SOUTHERN ENVIRONMENTAL LAW CENTER

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January 10, 2019

Via electronic mail

Dr. Thomas Armitage
Designated Federal Officer
EPA Science Advisory Board Office
USEPA Science Advisory Board (1400R)
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460
armitage.thomas@epa.gov

Re: Response to "Commentary on the Proposed Rule Defining the Scope of Waters Federally Regulated Under the Clean Water Act"

Dear Dr. Armitage:

The Southern Environmental Law Center ("SELC") submits these comments, along with the comments it previously submitted on behalf of 80 non-profit organizations (attached),[1] for the Science Advisory Board's consideration in finalizing its Commentary on the Proposed Rule Defining the Scope of Waters Federally Regulated under the Clean Water Act ("Proposed Rule").

We applaud the Board for identifying the Proposed Rule's lack of scientific basis and urge the Board to maintain its critiques in the final commentary, including but not limited to:

- The Rule "is in conflict with established science, the existing WOTUS rule developed based on the established science, and the objectives of the Clean Water Act."[2]
- The Rule "decreases protection for our Nation's waters and does not support the objective of restoring and maintaining 'the chemical, physical and biological integrity' of these waters."[3]
- The "departure of the proposed Rule from EPA recognized science threatens to weaken protection of the nation's waters by disregarding the established connectivity of ground waters and by failing to protect ephemeral streams and wetlands which connect to navigable waters below the surface. These changes are

[1] *See* Letter from K. Moser, SELC, to A. Wheeler, U.S. EPA, & R.D. James, Dep't of Army (Apr. 15, 2019) (Submitted by SELC to EPA Docket Center EPA-HQ-OW-2018-0149 on April 15, 2019) ("SELC Comments on Proposal").
[2] Science Advisory Board, Draft Commentary on the Proposed Rule Defining the Scope of Waters Federally Regulated Under the Clean Water Act, 1 (Oct. 16, 2019) ("Draft Commentary").
[3] *Id*. at 2.

> proposed without a fully supportable scientific basis, while potentially introducing substantial new risks to human and environmental health."[4]

We also urge the Board to go farther in pointing out the agencies' errors and to reconsider its conclusion that "a conflict exists between current, recognized hydrological science versus the [Clean Water Act] and its subsequent case law."[5]

First, the Board should assess and comment on the flaws in the agencies' Economic Analysis,[6] as it has for other rules.[7] SELC, its partners, and its experts—Dr. John Whitehead and Dr. Jeff Mullen—identified just some of those errors in the attached comments and expert reports.[8] Among several errors, two stand out. First, the agencies assume that wetland benefits are valued only by in-state residents. Second, the agencies dramatically understate the number of wetlands in each state as part of their wetland benefit analysis. Correcting those errors demonstrates that the true value of "loss of wetland benefits" is more than $2.4 billion every year as a result of this proposal. We encourage the Board to review SELC's comments and expert reports and to incorporate these and our other critiques into its final commentary.

Second, there is no conflict between current, recognized hydrological science and the Clean Water Act and its subsequent case law. As the Board acknowledges, Congress's primary goal for the Clean Water Act is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The case law interpreting the Act firmly establishes that the Act's reach is, and must be, broad—*consistent with science*—in order to achieve this goal.[9]

To support their ill-advised proposal, the agencies offer various misinterpretations of case law, which, if accepted, would upend decades of established law and agency interpretation of the Clean Water Act. Their approach would remove protections from ephemeral (and possibly intermittent and some perennial) streams, as well as from a majority of wetlands. Their current interpretation "is inconsistent with the Act's text, structure, and purpose." *Rapanos v. United States*, 547 U.S. 715, 778 (Kennedy, J. concurring) (criticizing Justice Scalia's test for jurisdiction, which now forms the basis for the agencies' Proposed Rule). As Justice Kennedy concluded in *Rapanos*, the approach adopted by the agencies here "makes little practical sense in a statute concerned with downstream water quality." *Id*. at 769.

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[4] *Id*. at 3-4.
[5] *Id.* at 4.
[6] U.S. EPA and Dep't of Army, Economic Analysis for the Proposed Revised Definition of "Waters of the United States," EPA-HQ-OW-2018-0149-0004, 46 (Dec. 14, 2018) ("Economic Analysis").
[7] *See, e.g.*, Science Advisory Board, Consideration of the Scientific and Technical 21 Basis of EPA's Proposed *Mercury and Air Toxics Standards for Power Plants 22 Residual Risk and Technology Review and Cost Review* (Draft) (Oct. 16, 2019), https://yosemite.epa.gov/sab/sabproduct.nsf/WebBOARD/recentadditions?OpenDocument.
[8] SELC Comments on Proposal at 4, 23-27, 41-50; John. C. Whitehead, Comments on "Economic Analysis for the Proposed Revised Definition of 'Waters of the United States'" (EPA-Army 2018) (Apr. 9, 2019), attached as Ex. C to SELC Comments on Proposal; Jeffrey D. Mullen, Ph.D., Draft Review of the 2018 EPA Economic Analysis for the Proposed Definition of "Waters of the United States" (Apr. 10, 2019), attached as Ex. D to SELC Comments on Proposal.
[9] *See* SELC Comments on Proposal at 11-16, 29-40 (summarizing case law).

As the Board correctly recognized in its draft commentary,[10] the agencies' Proposed Rule will only add confusion and perpetuate the ongoing interpretation and re-interpretation of the definition of waters of the United States. Science provides clarity. There is a vast body of scientific knowledge that clearly demonstrates the importance of small streams and wetlands to downstream water quality. As science advances, our knowledge grows but it does not fluctuate whimsically as the agencies' reinterpretation of 40 years of case law does. Divorcing this rule from its scientific moorings will foster greater confusion and uncertainty.

As a Nation, we are far from achieving the Clean Water Act's objective. Now is not the time for the agencies to abdicate their responsibility to protect the Nation's waters. Should the agencies proceed with their current proposal, they do so despite the known risks to our economy, our infrastructure, and the health and well-being of our communities. We urge the Board to maintain and strengthen its critiques, by incorporating SELC's and its experts' comments, when finalizing the Board's commentary on the Proposed Rule.

Thank you for your consideration.

Attachments (3):
SELC Replacement Rule Comments. April 15, 2019
SELC Replacement Rule Comments. April 15, 2019 (unsigned)
Exhibits A - E

[10] Draft Commentary at 3.

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April 15, 2019

Via www.regulations.gov

The Honorable Andrew Wheeler
Administrator
U.S. Environmental Protection Agency
Office of the Administrator
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

The Honorable R.D. James
Assistant Secretary of the Army
Department of the Army
108 Army Pentagon
Washington, DC 20310

Re: Revised Definition of Waters of the United States
Docket No. EPA-HQ-OW-2018-0149[1]

Dear Administrator Wheeler and Assistant Secretary James:

Together, our 80 organizations write to ask you to protect the streams, rivers, and wetlands that are essential to our country's natural environment, cultural history, and economy. We and our millions of members recognize that clear, predictable protections for streams and wetlands are essential to safeguarding the waters where Americans swim, fish, boat, paddle, hunt, and get their drinking water. This rulemaking would eliminate these protections without justification. We respectfully request that the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers withdraw the proposed rule.

[1] Aside from the documents cited from the rulemaking record, documents designated as exhibits A-E, case law, and federal and state statutes and regulations, the documents cited herein were submitted to the docket center by hand-delivery on April 15, 2019. (A stamped copy of the transmittal cover letter and document list is attached as Appendix 1.)

The Southern Environmental Law Center submits these comments on behalf of:

Alabama Rivers Alliance
Altamaha Riverkeeper
American Rivers
Appalachian Voices
Audubon Naturalist Society
Audubon South Carolina
Black Warrior Riverkeeper
Blue Ridge Land Conservancy
Cahaba River Society
Cahaba Riverkeeper
Cape Fear River Watch
Capital Region Land Conservancy
Carolina Wetlands Association
Catawba Riverkeeper
Center for a Sustainable Coast
Charleston Waterkeeper
Chattahoochee Riverkeeper
Clean Water Action
Coalition for Smarter Growth
Coastal Conservation League
Congaree Riverkeeper
Coosa River Basin Initiative
Coosa Riverkeeper
Defenders of Wildlife
Dogwood Alliance
Endangered Habitat League
Environment Georgia
Flint Riverkeeper
Friends of Accotink Creek
Friends of the Rappahannock
Harpeth Conservancy
Haw Riverkeeper
Healthy Gulf
Hip Hop Caucus
Illinois Council of Trout Unlimited
James River Association
Lake James Environmental Association
Land Trust of Virginia
Loudoun Wildlife Conservancy
Lumber Riverkeeper
Lynnhaven River NOW
Mobile Baykeeper
MountainTrue
Natural Heritage Institute
North Carolina Coastal Federation
North Carolina Wildlife Federation
Obed Watershed Community Association
Ogeechee Riverkeeper
One Hundred Miles
Passaic River Coalition
Piedmont Environmental Council
Potomac Riverkeeper Network
Protect Our Aquifer
Rivanna Conservation Alliance
Roanoke River Basin Association
Rockbridge Area Conservation Council
Satilla Riverkeeper
Savannah Riverkeeper
Save EPA
Save Our Saluda
Sierra Club
Sound Rivers
South Wings
St. Mary's Earthkeepers
Statewide Organizing for Community eMpowerment
Surfrider Foundation Georgia Chapter
Tennessee Citizens for Wilderness Planning
Tennessee Clean Action Network
Tennessee Conservation Voters
Tennessee Environmental Council
Tennessee Scenic Rivers Association
Upstate Forever
Virginia Aquarium and Marine Science Center
Virginia Conservation Network
Virginia League of Conservation Voters
Waccamaw Riverkeeper
Wetlands Watch
Winyah Rivers Alliance
Yadkin Riverkeeper

I. SUMMARY OF COMMENTS

In what would be the biggest rollback in clean water protections in the 47 years since the Clean Water Act became law, this administration's proposal to redefine "waters of the United States" would drastically restrict Clean Water Act jurisdiction, particularly over streams and wetlands. The statutory term at issue—"waters of the United States"—is the jurisdictional "linchpin" for virtually every one of the Act's critical safeguards, including the Act's core prohibition established by section 402 against the discharge of pollutants without a "National Pollutant Discharge Elimination System" permit, the requirements regarding dredge and fill material in section 404 of the Act, the obligation that states develop water quality standards, and several other key statutory provisions.[2] Removing these protections would allow more pollution into our rivers, lakes, and drinking water sources, which are only as clean as the source waters that feed them. It would deal a devastating blow to people's health, clean water, and our economy—resulting in lost benefits of more than $2.4 billion each year from wetland loss alone. That damage would only be exacerbated if the administration adopts the even more extreme restrictions of federal clean water protections proposed in its solicitation of comments.

At the outset, it must be emphasized that based on EPA' own assessment, we are far from reaching the objective of the Clean Water Act: "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." More than half of streams evaluated by EPA are impaired. Our coastal waters that those streams and rivers flow into are much worse—nearly 80 percent of bays and estuaries are impaired, as are 91 percent of ocean and near-coastal waters and 100 percent of the Great Lakes open waters. By all accounts, more protection for clean water is necessary if we are to achieve the Clean Water Act's objective.

Yet the proposal acknowledges that it would make an already bad situation worse and, nonetheless, proceeds based on faulty rationale. Two legal fictions control this rulemaking. First is the agencies' dependence on the plurality opinion in *Rapanos*[3] as controlling—even though the opinion was rejected by the majority of the Supreme Court. Dozens of federal courts have rejected the plurality opinion as controlling, yet the agencies treat it as binding. This proposal jettisons Justice Kennedy's opinion in *Rapanos* as that of "a single justice."[4] But Justice Kennedy's opinion, and its significant nexus test, is controlling, and it sets forth the science-backed analysis that previous Supreme Court case law requires. The approach outlined in the proposal reverses decades of law and agency practice, but lacks any meaningful, valid explanation for the agencies' departure.

The second foundational fallacy is the agencies' assertion that Congress intended for section 101(b) to put the success of the statute exclusively in the states' hands when passing the 1972 Clean Water Act. That is not so. Congress did the opposite. Faced with two competing proposals to define the role of federal and state governments in implementing the Act, Congress rejected an approach like the one proposed here—the abandonment of federal jurisdiction to give

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[2] *See* 33 U.S.C. § 1342; *see also* 43 Op. Att.y Gen. 197, at 200-201 (Sept. 5, 1979) ("The term navigable waters . . . is a linchpin of the Act . . . . Its definition is not specific to § 404, but is included among the Act's general provisions.").

[3] *Rapanos v. United States*, 547 U.S. 715 (2006).

[4] Revised Definition of "Waters of the United States," 84 Fed. Reg. 4,154, 4,196 (Feb. 14, 2019).

states sole rein when it comes to protections for smaller streams and wetlands. Instead, Congress carefully defined the role of states by giving states the authority to implement sections 402 and 404 of the Act if their state programs meet federal minimum requirements. As our Supreme Court has long recognized, when Congress speaks so clearly, "that is the end of the matter; for the court, as well as the agency, must give effect to the unambiguously expressed intent of Congress."[5]

Though the agencies have proposed a reversal of decades of law and policy, the proposal lacks any meaningful assessment of the damage that the proposal would do to our Nation's waters. In these comments, we attempt to provide part of that analysis. The attached analysis by Moffat and Nichol shows that, in some watersheds in North Carolina, the proposal could eliminate protection for more than 90 percent of the stream network. In other watersheds in Virginia, North Carolina, South Carolina, and Georgia, the proposal could strip away protection for more than 40 percent of streams. Wetlands are similarly vulnerable—as much as 78 percent of headwater wetlands in coastal North Carolina could lose protection in addition to most basin, bog, bottomland hardwood forest, Carolina bay, floodplain pool, hardwood flat, headwater forest, non-riverine swamp forest, pine savanna, pocosin, and seep wetland types found in the state. Similar impacts are likely to occur throughout the Southeast.

The partial analysis provided in these comments does not, however, negate the agencies' obligation to conduct a complete one. In short, the agencies must fully assess and disclose the proposal's likely impact on the overriding objective of the Clean Water Act: to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. The first step in that analysis should be based on the permitting data included in the docket. Based on our assessment of that permitting data, the effect of this proposal would be devastating—thousands of acres of wetlands and hundreds miles of streams would be destroyed each year by development and other industrial activities without a section 404 permit. Nationwide, thousands of NPDES permittees that discharge into small streams could see their pollution control limits substantially reduced or eliminated altogether—allowing more pollution into our waterways. These are only the beginning of the potential impacts.

The agencies' Economic Analysis, while incomplete and deeply flawed, foreshadows the breadth of the damage the proposal would cause. For example, it admits that the proposal would reduce ecosystem values provided by streams and wetlands, increase downstream flooding damages, require more expensive restoration efforts, increase costs for drinking water providers, and increase oil spill response costs. Yet the Economic Analysis concludes that the avoided costs of permitting outweigh the benefits lost. The flaw in the analysis is plain—despite quantifying the full suite of permitting costs avoided, the agencies omit the full costs incurred to the nation from a loss of protection by focusing narrowly on impacts to wetland mitigation. Even that analysis is arbitrarily narrow. As demonstrated in the attached reports from Dr. John Whitehead and Dr. Jeff Mullen, the benefits of wetland mitigation far exceed the costs when fairly calculated. If the other economic damages of this rule were included, the lost benefits would far exceed the cost savings identified. The cost savings to relatively few permittees do not outweigh the greater harm to the public.

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[5] *Chevron, U.S.A., Inc. v. Nat. Res. Def. Council, Inc.*, 467 U.S. 837, 842-43 (1984).

This proposal is a study in contrasts. Congress established and intended robust federal clean water protections; the proposal would hollow out those safeguards. Federal courts have unanimously rejected the *Rapanos* plurality as the controlling opinion in that case; the proposal is built on it. EPA data shows that more must be done to meet the Clean Water Act's objective; the proposal does less. Science compiled by the agencies tells us that protections for small streams and wetlands are essential to keeping downstream waters clean; the proposal leaves the fate of those waters to under-funded state agencies and the whims of heavy-polluting industries. History shows us that polluted water exacts a significant economic toll; the proposal concludes that eliminating protections for clean water is a net benefit. These contrasts not only make this proposal bad policy, they render it illegal. This administration's assault on clean water must stop. Withdraw this rule.

II. THE SOUTH HAS TREMENDOUS RESOURCES AT STAKE IN THIS RULEMAKING.

Southern streams, rivers, lakes, estuaries, and oceans are central to our region's history, culture, and economy. Compared to other regions, the South has more miles of streams and more acres of wetlands. Those resources, combined with the South's underfunded state water-quality programs, makes the region especially vulnerable to the loss of federal clean water protections. North Carolina, South Carolina, and Georgia alone have approximately 18 million acres of wetlands, many of which are pocosins, Carolina bays, cypress domes, or other unique wetland types that are only found in the South. These regional gems were rightly granted clearer protection by the Clean Water Rule, and are now at risk of destruction under the agencies' short-sighted proposal. Because of our tremendous natural resources, the agencies' proposal would have a significant effect on our region.

The southeastern United States is a hotspot for vital species of plants and animals, containing some of the most species-rich amphibian, reptilian, and freshwater fish communities in North America.[6] Freshwater biodiversity in this region is the highest in the nation. Alabama alone supports 38 percent of native freshwater fish species and 60 percent of native mussel species.[7] Our fisheries and recreation industry benefit when small streams and wetlands, which are integral for fish and wildlife habitat, are protected. In 2011, in the six states where SELC works—Virginia, North Carolina, South Carolina, Georgia, Alabama, and Tennessee—the U.S. Fish and Wildlife Service reported that a total of $19 billion was spent on wildlife recreation, including $5.7 billion on fishing; more than 15.9 million people participated in these recreational activities throughout the six-state region.[8] The Ecological Economics Journal estimates the Clean Water Act has been responsible for adding as much as $15.8 billion in economic benefits for the

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[6] Clinton N. Jenkins et al., U.S. Protected Lands Mismatch Biodiversity Priorities, PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, 5081 (2015); Guinessey et al., A Literature Review: The Chemical, Physical and Biological Significance of Geographically Isolated Wetlands and Non-Perennial Streams in the Southeast 11, 12, 28 (Apr. 12, 2019) ("Literature Review"), attached as exhibit A.

[7] Charles Lydeard & Richard L. Mayden, A Diverse and Endangered Aquatic Ecosystem of the Southeast United States, CONSERVATION BIOLOGY 802 (Aug. 1995); Ex. A, Literature Review at 28.

[8] *See* U.S. DEPARTMENT OF THE INTERIOR, U.S. FISH AND WILDLIFE SERVICE, U.S. DEPARTMENT OF COMMERCE, AND U.S. CENSUS BUREAU. 2011 NATIONAL SURVEY OF FISHING, HUNTING, AND WILDLIFE-ASSOCIATED RECREATION, 95-97 (Feb. 2014); *see also* Ex. A, Literature Review at 22.

Commonwealth of Virginia, alone.[9] And a host of Virginia industries rely on access to clean water—including tourism, which employs 350,000 Virginians and generates $18 billion for the economy.[10]

Each year, visitors from across the country vacation on southern beaches. In 2016 alone, tourism around our beaches generated nearly $8 billion in gross domestic product and over 190,000 jobs.[11] Recreational fishermen catch trout in our mountain streams, bass in our piedmont lakes and streams, and any number of saltwater fish in our extensive estuaries and beaches. [12] Commercial fishermen fish our estuaries and ocean waters, landing more than $300 million worth of catch in 2017.[13] Our populations are growing as people move to our expanding cities and our developing retirement communities. Each of these parts of the southern economy depends on clean water.

In addition to the impacts on tourism and industry, the agencies' proposal threatens drinking water sources for seven out of ten southerners, over 32 million people.[14] Southern states simply do not have the resources to protect the waters at risk under the agencies' proposal. Our states have some of the largest budget shortfalls in the county.[15] Even where Southern states are able to take action, they cannot address water quality issues on their own. Virginia regulators, for example, have worked hard to clean up the Chesapeake Bay. But without a strong, consistent level of nationwide protections for clean water, that effort stands to be undone. A patchwork of state laws would not maintain water quality in the many tributaries feeding the Chesapeake Bay from multiple states, and weaker protections imposed by other states would both unfairly add to Virginia's burden and prevent progress in the Bay.

Coming on the heels of hurricanes Florence and Michael, we have never depended more on our wetlands for flood control and storm surge protection. With abundant coastlines, lakes, marshes, and rivers, our Southern communities and states stand to lose the most if big polluters are allowed to dodge the basic protections that keep our water clean and safe from pollution. We depend on consistent minimum federal standards to safeguard clean water and protect our communities, families and everyday life.

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[9] Jim Epstein, *Clean Water Is Vital for Success of Virginia Business*, The Daily Progress, https://www.dailyprogress.com/opinion/opinion-column-clean-water-is-vital-for-success-of-virginia/article_54a3fad0-71c6-11e4-ab71-23593a302e82.html (last visited Apr. 8, 2019).
[10] *Id*.
[11] National Ocean Economics Program, *Ocean Economy Data* (GA, NC, SC, VA) (2016).
[12] *See* Pete Flood, *Top 10 Fishing Spots in the Southeast*, Folding Boat Co. Blog, https://www.foldingboatco.com/blog/2017/4/11/top-10-fishing-spots-in-the-southeast (last visited Mar. 18, 2019).
[13] *See* NATIONAL MARINE FISHERIES SERVICE, ANNUAL COMMERCIAL LANDINGS STATISTICS (AL, GA, NC, SC, VA) (2017), https://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html.
[14] SELC GIS, *Population Served by Drinking Water in the Southeast – Methodology* and SELC GIS, *Drinking Water Analysis Data* (collectively, "SELC GIS Analysis").
[15] Truth in Accounting, *Financial State of the States* (September 2018).

III. THE CLEAN WATER ACT WAS PASSED WITH BIPARTISAN SUPPORT TO RESTORE AND MAINTAIN THE INTEGRITY OF THE NATION'S WATERS.

By the late 1960s, the Nation's rivers, lakes, wetlands, and streams suffered mightily as the result of industrial pollution, municipal waste, and indiscriminate filling.[16] Rivers and streams were "little more than open sewers."[17] The Cuyahoga River was so polluted with industrial waste it caught fire.[18] Massive algae blooms choked the Great Lakes, killing millions of fish and tainting the water supplies of millions.[19] Biologically, Lake Erie was "dead."[20] Wetlands were disappearing at an alarming rate, depriving coastal areas and river valleys of critically important flood control protection and ecological benefits.[21] Of the estimated 221 million acres of wetlands that were originally present in the coterminous states, more than half had been lost to dredging, filling, draining, and flooding.[22]

The proverbial race to the bottom was underway, and the public was losing. Many of the states tasked with addressing water pollution had shirked their responsibility. To remedy the national crisis, Congress passed the Federal Water Pollution Control Act Amendments of 1972, commonly known as the Clean Water Act. The Act marked a major turning point.

Congress replaced the prior system—"a patchwork of ineffective state laws, and the Federal Water Pollution Control Act that dated to 1948,"[23]—with comprehensive legislation "to restore and maintain the . . . integrity of the Nation's waters."[24] "[T]o achieve this objective,"[25] Congress listed seven broad goals, including "protection and propagation of fish, shellfish, and wildlife," "recreation in and on the water," elimination of "the discharge of toxic pollutants in toxic amounts," and "the control of nonpoint sources of pollution."[26] Congress also required the states or federal government to adopt water quality standards for all waters covered by the Act "taking into consideration their use and value for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other purposes, and also taking into consideration their use and value for navigation."[27]

Support for the Clean Water Act has been "bipartisan and far reaching."[28] Large majorities of both parties in the Senate and House of Representatives voted for the major

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[16] *See, e.g.*, H.R. Rep. No. 92-911, at 1 (1972); S. Rep. No. 92-414, at 7 (1971).
[17] S. Rep. No. 111-361, at 1 (2010).
[18] *Id*.
[19] *Id*. (citing 138 CONG. REC. D612 (daily ed. Sept. 22, 1992) (Prepared Statement of LaJuana S. Wilcher, Assistant Administrator for Water, at EPA, Hearing Before the Committee on Environment and Public Works, United States Senate)).
[20] S. Rep. No. 111-361, at 1 (2010).
[21] *Id*.
[22] U.S. FISH & WILDLIFE SERVICE, WETLANDS: STATUS AND TRENDS OF WETLANDS IN THE COTERMINOUS UNITED STATES, MID-1970S TO THE MID-1980S (1991).
[23] S. Rep. No. 111-361, at 1 (2010).
[24] Pub. L. No. 92-500, § 101(a), 86 Stat. 816 (1972) (codified at 33 U.S.C. § 1251(a)).
[25] 33 U.S.C. § 1251(a).
[26] *Id*. § 1251(a)(1)-(6).
[27] *Id*. § 1313(c).
[28] S. Rep. No. 111-361, at 1 (2010).

enactments in 1972 and 1977.[29] Supportive of the bill's environmental aims, President Richard Nixon vetoed the 1972 bill for cost reasons, but the reaction to the veto was swift and decisive.[30] Congress overrode the veto just one day after it was issued, with overwhelming bipartisan margins in both houses of Congress.[31]

In setting the Act's objective and goals, Congress could not have established a more encompassing approach to protecting the Nation's waters, one aimed at addressing every aspect of the country's water quality crisis.

IV. THE CURRENT STATE OF THE NATION'S WATERS DEMANDS STRONGER CLEAN WATER PROTECTIONS, NOT ROLLBACKS.

Despite Congress's "broad, systemic view of the goal of maintaining and improving water quality,"[32] data show that we still have significant work to do to achieve the integrity of the Nation's waters—work that would not be done if Clean Water Act protections are slashed.

More than 50 percent of the rivers and streams assessed by EPA are impaired.[33] Nearly 80 percent of the bays and estuaries assessed are impaired, as are 91 percent of ocean and near-coastal waters and 100 percent of the Great Lakes' open waters.[34] These areas do not yet meet the Act's goal of making waters fishable and swimmable.[35] They suffer from harmful bacteria, nutrient pollution, and sediment overload that suffocate fish and other aquatic wildlife.[36]

In the Southeast, the health of our rivers and streams is especially dire. Toxic contaminants being dumped into our waterways by industry, development, and agriculture are seeping into our drinking water sources, and into our homes.[37] As of 2014, only *two miles* out of nearly 40,000 assessed miles of North Carolina's rivers and streams were in "good" condition (*see* Figure 1) so that they can be used for recreation, drinking water, and habitat.[38]

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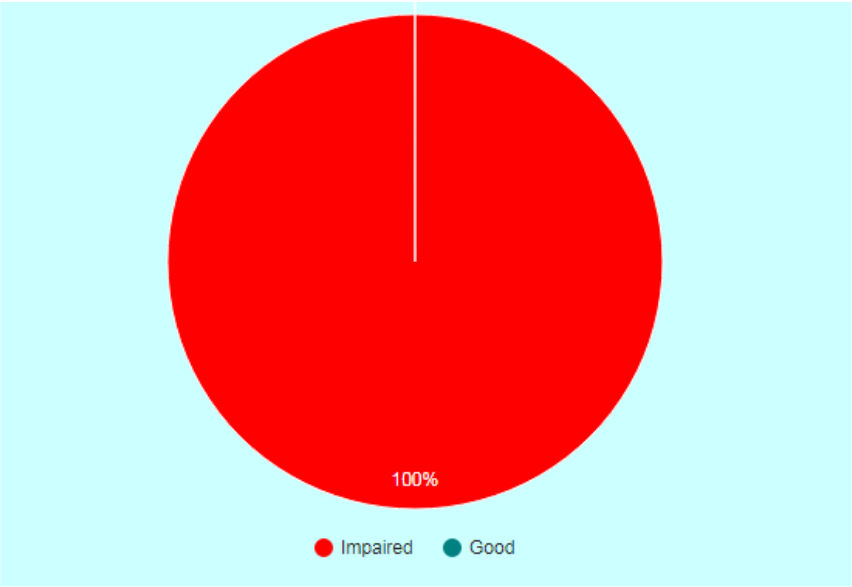
[29] *Id*.
[30] *Id*.
[31] *Id*.; *see also* 118 Cong. Rec. 36,879 (Senate vote of 52 to 12); *id.* 37060-61 (House vote of 247 to 23).
[32] *United States v. Riverside Bayview Homes, Inc.*, 474 U.S. 121, 132-33 (1985).
[33] *See* EPA, NATIONAL SUMMARY OF STATE INFORMATION: WATER QUALITY ASSESSMENT AND TMDL INFORMATION, http://ofmpub.epa.gov/waters10/attains_nation_cy.control (last visited Apr. 8, 2019); EPA, NATIONAL WATER QUALITY INVENTORY: 4 REPORT TO CONGRESS (Aug. 2017).
[34] *Id*.
[35] *Id*.
[36] *Id*.
[37] Editorial: *We Need More State Help with Water Quality*, FAYETTEVILLE OBSERVER (Apr. 7, 2019).
[38] EPA, NATIONAL SUMMARY OF STATE INFORMATION - NORTH CAROLINA RIVERS AND STREAMS 2014, https://ofmpub.epa.gov/waters10/attains_state.control?p_state=NC (last visited Mar. 14, 2019).



Attainment Status	Miles
Good	1.9
Threatened	.0
Impaired	38,230.0
Total Miles Assessed	**38,231.9**

Figure 1: Condition of North Carolina Rivers and Streams 2014[39]

Similarly, more than 65 percent of the rivers and streams studied in Virginia were impaired,[40] and in Georgia, more than 59 percent of the rivers and streams studied were impaired.[41] Unsurprisingly, given the problems facing streams and rivers, more than 70 percent of the Nation's lakes, reservoirs, and ponds studied by the EPA are impaired.[42] Widely contaminated by mercury and other metals, excess nutrients, and polychlorinated biphenyls (PCBs), they are neither suitable for habitat nor safe for fishing, swimming, and boating.[43] Indeed, *100 percent* of North Carolina's lakes, reservoirs, and ponds assessed are impaired (Figure 2)[44]; in Virginia, over 80 percent.[45]

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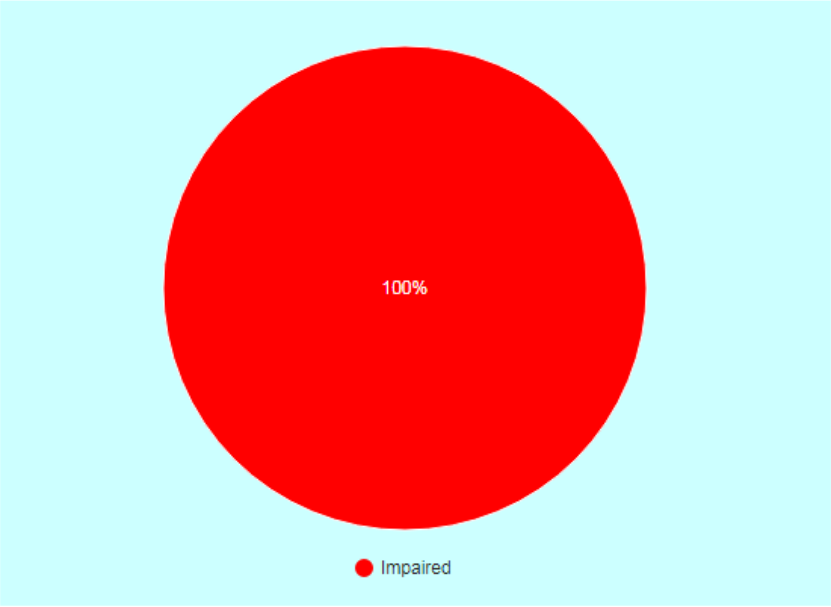
[39] *Id*.
[40] EPA, NATIONAL SUMMARY OF STATE INFORMATION - VIRGINIA RIVERS AND STREAMS 2008, https://ofmpub.epa.gov/waters10/attains_state.control?p_state=VA (last visited Mar. 14, 2019).
[41] EPA, NATIONAL SUMMARY OF STATE INFORMATION - GEORGIA RIVERS AND STREAMS 2014, https://ofmpub.epa.gov/waters10/attains_state.control?p_state=GA (last visited Mar. 14, 2019).
[42] EPA, NATIONAL SUMMARY OF STATE INFORMATION - WATER QUALITY ATTAINMENT IN ASSESSED LAKES, RESERVOIRS, AND PONDS, https://ofmpub.epa.gov/waters10/attains_nation_cy.control#LAKE/RESERVOIR/POND (last visited Mar. 14, 2019).
[43] *Id*.
[44] EPA, NATIONAL SUMMARY OF STATE INFORMATION - NORTH CAROLINA LAKES, RESERVOIRS, AND PONDS 2014, https://ofmpub.epa.gov/waters10/attains_state.control?p_state=NC (last visited Mar. 14, 2019).
[45] EPA, NATIONAL SUMMARY OF STATE INFORMATION - VIRGINIA LAKES, RESERVOIRS, AND PONDS 2008, https://ofmpub.epa.gov/waters10/attains_state.control?p_state=VA (last visited Mar. 14, 2019).



249,988.6 Acres of
Assessed Lakes, Reservoirs, and Ponds

Attainment Status	Acres
Good	.0
Threatened	.0
Impaired	249,988.6
Total Acres Assessed	**249,988.6**

Figure 2: Condition of North Carolina Lakes Reservoirs, and Ponds 2014[46]

The Nation's wetlands are in no better shape, largely due to development, silviculture, and agriculture.[47] Between 2004 and 2009, the country lost 630,000 acres of forested wetlands, primarily in the Southeast.[48] Previously teeming with mammals, birds, fish, and invertebrates, over half of the remaining wetlands are now unsuitable for habitat, threatened by severe oxygen depletion and heavy metal pollution.[49]

As a Nation, we are far from achieving the Clean Water Act's objective. Now is not the time for the agencies to abdicate their responsibility to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[50] Should the agencies proceed with their current proposal, they do so despite the known risks to our economy, our infrastructure, and the health and well-being of our communities.

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[46] EPA, NATIONAL SUMMARY OF STATE INFORMATION - NORTH CAROLINA LAKES, RESERVOIRS, AND PONDS 2014, https://ofmpub.epa.gov/waters10/attains_state.control?p_state=NC (last visited Mar. 14, 2019).
[47] *See* U.S. Fish and Wildlife Service, Status and Trends of Wetlands in the Coterminous United States 2004-2009 31 (2013).
[48] U.S. DEP'T OF INTERIOR, NEWS RELEASE: FIVE-YEAR SURVEY SHOWS WETLANDS LOSSES ARE SLOWING, MARKING CONSERVATION GAINS AND NEED FOR CONTINUED INVESTMENT IN HABITAT (Oct. 6, 2011), https://www.fws.gov/mountain-prairie/pressrel/11-doi-10-06-2011.html (last visited Mar. 14, 2019).
[49] EPA, NATIONAL SUMMARY OF STATE INFORMATION - WATER QUALITY ATTAINMENT IN ASSESSED WETLANDS, https://ofmpub.epa.gov/waters10/attains_nation_cy.control#WETLAND (last visited Mar. 14, 2019).
[50] 33 U.S.C. § 1251(a).

