Applicability of regional classification schemes and analytical tools to regional definitions of Waters of the United States (WOTUS)

Technical report following 2022 WOTUS workshop series

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Introduction

The federal Clean Water Act was designed to protect and restore water quality in the Nation's surface waters through a complex but flexible structure. It accounts for a balance of authority between the federal government and states and incorporates a suite of tools, including financial incentives to improve infrastructure, regulations used to control the most acute sources of pollution, and cooperative programs to integrate water quality into other land and water management programs. Importantly, the Clean Water Act provides for regional differences through the application of different beneficial uses and different numeric water quality standards in different parts of the country. This results in frequent differences among state implementation of Clean Water Act programs that reflect the variety of natural landscapes and climates, as well as different uses of waters. As the Nation's water quality regulators and regulated community continue to grapple with how to develop a durable definition of Waters of the United States (WOTUS), Western States Water Council (WSWC) has explored whether there may be value in a regional framing of the issue.

Objectives

Following the consensus approval of a revised position on Clean Water Act jurisdiction (#481) at the Council's Spring 2022 meetings, the Council committed to assisting states in studying how a regional approach to WOTUS could be implemented, both from a technical and a policy perspective. This commitment to bring states together to explore new ideas and new approaches to water policy aligns with the role of the Council to facilitate dialogue between states and federal agencies. The Council hosted a workshop series over the summer of 2022 that forms the basis of this technical white paper. While this paper does not aim to recommend any new policy solutions to WOTUS, it provides foundational materials for the Council to do so at a later date. Further, the Council hopes that the ideas and tools presented in this white paper prove useful to the U.S. Environmental Protection Agency (USEPA) and the Army Corps of Engineers (USACE) as they further investigate a regional framing of WOTUS as part of the ongoing rulemaking for this issue.

Summary of 2022 Workshop Series

Western States Water Council (WSWC) hosted a series of workshops over the summer to explore technical and policy elements of a regional approach to defining Waters of the United States (WOTUS). Two technical pre-workshops (virtual) preceded a full day policy-oriented workshop (hybrid) that coincided with the Western States Water Council summer meeting. This technical white paper represents the primary technical output of the workshop series.

WOTUS regional approach pre-workshop 1: Regional classification schemes (June 21, 2022)

The first technical pre-workshop explored existing regional classification schemes and their potential applicability to WOTUS determinations. There were 32 attendees from 16 states and several federal agencies. Participants considered five existing regional classification schemes presented by four federal agencies:

- *Watershed Boundaries and National Hydrography Dataset* (Kim Jones, USGS)
- *Ecoregions* (Brian Topping, USEPA)
- *Stream Flow Duration Assessment Method Regions* (Brian Topping, USEPA)
- *Regionalization of Wetland Delineation Guidance* (Kyle Gordon, USACE)
- *Major Land Resource Areas and Land Resource Regions* (Drew Kinney, NRCS).

A post-workshop survey indicated that most participants believe the number of regions should be limited to 10-25 across the country. Generally, the participants agreed that the Stream Flow Duration Assessment Method best balances the various regional factors of concern to states, although there was support for further exploring several of the other classification schemes. Insights and comments provided by participants are incorporated into this technical whitepaper. More information, including materials from the event, are available on the meetings tab of the WSWC website.

WOTUS regional approach pre-workshop 2: Operationalizing regional concepts in western states (July 11, 2022)

The second pre-workshop explored analytical tools and operational aspects that could be useful for differentiating between waters in a regional context. These tools are currently in use in state and federal agencies. There were 47 attendees from 21 states and two individuals from federal agencies. Participants considered five protocols presented by state and federal representatives:

- *Stream Flow Duration Assessment Methods: Scientific underpinnings and western region applications* (Tracie Nadeau, PhD, USEPA Region 10)
- *New Mexico's Hydrology Protocol for Surface Water Quality Management* (Shelly Lemon, New Mexico Environment Department)
- *Arizona flow regimes* (Erin Jordan, PhD, Arizona DEQ)
- *Oregon forest management stream typing* (Josh Seeds, Oregon DEQ)
- *Wyoming flow duration curve criteria* (Eric Hargett, Wyoming DEQ)

Participants commented on the similarities of many of the tools presented by states and the potential for them to be used in a regional WOTUS context. Several tools differentiate between waters that are perennial, intermittent, and ephemeral. Other tools are used to determine the levels of protection necessary for different stream types. More information, including materials from the event, are available on the meetings tab of the WSWC website.

WOTUS Regional Concept Workshop: Western States Water Council Summer Meeting (August 2, 2022)

A full day policy workshop was held in Polson, MT ahead of the Council's summer 2022 meeting. Participants explored several different approaches to integrating technical aspects of regional approaches to WOTUS with policy considerations. A separate policy memo has been prepared as an addendum to this report for state participants.

Lessons from the USACE Efforts to Regionalize Wetland Delineation Guidance

Federal agencies have explored and implemented the concept of regional implementation of Clean Water Act jurisdictional determinations in the past. In the early 1990s, Congress directed EPA to fund a study by the National Research Council to document methods for wetland delineation that included an evaluation of how to improve sensitivity to regional differences. The final report, *Wetlands: Characteristics and Boundaries* (NRC 1995), led to the regional wetland delineation guidance manuals still in use by the USACE. Several lessons can be learned from the work that NRC, USEPA, and USACE completed nearly 30 years ago. Excerpts of material from a 2002 USACE report (Wakeley 2002; TR-02-20) summarizing this effort relevant to our current efforts are provided below, unedited.

> In an effort to resolve some of the public and administrative confusion that existed in the early 1990s over the technical validity and credibility of wetland delineation methods, Congress directed EPA to fund a study by the NRC of the scientific basis for wetland characterization. The NRC report (National Research Council 1995) validated the basic structure and scientific foundations of the delineation methods that were in use at the time, including the 1987 Corps manual. However, it also listed a number of recommendations for improvement, including a call for improved sensitivity to regional differences in climate, hydrologic and geologic conditions, and other wetland characteristics.
>
> In the broad sense, "regionalization" of wetland delineation methods can involve both technical and policy considerations. Technical issues include whether wetland criteria are appropriate in a particular region, and whether indicators used to identify wetlands in the field are sensitive to regional variations in environmental conditions (National Research Council 1995). These are mainly scientific issues that can be addressed with appropriate research. This report discusses some of the scientific issues involved in the regionalization of wetland delineation methods.
>
> Policy issues include whether to extend regulatory jurisdiction to all areas encompassed by a strictly technical definition of wetlands or to exclude some wetlands from regulation based on political, social, or economic considerations. Furthermore, policy considerations may dictate that some areas that fail to meet wetland criteria (e.g., contiguous upland habitats or "buffers") should also be regulated. Regional factors that may affect wetland protection policy include the abundance or scarcity of wetlands in the region, historical rates of wetland loss, local development pressure, and public perceptions of wetland values.

> At the most basic level, policy judgments must be made in deciding where to draw the line between regulated and unregulated portions of the wetness gradient. The issue is not strictly technical. For example, it is largely a policy decision that extends jurisdiction to areas with water tables 12 in. from the surface but not 14 in., and inundation frequencies of 1 year in 2 but not 1 year in 3. The 1991 proposed revisions to the 1989 Federal delineation manual represented a policy shift that would have rescinded the Federal government's regulatory authority over groundwater-dominated wetlands, those which do not pond or flood in an average year. State programs, by policy, may also limit protection to only a portion of the overall wetland resource. For example, the wetland delineation method used in Florida for the administration of State wetland programs (Gilbert et al. 1995) is intended to identify wetlands that are a subset of the "surface waters" defined by statute, thus leaving groundwater wetlands unprotected at the State level. Policy judgments are pervasive in the world of wetland regulation, particularly in the wetland definitions that have been developed to describe the limits of government jurisdiction. Policy issues cannot be avoided in a discussion of regionalization of wetland delineation methods. However, to the extent possible, this report emphasizes scientific issues.

In NRC 1995, the authors also outline the process to establish regional guidance as follows:

> Regionalization is "a method of reducing or eliminating details which do not, on the average, hold true over large areas" (Wiken, 1986). Regionalization for the purpose of wetland delineation, therefore, would require the identification of areas with some degree of homogeneity in wetland characteristics and the development of specific regional procedures or indicators.
>
> A regionalized delineation approach involves several steps. First, regional boundaries must be circumscribed around an area with unifying properties. Second, the occurrence and fidelity of wetland indicators within that region must be determined. Finally, a regionally valid system must be adopted for applying indicators to wetland determinations. Regionalization thus extends beyond mere division of a national list of indicators into subsets (such as state lists) because true regionalization involves the regional adaptation of indicators and delineation methods.

Finally, the authors arrived at the following recommendations, which are relevant to the content of this white paper.

> 1. Wetland vary regionally to a great extent; regulatory systems must acknowledge this variation.
> 2. Regions for wetland delineation should be redefined on the basis of physiography, climate, vegetation, and prevailing land use and should be used by all agencies for all wetland characteristics, including vegetation, soils, and hydrology.
> 3. Regional protocols should conform with national standards that ensure consistency among regions.
> 4. Regional delineation practices should be based on regional research and documentation.
> 5. A uniform process should be used to develop regional standards; all federal agencies that assess wetlands… should participate in the development of regional protocols.
> 6. Proposals for and review of regional practices should be solicited from scientific experts in the private and public sectors, both within and outside of the region.
> 7. The process that has been used to develop the regional hydrophyte lists is sound, as is the use of fidelity categories as a means of indicating regional differences.
> 8. Regionalization of hydric soils should be attempted by the use of regional fidelity categories analogous to those used for the Hydrophyte List.
> 9. Numeric thresholds for duration and frequency of saturation should be selected on the basis of their regional relationship to hydrophytic vegetation and hydric soils.
> 10. A central record should be maintained for the Hydrophyte List, as is currently done for the Hydric Soils List. Both records should be accessible via Internet, and both should contain information on the rationale for assignment of indicators.

History of WOTUS Rulemaking and Scope of CWA Jurisdiction

1986 WOTUS: *Traditional navigable waters, interstate waters, all other waters that could affect interstate or foreign commerce, impoundments of waters of the United States, tributaries, the territorial seas, and adjacent wetlands.*

2015 WOTUS: *Traditional navigable waters, interstate waters, and the territorial seas; impoundments of jurisdictional waters; tributaries and adjacent waters due to their presumed significant nexus; and certain regional waters or waters within a floodplain, high tide line, or ordinary high water mark, on a case-by-case analysis for significant nexus, if shown to affect the chemical, physical, or biological integrity of jurisdictional waters, individually or in combination.*

2020 WOTUS: *Significant nexus test eliminated. WOTUS defined by 4 categories of waters: 1) territorial seas and traditional navigable waters; (2) tributaries of such waters; (3) certain lakes, ponds, and impoundments of jurisdictional waters; and (4) wetlands adjacent to other jurisdictional waters.*

2021 WOTUS (Rule 1): *Pre-2015 regime defined as: 1) All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide; 2) All interstate waters including interstate wetlands; 3) All other waters….the use, degradation or destruction of which could affect interstate or foreign commerce; 4) All impoundments of waters otherwise defined as waters of the United States under this definition; 5) Tributaries of waters identified [in 1-4 above; 6) The territorial sea; and 7) Wetlands adjacent to waters…identified [in 1-6 above].*

The purpose of the Clean Water Act (CWA) is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters,"[1] but this stated purpose does not confer federal jurisdiction over all waters located within the boundaries of the United States. Many waters are hydrologically interconnected, but that connection alone does not necessarily confer sufficient authority for federal regulation. Temporary or permanent upstream waters have the potential to impact downstream waters over a variety of temporal and spatial scales.

