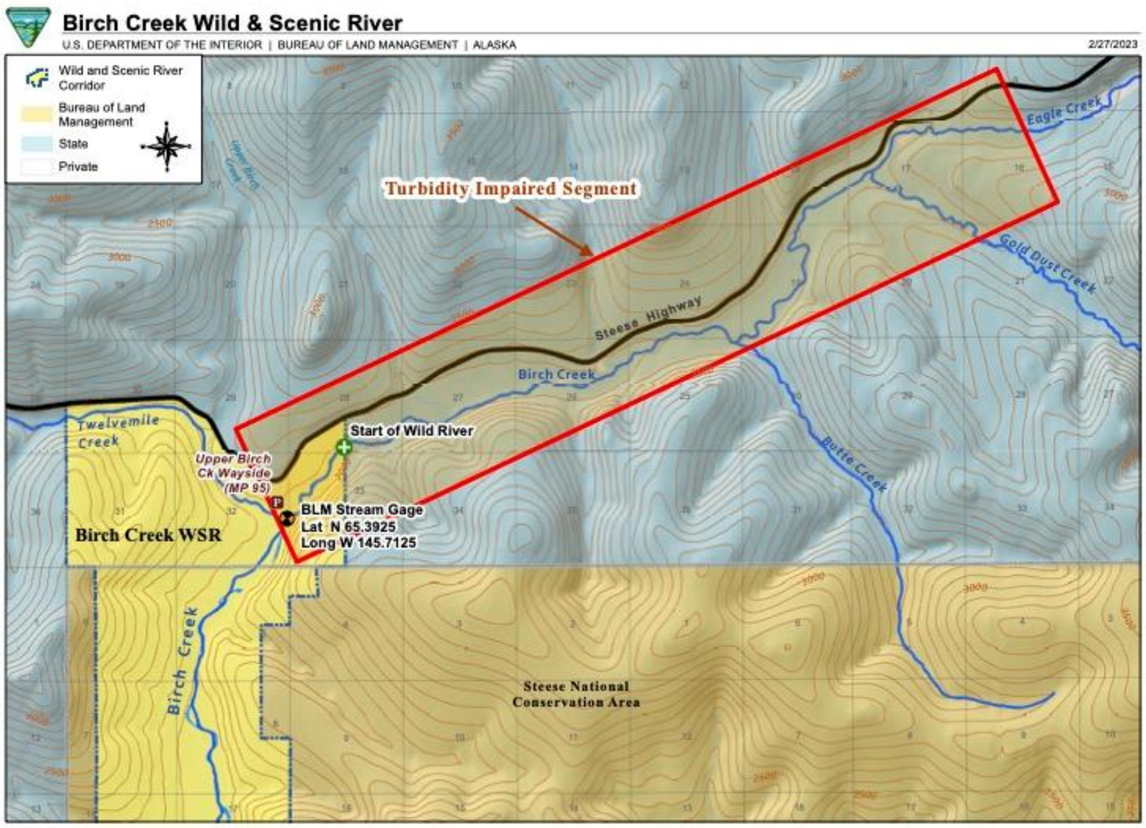

Figure 2. Birch Creek Wild and Scenic River stream gage location map.

Outstandingly Remarkable Values

The BLM 2016 Steese Record of Decision and Approved Resource Management Plan (RMP) identified the following Outstandingly Remarkable Values (ORVs) for Birch Creek WSR. Protection and enhancement of these ORVs has both direct and indirect relationships to water quality.

- Scenic – Birch Creek offers changes in topography from a headwaters stream to a more mature river with meander bends and braided systems, a landscape that includes broad flats, foreground hills, and middle-distance mountains.

- Recreation – Birch Creek is recognized regionally and nationally as an accessible whitewater wild river that provides multi-day primitive floating and camping with frequent opportunities for wildlife watching.

- Fish Populations and Habitat – Birch Creek has one of the highest diversity of fish species of all rivers in the region, including arctic grayling, northern pike, sheefish, and three species of salmon.

Human Uses of Birch Creek Wild and Scenic River

The Birch Creek watershed has been mined for placer gold since the late 1800s (Cobb 1973) and continues to be one of the most active placer gold districts in interior Alaska. In addition to the historic and current mining uses of the river corridor, other common uses of the river corridor include traditional uses by local communities for subsistence purposes including hunting, fishing, and trapping, and recreational purposes including multi-day float trips, winter snow machine use, and sled dog races.

Description of Birch Creek Watershed

The upper Birch Creek WSR is accessible by road approximately 90 miles east of Fairbanks on the Steese Highway (Figure 1), generally near Central, AK. About 53 percent of the Birch Creek watershed is owned and managed by federal land management agencies.

The Birch Creek watershed has a continental sub-arctic climate. The average high temperature in July ranges from 65 to 72 °F. The average low temperature during January is well below zero with extended periods ranging from -50 to -60 °F. Measured temperature extremes range from a low of -71°F to a high of 97°F. Annual rainfall averages 6.5 inches, and snowfall averages 43.4 inches per year. Birch Creek is ice-free from mid-June to mid-October. Daylight hours range from a minimum of about 4 hours per day in winter to more than 20 hours per day in summer. (See Photo 1 for an overview of a typical reach of Birch Creek).

Peak flows on Birch Creek are typically associated with snowmelt in May or early June, with subsequent peak flows associated with heavy precipitation events during late summer. Flows increase and decrease rapidly in response to rainfall or rapid snowmelt events because the relatively steep slopes, thin soil cover, and permafrost in the watershed have a low capacity for retaining precipitation or meltwater.

The headwaters of Birch Creek are within the Circle Mining District, one of the richest placer gold mining districts in Alaska (Figure 1). Placer mining has been intermittently active, primarily on tributaries, within the Birch Creek watershed since the mid-1890s, nearly a century before upper Birch Creek was congressionally designated as part of the national wild and scenic rivers system.


Photo 1. Overview of a typical reach of Birch Creek WSR.

Placer mining typically involves rerouting streamflow into bypass channels and stripping riparian vegetation and overburden to reach gold-bearing streambed and floodplain gravels. Much of the gold recovered from stream placers is in the lowermost 3 feet of gravel and in cracks and holes in the bedrock. Prior to initiation of regulatory controls in the 1980s, placer mine operations often altered stream channels with little or no reclamation. Many abandoned placer mines left streams in bypass channels that are neither stable nor representative of the natural morphology of undisturbed reaches. Draglines, bulldozers, and excavators were used to move bed material to large trommel and wash plants that fed into a sluice with trough and riffle networks. Waste material was disposed in a series of tailing piles and settling ponds that were formed as mining progressed along the stream channel. Fine-grained materials were washed downstream or buried in settling ponds.

Mined channels and hillslopes are generally unstable due to the lack of vegetation. Vegetation does not readily grow on coarse tailings and even if the site is re-contoured, the lack of organic soils and other fine-grained material greatly extends the period of time required for natural revegetation. Moderate to heavy precipitation events can result in high sediment loads and turbid stormwater runoff from mined areas. (See Photo 2 for an illustration of the typical impacts associated with placer mining operations).


Photo 2. Impacts associated with placer mining on Birch Creek.

Alaska Water Quality Standards

Alaska's water quality standards (WQS) are established in Title 18, Chapter 70, of the *Alaska Administrative Code* (AAC) (18 AAC 70.005 - 18 AAC 70.050). A water quality standard defines the water quality goals of a water body by designating the use to be made of the water body and criteria that protect the designated uses of the water body.

The Alaska WQS (ADEC, 2020) identifies up to seven designated uses for fresh waters, as follows: (1) drinking water, (2) agriculture, (3) aquaculture, (4) water supply for industrial uses, (5) contact recreation, (6) secondary recreation, and (7) growth and propagation of fish, shellfish, other aquatic life, and wildlife. Where multiple uses are designated, the most stringent criterion applies. The designated uses of Birch Creek include water supply for drinking water, both contact and secondary recreation, and propagation of fish and aquatic life. The most stringent water quality criteria for turbidity are for drinking water and contact recreation (Table 1).

The best estimate of the natural turbidity of Birch Creek was derived from turbidity data at a station on Miller Fork in the uppermost part of the watershed, located above the areas that were disturbed by mining activity (EPA, 1996). The median turbidity at the Miller Fork station was determined to be 0.85 NTU. Therefore, the state criteria for turbidity for Birch Creek is equal to this value plus 5 NTU, or 5.85 NTU.

Table 1. Summary of Alaska Water Quality Standards for Turbidity that are Applicable to Upper Birch Creek (Source: ADEQ Water Quality Standards, Amended as of November 13, 2022).

Designated Use	**Criterion**
A. Drinking Water Supply	May not exceed 5 nephelometric turbidity units (NTUs) above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 25 NTU.
B. Water Recreation (i) contact recreation	May not exceed 5 NTU above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 15 NTU.
B. Water Recreation (ii) secondary recreation	May not exceed 10 NTU above natural conditions when natural turbidity is 50 NTU or less, and may not have more than 20% increase in turbidity when the natural turbidity is greater than 50 NTU, not to exceed a maximum increase of 15 NTU.
C. Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	May not exceed 25 NTU above natural conditions.

Turbidity in Birch Creek is affected by both point and nonpoint source discharges throughout the watershed. Point sources include active placer mining discharges, while potential nonpoint sources in the watershed include streambank erosion, resuspension of deposited sediment, and runoff from abandoned mine sites. Excess turbidity in the water column impacts drinking water sources, diminishes fish rearing success, and impairs recreational uses. Ambient water quality monitoring data has shown that segments within the upper Birch Creek drainage are water-quality limited due to turbidity.