V. THE FOUNDATION OF THE RULEMAKING IS INVALID.

The agencies' proposal is built on three themes, none of which withstand scrutiny. First, the agencies distort the role of states, interpreting section 101(b) to directly conflict with Congress's intent. Second, the agencies adopt the reasoning in Justice Scalia's plurality opinion in *Rapanos* even though it was rejected by the majority of the Court. Finally, the rule prioritizes "regulatory certainty" as an end in and of itself, above the Act's singular objective to restore the Nation's waters, yet the proposal generates confusion rather than clarity.

A. Congress Did Not Intend to Elevate States' Rights Above the Integrity of the Nation's Waters.

The foundational premise of the agencies' proposal is that the first sentence of section 101(b) reflects congressional intent to limit federal jurisdiction in deference to states. That premise could not be more incorrect.

The statutory and legislative history of the Clean Water Act creates an undeniable preeminent role for the federal government in protecting the nation's water quality, one that cannot be discarded based on a misinterpretation of section 101(b). In the proposed rule's preamble, the agencies erroneously supplant the Clean Water Act's explicit objective of protecting the integrity of the Nation's waters, as outlined in section 101(a), with a newly posited elevation of states' roles that they allege is required by that first sentence in section 101(b). The agencies' inordinate reliance on that single, dated sentence to define the scope of the entire statute is improper.

The language in section 101(b) dates back to 1948 and the country's earliest, feckless efforts to address water pollution through state action.[51] In that introductory sentence, Congress provided that "[i]t is the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of the States to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources."[52] At the time, states did retain primacy over water pollution control, with the federal government providing funding and acting solely in an advisory role. In the absence of minimum federal standards, states found themselves in a race to the bottom to attract industry, sacrificing water quality.

Congress recognized that the states failed to protect water quality—indeed they made it worse. "By 1972, when Congress was moved to act again, one-half of the states had no water quality standards, fewer still had set numerical limits in them, and fewer still had permit systems applying them to polluters."[53] Congress decided to drastically change the law to give the federal

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[51] Oliver Houck, *Cooperative Federalism, Nutrients, and the Clean Water Act: Three Cases Revisited*, ENVIRONMENTAL LAW REPORTER, 44 ELR 10,426, 104, 27 (2014), https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=2ahUKEwi46Ivc9NHhAhXJrFkKHe5jBKYQFjABegQIBhAC&url=http%3A%2F%2Fudel.edu%2F~inamdar%2Fnps2007%2FHouck2014.pdf&usg=AOvVaw1tAf6gLse2StebbO4VgkU_ (last visited Apr. 14, 2019).

[52] Federal Water Pollution Control Act Amendments of 1972, Pub. L. No. 92-500, 86 Stat. 816 (1972).

[53] Houck, *supra* note 51, at 10,427

government primary authority over the health and safety of our waters.[54] The Senate Committee on Public Works, which went on to draft the Clean Water Act of 1972, summed up the situation as follows: "[T]he national effort to abate and control water pollution has been inadequate in every vital aspect."[55]

With the Clean Water Act of 1972, Congress replaced the state-led nuisance/abatement regulatory scheme that only addressed pollution if it caused "unreasonable harm" with a framework based on regulating pollution before it was discharged.[56] At the time, Congress knew the states could not be relied on to "develop sufficiently tough regulatory controls on water pollution to make real progress on cleaning up the nation's rivers and lakes."[57] Because the Clean Water Act of 1972 was intended as a "total restructuring,"[58] to put the federal government in the primary role for implementing the new water pollution control system, Congress added section 101(a). "Section [101](b) was trumped by new § [101](a), announcing a national goal to 'restore and maintain' the nations waters."[59]

Still, questions arose regarding the states' role under the new Act—the same questions that are raised by the agencies here. Notably, section 101(b) of the 1972 Act provided little detail describing what it meant for states to maintain "the primary responsibilities" to "prevent, reduce, and eliminate pollution."[60] It lacked the second sentence of the current statute—"It is the policy of Congress that the States manage the construction grant program under this chapter and implement the permit programs under sections 1342 and 1344 of this title."[61] This uncertainty was laid to rest in the 1977 Clean Water Act amendments, which set forth the parameters for state involvement.

Leading up to the 1977 amendments, the House of Representatives and Senate took different approaches to resolving concerns about the role of states under the Clean Water Act. The House bill dramatically limited federal jurisdiction, leaving states complete discretion; the Senate described the states' role within the statute with more specificity.

The House bill mirrors, in many ways, the agencies' proposal. Much like the agencies, the House Committee on Public Works and Transportation argued that "[t]he activities addressed

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[54] Houck, *supra* note 51, at 10,428.
[55] Robert L. Glicksman & Matthew R. Batzel, Science, Politics, *Law and the Arc of the Clean Water Act: The Role of Assumptions in the Adoption of a Pollution Control Landmark*, 32 WASH. U.J.L. & POL'Y 99, 103 (2010) (quoting S. Rep. No. 92-414 at 7 (1972)).
[56] N. William Hines, History of the 1972 Clean Water Act: *The Story Behind the 1972 Act Became the Capstone on a Decade of Extraordinary Environmental Reform*, JOURNAL OF ENERGY & ENVIRONMENTAL LAW 80 (Summer 2013).
[57] *Id*. at 82.
[58] *See City of Milwaukee v. Illinois*, 451 U.S. 304, 317 (1981) (explaining that explained that the CWA was "not merely another law 'touching interstate waters'" but was "viewed by Congress as a 'total restructuring' and 'complete rewriting of the existing water pollution legislation.'"); *see also id*. at 318 ("Congress' intent in enacting the [CWA] was clearly to establish an all-encompassing program of water pollution regulation.); *see also Middlesex Cnty. Sewerage Auth. v. Nat'l Sea Clammers Ass'n*, 453 U.S. 1, 22 (1981) (existing statutory scheme "was completely revised" by the enactment of the Clean Water Act).
[59] Houck, *supra* note 51, at 10,428.
[60] Pub. L. No. 92-500, 86 Stat. 816 (1972).
[61] 33 U.S.C. § 1251(b); *see* Pub. L. No. 92-500, 86 Stat. 816 (1972).

by section 404, to the extent they occur in waters other than navigable waters . . . are more appropriately and more effectively subject to regulation [by] the States."[62] The Committee raised concerns that "under the existing section 404 program given its broadest reach, all matters of small agricultural and forestry activities could be subject to Federal permit regulation."[63] To address these concerns, the House bill defined navigable waters to dramatically reduce federal jurisdiction.

The Senate took an approach that preserved minimum federal standards—adding the ability for states to assume permitting responsibilities under section 404 as long as they met certain requirements and including exemptions for certain industries, like agriculture. The underlying premise of the Senate's approach was that "the discharge of waste directly into the Nation's waters and oceans is permitted . . . only where ecological balance can be assured."[64] The Senate recognized that "[t]here is no question that the systematic destruction of the Nation's wetlands is causing serious, permanent ecological damage."[65] The chamber found it "both necessary and appropriate to make a distinction as to the kinds of activities that are to be regulated by the Federal Government and the kinds of activities which are to be subject to some measure of local control."[66]

The Senate bill did three things. First, it made clear that "[t]o limit the jurisdiction of the [act] with reference to discharges of the pollutants of dredged or fill material would cripple efforts to achieve the act's objectives."[67] Second, it added the extensive exclusions included in section 404(f).[68] Third, it adopted an amendment to implement the "stated policy of Public Law 92-500 of 'preserving and protecting the primary responsibilities and rights of States [to] prevent, reduce, and eliminate pollution.'"[69] That amendment did so by providing "for assumption of the permit authority by States with approved programs for control of discharges for dredged and fill material in accord with the criteria and with guidelines comparable to those contained in 402(b) and 404(b)(1)."[70]

The Senate bill prevailed, was agreed to by the House, and represents Congress's unmistakable intent. As the conference report notes, Congress clarified its intent regarding states' roles by amending section 101(b) to authorize them to "manage the construction grant program and implement the 402 and 404 permit programs."[71] In doing so, Congress created "a State program . . . which is established under State law and which functions in lieu of the Federal program" as long as the program complied with minimum federal standards.[72] This was Congress's plain intent for implementing section 101(b).

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[62] H.R. 95-139 at 22 (1977).
[63] *Id.* at 23.
[64] S. Rep. 95-370 at 4 (1977).
[65] *Id.* at 10.
[66] *Id.*
[67] *Id.* at 75.
[68] *Id.* at 76.
[69] *Id.* at 77.
[70] *Id.*
[71] H.R. Conf. Rep. 95-830 at 66 (Dec. 5, 1977).
[72] *Id.* at 104.

The EPA accurately summarized Congress's intent in the summer of 1978 in "A Guide to the Clean Water Act Amendments."[73] Recognizing that the 1972 law "had defined the Federal interest to be both broad and, in some areas, pre-eminent[,] . . . [t]he 1977 amendments respond to this problem by more explicitly defining the roles of the different levels of government."[74] EPA recognized that "[a] major thrust of the 1977 amendments is to shift toward the exercise of more authority by the states."[75] The changes "amended the Act to assure that it would not interfere with state water rights and water allocation systems."[76]

In signing the 1977 amendments, President Carter emphasized that "[t]he Nation's wetlands will continue to be protected under a framework which is workable and which shares responsibilities with the States."[77] Carter noted that framework included not only the ability for states to assume the dredge and fill program, it added exclusions for farming and forestry activities left to state and local control.[78]

In *Riverside Bayview*, the Supreme Court unanimously recognized Congress's choice. There, the Court instructed that Congress "dealt with the perceived problem of overregulation by the Corps by exempting certain activities (primarily agricultural) from the permit requirement and by providing for assumption of some of the Corps' regulatory duties by federally approved state programs."[79]

The legislative history clearly explains Congress's intent with section 101(b). The first sentence announces that states are to have a primary role in controlling water pollution. The second sentence says how: by giving states the ability to assume the lead role in issuing permits and carrying out the Act's requirements. Rather than signal a division of waters—one subject to federal protection, but a vast network of upstream tributaries and wetlands immune from it—the provision read as a whole divides the federal and state functions in protecting national waters. This common sense reading of section 101(b) fits with the legislative history and forecloses the agencies' interpretation.[80]

Section 101(b)'s plain language "is the end of the matter."[81] It does not, and cannot, support the EPA and the Corps abdicating their statutory mandate to enforce the Act in a manner that serves the objective of restoring and maintaining the integrity of our waters. That intent of Congress controls; the agencies have no authority to make a different choice. "If the intent of Congress is clear, that is the end of the matter; for the court, as well as the agency, must give

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[73] *See generally*, EPA, A GUIDE TO THE CLEAN WATER ACT AMENDMENTS (Nov. 1978).
[74] *Id*. at 2.
[75] *Id*. at 13.
[76] *Id*. at 14.
[77] Pres. J. Carter, Clean Water Act of 1977: Statement on signing HR 3199 into law (Dec. 28, 1977).
[78] *Id*. at 2.
[79] 474 U.S. 121 at 136 (1985).
[80] *Id*. at 14.
[81] *Chevron*, 467 U.S. at 842-43; *see also Pennsylvania v. Trump*, 281 F.Supp.3d 553, 578 (E.D. PA 2017) ("When Congress provides exceptions in a statute . . . [t]he proper inference . . . is that Congress considered the issue of exceptions and, in the end, limited the statute to the ones set forth") (quoting *U.S. v. Johnson*, 529 U.S. 53, 58 (2000)).

effect to the unambiguously expressed intent of Congress."[82] Accordingly, the foundation of this rulemaking crumbles. Congress has expressly rejected your interpretation of section 101(b).

B. The Administration Erroneously Relies on Justice Scalia's Plurality Opinion in *Rapanos*.

In addition to ignoring congressional intent, the agencies misinterpret Supreme Court precedent. Rather than follow Justice Kennedy's controlling opinion, they adhere solely to Justice Scalia's, an opinion rejected by the majority of the Court and described by Justice Kennedy as "unprecedented."[83] Apparently recognizing the error in this approach, the proposal quotes from Kennedy's opinion and attempts to interpret it as consistent with Justice Scalia's. The incompatibility of the two is made clear by the agencies' decision to discard the significant nexus test at the core of Kennedy's opinion.

Justice Scalia's opinion upends decades of established law and agency interpretation of the Clean Water Act.[84] The approach would remove protections from ephemeral and intermittent streams, as well as from a majority of wetlands. It is an interpretation that "is inconsistent with the Act's text, structure, and purpose."[85] As Kennedy concluded, Scalia's approach "makes little practical sense in a statute concerned with downstream water quality."[86]

Still, the agencies use Scalia's plurality opinion to restrict the scope of Clean Water Act jurisdiction to "relatively permanent flowing and standing waterbodies that are traditional navigable waters in their own right or that have a specific connection to traditional navigable waters, as well as wetlands abutting or having a direct hydrologic surface connection to those waters."[87] The agencies have overtly rejected the Court's significant nexus test in defining the reach of jurisdiction under the proposal.[88]

Perhaps aware of the peril in rejecting the significant nexus test at the heart of Justice Kennedy's opinion, the agencies falsely claim their current approach is consistent with both that opinion and the plurality.[89] But in attempting to square that circle, the agencies have stretched Justice Kennedy's decision beyond its breaking point.

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[82] *Chevron*, 467 U.S. at 842-43.
[83] *Rapanos*, 547 U.S. at 769.
[84] We criticize the agencies for relying solely on Justice Scalia's opinion with respect to the arbitrary limits he placed on federal jurisdiction over the nation's waters. On that issue, he was wrong. But on the well-established principle that the Clean Water Act "holds liable those who discharge a pollutant from a defined point source to [a navigable water]," Justice Scalia was correct. *Hawaii Wildlife Fund v. Cty. of Maui*, 886 F.3d 737, 748–49 (9th Cir. 2018), *cert. granted*, 87 U.S.L.W. 3319 (U.S. Feb. 19, 2019) (No. 18-260). No Justice disagreed with him on this principle, nor do we. *Id*.
[85] *Rapanos*, 547 U.S. at 778.
[86] *Id*. at 769.
[87] 84 Fed. Reg. at 4,170.
[88] *Id*.
[89] *See, e.g.*, 84 Fed. Reg. at 4,167 ("[A]lthough the standards that the plurality and Justice Kennedy established are not identical, and each standard excludes some waters that the other standard does not, the standards contain substantial similarities."); *id.* at 4,168 ("[W]hile the plurality and Justice Kennedy viewed the question of federal CWA jurisdiction differently, there are sufficient commonalities between these opinions to help instruct the agencies on where to draw the line between Federal and State waters.").

First, the agencies distort Justice Kennedy's opinion to say that they can discard the "significant nexus" test because they have proposed "more specific regulations."[90] When read in context, Justice Kennedy's intent is clear: the agencies have authority to designate by regulation categories of waters that *meet* the significant nexus test—not promulgate regulations that ignore it.[91]

Second, the agencies ignore differences between the Kennedy and Scalia tests that cannot be squared by a wave of the rhetorical wand. Not only did Justice Kennedy define "wetlands" using the science-based, regulatory definition (whereas Justice Scalia, essentially described them as "moist patches of earth"[92]), Justice Kennedy faulted the Justice Scalia for ignoring the significant nexus test from *SWANCC*.[93] Kennedy's opinion also rejects two restrictions that Scalia would have placed on waters of the United States—(1) that they must be relatively permanent, and (2) that they must have a continuous surface connection to a relatively permanent water—as being unsupportable under a pragmatic, functional, or legal approach to the statute.[94] "In sum," wrote Justice Kennedy, the "plurality's opinion is inconsistent with the Act's text, structure, and purpose."[95]

The Courts of Appeals that have decided post-*Rapanos* cases have rejected the plurality opinion as the controlling test. None of these Courts have suggested that the Kennedy and Scalia tests are similar, and they have overwhelmingly held that where the Scalia test would find no jurisdiction, but Justice Kennedy's significant nexus would, the latter controls.[96] The agencies are not now free to disregard Justice Kennedy's opinion. [97]

As the Supreme Court has instructed: "[o]nce we have determined a statute's clear meaning, we adhere to that determination under the doctrine of *stare decisis*, and we judge an agency's later interpretation of the statute against our prior determination of the statute's meaning."[98] The Supreme Court has held that the clear purpose of the Clean Water Act is to "to establish a comprehensive long-range policy for the elimination of water pollution"[99] and "to

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[90] 84 Fed. Reg. at 4,175, 4,186 (alteration in original).
[91] *Rapanos*, 547 U.S. at 782 (Kennedy, J. concurring) (emphasis added).
[92] *Id*. at 761.
[93] *Id*. at 767 (citing *Solid Waste Agency of N. Cook County v. Corps of Eng'rs*, 531 U.S. 159, 165 (2001) ("*SWANCC*")).
[94] *Id*. at 768-769, 778 ("the plurality reads nonexistent requirements into the Act.").
[95] *Id*. at 776.
[96] *See, e.g.*, *United States v. Gerke Excavating, Inc*., 464 F.3d 723, 724–25 (7th Cir. 2006); *United States v. Robison*, 505 F.3d 1208, 1222 (11th Cir. 2007); *United States v. Moses*, 496 F.3d 984, 989–91 (9th Cir. 2007); *N. California River Watch v. City of Healdsburg*, 496 F.3d 993, 999–1000 (9th Cir. 2007); *United States v. Bailey*, 571 F.3d 791, 798–800 (8th Cir. 2009); *United States v. Cundiff*, 555 F.3d 200, 210–13 (6th Cir. 2009); *United States v. Lucas*, 516 F.3d 316, 325–27 (5th Cir. 2008); *United States v. Donovan*, 661 F.3d 174, 183–84 (3d Cir. 2011); *Precon Dev. Corp. v. U.S. Army Corps of Engineers*, 633 F.3d 278, 289 (4th Cir. 2011); and D*eerfield Plantation Phase II-B Prop. Owners Ass'n, Inc. v. U.S. Army Corps of Engineers, Charleston Dist*., 501 F. Appx. 268, 275 (4th Cir. 2012).
[97] The administration itself acknowledged last month that "[e]very court of appeals to have considered the question has determined that the government may establish Clean Water Act jurisdiction under the standard set forth in Justice Kennedy's concurrence in *Rapanos*"; thus, there is "no sound reason" for the U.S. Supreme Court to revisit the question. Br. for U.S. in Opp'n to Pet. for Writ of Cert. at 10, *Robertson v. United States*, No. 18-609 (Mar. 2019).
[98] *Maislin Indus., U.S., Inc. v. Primary Steel, Inc.*, 497 U.S. 116, 131 (1990).
[99] *Milwaukee*, 451 U.S. at 318 (emphasis added). *See Rapanos*, 547 U.S. at 804 (Stevens, J., dissenting).

restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[100] That goal is paramount, and the agencies do "not have the power to adopt a [conflicting] policy," as they have proposed here.[101]

C. The Administration Promised Clarity, but Delivers Confusion.

One of the administration's primary talking points is that its proposal promotes "regulatory certainty"[102] while "providing fair and predictable notice of the limits"[103] to the Clean Water Act's reach. The agencies' approach fails for two reasons. First, regulatory certainty is not a proper stand-alone goal of rulemaking. Regulatory certainty acts in service of a statute's objective. Here, the agencies have not offered any argument that whatever certainty is provided by the proposal, if any, would serve the Clean Water Act's objective, as discussed in more detail in section VI(A)(3) below. Second, the agencies' proposal is anything but clear.[104]

Despite the administration's claims, people will not be able to determine whether a stream or wetland is jurisdictional by standing on their property. Rather, a property owner would need to determine the source of flow (illogically, under the proposal, groundwater or snowpack can support jurisdiction, while rain and snowfall cannot[105]), whether the stream flows into a navigable water off-property, whether wetlands abut a jurisdictional water, and whether a downstream segment lacks sufficient flow or otherwise breaks jurisdiction. Many of these inquiries would require the decision maker to trespass onto properties of others. As the agencies concede, making these determinations "can be challenging.[106]

The limits and identification of jurisdictional tributaries and wetlands must be determined by a convoluted "typical year" test and other criteria. "Typical year" is defined in the proposed rule to mean "within the normal range of precipitation over a rolling thirty-year period for a particular geographic area." But, to demonstrate that a year is "typical" requires that "the observed rainfall from the previous three months fall[] within the 30th and 70th percentiles established by a 30-year rainfall average generated at NOAA weather stations." This is not a simple test; it requires expert analysis to determine what is "typical" in light of drought, and floods, and leaves much to interpretation.

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[100] *Rapanos*, 547 U.S. at 759 (Kennedy, J., concurring).
[101] *Maislin*, 497 U.S. at 134-35; *see also U.S. v. Am. Trucking Ass'ns*, 310 U.S. 534, 542-43 (1940) ("There is, of course, no more persuasive evidence of the purpose of a statute than the words by which the legislature undertook to give expression to its wishes."); *Maryland v. Exxon Mobil Corp*., 352 F. Supp. 3d 435, 464 (D. Md. 2018) ("When the words of the statute are 'sufficient in and of themselves to determine the purpose of the legislation' and do not produce unreasonable results 'plainly at variance with the policy of the legislation as a whole,' courts must follow their plain meaning.").
[102] 84 Fed. Reg. at 4,169.
[103] *Id*.
[104] Additional issues with your agencies' rule are outlined in Moffat & Nichol, Proposed Changes to the Waters of the United States (WOTUS) Definition–Summary of M&N Conclusions (Apr. 7, 2019), attached as Exhibit B ("Moffat & Nichol Report"). Moffat & Nichol Report is incorporated here by reference and should be considered supplemental comments, which the agencies must respond to, by the organizations listed above.
[105] 84 Fed. Reg. at 4,173.
[106] 84 Fed. Reg. at 4,177-4,178 ("landowners may find it difficult to determine whether there is a jurisdictional break downstream of a feature on their property"); *id.*at 4,189 ("identifying remotely whether wetlands abut a jurisdictional water can be challenging").

The proposed rule is also confusing with regard to coverage of intermittent streams, which the agencies define as those streams that have continuous flow for "certain times of a typical year."[107] Unfortunately, the proposed rule offers no objective basis for determining whether or not an intermittent stream meets that description or when "certain times" occur. There exists no database of flow information that provides an answer to such a question. The proposed rule would substitute a confusing, nebulous definition of an intermittent stream for the objective, observable approach defined by the 2015 Clean Water Rule.[108]

As the agencies admit in their proposal, assessing flow regimes would also require sophisticated professional-level tools, in conjunction with a field visit, such as:

> remote and field-based tools, such as visual observations, photographs, data collection on flow, trapezoidal flumes and pressure transducers for measuring surface flow and comparing that to rainfall, StreamStats by the U.S. Geological Survey (USGS) (available at https://streamstats.usgs.gov/ss/), Natural Resources Conservation Service (NRCS) hydrologic tools and soil maps, desktop tools that provide for the hydrologic estimation of a discharge sufficient to generate intermittent or perennial flow, such as a regional regression analysis or hydrologic modeling, USGS topographic data, or modeling tools using drainage area, precipitation data, climate, topography, land use, vegetation cover, geology, and other publicly available information.[109]

Requiring a specific flow rate for jurisdiction, an issue solicited for comment, would similarly be difficult and costly to implement because many streams do not have stream gauges.[110] It is also wrong.[111]

The agencies' proposal for impoundments could also set the stage for extreme confusion. During high precipitation periods where an impoundment was generating continuous flow, the impoundment and its tributaries would be jurisdictional, whereas in drier years the reverse may be true. Those living upstream of an impoundment would be caught in the middle of a regulatory ping pong match. Some activities would be legal one year, but not the next.

All of this complexity is compounded by climate change, which the proposal does not take into account. Failing to allow for the impacts of climate change and human activities risks the loss of federal protections for vulnerable streams, rivers, and wetlands. Studies have shown that climate change and human activities have and will affect the quality and surface flow of our Nation's waters.[112] By limiting jurisdiction based on that flow, waters that shift to ephemeral risk losing protection.[113]

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[107] *E.g.*, 84 Fed. Reg. at 4,204.
[108] Clean Water Rule: Definition of ''Waters of the United States''; Final Rule, 80 Fed. Reg. 37,054, 37,104, 37,105-37,106 (June 29, 2015) ("physical indicators of a bed and banks and an ordinary high water mark").
[109] 84 Fed. Reg. at 4,176.
[110] Ex. B, Moffat & Nichol Report at 13.
[111] *See id.*; *see also* 84 Fed. Reg. at 4,175 ("The agencies believe establishing a specific flow volume requirement for all tributaries would be inappropriate given the wide spatial and temporal variability of flow volume in rivers and streams across the country.")
[112] SAB Members Comments at 7; Susan Colvin et al., Headwater Streams and Wetlands are Critical for Sustaining Fish, Fisheries, and Ecosystem Services, FISHERIES 76 (Feb. 2019),

At base, the waters of the United States proposed definition (which is confusing) does not fit with the agencies' rationale for it (regulatory clarity), making it arbitrary and capricious.

VI. THE PROPOSED RULE VIOLATES THE APA, CLEAN WATER ACT, AND ENDANGERED SPECIES ACT.

A. The Proposal Violates the Administrative Procedure Act.

This administration has made a practice of violating the Administrative Procedure Act.[114] One of the more recent examples, *New York v. U.S. Department of Labor*,[115] is perhaps the most applicable here. In that case, the Department of Labor implemented an executive order by the President to undo the Affordable Care Act. To do so, the Department reversed decades of agency policy and reinterpreted a key term under the Employment Retirement Income Security Act in a way that "scraps ERISA's careful statutory scheme" and "exceeds the statutory authority delegated by Congress."[116]

This rulemaking is no different. The President issued an Executive Order on February 28, 2017 directing the agencies to conduct this rulemaking. Since that time, the agencies have been set on achieving a pre-determined goal—implementing a rule based on Justice Scalia's decision in *Rapanos*. The docket here demonstrates that pre-determination. As discussed below, although the agencies have produced lengthy documents—mostly through repeated, uninformative analyses—they have failed to provide a valid, reasoned basis for departing from decades of agency practice or explanation for how this proposal would meet the Clean Water Act's objective. The agencies' single-mindedness has also resulted in their consideration of factors not allowed by Congress, including their elevation of states' rights and regulatory certainty over the purpose of the Clean Water Act. For these reasons, this proposal must be withdrawn.

1. The proposal fails to allow for meaningful comment.

Despite proposing a definition of waters of the United States that reverses more than 40 years of protections for waters across the country and discards the agencies long-standing interpretations of Supreme Court case law, the agencies provided just 60 days for public comments. More than 23 requests for extension that include members of Congress and hundreds of citizen groups were denied.

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https://afspubs.onlinelibrary.wiley.com/doi/epdf/10.1002/fsh.10229?shared_access_token=n0H65fhj7meitiMO7UqEgU4keas67K9QMdWULTWMo8M0mooN-TbkwZVijk4pBluA_dzFAWXHzMoTvitIs3grkj9paRTrkh1P9AAL7TLrpGhR0GEciIbaFsUk4SjEm0c8yB-ofqy7tyByhVUqi4OWwg%3D%3D& (last visited Apr. 8, 2019).

[113] *Id*.

[114] Fred Barbash & Deanna Paul, *The Real Reason the Trump Administration is Constantly Losing in Court*, WASHINGTON POST (Mar. 19, 2019), https://www.washingtonpost.com/world/national-security/the-real-reason-president-trump-is-constantly-losing-in-court/2019/03/19/f5ffb056-33a8-11e9-af5b-b51b7ff322e9_story.html?utm_term=.75ba7ff15b2f (last visited Apr. 11, 2019).

[115] ___F. Supp. 3d___, No. 18-1747 (JDB), 2019 WL 1410370 (D.D.C. Mar. 28, 2019)

[116] *Id*. at *2.

In addition to the short comment period, the agencies' rationale is poorly explained. It is essential that a notice of proposed rulemaking "not only give adequate time for comments, but also must provide sufficient factual detail *and rationale* for the rule to permit interested parties to comment meaningfully."[117] As courts have recognized:

> The purpose of the comment period is to allow interested members of the public to communicate information, concerns, and criticisms to the agency during the rule-making process. *If the notice of proposed rule-making fails to provide an accurate picture of the reasoning that has led the agency to the proposed rule, interested parties will not be able to comment meaningfully upon the agency's proposals.* As a result, the agency may operate with a one-sided or mistaken picture of the issues at stake in a rule-making.[118]

As discussed in more detail below, the notice fails to provide the agencies' rationale on a wide variety of poorly described possibilities for further reducing jurisdiction. The agencies provide little clue as to how agencies and regulated entities would implement the proposed rule. In addition, the agencies have requested comment on dozens of issues, making it impossible for the public to predict with any confidence what the agency is actually considering. For example, the notice seeks comment on whether to exclude protections for intermittent streams, to redefine intermittent streams, or to impose a minimum flow requirement prompts numerous questions. What is the scientific basis? What is the legal basis? How would those proposals be implemented? What would be their impacts? Asking for comment on every possibility under the sun sheds no light on what the agency proposes to do.

Similar questions could be asked for every aspect of the proposal. With no valid legal or scientific analysis to inform the public of what the agencies may do, it is not possible meaningfully comment on the full array of possibilities. Courts are reluctant to allow agencies to "issue broad [notices of proposed rulemaking] only to justify *any* final rule it might be able to devise by whimsically picking and choosing within the four corners of a lengthy 'notice.'"[119] It is

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[117] *Fla. Power & Light Co. v. United States*, 846 F.2d 765, 771 (D.C. Cir. 1988) (emphasis added) (citing *Connecticut Light & Power Co. v. NRC*, 673 F.2d 525, 530–31 (D.C. Cir.) (1982); *Home Box Office, Inc. v. FCC*, 567 F.2d 9, 35 (D.C. Cir. 1977); *see also Nat'l Elec. Mfrs. Ass'n v. EPA*, 99 F.3d 1170, 1172 (D.C. Cir. 1996).

[118] *Connecticut Light*, 673 F.2d at 530-31 (emphasis added); *see also Nat'l Cable Television Ass'n, Inc. v. F.C.C.*, 747 F.2d 1503, 1507 (D.C. Cir. 1984) ("The purpose of the NPRM is to 'provide an accurate picture of the reasoning that has led the agency to the proposed rule,' so that interested parties can contest that reasoning if they wish.") (*citing Connecticut Light*, 673 F.2d at 530-31); *Shands Jacksonville Med. Ctr. v. Burwell*, 139 F. Supp. 3d 240, 265 (D.D.C. 2015) ("[T]he APA does require the disclosure of assumptions critical to the agency's decision, in order to facilitate meaningful comment and allow a 'genuine interchange' of views.") (citing *Connecticut Light*, 673 F.2d at 530-31); *Home Box Office, Inc. v. F.C.C.*, 567 F.2d 9, 35 (D.C. Cir. 1977) ("there must be an exchange of views, information, and criticism between interested persons and the agency. […]Consequently, the notice required by the APA, or information subsequently supplied to the public, must disclose in detail the thinking that has animated the form of a proposed rule and the data upon which that rule is based.") (citations omitted); *Ohio Valley Envtl. Coal. v. U.S. Army Corps of Engineers*, 674 F. Supp. 2d 783, 802-04 (S.D.W. Va. 2009) (finding that notices which contained "no substantive information on mitigation" did not give the public "a clear understanding of the nature and magnitude of the activity to generate meaningful comment" and "failed to provide an accurate picture of the Corps' reasoning").

[119] *CSX Transp., Inc. v. Surface Transp. Bd.*, 584 F.3d 1076, 1082 (D.C. Cir. 2009) (quotation marks omitted).

clear that "[s]uch a rule would hardly promote the purposes of the APA's notice requirement." Here, the agencies do not meet that requirement.

2. The proposal fails to justify reversal of decades of agency practice.

The proposal attempts to sidestep its most significant administrative obstacle—decades of agency practice that culminated in the extensive record supporting the Clean Water Rule. The agencies have spent decades making clear that more, not less, protection for water quality is needed if we are to ever achieve the Clean Water Act's objective. While the proposal appears to concede this reversal, it fails to confront or even superficially address the extensive record of the Clean Water Rule. "The agency must articulate a satisfactory explanation for its action including a rational connection between the facts found and the choices made."[120] In addition, "the new policy must be permissible under the statute, and the agency must acknowledge it is changing its policy and show that there are good reasons for the new policy and that the agency believes it to be better, which the conscious change of course adequately indicates."[121]

One of the most glaring errors in the notice is the agencies' failure to address the comprehensive administrative record for the Clean Water Rule. In taking action to replace the Clean Water Rule, the agencies must "display awareness that … [they are] changing position" and "show that there are good reasons for the new policy[,]" as federal agencies "may not … simply disregard rules that are still on the books."[122] The agencies cannot acknowledge their reversal without addressing the factual and scientific basis for the Clean Water Rule. The proposal fails to include any meaningful analysis of the agencies' prior responses to comments for the Clean Water Rule, much less an explanation as to why this rulemaking reverses course. Accordingly, the agencies have not provided the "reasoned explanation [] needed for disregarding facts and circumstances that underlay or were engendered by the prior policy."[123]

As stated in its preamble, the Clean Water Rule made coverage under the Clean Water Act "easier to understand, more predictable, *and consistent with the law and peer-reviewed science, while protecting the streams and wetlands that form the foundation of our nation's water resources*."[124] The rule sought to "clarify and simplify the implementation of the CWA *consistent with its purpose*."[125] The rule, therefore, "interprets the CWA to cover those *waters that require protection in order to restore the chemical, physical, and biological integrity" of the Nation's waters*.[126] To that end, it identified and clarified protections for waters that are "integral parts of the aquatic environment" that if "polluted or destroyed" would have "a significant effect downstream," and protects those waters by avoiding the "resource intensive process [that] results in inconsistent interpretation of CWA jurisdiction and perpetuate[s] ambiguity over where the

[120] *Nat'l Lifeline Ass'n v*, 915 F.3d at 27 (quoting *Motor Vehicle Mfrs. Ass'n v. State Farm Mut. Auto Ins. Co.*, 463 U.S. 29, 43 (1983)).
[121] *Id.*
[122] *FCC v. Fox Television Stations, Inc.*, 556 U.S. 502, 515 (2009).
[123] *Id*. at 515-16.
[124] Clean Water Rule, 80 Fed. Reg. 37,054, 37,055.
[125] *Id.* (emphasis added).
[126] *Id.* (emphasis added).

CWA applies," as experienced under the prior regulatory scheme.[127] Those clarified protections included provisions for Carolina bays, pocosins, and other vulnerable wetlands.[128] The rule's ultimate goal was to "more effectively focus the rule on identifying waters that are clearly covered by the CWA and those that are clearly not covered, making the rule easier to understand, consistent, *and more environmentally protective*."[129] The agencies' new claim that replacing this rule—adopting a wholly new regulatory scheme that would fundamentally upset the existing federal-state partnership—would promote regulatory certainty is nonsense. And they have not acknowledged what a loss of clearer protections for vulnerable waters likely means: those waters' degradation and destruction, which would in turn substantially reduce the integrity of navigable waters.