In 2015, the USEPA and the USACE undertook rulemaking for the Clean Water Rule, which attempted to provide a more precise definition of WOTUS. The rule was developed by looking at physical indicators of flow (bed and banks, ordinary high-water mark) with sufficient volume and frequency to transport sediments, organic matter, nutrients, and organisms to downstream waters, establishing a significant nexus to make the waters jurisdictional. Under the 2015 Rule, wetlands were considered "adjacent waters" (along with ponds, lakes, oxbows, impoundments, and other similar water features) if they were sufficiently close to traditional navigable waters, interstate waters, and territorial seas (jurisdictional waters). The Rule used the terms "bordering," "contiguous," and "neighboring," with a complex definition of the latter term that encompassed:
(1) waters within 100 ft. of the ordinary high-water mark (OHWM) of jurisdictional waters;
(2) waters within a 100-year floodplain plus 1,500 ft. of the OHWM of jurisdictional waters; and
(3) waters within 1,500 ft. of the high tide line of jurisdictional waters.
Other wetlands outside this geographic proximity could be included on a case-by-case basis if the agencies determined that there was a significant nexus with jurisdictional waters (i.e. the wetlands "significantly affect the chemical, physical, or biological integrity").

With a change in federal administration, the USEPA and USACE repealed the Obama Administration's 2015 Clean Water Rule on October 22, 2019. On April 21, 2020, the USEPA and USACE published the Navigable Waters Protection Rule, which eliminated the "significant nexus" test for individual waters that had been used in practice since 1986 and was specified in the 2015 rule. The 2020 Rule established four categories of waters considered to be jurisdictional under the CWA:

(1) territorial seas and traditional navigable waters;
(2) tributaries of such waters;

[1] 33 USC §1251(a)

(3) certain lakes, ponds, and impoundments of jurisdictional waters; and
(4) wetlands adjacent to other jurisdictional waters.

The rule also included 12 categories of waters excluded from CWA jurisdiction, including groundwater, ephemeral features, diffuse stormwater runoff, ditches, prior converted crop land, artificially irrigated waters, water-filled depressions constructed or excavated incidental to mining or construction activity, and water filled-pits excavated for the purpose of obtaining fill, sand, or gravel, and waste treatment systems.

On August 30, 2021, the U.S. District Court vacated and remanded the Navigable Waters Protection Rule, causing USEPA to revert to interpreting WOTUS consistent with the pre-2015 regulatory framework. This approach is also reflected in the most recent rulemaking announced by the USEPA and USACE in June 2021, initiated on November 18, 2021 and proposed on December 7, 2021. The public comment period for this rulemaking closed on February 7, 2022 and a final rule is expected in fall 2022. More specifically, the 2021 Rule identifies the following waters as WOTUS:

(1) All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
(2) All interstate waters including interstate wetlands;
(3) All other waters….the use, degradation or destruction of which could affect interstate or foreign commerce;
(4) All impoundments of waters otherwise defined as waters of the United States under this definition;
(5) Tributaries of waters identified in paragraphs (s)(1) through (4) of this section;
(6) The territorial sea; and
(7) Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (s)(1) through (6) of this section.

In spring 2022, the USEPA and USACE indicated an intent to initiate rule making on a second WOTUS rule, although it has not been released at the time of this report.

The following sections discuss a legal framework for defining the jurisdictional scope of the "waters of the United States," with considerations pulled from case law, existing regulations, state feedback, and the discussion of potential alternatives. Over time, Supreme Court decisions have made clear that the jurisdictional scope of the CWA is something more than traditional navigable waters, but something less than all waters. Further, the CWA explicitly states Congress intended to protect the primary rights and responsibilities of states over water quality and the allocation and protection of land and water resources.

More than Navigable Waters

In the century prior to passage of the Clean Water Act, the courts and the Corps interpreted "navigable waters" to mean navigable in fact, or readily susceptible of being rendered so.[2] Following CWA enactment, in 1975, a district court held, in a one-page decision, that this definition was too narrow,[3] and the USACE adopted a far broader definition, deliberately seeking to expand the definition of "the waters of the United States" to the outer limits of Congress' commerce power consistent with the district court's order.[4] While the Supreme Court has placed some outer limits on the regulatory definition of "navigable waters," past decisions have also made clear that the CWA term means something more than traditional navigable waters.[5]

[2] *Rapanos v. United States*, 547 U.S. 715, 723 (2006); also citing 39 FR 12119 and 33 CFR 209.120(d)(1) (1974) to illustrate the Corps' initial limited jurisdictional definitions following immediate passage of the CWA.

[3] *Id.*, at 724, citing *Natural Resources Defense Council, Inc. v. Callaway*, 392 F. Supp. 685, 686 (DC 1975); *but see Solid Waste Agency of Northern Cook County (SWANCC) v. Corps*, 531 U.S. 159, 172 (2001) ("Where an administrative interpretation of a statute invokes the outer limits of Congress' power, we expect a clear indication that Congress intended that result.").

[4] *Id.*, citing 40 FR 31324 (1975) and 42 FR 37144 (1977).

[5] *Id.* at 731, citing *SWANCC*, 531 U.S. at 167 and *U.S. v. Riverside Bayview Homes, Inc.*, 474 U.S. 121, 133 (1985).

Less than All Waters

The U.S. Supreme Court has not delineated clear inner and outer boundaries for the scope of the CWA jurisdiction, but in *SWANCC v. Corps* (2001), the Court held that an abandoned sand and gravel pit with no significant nexus to a navigable water, or ponds not adjacent to open water, could not fall under the definition of a "water of the United States."

The *Rapanos* (2006) Court attempted to provide clearer jurisdictional boundaries, but was unable to reach a majority opinion. In a brief concurring opinion, Chief Justice Roberts lamented the failure of the agencies to complete their proposed rulemaking in 2003 following the curtailment in *SWANCC*, and labeled the *Rapanos* decision as another defeat of the USACE's boundless view of the scope of its power.

The agencies were left to formulate a rule that would modify the 1986 efforts to define the scope of waters protected under the CWA based on the guidance contained in *U.S. v. Riverside Bayview*, *SWANCC v. Corps*, and *Rapanos v. U.S.*

The absence of federal jurisdiction over all waters under the limits of the CWA does not mean that those waters fall outside of state jurisdiction. Congress recognized the role of the states when it passed the CWA. Section 101(b) supports the states' critical role in protecting water quality by stating: "It is the policy of Congress to recognize, preserve, and protect the primary responsibilities and rights of States to prevent, reduce, and eliminate pollution…." Section 101(g) of the CWA further provides that the primary and exclusive authority of each state to "allocate quantities of water within its jurisdiction shall not be superseded, abrogated, or otherwise impaired by this Act."

States have authority pursuant to their "waters of the state" jurisdiction to protect the quality of waters within their borders, and such jurisdiction generally extends beyond the limits of federal jurisdiction, including groundwater. Excluding waters from federal jurisdiction does not necessarily mean that they will be exempt from regulation and protection, though the legislative authority to regulate state waters varies significantly. States are well positioned to manage the water within their borders because of their on-the-ground knowledge of the unique aspects of their hydrology, geology, and legal frameworks, including laws to allocate water. Western states, in particular, have specific conditions and needs where water may be scarce and a variety of unique waterbodies exist, including small ephemeral washes, effluent-dependent streams, prairie potholes, playa lakes, and numerous human-made reservoirs, waterways, and water conveyance structures. Additionally, most states are co-regulators with authority and experience in implementing various provisions of the CWA.

Rapanos: Scalia and Kennedy Opinions

Justice Scalia delivered a four-member plurality opinion in *Rapanos*, joined by Chief Justice Roberts, and Justices Thomas and Alito. Justice Kennedy wrote an opinion that concurred in the judgment, but for different reasons. The Obama Administration emphasized the Justice Kennedy approach in the 2015 Rule, while the Trump Administration emphasized the Justice Scalia approach in the 2020 Rule.

Plurality decisions have a muddled precedential value, generally considered more than persuasive and less than binding.[6] The Supreme Court held in *Marks v. United States* that binding precedential value is found in the position taken by the justices who concurred in the judgment on the narrowest grounds.[7] However, lower courts and even later Supreme Court cases have been ambivalent about the *Marks* rule, due to the complications of identifying the relevant reasoning between justices that concurs on the narrowest grounds.[8] In 2018, the Supreme Court declined to provide better guidance on the *Marks* rule.[9]

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[6] See, *e.g.*, James A. Bloom, *Plurality and Precedence: Judicial Reasoning, Lower Courts, and the meaning of United States v. Winstar Corp.*, 85 WASH. U. L. REV. (2008).

[7] *Id.*, citing *Marks v. United States*, 430 U.S. 188, 193 (1977).

[8] *Id.*

[9] See, *e.g.*, Amanda Reilly, *Justices sidestep chance to clarify Rapanos' reach*, E&E News 6/4/18, involving a fractured 11th Circuit decision in a criminal sentencing case, *Hughes v. United States* (quoting Justice Breyer, "I think law is part art and part science. If you ask me to write something better than *Marks*, I don't know what to say.")

Sackett v. Environmental Protection Agency

The Supreme Court began hearing oral arguments in Sackett v. USEPA on October 3, 2022. This represents the fourth case before the Supreme Court related to the question of defining WOTUS for purposes of establishing jurisdiction under the federal Clean Water Act. In this case, the Sackett's are arguing for a narrow definition of WOTUS to exclude any wetlands that are not immediately abutting a Traditional Navigable Water. USEPA is arguing that a significant nexus test is necessary. A decision in this case is expected in late 2022 or early 2023.

Western States Water Council WOTUS Position

Western States Water Council has maintained a position on Clean Water Act jurisdiction since 2014. Amendments over the years reflect the various changes that have been made to defining WOTUS under three different presidential administrations. The Council's current WOTUS position (#481) is available on the Council's website. Because the definition of WOTUS issue is a highly contentious issue, the Council has carefully crafted the current position to reflect the areas of bi-partisan consensus across western states. These areas include durability and clarity in rule and in process, principles of cooperative federalism, and the importance of recognizing regional differences. Excerpts from the current position, relevant to the Council's efforts to explore regional WOTUS concepts, are listed below.

> "NOW, THEREFORE BE IT RESOLVED that Congress and the Administration should ensure that any federal effort to clarify or define CWA jurisdiction and define Waters of the United States:
>
> 1. Creates an enduring and broadly supported definition.
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> ….
>
> 10. Provides for mapping of jurisdictional waters as a joint federal/state/tribal effort employing the best available data and tools, with appropriate provisions and processes for map maintenance.
>
> ….
>
> 12. Recognizes the need to balance definitional clarity with flexibility in implementation to address the unique landscapes, flow regimes, and legal frameworks in various regions of the Nation and appropriately weighs all factors of science, law, and effective policy to draw jurisdictional conclusions that are appropriate, and that do not impinge on the rights of States.
>
> ….
>
> 13. Considers a regional approach to the definitions of terms for foundational and any categorical waters in the rule including terms such as "relatively permanent" and "significant nexus" and defines regions building upon existing classification systems based on hydrology, geology, and climate.

Western State Comments and Concerns regarding WOTUS

As states have varied opinions about various aspects of WOTUS, it is difficult to represent all of the nuanced perspectives accurately in a summary of western state concerns. However, the western states have raised several themes in the context of WOTUS over the years. Most recently, western states participated in the 2022 summer WOTUS regional roundtables organized by USEPA and hosted by a variety of organizations across the country. Below is a summary of some of the themes that were discussed at the western-focused roundtables.

Uniqueness of Western Landscapes

Many participants talked about the uniqueness of western landscapes and hydrology. Jennifer Carr, Nevada DEP and WSWC member, said that "the vastness of western topography" needs to be considered carefully when considering WOTUS, noting that the characteristics of ephemeral waters can differ significantly across the West, with some ephemeral features only experiencing flow every few decades. There was extensive discussion about the nature of ephemeral waters in the west. Hawaii only has one inland navigable water and, in many areas, localized rains between valleys create numerous ephemeral and intermittent features. Others discussed the diversity and uniqueness of the intermountain west including high deserts and forested areas in the north and at high elevations. Many ephemeral features in southern California percolate before reaching perennial waters or only flow when they receive Title 22 recycled water. Several participants spoke about the importance of ephemeral and intermittent wet meadows and their importance to moderate temperature, sediment, and nutrient impacts in downstream waters. Some of these features provide critical hydrologic and geomorphic functions that are especially important in the context of climate change to provide water storage and flood protection.