Section 305(b) of the Clean Water Act (CWA) requires states to report on the health of all its waters (stream/river segments and lakes) every two years. In addition, Section 303(d) of the CWA requires states to identify threatened or impaired waters where required pollution controls are not sufficient for the water body to attain or maintain applicable WQS. The list of impaired or threatened waters is known as a Section 303(d) list.

In 2002, the Environmental Protection Agency (EPA) released new guidance to states for integrating the submission of Section 305(b) water quality reports and Section 303(d) lists of impaired waters (EPA, 2002). Since then, states have commonly combined the two reporting requirements into one report, which is now generally referred to as an Integrated Report. The 2002 guidance on preparing Integrated Reports recommended the use of five numbered categories that describe the water quality status of each assessed water body (Table 2). Based on this recommended framework, impaired waters that require the development of a total maximum daily load (TMDL) are determined to be Category 5 waters and make up the Section 303(d) list.

EPA policy allows states to remove water body segments from the 303(d) list, or delist them, after the states have developed a TMDL or after implementing other changes to correct water quality problems. For example, once a TMDL has been approved, the waters can be moved from Category 5 to Category 4a.

Table 2. Environmental Protection Agency recommended water quality categories for reporting water quality status (Source: https://www.epa.gov/sites/default/files/2018-09/documents/attains_calculations_of_epa_ir_categories_2018-08-31.pdf

Category	Description
1	All designated uses are supported, no use is threatened
2	Available data and/or information indicate that some, but not all, designated uses are supported
3	There is insufficient available data and/or information to make a designated use support determination
4	Available data and/or information indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed
4a	Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is established
4b	Available data and/or information indicate that at least one designated use is not being supported or is threatened, but other required control measures are expected to result in attainment of an applicable water quality standard in a reasonable period of time
4c	Available data and/or information indicate that at least one designated use is not being supported or is threatened, but non-attainment of any applicable water quality standard is not caused by a pollutant
5	Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed
5m	Non-attainment of any applicable water quality standard for mercury is the result of mainly atmospheric deposition sources and comprehensive mercury reduction programs are in place to address the impairment

Timeline of River Management Plans

1983: The Birch Creek River Management Plan (BLM, 1983), prepared by the BLM and U.S. Fish and Wildlife Service, established a management and development plan and detailed boundaries for the river corridor. The river management plan also provided an early 1980’s overview of water quality impacts related to placer mining activities.

Water quality in Birch Creek has historically been variable due primarily to the fluctuation of placer mining activities in the watershed. During periods of active placer mining activity water quality has been poor. During the period of low mining activity (1940's through 1960's), water quality improved to near natural conditions for Interior Alaska streams. Presently, water quality is poor, again due to a resurgence of placer mining activity in the headwaters area and other tributaries to Birch Creek.

This situation is expected to improve as technologies to control sediment additions to the river are developed and as the State and Federal governments continue to work with the miners to reduce the turbidity and suspended solids levels entering the river.

Water quality data collected in the late 1980s and early 1990s by the Alaska Department of Natural Resources (ADNR), Alaska Department of Fish and Game (ADF&G), and ADEC, indicated that waters of upper Birch Creek persistently exceeded the 5 NTUs above background criteria for turbidity.

1992: The ADEC listed upper Birch Creek on the state's Section 303(d) list as impaired for turbidity based on the 1980s-1990s water quality data.

1996: The EPA issued a TMDL for turbidity for upper Birch Creek including headwater tributaries Eagle Creek and Gold Dust Creek (EPA, 1996). The EPA estimated a natural turbidity level of 0.85 NTUs for upper Birch Creek based on turbidity data from the uppermost part of the watershed, above areas disturbed by mining activity. The TMDL was calculated as the natural background turbidity value of 0.85 NTUs plus the ADEC turbidity standard of 5 NTUs, or 5.85 NTUs.

The EPA determined sources of turbidity in upper Birch Creek were both point sources, including active placer mines, and nonpoint sources, including abandoned placer mines, stream bank erosion, and re-suspension of deposited sediment, as well as stormwater runoff from both abandoned and active mine sites. The 1996 TMDL report specifically noted:

"Data for upper Birch Creek above Twelvemile Creek shows dramatic improvement towards reduction of median values for Turbidity and Total Suspended Solids (TSS) between 1984 and 1994. This reflects efforts of both the regulatory agencies and the mining community in implementing sediment controls for point source discharges. However, several concerns remain, as evidenced by maximum values for both parameters, due to both nonpoint and point source inputs during rainstorms."

1998: Because a TMDL had been developed and finalized, the turbidity impairment for upper Birch Creek was removed from the Section 303(d)/Category 5 list and moved to Category 4a in the 1998 ADEC Integrated Report. Priority actions for this waterbody included continued inspections to monitor reduction of discharges from active mine sites, particularly during storm events; continued implementation of reclamation activities in key areas to address high-priority nonpoint source problems; and monitoring at key sites in the drainage to determine the extent of the water quality improvements.

2023: The BLM Alaska Eastern Interior Field Office is currently working to complete an updated River Management Plan for Birch Creek National Wild River.

Timeline of Water Quality Monitoring Actions

2001-2005: The U.S. Geological Survey (USGS), through an interagency agreement with the BLM, conducted water quality sampling in the upper Birch Creek watershed. The USGS also installed and operated a stream gage at Birch Creek above Twelvemile Creek (USGS stream gage number 15392000). Results were published in a 2007 USGS report (Kennedy and Langley, 2007). Similar to the EPA 1996 TMDL report, the USGS found water quality was generally good during low to moderate flow conditions, but recommended reclamation of abandoned placer mined lands to reduce excess sediment transport from disturbed areas during high-water events.

2006-2012: The BLM continued utilizing an interagency agreement with the USGS for operation of the upper Birch Creek stream gage, which included recording continuous streamflow data and periodic discrete and continuous water quality data. Collecting continuous water quality data on Birch Creek is difficult due to the extreme environment and frequent loss or damage to equipment during highwater events. Continuous water quality data were successfully collected during June-September of 2011 and 2012. Review of the daily mean turbidity values for 2011 and 2012 found the 5.85 NTUs turbidity standard was exceeded on about 32 percent of the days in the period of record. Active placer mines operating in the floodplain of upper Birch Creek (Photo 2) likely contributed to elevated turbidity values in 2011 and 2012. The USGS Birch Creek above Twelvemile Creek stream gage #15392000 was discontinued at the end of 2012 due to insufficient BLM funding. Annual cost of operating the USGS Birch Creek above Twelvemile Creek stream gage was $25,000.

The Eastern Interior Steese Record of Decision and Approved Resource Management Plan (RMP) (BLM, 2016) called for installation of stream gages on Birch Creek WSR to inventory streamflow and monitor water quality. The RMP identified management goals and decisions for protecting water quality, including the management decision for water identified as Management Decision – Water 14, which states the following:

> *To the extent it is economically and operationally feasible the BLM and/or cooperating agencies will operate and maintain long-term daily stream gage(s) near the beginning and/or end of the 126-mile Birch Creek Wild River Segment, consistent with the latest U.S. Geological Survey Standards and Methods. The stream gage should have satellite telemetry capability reporting hourly stage, discharge, water temperature, water turbidity, air temperature, and precipitation with data available on a public website.*

2016: With ADEC guidance and approval, the BLM completed a Surface Water Monitoring Quality Assurance Project Plan (QAPP) for upper Birch Creek. The surface water monitoring QAPP focused on establishing a stream gage site on upper Birch Creek, near WSR mile zero, for monitoring water quality compliance with Alaska's water quality turbidity standard for Birch Creek of 5.85 NTUs.

In addition, the ADEC also issued final guidance for listing turbidity impaired waters in a document titled "Listing Methodology for Determining Water Quality Impairments from Turbidity" (ADEC, 2016). This publication presents the applicable regulations as adopted in Alaska's WQS and includes information on the quantity and characteristics of data needed to be deemed sufficient and credible for determining water quality impairments. The 2016 Listing Methodology describes (1) how to evaluate turbidity data sets, and (2) how to determine if a waterbody is impaired for turbidity based on specified magnitude, duration, and frequency threshold criteria (Table 2).

Table 3. Turbidity Impairment Threshold Criteria

Criteria	Description
Magnitude	May not exceed 5 NTUs above natural conditions when the natural turbidity is 50 NTUs or less.
Duration	24-hour daily average is recommended to evaluate the duration of a turbidity exceedance. Continuous data collection is preferred with one or more samples collected per hour.
Frequency	Turbidity does not exceed 5 NTUs above natural conditions during more than 10 percent of the days sampled.

ADEC data requirements specify that turbidity data should be collected using in-water instruments that measure turbidity in nephelometric turbidity units (NTUs) and meet EPA method 180.1 requirements (EPA, 1993). The assessment period over which data is collected should span a minimum of two years. The years do not need to be consecutive, but should be within five years, if possible. During each year of data collection, samples should be collected over a minimum three-week annual period of concern, to ensure isolated impacts or weather events do not skew the dataset. Current data (less than five years old) are generally used for evaluation of turbidity.

2017: In June of 2017 the BLM installed a new stream gage/climate station at approximately the same location as the discontinued USGS stream gage 15392000, upstream of the BLM Birch Creek Wayside at mile 94 of the Steese Highway (Shown in Photo 3 and Figure 2). Stage, water temperature, air temperature, cumulative precipitation, and water turbidity data are recorded at 15-minute intervals and transmitted hourly utilizing Geostationary Operational Environmental Satellite (GOES) telemetry. Streamflow data is collected to determine instream flow quantities necessary for recreational use, healthy fish populations, and maintaining ecologically and physically sound watersheds. Water quality parameters are collected to monitor changes in health of the watershed and to document that water quality is meeting ADEC standards. Streamflow and climate observations are available online to the public to assist planning recreational float trips. Web-site links to the stream gage data are available on BLMs Birch Creek web page.