The clearer, science-based protections in the Clean Water Rule matter. As the agencies found, the small streams and wetlands that are better protected under the Clean Water Rule are "critical to maintaining the integrity of downstream waters" and "if these waters are polluted or destroyed, there is a significant effect downstream."[130] The headwater stream protections clarified by the rule maintain those streams' "important role in the transport of water, sediments, organic matter, nutrients, and organisms to downstream waters."[131] The case-specific guidance for Carolina bays, pocosins, and other vulnerable wetlands recognized that these waters "function alike and are sufficiently close to function together in affecting downstream waters" and, therefore, must be considered in that context.[132] These protections were supported by an extensive scientific analysis.[133] In their rush to replace the Clean Water Rule, the agencies ignore its rationale and results completely and arbitrarily.

The agencies attempt to justify such an approach based on the adoption of Justice Scalia's decision in *Rapanos* and section 101(b). As discussed above, these form an improper legal basis for abandoning the functional, science-based approach of the significant nexus test implemented in the Clean Water Rule and under prior agency guidance. Indeed, apart from the February 28, 2017 Executive Order, [134] the agencies offer no basis for abandoning the significant nexus test that has been the cornerstone of the agencies' analysis for more than a decade and adopted by every court to consider the issue since the *Rapanos* decision. The recent decision in *New York v. U.S. Department of Labor* is instructive on this point. The department adopted a final rule that "departs significantly from DOL's prior sub-regulatory guidance."[135] The final rule was a reversal of the "more-than-forty-year history" under the act in question—one that "twist[s] the language of the statute and defeat[s] the purposes of Congress."[136] The court rejected the rule that "scraps ERISA's careful statutory scheme . . . and exceeds the statutory authority delegated

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[127] *Id.* at 37,056.
[128] *Id.*
[129] *Id.* at 37,057 (emphasis added).
[130] *Id.* at 37,056.
[131] *Id.* at 37,058.
[132] *Id.* at 37,059.
[133] *See id.* at 37,062-37,064.
[134] Exec. Order No. 13778, 82 Fed. Reg. 12,497 (Feb. 28, 2017) (Restoring the Rule of Law, Federalism, and Economic Growth by Reviewing the "Waters of the United States" Rule).
[135] *New York*, No. 18-1747 (JDB), 2019 WL 1410370 at *12.
[136] *Id*. at *17.

by Congress."[137] This rule, and its rejection of more than 40 years of understanding of the reach of the Clean Water Act, is no different and, if finalized, this rule should suffer the same fate.

3. The proposal considers factors not allowed by Congress.

In departing from decades of agency efforts to achieve the objective of the Clean Water Act, the agencies have considered factors that were not intended by Congress. Courts recognize that "[a]gency action is arbitrary and capricious if the agency has relied on factors which Congress has not intended it to consider."[138] Two factors warrant comment here: the agencies' elevation of regulatory certainty as a stand-alone purpose and the reliance on voluntary actions by regulated entities.

Even if this convoluted proposal delivered regulatory certainty (it doesn't), certainty for the sake of certainty is not a permissible sole consideration in rulemaking. It cannot be an end in and of itself. It can only be considered in the context of achieving the objective of the Clean Water Act, as it was for the agencies in 2015. At that time, the agencies recognized that the Clean Water Rule would "ensure protection for the Nation's public health and aquatic resources, and increase CWA program predictability and consistency by clarifying the scope of 'waters of the United States' protected under the Act." [139] That is the only circumstance in which regulatory certainty can be considered—if it advances the statute's purpose. Here, the agencies fail to make an argument that this proposal does so.

A recent decision in the Fourth Circuit affirming EPA's responsibility to use science succinctly summarizes why scientific expertise cannot be dispensed with in the name of regulatory certainty.

> Public debate on environmental issues often rejects and disowns the relevant science when it proves convenient to do so. The law, however, reflects a different posture. Through standards of review and court/agency interactions, this case and many others underscore that law and science must work in tandem on environmental issues, not at loggerheads. Indeed, it is that partnership between law and science, as illustrated here, that offers the best hope of avoiding environmental disruptions that may one day visit serious adverse consequences upon us all.[140]

Here, the agencies are leading the effort to "reject[] and disown[] the relevant science" under the guise of regulatory certainty. That effort is unlawful.

The next notable factor that the agencies unlawfully considered would be comical if the consequences were not so serious. Throughout the Economic Analysis, the agencies considered the prospect of regulated entities voluntarily complying with existing standards (either the pre-

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[137] *Id*. at *2.
[138] *Nat'l Lifeline Ass'n v. FCC*, 915 F.3d 19 (DC Cir. 2019) (quoting *State Farm*, 463 U.S. at 43).
[139] Clean Water Rule, 80 Fed. Reg. at 37,054.
[140] *Sanitary Bd. of City of Charleston, WV v. Wheeler*, 918 F.3d 324, 338 (4th Cir. 2019).

2015 rule or the Clean Water Rule). The agencies note that "if an entity voluntarily continues baseline compliance practices, then there would be no change in cost or environmental outcomes."[141] The Economic Analysis revisits this notion repeatedly, postulating that "facilities . . . that discharge to receiving water that will lose their jurisdictional status . . . may willingly continue operating under their permit and see no need to challenge the jurisdictional status of the receiving waters."[142] Similarly, construction stormwater requirements may be "voluntarily implemented by developers."[143] The reliance on volunteer pollution control litters the Economic Analysis.[144]

In creating a strict-liability statute with significant penalties for the purpose of addressing a national crisis, it is safe to say that Congress did not intend for the Clean Water Act's success to depend on voluntary efforts. The agencies have never depended on such goodwill as the primary driver of Clean Water Act implementation, and they have provided no basis for reaching a different position here.

4. The proposal fails to consider important aspects of the rulemaking.

By focusing on factors that the agencies cannot lawfully consider, the proposal fails to consider important aspects of the rulemaking. It is basic administrative law that "an agency rule would be arbitrary and capricious if the agency . . . entirely failed to consider an important aspect of the problem."[145] Not only do the agencies fail to consider important aspects of the problem, the proposal ignores *the most* important aspect of the problem: whether the proposed rule advances the objective of the Clean Water Act.

The agencies have not assessed this proposal's effect on the ability to achieve the Clean Water Act's sole objective: to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[146] As discussed in section IV, our Nation's waters are in trouble. In short, where they have been assessed, most have been found not to meet the Act's objective. We must do more, not less, if we are to achieve that objective.

There is no question that the proposal would do less to protect our waters and create an obstacle to achieving the Act's purpose. The Economic Analysis concedes that many states (perhaps most) would not "have the resources to staff and manage the new or expanded programs" and that "decentralized programs are also more likely to be swayed by political influences which could distort the regulatory process in ways that are detrimental to social welfare."[147] The "changes to the definition of 'waters of the United States' . . . could have a

[141] U.S. EPA and Dep't of Army, Economic Analysis for the Proposed Revised Definition of "Waters of the United States," EPA-HQ-OW-2018-0149-0004, 46 (Dec. 14, 2018) ("2018 Economic Analysis").
[142] 2018 Economic Analysis at 88.
[143] *Id*. at 92.
[144] *See id*. at 93, 99, 101, 107, 109, 113-115, 211.
[145] *State Farm*, 463 U.S. 29, 43.
[146] 33 U.S.C. § 1251(a).
[147] 2018 Economic Analysis at 45.

significant effect in states with large impact areas."[148] The diagram below documents the myriad ways that the proposal would dirty our waters.

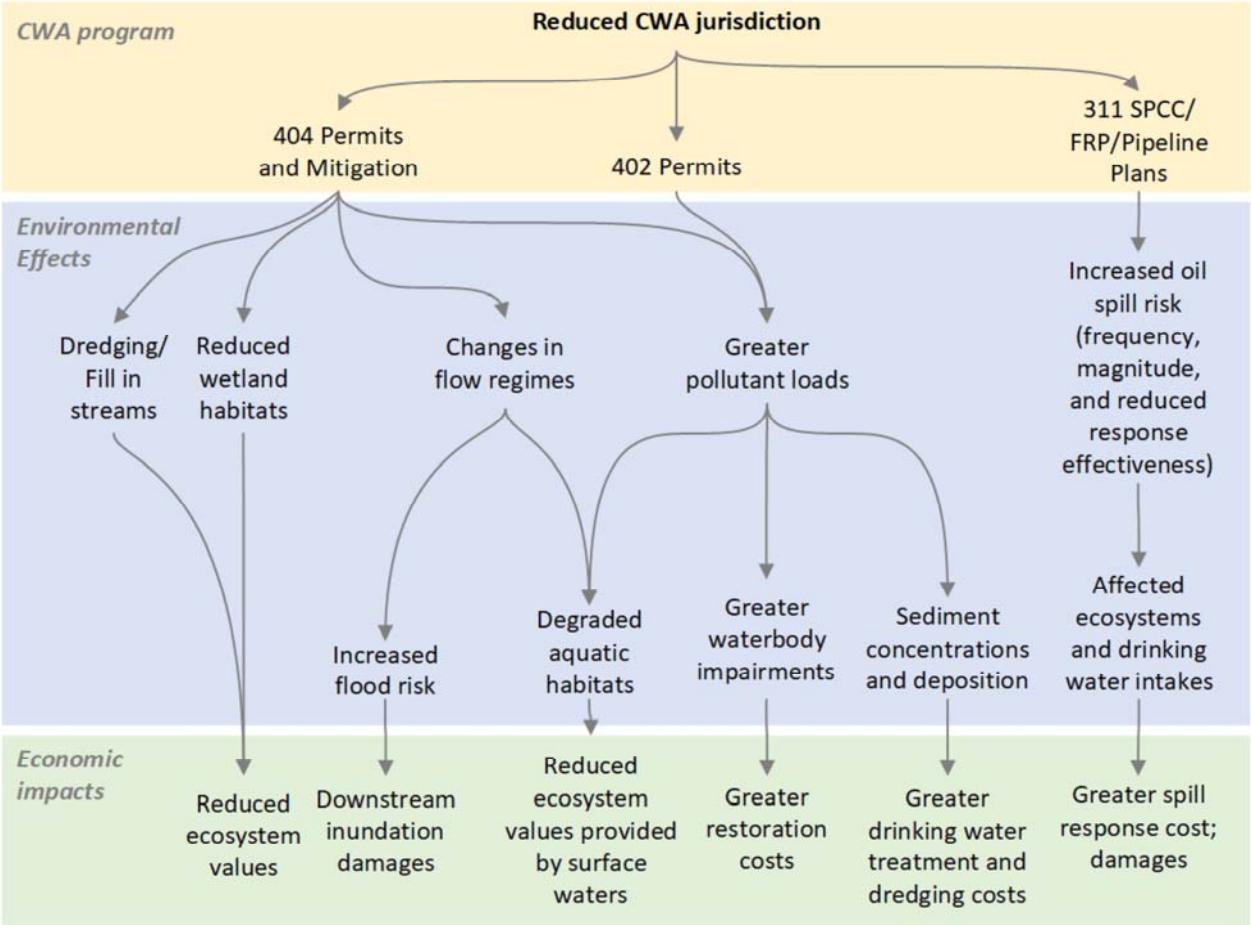

Figure 3: Overview of potential environmental impacts to selected CWA programs from proposed changes in CWA jurisdiction for certain waters.[149]

It is also an attack on citizens' ability to bring suit under the Clean Water Act, a necessity we have seen time and again achieve clean water. In Columbia, South Carolina, for example, SELC filed a citizen suit to stop unlawful discharges from the Carolina Water Service I-20 plant, which had been ongoing despite permit terms prohibiting that discharge. The United States District Court for the District of South Carolina agreed with the citizen plaintiffs and ordered the pollution to stop, which it now has. Actions like these have taken place across the Nation for decades, with citizens enforcing the Clean Water Act in federal court despite state agency inaction. Yet the proposal does not assess how the revised definition affects the ability to meet the purpose of the Clean Water Act. As discussed in section VIII, it does not meet the purpose of the Act.

[148] *Id.* at 98.
[149] *Id.* at 133 (Table IV-9).

In addition, the agencies failed to adequately evaluate the state programs that would purportedly rescue the Nation's waters. As noted in the Economic Analysis, "[e]ffective regulation of the resources, however, requires the political capital and fiscal resources to do so."[150] As discussed in section VIII(B), there are significant political and fiscal challenges that would prevent states from protecting newly non-jurisdictional waters, the agencies simply failed to meaningfully consider these challenges.

5. The proposal fails to consider the effect of the proposal on the restoration industry and drinking water providers.

One of the problems with upending the understanding of waters of the United States as proposed is that many industries and the public rely on the protections provided by the Clean Water Act. The Supreme Court has recognized that an agency must "provide a more detailed justification than would suffice for a new policy . . . when, for example, . . . its prior policy has engendered serious reliance interest that must be taken into account."[151] The Court continued, "[i]t would be arbitrary and capricious to ignore such matters."[152] Here, two examples warrant a close look: the ecological restoration economy and drinking water utilities.

The agencies have failed to take into account the recent growth in the restoration industry, which is dependent on existing protections. The Economic Analysis discards the restoration interests with a cursory statement that "[b]ecause fewer waters would be subject to CWA jurisdiction under the proposed rule than are subject to regulation under the 2015 Rule or current practice, there would be a reduction in demand for mitigation and restoration services, under the section 404 permitting program and a corresponding reduction in revenue for the businesses."[153]

That is not sufficient. The restoration industry depends on the existing regulatory structure and protection of streams and wetlands that would be lost under this proposal.[154] It provides significantly more jobs per $1 million than the oil and gas industry, school construction, or pipeline construction.[155] In a survey of restoration providers, nearly a third primarily worked in wetland restoration or aquatic and riparian restoration, reflecting "the role of the Clean Water Act's section 404 compensatory mitigation requirements in inducing restoration work."[156]

The restoration industry directly provides 126,111 jobs a year in a variety of sectors, from engineers and construction firms to greenhouses and nurseries.[157] Including indirect and induced effects, the restoration industry has a total effect of adding 221,398 jobs each year which have a

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[150] *Id*. at 37.
[151] *Fox Television*, 556 U.S. at 515.
[152] *Id*.
[153] 2018 Economic Analysis at 213.
[154] Todd BenDor et al., Estimating the Size and Impact of the Ecological Restoration Economy, PLOS ONE, 3 (2015).
[155] *Id*.
[156] *Id*. at 7.
[157] *Id*.

gross economic impact of nearly $25 billion each year.[158] The agencies cited the study that summarizes these values, yet did not evaluate the effect of the proposal on the restoration industry.

As demonstrated in the data summarized below in Figures 4 and 5, both stream and wetland mitigation credit inventory has grown significantly over the last two decades.

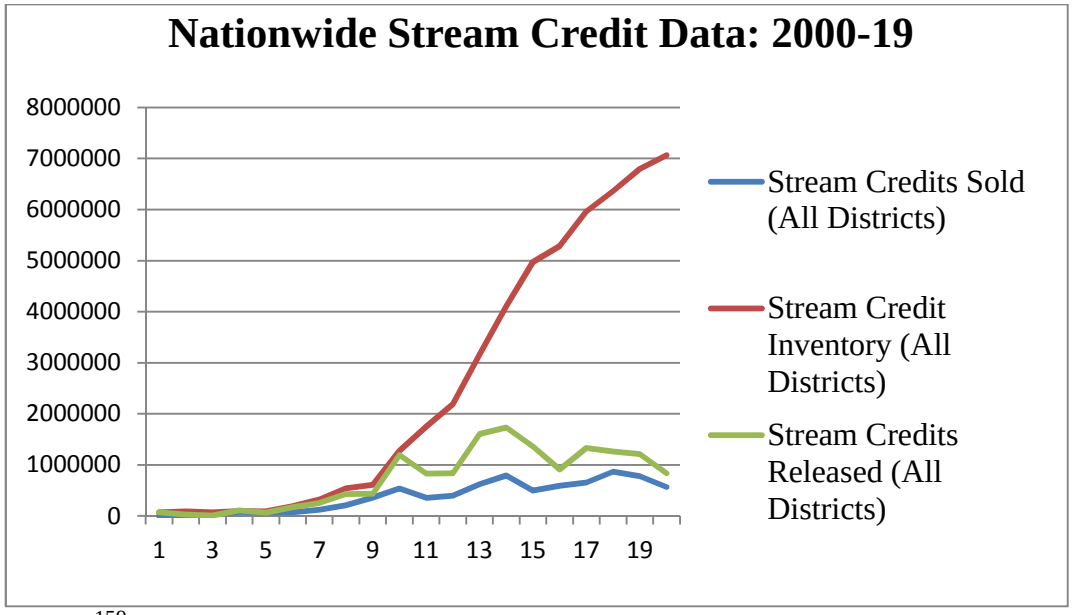

Figure 4[159]

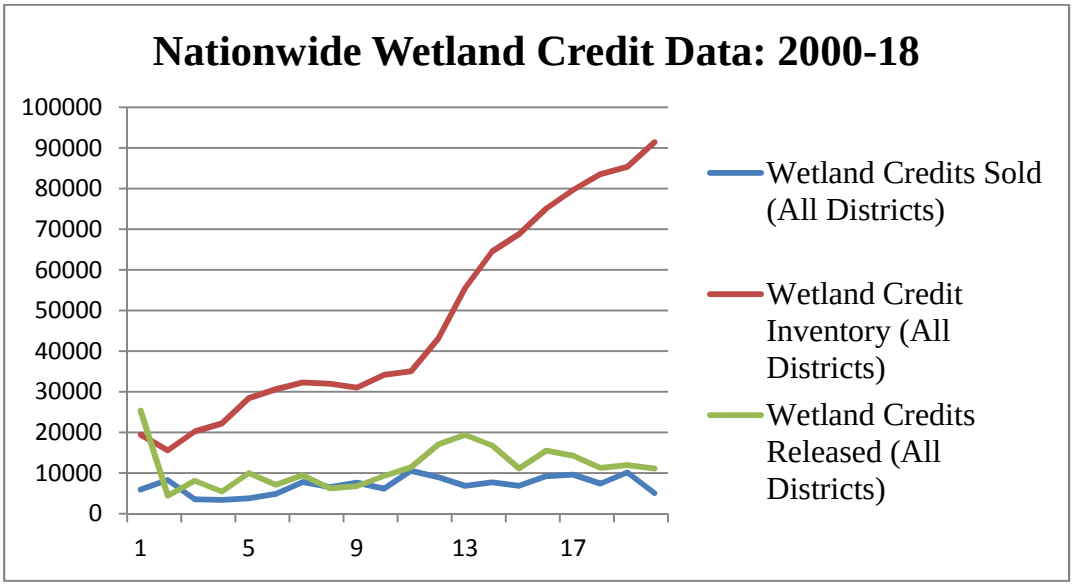

Figure 5[160]

[158] *Id.* at 9.
[159] Data collected and analyzed by Eco Blu Analyst, http://ecobluanalyst.com.
[160] Data collected and analyzed by Eco Blu Analyst. http://ecobluanalyst.com.

As a result, companies engaged in restoration have significant investments in restored streams and wetlands that not only improve water quality, but are worth approximately $1 billion.

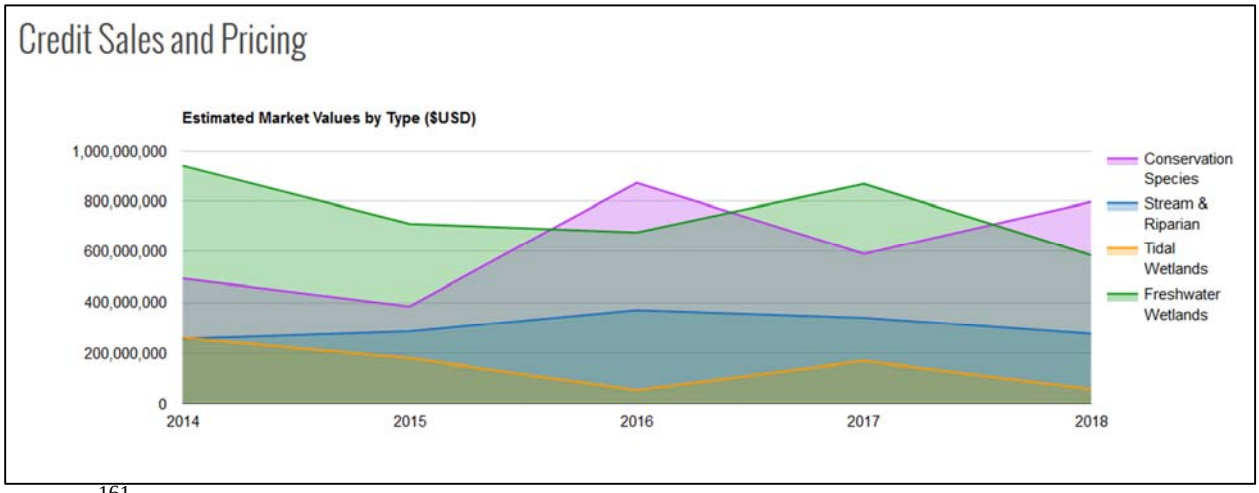

Figure 6[161]

North Carolina has similarly invested millions in restoration. According to the N.C. Division of Mitigation Services, as of May 2018, the state had awarded contracts for stream and wetland restoration valued at $508,545,591.[162] These contracts not only resulted in better water quality through watershed restoration, they represent a significant economic benefit and an investment that the state is at risk of losing with this proposal.

Similarly, little thought is given to costs that would be incurred by downstream drinking water providers. Water treatment plants are simply not equipped to handle the increasingly polluted water that would result from the proposal. They have planned, designed, and built facilities based on the existing protections. Even then, our drinking water infrastructure is in need of significant upgrades nationwide. If drinking water quality were EPA's top priority as Administrator Wheeler has stated,[163] this proposal would be withdrawn.

6. The proposal fails to treat similar situations similarly.

Because the agencies' approach is not centered on the Clean Water Act's objective, it treats similarly situated waters differently. In contrast, Justice Kennedy's opinion in *Rapanos* applies a single test for waters of the United States. Those that have a significant nexus to navigable waters are included; those that do not are excluded. The Clean Water Rule implemented the significant nexus standard and, therefore, was similarly consistent. But here, the agencies haphazardly fail to treat similar situations by:

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[161] Data collected and analyzed by Eco Blu Analyst, http://ecobluanalyst.com.
[162] N.C. Division of Mitigation Services, Processes and Awards: Contract Awards, https://deq.nc.gov/about/divisions/mitigation-services/dms-vendors/process-protocol.
[163] Ellie Kaufman, *EPA Head says clean-water access is "biggest environmental threat"—despite regulation rollbacks*, CNN (Mar. 20, 2019), https://www.cnn.com/2019/03/20/politics/epa-andrew-wheeler-clean-water-speech/index.html.

- Excluding ecological considerations as a basis for asserting jurisdiction, yet proposing to use methodologies based on assessment of the biological community as the basis for determining stream jurisdiction.

- Including wetlands that provide important water quality benefits to traditional navigable waters and directly abut the traditional navigable water as jurisdictional, but excluding wetlands with important water quality benefits to traditional navigable water that are separated by a natural or man-made levee.

- Including natural tributaries that continuously flow into jurisdictional waters as jurisdictional, but excluding ditches that continuously flow into jurisdictional waters and serve the same functions as tributaries.

- Including highly modified water bodies with little "chemical, physical, or biological integrity," such as the Los Angeles River, but excluding wetlands in close proximity to traditional navigable waters that provide important ecosystem services.

- Including groundwater as a required source of flow for jurisdictional tributaries, and a permitted source for ponds and lakes, yet excluding wetlands connected to jurisdictional waters via groundwater from jurisdiction.

- Allowing flooding from a jurisdictional water to make a lake or pond jurisdictional, but denying the same protection for flooded wetlands.

- Following Justice Scalia's opinion in *Rapanos*, which relied in part on dictionary definitions,[164] and then in the proposal defining the term "abut" consistent with Webster's II, New Riverside Dictionary (1994), but irrationally removing key parts of the definition of "adjacent," which Webster's II defines as "next to," "adjoining," "to lie near," or "close to," when limiting "adjacent" by the direct surface connection requirement.

The agencies' proposal is a hodge-podge of rationales that has no unifying theme. As a result, it violates the basic premise that "[a]n agency must treat similar cases in a similar manner unless it can provide a legitimate reason for failing to do so."[165]

B. The Proposal Violates the Clean Water Act by Unlawfully Narrowing Federal Jurisdiction.

The proposal's detachment from the objective of the Clean Water Act results in an additional error: the agencies' novel interpretation of Supreme Court case law adopts a narrow view of precedent that has never been applied by the Court or the agencies. The narrowly circumscribed jurisdiction described in the proposal has not been applied by the Court or the

[164] 547 U.S. at 732, 735.
[165] *Indep. Petroleum Ass'n v. Babbitt*, 92 F.3d 1248, 1258 (D.C. Cir. 1996).

agencies because it would defeat the objective of the Act. It cannot be accepted here for that reason.

1. The agencies' interpretation of Rapanos is erroneous.

Perhaps most indicative of the errors in the agencies interpretation of *Rapanos* is their treatment of Justice Kennedy's opinion. Contrary to the proposal, which attempts to meld Kennedy's opinion with Justice Scalia's, Kennedy rejected the plurality decision, finding that the decision "is inconsistent with the Act's text, structure, and purpose."[166] He specifically repudiated the two requirements for jurisdiction that the agencies accept here as the controlling law.

Justice Kennedy found that requiring "permanent standing water or continuous flow, at least for a period of 'some months' . . . makes little practical sense in a statute concerned with downstream water quality."[167] Justice Kennedy noted that the Los Angeles River, which "ordinarily carries only a trickle of water and often looks more like a dry roadway than a river . . . is illustrative of what often-dry watercourses can become when rain waters flow."[168] Kennedy points out the essential flaw in Scalia's dictionary-based test: it would include the "merest trickle, if continuous" yet exclude "torrents thundering at irregular intervals."[169] The significant nexus test, which relies on the stream or wetland's function, avoids this absurd outcome.[170] Contrary to the agencies' assumptions here, he concluded that although "Congress could draw a line to exclude irregular waterways, [] nothing in the statute suggests it has done so."[171] "It follows that the Corps can reasonably interpret the Act to cover the paths of such impermanent streams."[172]

Justice Kennedy also rejected the second key component of this rulemaking—"exclusion of wetlands lacking a continuous surface connection to other jurisdictional waters."[173] Kennedy recognized that the "*Riverside Bayview*'s observations about the difficulty of defining the water's edge cannot be taken to establish that when a clear boundary is evident, wetlands beyond the boundary fall outside the Corps' jurisdiction."[174] He found that the plurality decision "overlook[ed] [*Riverside Bayview's*] broader focus on wetlands' significant effects on water quality and the aquatic ecosystem."[175] He concluded that "a continuous connection is not necessary for moisture in wetlands to result from flooding—the connection might well exist only during floods."[176] These conclusions plainly reject the proposed rule's elimination of jurisdiction over wetlands that lack an intermittent surface water connection.

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[166] *Rapanos*, 547 U.S. at 776 (Kennedy, J., concurring).
[167] *Id*. at 769.
[168] *Id*. at 769-770.
[169] *Id*. at 769.
[170] *See id*. at 779.
[171] *Id*. at 770.
[172] *Id*.
[173] *Id*. at 772.
[174] *Id*. at 773.
[175] *Id*. (quotation marks omitted).
[176] *Id*. at 773-74.

"*SWANCC*, likewise, does not support the plurality's surface-connection requirement,"[177] which the agencies adopt here. As Kennedy stated, the Court's *SWANCC* decision "is not an explicit or implicit overruling of *Riverside Bayview's* approval of adjacency as a factor in determining the Corps' jurisdiction."[178] He went on to emphasize, as the Court recognized in *Riverside Bayview*, that "[i]n many cases, moreover, filling in wetlands separated from another water by a berm can mean that floodwater, impurities, or runoff that would have been stored or contained in wetlands will instead flow out to major waterways."[179] As he put it:

> wetlands possess the requisite [significant] nexus, and thus come within the statutory phrase 'navigable waters,' if the wetlands, alone or in combination with similarly situated lands in the region, significantly affect the chemical, physical, and biological integrity of other covered waters understood as navigable in the traditional sense. When, in contrast, their effects on water quality are speculative or insubstantial, they fall outside the zone fairly encompassed by the term "navigable waters.[180]

Another indication that the agencies wrongly rely on the plurality is that both Justice Kennedy and Justice Stevens, in the dissent, strongly disagreed with Justice Scalia's treatment of ditches, which is followed here by the agencies. In the plurality decision, Justice Scalia argues that a ditch cannot be a water of the United States and a point source. As he contends, (i) the word "ditch" appears in the definition of a "discharge of a pollutant," (ii) ditches carry intermittent flow, and (iii) waters of the United States cannot have intermittent flow; therefore, ditches must be point sources and generally not waters of the United States.[181] He noted that his approach to regulating ditches was at odds with the Corps' approach applicable at the time. Under the Corps' reading of the Clean Water Act, as required by federal courts, a ditch was a tributary and was regulated if it had a perceptible ordinary high water mark.[182]

In rejecting Justice Scalia's position, Justice Kennedy begins by explaining that the Clean Water Act contains no support for the conclusion that ditches, or any water, has to be perennial to be considered a water of the United States. He then states that there is no basis to conclude that a water cannot be both a point source and a water of the United States.[183] In his conclusion, Justice Kennedy characterized ditches as tributaries.[184]

Justice Stevens, writing for the minority, focused on Justice Scalia's assertion that ditches are intermittent by pointing out several cases decided by the Court involving perennial ditches.[185]

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[177] *Id*. at 774.
[178] *Id.*
[179] *Id*. at 775.
[180] *Id.* at 717-18 (emphasis added).
[181] *Id.* at 735 (Scalia, J. opinion).
[182] *Id.* at 735 (citing 33 C.F.R. §§ 328.3(a)(5), (e)); Final Notice of Issuance and Modification of Nationwide Permits, 65 Fed. Reg. 12,818, 12,823 (Mar. 9, 2000).
[183] *Rapanos*, 547 U.S. at 771-72 (Kennedy, J., concurring).
[184] *Id.* at 787.
[185] *Id*. at 736 n.7 (citing *Jennison v. Kirk*, 98 U.S. 453 (1879); *Knoxville Water Co. v. Knoxville*, 200 U.S. 22, 27 (1906); *PUD No. 1 of Jefferson Cty. v. Washington Dep't of Ecology*, 511 U.S. 700, 709 (1994); *New Orleans Water–Works Co. v. Rivers*, 115 U.S. 674, 683 (1885)).

Then, Justice Stevens explained that "[t]he plurality's attempt to achieve its desired outcome by redefining terms does no credit to lexicography—let alone to justice."[186]

2. SWANCC was limited to the Migratory Bird Rule.

The agencies' proposal also erroneously asserts that *SWANCC* stands for the premise that biological features can never be used to determine jurisdiction. That is incorrect. In reality, the Court's decision in *SWANCC* was limited to one aspect of the agencies' rule—the Migratory Bird Rule.[187] The agencies recognized that immediately following the decision[188] and have interpreted *SWANCC* as limited ever since.[189] In *Rapanos*, Justice Kennedy recognized that *SWANCC* could not be interpreted to demand the surface-connection requirement that the agencies would impose here.[190]

Moreover, the proposal relies on biological factors to determine jurisdiction, seemingly in contradiction of the proffered interpretation of *SWANCC*. The proposal suggests that intermittent and perennial stream jurisdiction may be determined using methodology similar to that used by the EPA in the Pacific Northwest.[191] The first question in that analysis is "Are aquatic macroinvertebrates present?" The second is "Are 6 or more individuals of the Order Ephemeroptera present?" The third also evaluates the biological makeup of the stream, asking "Are perennial indicator taxa present?" As a result, the proposal both interprets *SWANCC* to bar use of biological features to determine jurisdiction and proposes to use biological features to determine jurisdiction.

3. Traditional navigable waters must be interpreted broadly.

It appears that the agencies are open to restricting the reach of traditional navigable waters in two ways that are not supported by the case law. First, the agencies suggest limiting what is considered "navigable-in-fact" and second, they propose to eliminate the historic commerce test. Because the proposal is inextricably linked to the reach of traditional navigable waters, it is imperative that traditional navigable waters are properly recognized. They are not.

A century of well-developed Supreme Court precedent firmly establishes the broad reach of traditional navigable waters. The terms "navigable-in-fact" and "navigable-in-law" first appeared in *The Daniel Ball*. In that decision, the Supreme Court adopted the basic principle that, if a waterbody is used to transport goods on a ship in interstate commerce, the waterbody is subject to federal regulation.[192] The Court revisited the issue of navigability later in *The Montello*, where it recognized that the vessels involved can be small.[193] The case also accepted

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[186] *Id.* at 803 n.12.
[187] *SWANCC*, 531 U.S. 159, 165 (2001).
[188] Advance Notice of Proposed Rulemaking on the Clean Water Act Regulatory Definition of "Waters of the United States," 68 Fed. Reg. 1,991, 1,996 (January 15, 2003).
[189] 84 Fed. Reg. at 4,159.
[190] *Rapanos*, 547 U.S. at 774.
[191] 84 Fed. Reg. at 4,176.
[192] 77 U.S. 557, 563 (1870).
[193] 87 U.S. 430 (1874).

that commercial use can be historical; the Court relied on past use by fur trappers to transport their pelts to market as the commercial activity. [194]

Building on *The Montello*, the Court held in *Economy Light & Power v. United States*, that a water does not have to be continuously navigable regardless of whether that interruption is due to obstacles or low water levels.[195] The understanding of navigable waters was further expanded in *United States v. Appalachian Electric Power Company*, where the Court held that so long as a water is *susceptible* of use as a highway of commerce, it is navigable-in-fact, even if the water has never been used for any commercial purpose.[196] Small rafts are sufficient to demonstrate navigability.[197]

As demonstrated by these decisions, the legal test for navigability is whether a canoe or kayak or other small craft can navigate the water in such a manner that demonstrates that meaningful commerce is or could occur. To the extent that the agencies intend to clarify Appendix D of the *Rapanos* guidance,[198] the test must include waters navigable by these small watercraft.

4. Ditches that function as tributaries should be jurisdictional.

Under the proposed rule, the agencies limit jurisdictional ditches to those that are constructed in a jurisdictional water and satisfy the definition of a tributary.[199] This definition is not consistent with the Clean Water Act.[200]

While it is true that the Corps initially attempted to side-step its obligations under the Clean Water Act by illegally equating the jurisdiction of the Clean Water Act with that of the Rivers & Harbors Act of 1899,[201] the Corps, under court order, soon broadened their definition of "waters of the United States."