Appropriate Balance between State and Federal Authority

Participants reminded the agencies that they need to stay true to the legislative intent of the Clean Water Act, which was to strike a balance between state and federal regulation with clear exemptions. Several participants noted areas of overlap and duplication between state and federal programs, and several said that some state laws are more stringent than federal regulations with respect to water quality protections and that it is important not to duplicate or complicate regulations. Further, some felt that Congress assumed that states would address land management issues and that these should not be subject to federal permitting requirements. Some questioned what the natural resource protection value would be of regulating, as waters, large areas of arid land in the West considering other state and federal environmental protections. There was discussion about how state agencies and local partnerships were best placed to manage water quality in coordination with water resource and land managers. Many participants felt that state agencies can communicate clearly with one another and local staff have the best handle on the hydrology and communities in a watershed. Most states have CWA primacy and can therefore provide clean water through a blend of federal and state programming. There is also a concern that there is insufficient capacity for federal regulators to monitor, inspect, and enforce on a broader suite of waters.

Protecting agricultural economic interests

Many participants talked about the importance of agriculture to western economies and emphasized the need not to hamper production agriculture. Most participants emphasized the importance of maintaining current agricultural exemptions. More specifically, several participants argued that irrigation canals, ditches, stock ponds, and other western irrigation infrastructure must be excluded from WOTUS to allow for regular maintenance critical to maintaining agricultural production.

The lack of clarity and the need for case-by-case determinations was identified as a source of significant uncertainty for landowners. In some areas of the west, farms can be very small and are owned by traditionally underserved and socially disadvantaged people that often do not have the means to comply with the proposed rules. A concern exists that an uncertain regulatory process interferes with environmental justice and food security goals for some states.

Others reminded participants that most agricultural activities and features are already exempted from Clean Water Act jurisdiction and that there was some confusion about whether an expanded definition of WOTUS would affect the existing exemptions.

Several participants requested that USEPA maintain the prior converted cropland (PCC) exclusion as outlined in the 2020 rule. In many western states, PCC could convert to a wetland if fallowed because an agricultural producer does not have a senior water right to keep it in active production. Participants emphasized that the exemption for PCC from WOTUS must recognize western water rights and water law to ensure there are no unintended consequences of PCC reverting to wetlands.

Other Exemptions

Several participants also discussed the importance of clearly exempting water treatment infrastructure, and some upland waters that may only be connected to a traditional navigable water (TNW) via groundwater. Most participants reiterated the importance of state oversight of groundwater and the need for clear guidelines associated with WOTUS in light of the Supreme Court decision in *County of Maui v. Hawaii Wildlife Fund,* 140 S. Ct. 1462 (2020).

Clarity

Participants emphasized the importance of clarity and predictability in the final rule, noting that subjective terms with case-by-case determinations are very difficult for landowners to navigate. Clarity and certainty are also necessary to ensure that the permit process is timelier. One participant highlighted the work that has been done recently in Oregon under the private forest accords which looks at how to alter protections for different types of systems and evaluate the probability that a stream is perennial.

Applicability of Existing Regional Classification Schemes

In considering a regional approach to WOTUS, we first explore how the country could be divided into regions that reflect the major important differences across the country and that are practical to implement. In this section, we explore several existing regional classification schemes that could be used or adapted to regionalize on the basis of hydrologic, landscape, and climatic factors. These include the nested basins established in the National Hydrography Dataset developed and maintained by the US Geological Survey (USGS), the Ecoregion classification scheme developed and maintained by the USEPA, and the Land Resource Regions developed and maintained by the Natural Resources Conservation Service (NRCS). In addition, we describe two other classification schemes that build on the three foundational schemes listed above. These include the regions used by the USACE for purposes of wetland delineation guidance and the regions established by USEPA for the development of Stream Flow Duration Assessment Methods.

National Hydrography Dataset – Watershed Boundary Dataset

The Watershed Boundary Dataset (WBD) is a data product housed within the broader National Hydrography Dataset (NHD) that includes boundaries of nested or multilevel hierarchical watersheds for the nation. Boundaries are defined by hydrographic and topographic criteria using federal standards for delineation and resolution published by the USGS (USGS and NRCS 2013). The goal of the WBD is to create a "national, consistent, seamless, and hierarchical hydrologic unit dataset based on topographic and hydrologic features across the United States and territories." The WBD defines the perimeters of drainage areas (hydrologic units), formed by the terrain and other landscape characteristics, at a 1:24,000 scale in the United States, except for Alaska at 1:63,360 scale and 1:25,000 scale in the Caribbean, and it consists of digital geographic data that include six levels of detailed nested hydrologic unit boundaries. The National Hydrography Dataset, including the Watershed Boundary Dataset, represents the highest standards of quality, consistency, and accessibility for hydrologic unit data nationwide.

The Watershed Boundary Dataset was originally developed in the mid-1970s under a system that divided and subdivided the country into four nested levels based on surface topography, drainage area, and number of divisions per nested level. These four levels eventually became the basis of the 8-digit hydrologic unit numbers prevalent in watershed management today. There are 22 of the highest level watershed boundaries (HUC-2) representing the major drainage basins in the country at a scale that is relatively consistent (Figure 1). The average size of each drainage area is 177,560 mi^2. The next level of drainage area (HUC-4) subdivides the HUC-2 watersheds into 227 drainages areas averaging 16,800 mi^2. All references to hydrologic unit codes (HUCs) of varying levels in this report follow the USGS Watershed Boundary Dataset standards.

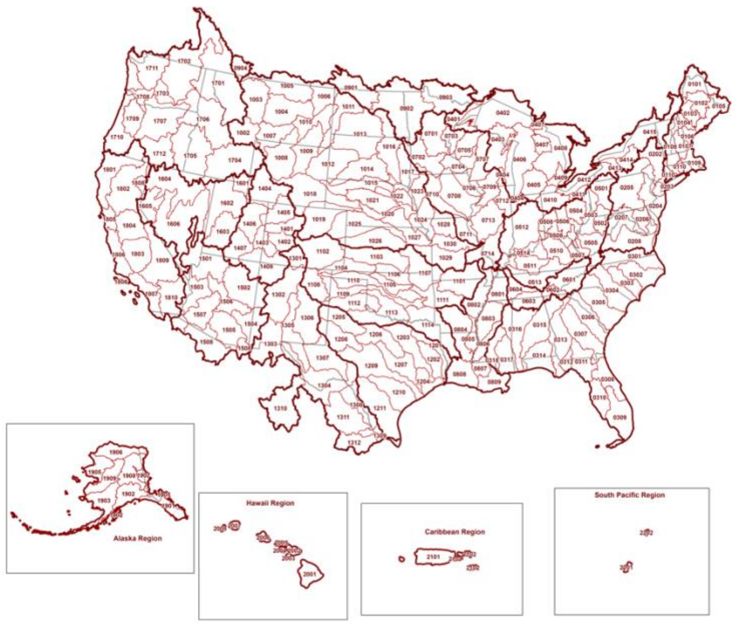


Figure 1. Watershed boundary dataset (HUC-2 and HUC-4) for the nation (Source: USGS NHD).

Ecoregions – Level I, II, III

The USEPA, in collaboration with other federal and state partners, developed and maintains an ecoregion framework that aggregates areas of the country (and continent) where ecosystems are generally similar. Ecoregions are based on the type, quality, and quantity of environmental resources. Ecoregions are not tied to any specific use case and are intended to support general research, assessment, and monitoring of both aquatic and terrestrial ecosystems.

Ecoregions are based on a weight of evidence approach rather than a formulaic model that can be automated. The ecoregion analysis is based on patterns and composition of both biotic and abiotic aspects of ecosystem quality and integrity (Omernik 1987, 1995). The primary factors considered in the ecoregion data are geology, landforms, soils, vegetation, climate, land use, wildlife, and hydrology. The framework incorporates both aquatic and terrestrial factors, including patterns of human use or human modification. The relative importance of each factor changes for different ecoregions (Omernik and Griffith 2014, McMahon et al. 2001).

The first ecoregion framework was published in 1987 (Omernik 1987) and has been modified and expanded over time in collaboration with many partners, including state resource management agencies. With each increasing level, there is an increasing number of categories in the nation. There are 12 Level I ecoregions, 25 Level II ecoregions, and 105 Level III ecoregions (Figure 2). The complexity also increases with each level.

More information on ecoregions is available on the USEPA website and in the underlying publications including Omernik and Griffith (2014), Omernik (1995, 2004), and CEC (1997).

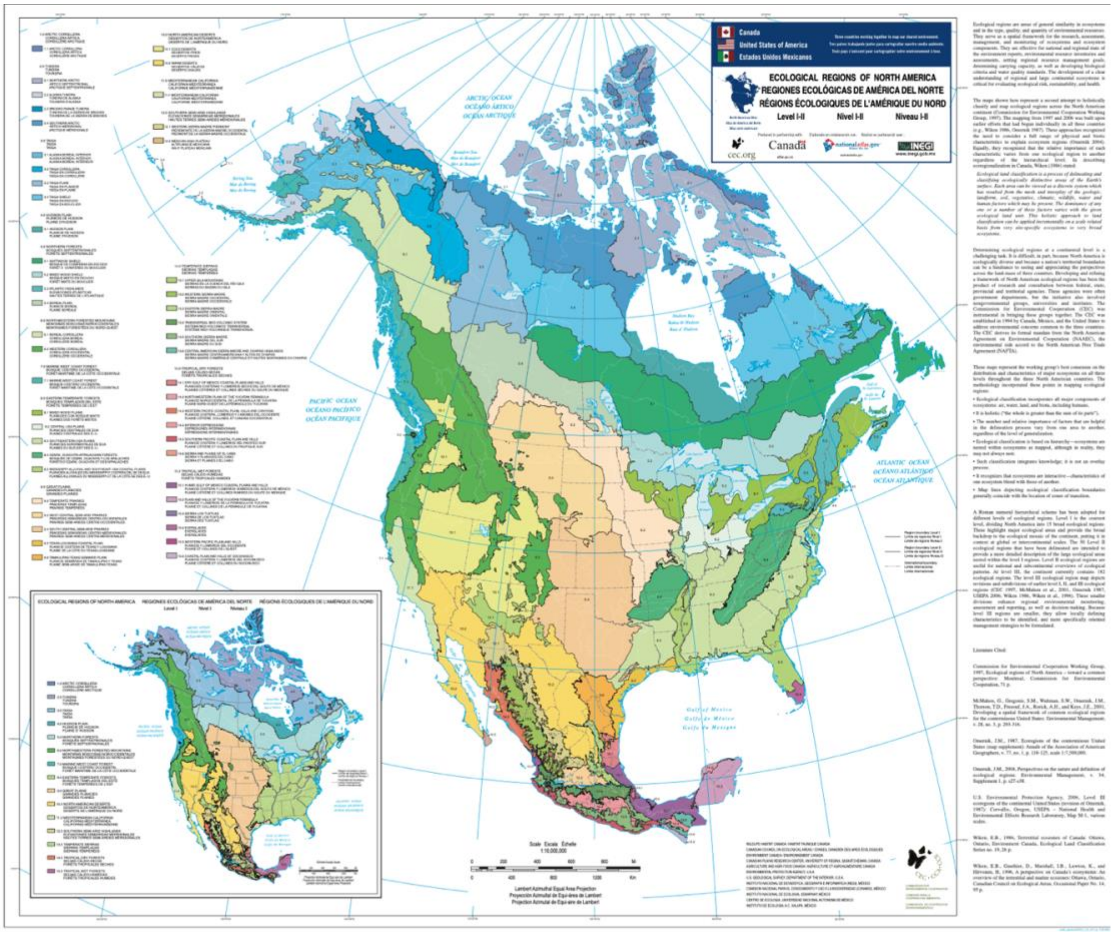


Figure 2. Ecoregions of North America (Level II shown in large image and Level I embedded image). Source: USEPA, Ecoregions.

USDA Land Resource Regions and Major Land Resource Areas

The United States Department of Agriculture (USDA) maintains regional classification systems for Land Resource Regions (LRR) and Major Land Resource Areas (MLRA) across the country. The LRR and MLRA classifications are based on patterns of physiography, geology, climate, water resources, soils, biological resources, and land use (Austin 1965). Since 1965, USDA has published multiple updates to the methods and maps in Agricultural Handbook 296, most recently in May 2022.