Initial start-up cost for the stream gage instrumentation shelter, satellite telemetry equipment, and vented pressure transducer for monitoring water stage was approximately $10,000 with funding provided by the BLM Aquatic Habitat program and the Recreation program. Additional funding of $9,000 for an automated multi-parameter water quality meter was provided by the BLM Aquatics program. Annual operating cost, not including labor, is about $2,500 for maintenance and calibration of equipment.

In mid-September of 2017, spikes in turbidity levels recorded at the new BLM stream gage station directly led to an ADEC investigation and enforcement action against a placer-mine operation illegally discharging turbid wastewater about 4 miles upstream of the Birch Creek stream gage.

2023: The ADEC began reviewing the most recent five years (2018 – 2022) of turbidity data for Birch Creek above Twelvemile Creek to determine to what extent upper Birch Creek is attaining turbidity water quality standards (Table 2). The 2018 through 2022 turbidity data are not continuous due to restricted field work during the COVID-19 pandemic, staff shortages, and occasional equipment problems. Nonetheless, preliminary analysis of the 2018-2022 data indicates that daily mean turbidity levels for upper Birch Creek are showing improvement (Table 4). Alaska's water quality turbidity standard of 5.85 NTUs, specified in the 1996 TMDL document issued by the EPA (EPA, 1996), was exceeded less than 15 percent of the days during the 2018 and 2020 period of record and less than 5 percent of the days during the 2021 and 2022 period of record. The 2018 turbidity record includes several days of data recorded during spring break-up. The 2020 turbidity record includes data recorded during multiple late summer storm events. No large storm events occurred during the 2021 period of record. As reference, Photograph 3 shows July 2020 low-flow clearwater conditions at the BLM stream gage site and Photograph 4 shows May 2018 high-flow turbid water conditions at the same location. Results of the ADEC 2018-2022 turbidity data review will be included in the ADEC 2024 Integrated Report.

Photo 3. Birch Creek with BLM stream gage and climate monitoring station.


Photo 4. Birch Creek at BLM stream gage site showing high flow turbid water conditions.

Future Actions

The WSR Act requires that state water pollution control agencies and river managing agencies work cooperatively to eliminate and reduce water quality pollution in designated rivers. Working cooperatively with ADEC to assess the water quality of Birch Creek is a high priority for the BLM, and installation of the 2017 long-term stream gage is a major addition to interagency efforts. Along with stream gaging efforts, BLM will continue to conduct mining compliance inspection and continue to work with the mining community to limit turbidity caused by disturbed sites. Advances in stream reclamation methods, more stringent regulations, increased mining compliance inspections, and ongoing natural regrowth of vegetation in disturbed areas have all likely contributed to reduced turbidity levels in the watershed.

Table 4. Number of days when daily mean turbidity levels exceeded the EPA TMDL of 5.85 NTUs for upper Birch Creek from 2018 – 2022.

	Years					Period of Record
	2018	2019	2020	2021	2022	2018-2022
Start Date	05/23/18	NA	06/10/20	07/08/21	06/03/22	05/23/18
End Date	08/29/18	NA	09/30/20	09/17/21	09/28/22	09/28/22
No. of days in record	99	NA	113	72	118	402
No. of days where daily mean NTU > 5.85	11	NA	12	0	3	26
percentage of days where daily mean NTU >5.85	11%	NA	11%	0%	3%	6%
Instrument Mfg./model	DTS-12	NA	YSI 6920	YSI EXO2	YSI EXO2	

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Case Study 2 – Monitoring Harmful Algal Blooms on the Virgin Wild and Scenic River, UT

Introduction

The Virgin River is located on the Colorado Plateau in southwestern Utah (Figure 1). The Omnibus Public Land Management Act of 2009 (Public Law 111-11) designated 163.3 miles of the Virgin River and its tributaries as a Wild and Scenic River (145.4 miles wild, 11.3 miles scenic; and 12.6 miles recreational)[16]. The designated river segments and associated boundaries cover 39,407 acres of lands managed by Zion National Park (Zion NP) and the Bureau of Land Management (BLM). Generally, segments begin within lands managed by the BLM upstream from Zion NP and designation terminates at the downstream boundary in Zion NP.

The majority of the Virgin Wild and Scenic River (WSR) occurs within wilderness. Upstream development is limited to small, rural, seasonal homesteads and cattle ranches. Within the designated segments, recreational development occurs only within Zion NP in those sections of the North Fork of the Virgin River below the Temple of Sinawava, Clear Creek, and portions of Taylor Creek. Recreational development consists of roads, pedestrian, and vehicular bridges, multiuse trails, campgrounds, parking lots, comfort stations, and a visitor center. The BLM St. George Field Office and the Zion National Park share management of the river.

Despite being located within a relatively undeveloped watershed, benthic Harmful Algal Blooms (HABs) emerged as a river management problem in the Virgin WSR. River managers first became aware of the HABs in 2020 and since that time have devoted substantial resources and staff time to monitoring and managing recreational use.

Outstandingly Remarkable Values

The Virgin WSR supports multiple Outstandingly Remarkable Values (ORVs) including cultural, geologic, recreational, ecological processes, fish, and wildlife, most of which are dependent on outstanding water quality.

- **Cultural** – In the arid southwest, plentiful water from the Virgin River and its tributaries has provided and supported resources allowing communities for thousands of years to flourish, supplying both drinking water and water for irrigation of agricultural lands.
- **Geologic** – Situated on the western edge of the Colorado Plateau, the geologic structure of the Virgin River area has allowed the river to carve a complex network of narrow canyons into the depths of the Navajo Sandstone (Photo 1).
- **Recreational** – The canyons within the Virgin River system have drawn visitors for activities such as canyoneering, hiking, and backpacking, as well as photography and other artistic ventures.
- **Scenic** – The lushness supported by the river and tributaries exist in stark contrast with the arid desert landscape.

[16] Retrieved 6/05/2023 from https://www.rivers.gov/rivers/virgin.php

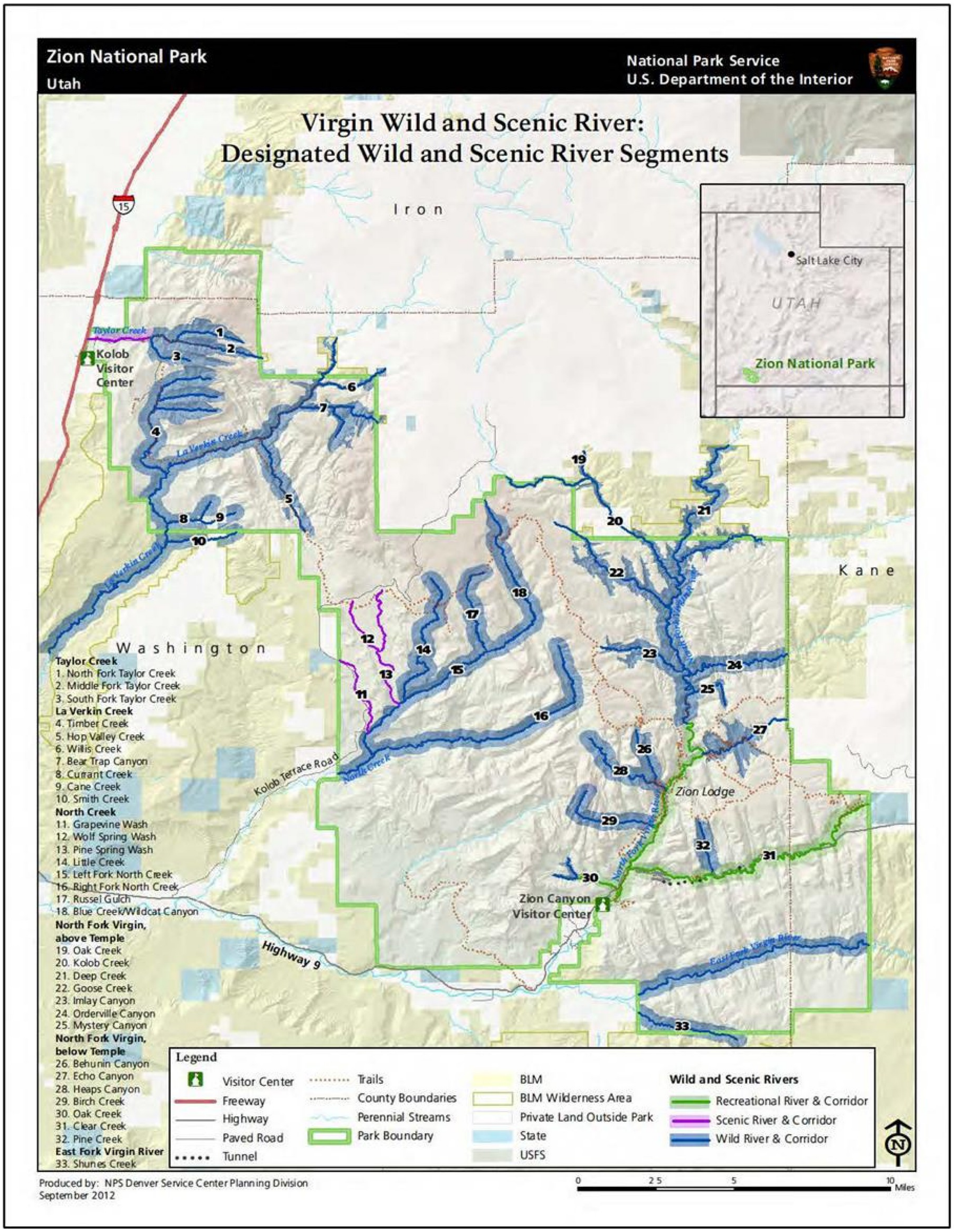

Figure 1. Virgin Wild and Scenic River in Zion National Park.