In 1975, the District Court for the District of Columbia held that the Corps' narrow interpretation of its jurisdiction was unacceptable and demanded that the Corps expand its jurisdiction to include many additional water bodies, including ditches.[202] In *Callaway*, the court berated the Corps for "act[ing] unlawfully and in derogation of their responsibilities under section 404 of the Water Act . . . ."[203] Another federal district court held similarly that the Corps' jurisdiction under the Clean Water Act was significantly broader than its jurisdiction under the Rivers & Harbors Act.[204] As that court stated, the Clean Water Act "was designed to deal with all facets of recapturing and preserving the biological integrity of the nation's water by creating a

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[194] *Id.* at 442.
[195] 256 U.S. 113, 123-24 (1921).
[196] 311 U.S. 377, 407 (1940)
[197] *Alaska v. Ahtna*, 891 F.2d 1401, 1405 (9th Cir. 1989).
[198] *See* 84 Fed. Reg. at 4,170.
[199] 84 Fed. Reg. at 4,179.
[200] *See id.* at 4,155.
[201] Army Corps of Engineers, Permits for Activities in Navigable Waters or Ocean Waters, 39 Fed. Reg. 12,081, 12,115 (Apr. 3, 1974).
[202] *Nat. Res. Defense Council v. Callaway*, 392 F. Supp. 685, 686 (D.D.C. 1975).
[203] *Callaway*, 392 F. Supp. at 686.
[204] *United States v. Holland*, 373 F. Supp. 665, 668 (M.D. Fla. 1974).

web of complex interrelated regulatory programs."[205] Although the agencies are correct that the Corps did not regulate upland ditches initially, it was doing so by 1977.

In *United States v. Eidson*,[206] the Eleventh Circuit Court of Appeals clearly articulated the rationale for finding ditches that function as tributaries jurisdictional.[207] The court held:

> There is no reason to suspect that Congress intended to regulate only the natural tributaries of navigable waters. Pollutants are equally harmful to this country's water quality whether they travel along man-made or natural routes. The fact that bodies of water are 'man-made makes no difference . . . . That the defendants used them to convey the pollutants without a permit is the matter of importance.'[208]

Citing *Eidson*, the Ninth Circuit in *Headwaters, Inc. v. Talent Irrigation District* went one step further and concluded that man-made structures should be treated the same as streams because they are tributaries. The court held that "[a]s tributaries, the [irrigation] canals are 'waters of the United States,' and are subject to the [Clean Water Act] and its permit requirement."[209] Cases decided after *SWANCC* only reinforced the holdings, that streams and ditches should be treated alike. In *Community Association for Restoration of the Environment v. Henry Bosma Dairy*,[210] the Ninth Circuit was confronted with a case involving pollutants that flowed through a series of canals and natural water bodies that ultimately flowed back into the river. The court held that the canals, like the river, were jurisdictional.[211] The Fourth Circuit has similarly recognized the importance of extending jurisdiction to ditches that function as tributaries, finding that "[i]f this court were to conclude that the I-64 ditch is not a 'tributary' solely because it is manmade, the [Clean Water Act's] chief goal would be subverted." [212]

In the three Supreme Court cases that have interpreted the term "navigable waters," Justice Scalia's plurality opinion was alone in adopting a narrow standard. In *Riverside Bayview*, the justices voted unanimously in upholding an approach that established comprehensive jurisdiction with the goal of addressing "pollution at its source."[213] In *SWANCC*, five justices placed a single restriction on Clean Water Act jurisdiction, barring the Corps from using the migratory-bird rule in determining whether geographically isolated waters are "waters of the United States," but leaving the door open for the agencies to base their jurisdiction over such waters on other factors.[214] And in *Rapanos*, five justices—Justice Kennedy and the dissenting justices—correctly interpreted the Clean Water Act as having a broad reach. Case law on

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[205] *Id.* at 668.
[206] 108 F.3d 1336 (11th Cir. 1997).
[207] *Id.* at 1340.
[208] *Id*. at 1336 (quoting *Holland*, 373 F. Supp. at 673 and *Leslie Salt Co. v. United States*, 896 F.2d 354, 358 (9th Cir. 1990)).
[209] 243 F.3d 526, 533 (9th Cir. 2001).
[210] 305 F.3d 943, 954 (9th Cir. 2002).
[211] *Id*.
[212] *Treacy v. Newdunn Assoc., LLP*, 344 F.3d 407, 416-417 (4th Cir. 2003), *cert. denied sub nom, Newdunn Assoc., LLP v. U.S. Army Corps of Eng'rs*, 541 U.S. 972 (2004); *United States v. Deaton*, 332 F.3d 698, 710-11 (4th Cir. 2003).
[213] *Riverside Bayview*, 474 U.S. at 132-33 (citing S. Rep. No. 92-414 at 77 (1972)).
[214] *SWANCC*, 531 U.S. at 165.

traditional navigable waters and ditches is similarly broad. The agencies proposal to rely on Justice Scalia's narrow plurality opinion as the controlling interpretation of "waters of the United States" is unlawful, arbitrary and capricious.

C. The Clean Water Act Requires the Agencies to Assert Full Commerce Clause Authority.

Congress's power to regulate the Nation's waters derives from the Commerce Clause of the United States Constitution. The Clean Water Act requires the agencies to ensure the "integrity of the Nation's waters." To fulfill this obligation, the agencies must give the Clean Water Act "the broadest possible constitutional interpretation,[215] as Congress demanded.[216]

The Commerce Clause grants Congress the power "[t]o regulate Commerce . . . among the several States,"[217] including (1) channels of interstate commerce; (2) persons or things in interstate commerce; and (3) activities that substantially affect interstate commerce.[218] Federal jurisdiction over the Nation's waters falls squarely within each of these categories. Despite the proven breadth of Congress's Commerce Clause powers, and the clarity of Congress's mandate under the Clean Water Act, the agencies now claim that limited authority and the need to preserve the traditional power of the States to regulate land and water drive their scheme to dismantle critical clean water protections.[219] Justice Kennedy explicitly dismissed these constitutional concerns in *Rapanos*, stating "In *SWANCC*, by interpreting the Act to require a significant nexus with navigable waters, the Court avoided applications—those involving waters without a significant nexus—that appeared likely, as a category, to raise constitutional difficulties and federalism concerns."[220]

To fulfill their duties under the Clean Water Act, the agencies must give full effect to Congress's Commerce Clause authority in protecting our Nation's waters and define "waters of the United States" consistent with Justice Kennedy's *Rapanos* opinion—as further defined by the 2015 Clean Water Rule. This is the only course that is consistent with the Constitution, Supreme Court jurisprudence, and the Clean Water Act.

1. Congress's power to protect channels of interstate commerce extends to non-navigable streams, wetlands, and interstate waters.

When enacting the Clean Water Act, Congress understood the scientific reality that waters are "interconnected" and protections under the Act must extend to "navigable waters, portions thereof, and their tributaries," for the health of the "aquatic ecosystem" and "well-being of human society."[221] Only three years after the Act was passed, a federal court confirmed that

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[215] H.R. Rep. No. 92-911 at 131 (1972); S. Conf. Rep. No. 92-1236 at 144 (1972).
[216] 33 U.S.C. § 1251(a).
[217] U.S. CONST., art. I, § 8, cl. 3.
[218] *Gonzales* v. *Raich*, 545 U.S. 1, 16-17 (2005); *United States v. Lopez*, 514 U.S. 549, 558-59 (1995).
[219] 84 Fed. Reg. at 4,156.
[220] *Rapanos*, 547 U.S. at 776 (Kennedy, J., concurring).
[221] S. Rep. No. 92-414 at 76-77 (1972) (requiring "that any changes in the environment resulting in a physical, chemical or biological change in a pristine water body be of a temporary nature, such that by natural processes, within a few hours, days or weeks, the aquatic ecosystem will return to a state functionally identical to the

Congress asserted, and the Act extends, "federal jurisdiction over the nation's waters to the *maximum extent permissible* under the Commerce Clause of the Constitution."[222]

Consistent with the Act's broad reach, Justice Kennedy reasoned in *Rapanos* that an interpretation of waters of the United States that relies on a significant nexus between upstream non-navigable waters and downstream traditional navigable waters raises no serious Commerce Clause concerns.[223] Justice Kennedy's opinion relied, in part, on the well-settled proposition that Congress's power to regulate channels of interstate commerce also includes the power to adopt "federal legislation 'aimed at improving safety in the channels of commerce'"[224] For example, "[j]ust as control over the non-navigable parts of a river may be essential or desirable in the interests of the navigable portions, so may the key to flood control on a navigable stream be found in whole or in part in flood control on its tributaries . . . ."[225] Thus, the Commerce Clause sanctions the federal government's regulation of activities *outside* of the traditional navigable waters—*i.e.*, non-navigable tributaries—that potentially threaten navigation *within* those waters.[226] Because damage to small streams and wetlands impairs navigation in a number of ways—by causing flooding downstream, by allowing silt to run off and accumulate in a downstream waterway, or (if the discharge contains toxic chemicals that flow downstream) by making use of the waterway dangerous[227]—they must be protected consistent with Congress's mandate.[228]

Congress's power to keep the channels of commerce free from injurious uses is also well-settled.[229] Its power over channels of commerce extends to all waters that have a hydrologic connection to and form part of the tributary system of a traditionally navigable water, including

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original"); *see also* H.R. Rep. No. 92-911 at 76-77 (1972) (discussing the goal of the legislation as preserving natural ecosystem structure and function); Brief for the Honorable John D. Dingell, The Honorable John Conyers, Jr., The Honorable Robert F. Drinan, The Honorable Gary W. Hart, The Honorable Kenneth W. Hechler, The Honorable Charles McCurdy Mathias, Jr., The Honorable Paul N. McCloskey, Jr., The Honorable Charles B. Rangel, and the Honorable Senator Richard Schultz Schweiker as Amici Curiae in Support of the Resp. at 11, *Rapanos v. United* States, 574 U.S. 715 (January 2006) (Nos. 04-1034, 04-1384) ("Amicus Br. of Congress").

[222] *Callaway*, 392 F. Supp. at 686; *see also Katzenbach v. McClung*, 379 U.S. 294 (1974); *Heart of Atlanta Motel, Inc. v. United States*, 379 U.S. 241 (1964); *Wickard v. Filburn*, 317 U.S. 111 (1942).

[223] *Rapanos*, 547 U.S. at 782-83 (citations omitted); *see also United States v. Cundiff*, 555 F.3d 200, 213 n.6 (6th Cir. 2009) (citations omitted) (noting a commerce clause challenge would be "rather tenuous").

[224] *Rapanos*, 547 U.S. at 782 (Kennedy, J., concurring) (citing *Pierce Cty. v. Guillen*, 537 U.S. 129, 147 (2003)).

[225] *Id*. (citing *Oklahoma ex rel. Phillips* v. *Guy F. Atkinson Co.*, 313 U.S. 508, 525-526 (1941)); *see also Guy F. Atkinson Co.*, 313 U.S. at 525-526 ("Flood protection [along with] watershed development [are] parts of commerce control; and [thus] the power of flood control extends to the tributaries of navigable streams") (quoting *United States* v. *Appalachian Elec. Power Co.*, 311 U.S. 377, 426 (1940)).

[226] *See United States v. Grand River Dam Auth*., 363 U.S. 229, 232 (1960); *United States v. Rio Grande Dam & Irrigation Co.*, 174 U.S. 690, 709-10 (1899); *see also Guy F. Atkinson Co*., 313 U.S. at 525 ("There is no constitutional reason why Congress cannot, under the commerce power treat the watersheds as a key to flood control on navigable streams and their tributaries.").

[227] See section X; *see also* Br. of the States as Amici Curiae in Support of Respondents, *Rapanos v. United States* (Nos. 04-1034, 04-1384) (January 2006) ("The federal government rationally may conclude that pollution discharged into these wetlands substantially affects downstream traditional navigable waters.") at 20.

[228] *See Appalachian Elec. Power Co.*, 311 U.S. at 426 ("the authority of the United States is the regulation of commerce [over] waters … [f]lood protection, watershed development, [and] recovery of the cost of improvements through the utilization of power are likewise parts of commerce control.")

[229] *See, e.g., Lopez*, 514 U.S. at 558.

streams that flow that intermittently or ephemerally, non-navigable interstate waters, and ditches that function as tributaries.[230] This is so "because pollutants added to any of these tributaries will inevitably find their way to the very waters that Congress has sought to protect."[231] "It would, of course, make a mockery of [Congress's] powers if its authority to control pollution was limited to the bed of the navigable stream itself."[232] In the absence of federal control, "[t]he tributaries which join to form the river could then be used as open sewers" carrying waste into the navigable waters and completely undermining the federal protection over the channels of commerce.[233] Congress's power must extend so far to further the express purposes in the Act to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters," and attain "water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water."[234] The agencies must act consistently.

2. Protection of non-navigable interstate waters is a valid exercise of Congress's power to regulate persons and things in interstate commerce.

Water is itself an article in commerce and is a necessary and vital component of commercial activities.[235] About 9 trillion gallons of fresh water are used each year to manufacture goods.[236] The burgeoning craft brewing industry relies on sources of clean water in contributing $76.2 billion to the U.S. economy each year, along with 500,000 jobs.[237] According to the United States Geological Survey, water is used for fabricating, processing, washing, diluting, cooling, or transporting a product.[238] Water is also used by smelting facilities, petroleum refineries, and industries producing chemical products, food, and paper products.[239] Water regulation by the federal government, therefore, is beyond question.

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[230] *Treacy*, 344 F.3d at 416-17 (upholding Corps' assertion of jurisdiction over wetlands connected to a traditionally navigable water through approximately 2.4 miles of ditches and streams). *See also, e.g., United States v. Hubenka*, 438 F.3d 1026, 1032 (10th Cir. 2006) (Commerce power includes "the power to regulate waters to limit pollution, prevent obstructions to navigation, reduce flooding, and control watershed development.") (citations omitted); *United States v. Interstate General Co.*, No. 01-4513, 39 Fed. Appx. 870, 2002 WL 1421411 *3 (4th Cir. July 2, 2002) (rejecting argument that *SWANCC* eliminated jurisdiction over wetlands adjacent to non-navigable tributaries); *Headwaters* v. *Talent Irrigation Dist.*, 243 F.3d 526, 534 (9th Cir. 2001) ("Even tributaries that flow intermittently are 'waters of the United States').

[231] *Treacy*, 344 F. 3d at 416-17.

[232] *United States v. Ashland Oil and Transp. Co.*, 504 F.2d 1317, 1325-1326 (6th Cir. 1974).

[233] *Id*. at 1326 ("The navigable part of the river could become a mere conduit for upstream waste.")

[234] 33 U.S.C. § 1251(a)(1)-(2).

[235] *Sporhase v. Nebraska*, 458 U.S. 941 (1982). *Cf. Chem. Waste Mgmt., Inc. v. Hunt*, 504 U.S. 334, 340 n.3 (1992) (noting that waste, even if it has no value, is an "article of commerce").

[236] EPA, OFFICE OF WATER, LIQUID ASSETS 2000: AMERICA'S WATER RESOURCES AT A TURNING POINT 2(2000).

[237] Brewers Association, Comment Letter Submitted on EPA-HQ-OW-2018-0149 (Mar. 7, 2019).

[238] U.S.G.S., INDUSTRIAL WATER USE, https://www.usgs.gov/mission-areas/water-resources/science/industrial-water-use?qt-science_center_objects=0#qt-science_center_objects (last visited Apr. 8, 2019).

[239] U.S.G.S., ESTIMATED USE OF WATER IN THE UNITED STATES IN 2015: U.S. GEOLOGICAL SURVEY CIRCULAR 1441, 59-60 (2018), https://doi.org/10.3133/cir1441. The need for water in these processes provides more than sufficient basis for federal regulation of those resources under the Commerce Clause. *See Sporhase*, 458 U.S. at 953-54 (finding a "significant federal interest" in conservation of scarce ground water was "a national problem" that Congress could regulate pursuant to Commerce Clause).

3. *Protection of non-navigable interstate waters is a valid exercise of Congress's power to regulate classes of activities that substantially affect interstate commerce.*

The Supreme Court has "recognized . . . that '[t]he power of Congress over interstate commerce is not confined to the regulation of commerce among the states,' but extends to activities that 'have a substantial effect on interstate commerce.'"[240] "Congress's power, moreover, is not limited to regulation of an activity that by itself substantially affects interstate commerce, but also extends to activities that do so only when aggregated with similar activities of others."[241]

a. Broad protection of waters is required under the Commerce Clause because of clear and direct connections between the degradation of small streams, wetlands, and non-navigable interstate waters and interstate commerce.

Just as water is an article in commerce and is a component of commercial activity, water pollution has a significant impact on commerce and preventing water pollution has a substantial commercial effect.

Americans spend about $44 billion each year on trips to coastal areas; the American fishing industry produces more than 10 billion pounds of fish and shellfish each year; and farmers, who produce food and fiber products worth at least $197 billion per year, rely heavily on clean water for irrigation.[242] Headwater streams provide drinking water for 200 million Americans.[243] According to EPA, however, nitrates and algal blooms in drinking water sources "can drastically increase treatment costs."[244] The tourism industry loses close to $1 billion each year, mostly through losses in fishing and boating activities, as a result of water bodies that have been affected by nutrient pollution and harmful algal blooms.[245] Annual losses to these industries from nutrient pollution are estimated to be in the tens of millions of dollars.[246]

The protection of wetlands is also directly linked to interstate commerce. For example, the Congaree Bottomland Hardwood Swamp in South Carolina removes a quantity of pollutants from the watershed equivalent to that which would be removed by a $5 million treatment plant.[247] A 2010 assessment prepared for the EPA of non-floodplain wetlands in 88 counties of

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[240] *Nat'l Fed. of Indep. Bus. v. Sebelius*, 567 U.S. 519, 549 (2012) ("*NFIB*") (opinion of Roberts, C.J.) (*quoting United States v. Darby*, 312 U.S. 100, 118–19 (1941)); *see Lopez*, 514 U.S. at 558–59.
[241] *NFIB*, 567 U.S. at 549 (opinion of Roberts, C.J.) (*citing Wickard*, 317 U.S. at 127-28).
[242] EPA, LIQUID ASSETS 2000 at 6-7.
[243] SELC GIS Analysis.
[244] EPA, NUTRIENT POLLUTION, THE EFFECTS - ECONOMY. Nitrate-removal systems in Minnesota caused supply costs to rise from 5-10 cents per 1,000 gallons to over $4 per 1,000 gallons. *Id*.
[245] *Id*.
[246] *Id*.
[247] EPA, ECONOMIC BENEFITS OF WETLANDS (2006).

the Carolinas also showed that non-floodplain wetlands stored significant amounts of water and, in doing so, captured heavy metals, nutrients, and carbon.[248]

The biological health of headwaters and their connection to waters of the United States also require regulation under the Act.[249] Anadromous fish—those that live at sea but spawn in freshwater—such as the Pacific salmon, need tributaries with specific water quantity and quality in which to spawn and rear their young. The presence of these fish in the Nation's waterways supports commercial and recreational activities that generate over $212 billion and 1.7 million jobs.[250]

Consistent with Congress's power over interstate commerce, the Clean Water Act requires the protection of healthy watersheds to preserve the value of water for "public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other purposes."[251] The agencies must apply broad water protections to achieve the Act's mandate.

b. Broad protection of waters under the Commerce Clause is valid because the activities being regulated are economic in nature, which substantially affect interstate commerce.

The activities resulting in the water pollution prohibited by the Clean Water Act are also economic in nature. The regulation of small streams, wetlands, and non-navigable interstate waters is therefore warranted.[252]

Discharges of pollutants into surface waters occur primarily as a result of industrial and commercial operations, including manufacturing, construction, resource extraction, land development, agriculture, and waste disposal.[253] To be sure, one of the policies that motivated passage of the Act was Congress' desire to end the use of the Nation's rivers, lakes, streams, and oceans as "waste treatment systems."[254] Similarly, dredging and filling of wetlands regulated under section 404 are undertaken by commercial interests for monetary gain.[255] These activities,

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[248] RTI International, Inc., *Assessing Geographically Isolated Wetlands in North and South Carolina: The Southeast Isolated Wetlands Assessment (SEIWA*), Final Report, Prepared for U.S. EPA (Feb. 11, 2011).
[249] *See Gibbs v. Babbitt*, 214 F.3d 483, 492 (2000) (finding it reasonable for Congress to regulate endangered species under the Commerce Clause because the species implicate commercial activities and interstate markets).
[250] U.S. DEPT. OF COMMERCE, FISHERIES ECONOMICS OF THE UNITED STATES: ECONOMICS AND SOCIOCULTURAL STATUS AND TRENDS SERIES (Dec. 2018).
[251] 33 U.S.C. § 1313(c)(2)(A).
[252] *See SWANCC*, 531 U.S. at 193 (Stevens, J., dissenting) ("[t]here can be no doubt that, unlike the class of activities Congress was attempting to regulate in *United States v. Morrison*, 529 U.S. 598, 613, 120 S.Ct. 1740, 146 L.Ed.2d 658 (2000) ('[g]ender-motivated crimes'), and *Lopez*, 514 U.S., at 561, 514 U.S. 549 (possession of guns near school property), the discharge of fill material into the Nation's waters is almost always undertaken for economic reasons."). *See also Perez v. United States*, 402 U.S. 146 (1971) (noting that it is the "class" of regulated activities, not the individual instance, that is to be considered in the "affects" commerce analysis).
[253] *See, e.g.*, 40 C.F.R. pts. 403-610 (listing Clean Water Act effluent guidelines for 73 categories of industrial activities, which fill over 1500 pages of the Code of Federal Regulations).
[254] S. Rep. No. 92-414 (Oct. 28, 1971).
[255] *SWANCC*, 531 U.S. at 193 (Stevens, J., dissenting); *see also* U.S. FISH & WILDLIFE SERVICE, STATUS AND TRENDS OF WETLANDS IN THE CONTERMINOUS UNITED STATES 1986 TO 1997 12 (2000).

and their impacts on water quality, are within the federal government's broad authority to regulate interstate commerce, and the agencies cannot ignore them.

c. Broad protection of waters under the Commerce Clause is required to safeguard downstream states from out-of-state pollution that they cannot themselves regulate.

Congress's Commerce Clause power extends to "activities causing air or water pollution, or other environmental hazards that may have effects in more than one state."[256] As Justice Kennedy observed in *Rapanos*, "the [Clean Water Act] protects downstream States from out-of-state pollution that they cannot themselves regulate."[257] Downstream states cannot control the actions of their upstream neighbors, and these upstream states have strong incentives to choose growth over resource protection because much of the cost of resource destruction is borne by downstream neighbors. Waters that are critical to our region, and which cross state lines, like pine flatwood forested wetlands that span across the Florida/Georgia state line or large Carolina bays, could be lost without a meaningful federal floor.

Moreover, voters in upstream states likely would reject regulatory measures that impose costs where they live, but deliver benefits to communities downstream. [258] Voters in downstream states likely would conclude that regulation in their state is not worthwhile because it cannot solve the water pollution problem by itself due to the lack of protections in upstream states.[259] As the Supreme Court clarified in *Hodel*, "prevention of this sort of destructive interstate competition is a traditional role for congressional action under the Commerce Clause."[260]

The regulation of small streams, wetlands, and non-navigable interstate waters derives from a combination of congressional concerns. Due to the harm to channels of commerce, downstream states, and interstate commerce that would result from the loss of these waters, federal protections for these waters lie at the very heart of federal Commerce Clause authority.

D. In Proposing This Rule, the Agencies Unlawfully Abdicate Their Charge to Restore and Maintain the Nation's Waters.

As with all administrative agencies, the agencies are "creature[s] of statute and they derive [their] existence and all of [their] power from Congress."[261] Congress entrusted the agencies with the unequivocal goal of "restor[ing] and maintain[ing] the chemical, physical, and biological integrity of the Nation's waters."[262] To achieve this objective, Congress made it "the national goal" to eliminate the discharge of pollutants into the Nation's waters by 1985. That deadline has long past, discharges have not been eliminated,[263] and the agencies cannot now

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[256] *Hodel v. Va. Surface Mining & Reclamation Ass'n*, 452 U.S. 264, 282 (1981).
[257] 547 U.S. at 777 (citation omitted).
[258] Br. of the Ass'n of State and Interstate Water Pollution Control Administrators as Amicus Curiae in Support of Resp., *Rapanos v. U.S.*, 574 U.S. 715 (Jan. 2006) (Nos. 04-1034 & 04-1384) at 25.
[259] *Id.*
[260] *Hodel*, 452 U.S. at 282.
[261] *Jones Bros., Inc. v. Sec'y of Labor*, 898 F.3d 669, 674 (6th Cir. 2018).
[262] 33 U.S.C. § 1251(a).
[263] *See supra* section IV.

undermine the very charge Congress gave them[264] by stripping protections from the headwaters, streams, and wetlands needed to maintain the structure, function, and overall integrity of our rivers, lakes, estuaries, and oceans.[265] To do so would be "inconsistent with [the clear] statutory mandate" that it protect Nation's waters and it would "frustrate the congressional policy underlying [the Clean Water Act]"[266]—that is, the "exercise[of] comprehensive jurisdiction over the Nation's waters to control pollution to the fullest constitutional extent."[267] Numerous courts have rejected similar agency interpretations of statutes that are in conflict with the legislative history and fundamental purpose of a statute.[268]

The agencies' proposed rule would be a categorical, dramatic, and unprecedented loss of protections for the Nation's waters. It strips protection from all ephemeral streams and threatens safeguards for intermittent streams. Ending protections for these water bodies would harm all of the larger streams, rivers, lakes, and reservoirs that they flow into. The rule would further endanger more than half of the Nation's wetlands, which perform essential functions such as purifying the water that drains into nearby water bodies. It would invalidate the entire purpose of the Clean Water Act and is wholly inconsistent with congressional intent.[269] There is no reasonable interpretation of the Clean Water Act's text, purpose, or legislative history under which the agencies can legally move forward with this rule.

E. The Economic Analysis Is Arbitrary and Capricious.

The Economic Analysis extends for hundreds of pages, yet provides little useful information. There are four primary flaws that prevent the analysis from serving as a rational basis for the proposed reversal in policy. The analysis, therefore, falls short of demonstrating that "there are good reasons for the new policy," as required with such an extreme change in agency position. [270] As discussed below, if the errors in the analysis were remedied, it would support maintaining robust stream and wetland protections.

Two errors are of the utmost importance. First, the agencies assume that wetland benefits are only valued by in-state residents. That is economically and practically baseless. Second, the agencies dramatically understate the number of wetlands in each state as part of their wetland benefit analysis. Correcting those errors, even using conservative estimates, results in a loss of wetland benefits of more than $2.4 billion every year as a result of this proposal.

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[264] *Jones Bros.*, 898 F.3d at 673 (stating an agency "may not invalidate the statute from which it derives its existence and that it is charged with implementing.")

[265] *See generally* Alexander et al., Featured Collection Introduction: Connectivity of Streams and Wetlands to Downstream Waters, JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION 287 (Apr. 2018).

[266] *N.L.R.B. v. Brown*, 380 U.S. 278, 291 (1965); *see also S.E.C. v. Sloan*, 436 U.S. 103, 118 (1978); *Rapanos*, 547 U.S. at 717 (Kennedy, J., concurring) ("The nexus required [with navigable waters] must be assessed in terms of the [Clean Water Act's] goals and purposes.").

[267] S. Rep. No. 95-370, at 75 (1977).

[268] *See Kyle v. Dir., Office of Workers' Comp. Programs, U.S. Dep't of Labor*, 819 F.2d 139, 144 (6th Cir. 1987); *Santa Fe Pac. R. Co. v. Sec'y of Interior*, 830 F.2d 1168, 1180 n. 91 (D.C. Cir. 1987); *Southland Royalty Co. v. Fed. Energy Admin.*, 512 F. Supp. 436, 451 (N.D. Tex. 1980); *Wilcox v. Ives*, 864 F.2d 915, 925 (1st Cir. 1988).

[269] *Morton v. Ruiz*, 415 U.S. 199, 237 (1974).

[270] *Nat'l Lifeline Ass'n*, 915 F.3d at 27 (quoting *State Farm.* 463 U.S. at 43).

1. *The agencies cannot lawfully consider state responses to abandoning federal jurisdiction.*

The premise of the agencies' proposal—that it is appropriate for the federal government to cede jurisdiction to states under section 101(b)—leads the agencies to rely on factors that Congress has not authorized. "Agency action is arbitrary and capricious if the agency has relied on factors which Congress has not intended it to consider."[271] Congress created the Clean Water Act as a comprehensive statutory scheme. It intended to achieve the objective of the Act through the implementation of its provisions. That could not be any clearer following the 1977 Amendments. Congress rejected the notion embraced by this rulemaking—that section 101(b) is to be implemented by abandoning federal protections for waters of the United States. The agencies cannot consider whether states would make up for the agencies' failure to exercise oversight mandated by Congress. Yet the Economic Analysis is centered on a mix of scenarios in which the agencies speculate about potential future state protections. Congress did not intend for the Act to depend on wholly independent state action.

2. *The Economic Analysis systematically underestimates the benefits of stream and wetland protections.*

The Economic Analysis underestimates the benefits of protecting streams and wetlands in two principal ways. First, it narrowly defines the geographic scope of households that benefit from protections. Second, the analysis excludes any estimate of most of the impacts that are expected from the proposal.

The primary flaw in the economic analysis is the agencies' restriction of benefits to those living in the state where wetland mitigation is done. That approach is flawed both with respect to economic theory and as a practical matter.

As a matter of economic theory, there is no basis for limiting benefit calculations to state lines. Dr. John Whitehead describes in detail in the attached analysis[272] that "willingness to pay for natural resources is not constrained by political jurisdiction."[273] Willingness to pay declines as distance from the natural resource increases, but that benefit can extend thousands of miles.[274] One study that evaluated willingness to pay for dam removals in Washington State found that the mean willingness to pay declined from $78 in the state to $58 two thousand miles away.[275] As a result, 97 percent of the benefits from dam removal were out of state.

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[271] *Id*.
[272] John. C. Whitehead, Comments on "Economic Analysis for the Proposed Revised Definition of 'Waters of the United States'" (EPA-Army 2018) (Apr. 9, 2019) ("Whitehead Report"), attached as Ex. C. Dr. Whitehead's analysis is incorporated here by reference and should be considered supplemental comments, which the agencies must respond to, by the organizations listed above.
[273] Ex. C, Whitehead Report at 3.
[274] *Id*. at 3-4.
[275] *Id*. at 4.

There are established economic equations for evaluating the reach of benefits. As described by Dr. Whitehead, "[t]he economic jurisdiction, in contrast to the political jurisdiction, is determined by this data-driven model and not by assumption."[276]

That conclusion is well-grounded in reality. Numerous state boundaries are defined by rivers. Virginia and Maryland are separated by the Potomac River. The Savannah River creates the border between Georgia and South Carolina. The Chattahoochee River divides Georgia and Alabama. Even in the case study, the Ohio River starts in Pennsylvania and borders Ohio, West Virginia, Kentucky, and Illinois before it flows into the Mississippi River, which touches Missouri, Tennessee, Arkansas, Mississippi, and Louisiana. Clearly, wetland and stream protection, restoration, or preservation in any of these states benefits households that share the respective river.

Taking into account adjacent states in the willingness to pay analysis significantly increases the estimated benefits provided by wetland mitigation. As Dr. Jeff Mullen has calculated,[277] including neighboring states in the Stage 1 analysis increases the benefits under every scenario analyzed by the agencies—so much so that the foregone benefits of the proposal, even if limited to wetland mitigation, outweigh the avoided costs (i.e., cost savings) when comparing the high-end costs to the high-end benefits. For example, as demonstrated in Dr. Mullen's analysis is below, the high-end annual wetland benefits for Scenario 0 ($445.8M) are almost twice as much as the avoided costs of regulation ($234.4M). These estimates demonstrate that the Clean Water Rule, from a cost-benefit perspective, should not be rescinded.[278]

[276] *Id*. at 2.
[277] Jeffrey D. Mullen, Ph.D., Draft Review of the 2018 EPA Economic Analysis for the Proposed Definition of "Waters of the United States" (Apr. 10, 2019) ("Mullen Report"), attached as Ex. D. Dr. Mullen's analysis is incorporated here by reference and should be considered supplemental comments, which the agencies must respond to, by the organization listed above.
[278] Ex. D, Mullen Report at 16.

Table 1.3: Stage 1 Annual Avoided Costs and Annual Foregone Benefits by Scenario and Scope, (q_0 = 40,000 acres)

2017$ millions	Annual Avoided Costs[a]		Annual Foregone Benefits		Annual Foregone Benefits	
			Scope = Single State		Scope = Adjacent States	
Scenario 0	Low	High	Mean[b]	High[c]	Mean[d]	High[e]
Permit	$29.8	$74.7				
Mitigation	$57.4	$159.7				
CWA 404 Total	$87.2	$234.4	$59.4	$121.4	$216.6	$445.8
Scenario 1	Low	High	Mean	High	Mean	High
Permit	$15.7	$39.5				
Mitigation	$37.7	$57.6				
CWA 404 Total	$53.4	$97.1	$16.7	$38.6	$90.4	$207.7
Scenario 2	Low	High	Mean	High	Mean	High
Permit	$10.2	$25.5				
Mitigation	$26.7	$42.1				
CWA 404 Total	$36.9	$67.6	$14.3	$33.1	$56.0	$127.3
Scenario 3	Low	High	Mean	High	Mean	High
Permit	$1.5	$3.8				
Mitigation	$2.3	$2.9				
CWA 404 Total	$3.8	$6.7	$1.2	$2.8	$11.8	$26.5

a: As reported in Tables III-10 through III-12 and Table B-1.
b: As reported in Tables III-10 through III-12 and Table B-1.
c: Uses Upper 95th WTP/household/acre from Table III-9; assumes WTP=0 for residents outside of the state.
d: Uses mean WTP/household/acre from Table III-9; includes WTP>0 for residents outside of the state.
e: Uses Upper 95th WTP/household/acre from Table III-9; includes WTP>0 for residents outside of the state.

Figure 7.

The agencies' Stage 2 analysis fares no better. Had the agencies properly accounted for adjacent states in their analysis, they would have calculated the following estimates of foregone benefits.[279]

[279] Ex. D, Mullen Report at 31.