The purpose of the LRR and MLRA classification system is primarily to support agricultural research and management in different areas of the country. This includes identification of crop suitability to different areas as well as recommended conservation practices promoted by NRCS and its partners.

There are 28 Land Resource Regions in the country representing the highest level in the classification scheme (20 in the conterminous United States, 5 in Alaska, and 1 each for Hawaii, the Caribbean, and the Pacific Basin Islands). The LRRs range in size from 885 mi^2 (Pacific Basin Islands) to 548,305 mi^2. The MLRA is the second-level in the classification scheme with 267 MLRAs across the region ranging in size from 3 mi^2 to 70,215 mi^2 (Figure 3).

Figure 3. Land Resource Regions (LRRs) and Multi-Resource Land Areas (MLRAs) for the United States (Source: USDA, LRR).

USACE wetland delineation regions

The USACE has primary responsibility to regulate dredge and fill of waters, primarily wetlands, under Section 404 of the Clean Water Act. In 1987, the USACE Wetland Delineation Manual was developed as a national guidance document for wetland delineation practices for purposes of determining jurisdiction under the Clean Water Act. The manual identified indicators for wetland hydrology, hydrophytic vegetation, and hydric soils. In the early 1990s, the combination of multiple wetland delineation guidance manuals issued by separate federal agencies and the long-standing practice to apply aspects of the delineation differently in different parts of the country, led to a federal undertaking to develop a regional approach to wetland delineation.

In 1993, Congress funded a study by the National Research Council (NRC) to evaluate a scientific basis for a regional approach to wetland delineation. This study resulted in *The Wetlands Characteristics and Boundaries* report published in 1995 by the NRC. The report recognized that "wetlands vary regionally to a great extent and that regulatory systems must acknowledge this variation." Further, the report found that "regional protocols should conform with national standards that ensure consistency among regions…..Regional delineation practices should be based on regional research and documentation….Regionalization would require the identification of areas with some degree of homogeneity in wetland characteristics and the development of specific regional procedures or indicators."

The report also provided suggestions for how agencies could draw regional boundaries. The report evaluated the NHD Watershed Boundary Dataset, existing administrative boundaries, EPA's Ecoregions, and the NRCS LRR and MRLA regional frameworks. The report recommended the use of LRRs because they incorporate multiple factors including human influences on wetland abundance and characteristics.

The USACE decided to divide the country into 10 regions by aggregating the existing 28 LRRs into similar categories (Figure 4). The resulting regional classification accounts for anthropogenic influences, aligns with National Technical Committee for Hydric Soils (NTCHS) field indicators of hydric soils, and provides meaningful regionalization without being overly specific.

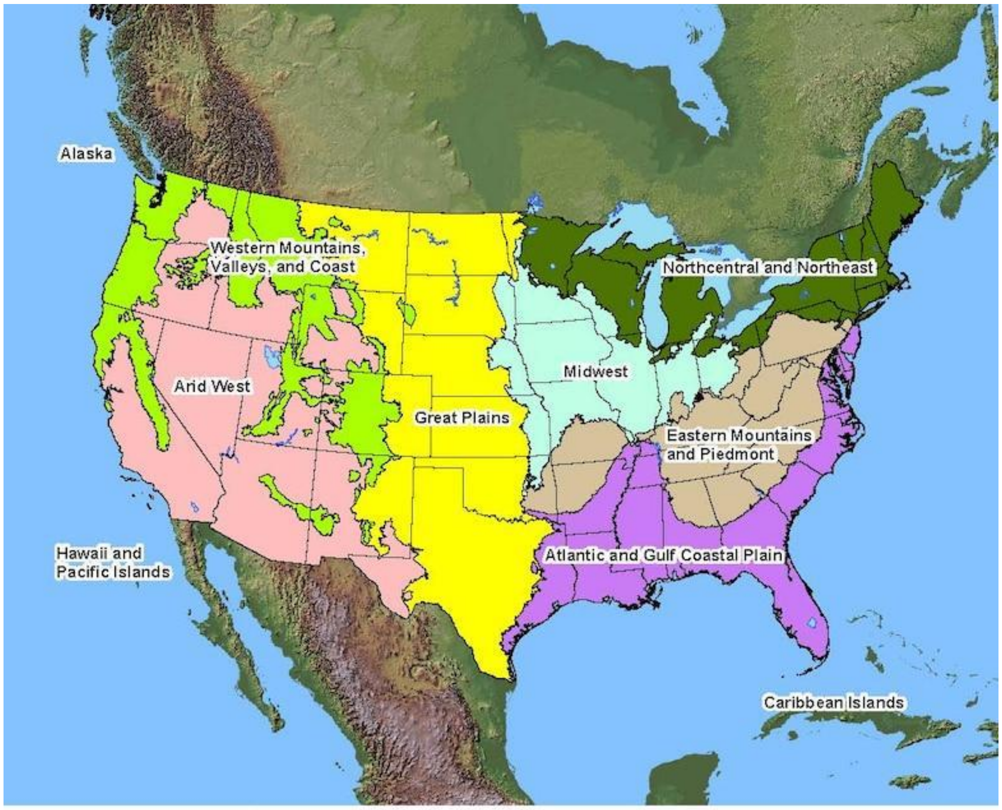


Figure 4. USACE Wetland delineation regions.

Stream Flow Duration Assessment Method Regions

Stream Flow Duration Assessment (SDAM) methods are a tool used to classify streamflow duration at a reach scale using data collected in one field visit. These methods and their applicability to WOTUS are described in the analytical tools section below. EPA divided the country into various regions for method development purposes. The SDAM regions were based first on the administrative boundary of EPA Region 10 (Pacific Northwest), and later on the regions defined in the Ordinary High Water Mark manuals and the National Wetland Plant list, which roughly correspond to the USACE wetland delineation regions. Recently, EPA decided that there was not sufficient variability in terms of stream characteristics in the mid-west and eastern states to justify using all of the regions identified for wetland delineation. Instead, EPA divided the mid-west and eastern states into four regions shown in Figure 5 and following Wohl et al. 2016.

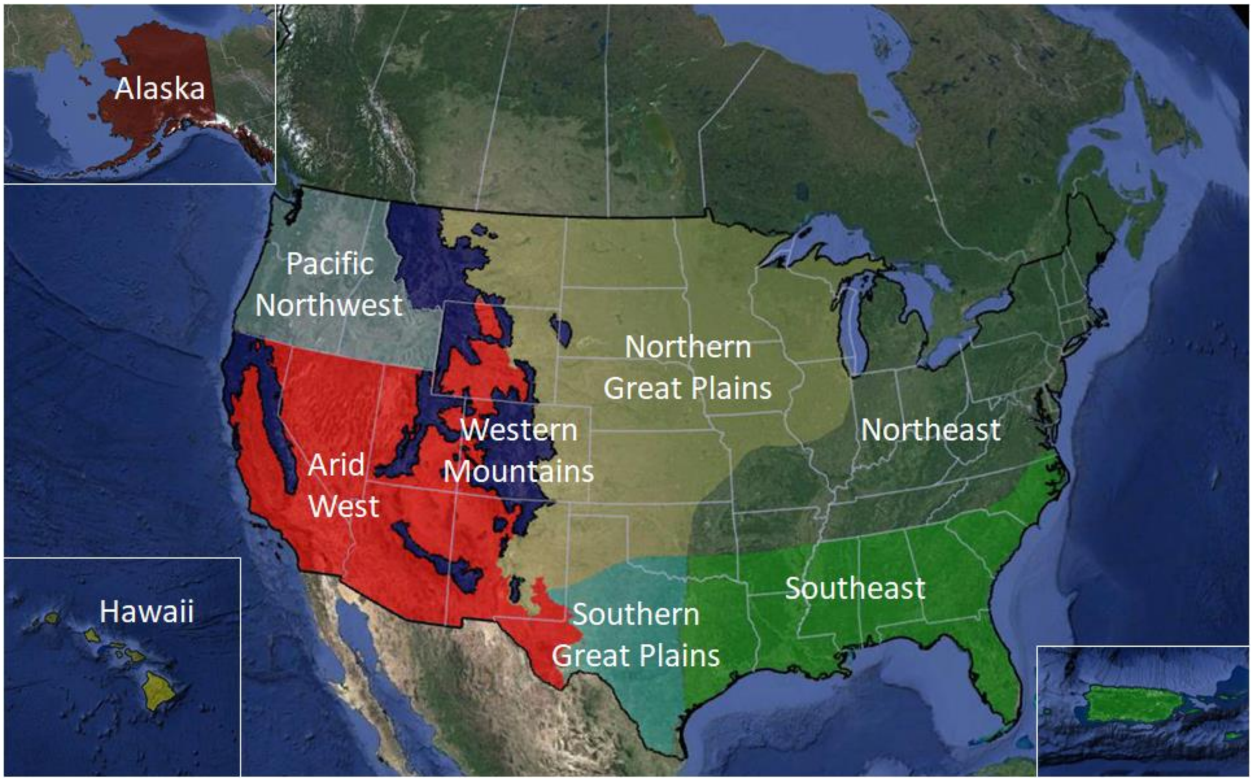
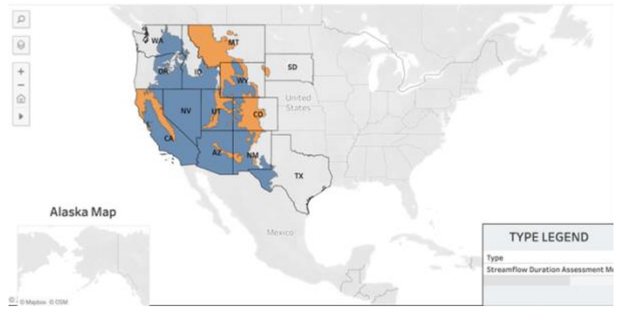


Figure 5. USEPA Streamflow Duration Assessment Method regions.

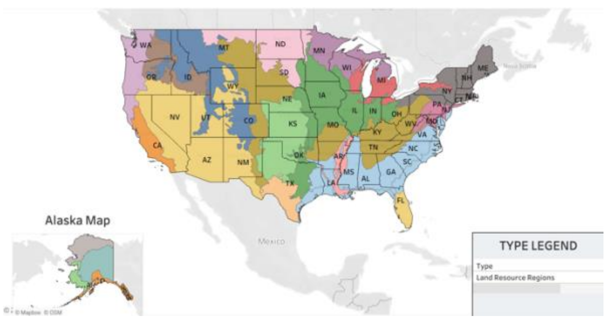
Comparison

Whereas the USGS NHD is based entirely on watersheds established by flow paths of surface waters, the other classification schemes are based on various landscape and climatic factors. The Ecoregions (USEPA) and Landscape Resource Regions (NRCS) classification schemes are grounded primarily in landscape and climatic factors. The Ecoregions and LRR schemes were both established in the 1980s and draw from one another to a certain extent, but have different end uses. Whereas USEPA's Ecoregion concept is meant to provide a general framework for use in monitoring, assessing, and managing the nation's aquatic and terrestrial ecosystems, the NRCS LRR concept aims to inform agricultural practices and resource conservation across the country. The regions used for USACE wetland delineation guidance are aggregated from the NRCS LRR regions. And the regions used in the Streamflow Duration Assessment Methods are grounded in both the NRCS LRR regions and the EPA Ecoregions. These similarities can be seen visually in Figure 6. The differences between the factors used to establish each regional classification scheme are summarized in Table 1. Table 2 summarizes the number of different regions in each western state for each of the classification schemes.