- **Ecological Processes –** Some tributaries of the Virgin River preserve exemplary riparian corridors and rare plant communities despite human use over thousands of years.
- **Wildlife** – The Virgin River system supports successful populations of river dependent species such as desert bighorn sheep, Mexican Spotted Owl, and the endemic Zion snail.
- **Fish Values** – The Virgin River system is home to healthy populations of four native fish species who are reliant upon the unique high flow and high turbidity regimes precluding non-native fish groups, such as trout, from colonizing the river.

Human Uses of the Virgin Wild and Scenic River

The Virgin WSR supports a range of beneficial uses. Zion NP, several downstream municipalities, and private entities divert water from the Virgin River for different uses including municipal and irrigation water supplies within designated WSR segments. The Virgin WSR and its designated tributaries are a primary attraction to Zion NP, which brought over five million visitors to the park in 2021. Backcountry wilderness areas within the BLM designated sections and within Zion NP see a variety of recreational uses from hiking, backpacking, and canyoneering. For a brave contingent of seasoned whitewater kayakers, the Virgin River can be floated during high flow events. Within the front-country in Zion NP, visitors to the river and its corridor enjoy camping, hiking, bike riding, and swimming.

The two river co-managing agencies, the BLM and NPS, co-authored the “Virgin River Comprehensive River Management Plan/Environmental Assessment” (CRMP/EA) in July 2013. The plan speaks broadly to the need to protect and enhance the river’s water quality by controlling fecal contamination and managing stormwater runoff over developed surfaces. At the time that the plan was in development, the designated rivers were not known to have a Harmful Algal Bloom (HAB), nor had there been a known issue in the region regarding HABs in river systems. Therefore, there was no specific mention of HABs in the CRMP/EA.

Overview of Water Quality Issue

HABs are a complex ecological phenomenon which occur when toxin-producing cyanobacteria become abundant or dominate an aquatic ecosystem. These toxin cyanobacteria may exist throughout the water column (pelagic zone) or may form mats attached to the bottom (benthic zone) of a waterbody. These mats can detach from the waterbody bottom and float to the surface after disturbance. When the toxin-producing cyanobacteria become prolific, the risk of human exposure to the harmful cyanotoxins they produce increases (ITRC, 2022).

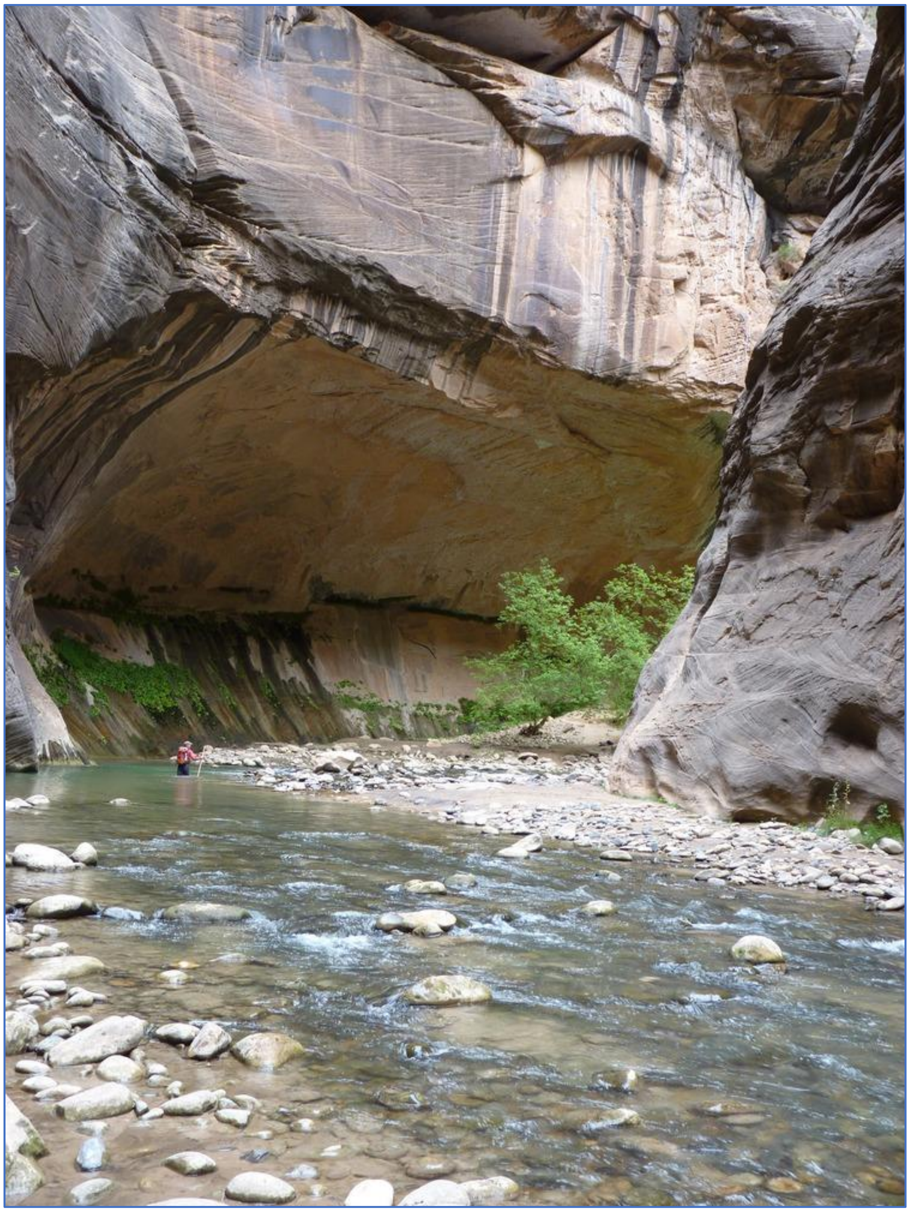

Photo 1. One of Zion NP's most popular hikes, the Narrows, requires hikers to walk through and along the North Fork of the Virgin River.

A reported suspicious dog death on July 4, 2020, alerted Zion NP and the Utah Department of Environmental Quality (UDEQ) officials of a suspected benthic HAB in the North Fork of the Virgin River. In this case, a dog was seen snapping at a floating mat in the river by its owner and quickly thereafter began exhibiting symptoms consistent with neurotoxic poisoning. In response to the reported incident, park officials collected cyanobacteria and cyanotoxin samples in the North Fork of the Virgin River and found two species present that are known to produce a cyanotoxin, anatoxin-a (Photos 2 and 3). Some of the benthic mats analyzed contained high levels of this cyanotoxin, including at the site the deceased dog was exposed to the river. Subsequent sampling found the toxin-producing species present throughout the Virgin River and its tributaries within Zion NP including North Creek, La Verkin Creek, and the East Fork of the Virgin River designated WSRs.

Photo 2. Cyanobacteria growing on the side of a boulder at the site of the dog exposure in the North Fork of the Virgin River five days after the dog's reported death.

Photo 3. Growth of light to dark brown Microcolues anatoxicus along the edge of the North Fork of the Virgin River near the Zion NP Lodge

Since discovery of the benthic HAB in Zion NP, cyanobacteria have been identified in other waterbodies across the Colorado Plateau. Therefore, it is possible that this type of cyanobacteria is native to the Virgin River system and the Colorado Plateau region. However, the HAB event at Zion NP was the first known benthic HAB event in a river system in the region.

Human exposure to harmful cyanotoxins may occur through primary and secondary contact recreation as well as through backcountry and municipal drinking water through a culinary water intake on the North Fork of the Virgin River within the park.

Site Specific Water Quality Regulations

There are no federal regulations for cyanotoxins in drinking water in the United States. Cyanobacteria and their cyanotoxins have been included in the U.S. Environmental Protection Agency (EPA) Contaminant Candidate List, a list of unregulated contaminants known or anticipated to occur in drinking water supplies and may require regulation. While the EPA has established non-regulatory guidance values for some cyanotoxins, such guidelines do not exist for the type of cyanotoxin (anatoxin-a) observed in the Virgin River, for either drinking water or recreation. The World Health Organization (WHO) published provisional short-term drinking water guidance values for anatoxin-a of 30 µg/L for adults and 6 µg/L for children and infants. The WHO also published provisional recreational water guidance values of 60 µg/L for anatoxin-a (Chorus and Welker, 2021). The UDEQ has established a recommended recreational advisory threshold of 15 µg/L of anatoxin-a for issuance of a Warning Advisory and 90 µg/L for issuance of a Danger Advisory (Table 1).

However, there do not exist world-wide, national, or state standards or guidance for issuance of human health recreational advisories developed specifically for benthic HABs. Recommended and provisional recreational advisory thresholds described above have been developed only for anatoxin-a assuming that exposure occurs when cyanotoxins are suspended in the water column. In Zion NP's benthic HAB event, cyanotoxins were found only in extremely low levels within the water column (under 1 µg/L), whereas extremely high toxin concentrations (over 3,000 µg/L) have been detected in the mat material. This signifies the greatest risk to human and domestic animal exposure comes from incidental ingestion of the mat material. Given the high level of recreation occurring in Zion NP, these benthic mats are easily disturbed by visitors walking or playing along the river edge (where the benthic mats are most abundant) or during flood events when mats may become dislodged naturally. Further, there are no existing worldwide, national, or state advisory thresholds that are based on the abundance of benthic cyanobacteria. States have issued advisories based on either a presence/absence approach when toxin-producing cyanobacteria are detected in a system or based on the highest concentration of toxins detected in a system (ITRC, 2022).