Table 2.1: Stage 2 Annual Avoided Costs and Annual Foregone Benefits by Scenario and Scope, q_0 = 40,000 acres

2017$ millions	Annual Avoided Costs[a]		Annual Foregone Benefits		Annual Foregone Benefits	
			Scope = Single State		Scope = Adjacent States	
Scenario 0	Low	High	Mean[b]	High[c]	Mean[d]	High[e]
Permit[f]	$26.6	$26.2				
Mitigation[g]	$209.9	$470.0				
CWA 404 Total	$236.5	$496.6	$135.6	$300.3	$419.5	$898.3
Scenario 1	Low	High	Mean	High	Mean	High
Permit	$16.0	$16.0				
Mitigation	$118.6	$249.7				
CWA 404 Total	$134.6	$265.7	$46.8	$104.0	$233.9	$496.4
Scenario 2	Low	High	Mean	High	Mean	High
Permit	$10.6	$10.6				
Mitigation	$101.9	$204.3				
CWA 404 Total	$112.5	$214.9	$41.7	$92.7	$193.4	$408.3
Scenario 3	Low	High	Mean	High	Mean	High
Permit	$2.4	$2.4				
Mitigation	$25.3	$60.2				
CWA 404 Total	$27.6	$62.6	$6.9	$14.2	$74.3	$152.9

a: As reported in Table IV-61.
b: As reported in Table IV-62.
c: Uses Upper 95th WTP/household/acre from Table IV-62.
d: Uses mean WTP/household/acre from Table IV-62; includes WTP>0 for residents outside of the state.
e: Uses Upper 95th WTP/household/acre from Table IV-62; includes WTP>0 for residents in adjacent states.

Figure 8.

Combining the foregone benefits of the Stage 1 and Stage 2 analyses highlights the seriousness of the agencies' error here, resulting in an average of $636.1 million and potentially more than $1.3 billion in foregone wetlands benefits. But failing to account for wetland benefits to adjacent states is not the only essential error in the Economic Analysis.

In addition to narrowing the scope of the analysis to individual states, the agencies also dramatically underestimated the baseline number of wetlands in each state—assuming 40,000 acres.[280] In states like Alabama, Georgia, North Carolina, South Carolina, and Virginia, which Appendix A of the Economic Analysis estimates have a combined 20,000,000 acres of wetlands, using a baseline estimate that is less than 1 percent of that total significantly underestimates the wetland benefits lost under the proposal. Using even a modestly increased value, a baseline

[280] Ex. D, Mullen Report at 19.

estimate of 220,000 acres per state, results in significantly higher values for average wetland benefits, as summarized below.[281]

Table 8.1: Single Stage Annual Foregone Benefits by Scenario and Scope (q_0 = 220,000)

2017$ millions	Annual Foregone Benefits	
	Scope = Single State	Scope = Adjacent States
Scenario 0	$772.9	$2,403.4
Scenario 1	$275.2	$1,295.2
Scenario 2	$244.2	$984.1
Scenario 3	$29.8	$315.1

Figure 9.

Reliance on the artificially narrow scope and an underestimation of baseline wetland acreage considered by the agencies is arbitrary and capricious on its own, but is even more so given the range of economic effects that the agencies failed to evaluate. According to the agencies, the proposal is expected to reduce ecosystem values for streams and wetlands, increase downstream inundation damage, increase restoration costs, increase costs for drinking water providers, and increase the frequency and damage caused by oil spills.[282] Yet the analysis does not quantify any of those foregone benefits of existing protections.

Nor did the agencies include the cost to states of developing programs necessary to provide the protections assumed in Scenarios 1, 2, and 3. As Dr. Mullen summarizes, there are likely economies of scale that the Corps' regulatory program can take advantage of that are not available to state agencies.[283]

In sum, a fair economic analysis would demonstrate what history tells us is true—that the economic benefits of clean water protections far exceed the cost. In the 47 years since the passage of the Clean Water Act our economy has flourished—and our water has been made cleaner. This proposal jeopardizes those gains.

3. The Economic Analysis's methodology fails to meaningfully evaluate existing data.

The agencies use several methods to evaluate parts of this rulemaking rather than attempting to implement a nationwide analysis, resulting in a fractured, unhelpful assessment. It is clear from the docket, and the fractured analysis, that the agencies have the data to conduct a consistent, nationwide analysis. The absence of such an analysis has prevented the public from understanding the scope of the impact of this proposal.

The agencies have access to datasets for section 404 and 402 permits, which have been posted to the docket of this rulemaking. The section 404 permit database includes nearly 400,000

[281] Ex. D, Mullen Report at 34.
[282] *See* 2018 Economic Analysis at 133.
[283] Ex. D, Mullen Report at 13, 17.

decisions.[284] The database includes water type, impacts authorized, sector, flow characteristics, and numerous other categories of information. But the agencies chose not to evaluate that database using a consistent, clearly explained methodology. While it is difficult to predict future land use changes, analyzing whether past permitting decisions would be decided differently under the new proposal does not, however, present the same difficulties. The agencies took such an approach in 2015 and did so, to a very limited extent, in the case studies here.

The information necessary to conduct a basic form of that analysis is in the Economic Analysis and the Resource and Programmatic Assessment. The Economic Analysis identifies stream and wetland types likely to lose jurisdiction.[285] The Resource and Programmatic Assessment expands on those identifications.[286] Using that information as well as the agencies' notice, as we have done in the below table, shows that agencies could present to the public a baseline assessment of stream and wetland types that would no longer be jurisdictional under the proposal.

[284] Clean Water Act Section 404 Data Used in Proposed Rule Economic Analysis and Resource and Programmatic Assessment, EPA-HQ-OW-2018-0149-0052 (Feb. 14, 2019).
[285] 2018 Economic Analysis at 131-132 (describing classifications of R4, R6, RPWWN).
[286] *See* U.S. EPA and Dep't of Army, Resource and Programmatic Assessment for the Proposed Revised Definition of "Waters of the United States," EPA-HQ-OW-2018-0149-0005 (Dec. 11, 2018) ("2018 Resource and Program Assessment") (describing isolated, Non-Relatively Permanent Water ("NRPW"), Non-Relatively Permanent Water Wetland ("NRPWW"), Tributary with Relatively Permanent Wetlands and Non-Relatively Permanent Wetlands ("TNWRPW"), Traditional Navigable Water Wetland ("TNWW"), Relatively Permanent Water ("RPW") and Relatively Permanent Water Wetland Neighboring ("RPWWN") classifications).

Water Type	Description	Jurisdictional
Isolated	Isolated (interstate or intrastate) waters, including isolated wetlands	No[287]
NRPW	Non- Relatively Permanent Waters (RPWs) that flow directly or indirectly into TNWs	No[288]
RPW (R4, R6)	RPWs that flow directly or indirectly into TNWs, but are categorized as intermittent or ephemeral	No[289]
NRPWW	Wetlands adjacent to non-RPWs that flow directly or indirectly into TNWs	No[290]
RPWWN	Wetlands adjacent to but not directly abutting RPWs that flow directly or indirectly into TNWs	No[291]
TNWRPW (R4, R6)	Tributary consisting of both RPWs and non-RPWs	No[292]
TNWW	Wetlands adjacent to TNWs	Approximately 45 percent non-jurisdictional[293]

Historical permitting information can also be used to begin to identify approximately how many streams and wetlands have been protected by the Clean Water Act that would lose protection under the proposal.[294] Using the permit data in the record, we were able to sort for permits assigned the classifications above as well as relatively permanent waters with an R4 or R6 Cowardin Code. Through this process, we can begin to approximate the scope of this proposal's impact on streams and wetlands previously permitted.[295]

[287] 84 Fed. Reg. at 4,135.
[288] Non-RPWs include intermittent and ephemeral streams, both of which the proposal states may lose jurisdiction. 84 Fed. Reg. at 4,177.
[289] Streams with a Cowardin Classification R4 or R6 are intermittent or ephemeral, both of which may lose jurisdiction. 84 Fed. Reg. at 4,177.
[290] Because NRPWs would lose jurisdiction, their adjacent wetlands would also lose jurisdiction.
[291] 2018 Economic Analysis at 132.
[292] Streams with a Cowardin Classification R4 or R6 are intermittent or ephemeral, both of which may lose jurisdiction. 84 Fed. Reg. at 4,177.
[293] 2018 Resource and Program Assessment at 45.
[294] Clean Water Act Section 404 Data Used in Proposed Rule Economic Analysis and Resource and Programmatic Assessment, EPA-HQ-OW-2018-0149-0052 (2019).
[295] *See* 2018 Economic Analysis at 131.

Water Type	Wetland Impacts No Longer Requiring a Permit Under Proposal (acres)	Stream Impacts No Longer Requiring a Permit Under Proposal (linear feet)
Isolated	709	35,721
NRPW	1,675	5,348,506
NRPWW	2,482	133,478
RPW (R4, R6)	918	3,365,684
RPWWN	7,144	945,413
TNWRPW (R4, R6)	83	162,952
TNWW	4,621	35,721
Total	17,632	10,027,475
Annual Losses	3,526	2,005,495
Additional Losses from Clean Water Rule Repeal[296]	1,154	--

The agencies can, and must, conduct a meaningful analysis of this existing data and release it for public comment.

The agencies can go beyond the summary permit data by evaluating approved jurisdictional determinations, as partially done to evaluate the change in jurisdiction for wetlands adjacent to traditional navigable waters. In that analysis, most of the Corps' districts reviewed approved jurisdictional determinations to determine if wetlands previously found to be jurisdictional would lose protection under the proposal.[297] But the districts did not conduct a consistent analysis. Some reviewed each jurisdictional determination made during the time period, while others reviewed "a random sample."[298] This basic approach, reviewing jurisdictional determinations to evaluate the effect of this rulemaking, is necessary to support the policy reversal that the agencies propose here. It must be done consistently and systematically in each Corps' district.

Similar data is available regarding the NPDES program; the docket includes NPDES permitting information for thousands of facilities.[299] EPA previously assessed the potential effect of the *Rapanos* decision on the NPDES permitting program in each state by evaluating which NPDES discharges are to intermittent or headwater streams. That analysis is attached to these comments.[300] There is no reason a similar analysis could not be conducted here; the data necessary to do the analysis are included in the docket. Based on our conservative analysis of the

[296] 2018 Economic Analysis at 77-78.
[297] 2018 Resource and Programmatic Assessment at 45.
[298] *Id*. at 45.
[299] Clean Water Act Section 402 Data Used in Proposed Rule Economic Analysis and Resource and Programmatic Assessment, EPA-HQ-OW-2018-0149-0058 (Feb. 14, 2019).
[300] EPA, Location of Individual NPDES Permits on State Streams, received via Freedom of Information Request, attached as Exhibit E.

NPDES permitting information in the docket, more than 750 dischargers in SELC's six-state region discharge to small streams that could lose protection under this proposal.[301]

The case studies analyzed by the agencies do not supplant the need for the agencies to, at a minimum, evaluate past permitting data. The agencies recognize that these are not representative sites and cannot be extrapolated to the rest of their respective regions or country as a whole.[302] More importantly, they are fundamentally flawed. For example, the Ohio River case study assumes that the Ohio River starts in Huntington, West Virginia.[303] To evaluate the effect of the proposal on the end point identified, the agencies would need to assess the entire watershed upstream, which includes more than 43,000 square miles in Pennsylvania, Maryland, West Virginia, and Virginia.[304] In addition, the case studies rely on the agencies' underestimation of wetland and stream impacts from the proposal.[305]

4. The Economic Analysis is poorly explained, includes counter-intuitive results, and fails to evaluate the full range of the proposal.

Finally, the Economic Analysis is not transparent and does not provide sufficient information to evaluate the analyses conducted. Without additional information, the agencies' analysis cannot be replicated or evaluated fully. Despite repeated efforts, Dr. Mullen, a professor of Agricultural and Applied Economics at the University of Georgia, was not able to replicate the agencies' analysis.[306] To begin, it is difficult to determine how the agencies calculated the wetland acreage for each state for the willingness to pay analysis.[307] The methods used to conduct the meta-analysis are not explained.[308] The willingness to pay analysis finds that wetlands that provide ecosystem services are worth *less* than those that do not.[309] The agencies have also estimated that wetlands with cultural values are worth less than wetlands that lack that attribute.[310] These issues raise significant concerns about the validity of the agencies' work.

The agencies also fail to analyze the full range of scenarios forecast by their request for comments on wide-ranging issues (*e.g.*, jurisdiction over perennial streams only, a minimum flow requirement for jurisdictional tributaries, and a distance limit for jurisdictional wetlands). Instead, the agencies only evaluate the scenario presented by the text of the proposed rule. That limited analysis constrains the public understanding of the implications of this proposal.

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[301] To conduct this analysis, SELC staff sorted data in EPA-HQ-OW-2018-0149-0058, to identify permitted discharges with location data, consolidated multiple entries for individual facilities, and identified discharge points in close proximity to an intermittent stream in the National Hydrography Dataset.
[302] 2018 Economic Analysis at 196.
[303] *See id.* at 200 (acknowledging that the water quality models cover a limited watershed and that "impacts of land use changes and forgone ecosystem services are not limited to these watersheds").
[304] Save LocalWaters.org, Ohio River Basin, http://www.savelocalwaters.org/ohio-river-basin.html (last visited April 13, 2019).
[305] *See id.* 2018 Economic Analysis at 198 (excluding non-abutting wetlands and narrowly assessing permanent wetland impacts).
[306] Ex. D, Mullen Report at 17-21.
[307] *Id*. at 25.
[308] Ex. C, Whitehead Report at 6.
[309] Ex. D, Mullen Report at 30-31.
[310] *Id*. at 31.

F. The Administration Failed to Consider Environmental Justice Impacts.

The high cost of polluted water frequently falls on low-income and disenfranchised communities, yet the agencies failed to give environmental justice any consideration.[311] Moving forward with this proposal without such an analysis violates Executive Order 12898, which mandates that federal agencies ensure their programs do not disproportionately impact, or limit the participation of, communities because of their race, color, national origin, or socio-economic status.[312]

Nationwide, low-income, rural, and communities of color are exposed to the highest levels of toxic pollutants, like lead, in their drinking water. The agencies acknowledge that their proposed rule would increase pollutant loads,[313] yet they fail to analyze the unjust burden that the proposed rule would place on the health and well-being of disenfranchised communities.

Low-income, rural, and communities of color already disproportionately face unaffordable rates for drinking water and water sanitation. Water bills are one of the highest utility costs for families; water prices have more than doubled since 2000, far exceeding the price of other utilities.[314]

Small, rural systems are especially vulnerable to drinking water violations and have less capacity and resources to manage harmful situations when they happen. For example, one study found that in 2015, 21 million people relied on community water systems that violated health-based drinking water standards, with rural areas facing the most health violations when compared to urban areas.[315] Urban areas are also struggling. Small-to-midsized cities across the country that are economically depressed are also facing problems as fewer residents and a declining tax base make it difficult for low-income residents to afford higher water rates.[316]

According to EPA's own economic analysis for the proposed rule, reduced Clean Water Act coverage for waterways would likely result in greater drinking water treatment costs,[317] a cost that is usually passed on to consumers and would exacerbate existing challenges in providing clean drinking water.

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[311] Paul Mohai & Bunyan Bryant, *Environmental Injustice: Weighing Race and Class as Factors in the Distribution of Environmental Hazards*, 63 U. COLO. L. REV. 921 (1992).
[312] Exec. Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations, 59 Fed. Reg. 32 (Feb. 11, 1994).
[313] 2018 Economic Analysis at 133.
[314] Joseph W. Kane & Lynn E. Broaddus, *Striking a Better Balance Between Water Investment and Affordability*, BROOKINGS (Sept. 12, 2016), https://www.brookings.edu/blog/the-avenue/2016/09/12/striking-a-better-balance-between-water-investment-and-affordability/ (last visited Apr. 8, 2019).
[315] Maura Allaire et al., *National trends in drinking water quality violations*, Proceedings of the National Academy of Sciences (Feb. 27, 2018), https://www.pnas.org/content/115/9/2078.short?rss=1 (last visited Apr. 8, 2019).
[316] Rep. Brenda Lawrence, *Environmental Injustice: Access and Affordability of Clean Water*, THE Hill (May 17, 2018), https://thehill.com/blogs/congress-blog/politics/388154-environmental-injustice-access-and-affordability-of-clean-water.
[317] 2018 Economic Analysis at 125, 133-34.

In addition, the proposal would harm under-represented communities that rely on subsistence fishing for their way of life. Fisheries would be degraded by increased pollution and the loss of fish habitat.[318] For low-income communities and communities of color that rely more heavily on subsistence fishing,[319] the rule threatens a food source and a means of family bonding.[320] The cultural identity for many Native American families is strongly linked to fishing; many tribes' existence is tied to the continued survival of indigenous fish species.[321] Yet the agencies failed to consider the impacts the proposal would have on subsistence fishing and the communities that rely on that tradition.

The proposal would further harm low income communities by threatening protections for most of the 110 million acres of wetlands in the contiguous United States.[322] The agencies acknowledge that increased flood risk would result from the loss of wetland protection under their proposal.[323] Low-income and disenfranchised communities are especially vulnerable to increased flooding.[324] They are not only among the least able to recover from the damage flooding causes, but they also tend to live in flooding-prone areas because the land was historically cheaper to build on.[325] The agencies failed to evaluate how the proposal would affect those communities most at risk.

Without conducting any analysis, the agencies bypass Executive Order 12898 by asserting "there is not significant evidence of disproportionately high and adverse human health or environmental effects" on these communities.[326] They are wrong. The agencies' proposal poses substantial risks to minority, low-income, and indigenous communities. The agencies must consider these impacts.

G. The Agencies Failed to Meet the Requirements of the Endangered Species Act.

In the rush to eliminate clean water protections, the agencies have disregarded the requirements of the Endangered Species Act. For more than four decades, the Endangered Species Act has "represented the most comprehensive legislation for the preservation of endangered species ever enacted by any nation."[327] The statute established a vital program for the conservation of both imperiled species and "the ecosystems upon which … [they]

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[318] Colvin et al., *supra* note 112, at 76-77.
[319] Ralph B. Brown & John F. Toth Jr., *Natural Resource Access and Interracial Associations: Black and White Subsistence Fishing in the Mississippi Delta*, 17 SOUTHERN RURAL SOCIOLOGY 81, 104 (2001).
[320] *Id.*
[321] Colvin et al., *supra* note 112, at 85.
[322] U.S. FISH AND WILDLIFE SERVICE, STATUS AND TRENDS OF WETLANDS IN THE CONTERMINOUS UNITED STATES 2004-2009 (2009) at 37.
[323] *See* 2018 Resource and Programmatic Assessment at 98; 2018 Economic Analysis at 133.
[324] Dalbyul Lee & Juchul Jung, *The Growth of Low-Income Population in Floodplains: A Case study in Austin, TX* KSCE JOURNAL OF CIVIL ENGINEERING (2014) at 684; Jonathan M. Katz, *Who suffers when disasters strike? The poorest and most vulnerable*, WASHINGTON POST (September 1, 2017).
[325] *See id.*
[326] 84 Fed. Reg. No. at 4,203.
[327] *Tenn. Valley Auth. v. Hill*, 437 U.S. 153, 180 (1978).

depend[.]"[328] Central to this program is the consultation requirements of section 7, which the agencies have ignored.[329]

Under section 7(a)(2) of the Act, "[e]ach Federal agency" is required,

> in consultation with and with the assistance of the Secretary [of the Interior or the Secretary of Commerce], [to] insure that any action authorized, funded, or carried out by such agency … is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of [critical] habitat[.][330]

This language imposes both substantive and procedural obligations on federal agencies. Substantively, agencies must make certain their actions are "not likely" to leave an imperiled species in jeopardy or adversely modify its critical habitat.[331] Procedurally, agencies must evaluate the potential impact of their actions "in consultation with" federal wildlife experts.[332] Before moving forward with the proposal, the agencies must satisfy these requirements.[333]

As the agencies acknowledge, their proposed changes to Clean Water Act jurisdiction would "result in the decline in wildlife habitat quantity and quality,"[334] by stripping essential water-quality protections from wetlands and streams across the United States.[335] One-third of all plants and animals listed as threatened or endangered depend on wetland ecosystems for their survival.[336] "Ephemeral waterbodies provide habitat to threatened and endangered species," including the threatened Strecker's chorus frog in Kansas, which breeds in ephemeral pools where there are no predator fish present.[337] Some species cannot survive outside the microclimates provided by ephemeral streams.[338] Headwaters on the whole are key to the

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[328] 16 U.S.C. § 1531(b).
[329] 16 U.S.C. §§ 1536, 1538(a), (g).
[330] *Id*. § 1536(a)(2); *see also id.* § 1536(a)(1) (requiring federal agencies to "utilize their authorities in furtherance of the purposes of … [the Endangered Species Act] by carrying out programs for the conservation of endangered species and threatened species listed" under the statute).
[331] *Id.* § 1536(a)(2).
[332] *Id*.
[333] *See, e.g., Cal. ex rel. Lockyer v. Dep't of Agric.*, 575 F.3d 999, 1018-19 (9th Cir. 2009) (holding that consultation was required under the Endangered Species Act before the defendant agency could repeal and replace regulatory protections that had been "in effect without injunction for three months," as the agency had "fail[ed] to cite any support for the proposition that it can ignore a valid rule, codified in the Code of Federal Regulations, simply because the rule was not in effect long enough").
[334] 2018 Economics Analysis at 133.
[335] *See, e.g.*, U.S. EPA and Dep't of the Army, Economic Analysis for the Proposed Definition of "Waters of the United States"—Recodification of Pre-Existing Rules at 2 (June 2017) (acknowledging that eliminating the Clean Water Rule's protections would "result[] in an overall reduction in positive jurisdictional determinations" under the Clean Water Act), *available at* https://www.epa.gov/sites/production/files/2017-06/documents/economic_analysis_proposed_step1_rule.pdf (last visited Apr. 8, 2019).
[336] National Park Service, *Why are Wetlands Important*?, https://www.nps.gov/subjects/wetlands/why.htm (last updated Apr. 15, 2019).
[337] 2018 Economics Analysis at 184.
[338] *Id*. at 196.

sustainability of fish stocks in both upstream and downstream waters. Thus, with their certain destruction under the proposal, threatened and endangered species would be harder to recover, and more species would be at risk of becoming imperiled.[339]

By allowing damage to critical wetlands and streams, the agencies' rollback of clean water protections would affect listed species by supporting activities that cause the destruction of important habitat for endangered birds and other animals. Accordingly, the agencies were obligated to consult with the United States Fish and Wildlife Service to "insure" that the implementation of their proposed revised definition of "waters of the United States" would not jeopardize threatened or endangered species.[340]

VII. THE ADMINISTRATION'S PROPOSAL IS ANTITHETICAL TO THE GOALS OF THE CLEAN WATER ACT.

A. The Agencies Ignore Science.

The agencies claim that their proposal is "informed by science,"[341] but, in fact, they defy it. That choice—to exclude any scientific analysis—is astonishing in light of EPA's history and purpose. As demonstrated in the citations below, the agency has historically conducted, compiled, and funded leading research about our natural world. This proposal openly rejects the EPA's own expertise. The proposed rule dismisses the indisputable scientific reality—long recognized in legislative history, federal court precedent, agency policy, and peer-reviewed science—that water moves in "hydrologic cycles,"[342] and that the degradation of one part of the cycle will adversely affect the chemical, physical, and biological functions of waters throughout the entire system.[343] Instead, the proposal is controlled by the layperson's understanding of waters and wetlands outline by Justice Scalia, no matter how scientifically uninformed it may be.

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[339] *See also, e.g.*, U.S. EPA, Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence B-4 (Jan. 2015) ("EPA Connectivity Report") (noting that Carolina bays, which are granted additional protections under the Clean Water Rule, have been found to support "amphibians [that] are endangered or threatened, including the flatwoods salamander (*Ambystoma cingulatum*) and the gopher frog (*Rana capito*)"); *id.* (noting that "[e]ndangered wood storks (*Mycteria americana*) nest in Carolina bays"); U.S. EPA Science Advisory Board, SAB Review of the Draft EPA Report "Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence," 20 (Oct. 17, 2014) ("SAB Review") (noting that "[h]abitats that are seasonally dry or even dry for several years in a row can be critical to the biological integrity of downgradient waters because a wide range of species (*e.g.*, fish, amphibians, reptiles, birds, mammals, and invertebrates) use them to complete certain annual or life-cycle stages[,]" and "[w]hen these upstream, lateral, and disconnected aquatic habitats are degraded or destroyed, populations decline and species can become threatened or endangered (or otherwise imperiled), or are extirpated"); *id.* at 43 (noting that "floodplain wetlands and off-channel waters play an important role as spawning grounds and fish nurseries during high-water seasons for species (including several endangered fishes) that ultimately populate downstream fisheries").

[340] *See* 16 U.S.C. § 1536(a).

[341] 84 Fed. Reg. at 4,175; *see also id*. at 4,176 ("Thus, the agencies use the Connectivity Report to inform certain aspects of this proposed definition . . . but acknowledge that science cannot be used to draw the line between Federal and State waters[.]"); and 4,187 (definition "informed by, though not dictated by, science").

[342] *See* Clean Water Rule, 80 Fed. Reg. at 37,056 (citing *Riverside Bayview*, 474 U.S. at 132-133 (citing S. Rep. No. 92-414 at 77 (1972)).

[343] *See generally* EPA Connectivity Report; Ex. A, Literature Review.

The 2015 Clean Water Rule, by contrast, is supported by an overwhelming scientific record that reflects the necessity of a broad "waters of the United States" definition if we are to achieve the Act's objective. In promulgating the Clean Water Rule, EPA's Office of Research and Development developed a scientific report entitled "Connectivity of Stream and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence."[344] The Connectivity Report was the culmination of an exhaustive evaluation of over 1,200 peer-reviewed scientific reports[345] on the "connectivity and mechanisms by which streams, wetlands, open waters, singly or in the aggregate, affect the physical, chemical, and biological integrity of downstream waters."[346] The Connectivity Report reached five major conclusions, summarized below, which the agencies openly ignore here:

- Streams, regardless of size or frequency of flow, are "physically, chemically, and biologically connected to downstream waters and strongly influence their function."

- Riparian and floodplain wetlands are "physically, chemically, and biologically integrated with rivers via functions that improve downstream water quality. These systems act as effective buffers to protect downstream waters from pollution and are essential components of river food webs."

- Wetlands located "outside of riparian areas and floodplains, even when lacking surface water connections, provide physical, chemical, and biological functions that could affect the integrity of downstream waters. Some potential benefits of these wetlands are due to their isolation rather than their connectivity."

- "Variations in the degree of connectivity are determined by the physical, chemical and biological environment, and by human activities. These variations support a range of stream and wetland functions that affect the integrity and sustainability of downstream waters."

- The "incremental contributions of individual streams and wetlands are cumulative across entire watersheds, and their effects on downstream waters should be evaluated within the context of other streams and wetlands in that watershed."[347]

To ensure the accuracy of the Connectivity Report, the EPA's Science Advisory Board, which provides the agency with independent advice on technical issues, reviewed it ("SAB Review").[348] The Science Advisory Board panel that reviewed the Connectivity Report was comprised of 27 experts, which included hydrologists, stream and wetland ecologists, biologists, and geomorphologists from academia, industry, environmental groups, and consulting firms.[349] Because the current proposal is "inconsistent with science, based on flawed logic, and too

[344] EPA Connectivity Report.
[345] EPA Connectivity Report at ES-2.
[346] *Id*. at ES-6.
[347] *Id*. at ES-2 to ES-6.
[348] Clean Water Rule, 80 Fed. Reg. at 37,062.
[349] *Id*.

ambiguous for decision-making," thirteen members of the Science Advisory Board panel have submitted comments "strongly oppos[ing]" it.[350]

Although the proposal contains some text from the SAB Review, the SAB Review does not support the agencies' policies here. As members of the Board put it in their recent comment letter, the proposal "is fully at odds with the EPA's own scientific Connectivity Report"; "[i]n cases where the agencies [do] refer to science, they cherry pick from the SAB Review, misinterpreting and taking information out of context."[351]

By limiting jurisdiction as proposed, the agencies rely solely on surface water connections,[352] adopting the very "binary"—"connected versus not connected"—approach rejected by the Science Advisory Board.[353] As the Board made clear, the connectivity of waters cannot be determined by looking at "*hydrologic* connectivity alone,"[354] *much less surface water connections alone*. Rather, connectivity must be evaluated in terms of all of the physical, chemical, and biological functions streams and wetlands provide downstream waters, including the transport and transformation of groundwater, wood, food resources, sediment, nutrients, and contaminants; habitat for fish and other species; movement of organisms or their seeds and eggs; and the delayed or regulated release of stormwater.[355]

Much of the agencies' arbitrary line-drawing is also based on their misconception that "connectivity" only matters when there is a *high* "frequency, duration, magnitude, timing, and rate" of surface water flow (*i.e.*, "ephemeral flows are less important than intermittent or perennial ones").[356] For this principle, they cite a "conceptual model" lifted without context to claim that "the SAB found perennial and intermittent streams have a greater probability to impact downstream waters compared to ephemeral streams."[357] The notion that the proposal reflects the science of connectivity or the SAB's conclusions is false. In their comments on the current proposal, Science Advisory Board members criticize the agencies for misrepresenting the conceptual model, distorting the Board's conclusions, and failing to recognize that "***even low levels of connectivity can be important relative to impacts on the chemical, physical, and biological integrity of downstream waters.***"[358]

Indeed, it is *the variations* in "frequency, duration, magnitude, timing, and rate" of *all* streams and wetlands functions that are critical to the integrity and sustainability of downstream waters.[359] As the agencies previously explained:

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[350] Sullivan et al., Scientific Societies Comments on Proposed Rule - Revised Definition of "Waters of the United States," 1, 7 (Apr. 5, 2019) ("SAB Members Comment Letter").
[351] *Id*. at 3.
[352] *E.g.*, 84 Fed. Reg. at 4,188 (requiring a "direct hydrologic surface water connection to a jurisdictional water" and stating "ecological connections between physically separated wetlands and otherwise jurisdictional waters cannot be used to determine adjacency according to this proposal").
[353] SAB Review at 2; SAB Members Comment Letter at 5.
[354] SAB Review at 54 n.3.
[355] *See* SAB Review at 21, 30.
[356] 84 Fed. Reg. at 4,176.
[357] *Id*. (citing SAB Review fig. 3 at 54).
[358] SAB Members Comment Letter at 3 (emphasis in original).
[359] U.S. EPA, CWR Response to Comments – Topic 9 Scientific Evidence Supporting Rule 20 (emphasis added).

> Connections with low values of one or more descriptors (e.g., low-frequency, low-duration streamflows caused by flash floods) can have important downstream effects when considered in the context of other descriptors (e.g., large volume or magnitude of water transfer). At the other end of the frequency range, high-frequency, low-magnitude vertical (surface-subsurface) and lateral flows contribute to aquatic biogeochemical processes, including nutrient and contaminant transformation and organic matter accumulation. The timing of an event can alter both connectivity and the magnitude of its downstream effect. For example, when soils become saturated by previous rainfall effects, even low or moderate rainfall can cause streams or wetlands to overflow, transporting water and other materials to downstream waters. Fish that use non-perennial or perennial headwater stream habitats to spawn or rear young, and invertebrates that move into seasonally inundated floodplain wetlands prior to emergence, have life cycles that are synchronized with the timing of flows, temperature thresholds, and food resource availability into those habitats.[360]

The agencies ignore this well-founded concept by categorically excluding ephemeral streams—and by soliciting comment on whether to exclude intermittent streams,[361] whether and how a downstream segment should break jurisdiction,[362] and whether to set a minimum flow rate (*e.g.*, 5 cubic feet per second),[363] which would exclude all intermittent and some perennial streams.[364] The agencies' hydrologic surface connection and "abutting" requirements for wetlands coverage dismiss "the importance of chemical and biological connectivity between wetlands and downstream waters."[365] They would also exclude a wide range of non-floodplain wetlands (*i.e.*, wetlands with no direct surface water connection to a water of the United States), and even potentially some riparian and floodplain wetlands, despite their water quality and ecological connections to jurisdictional waters.[366] Here again, the Science Advisory Board relies on science where the agencies do not:

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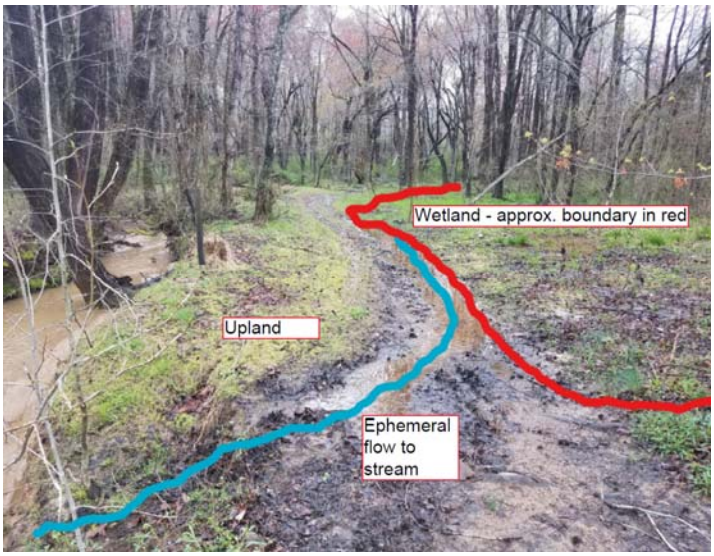
[360] *Id.*; *see also* SAB Review at 22 ("Low-frequency, high-magnitude flows connect channels to the furthest reaches of the floodplains, thereby controlling species composition and abundance in forests and aquatic habitats in the floodplain and transporting large clasts and/or woody debris that otherwise cannot be transported by more-frequent, lower-magnitude flows.") (internal citations omitted); *id.* at 37 ("Finally, the SAB recommends that the conclusions concerning ephemeral streams be strengthened by clarifying how and when ephemeral headwaters provide critical habitat and corridors for biota commonly connected to habitats associated with downstream rivers.").
[361] 84 Fed. Reg. at 4,177.
[362] *Id*.
[363] *Id*.
[364] SELC GIS Analysis; Ex. B, Moffat & Nichol 2019 at 9-15.
[365] SAB Members Comment Letter at 5.
[366] *See id.* at 5.