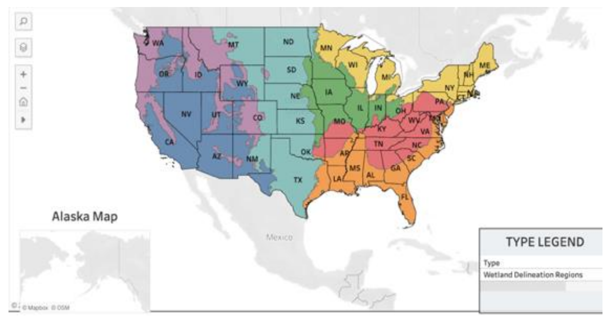
a. National Hydrography Dataset - HUC2 (USGS)



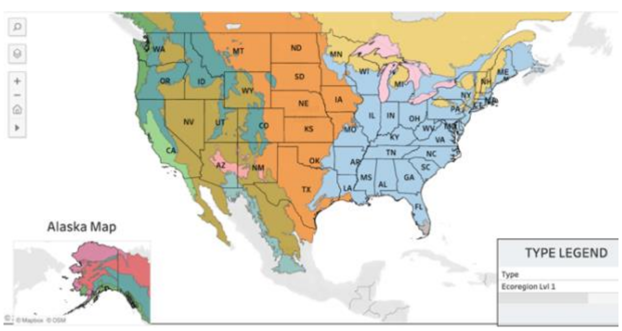
d. Streamflow Duration Assessment Method regions (USEPA).
Note: EPA has not yet published SDAM boundaries for other regions of the country.



b. Land Resource Regions (NRCS)



e. Wetland delineation regions (USACE)



c. Level 1 Ecoregions (USEPA)

Figure 6. Spatial comparison of existing regional classification systems.

Table 1. Summary of Regional Classification Schemes

	Agency	**Total number of regions in US**	**Factors incorporated into regional delineations**	**Average or range in size of categories (mi^2)**
National Hydrography Dataset (HUC 2)	USGS	HUC 2: 22 HUC 4: 227	Topography Hydrology Watershed Size	HUC-2: 177,560 mi^2 HUC-4: 16,800 mi^2
Ecoregions	USEPA	Level I: 13 Level II: 26 Level III: 107	Geology Landforms Soils Vegetation Climate Land use Wildlife Hydrology	
USDA Major Land Resource Areas	NRCS	LRRs: 25 MLRAs: 255	Physiography Geology Climate Water Resources Soils Biological Resources Land Use	LRRs: 885 mi2 to 548,305 mi^2 MLRAs: 3 mi2 to 70,215 mi^2
USACE wetland delineation regions	USACE	10	Aggregated MLRA	
Stream Flow Duration Assessment Method Regions	USEPA	5	Regional Supplements to the Wetland Delineation Manual Regional OHWM Manuals – Arid West and Western Mountains	

Table 2. Summary of Regional Classification Schemes

	NHD	Ecoregions (Level I)[10]	USDA LRR/MLRA	USACE wetland delineation regions	SDAM Regions
Topography	USGS 7.5 minute topographic maps (USGS 15-minute topo maps in Alaska)[11].				
Landforms/Physiography		Classes of Land-Surface Form (Hammond 1970)	Fenneman and Johnson (1946), Wahrhaftig (1965), Thornbury (1965), and Hunt (1967)	USDA LRR	USDA LRR
Geology		Surficial Geology (Hunt 1979)	State and Federal geologic maps and reports	USDA LRR	USDA LRR
Hydrology	USGS 7.5 minute topographic maps (USGS 15-minute topo maps in Alaska).	Not referenced for Level I	Seaber et al. 1984	USDA LRR	Ordinary High Water Mark (Wohl et al. 2016)
Water Resources			Lumia et al. 2005. USGS Estimated Use of Water in the United States in 2000.	USDA LRR	USDA LRR
Watershed Size	USGS 7.5 minute topographic maps (USGS 15-minute topo maps in Alaska).				
Climate		Climates of the United States (Baldwin 1973)	Parameter elevation regression on Independent sloped model (PRISM) for lower 48 states National Weather Service climate records from 1981 through 2010 for Alaska and Hawaii	USDA LRR	USDA LRR
Soils		Various sources	NRCS soil survey geographic database (SSURGO)	USDA LRR	USDA LRR
Vegetation		Potential Natural Vegetation (Kuchler 1970)	"See reference section of Ag Handbook 296"	National Wetland Plant List	
Land use		Major Land Uses (Anderson 1970)	NRCS Natural Resource Inventory (NRI) data.	USDA LRR	USDA LRR
Wildlife		Not referenced in Level I			
Biological resources			"See reference section of Ag Handbook 296"	USDA LRR	USDA LRR
Other		Land Resource Regions and Major Land Resource Areas of the United States (USDA 1981)		LRR aggregated regions	*USACE wetland delineation regions and OHWM aggregated regions*

[10] All references are cited in Omernik 1987.

[11] Future elevation data will come from 3DEP, Lidar, IISAR or other sources.

Table 3. Count of regions within each western state for existing regional classification schemes

	Ecoregions			National Hydrography Dataset Watersheds		Major Land Resource Area	Streamflow Duration Assessment Methods	Wetland Delineation Regions
	Level I	*Level II*	*Level III*	*HUC2*	*HUC4*			
Alaska	4	6	21	1	8	25		
Arizona	3	4	7	2	10	6	2	2
California	4	5	12	4	16	17	2	2
Colorado	3	3	6	4	17	16	2	3
Hawaii	1	8	13					
Idaho	2	2	10	3	7	13	2	2
Kansas	2	3	8	2	13	15	3	
Montana	3	3	7	3	15	16	2	3
North Dakota	1	2	4	3	8	13		2
Nebraska	1	3	7	1	14	15		2
New Mexico	5	6	8	5	19	16	2	3
Nevada	2	3	5	4	12	11	2	2
Oklahoma	2	4	12	1	10	22		4
Oregon	3	3	10	3	10	17	2	2
South Dakota	2	4	8	3	9	21	1	3
Texas	4	6	12	3	24	36	1	3
Utah	2	3	7	4	12	13	2	2
Washington	3	3	9	1	8	11	1	2
Wyoming	3	4	7	4	14	17	2	3

Analytical Tools in Use by States and Federal Agencies

This section discusses the technical capabilities of several tools that are already in use by states and EPA. Most of the tools described in this white paper are already designed within a regional construct or could be adapted to reflect important regional differences. With respect to WOTUS, analytical tools can be used to help evaluate the following aspects of stream hydrology:

- Connectivity of surface waters
- Differentiation of perennial, intermittent, ephemeral flow regimes
- Estimation of the degree of ephemerality or intermittency on a continuum
- Evaluation of significant nexus with respect to flow and pollutant transport to downstream TNWs

Stream Flow Duration Assessment Methods

USEPA describes Stream flow Duration Assessment Methods as follows (EPA 2022).

> Long-term hydrologic data to assess streamflow duration is often limited, especially for streams that do not flow year round. SDAMs are rapid field assessment methods that use hydrological, geomorphological, and/or biological indicators, observable in a single site visit, to classify streamflow duration as perennial, intermittent, or ephemeral at the reach scale. Regulators and water resource managers can use rapid, reach-scale methods to determine streamflow duration classifications (i.e., perennial, intermittent, ephemeral) and to help implement many federal, state and local programs. SDAMs have proven to be highly accurate; the Pacific Northwest SDAM, for example, correctly classified 84% of observations from a three-state study area and distinguished between ephemeral and intermittent/perennial streamflow with 94% accuracy.

There are several uses for SDAMs in federal and state water programs including:

1) implementation of state and local ordinances;
2) improved ecological assessment;
3) application of appropriate water quality standards;
4) prioritization of restoration and protection efforts;
5) ambient monitoring and understanding responses to a changing climate; and
6) assisting with timely and predictable jurisdictional determinations.

The general process of developing a SDAM begins with data collection of candidate indicators from study sites with known hydrology using consistent field protocols with appropriate QA/QC. Examples of candidate indicators include biological (aquatic invertebrates, algae, riparian vegetation, hydrophytic vegetation, iron-oxidizing bacteria, fish, amphibians, bryophytes), hydrological (soil moisture, hydric soils, wood jams), geomorphological (slope, channel width, sinuosity, entrenchment ratio, riffle-pool sequence, substrate sorting, sediment deposition), and GIS (climate, ecoregion, land cover, watershed, geology, and soils). Data are analyzed with machine learning techniques to build a "forest" of decision-trees to identify top candidate (predictor) indicators. Finally, the SDAM method (or model) is built with the results of the random-forest model while also considering factors such as field collection rapidity, repeatability, and robustness of top predictor indicators.

The USEPA and USACE are working collaboratively to develop robust SDAMs at appropriate regional scales nationwide and to identify and test existing and candidate indicators of streamflow duration assessment. This includes conducting validation studies that result in accurate, consistent, and defensible SDAMs and contribute to our understanding of intermittent and ephemeral streams. USEPA has already developed and published three regional SDAMs: Pacific Northwest, Western Mountains (beta version), and Arid West (beta version). Additional SDAMs will be completed for the Great Plains and eastern regions of the country by the end of 2022. The underlying datasets, models, and criteria used in each SDAM differ by region. A summary of each is provided in the sections below with a comparison in Table 3.

Table 3. Comparison of regional SDAMs developed by USEPA.

	Western Mountains (beta)	Arid West (beta)	Pacific Northwest
Types of indicators	Biological, geomorphological, and climatic	Biological	Biological and geomorphological
Single indicators	Fish	Fish Algal cover ≥10%	Fish Aquatic life stages of snakes or amphibians
Type of tool	Random forest model	Classification table (simplified from random forest model)	Decision tree (simplified from random forest model)
Stratification	Snow-influence	None	None
Classifications	Perennial, intermittent, ephemeral, and at least intermittent.	Perennial, intermittent, ephemeral, at least intermittent, and need more information.	Perennial, intermittent, ephemeral, and at least intermittent.
Aquatic invertebrate identification	Required at Family level	Required at Order level	Required at Family level
Hydrophytic plant identification	None	Required	Required
Field time required	Up to 2 hours	Up to 2 hours	Up to 2 hours

Streamflow Duration Assessment Method for the Pacific Northwest

The SDAM was developed for the Pacific Northwest in partnership between USEPA Region 10, USACE Portland District, and the Oregon Department of State Lands. It focused on low-order headwater streams that are on public lands. The Pacific Northwest SDAM was based on data collected at 178 sites in Oregon in 2009 and 2010 and at 86 sites in Idaho and Washington in 2010 and 2011. Data were collected in the wet spring season as well as the late summer dry season. Data were collected for 43 field indicators (geomorphology, hydrology, and biological) from 264 stream reaches totaling 528 observations (Nadeau 2015; Nadeau et al. 2015).

A machine learning technique was used to build a forest of decision trees to identify nine candidate indicators (Nadeau et al. 2015):

1. All macroinvertebrates (ordinal)
2. Perennial or intermittent macroinvertebrates (ordinal)
3. Presence of perennial macroinvertebrates
4. Sum of 2 & 3
5. Ephemeroptera abundance
6. Indicator status of most hydrophytic plant in streambed
7. Channel slope (%)
8. Streamer mosses or algal mats on streambed (ordinal)
9. Leaf litter or other debris accumulated in thalweg (ordinal)

The final constructed decision tree was selected because it had the highest agreement with direct hydrologic classifications (84.3% accuracy; 94.3% for at least intermittent) and relies on seven indicators, two of which are single indicators for fish and amphibians that strongly indicate at least intermittent streamflow when present, and five of which are included in the decision tree. The final decision tree with those five indicators is shown in Figure 7 below.

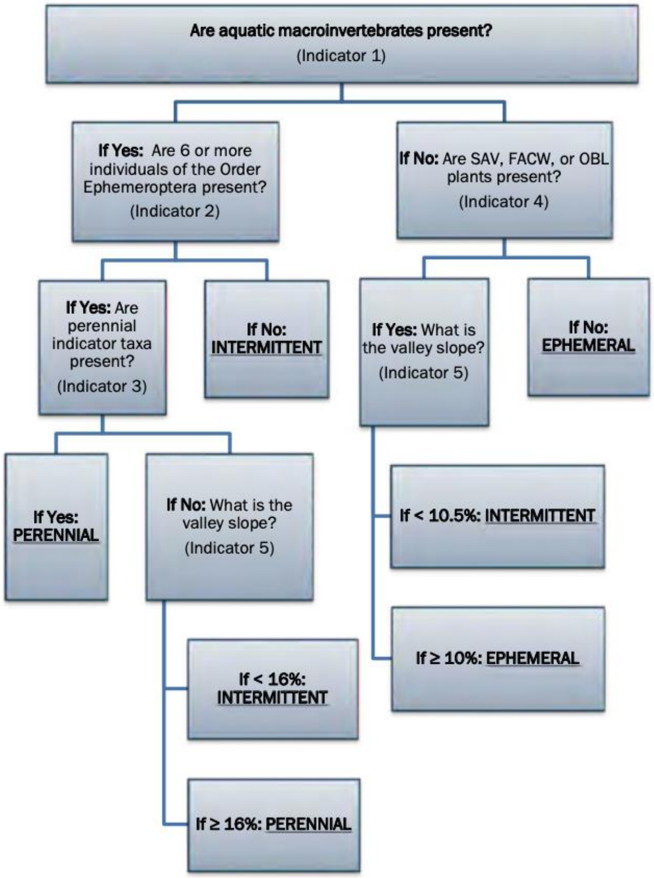


Figure 7. Pacific Northwest SDAM Decision tree for drawing conclusions from assessed indicators.