Table 1. 2021 UDEQ Recommended Advisory Thresholds.

<table>
<tr><th>Observed / Potential Bloom</th><th></th><th>Warning Advisory</th><th>Danger Advisory</th></tr>
<tr><td rowspan="6">This is not a formal advisory level. Rather, these are indicators that a bloom may exist or may become more severe. Increased monitoring and surveillance are strongly recommended. Indicators may include:
• Visual reports
• Reports of animal or human illness
• Detection of cyanotoxins or toxigenic cyanobacterial cell density below thresholds
• Detectable levels should be defined using appropriate QA/QC procedures

Consider cautioning users of the waterbody depending on specifics of the event and waterbody.</td><td>Toxigenic Cyanobacteria Cell Density (cells/mL) [1, 2, 3]</td><td>100,000 [A]</td><td>See footnote B</td></tr>
<tr><td>Microcystins (µg/L) [1, 2, 3]</td><td>8</td><td>2,000</td></tr>
<tr><td>Cylindrospermopsin (µg/L) [3]</td><td>15</td><td>See footnote B</td></tr>
<tr><td>Anatoxin-a (µg/L) [3, 4, 5]</td><td>15</td><td>90</td></tr>
<tr><td>Health Risks [1, 2, 3]</td><td>Potential for long-term illness
Short-term effects (e.g., skin and eye irritation, nausea, vomiting, diarrhea)</td><td>Potential for acute poisoning
Potential for long-term illness
Short-term effects (e.g., skin and eye irritation, nausea, vomiting, diarrhea)</td></tr>
<tr><td>Recommended Actions</td><td>Issue WARNING advisory to avoid primary contact recreation

Post WARNING signs

Sampling recommended at least weekly</td><td>Issue DANGER advisory to stay away from the waterbody

Post DANGER signs

Consider CLOSURE

Sampling recommended at least weekly</td></tr>
</table>

[1]WHO, 1999. Toxic cyanobacteria in water.
[2]WHO, 2003. Guidelines for safe recreational water environments, Volume 1, Chapter 8: Algae and cyanobacteria in fresh water.
[3]EPA, 2019. Recommended human health recreational ambient water quality criteria or swimming advisories for microcystins and cylindrospermopsin.
[4]OHA, 2019. Oregon Health Authority. Recreational use public advisory guidelines: cyanobacterial blooms in freshwater bodies.
[5]CWQMC, 2016. California Water Quality Monitoring Council. Cyanobacteria guidance for recreational and related water uses (2016 update).
[A]Human symptoms have been reported between 5,000 – 100,000 cells ml (EPA 2019). At 5,000 – 100,000 cells/mL, LHDs should take into account contextual information and consider issuing an advisory.
[B]Data are sparse on where cylindrospermopsin and cell density danger advisory breakpoints should be. Consult with UDEQ and UDOH as needed on this issue. LHDs should take into account contextual information and consider issuing an advisory.

Management Actions

Zion NP has been monitoring for toxin-producing cyanobacteria and cyanotoxins monthly since September 2020 in three of its major tributaries to the Virgin River: North Fork of the Virgin River, North Creek, and La Verkin Creek. While toxin-producing cyanobacteria and cyanotoxins were identified in the East Fork of the Virgin River in September 2020 through distribution surveys, the East Fork of the Virgin River through Zion NP is managed as a Research Natural Area precluding public access. In the absence of human recreation, the East Fork of the Virgin River is not regularly monitored.

Monitoring is completed by park staff and most lab analysis costs are covered by the park. During the recreation season, May through October, EPA Region 8 has provided some analytical services for Zion

NP samples free-of-charge through an agreement with the State of Utah. The NPS works closely with the UDEQ in administering the monitoring plan and issuing recreational health advisories. The NPS has also been working closely with the river's co-managing agency, the BLM, in developing a monitoring plan for WSR sections outside of the park.

Zion NP uses three different criteria as part of a multiple-lines-of-evidence approach to monitor HAB events and issue recreational water body advisories. The three different criteria are based on visual inspections for toxigenic cyanobacteria species, collection of benthic disturbance samples, and an emerging sampling technology, Solid Phase Adsorption Toxin Tracking (SPATT) samples.

- **Visual Inspection:** The first criterion is visual inspection for toxigenic cyanobacteria species. Since exposure risk in river systems is not currently well understood, any visual confirmation of a toxigenic cyanobacteria species warrants an advisory to the public. Visual inspection consists of inspecting both sides of the water body 25 meters upstream and downstream of each permanent SPATT monitoring site for one or more toxigenic species. A sample may be collected for further taxonomic analysis. A visual confirmation of one or more toxigenic cyanobacteria species anywhere in the water body during the sampling period may be considered as well. Importantly, the absence of cyanobacteria based on visual inspection does not assure that cyanotoxin are not present.

- **Benthic Disturbance Samples:** The second criterion is benthic disturbance samples. Benthic disturbance samples aim to capture the reasonable worst-case recreational exposure scenario by artificially disturbing colonies of toxigenic cyanobacteria and creating a reasonable exposure situation for which the cyanotoxin thresholds set by the State of Utah can be applied. Benthic disturbance sampling consists of stepping for five seconds on a roughly one square meter area where a toxigenic cyanobacteria mat is present, using a 2.5-gallon bucket to scoop the disturbed bacterial mats and water and then subsampling from the bucket of disturbed water. If no toxigenic species are visibly present within 25 meters upstream and downstream of the permanent SPATT monitoring site for the water body, the benthic disturbance samples are taken nearest to the SPATT monitoring site. In some cases, multiple benthic disturbance samples may be taken from one waterbody. To be protective, the highest concentration detected will be used to issue advisories for the entire connected waterbody.

- **Solid Phase Adsorption Toxin Tracking (SPATT) Samples:** The third criterion is SPATT. SPATT is an emerging technology that passively collects dissolved cyanotoxins in the water column over a period of time (Photo 4). SPATT bags are comprised of resin beads sandwiched between two layers of fabric held by an embroidery hoop. As water filters through the hoop, dissolved toxins adsorb to the resin beads. Those toxins are later extracted from the outside of the beads in a laboratory. Zion NP staff chose to deploy SPATT samplers for a period of 8–10 days as initial SPATT testing in July 2020 detected a higher concentration of toxins per day when bags were deployed for 10 days as opposed to 5 days. Concentrations of cyanotoxins in the SPATT bags may be subject to a variety of factors such as flow, turbidity, and pH. Therefore, under guidance from UDEQ, Zion NP staff issue advisories from SPATT cyanotoxin results as detect or non-detect rather than as a concentration per weight of resin beads.

Zion NP issues three levels of advisories based on the different criteria. These advisories mirror the State of Utah's Harmful Benthic Cyanobacteria (HCB) advisory levels: Danger, Warning, and Health Watch (Table 2). Any one of these three criteria may be used to issue or update an advisory since the scientific and regulatory community do not fully understand the conditions under which benthic toxigenic cyanobacteria species produce cyanotoxins, or the most appropriate monitoring method to protect public health (Wood et al. 2020).

For example, benthic disturbance samples of toxigenic cyanobacteria colonies have not detected cyanotoxins, but SPATT results from a bag deployed during the same time in the same waterbody have detected cyanotoxins. This scenario implies that somewhere in the waterbody there was toxigenic cyanobacteria colony that produced cyanotoxins harmful to human health, but park staff did not happen to sample a toxigenic cyanobacteria mat while it was producing cyanotoxins through the benthic disturbance sample. Under this scenario, the waterbody would be issued a Warning Advisory due to the positive SPATT results.

Photo 4. SPATT bag deployed in the North Fork of the Virgin River.

A municipal water intake for a local gateway community is located on the North Fork of the Virgin River within the park. Monitoring data is closely shared with the agency responsible for water quality monitoring of this municipal drinking water supply. No detections of the cyanotoxin associated with the Zion NP benthic HAB have been found in the finished drinking water of this system to date. Local stakeholders are notified of changes to advisories via e-mail to government leaders and municipal administrators. Visitors are notified of the current recreational advisory via signs posted at all trailheads, permits, visitor contact stations and major river access points (Figure 3), posts on the park website, social media, and through in-person ranger contacts. The park may issue press releases when the advisory is elevated to a Danger Advisory and these notifications tend to be reported on by local news outlets.

The park has also been working with the Utah Division of Wildlife Resources to monitor the health of wildlife and fish since 2020 to understand if HAB events have had a measurable effect on the ecological community. Data does not suggest that HAB events have affected fish resources as post-event monitoring data has shown steady populations and successful reproduction compared to data prior to July 2020. There have been no observed effects on other wildlife in the park.