> [T]he available science supports defining adjacency or determination of adjacency [for waters and wetlands] on the basis of functional relationships, not [solely] on how close an adjacent water is to a navigable water. The Board also notes that local shallow subsurface water sources and regional groundwater sources can strongly affect connectivity.[367]

Indeed, some wetland functions, such as protecting downstream waters from pollutants, are "enhanced by the relative isolation" of wetlands.[368] As detailed in the Connectivity Report, wetlands "next to," "near," or "close to"[369] other "waters of the United States," but not necessarily abutting or having a direct hydrologic surface connection (*e.g.*, many floodplain wetlands), often exhibit functional connections to other waters of the United States and merit protection.[370] Take for example the floodplain wetlands in the Inner Coastal Plain and Piedmont regions of North Carolina, most of which would be lost under the proposal.[371] These wetlands provide habitat for amphibians, store floodwaters, and remove pollutants from stormwater runoff that would otherwise pollute nearby jurisdictional waters.[372] Under the science-backed Clean Water Rule, these wetlands, as shown in the Piedmont below,[373] would appropriately be protected:



Next, the agencies draw "artificial distinctions between upland and bottomland, with direct implications for determining jurisdiction (*e.g.*, of ditches)."[374] They draw artificial lines in

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[367] Science Advisory Board, Consideration of the Adequacy of the Scientific and Technical Basis of the Clean Water Rule 2-3 (Sept. 30, 2014).
[368] SAB Review at 21.
[369] Clean Water Rule, 80 Fed. Reg. at 37,063; Webster's II, New Riverside University Dictionary (1994) (defining "adjacent" as "next to," "adjoining," "to lie near," or "close to"). The agencies arbitrarily limit the definition.
[370] *See* SAB Members Comment Letter at 5.
[371] Ex. B, Moffat & Nichol 2019 at 4-6.
[372] *Id.* at 53.
[373] Photo credit - Phil May (2019).
[374] SAB Member Comment Letter at 5.

suggesting that ephemeral or underground segments break connectivity—and thus jurisdiction—in an otherwise jurisdictional stream.[375] They fail to account for broad watershed processes or the cumulative, aggregate effects of streams and wetlands on downstream waters.[376] And their suggestion for setting a distance limit for jurisdictional wetlands ignores the physical, chemical, and biological connections between contiguous wetlands and downstream jurisdictional waters.[377]

Even though science has shown that surface water and groundwater are a single resource,[378] the agencies disregard groundwater connectivity.[379] Likewise the agencies exclude "features that flow only in response to precipitation" (*i.e.*, rain or snowfall) and connections through groundwater,[380] even though"[v]irtually every 'water' is fundamentally dependent on rates of precipitation, accumulation on the surface, and infiltration into the ground."[381]

The agencies proposed rule requires streams and wetland surface water connections to be intermittent or perennial *in a typical year*, and they solicit comment on whether there should be a specific duration of flow required for intermittency.[382] These proposals also reject science.

Streams, wetlands, lakes, and ponds that do not have a direct hydrologic surface connection to a jurisdictional water "in a typical year" "can be functionally important to downstream [and nearby] waters."[383] The agencies should protect all tributaries including ephemeral and use long-tested, scientifically accepted geomorphic characteristics of bed, bank, and ordinary high-water marks.[384] A specific duration of intermittency similarly ignores scientifically meaningful connections and would require needlessly complex implementation. Moreover, to require a minimum flow annual duration, such as at least one month per calendar year, would arbitrarily exclude vast numbers of intermittent streams.[385]

A litany of other issues proposed or solicited for comment run contrary to science and the goals of the Clean Water Act, including:

- An alternative definition that would exclude wetlands separated by a dike, even if they have a direct hydrologic surface connection.[386] Although connectivity cannot be determined based on hydrologic connections alone, [387] features with a

[375] 84 Fed. Reg. at 4,178.
[376] SAB Review at 2; *see also* SAB Members Comment Letter at 3.
[377] Ex. B, Moffat & Nichol at 9-11.
[378] SAB Review at 36 ("A substantial body of evidence unequivocally demonstrates connectivity *above and below ground*.") (emphasis in original); SAB Member Comment Letter at 5.
[379] SAB Members Comment Letter at 5.
[380] 84 Fed. Reg. at 4,155.
[381] SAB Member Comment Letter at 6.
[382] 84 Fed. Reg. at 4,178.
[383] SAB Members Comment Letter at 5.
[384] *Id*.
[385] *Id*. at 6.
[386] 84 Fed. Reg. at 4,209.
[387] *E.g.*, SAB Review at 54 n.3.

hydrologic surface connection to downstream waters must remain jurisdictional.

- The possibility of removing jurisdiction over certain categories of impoundments, such as those that release water downstream on a less-than-intermittent basis.[388] As has been established, ephemeral flow should be sufficient for jurisdiction.[389] Still, research has found that large impoundments will increasingly suffer significant flow shortages—up to 20 percent by 2050 and up to 35 percent by 2100.[390] Those managing impoundments may, in the face of a crisis (or to avoid jurisdiction) drastically reduce the amount of water released downstream. Hinging jurisdiction for the impoundment, as well as for entire watershed upstream of the impoundment, on the amount of downstream flow is unsound.

- Potentially eliminating jurisdiction if a jurisdictional wetland becomes a pond, but no longer meets the elements of the lakes and ponds category.[391] Ponds can be created in wetlands by wildlife, such as beavers; despite the change, the connectivity remains, as should jurisdiction.[392]

It is not surprising that the agencies have failed to produce a record that responds to this body of science. The outcome of the rulemaking was pre-determined, driven not by science or any reasoned analysis, but by politics. The process began when President Trump signed the Executive Order seeking the repeal of the Clean Water Rule and the adoption of jurisdiction consistent with Justice Scalia's *Rapanos* opinion and is all but certain to end at that destination.[393] In the process, the agencies have abandoned their expertise. There is no science that supports this proposal. Decades of EPA research demonstrates that this proposal would prevent us from ever achieving the objective of the Clean Water Act. The waters of the United States definition rule must be driven by science and advance the congressional goals of the Clean Water Act. This proposal falls far short.

B. The Proposal Would Degrade Rather Than Maintain and Restore the Integrity of Our Nation's Waters in Violation of the Clean Water Act.

The agencies admit that their "proposed changes" to Clean Water Act jurisdiction "could have a wide range of impacts on the ecosystem services provided by aquatic resources, including decline in wildlife habitat quantity and quality, downstream inundation damages, greater drinking water treatment and dredging costs, greater spill response cost and damages."[394] But, nowhere in the agencies' entire rulemaking record did the agencies quantify impacts of the proposed rule on the integrity of the Nation's waters. Failure to do that is fatal to the proposal.

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[388] 84 Fed. Reg. at 4,173.
[389] *Id.*; *see also* SAB Review at 37.
[390] Bradley Udall & Jonathan Overpeck, *The Twenty-First Century Colorado River Hot Drought and Implications for the Future*, 53 WATER RESOURCES RESEARCH 2404, 2404 (2017), https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016WR019638.
[391] 84 Fed. Reg. at 4,182.
[392] Several other issues are highlighted throughout Ex. B, Moffat & Nichol 2019.
[393] Exec. Order No. 13,778.
[394] 2018 Economic Analysis at 136-137.

By limiting federal jurisdiction so narrowly, the agencies ensure the degradation of our Nation's waters and a return to pre-Clean Water Act water conditions. The proposed rule threatens fish and the headwater ecosystems on which they rely. It would also make it impossible for other critical Clean Water Act programs to succeed. It would result in severe economic losses, and cause irreparable cultural and social damage. The agencies' proposed new definition of "waters of the United States" would immunize from direct federal regulation disposal of oil, chemicals, and other pollutants into the vast majority of our Nation's wetlands and waterways. It would also allow indiscriminate filling and destruction of wetlands. It ignores the scientific importance of these waters and would make it impossible to protect the chemical, physical, and biological integrity of downstream and other navigable waters.

1. Loss of protection over headwaters and small streams guarantees more pollution downstream, the loss of habitat, and impacts to drinking water.

Without considering science or assessing the impact, the agencies' proposal would categorically remove jurisdiction from ephemeral streams despite their well-documented contributions to the hydrological, biogeochemical, and ecological health of watersheds. Among other issues, the agencies have also asked the public to comment on proposals to limit jurisdiction to perennial streams only or to impose minimum flow requirements. If implemented, these approaches could strip protections from at least 60 percent of the stream miles in the continental United States.[395] In addition, the agencies' defition of ditches ignores that ditches often function as tributaries.[396] The only ditches that would be regulated are those that have been carved out of intermittent or perennial streams, qualify as a traditional navigable water, or flow through an adjacent wetland.[397] No ditch constructed in uplands regardless of its flow or connections to downstream waters would be considered a water of the United States.

Because of the importance of these waters,[398] any rule that excludes or greatly reduces their protection will have far reaching implications for fish, wildlife, and their habitats, as well as economies dependent on those ecosystems.

As the agencies accept, ephemeral streams "perform similar hydrological and ecological functions [as those provided by perennial and intermittent streams], including moving water, sediments, and nutrients, providing connectivity within the watershed and habitat to wildlife."[399] They support the greatest concentrations of wildlife in arid regions.[400] And, some species cannot survive outside them.[401] With their certain destruction under the proposal, threatened and endangered species would be harder to recover, and more species would be at risk. Many threatened desert fishes, such as pupfishes, that depend on one or more isolated spring-fed headwaters, would lose their only habitat.[402] Karst features critically important to threatened and

[395] *See* 2018 Economic Analysis, Appendix A.
[396] 84 Fed. Reg. at 4,179.
[397] *Id*.
[398] *See supra* section VII.A; *see generally* EPA Connectivity Report; Ex. A, Literature review; Colvin et al., *supra* note 112; AQ Scientists Comments.
[399] 2018 Economic Analysis at 198.
[400] *Id.* at 199.
[401] *Id*.
[402] Colvin et al., *supra* note 112, at 79.

endangered cavefish, intermittent streams used by imperiled fish for spawning and early rearing, and intermittent side channels and floodplains that provide critical habitat for juvenile salmon are all at risk.[403]

The proposal would also open up our Nation's waters to pollution. Any person or corporation wanting to dispose of toxic "chemical wastes or any other pollutant could (and presumably some of them would) send their tanker trucks loaded with those toxic chemicals to some [stream or wetland], anywhere upstream . . . of the end or limit of CWA jurisdiction."[404] "Of course, within hours or days of the dumping, those chemical wastes would be carried downstream"[405] where they would become part our Nation's drinking water supplies, the flesh of the fish and shellfish that we eat, and our ecosystem in general, where they would poison people, as well as fish, shellfish, and wildlife.

Channel alterations, excess nutrients and sediments, and losses of flows in headwater streams would further deteriorate water quality (*e.g.*, eutrophication and hypoxia) in downstream systems throughout the United States. The destruction caused by pollutants transported downriver to coastal communities is well documented, and sure to occur under the current proposal. For example, NOAA estimates that the annual cost of damages to the Gulf of Mexico from agricultural runoff in the Midwest is nearly $82 million. Throughout New England, pollution in freshwater systems has depressed runs of migratory fish, including river herring, since the early 1900s. These species play a critical role in the marine food web, providing a forage base to commercially harvested fish such as Atlantic Cod.[406]

Ultimately, communities across the Nation would also lose the economic, social, and cultural benefits derived from headwaters.[407] Even more so than perennial streams, ephemeral streams play a critical role in carbon sequestration.[408] And they are critically important because they connect many wetlands—29 percent of the headwater forests in the North Carolina Piedmont and Inner Coastal Plain,[409] for example—which provide physical, chemical, and biological functions to downstream waters of the United States. All of these wetlands, and their associated functions, would be lost.

Although the cumulative effects from losing ephemeral streams, and associated wetlands, would be debilitating, the agencies' threat (through requests for comments) to further reduce

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[403] *Id*.
[404] Lance Wood, Don't Be Misled: CWA Jurisdiction Extends to All Non-Navigable Tributaries of the Traditional Navigable Waters and to Their Adjacent Wetlands (A Response to the Virginia Albrecht/Stephen Nickelsburg ELR Article, to the Fifth Circuit's Decision In re Needham, and to the Supreme Court's Dicta in SWANCC), ENVIRONMENTAL LAW INSTITUTE, 34 E.L.R. 10,187, 10,195 (2004).
[405] *Id*. Even if the pollutant, once reaching downstream waters, could give rise to Clean Water Act liability in the abstract sense, the practical problems of matching the discharged pollutant downstream with a discharger in an upstream-but-non-jurisdictional area are immense and must be addressed as a foreseeable result of your proposal.
[406] Martin D. Smith et al., Seafood Prices Reveal Impacts of a Major Ecological Disturbance, PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 114, no. 7, 1512–17 (February 14, 2017), https://doi.org/10.1073/pnas.1617948114 (last visited Apr. 15, 2019).
[407] Colvin et al., *supra* note 112, at 85-86.
[408] Ex. A, Literature review at 30-31.
[409] Ex. B, Moffat & Nichol at 8.

protections would be catastrophic. In particular, removing protections for intermittent streams[410] or imposing a 5 cubic-foot-per-second minimum flow[411] would likely eliminate protections from more than 90 percent of streams in parts of North Carolina.[412] In significant parts of Virginia, North Carolina, South Carolina, and Georgia, the proposal could strip protection for more than 40 percent of streams[413]; in the arid and semi-arid Southwest United States, for at least 80 percent for streams.[414] A minimum flow requirement could eliminate protections for even perennial streams that have low flow rates due to little topography.[415]

Significantly, EPA has estimated that more than 40 percent of individual NPDES discharges outside Alaska are into headwaters, and that more than 90 percent of drinking water intakes are in small headwaters.[416] Conservatively, this translates into at least 43 percent of the permitted industrial pollutant discharges in the Southeast going into headwater streams, a main source of our region's drinking water.[417] If jurisdiction under the Clean Water Act no longer reaches these streams, then the numerous industrial facilities holding Clean Water Act section 402 permits could dump their untreated chemical and industrial wastes into the tributary streams without direct regulation under the Act, just as they did before enactment of the law, leading to significant negative effects on people and the environment downstream.[418]

2. Loss of protections over wetlands guarantees downstream pollution, more flooding, and the loss of fisheries.

Wetlands would be particularly hard hit by this proposal. The agencies have proposed to limit jurisdiction to those wetlands that directly touch a jurisdictional stream or river or have a surface water connection to a covered stream or river. Because wetland jurisdiction is also dependent on streams, loss of stream jurisdiction would make wetland losses even more extreme.

Estimates show that most of the 110 million acres of wetlands across the contiguous United States could lose protection under the extreme limits in this proposal.[419] At-risk wetlands provide essential functions such as improving water quality, recharging groundwater, augmenting low flow for nearby streams, storing floodwater, and providing habitat for threatened and endangered aquatic species, such as amphibians. Wetlands often provide these benefits

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[410] 84 Fed. Reg. at 4,177.
[411] *Id*. at. 4,178.
[412] Ex. B, Moffat & Nichol at 10.
[413] Ex. B, Moffat & Nichol at 12-15.
[414] Leibowitz et al., Connectivity of Streams and Wetlands to Downstream Waters: An Integrated Systems Framework, JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION 304 (Apr. 2018).
[415] Ex. B, Moffat & Nichol at 10.
[416] Br. of Amici Curiae Association of State Wetland Managers et al., *Rapanos v. United* States, 574 U.S. 715 (January 2006) (Nos. 04-1034, 04-1384) at 19-20, Appx. A at 3a-4a (Letter to J. Christie, Association of State Wetland Managers from B. Grumbles, Asst. Administrator, U.S. EPA (Jan. 9, 2005)).
[417] Ex. E, U.S. EPA, Location of Individual NPDES Permits on State Streams. Based on NHD data, an incomplete dataset of the Nation's streams, and NPDES Permit Data as of June 7, 2004, there were 7,146 total NPDES Individual Permits issued in the Southeast Region. *Id*. Of the 87 percent of those permits with data on the discharge locations, 43 percent discharged into headwater streams. *Id*.
[418] Wood, *supra* note 404, at 10,187, 10,195.
[419] *See* U.S. FISH AND WILDLIFE SERVICE, STATUS AND TRENDS OF WETLANDS IN THE CONTERMINOUS UNITED STATES 2004-2009 37 (2009).

because they lack permanent surface water, a characteristic that would eliminate existing protections under the proposed rule.[420]

Moreover, more distant wetlands—unprotected under this proposal—can have higher connectivity than wetlands that are closer to downstream waters due to variability in factors such as topography, slope, and soil permeability. For example, in the prairie pothole region, an area dominated by flat, open basins and lakes, small changes in surface-water levels can consolidate wetlands that were previously disconnected by distances more than 1 km; these wetlands connect to one another first, forming wetland complexes, prior to connecting to a stream channel.[421] Should the agencies impose a limit on the distance beyond which wetlands would no longer be jurisdictional, they would ignore the connectivity of wetlands to each other and to downstream waters. Unless the agencies protect all wetlands within a "complex of wetlands," they effectively are not protecting any.[422]

As EPA has acknowledged: "If wetlands are destroyed or damaged, it can be difficult or impossible to replace all of these functions."[423] The agencies' misguided proposal could result in the loss of over 50 percent of our Nation's wetlands. Unregulated and uncontrolled destruction of wetlands would adversely affect water quality and flood control for the rivers and streams downstream, and would destroy valuable fish and wildlife habitat.[424]

In the absence of wetlands, increased levels of agricultural run-off and other pollutant-saturated wastewater make their way directly into tributaries and then into larger downstream waters, including rivers, lakes, and estuaries. The effects of nutrient pollution can be devastating. A striking example is where nutrient-rich runoff from the Mississippi River has caused the Gulf of Mexico's "dead zone," a vast oxygen-depleted area that damages biodiversity and commercial fisheries, with major economic and social costs.[425] According to EPA, over 166 dead zones have been documented nationwide, affecting waterbodies like the Chesapeake Bay.[426]

Pocosins, Carolina bays, and similar wetlands, are all at-risk under the agencies' proposal, as are the biologically diverse species that depend on them. Out of the total of 274 at-risk plant and animal species supported by non-floodplain wetlands, 35 percent are not known to be supported *by any other type of habitat*.[427] Additionally, 86 plant and animal species that have been identified as "threatened," "endangered," or candidates for listing under the Endangered Species Act are found in non-floodplain wetland habitats,[428] including the endangered Venus flytrap.

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[420] *See, e.g.*, Ex. B, Moffat & Nichol at 2-3.
[421] Leibowitz et al., *supra* note 414, at 311.
[422] *Id*.
[423] U.S. EPA, ECONOMIC BENEFITS OF WETLANDS.
[424] *See* Wood, *supra* note 404, at 10,193.
[425] Colvin et al., *supra* note 112, at 76.
[426] CONGRESSIONAL RESEARCH SERVICE, FRESHWATER HARMFUL ALGAL BLOOMS: CAUSES, CHALLENGES, AND POLICY CONSIDERATIONS 3 (2018).
[427] P. Comer et al., Biodiversity Values of Geographically Isolated Wetlands in the United States, NATURE SERVE 1 (2005), http://www.natureserve.org/sites/default/files/projects/files/isolated_wetlands.pdf (last visited Apr. 15, 2019).
[428] *Id*.

Finally, the revised exclusion for prior converted cropland creates a significant loophole that allows the development or further degradation of these converted wetlands without obtaining a 404 permit. Under the proposed rule, the only way for prior converted cropland to lose its status as an excluded water under the Act is when the area is abandoned (*i.e.*, not in the previous five years "used for, *or in support of, agricultural* purposes"[429]) *and* has reverted to a wetland meeting the regulatory definition of "wetlands."[430] That means, according to the agencies, the "majority" of these converted wetlands would never regain protection, even after abandoned, because of their "altered nature."[431] That this provision opens the door for development of these converted wetlands without a 404 permit is signaled by the fact that the National Association of Realtors lists "Discussions with the Environmental Protection Agency regarding the Waters of the U.S. (WOTUS) rule and the prior converted cropland exclusion" as one if its key lobbying interests for 2019.[432] The agencies must disclose and address the impacts of this proposed change and what it means for the integrity of the Nation's waters.

3. Interpreting waters of the United States narrowly would make it impossible for other Clean Water Act programs to succeed.

Limiting discharges of pollutants including dredge and fill is the cornerstone for the Clean Water Act's programs. Clean Water Act programs to develop restoration plans, protect the Great Lakes, restore our estuaries and others cannot succeed with this proposal.

The National Estuary Program established by section 320 is just one example. As discussed above, our estuaries are in trouble. That is not surprising—streams flow into rivers which flow into estuaries. As small streams and rivers become more polluted, so too do the estuaries. EPA is well aware of this problem, citing "[c]ommercial, industrial, and residential development" as well as "[h]ighway construction" as the primary threats to estuaries due to "increased runoff of sediment, nutrient and chemical pollutants."[433] The solution is no mystery: we must protect our wetlands. "[W]etlands protect water quality; riparian and coastal wetlands provide storage for excess water during flooding, as well as support valuable fisheries."[434] When those wetlands are lost and water quality is degraded, estuaries "are less able to perform the

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[429] *See, e.g.*, 84 Fed. Reg. at 4,204 (emphasis added). Under the proposal, the terms "agricultural purposes" are undefined. The use of these terms "for, or *in support of, agricultural purposes*" appear much broader that prior agency practice whereby prior converted cropland was "abandoned unless*:* [f]or once in every five years the area has been used *for the production of an agricultural commodity*." 58 Fed. Reg. at 45,034.
[430] *Id*.
[431] 84 Fed. Reg. at 4,194-4,195 ("The altered nature of prior converted cropland and its conditions constitute the 'normal circumstances' of such areas. The agencies expect the majority of prior converted cropland in the Nation to fall into this category and not be subject to CWA regulation, even after it is abandoned.").
[432] National Association of Realtors, LD-2 Disclosure Form 19 (2019). *Cf.* 2018 Resource and Programmatic Assessment at 50 (under the proposed prior converted cropland exclusion "fewer wetlands may be identified as jurisdictional under the proposed rule compared to [the 2015 Clean Water Rule and the regulations that preceded it]").
[433] U.S. EPA, ESTUARY HABITAT LOSS AND DEGRADATION: WHAT'S THE PROBLEM?, https://www.epa.gov/nep/estuary-habitat-loss-and-degradation (last visited Apr. 15, 2019).
[434] *Id*.

economic, environmental and aesthetic functions that coastal populations depend on for their livelihoods and protection."[435]

The Great Lakes would likewise suffer under this proposal. As EPA has recognized, the lakes "are sensitive to pollutants" because "[p]ollutants that enter the lakes are retained in the system and become more concentrated with time."[436] EPA has spent millions of dollars in recent years to restore the lakes, including the restoration of 32 acres of wet prairie[437]—a type of wetland that would lose protection under this proposal. The Great Lakes would never be restored with this proposal, rendering this Clean Water Act program, and others like it, useless.[438]

This proposal must be rejected. Agencies "cannot interpret federal statutes to negate their own stated purposes."[439] Here, the proposal not only negates the overall objective of the Clean Water Act, it would ensure that the various geographically focused restoration efforts implemented under the Act fail as well.

C. The Proposed Rule's Degradation of the Nation's Waters Would Have a Significant Negative Economic Impact.

EPA has recognized that "protecting and efficiently managing our water resources is essential to maintaining a strong, vibrant economy,"[440] yet now the agencies propose a rule that would expose every river, creek, lake, bay, and estuary in our country to far greater levels of degradation. The proposal puts both our waters and our economy at risk.

Without intact wetlands, there would be an increased risk of flooding. A single acre of wetlands can store approximately 1 million gallons of floodwater.[441] During Hurricane Sandy, in 2012, wetlands prevented $625 million in flood damage by shielding property in 12 states.[442] Since that time, incidents of flooding have only increased. NOAA officials have referred to the current flood season as "potentially unprecedented."[443] These floods have already caused billions of dollars in damages throughout the Midwest and multiple deaths.[444] The EPA has reported that

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[435] *Id*.
[436] U.S. EPA, RESTORING THE GREAT LAKES, https://www.epa.gov/greatlakes/restoring-great-lakes (last visited Apr. 15, 2019).
[437] U.S. EPA, News *Release: EPA provides $300,000 to Metroparks Toledo to restore wet prairie in Maumee River AOC* (June 26, 2018), https://www.epa.gov/newsreleases/epa-provides-300000-metroparks-toledo-restore-wet-prairie-maumee-river-aoc (last visited Apr. 15, 2019).
[438] *See* 33 U.S.C. §§ 1258, 1268.
[439] *New York State Dep't of Soc. Servs. v. Dublino*, 413 U.S. 405, 419-20(1973)
[440] U.S. EPA, THE IMPORTANCE OF WATER TO THE U.S. ECONOMY 5 (2013), https://www.bafuture.org/sites/default/files/key-topics/attachments/Importance-of-water-synthesis-report.pdf (last visited Apr. 9, 2019 ("EPA 2013 REPORT").
[441] U.S. EPA, WETLANDS: PROTECTING LIFE AND PROPERTY FROM FLOODING 1 (May 2006).
[442] Siddharth Narayan, et al., The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA, SCIENTIFIC REPORTS (Aug. 31, 2017), https://www.nature.com/articles/s41598-017-09269-z.
[443] NOAA, SPRING OUTLOOK: HISTORIC, WIDESPREAD FLOODING TO CONTINUE THROUGH MAY (Mar. 21, 2019), https://www.noaa.gov/media-release/spring-outlook-historic-widespread-flooding-to-continue-through-may.
[444] John Schwartz, *25 States Are at Risk of Serious Flooding This Spring, U.S. Forecast Says*, N.Y. TIMES (Mar. 21, 2019), https://www.nytimes.com/2019/03/21/climate/climate-change-flooding.html; Mark Berman & Reis Thebault, *Two dead, two missing amid 'historic' flooding across the Midwest*, WASHINGTON POST (Mar. 18, 2019),

it would cost $1.5 million annually to replace the natural flood-control functions of a 5,000-acre tract of drained Minnesota wetlands alone.[445] The Midwest's flooding has only risen in recent years, in both frequency and severity.[446] Our Nation's flooding risks are going to grow.[447]

Record-setting algal blooms and associated "dead zones"–oxygen depleted areas created when algae die and decompose–threaten drinking water quality and Lake Erie's critical $12.9 billion tourism industry and world class fishery.[448] These are caused by excessive levels of nutrients, specifically phosphorus carried from major rivers during storms.[449] In August 2014, more than 500,000 people were without drinking water for three days when elevated levels of algal toxins forced the closure of the Toledo, Ohio, drinking water treatment plant.[450] Algal toxins can make pets, livestock, and humans sick, and can even cause death.[451]

Drinking water contamination is not only dangerous to human health, it is extremely costly for our economy. Polluted drinking water is cripplingly expensive to clean up. In North Carolina, two water utilities are spending nearly $150 million, collectively, to clean up water polluted with toxic chemicals from an upstream manufacturing facility.[452] And when drinking water does not get cleaned up—because municipalities cannot afford expensive treatment technologies, because even costly technologies cannot remove some pollutants, or because those affected depend on private wells rather than public water supplies—the country's economy suffers when people drinking the water get sick. In one such example, a disease outbreak caused by polluted runoff in Milwaukee, Wisconsin cost $96.2 million in medical costs and productivity losses.[453] The proposed rule, by leaving out protections for headwaters and small streams, threatens drinking water across the Nation.

The proposal also threatens food sources and related industries that depend on clean water. As we have seen all too often, the agriculture industry, which contributed $992 billion to the U.S. gross domestic product in 2015,[454] and human health both take a hit when polluted

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https://www.washingtonpost.com/nation/2019/03/16/emergencies-declared-across-midwest-amid-historic-flooding/?utm_term=.c263edbe6d83 (last visited Apr. 15, 2019)..

[445] U.S. EPA, WETLANDS: PROTECTING LIFE AND PROPERTY FROM FLOODING (May 2006).

[446] Gary Galluzo, *Study finds Midwest flooding more frequent*, IOWA NOW (Feb. 9, 2015), https://now.uiowa.edu/2015/02/study-finds-midwest-flooding-more-frequent (last visited Apr. 15, 2019).

[447] NOAA, *supra* note 443.

[448] U.S. EPA, U.S. ACTION PLAN FOR LAKE ERIE 1 (Feb. 2018).

[449] *Id*.

[450] *Id*. at 2.

[451] *Id*.

[452] Tim Buckland, *CFPUA: Filtering GenX can be done, but will cost customers,*" WILMINGTON STAR NEWS, (Aug. 15, 2018), www.starnewsonline.com/news/20180815/cfpua-filtering-genx-can-be-done-but-will-cost-customers; Johanna Ferebee, *Brunswick's $100-million treatment plant will concentrate contaminants, discharge them back into Cape Fear River*, PORT CITY DAILY (Oct. 12, 2018), https://portcitydaily.com/local-news/2018/10/12/brunswicks-100-million-treatment-plant-will-concentrate-contaminants-discharge-them-back-into-cape-fear-river/.

[453] EPA 2013 REPORT AT 16.

[454] U.S. DEPARTMENT OF AGRICULTURE: ECONOMIC RESEARCH SERVICE, *AG AND FOOD SECTORS AND THE ECONOMY*, https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/ag-and-food-sectors-and-the-economy.aspx (last visited Apr. 8, 2019).

water used for crop irrigation leads to food-borne illnesses.[455] Likewise, "[l]ong-term degradation of aquatic or coastal habitat . . . [can] have a devastating effect act on commercially viable fish stocks,"[456] jeopardizing the Nation's commercial and seafood industry responsible for 1.2 million jobs and $144.3 billion in sales in 2016.[457]

Recreational activities that rely on clean water, such as boating, fishing, and swimming, are also at risk. In 2016, boating and fishing alone accounted for nearly $37 billion.[458] Recognizing this economic boon, Congress recently enacted the Outdoor Recreation Jobs and Economic Impact Act authorizing the Department of Commerce's Bureau of Economic Analysis to assess outdoor recreation's contribution to the Nation's gross domestic product.[459]

Just as clean water boosts our economy, polluted water burdens it. For instance, nutrient pollution alone "can [] cost billions of dollars to clean up polluted water bodies."[460] As EPA put it, "[e]very dollar spent on protecting sources of drinking water [from pollution] saves in water treatment costs."[461]

The agencies' narrow definition of "Waters of the United States" would make it impossible to achieve the Clean Water Act's mandates. It would also impose significant costs and harms on American citizens, businesses, and communities, as they experience deteriorated water quality, more limited water supplies, more severe flood and storm damage, lost fisheries, reduced recreational activities, and degraded wildlife habitat. Compensating for these losses will result in significant additional financial burden. In all, the agencies' proposal would deal a significant blow to our Nation's economy.

VIII. IF LEFT TO THE STATES, THE INTEGRITY OF THE NATION'S WATERS WOULD SUFFER.

Contrary to the agencies' rhetoric, states would not serve as a backstop against the elimination of federal clean water protections, regardless of how broadly they define "waters of the state."[462] Thirty-six states, or two-thirds of the country, have laws on the books that hinder

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[455] *See* CDC, SURVEILLANCE FOR WATERBORNE DISEASE OUTBREAKS ASSOCIATED WITH DRINKING WATER – UNITED STATES, 2013-2014 (2017), https://www.cdc.gov/mmwr/volumes/66/wr/pdfs/mm6644a3-H.pdf; CDC, WATERBORNE AND FOODBORNE DISEASE OUTBREAKS, https://www.cdc.gov/pictureofamerica/pdfs/picture_of_america_outbreaks.pdf; David Pimental et al., Water Resources: Agricultural and Environmental Issues, BIOSCIENCE 913 (Oct. 2004).
[456] EPA 2013 Report at 17.
[457] NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, FISHERIES ECONOMICS OF THE UNITED STATES (2016), https://www.fisheries.noaa.gov/resource/document/fisheries-economics-united-states-report-2016 (last visited Apr. 8, 2019).
[458] U.S. BUREAU OF ECONOMIC ANALYSIS, OUTDOOR RECREATION SATELLITE ACCOUNT: UPDATED STATISTICS FOR 2012-2016, RELATED MATERIALS: TABLE – GROSS OUTPUT BY ACTIVITY, *available at* https://www.bea.gov/system/files/2018-09/orsa0918-Gross-Output-by-Activity_0.xlsx (last visited Apr. 8, 2019).
[459] Pub. L. No: 114-249 (Dec. 8, 2016).
[460] U.S. EPA, NUTRIENT POLLUTION, THE EFFECTS: ECONOMY, https://www.epa.gov/nutrientpollution/effects-economy (last visited Mar. 18, 2019).
[461] *Id*.
[462] 2018 Resource and Programmatic Assessment at 55 ("[S]tates typically have very broad definitions which include waters that are not 'waters of the United States' under the CWA, *i.e.* groundwater. Many states choose to then limit their regulations to fewer waters, even though the definition itself is broader in scope.") (internal citations omitted).

them from protecting waters that are left unprotected by the federal government.[463] In these states, loss of federal protection means a loss of state protection. As evidenced by history, many would exploit the absence of federal regulation, and allow the unfettered destruction of our Nation's waters. For the agencies to claim otherwise is disingenuous. Congress learned from experience that only a comprehensive approach to water-pollution regulation at the federal level can achieve the Nation's hopes for clean water.

A. The Clean Water Act Provides the Only Lawful Mechanism for More State Control Over Stream and Wetland Permitting.

Under the Clean Water Act, Congress provided the specific mechanism for states to exert more authority over the waters within their borders: the option to assume the regulatory program under section 404(g).[464] Only two states have opted for assumption, Michigan and New Jersey.[465]

The reality is it is extremely expensive and difficult for states to take total control of the regulatory program under section 404(g). The states that are serious about protecting their waters almost invariably do so in partnership with the Corps and EPA enforcing the Clean Water Act. Some two-thirds of states lack independent regulatory programs that would fully protect non-floodplain wetlands and other waters that the proposal would not protect; instead, they rely on the longstanding state-certification requirements under section 401 of the Clean Water Act for federally issued permits.[466] Through this certification authority, many states implement vigorous protections for their wetlands without the prohibitive expense of creating and administering independent state permitting programs. Said another way, removing federal jurisdiction shrinks state authority to review and certify projects to reduce water quality impacts.

B. States Lack the Resources and Knowledge to Protect the Nation's Waters.

If forced to assume sole responsibility for regulating fill activities in the millions of acres of wetlands that lose federal protections under the proposal, many states simply could not afford to take over. The agencies concede this.[467] And the states that have considered, but rejected the idea of assuming the 404 program, have cited a lack of resources—staff, financial resources, training, and knowledge—to develop a compliance and enforcement program consistent with the

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[463] ENVIRONMENTAL LAW INSTITUTE, STATE CONSTRAINTS: STATE-IMPOSED LIMITATIONS ON THE AUTHORITY OF AGENCIES TO REGULATE WATERS BEYOND THE SCOPE OF THE FEDERAL CLEAN WATER ACT 7 (2013), https://www.eli.org/sites/default/files/eli-pubs/d23-04.pdf; *see also* 2018 Resource and Programmatic Assessment at 56-57.

[464] 33 U.S.C. § 1344(g).

[465] 2018 Resource and Programmatic Assessment at 58; *see also* Oliver A. Houck & Michael Rolland, *Federalism in Wetlands Regulation: A Consideration of Delegation of Clean Water Act Section 404 and Related Programs to the States*, 54 MD. L. REV. 1242, 1276 (1995); Lance D. Wood, *The Ecos Proposal for Expanded State Assumption of the CWA § 404 Program: Unnecessary, Unwise, and Unworkable*, 39 ENVTL. L. REP. NEWS & ANALYSIS 10209, 10213 (2009).

[466] *See* Jon Kusler, Ass'n of State Wetland Managers, *The* SWANCC *Decision: State Regulation of Wetlands to Fill the Gap*, at 13-14 (Updated and Revised Mar. 4, 2004), https://www.aswm.org/pdf_lib/swancc_decision_030404.pdf (last visited Apr. 8, 2019).