Streamflow Duration Assessment Method for the Arid West (beta version)

The SDAM developed for the Arid West is based on data collected at 89 sites across nine states between 2018 and 2019. Data were collected for 21 indicators on 30 ephemeral, 34 intermittent, and 25 perennial streams of known flow duration (Mazor et al. 2021a). Five biological indicators were found to best predict streamflow class:

1. Number of hydrophytic plant species (up to 5)
2. Number of aquatic macroinvertebrates
3. Presence of EPT taxa
4. Presence of algae
5. Presence of fish; % algal cover

The resulting beta model, shown in Figure 8 below, resulted in 81% accuracy for at least intermittent classification and 56% accuracy distinguishing all three classes. An additional 100 sites are being sampled per region in 2022 with special attention to states that were previously underrepresented (TX, MT, SD) with anticipated release of final methods in 2023.

1. Hydrophytic plant species	2. Aquatic invertebrates	3. EPT taxa	4. Algae	5. Single indicators • fish present • algae cover ≥ 10%	Classification
None	None	Absent	Absent	Absent	**Ephemeral**
				Present	**At least intermittent**
			Present	Absent	**Need more information**
				Present	**At least intermittent**
	Few (1-19)	Absent	Absent	Absent	**Need more information**
				Present	**At least intermittent**
			Present	Absent	**Need more information**
				Present	**At least intermittent**
		Present			**At least intermittent**
	Many (20+)	Absent	Absent	Absent	**Need more information**
				Present	**At least intermittent**
			Present	Absent	**Need more information**
				Present	**At least intermittent**
		Present			**At least intermittent**
Few (1-2)	None	Absent	Absent	Absent	**Need more information**
				Present	**At least intermittent**
			Present		**At least intermittent**
	Few (1-19)	Absent	Absent		**Intermittent**
			Present		**At least intermittent**
		Present			**At least intermittent**
	Many (20+)	Absent	Absent		**Intermittent**
			Present		**At least intermittent**
		Present	Absent		**At least intermittent**
			Present		**Intermittent**
Many (3+)	None	Absent	Absent	Absent	**Need more information**
				Present	**At least intermittent**
			Present		**At least intermittent**
	Few (1-19)	Absent			**At least intermittent**
		Present			**Perennial**
	Many (20+)	Absent			**At least intermittent**
		Present			**Perennial**

[2] Shading provided to enhance readability by increasing the contrast between neighboring cells; empty cells indicate the classification will not change with additional information however it is recommended that all five indicators be measured and recorded during every assessment.

Figure 8. Streamflow duration classifications for the Arid West based on key indicators (Source: Mazor et al. 2021a).

Streamflow Duration Assessment Method for Western Mountains (beta version)

The beta SDAM developed for the Western Mountains is based on data collected at 149 sites across eight states between 2019 and 2020. Data were collected for 21 indicators on 31 ephemeral, 66 intermittent, and 25 perennial streams of known flow duration (Mazor et al. 2021b). Data indicated a need to stratify the methods for this region by the degree of snow influence at the assessment reach. The indicators found to best predict streamflow class are summarized in Table 5. The resulting predictive indicators, shown in Table 5 below, resulted in 89% accuracy for at least intermittent classification and 69% accuracy distinguishing all three classes. An additional 100 sites are being sampled per region in 2022 with special attention to states that were previously underrepresented (MT, NV, SD), with anticipated release of final methods in 2023. Whereas the other SDAMs have a decision tree or chart, obtaining a classification result for the Western Mountains regions requires a web application that runs a random forest model based on user inputs.

Table 5. Indicators of the beta SDAM for Western Mountains in snow-influenced and non-snow influenced areas.

Snow-influenced areas	Non-snow influenced areas
Aquatic invertebrates: • Total abundance • Abundance of perennial indicator families • Number of perennial indicator families	Aquatic invertebrates: • Abundance of mayflies • Number of perennial indicator families
Algal cover on the streambed	Algal cover on the streambed
Fish presence (as a single indicator)	Fish abundance (as a core indicator) and Fish presence (as a single indicator)
	Differences in vegetation
Bankfull channel width	Bankfull channel width
	Sinuosity
Climate • October precipitation	Climate • May precipitation • Annual maximum temperature

New Mexico's Hydrology Protocol for Surface Water Quality Management

The New Mexico Environment Department (NMED) has established a hydrology protocol to distinguish between ephemeral, intermittent and perennial streams and rivers using hydrologic, geomorphic, and biological indicators. NMED uses these determinations in the implementation of federal Clean Water Act programs and New Mexico's Water Quality Act including development of water quality standards, assessment of water quality, issuance of permits for discharges into surface waters, and development of TMDLs for impaired waters. The Hydrology Protocol is designed to help make hydrologic determinations to ensure that the appropriate protections (i.e., designated uses and water quality criteria) are applied to a particular stream or river. This is because New Mexico's water quality standards (WQS) set distinct protections for ephemeral, intermittent, and perennial waters (20.6.4.97 - 99 NMAC). New Mexico's WQS also identify many classified waters by their hydrology. For example, "perennial tributaries to" or "perennial reaches of" (20.6.4.101 - 899 NMAC).

The Hydrology Protocol (HP) is a qualitative field methodology that generates the scientific technical support to determine the hydrology of a stream or river. The protocol relies on hydrologic, geomorphic, and biological indicators of the persistence of water, and is organized into two levels of evaluations.

A Level 1 evaluation should provide enough information to give a clear indication of the hydrologic status of the stream. In the Level 1 evaluation, 14 different attributes are evaluated and assigned a numeric score using a four–tiered, weighted scale (strong, moderate, weak, or absent). Hydrologic indicators include water in the channel, riffle-pool sequences, hydric soils, evidence of sediment/debris transport, and seeps/springs. Geomorphic indicators include sinuosity, floodplain and channel dimensions, substrate particle size and sorting. Biological indicators include the presence or absence of fish, benthic macroinvertebrates, algae/periphyton, vegetation within/near the stream channel, and iron-oxidizing bacteria.

Level 2 evaluations rely on more focused, quantitative data collection efforts and may be used to make a final hydrologic determination if the Level 1 Evaluation is inconclusive (or to provide supporting documentation). Level 2 includes benthic macroinvertebrate and fish collections, as well as other presence/absence data.

Thresholds for scores derived through the hydrology protocol are used to determine whether a reach is ephemeral, intermittent, or perennial. The thresholds were developed using data collected in 2008 and 2009 at 57 sites with known hydrology (Table 6). Areas of overlap (i.e., gray zones) are assumed to be the “higher” stream determination, unless a Level 2 analysis is completed. EPA approved New Mexico’s Water Quality Management Plan (WQMP) (NMED 2020), which includes the Hydrology Protocol as an appendix, on December 23, 2011 for purposes of implementing the federal Clean Water Act.

Table 6. Score thresholds for the New Mexico Hydrology Protocol

Waterbody Type	Level 1 Total Score	Stream Determination
Ephemeral	**Less than 9.0***	**Stream is ephemeral**
	≥ 9.0 and < 12.0	Stream is recognized as **intermittent until further analysis**
Intermittent	**≥ 12.0 and ≤ 19.0**	**Stream is intermittent**
	> 19.0 and ≤ 22.0	Stream is recognized as **perennial until further analysis**
Perennial	**Greater than 22.0**	**Stream is perennial**

** If macroinvertebrates and/or fish are present, then the stream is at least intermittent.*

Jurisdictional Evaluations in Arizona

The Arizona Department of Environmental Quality (ADEQ) applies a series of tools and processes to classify stream reaches for assessment and permitting under the Clean Water Act or a state Surface Water Protection Program. To date, Arizona has identified 1,561 unique reaches within the state and has used tools and processes to classify 1,266 as WOTUS, 92 as non-WOTUS, and 205 as inconclusive under the pre-2015 WOTUS definition. The non-WOTUS waters may be eligible for protection under the state Surface Water Protection Program.

The first tools employed by ADEQ is an evaluation of connectivity for the reach along the flow path using the USGS Raindrop Tool in StreamsStats along with the USGS National Elevation Dataset and/or FEMA 100-Year Flood Hazard Map. Next ADEQ reviews the flow regime of each reach along the flow path. Those waters that are perennial and flow into a TNW are WOTUS. Those that are disconnected from the TNW with no indication of connectivity are determined to be non-WOTUS. However, those waters that are intermittent, ephemeral or do not yet have a flow regime assigned are determined to be inconclusive until data shows either there is a significant nexus to a TNW or the reach is a relatively permanent water with connectivity to a TNW.

To determine the flow regime of reaches in Arizona, ADEQ applies a flow regime algorithm that assesses the quality of observational data by priority and assigns flow regimes based on a weight of evidence. Observational data types with higher accuracy receive greater weight. Observational data sources are then ranked based on scope with the greatest scope (the entire reach) ranking highest. Based on the underlying data and the ranking for accuracy and scope, a GIS-based algorithm uses a weight of evidence approach to assign a flow regime. If data quality thresholds are not attained, then the reach is assigned ‘Undetermined’; if there is no data for the reach, it is assigned ‘Null.’ ADEQ created a fact sheet available at azdeq.gov/flowregimes to explain how the algorithm works.

The most relevant data in the GIS algorithm is flow data directly available from USGS or other agencies. Through a review of published research, ADEQ determined a methodology for application of credible flow gauge data as an indicator for estimating intermittent or ephemeral flow regimes with breakpoints established by the percent of zero-flow days in a year (Huth et al., 2021). While this research does identify a breakpoint between intermittent and ephemeral reaches, it does not identify if a water is seasonally intermittent, which is required to determine if a water is relatively permanent. ADEQ is in the process of reviewing current scientific literature to understand seasonal intermittency in arid lands and is investigating if additional research is needed to determine thresholds.

ADEQ also uses a series of other tools to evaluate riparian vegetation, depth to groundwater, and snowpack to provide an estimate of flow regime. These tools received the 2022 National Association of Environmental Professionals Award for Best Available Innovative Technology.

The Riparian Vegetation Tool uses satellite imagery from the National Agriculture Imagery Program (NAIP) to evaluate the extent of riparian corridor vegetation (Spindler et al. 2022). The density of vegetation in riparian areas can be used to evaluate the probability that a reach is intermittent versus ephemeral as the presence of riparian or xeroriparian vegetation corridors in arid environments indicates the presence of shallow groundwater and an increased probability for intermittent flow in a surface water (Spindler et. al 2022; Nadeau & Megdal, 2012; Stromberg & Merritt, 2016; Manning et al., 2020; Mazor et al., 2021). ADEQ established a threshold of 50 percent or higher riparian vegetation corridor through NAIP imagery analysis to determine a potentially intermittent flow regime for a reach. This threshold was derived through a statistical evaluation of riparian vegetation cover in known intermittent reaches (Jones 2018) and reaches with an assigned flow regime of ephemeral (Spindler et al. 2022).

ADEQ also developed a Groundwater Tool to estimate probable intermittent or ephemeral flow regime based on knowledge of riparian vegetation rooting depths (Huth et al. 2022a). The approximate depth to groundwater is calculated by comparing groundwater elevations in well data from the Arizona Department of Water Resources to the elevation of the thalweg of the stream. ADEQ has established a threshold of 33 feet or less to classify the water as potentially intermittent.