Table 2. Zion NP Benthic HAB Recreational Advisory Decision Criteria

Harmful Benthic Cyanobacteria Recreational Advisory Decision Criteria					
Advisory	Permitted Activities	Human Health Risk	Data		
			Presence of Toxigenic Cyanobacteria Species	Benthic Disturbance Sample	8 to 10-day SPATT
Danger Advisory (avoid all contact with the water, never drink the water)	Permitted waterbody-related activities allowed; language in the permits indicating Danger	Potential for acute poisoning		Greater than 90 µg/L of anatoxin-a	
Warning Advisory (avoid primary contact recreation, never drink the water)	Permitted waterbody-related activities allowed; language in the permits indicating Warning	Potential for long-term illness Short term effects (e.g. skin and eye irritation, nausea, vomiting, diarrhea)		Less than 90 µg/L but greater than 15 µg/L of anatoxin-a	Detection anatoxin-a
Health Watch (avoid primary contact recreation, never drink the water)	Permitted waterbody-related activities allowed, permanent language indicating risk	Unknown	Toxigenic cyanobacteria present	Detection of anatoxin-a but less than 15 µg/L	Non-detect anatoxin-a
No Advisory (never drink the water)	Permitted waterbody-related activities allowed, permanent language indicating risk		Toxigenic cyanobacteria not present	Non-detect anatoxin-a	Non-detect anatoxin-a

Figure 3. Zion NP Warning Advisory Signage.

Results of Monitoring and Water Quality Actions

While there are several studies underway attempting to understand habitat preferences of toxin-producing cyanobacteria and evaluating the link between benthic HABs and other water quality parameters, a clear factor attenuating the occurrence of HABs in the Virgin River system is scouring high flow events. The Virgin River system tends to see two distinct high flow regimes: snowmelt and monsoon. During snowmelt, which typically occurs from March through June, the Virgin River sustains high flows precluding the growth of cyanobacteria mats. During a typical monsoon from July through September, regularly occurring storm events in the Virgin River watershed cause scouring high flows that limit the growth of benthic cyanobacteria. The 2020 monsoon season, the season in which the park initially discovered the occurrence of benthic HABs, was the second driest season in a record dating back to 1928 with only a single minor flood event during the entire season. The abnormally low flow conditions during this season likely allowed the benthic cyanobacteria to flourish. Since 2020, the park has detected several short-lived HAB events necessitating Warning and Danger advisories to be issued. Each of these events are linked to periods of low flow and drier hydrological conditions.

Zion NP will continue monitoring HABs to protect public health. Results of several on-going studies in the park, including those evaluating the efficacy of backcountry drinking water methods on reducing toxin-levels and identifying habitat preferences of cyanobacteria, will be made available upon completion.

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Case Study 3 –Water Quality Management on the Red River Wild and Scenic River, KY

Introduction

The Red River flows for over 97 miles through eastern Kentucky, until it reaches the Kentucky River near Winchester. Over the years, the river formed the Red River Gorge, a beloved and heavily visited part of the state known for its natural stone arches, caves, rock shelters, and cliffs overlooking magnificent stream valleys.

The Red River Designation Act of 1993 (Pub. L. No. 103-170, 107 Stat. 1986, 1993) amended the Wild and Scenic Rivers Act to designate 19.4 miles of the Red River as part of the national Wild and Scenic River system.[17] Congress found that "the natural, scenic, and recreational qualities of the Red River in Kentucky are unique and irreplaceable resources; and the majority of the Red River corridor is within the Red River National Geologic area, which contains sedimentary rock formations unique to Kentucky and the United States and should therefore be preserved for public enjoyment." The Red River Designation Act of 1993 designated a 9.1-mile segment known as the "Upper Gorge," extending from the Highway 746 Bridge to Swift Camp Creek, as a wild river, and a 10.3-mile segment known as the "Lower Gorge," extending from Swift Camp Creek to the School House Branch, as a recreational river. The Red River is Kentucky's only National Wild and Scenic River.

The Red River Gorge is located southeast of Lexington, KY, and downstream of privately owned lands, small towns, and farms (Figure 1). Streams in these headwater areas are mostly in good condition but are threatened by illegal dumps, loss of streamside vegetation, and runoff from towns, agriculture, and rock quarries. Pathogens in several creeks threaten public health and drain into the Red River Gorge. Swift Camp Creek and one of its unnamed tributaries, upstream of the gorge, are listed as impaired in the Kentucky Division of Water (KDOW) 2010 Integrated Report to Congress (KDOW, 2011) for sedimentation, loss of riparian habitat, sewage disposal, and other unknown causes.

The Red River Gorge Restoration and Watershed Plan is part of a watershed planning project that addresses watershed-scale issues facing the Red River Watershed. In 2009, the first in a series of Clean Water Act §319(h) grant applications were submitted and funded. These grants focused on four tributaries to the Red River: Swift Camp Creek in Wolfe County, Clifty Creek in Menifee and Wolfe Counties, Gladie Creek in Menifee County, and Indian Creek in Menifee and Powell Counties. These tributary streams are headwater streams to the Red River, and they each begin on private land surrounding the Gorge.

There were two main goals of the project: protection of the Red River Gorge by reducing erosion and stream sedimentation from recreation; and developing a watershed-based plan that focuses on identifying pollution sources in the watershed, quantifying pollution coming from each source, and making recommendations for Best Management Practices (BMPs) to improve water quality in the future. Accomplishments included trash removal and river clean-up projects (Figure 2), trail restoration and erosion control (Figure 3), and volunteer engagement (Figure 4).

[17] Retrieved 6/5/2023 from https://www.rivers.gov/rivers/red.php

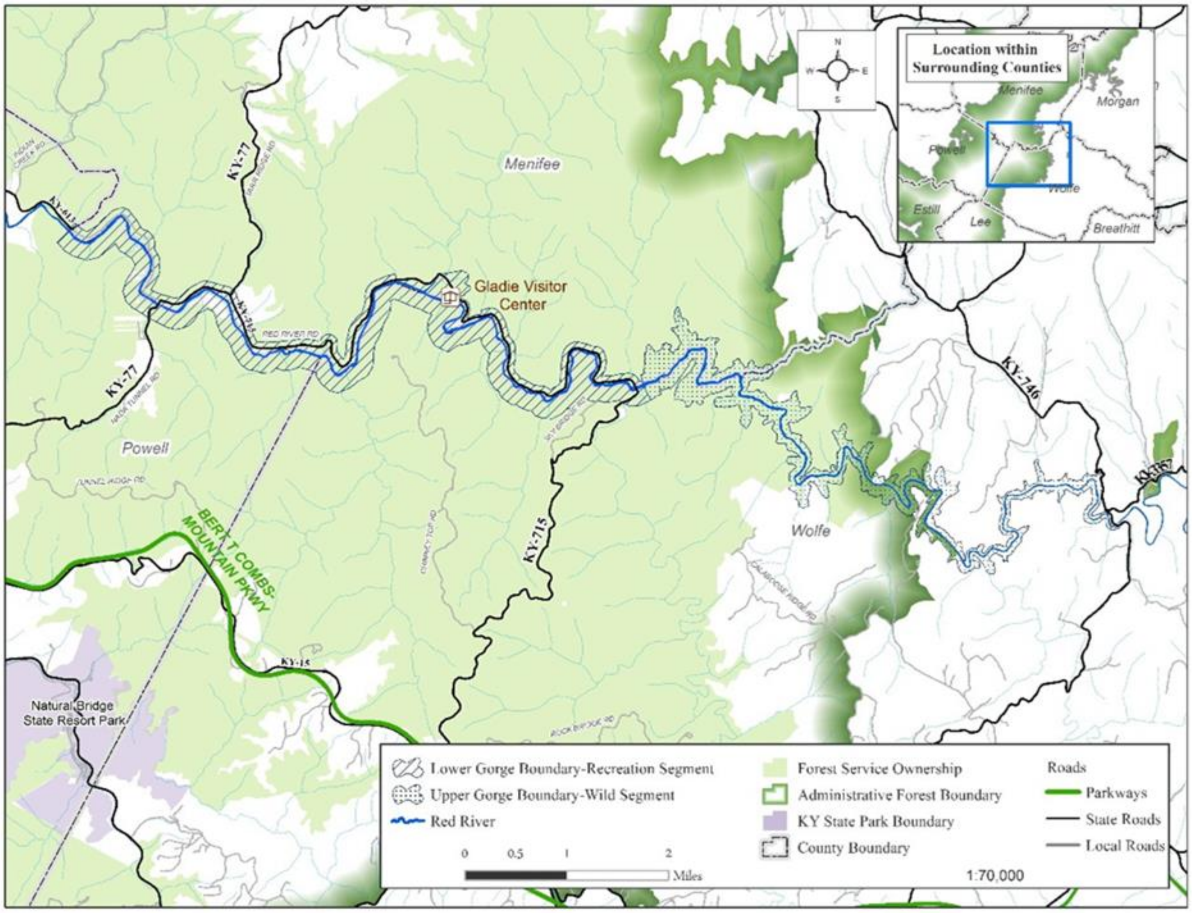

Figure 1. Map of Vicinity and Final Red Wild and Scenic River Boundary

Specific accomplishments of this project included:

- Rehabilitating 157 eroding user-developed campsites
- Reducing erosion on over 32 miles of trail
- Eliminating 416 tons of stream sedimentation per year
- Cleaning trash from over 75 miles of stream
- Developing watershed plans for the Red River Gorge and the upper portions of four sub-watersheds

Many public involvement and educational components were part of this project, including:

- Formation of a watershed group
- Educating Red River Gorge visitors about ways to reduce erosion and "Leave No Trace"
- Classroom and outside environmental education
- Development and distribution of educational banners and brochures

The Red River Gorge Restoration and Watershed Plan project achieved the "Measures of Success" established during planning. Each goal and objective for the project was met. Information demonstrating the amount of nutrients and sediment removed as part of the Watershed-Based Plan implementation are shown in Table 1. The lessons learned during this project will be used in other areas of the Daniel Boone National Forest (DBNF) and across the southeastern United States.

Figure 2. Trash removal from the Red River

Figure 3. Interns and trail crew members planting trees for slope stability.

Figure 4. Student volunteers collecting stream information on Indian Creek.