[467] 2018 Economic Analysis at 48 (Many states do not "have the resources to staff and manage the new or expanded programs").

federal program.[468] The State of Minnesota, for instance, calculated that it would need 102 regulators to run the program at the level the Corps' St. Paul's district is currently doing.[469] Because Minnesota already has a robust state wetlands program, its staffing needs are likely lower than for the majority of states without a wetlands program.[470] Virginia determined that administering a program as robust as the federal program would cost $18 million to implement initially and $3.4 million annually.[471] One of the key costs identified by Virginia in deciding against assumption was the loss of the Corps' knowledge base.[472]

In the face of multi-billion dollar budget shortfalls,[473] states simply lack the funds, staff, and training to protect our waters. Tellingly, even without this added responsibility, states already frequently do not meet water quality goals.[474] And in states with the resources and desire to fill the gap, experience shows, that during the time it would take to enact and implement new state protections, many developers would rush to destroy unprotected streams and wetlands, and the states could suffer devastating and irreplaceable losses.[475] Withdrawal of Clean Water Act jurisdiction would simply mean open season for millions of acres of wetlands and headwaters.

In addition to the considerable costs associated with setting up and maintaining as many as 50 different state 404 programs with new state 404 bureaucracies, the economies of scale—and uniformity and predictability for regulated entities—that came with single federal government program would be lost. Given that all but two states have been unwilling to dedicate the resources required for assuming the 404 program, it is highly unlikely that states would develop a wetlands program of any substance now. Even if they did, the result would be a messy patchwork of conflicting regulatory requirements among the states—a reality that the agencies must disclose and address.

C. States Lack the Political Will and Capital to Take on Powerful Polluters.

Another critical limitation is the vulnerability of both existing and emerging state permitting programs to political and legal attack by industrial and development interests in the

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[468] Florida and Minnesota may assume the program in the coming year. FLORIDA DEP'T OF ENVTL. QUALITY, STUDY OF THE COSTS AND BENEFITS OF STATE ASSUMPTION OF THE FEDERAL § 404 CLEAN WATER ACT PERMITTING PROGRAM, (Dec. 2012); FLORIDA DEP'T OF ENVTL. PROT., CONSOLIDATION OF STATE AND FEDERAL WETLAND PERMITTING PROGRAMS IMPLEMENTATION OF HOUSE BILL 759 (Chapter 2005-273, Laws of Florida) (Sept. 2005); MINNESOTA DEP'T OF NAT. RES., STATE OF MINNESOTA FEDERAL SECTION 404 ASSUMPTION FEASIBILITY STUDY, No. 66-505 (Aug. 31, 1989).

[469] DEP'T OF NAT. RES., MINNESOTA FEDERAL CLEAN WATER ACT SECTION 404 PERMIT PROGRAM FEASIBILITY STUDY 62 (Jan. 17, 2017).

[470] *See* ASS'N OF STATE WETLAND MANAGERS, STATUS & TRENDS REPORT ON STATE WETLAND PROGRAMS IN THE U.S. (2015).

[471] VIRGINIA DEP'T OF ENVTL. QUALITY, REPORT TO LEGISLATURE: STATE ASSUMPTION OF FEDERAL § 404 CLEAN WATER ACT PERMITTING PROGRAM FEASIBILITY STUDY at 2 (Dec. 2012), https://www.aswm.org/pdf_lib/va_study_state_assumption_2012.pdf (last visited Apr. 15, 2019).

[472] *Id.* at 3.

[473] Truth in Accounting, *Financial State of the States* (Sept. 2018). For example, they found that Virginia had a $5.4 billion shortfall, Georgia had a $11.1 billion shortfall, North Carolina had a $24.3 billion shortfall, and South Carolina had a $26.2 billion shortfall. *Id*.

[474] *See supra* section IV.

[475] *See* Traci Watson, *Developers rush to build in wetlands after ruling*, USA TODAY (Dec. 6, 2002).

absence of a federal floor. For example, North Carolina's "isolated" wetlands program—used by the agencies to predict that the state "may" strengthen its regulations[476]—has been under attack in the courts ever since it was promulgated over fifteen years ago.[477] In 2015, North Carolina narrowed these already limited[478] protections to just two types of wetlands: basin wetlands and bogs.[479] North Carolina's wetland program would therefore provide little, if any, coverage for wetlands that lose federal protection under the agencies' proposal, including pocosins, Carolina bays, pine savannas, pine flats, and headwater forest wetlands.[480]

States also do not always have the political will to take on powerful companies. For example, when North Carolina's Department of Environmental Quality under Republican Governor Pat McCrory was investigated for its cozy relations with Duke Energy and not enforcing the law, the EPA conducted a criminal investigation which resulted in Duke Energy pleading to nine criminal violations of the Clean Water Act at its leaking, unlined coal ash sites across the state and agreed to pay a $68 million criminal fine and spend $34 million on environmental projects and land conservation to benefit rivers and wetlands in North Carolina and Virginia.[481] In the absence of a federal backstop, companies would feel more emboldened to push back against state enforcers, likely resulting in fewer and smaller settlements, and less deterrence of future violations.[482]

As we have seen time and time again, states alone do not and cannot protect our waters: sometimes for a lack of resources or political capital, and still others where they simply do not do their jobs. For example, located roughly 20 miles west of Birmingham, the Maxine Mine site, owned by Drummond Company, is one of the worst of hundreds of abandoned mines in the Black Warrior River basin. Maxine Mine and many of the other inactive mine sites continue to pollute Alabama's streams and groundwater. Despite this ongoing pollution, Alabama regulators have basically ignored abandoned mine sites like Maxine. As a result, these mine sites are unregulated and unchecked. There are no discharge permits in place, and no one in state government is testing for pollution at these sites, or trying to control the pollution from them. SELC stepped into the void in late 2016 and, on behalf of the Black Warrior Riverkeeper, filed a Clean Water Act citizen suit against Drummond to stop the company's pollution from seeping into the Black Warrior Basin.

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[476] 2018 Economic Analysis at 41-42 & n.1 ("Any states that have already expanded their regulatory scope . . . will be assumed to continue such practices.").
[477] *See* Richard Whisnant, Wetlands in North Carolina, ENVIRONMENTAL AND CONSERVATION LAW 6 (Dec. 1999).
[478] North Carolina's Isolated Wetlands law provides limited protections for Basin Wetlands and Bogs. N.C. Sess. Law 2015-286, s. 4.18(c).
[479] N.C. Sess. Law 2015-286, s. 4.18.
[480] Ex. B, Moffat and Nichol at 5-9.
[481] *See* SELC, *Groups Sue Drummond over Abandoned Mine's Pollution of the Locust Fork*, https://www.southernenvironment.org/news-and-press/press-releases/groups-sue-drummond-over-abandoned-mines-pollution-of-the-locust-fork (last visited Apr. 14, 2019); SELC, *SELC, Partners Urge Cleanup of Abandoned Mine Site Polluting Black Warrior River*, https://www.southernenvironment.org/news-and-press/news-feed/selc-partners-urge-cleanup-of-abandoned-mine-site-polluting-black-warrior-r (last visited Apr. 14, 2019).
[482] INSTITUTE FOR POLICY INTEGRITY, IRREPLACEABLE: WHY STATES CAN'T AND WON'T MAKE UP FOR INADEQUATE FEDERAL ENFORCEMENT OF ENVIRONMENTAL LAWS 2 (June 2017).

More pollution would surely occur if individual states are left responsible for the integrity of our Nation's waters. The country needs broad federal jurisdiction to ensure our Nation's waters are protected.

D. States Are Incapable of Protecting Water Quality Because Water Pollution Is Not Confined Within State Boundaries.

Federal regulation is particularly important because of the "transboundary" nature of water pollution.[483] Water knows no political boundaries, so inevitably states often share rivers, lakes, bays, etc.[484] Discharges into small streams and wetlands in one state affect the waters of downstream states.[485] This is "[o]ne reason why the state and local governments had proven themselves both incapable of and unwilling to control water pollution in the years before the [Clean Water Act]."[486] Without federal standards, the country would suffer from "tragedy of the commons."

Downstream states would find themselves significantly hampered in protecting their own water quality. No "downstream" state could benefit from local efforts to control water pollution as long as upstream states continued to send their uncontrolled, polluting wastes downstream.[487] Instead, states would "race to the bottom," as they have done in the past, [488] refusing to enforce laws within their own borders, spend local tax dollars on pollution control, or jeopardize industrial development, by enacting effective measures to control water pollution.[489] Moreover, most states would not invest in preventing pollution within their own borders when the people who would benefit live downriver in another state. [490] Meanwhile, "any state with strong pollution control regulation could lose industry to competing states and still suffer from water pollution coming from other, *e.g.*, "upstream," states."[491]

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[483] Wood, *supra* note 404, at 10,194.
[484] *Id*.
[485] N.Y. STATE DEP'T OF ENVTL. CONSERVATION & CONN. DEP'T OF ENVTL. PROT., A TOTAL MAXIMUM DAILY LOAD ANALYSIS TO ACHIEVE WATER QUALITY STANDARDS FOR DISSOLVED OXYGEN IN LONG ISLAND SOUND 16-18 (Dec. 2000), https://www.dec.ny.gov/docs/water_pdf/tmdllis.pdf (last visited Apr. 9, 2019). For example, a study of Long Island Sound by New York and Connecticut found that 13.5 percent of the estimated 100,436 tons of nitrogen entering the Sound each year came from headwater tributary watersheds north of Connecticut. *Id*.
[486] Wood, *supra* note 404, at 10,194.
[487] *Id*.
[488] Per. G. Fredriksson, *Environmental Federalism: Lessons Learned from the Literature*, EPA-HQ-OW-2018-0149-0011, 3 (Feb. 28, 2018).
[489] Wood, *supra* note 404, at 10,194.
[490] *Id*.
[491] *Id*.; *see also, e.g.*, Delaware Dep't of Nat. Res. and Envtl. Control, Comments on Advance Notice of Proposed Rulemaking On Definition of "Waters of the United States," Docket ID No. OW-2002-0050, 14 (Apr. 16, 2003) ("Loss of federal regulation would put environmentally protective states at an economic disadvantage relative to less protective neighbor states, removing the 'level playing field' that now exists and creating pressure for reduced state protection."); State of Maine, Dep't of Envtl. Prot., "Advance Notice of Proposed Rulemaking On Definition of "Waters of the United States," Docket ID No. OW-2002-0050, 1 (Apr. 16, 2003) ("[T]he competitive disadvantage this may impose on Maine with respect to other states might lead to pressures to roll-back our own protections."); State of New York, Dep't of Envtl. Conservation, Comments on Advance Notice of Proposed Rulemaking On Definition of "Waters of the United States," Docket ID No. OW-2002-0050, 2 (Mar. 27, 2003) ("It is imperative that we maintain strong nationwide Clean Water Act standards to ensure that individual states, or groups of states, cannot

Both upstream and downstream states voiced these concerns when commenting on the agencies' 2003 rulemaking proposal that similarly threatened to narrow federal jurisdiction. It is unsurprising that downstream states would be concerned over a rollback of water protections. For instance, Michigan—one of the only two states that have assumed responsibility for implementing section 404 of the Clean Water Act—stressed the importance of broad federal protections because, even if Michigan responsibly manages its waters, the health of the state's waters also depends on the actions of other states. Michigan recognized that other states may not fill the gaps left by the federal government's abandonment of its water protection obligations. In Michigan's words:

> [G]iven the fundamental importance of our freshwater resources to the public, it is essential that the federal standards be maintained not only in Michigan but in states whose actions impact Michigan. The State of Michigan exists on two peninsulas in the center of the Great Lakes, and we are ever aware that the quality of those interstate and international waters that surround us is influenced not only by the actions of our own citizens, but by those of other states (and other nations).[492]

Even upstream states recognized the danger of pulling back federal protections. For instance, Montana, a "headwater state"[493] upstream of other states, acknowledged that it might not be able to control development within its borders in order to prevent flooding in downstream states.[494] Headwater states, like Montana, export floodwaters, with the greatest flood damage frequently occurring hundreds of miles and many states downstream. Much of the water that Montana would otherwise export is contained in wetlands that play an invaluable role by "absorbing runoff and moderating flood flows for downstream states."[495] Montana recognized the benefits of preserving these wetlands, but concluded that "[t]hese wetlands will be highly vulnerable to filling and draining in the absence of protection under Section 404 of the Clean Water Act."[496] It is politically difficult—if not impossible—for a state to tell its own citizens that they have to forego development on a portion their own property in order to prevent the risk of exacerbating flooding in a state downstream. The Clean Water Act tackles that obstacle head on, with the science-based premise that we can only achieve clean water if we each do our part. Federal jurisdiction ensures that.[497]

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benefit from the location of industry, business, or other activities within those states, on the expectation of lower environmental regulatory hurdles.").

[492] State of Michigan, Dep't of Envtl. Quality, Comments on Advance Notice of Proposed Rulemaking On Definition of "Waters of the United States," Docket ID No. OW-2002-0050, 2 (Apr. 16, 2003).

[493] Montana Dep't of Envtl. Quality, Comments on Advance Notice of Proposed Rulemaking On Definition of "Waters of the United States," Docket ID No. OW-2002-0050, 4 (Apr. 16, 2003).

[494] *See id*. at 2-4.

[495] *Id*. at 4.

[496] *Id*. at 2.

[497] *See id*.

Relying on state regulation to keep our waters clean is simply an unrealistic solution. No matter how comprehensively one state regulates its waters, if a neighboring state does not, everyone would suffer.[498]

E. The Agencies' Proposal Would Strip Away the States' Existing Tools for Protecting Water Quality.

Redefining "waters of the United States" as proposed would eliminate the existing tools states have under the Clean Water Act to protect the waters within their borders. For example, section 402(b) gives downstream states notice, the opportunity for comment, and the opportunity for a hearing on any upstream discharger's NPDES permit application.[499] These rights would disappear if the upstream discharger no longer had to obtain a permit because the water discharged into was no longer jurisdictional. In addition, section 401(a)(2) prohibits the issuance of any federal license or permit, which "may result" in any discharge into waters of the United States over the objection of an affected state unless compliance with the affected state's water quality requirements can be ensured.[500] This right would be lost for every federal license or permit authorizing a discharge into waters whose protection had been abandoned.

Restricting the Act's coverage would also diminish the states' water quality standards certification authority under section 401.[501] This authority allows states to condition or, if necessary, bar federal permits, including section 404 dredge and fill permits, to ensure that federally permitted activities comply with the state's water quality standards. Most states rely exclusively on their 401 certification authority to protect their wetlands, lakes, streams and other waters from activities that result in discharges of dredged or fill material into those waters. Although South Carolina, Tennessee, and Virginia have some extended coverage beyond the 401 certification, that coverage would not make up for loss of federal protections because they either do not operate independently of other permits (South Carolina),[502] are infrequently enforced (Tennessee),[503] or are inadequately staffed (Virginia).[504] Thus, with the proposed rollbacks, most

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[498] *See, e.g.*, Indiana Dep't of Envtl. Mgmt., Comments on Advance Notice of Proposed Rulemaking On Definition of "Waters of the United States," Docket ID No. OW-2002-0050, 2 (Apr. 16, 2003) ("Even if we manage to fill the gaps that would be created by a redefinition of 'Waters of the U.S.' in Indiana, nothing guarantees that all of our nearby states will also fill these gaps."); Vermont Dep't of Envtl. Conservation, Comments on Advance Notice of Proposed Rulemaking On Definition of "Waters of the United States," Docket ID No. OW-2002-0050, 8 (2003) ("Vermont cannot control its own destiny and must rely on effective, uniform regulation at the federal level to manage these out-of-state resources that significantly impact the state's economy.").
[499] 33 U.S.C. § 1342(b).
[500] *Id*. at § 1342 (a)(2).
[501] *Id*. at. § 1341.
[502] *See* S.C. DEP'T OF HEALTH AND ENVTL. CONTROL, FACT SHEET: FRESHWATER WETLANDS MANAGEMENT 1 (Mar. 7, 2003) (stating that "applications are reviewed for consistency with the SCCMP, which includes policies for managing freshwater wetlands without distinction between isolated & contiguous wetlands"), http://www.scdhec.gov/HomeAndEnvironment/Docs/FS_FWM.pdf.
[503] *See* ENVIRONMENTAL LAW INSTITUTE, STATE CONSTRAINTS: STATE-IMPOSED LIMITATIONS ON THE AUTHORITY OF AGENCIES TO REGULATE WATERS BEYOND THE SCOPE OF THE FEDERAL CLEAN WATER ACT 203 (May 2013), https://www.eli.org/sites/default/files/eli-pubs/d23-04.pdf.
[504] *See* VIRGINIA DEP'T OF ENVTL. QUALITY: REPORT TO THE LEGISLATURE, STATE ASSUMPTION OF FEDERAL § 404 CLEAN WATER ACT PERMITTING PROGRAM FEASIBILITY STUDY 2 (Dec. 2012).

states would lose their only tool for preventing discharges of dredged and fill material in their waters.[505]

The proposed rollbacks would also mean that the number of waters for which states develop water quality standards would be radically reduced. The agencies correctly describe water quality standards as "the foundation for a wide range of programs under the CWA."[506] Without them, water quality is guaranteed to further deteriorate. To be sure, "[t]hey serve multiple purposes including establishing the water quality goals for a specific waterbody, or portion thereof, and providing the regulatory basis for establishing water quality-based effluent limits beyond the technology-based levels of treatment required by Clean Water Act sections 301(b) and 306."[507] States must "hold a public hearing to review their standards at least once every three years (i.e., triennial review)," and the EPA must "review and approve or disapprove" any new or revised state standards for "waters of the United States."[508] States must develop total maximum daily loads (TMDLs) for waters that are not meeting established water quality standards and must submit those TMDLs to EPA for approval.[509] But states are only required to develop water quality standards for "waters of the United States."[510] For waters that are no longer jurisdictional, water quality standards and the associated requirements (TMDLs, triennial reviews) "would not be in effect for Clean Water Act purposes."[511]

Against this backdrop, many states would not replace federal clean water protections with state protections. They would more likely revert to the pre-1972 actions that pitted state against state, sacrificed water quality in favor of industrial polluters, and gave rise to the need for the bipartisan Clean Water Act in the first place.

IX. THE LEGISLATIVE HISTORY OF THE CLEAN WATER ACT CONFIRMS THAT CONGRESS INTENDED THE ACT TO APPLY BROADLY TO PROTECT THE NATION'S WATERS.

Congress's intent in enacting the Clean Water Act is clear. Set out in the first section of the statute, the Clean Water Act's objective "is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[512] This unequivocal objective incorporates Congress's "broad, systemic view of the goal of maintaining and improving water quality."[513] As "the House Report on the legislation put it, the word 'integrity' . . . refers to a condition in which the natural structure and function of ecosystems [are] maintained."[514] "Protection of aquatic

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[505] *See* 2018 Resource and Programmatic Assessment at 13.
[506] *Id*. at 70.
[507] *Id*.
[508] *Id*. at 71.
[509] *Id*. at 72.
[510] 40 C.F.R. § 131.3(i) ("Water quality standards are provisions of State or Federal law which consist of a designated use or uses for the *waters of the United States* and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the Act.") (emphasis added).
[511] 2018 Resource and Programmatic assessment at 72.
[512] 33 U.S.C. § 1251(a).
[513] *Riverside Bayview Homes*, 474 U.S. at 132-33.
[514] *Id.* (quoting H.R.Rep. No. 92-911, at 76 (1972) (alterations in original)).

ecosystems, Congress recognized, demanded broad federal authority to control pollution because '[w]ater moves in hydrologic cycles and it is essential that discharge of pollutants be controlled at the source.'"[515] If the sources of our waterways were not included, Congress realized that it could not accomplish its goal of cleaning up the Nation's waters—polluters could release toxins into those waters, which would wash down into larger waters downstream. It would have been futile for Congress to pass the Clean Water Act but not extend its protections to, as the agencies propose, "physically remote wetlands and wetlands lacking a direct hydrologic surface connection"[516] (*i.e.*, non-floodplain wetlands) or small streams that, in some areas, comprise 80 percent or more of the stream miles in a watershed.

In keeping with these views, the Clean Water Act prohibits the unauthorized discharge of any pollutant—including dredged or fill material—into "navigable waters," defined as the "waters of the United, States, including the territorial seas."[517] Congress's use of the term "waters of the United States" was a deliberate rejection of the more limited concept of traditional navigable waters, in recognition of the fact that such a narrow focus was ill-suited to the Act's water quality goals.

The House and Senate Committees expressed concern that "navigable waters" might be given an unduly narrow reading.[518] While the House emphasized the Act's scope should be "given the broadest possible constitutional interpretation,"[519] and the Senate report spoke to the scientific reality of waters being interconnected, both signaled their desire to extend the reach of the act to "navigable waters, portions thereof, and their tributaries, for the health of the 'aquatic ecosystem'" and "well-being of human society."[520]

When the House and Senate met in conference committee, they took an additional step to ensure that the definition of "navigable waters" did not result in unduly narrow interpretations. As discussed in the report of the Conference Committee, the word "navigable" was deleted from the from the Act's definition of "navigable waters." Thus, the definition of navigable waters read: "The term 'navigable waters' means waters of the United States, including the territorial seas."[521] In explaining this change, the Conference report emphasized the same point made in the House: the term "navigable waters" must "be given the broadest possible constitutional

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[515] *Id.* (quoting S.Rep. No. 92-414, at 77 (1972)).
[516] 84 Fed. Reg. at 4,189.
[517] 33 U.S.C. §§ 1311(a), 1344, 1362(6), 1362(7).
[518] H.R. Rep. No. 92-911 at 131 (1972); S. Rep. No. 92-414 at 77 (1971).
[519] H.R. Rep. No. 92-911 at 131 (1972).
[520] S. Rep. No. 92-414, at 76-77 (1972) (requiring "that any changes in the environment resulting in a physical, chemical or biological change in a pristine water body be of a temporary nature, such that by natural processes, within a few hours, days or weeks, the aquatic ecosystem will return to a state functionally identical to the original"); *see also* H.R. Rep. No. 92-911, at 76-77 (1972) (discussing the goal of the legislation as preserving natural ecosystem structure and function); Br. for the Honorable John D. Dingell, The Honorable John Conyers, Jr., The Honorable Robert F. Drinan, The Honorable Gary W. Hart, The Honorable Kenneth W. Hechler, The Honorable Charles McCurdy Mathias, Jr., The Honorable Paul N. McCloskey, Jr., The Honorable Charles B. Rangel, and the Honorable Senator Richard Schultz Schweiker, as Amici Curiae in Support of the Respondent at 11, *Rapanos v. United States* (Nos. 04-1034, 04-1384) (Jan. 2006) ("Amicus Br. of Congress").
[521] S. Rep. No. 92-1236 at 144 (1971).

interpretation unencumbered by agency determinations which have been made or may be made for administrative purposes."[522]

The debate in Congress confirmed the intent that the Act's clean water protections apply broadly. Congressman John Dingell, an architect of the Act, explained the term "navigable waters" must be read "broadly for *water quality purposes*," meaning "all 'the waters of the United States' in a geographical sense"[523]—"*all water bodies, including main streams and their tributaries.*" [524]

Representative Dingell's statements, read together with the manner in which both the Senate and House committees defined the breadth of Clean Water Act jurisdiction, belie any possibility that Congress intended to focus on a narrow subset of waterbodies.[525] Because "aquatic ecosystems" consist of "intricately connected hydrological systems," this legislative history confirms Congress's understanding that protecting traditional navigable waters requires protecting the aquatic ecosystem as a whole.[526] It also clarifies that the Act "covers not only traditionally navigable waterways, but smaller streams, all tributaries, and wetlands that form components of and are essential to the 'chemical, physical, and biological integrity' of the larger aquatic ecosystem."[527]

Any doubt that remains concerning the intended reach of the Clean Water Act is laid to rest by looking at the 1977 amendments to the statute. Congress hotly debated proposals to limit the jurisdictional reach of section 404, including one proposal by Senator Lloyd Bentsen of Texas that would have limited jurisdiction to the "traditional navigable waters and their adjacent wetlands."[528] Arguing against Senator Bentsen's proposal, Senator Gary Hart (D-Co.) emphasized the connectivity of all waters,[529] the importance of broad clean water protections to the national interest, and the conference committee's adoption of broad clean water protections:

> The Congress can permit activities of a dredge-and-fill nature to go forward on those small streams, marshes, wetlands, and swamps which will make their way into the bigger waterways of this country and have a tremendous adverse effect on the people of this country and on their welfare, on their crops, on many of their activities. Or we can establish a program of the sort the committee has established, which will protect all of those water systems; which will protect all of the elements of those systems . . . .[530]

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[522] S. Conf. Rep. No. 92-1236 at 144 (1972).
[523] 118 Cong. Rec. 33,756-33,757 (statement of Sen. John Dingell (D-Mich.) (daily ed. Oct. 4, 1972) (emphasis added)
[524] *Id*. (emphasis added).
[525] Amicus Br. of Congress at 13.
[526] Amicus Br. of Congress at 14.
[527] *Id*.
[528] 123 Cong. Rec. 26,690, 26,710-11, 26,726 (Aug. 4, 1977) (amendment of Sen. Bentsen).
[529] 123 Cong. Rec. 26,713 (daily ed. Aug. 4, 1977) ("So now what the Senator from Texas is suggesting is that we are only going to treat the cancer if it occurs in the trunk of the body, but not allow any treatments for the arms or the legs, so that if you have cancer in the hand, the arm, the foot, or the knee, we cannot treat that even though it may spread to the rest of the body or cause the loss of that limb.").
[530] 123 Cong. Rec. 26,713 (1977).

On the other side of the aisle, Howard Baker, a Senator from Tennessee, similarly stressed the importance of uniform federal protections and comprehensive coverage for the "protection of the aquatic environment." He understood that the discharge of pollutants—whether into "small streams or into major waterways," "marshes," or "swamps"—threaten the "entire resource" because these "once seemingly separable types of aquatic systems are, we now know, interrelated and interdependent." In Senator Baker's opinion, downstream water users should not suffer the pollution of those located upstream. Whether it is to protect the ecological integrity of the Nation's waters or the wellbeing of the businesses that rely on those waters, Congress determined that selecting only certain waters for protection would not address the water-quality crisis facing the Nation.[531]

The Committee Report affirmed Congress's view that the "Clean Water Act exercised comprehensive jurisdiction over the Nation's waters to control pollution to the fullest constitutional extent."[532] In the end, Congress rejected proposals to narrow the scope of Clean Water Act jurisdiction.[533] Senator Bentsen conceded that the "program would still cover all waters of the United States, including small streams, ponds, [geographically] isolated marshes, and intermittently flowing gullies."[534] Congress endorsed the significant relationship between these waters and water quality; it intended to protect all interconnected waters to restore and maintain the integrity of the Nation's waters. In light of this history, the current proposal is indefensible.

X. CONSISTENT WITH THE LEGISLATIVE HISTORY, JURISDICTION UNDER THE CLEAN WATER ACT MUST BE CONSTRUED BROADLY TO PROTECT THE NATION'S WATERS.

Consistent with Congress's view,[535] EPA's Connectivity Report for the 2015 Clean Water Rule,[536] and the over 1,200 peer-reviewed scientific studies that support that report, headwater streams, wetlands, and other waters are critical to protecting the biological, chemical, and physical integrity of larger waterbodies.[537] This conclusion is corroborated by numerous other scientific studies and the attached Literature Review,[538] and is illustrated in Figures 1 and 2 from the Connectivity Report below, which show the hydrologic and biologic interconnectivity of waters. The health of streams, wetlands, and open waters directly affects the health of larger downstream rivers, lakes, estuaries, and oceans. They must be protected to ensure the integrity of the Nation's waters.

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[531] 123 Cong. Rec. 26718 (1977) (emphasis added).
[532] S. Rep. No. 95-370, at 75 (1977).
[533] 123 Cong. Rec. 26,707 (1977); U.S. EPA, Technical Support Document for the Clean Water Rule of the United States 424 (May 2015).
[534] 123 Cong. Rec. 26,711 (Aug. 4, 1977).
[535] 33 U.S.C. § 1251(a).
[536] *See* 80 Fed. Reg. at 37,062; *see generally* EPA Connectivity Report.
[537] *See generally* EPA Connectivity Report.
[538] *See generally*, Ex. A, Literature Review.

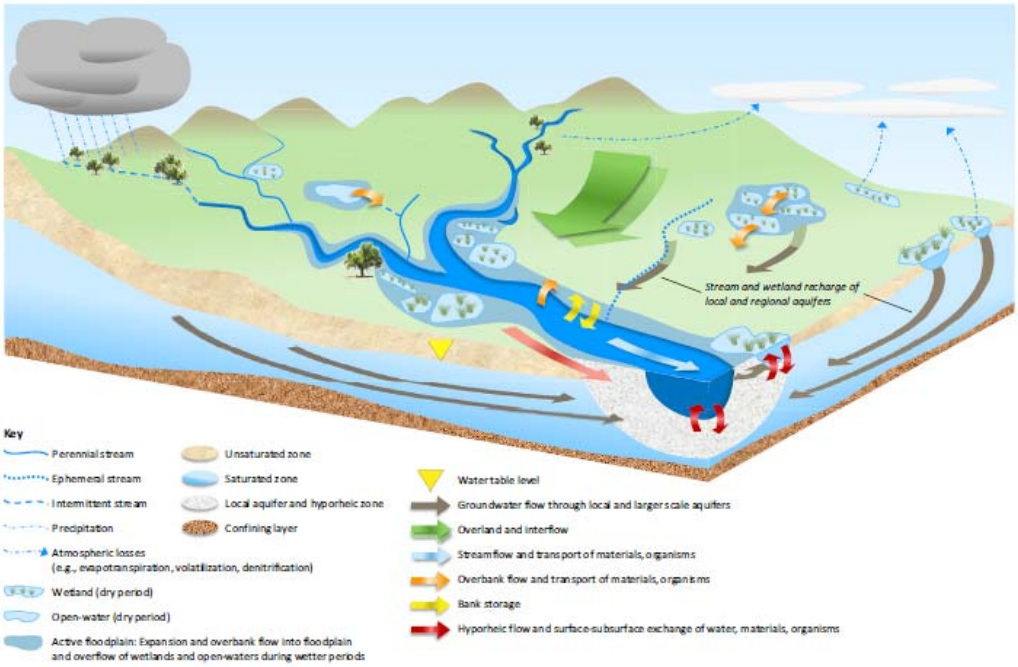

FIGURE 1. Hydrologic flow paths. Arrows are representative of surface water and groundwater flows occurring throughout a watershed. Subsurface flows are shown within the cross section, and by faded arrows outside the cross section. Source: USEPA (2015). [539]

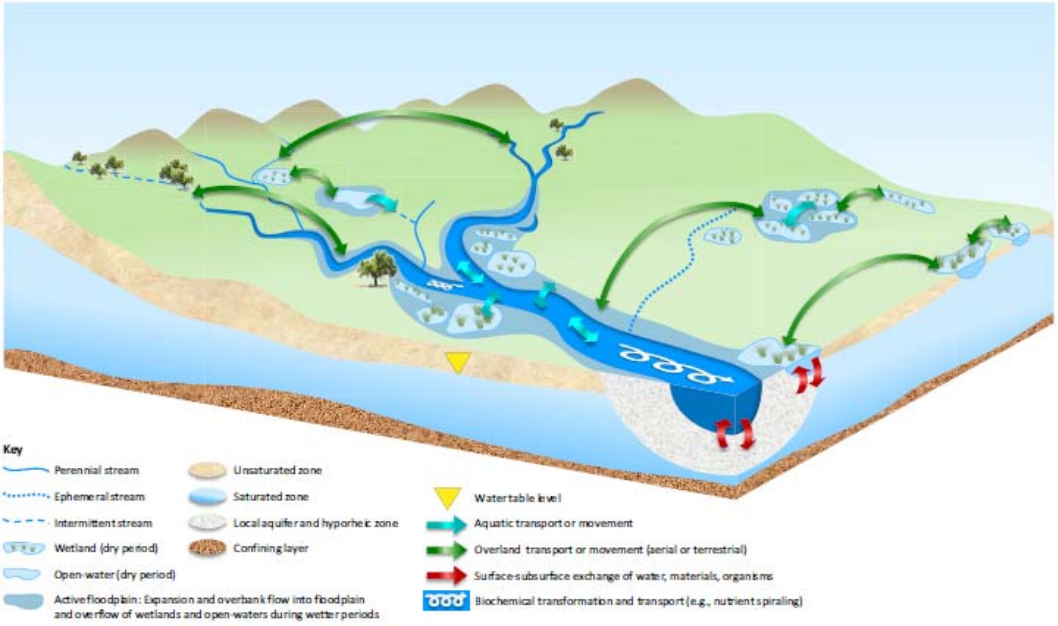

FIGURE 2. Biological pathways. Arrows are representative of biological pathways occurring throughout a watershed. This figure also includes representative biogeochemical pathways occurring in streams and floodplains. Source: USEPA (2015). [540]

[539] EPA Connectivity Report at 1-5; Alexander et al., *supra* note 265, at 289.
[540] EPA Connectivity Report at 1-6; Alexander et al., *supra* note 265, at 291.

A. The Protection of Intermittent and Ephemeral Streams and Headwaters Is Essential to the Chemical, Physical, and Biological Integrity of Downstream Waters.

Intermittent and ephemeral streams and headwaters ("small streams") make up a majority of the stream miles in the United States,[541] and they impact the chemical, physical, and biological integrity of our waters. Intermittent and ephemeral streams alone comprise 79 percent of river length in the coterminous United States, and they directly drain over 70 percent of the land area, underscoring the need for their protection.[542] In arid and semi-arid states, including Arizona, New Mexico, Nevada, Utah, Colorado, and California, over 81 percent of stream miles have been classified as ephemeral or intermittent.[543] Even in some non-arid states, intermittent streams are predominant; in Alabama, 80 percent of stream miles on national-forest lands are classified as intermittent.[544] The importance of these small streams to the Nation's clean and safe drinking water is indisputable. Not only do these waters sustain fisheries and important ecosystem functions,[545] they are the source of drinking water for 200 million Americans.[546]

Perennial, ephemeral, or intermittent headwater streams, whether considered individually or cumulatively, impact downstream flooding, base flows, water quality, and the entire food chain.[547] The processes occurring upstream within these waters affect the entire river network's chemical, physical, and biological structure and function.[548] For the health of larger downstream rivers, estuaries, and oceans, these waters cannot be ignored.

1. Ephemeral, intermittent, and headwater tributaries are essential to maintaining the chemical integrity of downstream waters.