In addition, ADEQ developed a Snowpack Tool (Huth et al. 2022b) to identify reaches that are likely to be in an area with sustained snowpack (greater than 30 days) and therefore have a higher probability of seasonal spring flow originating from snow melt (Svoma, 2011; Hunsaker et al., 2012). ADEQ selected a conservative value of 30 days for continuous snow on the ground as an assumption for seasonal snowpack in Arizona. ADEQ applies the Snowpack Tool only to reaches above 6,500 feet elevation to estimate an intermittent flow regime.

The Riparian Vegetation Tool, Groundwater Tool, and Snowpack tools are only used as indicators of flow regime for a reach until further verification work is completed. To assign a flow regime, ADEQ requires additional empirical data, including, but not limited to, flow gauge data, information from field visits, analysis of imagery (i.e. game cameras, satellite imagery, etc.), and/or results of a Streamflow Duration Assessment Methodology (SDAM) survey. Results of the tools can also assist ADEQ with prioritization of additional data gathering efforts (Spindler et al. 2022, Huth et al. 2022a, Huth et al. 2022b).

Additionally, ADEQ is in the process of developing additional analytical tools relevant to WOTUS including Arizona specific significant nexus guidance and is working to add additional data to the flow regime algorithm, such as the result of SDAM field surveys for the arid west, data from springs, historic water quality sampling reports, wet-dry mapping reports, game camera imagery, satellite imagery, and more.

Oregon forest management stream typing

Oregon has a broad *Waters of the State* Definition that includes all surface or groundwater including seeps and springs but excluding private waters unconnected to natural surface or groundwater (e.g. a lined rainwater reservoir). However, regulations for Waters of the State are not consistent across land uses, water types, and beneficial uses and are applied based, in part, on stream type.

The State of Oregon's Department of Forestry (ODF) determines stream type based on flow, beneficial uses, and geographic regions that form the basis of forestry regulations designed to protect streams on non-federal forested lands within the state. The classification of streams incorporates ecology and climate by differentiating streams west or east of the crest of the Cascade Mountains (wet side, dry side). Although all streams must meet water quality standards, there are generally more protections required for streams with aquatic life beneficial uses for sensitive cold-water fish such as salmon, steelhead, and bull trout (Type - SSBT). Other stream types include those protected for other game fish such as cutthroat trout (Type-F), domestic use without fish (Type-D), and non-fish and non-domestic uses (Type-N). Streams are also grouped based on size: large streams have an annual average flow greater than 10 cubic feet per second (cfs), medium streams have a flow of 2 -10 cfs, and small streams have a flow less than 2 cfs. Under Oregon statute, the seasonality of Type-N streams will also be considered in implementing stream protections with perennial streams having greater protections than seasonal streams that do not flow continuously during the summer months. The precise mechanisms for delineating whether streams are perennial or intermittent is under development by ODEQ but may rely on USGS observations and modeling.

Separately, the Oregon Department of Agriculture (ODA) regulates stream protections in Agricultural Water Quality Management Areas, typically a HUC8 subbasin or collection of ecologically similar subbasins. Protections are a combination of regulatory requirements and voluntary plans that include restoration. ODA and ODF both coordinate with Oregon Department of Environmental Quality to implement water quality standards and total maximum daily loads when nonpoint sources are a source of water pollution.

Conceptual Approach to Estimate Flow Duration at Regional Scales (Wyoming DEQ)

The Wyoming Department of Environmental Quality (WDEQ) is in the early phases of developing a tool for hydrologic evaluations in a WOTUS context (significant nexus) based on flow duration curve (FDC) methods. A conceptual outline of the approach is below and will be further developed in the future. The method aims to derive flow duration statistics using mean daily flow or annual flow. Flow duration curve methods define both duration of a given flow and the type of flow regime (Hargett pers comm 2022).

The FDC method would start with an *a priori* selection of homogenous hydrologic regions using other tools (e.g., combined HUC6 or HUC8 watersheds (USGS and NRCS 2013), level IV ecoregions, NHD+V2, etc.). Flow duration curves would then be developed, preferably with annual flow data, for all gauged[12] sites within each hydrologic region. *USGS gauges; state-operated gauges; state, federal, local and private stage recorders; university collected flow data; Annual FDCs are preferred because they can be used to evaluate inter-annual variability, and recurrence intervals can be developed. Abnormally wet or dry periods should have less weight. In addition, annual FDCs are representative of a median hypothetical year and not tied to a period of record.

The FDCs would be used to define hydrologic metrics for classification of the three flow regimes (ephemeral, intermittent, perennial) within each hydrologic region (e.g., % of year with flow). As an example, the percent of the year with flow might be used to define ephemeral (<25%), intermittent (25-80%), and perennial (>80%) waters. Physiographic and climatic variables (e.g., drainage area, precipitation, evaporation, channel slope) would be used to develop dimensionless empirical regression models that predict each of the three flow regimes within a hydrologic region. This could be done with Bayesian classification methods (random forest, regression trees) to determine the most important variables in prediction of a flow regime class. Next, the dimensionless models could be applied to ungauged sites (catchments) within the hydrologic region to determine flow regime.

This method establishes regional quantitative definitions of ephemeral, intermittent, and perennial with respect to WOTUS rule language and uses only hydrologic-based variables (gauged sites, geomorphic, climatic, and physiographic). It provides a prediction of each hydrologic class for a catchment with statistical significance and levels of confidence. Numeric thresholds could be developed using statistical models and confirmed with ground-truthing. Once developed, these methods could be applied using a desktop application.

WDEQ recommends that these methods only apply to lotic systems at regional scales smaller than those used by USEPA's SDAM to improve accuracy. This could be integrated into a broader SDAM application.

Summary

Most of the tools described in this section are used to differentiate perennial, intermittent, and ephemeral waters. They all rely on regionally relevant biological, geomorphic, climatic, and/or hydrologic indicators. The differences in specific indicators and factors are summarized in Table 7. The methods developed for New Mexico are the oldest of the tools summarized and have been used as the basis for other state tools. These tools could likely be adapted at least for the four corners region of the country.

Different factors and indicators of greatest importance have been identified in the tools used in different areas of the west, highlighting the need to have multiple tools or at least regional versions of tools available to implement any

[12] USGS gauges; state-operated gauges; state, federal, local and private stage recorders; university collected flow data.

WOTUS definition. However, if any of the tools were to be used to make jurisdictional determinations, the methods and significance thresholds would need to be further evaluated by states that were not involved in their development using supplemental datasets.

Table 7. Summary of analytical tools used by states and EPA in evaluating flow regime and stream type.

Analytical Tool	Primary Purpose	Hydrologic Classification Categories/Statistics	Indicators and factors used in method	Models and analytical methods
SDAM Pacific NW	1) implementation of state and local ordinances; 2) improved ecological assessment; 3) application of appropriate water quality standards; 4) prioritization of restoration and protection efforts; 5) ambient monitoring and understanding responses to a changing climate; and 6) assisting with timely and predictable jurisdictional determinations.	Perennial, intermittent, ephemeral, and at least intermittent	Presence of any aquatic macroinvertebrates (ordinal) Presence of perennial macroinvertebrates Presence of 6 or more ephemeroptera Indicator status of most hydrophytic plant in streambed Channel slope (%)	Decision tree derived from random forest model
SDAM Arid West (beta)		Perennial, intermittent, ephemeral, at least intermittent, and need more information.	Hydrophytic plant species Aquatic invertebrates EPT taxa Algae Single indicators present (fish/%algae cover)	Classification table derived from random forest model
SDAM Western Mountains, snow influenced (beta)		Perennial, intermittent, ephemeral, and at least intermittent	Aquatic invertebrates Algae cover on the streambed Fish presence Bankfull channel width Climate	Random forest model available through a web application.
SDAM Western Mountains, non-snow influenced (beta)		Perennial, intermittent, ephemeral, and at least intermittent	Aquatic invertebrates Algae cover on the streambed Fish presence or abundance Vegetation differences Bankfull channel width Sinuosity Climate	Random forest model available through a web application.
New Mexico Hydrology Protocol	Implementation of federal Clean Water Act programs and New Mexico's Water Quality Act including development of water quality standards, assessment of water quality, issuance of permits for discharges into surface waters, and development of TMDLs for impaired waters	Ephemeral, intermittent, perennial	Hydrologic indicators • Water in the channel • Riffle-pool sequences • Hydric soils • Evidence of sediment/debris transport • Seeps/springs Geomorphic indicators • Sinuosity • Floodplain • Channel dimensions • Substrate particle size and sorting Biological indicators • Presence or absence of fish • Presence or absence of benthic macroinvertebrates • Presence or absence of algae/periphyton • Presence or absence of vegetation within/near the stream channel • Presence or absence of iron-oxidizing bacteria.	Unitless score derived from testing the model on known intermittent and ephemeral waters. Data from perennial, intermittent, and ephemeral streams were assessed using analysis of variance (ANOVA) to verify which field indicators are useful in differentiating hydrologic systems in New Mexico by determining if the variation between groups was statistically significant ($p<0.01$ or $p<0.005$).
Jurisdictional Evaluations in Arizona	Clean Water Act program jurisdiction: 305(b) Biannual Assessment; 303(d) Impaired Waters; 402 Permitting State surface water program jurisdiction.	Perennial, intermittent, ephemeral, Undetermined, Null	Hydrology • Average number of precipitation events producing flow per year for intermittency • Percent days with zero flow for ephemeral status Riparian vegetation • Threshold of >50% riparian vegetation cover to support intermittency Groundwater • Thresholds of <33 feet below surface to support intermittency	Hydrology: Weight of evidence algorithm based on prioritized data sources (e.g. observation data types with higher accuracy receive greater weight). Supplemented by evaluations of riparian

			Snowpack • Threshold of 30 days of snow cover to support intermittency above 6,500 feet elevation	vegetation and groundwater.
Oregon Stream Typing	Basis of forestry regulations designed to protect streams on non-federal forested lands within the state	Type – SSBT (aquatic life beneficial uses for sensitive cold-water fish), Type-F (protected for other game fish), Type-D (domestic use without fish), and Type-N (non-fish and non-domestic uses).	Aquatic life and domestic beneficial use classes. Stratified based on stream size (small <2cfs, medium, and large >10cfs).	Categorical stream types.
Wyoming Flow Duration Curve Approach	Jurisdictional determinations; significant nexus	Perennial, intermittent, ephemeral	Hydrologic (annual flow at gauged sites) Geomorphic (channel slope) Climate (precipitation, evaporation) Physiographic (drainage area)	Dimensionless empirical regression models derived using Bayesian classification methods (random forest, regression trees)

Integrating Regional Classification Schemes and Analytical Tools in a WOTUS context

Regional Frameworks

Regions used for WOTUS implementation need to capture the most important attributes and differences across regions while ensuring that the regional scheme can be practically implemented by both federal regulatory agencies and states. Therefore, a regional classification scheme that results in approximately 10 regions across the country would strike the best balance. Of course, the tools applied within each region should reflect more site-specific and subregional landscape, climate, and hydrologic characteristics.

The Watershed Boundary Dataset represents one approach to regionalizing the country for WOTUS implementation based on hydrologic drainage patterns. The HUC-2 data layer of 22 drainages is most likely the only realistic regional scheme driven solely by hydrology. However, basing regional classification solely on hydrology will merge areas with very different elevation, precipitation, and ecological patterns. For example, high mountain streams and valley rivers are grouped together based on watershed boundary even though the ecology and geomorphology of these waters are quite different. Using this approach to divide the country may not provide sufficient opportunity to use tools that are tailored for different landscapes.

Ecoregions offer a classification scheme for the nation that incorporates many explanatory factors for surface water differences in different regions. Ephemeral features differ with respect to prevalence, significance, and hydrology based on geology, elevation, and precipitation, all of which are captured in the ecoregion classification scheme. The Level I classification with 13 regions is the most practical in terms of regional implementation of a WOTUS rule. Of course, such a classification scheme would encompass significant variability that would need to be addressed using regional versions of models or analytical tools.