Outstandingly Remarkable Values

Scenery, recreation, geology, fisheries, history/archaeology, and botany are outstandingly remarkable values for both the wild and recreational segments of the Red River (USFS, 2022). Short descriptions of each value are as follows:

- **Scenery -** Scenery along the Red River corridor, within the Red River Gorge, is exemplary within the region of comparison. The attributes of the concentration of unique geologic features, rich composition of plant communities, and distinct water characteristics meld together to create attractive and distinctive scenery.
- **Recreation -** The Red River attracts visitors from across Kentucky, the United States, and internationally to partake in canoeing, kayaking, hiking, sightseeing, photography, camping, rock climbing, and rappelling.
- **Geology -** The wild segment is remarkable for large boulders along the shore and in the river that have created class III rapids. Within the recreational section, the geologic features reach their greatest density and development.
- **Fisheries -** The Red River possesses the ability to support high native aquatic biodiversity and provide habitat for recreational fisheries and at-risk aquatic species. A total of 70 native fish species and 16 mussel species have been detected or are believed to occur in this part of the river.

- **History and Archaeology -** The wild and scenic river area and the surrounding Red River Gorge area has been occupied for over 10,000 years by multiple cultural groups and for sacred purposes. Within the 17.8 percent of the corridor that has been surveyed, at least 20 sites are contributing elements to the National Register of Historic Places.
- **Botany** – The corridor possesses a combination and stratification of many species. The flora in the corridor is relatively intact, especially in the federal ownership portion of the wild segment where access is somewhat more difficult and the corridor provides a good gradient of dry to mesic positions, sandstone to limestone bedrock, shaded to high-light areas, and seasonal variation. The recreational segment has somewhat more diverse flora than the wild segment as more discrete habitat types are available.

River Setting Description

The Red River runs through the Red River Gorge in the Cumberland District of the DBNF (Figure 1). The Red River Gorge is located on the western edge of the Cumberland Plateau where a resistant sandstone belt of cliffs and steep sided, narrow-crested valleys known as the Pottsville Escarpment hosts the highest concentration of natural arches east of the Mississippi. The Red River crosses this escarpment, meandering through multiple geologic strata with diverse geologic features while flowing freely through a variety of primarily forested habitat.

The wild segment is free of impoundments, meets water quality requirements, and the shoreline and immediate environment are primitive. No habitations or other signs of development can be seen from this stretch of river. It is relatively inaccessible except by trail at two sites where an undeveloped trail parallels the river for approximately 2.5 miles in the lower reach of the segment. The wild segment was designated in 1972 by the state as a Kentucky Wild River.

The recreational segment has some development along the shoreline but remains primarily forested, with some agricultural land, visible dwellings, and commercial subdivisions. Three public roads and some private lands are also located in this segment. This segment is non-wilderness, located entirely in the Red River Gorge Geological Area.

Kentucky Water Quality Standards for Surface Water

The Kentucky Administrative Regulations (KAR) establishes water quality standards for the state that consist of surface water-designated uses and the associated water quality criteria necessary to protect those uses. Surface water designated uses include warm water aquatic habitat, cold water aquatic habitat, primary contact recreation, secondary contact recreation, domestic water supply and outstanding state resource waters (401 KAR 10:026). The water quality criteria are the minimum requirements that apply to all surface waters in the state necessary to support their designated uses. They are subject to periodic review and revision in accordance with the Clean Water Act, 33 U.S.C. 1251-1387, 40 CFR 131 (2023).

The KAR Water Quality Standards (401 KAR 10:031) covers a range of water quality-related topics in 13 different sections, such as Nutrients Criteria (Section 1), Use Designations and Associated Criteria (Section 3), Aquatic Life (Section 4), Pollutants (Section 6), and Compliance Schedules (Section 12). The focus of this case study is on Recreational Waters (Section 7) and Outstanding State Resource Waters (Section 8).

Section 7 of 401 KAR 10:031 establishes water quality criteria for recreational waters, including specific limits for *Escherichia coli (E. coli)* concentrations. Specifically, *E. coli* "content shall not exceed 130 colonies per 100 ml as a geometric mean based on not less than five (5) samples taken during a thirty (30) day period. Content also shall not exceed 240 colonies per 100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period for *Escherichia coli*."

Section 8 of 401 KAR 10:031 provides a description of waters with an outstanding state resource water (OSRW) designated use. Section 8 states that "Waters designated pursuant to the Federal Wild and Scenic Rivers Act, 16 U.S.C. 1271-1287" are automatically included in this category, as are waters designated pursuant to the Kentucky Wild Rivers Act (Ky. Rev. Stat. § 146.200) and waters that support federally recognized endangered or threatened species pursuant to the Endangered Species Act of 1973 (16 U.S.C. §1531 et seq.,1973). Section 8(2)(c) addresses OSRW protection:

1. Existing water quality and habitat shall be maintained and protected in those waters designated as OSRW that support federally threatened and endangered species of aquatic organisms unless the Cabinet determines that lowering water quality or a habitat modification will not have an adverse effect on the threatened or endangered species that the water supports.
2. If the basis of the OSRW designation depends on or relates to instream water quality, the Cabinet shall:
    a. Review existing water quality criteria to determine if additional criteria or more stringent criteria are necessary to protect the water; and
    b. Evaluate the need to develop additional data upon which to base the determination.
3. If the Cabinet determines that more stringent instream water quality criteria are necessary to protect the basis of the OSRW designation as established in paragraph 2 of this subsection, those additional protective criteria shall not be effective until the Cabinet lists those criteria with the respective waterbody in 401 KAR 10:026.

Kentucky's antidegradation policies and implementation methods are included in KAR 401 10:030. Antidegradation procedures apply to surface waters in Kentucky based on four categories of water. Each category has specific antidegradation requirements and implementation procedures. The four categories are Outstanding National Resource Water (ONRW), Exceptional Water, High Quality Water, and Impaired Water. Both ONRW and Exceptional Water are categories of water that receive additional protections under the state's antidegradation policies.

Water Quality Concerns

Wild Segment - The water quality is generally good in the wild segment of the Red River (Red River Watershed Team, 2015). The entire designated reach is categorized as an ONRW (401 KAR 10:030, Section 1, Table 1) under the antidegradation policies of the KAR. ONRW in Kentucky are waters that have an OSRW designated use but are also of national ecological or recreational significance.

Neither the wild segment of the Red River nor any of its direct tributaries are listed as impaired. Clifty Creek and Big Calaboose Creek fully support warm-water aquatic habitat but have insufficient data to assess other designated uses.

Karst topography can be found at the boundary between the wild and recreational segments of the Red River. Karst topography can cause gaining and losing streams on the DBNF (Cherry 2019). Gaining and losing streams can pose a threat to water supply, as they can be direct conduits of pollution to groundwater.

Recreational Segment - The water quality in the Red River recreational segment is worse than in the wild segment. Swift Camp Creek, listed as impaired, flows into the Red River at the boundary between the wild and recreational sections. The headwaters of Swift Camp Creek are impaired from *E. coli* and sediment, and Swift Camp Creek mainstem is impaired from *E. coli*. Wolfpen Creek is designated as an OSRW, while Chimney Top Creek, Swift Camp Creek, and Gladie Creek are designated as cold-water aquatic habitat.

Wolfe County officials estimate that there are approximately 35 failing septic systems or direct discharges in the Swift Camp Creek area (Red River Watershed Team, 2015). This is likely a major factor for the Swift Camp Creek impairment for *E. coli*. A citizen-science water sample for *E. coli* was collected from Swift Camp Creek on August 1, 2020, showing levels well above acceptable thresholds defined by the EPA. Because *E. coli* levels can fluctuate greatly, it is not possible to draw conclusions about management practices from a single sample. However, in 2020, KDOW reassessed the impaired reach of Swift Camp Creek (from Rockbridge to the headwaters), confirming that the reach is impaired from *E. coli* (KDOW, 2020). Even though the DBNF has been working to remediate the sources of *E. coli* in Swift Camp Creek on lands under U.S. Forest Service jurisdiction, the 2020 assessment indicates more work is needed to reduce *E. coli* levels, including the replacement or repair of failing septic tanks upstream of those lands under U.S. Forest Service jurisdiction.

The Red River Gorge Restoration and Watershed Plan Project included in-depth monitoring of portions of the Red River recreational segment between 2011 and 2012. Indian Creek was also sampled downstream of the Red River recreational segment. These efforts established a critical framework for understanding the water quality in this segment. All the results are available in the Red River Gorge Restoration and Watershed Plan Project (Red River Watershed Team, 2015) and are summarized in the Red River Values Report (USFS, 2020).

The samples collected for the Red River Gorge Restoration and Watershed Plan Project, from 2011 to 2012, established baseline water-quality conditions for the Red River recreational segment and helped identify areas of concern. Since then, the DBNF has led multiple Clean Water Act Section 319(h)-funded projects in the Red River Gorge to improve conditions and reduce contaminant sources, especially along Swift Camp Creek.

Biological and Water-Quality Monitoring, Red River Gorge

The Red River WBP aggregated monitoring data collected between 1999 and 2012 at sites on the Red River and Swift Camp Creek. Additional data from project reports and state databases were used for this case study. Data were collected by volunteer-based groups including Kentucky River Watershed Watch (KRWW) and Adventure Scientists, state agencies (KDOW), and federal agencies (U.S. Forest Service Center for Aquatic Technology Transfer and DBNF staff). Additional monitoring data is available for the other sub-watersheds in the Red River Gorge area (Indian Creek, Gladie Creek, and Clifty Creek) in the Red River WBP.

Conductivity is a measure of water's ability to conduct an electric current and is an indicator of the presence of dissolved ions in the water (Pure water has a very low conductivity.). Conductivity levels above benchmark could indicate that the water isn't suitable for the life cycle conditions necessary for aquatic animals. A conductivity threshold of 218 µS/cm was set by the KDOW and was usually exceeded during periodic sampling events between 2011-2012. Between September 2017 and September 2022, conductivity measurements made on the Red River downstream of Swift Camp Creek and on Swift Camp Creek were below the state threshold. The headwaters of Swift Camp Creek near the town of Campton had some of the highest conductivity levels and exceeded the benchmark approximately half of the year, primarily during the warmer months. The higher conductivity levels are probably a result of urbanization, infrastructure issues, failing septic systems, and chemicals from runoff.

Bacteria (i.e., fecal coliform and *E. coli*) sample collection began in 1999. Between the late-1990s to the late-2000s, fecal coliform and *E. coli* samples were collected at the wild section of the Red River and results never exceeded the lower health-concern threshold (KRWW, 2022). Between July 2011 and June 2012, bacteria samples were collected at several sites in the Swift Camp Creek sub-watershed and all samples exceeded the instantaneous primary recreation threshold except for two samples from the most downstream location. Bacteria sampling resumed in 2018, and all the samples collected near Campton, Kentucky, which is upstream of the National Forest System lands, were above the instantaneous primary recreation threshold. About half the samples from the site further downstream, on National Forest System lands, were below the state threshold but were considerably lower than the upstream sites. The data suggests upstream concentrations of bacteria are above state thresholds and while the concentrations dilute downstream when lands become National Forest System, state thresholds are likely exceeded during rain events.

Nitrate samples collected between 1999 and 2005 on the wild section of the Red River never exceeded the lower health-concern threshold (KRWW, 2022). Between 2018 and 2022, based on a very limited number of samples (1-4), nitrate concentrations were higher in the Red River compared to anywhere along Swift Camp Creek.

Water temperature, pH, and dissolved oxygen measurements were collected periodically since 1999 at sites along the Red River and Swift Camp Creek. All measurements were within state standards which served as our thresholds.

Aquatic habitat and macroinvertebrates were monitored in 2006 by the Center for Aquatic Technology Transfer team at sites along the Red River and Swift Camp Creek. The aquatic habitat and macroinvertebrate index scores ranged from fair-to-poor and fair-to-very poor, respectively. These sites need to be included in upcoming monitoring schedules. The cost of a week of invertebrate sampling and identification, habitat assessments, and fish electroshocking is approximately $11,000.

Timeline of Management Plans and Water Quality Management Actions

The development and implementation of the recent projects to improve the water quality in Red River and tributaries was the culmination of a series of steps taken by the DBNF to recognize the condition of the river, communicate the condition to build partnerships, and ultimately, improve the quality of the shared resource to everyone's benefit. Below is a timeline of actions that ultimately resulted in the projects getting completed.

1972: The Kentucky Wild Rivers Act of 1972 designated a section of the Red River as a Kentucky Wild River, administered by the Office of Kentucky Nature Preserves.

1988: Swift Camp Creek, a tributary that feeds the Red River at the border of the wild and recreation sections, appeared on Kentucky's 303(d) list, and fecal contamination was the pollutant of concern, with inadequate septic systems as the source, and swimming was not advised (KDOW, 1988). Additionally, a 34-mile reach of the Red River was impaired because of siltation and nutrients; however, only a portion of the reach crossed National Forest System lands, and upstream land use was developed, pasture, and forest.

1993: The Red River Designation Act of 1993[18] identified 19.4 miles of the Red River as a wild and scenic river after the Wild and Scenic Rivers Act was amended by Congress (USFS, 2022).

2004: Because of visitor-created impacts to the Red River Gorge's natural resources, the DBNF began the Limits of Acceptable Change project, a public process that identified impact sources, developed actions to reduce impacts, and created a monitoring plan (USFS, 2008).

2005: Swift Camp Creek and one of its unnamed tributaries appeared on Kentucky's 303(d) list and the pollutant of concerns were (1) unknown from unknown sources and (2) siltation/sedimentation from loss of riparian cover and septage disposal, respectively (KDOW, 2020). Swift Camp Creek remains on the most current (2020) 303(d) list.

2009: The KDOW awarded $1,300,000 of Section 319(h) grant funds (including matching investments) to the DBNF to develop a watershed-based plan (WBP) for the four sub-watersheds that feed the Red River. The grant funded improvements on both National Forest System lands and private lands, which allowed the DBNF to take an all-lands approach to resource management. The grant also funded the implementation of Best Management Practices to reduce erosion and sedimentation issues identified in the Limits of Acceptable Change project and WBP.

2013: A previously impaired reach of the Red River that flows through the DBNF was assessed and the designated use was fully supported. The reach was labeled an OSRW (K. McKone, personal communication, 12/13/2022).

2015: A second Section 319(h) grant for $500,000 (including match investments) was awarded to the DBNF from the KDOW to reduce bacteria, nutrient, and sediment levels in the four sub-watersheds that feed the Red River. The grant funded septic system installation on private lands, so it was critical that partnerships were formed with local governments and non-profit organizations to gain the public's trust.

2019: A third Section 319(h) grant for $440,000 (including match investments) was awarded to the DBNF to reduce bacteria, nutrient, and sediment levels in the four sub-watersheds that feed the Red River. This grant also allowed the DBNF to work across ownerships, which is especially critical in the eastern United States. Partnerships with the EPA, KDOW, Kentucky Waterways Alliance, and Eastern Kentucky PRIDE were critical for the project's success.

2022: The Gladie Visitor Center began serving as a water-quality laboratory for Kentucky River Watershed Watch, where *E. coli* samples collected in the area could be processed. Kentucky River

[18] Pub. L. No. 103-170, 107 Stat. 1986, (1993).

Watershed Watch is a community-driven group of volunteers that collect water quality data across the Commonwealth. The first Kentucky River Watershed Watch sample collected on the Red River was in 1999.

In September 2022, the DBNF signed the Red River Comprehensive River Management Plan (USFS, 2022), establishing permanent boundaries and user capacities for the Red Wild and Scenic River. The management plan includes resource protection, development of lands and facilities, and other management practices necessary to protect and enhance the values for which the Red River was designated.

Results from Project Implementation

Over the course of 13 years, the Red River Gorge Implementation Project has accomplished a number of tasks that have had positive effects on the watershed. Among these accomplishments are the following:

- Awarded the DBNF $ 2,240,000 in Section 319(h) grant funds (includes match investments).
- Partnered the DBNF with the EPA, the KDOW, Kentucky Waterways Alliance, and Eastern Kentucky PRIDE.
- Developed a watershed-based plan that addressed public and private lands within four sub-watersheds of eastern Kentucky.
- Replaced 24 failing septic systems on private lands.
- Rehabilitated 628 user-developed campsites.
- Rehabilitated 118 miles of unauthorized trails.
- Removed trash from over 131 miles of streambank.
- Planted over 1,000 trees.
- Funded a local watershed coordinator.
- Implemented Best Management Practices on 1,096 acres of National Forest System lands.
- Formed a watershed group, the Friends of the Red River (FORR).
- Educated thousands of visitors about ways to reduce erosion and "Leave No Trace" techniques.
- Held numerous environmental education events in the classroom and in the woods.
- Developed and distributed educational banners and brochures on proper septic care.
- Held virtual and in-person septic workshops.

Lessons Learned and Future Actions

In retrospect, there are several reasons for the success of this project. First, public outreach, communication and participation with adjacent landowners, user groups and local officials was essential. In a popular area such as the Red River watershed, it would have been difficult to reduce erosion and create an effective and useable watershed plan without a collaborative effort.

Second, long-term planning was vital. Working collaboratively with the public to prepare a watershed plan is challenging and takes time. In addition, many of the management practices and activities require follow-up and adjustment, and a project's success may take more than one attempt. A long-term plan can help keep volunteers and public officials focused on the long-term goals of the project as each incremental step is being implemented.

Finally, the process of implementing the work needed to protect and enhance the water quality of the Red River could not have been completed without funding through the EPA §319(h) grant program and the assistance of the KDOW.

Overall, the DBNF and its partners consider the Red River Gorge Restoration and Watershed Plan project a great success, resulting in a model for future collaborative efforts to improve water quality on a WSR, and many other positive benefits for years to come. The continued collaboration between the USFS, Kentucky Waterways Alliance, and Friends of Red River to maintain the river corridor and to remove the trash that is left behind by recreationists and from upstream sources remains a priority. Long term *E. coli* monitoring of the impaired Swift Camp Creek, the Red River, and other streams that feed the Red River will continue and samples will be processed in a lab on the DBNF.

Table 1. ***Waterway reach, impairment or designation, pounds of nitrogen removed, pounds of phosphorus removed, and tons of sediment removed.***

Waterway reach and mileage	Impairment or Designation	Pounds of nitrogen reduced annually	Pounds of phosphorus reduced annually	Tons of sediment reduced annually
Red River mile 51.6 to 61.45	The reach fully supports the designated use and is an Outstanding State Resource Water	307	115	472
Swift Camp Creek mile 0.0 to 7.5	Impaired from an unknown cause	329	105	206
Swift Camp Creek mile 7.5 to 14.05	Impaired for E. coli from municipal, upstream, and non-point sources of pathogens	329	105	206
Unnamed tributary to Swift Camp Creek mile 0.0 to 2.2	Impaired for siltation from loss of riparian cover and post-settlement erosion.	329	105	206
Red River mile 64.65 to 68.25	Impaired for habitat and sedimentation from loss of riparian habitat and pasture grazing.	242	89	115

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