Alternatively, the ecoregion concept may be best used as a supporting tool to explain why some hydrologic features behave differently in one area of the country than another. It may be possible to combine elements of the NHD and WBD (see section above) with ecoregions to geographically delineate areas of the country that are dominated by ephemeral waters, particularly in the southwest. This may lend itself to more precise definitions of ephemeral features and their potential significance on downstream TNWs.

The experience of the National Research Council and the USACE in exploring regional classifications schemes and developing regional wetland delineation guidance is directly relevant to regionalizing the current WOTUS rule. Indeed, the regionalization of wetland delineation practices by the USACE demonstrates the practicality and policy soundness of such an approach. Adopting the USACE wetland delineation regions (10 regions) for use in a regionalized WOTUS rule would provide clarity and simplicity that are not offered by the other classification schemes. Further, the USACE wetland delineation regions build on the NRCS LRR regionalization, which in turn builds on the datasets and classification used for NHD and ecoregion classifications.

Using the regions established for EPA's Streamflow Assessment Duration Methods is also a practical approach that incorporates many of the regional considerations of importance to states. There are currently envisioned to be only 5 SDAM regions. However, the regions established for SDAMs are a blend of administrative boundaries (Pacific Northwest aligns with the state boundaries for EPA Region 10) and ecological boundaries (aligning with Level I Ecoregions for Western Mountains and the Arid West). Further, the regional boundaries for the Great Plains, northeast, and southeastern regions of the country have not yet been finalized, nor is it clear how Alaska and Hawaii would be integrated into the scheme.

There could be benefits to USACE and USEPA agreeing on a regional classification scheme that is applicable to all waters of the US rather than having separate, overlapping but different, schemes for wetlands and streams.

Applicability of Analytical Tools

A variety of analytical tools exist that could prove useful in implementing a WOTUS rule with regional considerations. The utility of the tools largely depends upon how the WOTUS rule is structured and which hydrologic "tests" are included.

Connectivity

The National Hydrography Dataset represents the best tool to evaluate connectivity between surface waters across the country. The NHDplus data product combines the existing National Hydrography Dataset and Watershed Boundary Dataset with a new 3D Hydrography Program that will be used to create a 3D National Topography Model. NHDplus will provide new tools to connect hydrologic attributes to landscape features. These tools could contribute to the development of nationally consistent modeling approaches, with regional specificity, for WOTUS implementation.

Flow Regime

Multiple tools are available to differentiate perennial, intermittent, and ephemeral waters, including the regional Stream Flow Duration Assessment methods developed by USEPA, the flow regime tools implemented by Arizona DEQ, the New Mexico Environment Department Hydrology Protocol, and the approach using flow duration curves proposed by Wyoming DEQ. Each of these tools could be adapted to different regions of the country through the establishment of the most regionally relevant criteria and their thresholds. These categorical methods would be especially useful in evaluating a "relatively permanent" test. Obviously, the tools do not answer the question of which categories of waters should be considered WOTUS, a topic of significant debate across the country.

There is also an opportunity to develop a tiered method that would rely on the nationally available stream layer in the National Hydrography Dataset along with the USACE list of Section 10 waters to define waters that are clearly perennial and/or TNW, while utilizing the other methods to define waters with less clear flow regimes. A tiered approach could reduce resource strains on regulatory agencies.

Significant Nexus

If the USEPA and USACE elect to include some, but not all, intermittent and/or ephemeral waters into the WOTUS definition, there would be value in tools that could differentiate within these broad categories to evaluate the degree of intermittency or ephemerality as well as the significance of each water to a downstream TNW. For example, there could be differentiation with the category of ephemeral waters based on flow frequency, e.g., waters that only flow once a decade could be categorized differently from those that flow annually. The tools described and evaluated in this technical report do not provide for evaluation of a continuum of ephemeral and intermittent waters. Rather, they all result in a categorical assignment of a stream to one of the three main categories. However, the methods outlined in both the New Mexico and Arizona tools create a scoring system that could be adapted for use in a more continuous context. Additional thresholds for criteria could be used to evaluate the degree of ephemerality or intermittency. Further, the methods proposed by Wyoming and used by Oregon for stream typing also provide some ability to develop a continuum of outputs rather than only using categorical definitions. The strictly categorical framework of the Streamflow Duration Assessment Method approach is a significant limitation of this tool for this purpose.

It could also be helpful to differentiate waters based on the probability of contributing "significant" flow or pollution to a TNW. One approach to evaluating significance would be existing pollutant transport and hydrologic models paired with thresholds for significance. The most appropriate modeling tools may vary from region to region as different models have different strengths with respect to simulating certain hydrologic processes. For example, areas with primarily snow-influenced hydrology may require different modeling tools than areas dominated by flashy desert hydrology. Further, the thresholds established in making determinations regarding significance will need to reflect the beneficial uses and water quality standards of the downstream TNWs, which are generally specific to states and can differ significantly across the country. Although there are numerous modeling tools available to evaluate hydrology and pollutant transport, they can be very data and time intensive to implement.

Watershed Size

The USEPA and USACE may also consider incorporating thresholds for watershed size into the differentiation of especially ephemeral waters within WOTUS. The nature of hydrology is such that nearly any area of land could be considered an ephemeral water at some scale, though clearly the entire landscape should not be considered a WOTUS. NHD products may be useful in this evaluation as USGS has established watershed size thresholds for some HUC levels. The smaller drainage boundaries developed for the Watershed Boundary Dataset include size thresholds that are applied uniformly across the country. Whereas HUC 10 drainages have a threshold of 250,000 acres and HUC 12 drainages have a threshold of 40,000 acres, no size thresholds have been determined yet for HUC 14 or HUC 16 drainages. Different drainage size thresholds for different regions could be explored as one element of determining significance within a WOTUS context.

Mapping WOTUS

Regardless of how WOTUS is defined, there has long been a need for a national mapping structure that provides clarity to regulators and the regulated community with respect to jurisdiction. Any new tools developed for use in implementing WOTUS should incorporate a spatial model or algorithm that can be integrated into existing GIS applications.

Disclaimers

The staff of the Western States Water Council (the WSWC) prepared this paper, and an accompanying policy memorandum, in Summer 2022 in collaboration with representatives from 17 western states. The participating states bring different perspectives and circumstances to this issue. These papers represent a summary of ideas that have been discussed and debated with the Council membership and does not represent a position or recommendation with respect to regional approaches to the implementation of a WOTUS definition. Although the Council has supported exploration of regional approaches to WOTUS, the views expressed herein do not necessarily reflect the views of the individual members. Further, it is anticipated that these papers could be further revised by a decision in the case Sackett v. EPA that is currently before the Supreme Court, and the pending finalization of the rule initiated by the Agencies on November 18, 2021 and proposed on December 7, 2021. The Council intends these documents to be helpful to states forming their own policy positions and in facilitating ongoing discussions amongst states and with federal agencies in our joint pursuit of a more durable, clear, and implementable definition of WOTUS.

References

ADEQ. 2022. *Jurisdictional Evaluations – Focus on Significant Nexus.* Whitepaper.

ADEQ. 2022. *Environmental, social, and economic cost/benefit analysis.* Whitepaper.

Austin, M.E. 1965. *Land Resource Regions and Major Land Resource Areas of the United States.* SCS-USDA, Agriculture Handbook #296. U.S. Gov. Print. Office, Washington, DC.

Hunsaker, C.T., Whitaker, T.W. and Bales, R.C., 2012. Snowmelt runoff and water yield along elevation and temperature gradients in California's Southern Sierra Nevada 1. *Journal of the American Water Resources Association*. 48(4), pp.667-678.

Huth, H., Spindler, P., Smart, M., Pace, M., and Jordan, E. 2021. *Application of flow gauge data utilizing a USGS approach to identify ephemeral and intermittent flow regimes in Arizona.* ADEQ White Paper.

Huth, H., Pace, M., Spindler, P., Smart, M., and Jordan, E. January 2022. *Analysis of snowpack for estimating flow regimes in Arizona*, ADEQ White Paper.

Huth, H., Spindler, P., Smart, M., and Jordan, E. January 2022. *Analysis of depth to groundwater for estimating flow regimes in Arizona*, ADEQ White Paper.

Manning, A., Julian, J.P. and Doyle, M.W., 2020. Riparian vegetation as an indicator of stream channel presence and connectivity in arid environments. *Journal of Arid Environments*, 178, p.104167.

Mazor, R.D., Topping, B., Nadeau, T.-L., Fritz, K.M., Kelso, J., Harrington, R., Beck, W., McCune, K., Lowman, H., Allen, A., Leidy, R., Robb, J.T., and David, G.C.L. 2021a. *User Manuel for a Beta Streamflow Duration Assessment Method for the Arid West of the United States*. Version 1.0. Document No. EPA800-5-21001

Mazor, R.D., Topping, B., Nadeau, T.-L., Fritz, K.M., Kelso, J., Harrington, R., Beck, W., McCune, K., Allen, A., Leidy, R., Robb, J.T., David, G.C.L., and Tanner, L. 2021b. *User Manual for a Beta Streamflow Duration Assessment Method for the Western Mountains of the United States*. Version 1.0. Document No. EPA840-B-21008.

McMahon, G., S.M. Gregonis, S.W. Waltman, J.M. Omernik, T.D. Thorson, J.A. Freeouf, A.H. Rorick, and J.E. Keys. 2001. Developing a spatial framework of common ecological regions for the conterminous United States. *Environmental Management* 28(3):293-316.

Nadeau, T. et al. 2015. Validation of rapid assessment methods to determine streamflow duration classes in the Pacific Northwest, USA. *Environmental Management*. 1/2015.

National Research Council, 1995. *Wetlands: Characteristics and boundaries*. National Academies Press.

Nadeau, J., Megdal, S.B. 2012. *Arizona Environmental water needs assessment report.* University of Arizona Water Resources Research Center. https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/Assessment_9-27-2012_indesign%20rev3bleed_0.pdf.

Nadeau, Tracie-Lynn. 2015. *Streamflow Duration Assessment Method for the Pacific Northwest.* EPA 910-K-14-001, U.S. Environmental Protection Agency, Region 10, Seattle, WA

Omernik, J.M. 1987. Ecoregions of the conterminous United States. *Annals of the Association of American geographers*, *77*(1), pp.118-125.

Omernik, J. 1995. *Ecoregions: a framework for environmental management.* Pages in Davis, W., and T. Simon, editors. Biological assessment and criteria: tools for water resource planning and management. DOI: 10.13140/RG.2.1.4916.2726

Omernik, J.M. and Griffith, G.E. 2014. Ecoregions of the conterminous United States: evolution of a hierarchical spatial framework. *Environmental management*, *54*(6), pp.1249-1266.

Stromberg, J.C. and Merritt, D.M. 2016. Riparian plant guilds of ephemeral, intermittent and perennial rivers. *Freshwater Biology*, *61*(8), pp.1259-1275.

Spindler, P., Smart, M., and Jordan, E. January 2022. *Analysis of percent riparian vegetation for estimating flow regimes in Arizona,* ADEQ White Paper.

State of New Mexico. 2020. *Statewide water quality management plan and continuing planning process. New Mexico Water Quality Control Commission.* Approved October 23, 2020.

Svoma, B.M. 2011. Trends in snow level elevation in the mountains of central Arizona. *International journal of climatology*, *31*(1), pp.87-94.

United States Department of Agriculture, Natural Resources Conservation Service. 2022. *Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin.* U.S. Department of Agriculture, Agriculture Handbook 296.

U.S. Geological Survey and U.S. Department of Agriculture, Natural Resources Conservation Service. 2013. *Federal Standards and Procedures for the National Watershed Boundary Dataset (WBD) (4 ed.)*. U.S. Geological Survey Techniques and Methods 11–A3, 63 p.

USEPA 2022. *Basic Information about SDAMs.* https://www.epa.gov/streamflow-duration-assessment/learn-about-streamflow-duration-assessment-methods-sdams. Accessed September 2022.

Wakeley, J.S. 2002. *Developing a" regionalized" version of the Corps of Engineers Wetlands Delineation Manual: issues and recommendations.* USACE Technical Report TR-02-20.

Wohl et al. 2016. *Synthesizing the scientific foundation for Ordinary High Water Mark delineation in fluvial systems.* USACE.