Small streams, regardless of flow permanence, control the transport of pollution, nutrients, and carbon to downstream waters. Through filtration, sequestration, storage, and

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[541] *See, e.g.*, Colvin et al., *supra* note 112, at 74, 77, 86.
[542] *Id*. at 74.
[543] Lainie R. Levick et al., The Ecological and Hydrological Significance of Ephemeral and Intermittent Streams in the Arid and Semi-arid American Southwest, U.S. EPA and USDA/ARS Southwest Watershed Research Center, EPA/600/R-08/134, ARS/233046 (2008); Goodrich et al., Southwestern Intermittent and Ephemeral Stream Connectivity, JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION 401 (Apr. 2018).
[544] J.L. Meyer et al., Comments of Professional Aquatic Scientists on Advanced Notice of Proposed Rulemaking for on the Clean Water Act Regulatory Definition of "Waters of the United States" (Docket ID No. OW-2002-0050) 2 (Apr. 10, 2003) ("AQ Scientists Comments").
[545] Colvin et al., *supra* note 112, at 74.
[546] SELC GIS Analysis; *see also* U.S. EPA, GEOGRAPHIC INFORMATION SYSTEMS ANALYSIS OF THE SURFACE DRINKING WATER PROVIDED BY INTERMITTENT, EPHEMERAL, AND HEADWATER STREAMS IN THE U.S. ("EPA, GIS Analysis"), *available at* http://water.epa.gov/lawsregs/guidance/wetlands/surface_drinking_water_index.cfm (117 million).
[547] *See generally* AQ Scientists Comments; Goodrich et al., *supra* note 543, at 402; Alexander et al., *supra* note, 265, at 291; Fritz et al., Physical and Chemical Connectivity of Streams and Riparian Wetlands to Downstream Waters: A Synthesis, JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION (Apr. 2018).
[548] *See generally* AQ Scientists Comments; Goodrich et al., *supra* note 543, at 402; Alexander et al., *supra* note, 265, at 291.

accumulation of toxins by microorganisms, algae, plants, and animals,[549] they prevent pollution and excess nutrients from entering downstream community water supplies, rivers, lakes, and eventually estuaries.[550] Dryer phases in intermittent and ephemeral streams allow precipitation and runoff to pass through soil and bed material, providing further opportunities for filtering pollution before it enters groundwater and downstream waterways.[551] This overall reduction in pollutants decreases the cost of water treatment, the degradation of downstream water quality, and the risks to human health and aquatic life while improving recreational opportunities such as fishing. Where small headwater streams are polluted, the impacts can be felt throughout a watershed, including in downstream perennial streams and rivers. [552]

Small streams process nitrogen, which is important because it decreases the loading of nitrogen to larger downstream waters.[553] Excess nitrogen exported downstream causes increased harmful algal growth, decreased light penetration, and reduced oxygen levels, which can lead to toxic water, fish kills, and economic damage.[554]

Small streams also transform and store carbon before it can be transported downstream.[555] They break down leaf litter and other organic matter, which ephemeral streams release downstream in pulses during storm events.[556] These pulses provide an important source of carbon for downstream animals.[557] Ephemeral streams—even more so than perennial—play a critical role in carbon sequestration, a process in which carbon is stored in sediment or taken up by organisms rather than being released into the atmosphere where it contributes to climate change.[558]

When intermittent and ephemeral streams are piped, buried or otherwise degraded, the intrinsic capacity of these stream reaches to purify water and process nutrients is compromised, which leads to declines in downstream water quality.[559] These processes are so important that having intact headwater streams is more predictive of downstream water quality than downstream factors such as local land use or riparian cover.[560]

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[549] *See generally* Thibault Datry et al., Flow intermittence and ecosystem services in rivers of the Anthropocene , JOURNAL OF APPLIED ECOLOGY (2017).
[550] Ex. A, Literature Review at 30-33; AQ Scientists Comments at 4; Fritz 2018.
[551] Ex. A, Literature Review at 30.
[552] Ex. A, Literature Review at 33.
[553] Ex. A, Literature Review at 31; Colvin et al., *supra* note 112, at 78; Judy L. Meyer et al., The Contribution of Headwater Streams to Biodiversity in River Networks, JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION 99 (2007).
[554] Ex. A, Literature review at 31; Colvin et al., *supra* note 112, at 76; Meyer et al., *supra* note 553, at 88.
[555] Ex. A, Literature Review at 30-31.
[556] Ex. A, Literature Review at 30-31.
[557] *Id*.
[558] *Id*.
[559] *Id.* at 33.
[560] *Id*.

2. Ephemeral, intermittent and small headwater streams contribute to the physical integrity of downstream waters.

Small streams are also physically connected to downstream waters. They retain and transfer sediment, organic matter, nutrients, contaminants, and heat energy to downstream waters.[561] They are closely connected with wetlands and groundwater flows, and are important in regulating the flow of water into downstream water bodies. An estimated 55 percent of the annual water volume in large rivers originates in small (first-order) streams, the majority of which only flow intermittently.[562] They also play an important role in replenishing groundwater in the arid West, which people heavily depend on for irrigation and drinking water.[563]

Small streams transport organic material, including large wood, from adjacent and upstream riparian systems, that are essential for the ecological condition of downstream ecosystems.[564] The provisioning of large wood for habitat development is crucial for aquatic species, including juvenile salmon and trout.[565]

Water temperature in small streams positively influences downstream waters and the species that depend on them.[566] For example, confluences with spring-fed streams were identified as the coldest patches along a northeastern Oregon river that otherwise had summer water temperatures too hot for native salmonids to survive.[567]

3. Ephemeral, intermittent, and headwater tributaries contribute to the biological integrity of downstream waters.

Small streams provide vital habitat and protection for insects, fish, mussels, and plants. Most aquatic species spend at least some portion of their lifecycle in perennial, intermittent, or ephemeral streams. "Ephemeral headwater streams can support levels of aquatic invertebrate diversity and abundance comparable to, or greater than, those estimated for perennial headwaters, as well as plants and animals found nowhere else in the watershed."[568]

a. Small streams serve as vital spawning habitats.

Small streams provide essential breeding habitat for numerous species, many of which live in larger waterbodies during most of the year.[569] The trispot darter, for instance, spends most months in large perennial streams, but "moves upstream to spawn and attaches its eggs to submerged blades of grass in tiny rivulets that flow from ephemeral ponds in fields."[570] In the Southeast, ephemeral streams can also have important aquatic life and hydrology functions during periods of protracted rainfall and related high local water tables.[571] In the Southwest, dry

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[561] *E.g.*, Fritz et al., *supra* note 547, at 329-330.
[562] Ex. A, Literature Review at 32; Fritz et al., *supra* note 547, at 327.
[563] 2018 Economics Analysis at 195.
[564] Colvin et al., *supra* note 112, at 77.
[565] *Id*.
[566] *E.g.*, Fritz et al., supra note, at 329.
[567] *Id*.
[568] Colvin et al., *supra* note 112, at 76.
[569] AQ Scientists Comments at 6.
[570] *Id*.
[571] Ex. B, Moffat & Nichol 2019 at 3-4.

streambeds are "seed and egg banks" for aquatic biota, and when flowing, disperse these downstream.[572] Many ephemeral headwaters of the western Great Plains and dry valleys of the intermountain West are important habitats for many minnows, suckers, sunfishes, and darters during months when they have water.[573] Intermittent streams are also important spawning and refuge habitats for trout, darters, minnows, suckers, and other fishes, including federally listed Coho salmon and Chinook salmon, whose juveniles occupy headwater tributaries and seasonal floodplain wetlands during winter.[574] Degradation of these habitats would impact the viability of fish populations in the entire watershed.[575]

b. Small streams serve as nursery habitat for juvenile fish.

Small headwater streams serve as vital nursery areas for numerous fish species, including brook trout.[576] Intermittent streams provide rearing habitat for juvenile Chinook salmon and Coho salmon.[577] Juvenile Coho salmon that inhabit pools in intermittent headwater streams in Oregon are larger than those from perennial streams in the same river.[578] Because larger Coho have higher ocean survival rates, the loss of these intermittent streams could be detrimental to salmon populations.[579]

c. Small streams provide a thermal refuge at critical life stages or during critical times of the year.

Small streams serve as a thermal refuge for species that spend most of their lives in larger river systems.[580] The Arkansas darter, a federal candidate darter species, uses small streams as a summer time refuge from heat and drought in the Ozarks.[581] Unpolluted headwaters are also essential for maintenance of coldwater fish, including Chinook Salmon, Coho Salmon, and Brook Trout.[582] Groundwater is often warmer than stream water during winter, so small spring-fed streams also provide a refuge from freezing for stream fishes.[583] Given climatic extremes, access to thermal refuges such as those provided by small spring-fed streams is important for stream fishes' survival.[584]

d. Small streams provide critical habitat for unique and threatened species.

Ephemeral and intermittent headwater streams provide critical habitat for diverse and often unique communities of aquatic organisms. The degradation and elimination of these streams increases the chance of extinction for aquatic invertebrate, amphibian, and fish species.

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[572] Colvin et al., *supra* note 112, at 78.
[573] *Id*. at 81-82.
[574] Colvin et al., *supra* note 112, at 80-81.
[575] *E.g.*, AQ Scientists Comments at 6.
[576] *Id*.
[577] *Id*.
[578] Colvin et al., *supra* note 112, at 81.
[579] *Id*.
[580] Colvin et al., *supra* note 112, at 78. 2019; AQ Scientists Comments at 5-6, 8.
[581] Colvin et al., *supra* note 112, at 78. 2019; AQ Scientists Comments at 5, 7.
[582] Colvin et al., *supra* note 112, at 78. 2019; AQ Scientists Comments at 5-6.
[583] Colvin et al., *supra* note 112, at 78. 2019; AQ Scientists Comments at 6.
[584] AQ Scientists Comments at 6.

In the National Forests of Alabama, for example, 70 of the 113 "at risk" aquatic species live primarily in these headwater streams, including crayfish, mussels, snails, amphibians, and fish.[585]

Ephemeral and intermittent streams provide vital habitat for amphibians, many of which are state and/or federally threatened and endangered, such as Chiricahua leopard frog.[586] Keeping headwaters free from sediment, silt, excessive nutrients, and toxins is critical, as amphibians are especially sensitive to changes in water quality.[587]

Headwater streams also support endangered and threatened fish. In the Southeast, headwaters support the most biodiverse and imperiled freshwater fish communities in North America.[588] Often, species in ephemeral and intermittent headwaters are a subset of the species found downstream. For example, brook trout are found in both perennial and intermittent Appalachian streams.[589]

Headwaters often provide the last refuge for species threatened by loss of habitat elsewhere in the watershed. The federally endangered Yellowcheek Darter (endemic to the Boston Mountains of Arkansas) and the federally threatened Leopard Darter (endemic to a few headwater streams in the Ouachita Mountains of southeastern Oklahoma and southwestern Arkansas) depend on headwater streams for survival.[590] Protecting headwaters also enables the recovery and delisting of endangered fishes. The recently delisted Modoc Sucker is now abundant in intermittent and low-flow headwater streams in northeastern California and southern Oregon. Its delisting was in large part due to the protection of headwater tributaries and wetlands on public and private lands from threats like livestock grazing and stream channelization, which had eliminated refuge pools.[591]

B. Protecting Wetlands Is Essential to Restoring and Maintaining the Chemical, Physical, and Biological Integrity of the Nation's Waters.

Wetlands perform critical hydrological, physical, and biological functions affecting downstream systems.[592] They can be connected to downstream waters through ephemeral or intermittent streams, shallow subsurface-water, groundwater flows, and through biological and chemical connections.[593] Even where wetlands lack a visibly consistent surface-water connection to a river network, they are connected to downstream waters. These non-floodplain wetlands are

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[585] AQ Scientists Comments at 6-7.
[586] *Id*. at 7.
[587] Kurt A. Buhlman et al., Habitat Management Guidelines for Amphibians and Reptiles of the Southeastern United States, Technical Bulletin 22, 30 (2016).
[588] Ex. A, Literature Review at 28.
[589] *Id*. at 29.
[590] Colvin et al., *supra* note 112, at 84.
[591] *Id*.
[592] *See generally*, Dennis F. Whigham & Thomas E. Jordan, Isolated Wetlands and Water Quality, 23 WETLANDS 541, 541-49 (2003); Charles R. Lane et al., Hydrological, Physical, and Chemical Functions and Connectivity of Non-Floodplain Wetlands to Downstream Waters: A Review, JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION (Apr. 2018); Colvin et al., *supra* note 112; Ex. A, Literature Review.
[593] *Id*.

connected from an "ecological"[594] and functional perspective.[595] Even in the absence of hydrologic connections, they are connected by overland or aerial movements of aquatic and semiaquatic organisms and the materials that they retain and transport.[596]

Because of these connections, even wetlands that appear geographically isolated can have significant effects on the health of downstream waters. They recharge groundwater that sustains river baseflows; retain and transform nutrients, metals, sediment, and pesticides; export organisms to downstream waters; store and release floodwaters; and provide habitats for stream species.[597] Some of these functions are inversely related to their rate of connectivity (*i.e.*, slower connections could result in larger effects). For instance, wetlands that intercept storm runoff store water and process entrained materials (*e.g*., nutrients) may have a slow or diffuse connection with downstream waters (*e.g*., via groundwater or atmosphere), but the functional effect of retaining nutrients and stormwater may be great.[598] Accordingly, the loss of chemically, physically, or biologically connected, yet geographically isolated, wetlands would have negative effects on the quality of downstream waters, as well as the human and ecological communities that rely on them.[599]

1. Wetlands are essential to maintaining the chemical integrity of downstream waters.

Wetlands are commonly referred to as "nature's kidneys" because they provide a similar function by absorbing waste products from the environment.[600] They treat and retain pollutants including toxic chemicals, sediments, and harmful levels of nutrients like nitrogen and phosphorus, thereby reducing pollution in downstream waters.[601] Wetlands reduce nitrogen pollution in surface waters by converting polluting forms of nitrogen into harmless gaseous forms in a process called denitrification. Since some forms of nitrogen are highly mobile in groundwater, wetlands that do not have a surface hydrologic connection but have a sub-surface groundwater connection can be important to reducing nitrogen pollution to nearby surface waters.[602] While other ecosystems provide some denitrification only, wetlands have this tremendous capacity to intercept and remove nitrogen, thus maintaining the water quality of adjacent and downstream waters.

A wetland's relative "isolation" from downstream waters can increase its ability to restore and maintain the integrity of those downstream waters. For example, waterborne contaminants that enter a wetland cannot be transported to a river, except by non-hydrologic

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[594] Whigham & Jordan, *supra* note 592, at 23; s*ee generally*, Schofield et al., Biota Connect Aquatic Habitats Throughout Freshwater Ecosystem Mosaics, JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION (Apr. 2018).
[595] *E.g.*, Leibowitz et al., *supra* note 414, at 304.
[596] Schofield et al., *supra* note 594, at 375-376; Alexander et al., *supra* note 265, at 294.
[597] *See* Ex. A, Literature Review at 13, 17, 21-26; Lane et al., *supra* note 592, at 353; Alexander et al., *supra* note 265, at 294.
[598] Lane et al., *supra* note 592, at 347.
[599] *Id*.
[600] Ex. A, Literature Review at 13.
[601] *Id*. at 13-14.
[602] NAT'L RESEARCH COUNCIL, NAT'S ACADEMY OF SCIENCES, CLEAN COASTAL WATERS: UNDERSTANDING AND REDUCING THE EFFECTS OF NUTRIENT POLLUTION (2000).

pathways, if the wetland is hydrologically isolated from the river. Increased isolation can also decrease the spread of pathogens and invasive species. Draining or filling these wetlands decreases their ability to filter out pollution and sequester carbon, nitrogen, and phosphorus.[603] Altering wetland hydrology in this way prevents wetlands from absorbing pollution, negatively affecting downstream waters.[604]

2. Wetlands contribute to the physical integrity of downstream waters.

Wetlands maintain the physical integrity of downstream waters by capturing and storing large amounts of water, acting as sponges. Wetlands store surface water following precipitation events and moderate flow of adjacent and downstream waters.[605] As wetlands absorb flood water, run-off, and rain, they also filter pesticides, excess nutrients, sediment, and other pollutants, protecting the health of downstream tributaries, rivers, and wetlands.[606]

Long-term surface water storage in wetlands maintains the base flow and seasonal flow distribution in adjacent streams. Wetlands slowly release stored water through surface and sub-surface connections and "recharge" the streams maintaining flow during periods of low precipitation.[607] Carolina bays provide a flow-through wetland system, receiving groundwater contained in adjacent uplands and recharging the groundwater to lower topographic areas.[608]

Wetlands also play a key role in filtering out sediments that would otherwise harm downstream and adjacent waters.[609] Sediment adversely affects water quality by smothering streambeds destroying and degrading aquatic habitat.[610] Other toxic materials including pesticides, industrial wastes, and metals can also be bound to sediment and carried into water bodies. Wetlands may remove up to 80 percent of suspended sediments from the water that flows through them.[611] Sediment accumulation can be similar or even greater in non-floodplain wetlands compared to other wetlands.[612]

3. Wetlands play a critical role in ensuring the biological integrity of downstream waters.

Wetlands are important to the overall maintenance of biodiversity and the aquatic ecosystem. They play a critical role in ensuring the biological integrity of downstream waters by supporting the growth of plants and animals that form the basis of the aquatic food chain and

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[603] Ex. A, Literature Review 15.
[604] *Id*.
[605] Ex. A, Literature Review at 200; *E.g.*, AQ Scientists Comments at 3-4.
[606] *E.g.*, AQ Scientists Comments at 3-4.
[607] T.C. Winter, U.S. Geological Survey Circular, Groundwater and Surface Water: A Single Resource 1139 (1999).
[608] Ge Sun et al., Modeling the Climatic and Subsurface Stratigraphy Controls on the Hydrology of a Carolina Bay Wetland in South Carolina, USA, 26 WETLANDS 567, 567-80 (2006).
[609] Ex. A, Literature Review at 18-19.
[610] U.S. EPA, NATIONAL WATER QUALITY INVENTORY: REPORT TO CONGRESS (Aug. 2017), https://www.epa.gov/sites/production/files/2017-12/documents/305brtc_finalowow_08302017.pdf (last visited Apr. 8, 2019).
[611] John F. Elder & Gerald L. Goddard, Sediment and Nutrient Trapping Efficiency of a Constructed Wetland Near Delevan Lake, Wisconsin, 1993-1995.
[612] Ex. A, Literature Review at 15.

providing habitat for aquatic species, like fish that spawn in wetlands and move to open waters later in life.[613]

Non-floodplain wetlands provide greater habitat diversity compared to other wetlands due to the inherent variability of non-floodplain wetlands. Numerous rare, threatened, and endangered species depend non-floodplain wetlands in the Southeast, including:

- Rare species like the Hessel's hairstreak butterfly, the federally endangered pine barrens tree frog, and the specialized swallowtail, rely on pocosins for their habitat.[614]

- The federally endangered red-cockaded woodpecker inhabits mature pond pines in pocosins.[615]

- The North Carolina state-endangered eastern diamondback rattlesnake and American alligator are found in pocosins.[616]

- The *Lindera melissifolia* (common name Pondberry or Southern Spicebush), a federally endangered shrub, is endemic to isolated wetlands of the southeast.[617] Unfortunately, habitat availability is declining steeply for the species due to wetland conversion to other land uses.[618]

Many species travel between wetlands, thereby linking wetlands to one another and to other waters. The following exemplify the presence and movement of ducks, fish, amphibians, and reptiles in Southeastern wetlands:

- Wood ducks living in the riverine wetlands of the Tennessee-Tombigbee Rivers and Waterway in Alabama and at Noxubee National Wildlife Refuge in Mississippi travel from these traditional navigable waters to non-floodplain scrub-shrub wetlands to breed.[619]

- Green tree frogs, which are typically found in permanent lakes, ponds, and swamps, and occasionally in temporary ponds, interbreed with barking frogs, which dwell entirely in non-floodplain wetlands. Their hybrids return to these non-floodplain wetlands to breed.[620]

- The semi-aquatic Eastern mud turtle is a bottom-dweller of shallow, slow-moving water bodies and non-floodplain wetlands, but during the late summer and fall,

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[613] Ex. A, Literature Review at 10; Colvin et al., *supra* note 112, at 84.
[614] Ex. A, Literature Review at 13.
[615] *Id*.
[616] *Id*.
[617] *Id*. at 10-11.
[618] *Id*.
[619] Brian Davis et al., Survival of Wood Duck Ducklings and Broods in Mississippi and Alabama. 71 JOURNAL OF WILDLIFE MANAGEMENT 507, 507-517 (2007).
[620] Margaret S. Gunzburger, Differential Predation on Tadpoles Influences the Potential Effects of Hybridization between *Hyla cinerea* and *Hyla gratiosa*, 39 JOURNAL OF HERPETOLOGY 682, 682-87 (2005).

individuals leave their aquatic habitat for extended periods to overwinter on land. Movement between water bodies is common.[621]

- Chicken turtles, which are found primarily in shallow and seasonally fluctuating wetlands in the Southeastern United States but are rare in permanent wetlands, move distances of several hundred meters between non-floodplain wetlands.[622]

- Sirens and salamanders in the Savannah River Site in South Carolina colonize non-floodplain wetlands through temporary aquatic connections to other bodies of water.[623]

- Fish found in non-floodplain Carolina-bay wetlands in the Savannah River Site confirm surface-water connections between the wetlands and the Savannah River during times of wetland overflow flooding.[624]

- Red-spotted newts in a series of mountain ponds in the Shenandoah Mountains of Virginia migrate "en masse" every August and September, moving to and from ponds to breed.[625]

- Several species of aquatic and semi-aquatic worm snakes, found primarily in non-floodplain wetlands, formed clustered populations in the Lower Atlantic Coastal Plain of South Carolina during periods of inundation when wetland boundaries expanded and the wetland system became more interconnected.[626]

- Alligators in southern Georgia depend on seasonal wetlands, uplands, and creek-river systems at various times in their lives. As alligators progress from juvenile life stages to adulthood, they shift from using wetland habitat to using riverine habitat. Females also return to wetlands to breed.[627]

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[621] Leigh Anne Harden et al., Terrestrial Activity and Habitat Selection of Eastern Mud Turtles (Kinosternon subrubrum) in a Fragmented Landscape: Implications for Habitat Management of Golf Courses and Other Suburban Environments, 1 COPEIA 78, 78-84 (2009).
[622] Kurt A. Buhlmann et al., Ecology of Chicken Turtles (Deirochelys Reticularia) in a Seasonal Wetland Ecosystem: Exploiting Resource and Refuge Environments, 65 HERPETOLOGICA 39, 39-53 (2009).
[623] Joel W. Snodgrass et al., Influence of Hydroperiod, Isolation, and Heterospecifics on the Distribution of Aquatic Salamanders (Siren and Amphiuma) among Depression Wetland, 53 CAN. J. FISH. AQUAT. SCI. 443 (1999).
[624] Joel W. Snodgrass et al., Factors Affecting the Occurrence and Structure of Fish Assemblages in Isolated Wetlands of the Upper Coastal Plain, U.S.A., 53 CAN. J. FISH. AQUAT. SCI. 443, 443-454 (1996).
[625] Douglas E. Gill, The Metapopulation Ecology of the Red-spotted Newt, Notophtalmus viridescens (Rafinesque), 48 ECOLOGICAL MONOGRAPHS, 145, 145-166 (1978).
[626] Kevin R. Russell, Aspects of the Ecology of Worm Snakes (Carphophis amoenus) Associated with Small Isolated Wetlands in South Carolina, 33 JOURNAL OF HERPETOLOGY 339, 339-344 (1999).
[627] Amanda L. Subalusky et al., Ontogenetic Niche Shifts in the American Alligator Establish Functional Connectivity Between Aquatic Systems, 142 BIOLOGICAL CONSERVATION 1507, 1507-1514 (2008).

In addition to providing essential habitat for a variety of species, non-floodplain wetlands preserve biodiversity by allowing the formation of clusters of organisms on a regional scale.[628] This phenomenon has been documented extensively in populations of pond-breeding amphibians, like newts.[629] Individuals migrate between non-floodplain wetlands and navigable waters and their tributaries via overland corridors that connect them, forming clusters, which are essential to maintaining the integrity of local and regional populations.[630]

Each of these functions provided by small streams and wetlands serve to protect and enhance the integrity of the Nation's water, as well as the health and wellbeing of all who depend on clean water. They must be meaningfully considered by the agencies in the present rulemaking.

XI. CONCLUSION

Clean water is not a political issue. It is a basic right of every American. To be effective, the Clean Water Act must control pollution at its source: upstream in the headwaters and wetlands that flow downstream through communities to our major lakes, rivers, and bays. That was Congress's clear intent, and it is backed by science.

We urge the agencies to change course. We urge you to abandon the current proposal, which is sure to return us to pre-Clean Water Act conditions. We urge you to reaffirm the 2015 Clean Water Rule, or propose and carefully consider a revised rule that is as scientifically, legally, and ecologically sound as the 2015 Clean Water Rule. Our members and supporters, and communities across the country, will settle for nothing less than a Clean Water Act that protects the Nation's waters.

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[628] J. Whitfield Gibbons, Terrestrial Habitat: A Vital Component for Herpetofauna of Isolated Wetlands, 23 WETLANDS, 630, 630-635 (2003).
[629] Douglas E. Gill, The Metapopulation Ecology of the Red-spotted Newt, Notophtalmus viridescens (Rafinesque), 48 ECOLOGICAL MONOGRAPHS, 145, 145-166 (1978).
[630] *Id*.

Exhibit A

UNIVERSITY OF GEORGIA

Odum School of Ecology

April 8, 2019

To whom it may concern: Comments on "A Literature Review: The Chemical, Physical and Biological Significance of Geographically Isolated Wetlands and Non-Perennial Streams in the Southeast"

Overall evaluation and context:

The U.S. Environmental Protection Agency and the U.S. Army Corp of Engineers have proposed to rescind the 2015 Clean Water Rule. As a result, many of the nation's freshwater ecosystems are at risk of being removed from protection. These systems include headwater streams that can be ephemeral or intermittent in nature (non-perennial streams), and any wetlands that do not have a surface connection with or abut other jurisdictional waters. This literature review describes the rich variety of wetlands that do not have direct hydrologic surface connection (i.e., geographically isolated wetlands (GIW)) and ephemeral and intermittent streams in the Southeast U.S. The literature review focuses on the ecosystem services provided by these systems and uses a rigorous framework for their description, which includes supporting, regulating, provisioning and cultural ecosystem services. The ecosystem services described are irreplaceable and contribute to human health and well-being, now and in the future. The literature review also describes case studies of human modification of these systems and the benefits in ecosystem services gained with restoration of degraded systems and services lost with degradation. These case studies are useful to illustrate what is at risk in removing protection from these freshwater systems.

Assessment of the Ecosystem Services provided by GIW and Intermittent and Ephemeral streams:

Ecosystem services derive from the structural components of ecosystems and the emergent properties of those systems in terms of their functions. Ecosystem structures are the building blocks of systems, such as the animals (large and small) that live in the systems to do the 'work', the food resources they depend on, and aspects of pollution concentrations, substrate, and habitat that comprise natural and human-modified systems[1,2]. Ecosystem functions include the rates of carbon and nutrient cycling, fish production, pollution removal, primary production, and decomposition. Ecosystem services are defined by aspects of ecosystem structures and functions that are valued by humans. In many cases, the terms to describe ecosystem services are the same ones used by scientists for ecosystem structures and functions. In other cases, the terms for ecosystem services are focused on integrative functions of systems that people can perceive or see value in. Thus, natural functioning ecosystems provide biodiversity, fish production, drinking water purification, water quantity, aesthetic pleasure, etc. – all of which are either ecosystem structures and functions (e.g., fish production), human perception of those (e.g., drinking water purification = pollutant removal and nutrient cycling), or new perceptions based on the human-nature relationship (e.g, aesthetics and recreation, flood mitigation).

Geographically isolated wetlands provide a diversity of ecosystem services that include the rich variety of plants and animals that live in these systems, and in many cases are found only in these systems. Animals

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include not only small invertebrates, but also reptiles and amphibians, and the terrestrial animals such as birds that depend on these systems. These systems are critical for the retention of cycling of carbon, nitrogen, and phosphorus. Upland systems retain essential water, nutrient, and energy sources available for the production of freshwater animals and keep the unwanted transport of these materials from going too quickly downstream (in the case of excess water or nutrients). These systems play critical roles in flood mitigation and water purification. These systems also provide cultural and economic benefit to humans through enabling opportunities for fishing, hunting, tourism, and reducing negative economic impact to downstream systems.

Non-perennial streams also deliver a multitude of ecosystem services to humans. Southeastern rivers are known as the 'treasure chest' of species of fish and mussels found nowhere else on earth. Conservation of these systems, particularly non-perennial streams, is paramount to the conservation of many imperiled fish species. Headwater and non-perennial streams are the 'branches' of river networks. The retention and processing of energy and nutrients in the smallest branches of river systems affects all downstream functions and conditions. The literature review provides a comprehensive view of the function of non-perennial streams relative to larger rivers that are the 'trunks' of river systems. Large river 'trunks' can only function if the functions and services of small branches are conserved.

<u>What is gained when GIW and Intermittent and Ephemeral streams are conserved or restored?:</u>

Geographically isolated wetlands that have been conserved for decades provide unique and valuable services. These include those associated with Ellenton Bay, SC and Green Swamp, NC, and include support of the growth and survival of many different kinds of plant, bird, mammal, reptile and amphibian species. These include turtles, migratory waterfowl, bear, and orchids. Without suitable habitat, these organisms would not thrive or persist. The literature review outlines ecosystem services that have been gained through restoration of damaged GIW and non-perennial streams. These include increases in flood control and protection of downstream water quality and significant amenities associated with recreation.

This literature review provides a comprehensive view of the ecosystem services that geographically isolated wetlands and non-perennial streams provide to citizens of the U.S. It provides the scientific basis for our understanding of how those services are derived by exploring the underlying ecosystem structures and functions that work together to provide these services. These services are critical now for the health and vitality of the people and economies of the U.S. and will be needed for future generations of Americans. Removing protection from these systems compromises these servi es. The literature review is well-researched and supported by credible and many peer-reviewed sources. It provides a good overview of the chemical, physical and biological significance of geographically isolated wetlands and non-perennial streams in the Southeast, which is consistent with my own research, teaching, and experience.

Sincerely,

Amy D. Rosemond
Professor of Ecology
President-Elect, Society for Freshwater Science

References: [1]Palmer and Febria. 2012. The heartbeat of ecosystems. *Science* 336, 1393; [2]Kominoski and Rosemond. 2012. Conservation from the bottom up: forecasting effects of global change on dynamics of organic matter and management needs for river networks. *Freshwater Science* 31, 51-68.

A Literature Review: The Chemical, Physical and Biological Significance of Geographically Isolated Wetlands and Non-Perennial Streams in the Southeast

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1 Introduction

The Clean Water Act protects all "waters of the United States" from unpermitted discharges of pollutants. In 2015, the Environmental Protection Agency and the Army Corps of Engineers promulgated the Clean Water Rule. The Clean Water Rule was challenged immediately by states and industry in federal courts across the country. Currently, the Trump administration is attempting to repeal and replace the Clean Water Rule with another rule. The proposed replacement rule would not extend Clean Water Act protections to many types of wetlands that are currently jurisdictional, including geographically isolated wetlands, ephemeral streams, and possibly intermittent streams.

The purpose of this literature review is to identify and comment on peer-reviewed studies and federal reports that discuss the importance of GIWs, intermittent streams, and ephemeral streams. These studies are organized by ecosystem services defined in Section 3. The literature review is limited to studies conducted in Alabama, Georgia, North Carolina, South Carolina, Tennessee, and Virginia, as well as states that have similar geography to these states. Waters that are particularly important or well-studied have been developed into case studies.

2 Definition of Waters

2.1 Geographically Isolated Wetlands

The Scalia test excludes protection under the Clean Water Act for many currently jurisdictional wetland types, including so-called *geographically isolated wetlands* (GIWs). Named for their lack of apparent surface water outlets, GIWs can be both non-floodplain and riparian/floodplain wetlands (U.S. EPA, 2015) and are defined broadly as wetlands that are completely surrounded by uplands (Tiner, 2003). The distinction between wetlands and uplands is based on three criteria: vegetation, soils, and hydrology (Cowardin et al., 1979).

GIWs are considered isolated because they display unmeasurable or limited surface water connections to other surface waters (Golden et al., 2014). However, this does not imply functional isolation given that GIWs exhibit hydrological connections to other waters (Leibowitz, 2003; Tiner, 2003; U.S. EPA, 2015). Additionally, the strength of GIWs hydrological connection continuously varies (Leibowitz et al., 2018). For example, GIWs can spill over into adjacent surface waterbodies during periods of high precipitation (Winter and LaBaugh, 2003). The connections between GIWs and surface water can occur in a variety of ways including overland flow, groundwater flow, perched groundwater discharge, or horizontal near-surface flow (Golden et al., 2014; U.S. EPA, 2015; Leibowitz, 2003). The impact to groundwater flow can be wide spread, GIWs have been hydrologically connected over long distances (∼18 miles; Ameli and Creed, 2017). In regions dominated by GIWs, like the Carolina bays of the upper coastal plain of South Carolina, the combined effect of GIWs play a significant role in regulating flows to downgradient waters (Rains et al., 2016, see Section 5.3). These hydrological connections can also impact downstream biogeochemical conditions (i.e. nitrogen, phosphorus, and carbon; see Sections 5.2.2 and 5.2.3).

This suggests GIWs are better viewed as occurring along a constantly changing hydrological connectivity continuum

instead of geographically isolated waters (Leibowitz and Nadeau, 2003; Euliss et al., 2004).

GIWs are common, comprising 15.6% of the freshwater wetland area in the contiguous U.S. (Lane and D'Amico, 2016). In other studies, scientists have found that of 276 vegetative-based wetland systems in the U.S., 29% are considered to be geographically isolated (Comer et al., 2005). In the southeastern states of interest, GIWs range from 4.1% to 12.2% of the total freshwater wetland habitat area by state for a total of 1.7 million acres [1] (Table 1).

Table 1: Geographically isolated wetlands in the southeast. The frequency and area of geographically isolated wetlands in the southeast U.S. Values calculated by Lane and D'Amico, 2016.

State	Count of GIWs	Total GIW Area (acres)[a]	GIW % of Total Freshwater Wetland Area
AL	87,653	161,073	4.1
GA	163,334	651,411	12.2
NC	83,581	362,064	8.7
SC	103,991	398,005	10.7
TN	130,951	92,662	6.2
VA	64,906	116,975	8.7

[a] A conversion factor of 2.47 acres per hectare, rounded to nearest whole number, was used.

2.2 Wetlands found in the southeastern U.S.[2]

While most GIWs occur in depressions, some naturally isolated wetlands occur on slopes or on broad flats (U.S. EPA, 2002; Tiner, 2003). The GIWs of the southeastern U.S. fall into one of these three categories (depressions, slopes, or flats).

2.2.1 Depressional wetlands

Depressional wetland systems are located in topographic depressions where surface water can accumulate (U.S. EPA, 2002). A majority of GIWs belong to the depressional wetlands category (Brinson, 1993; Leibowitz and Nadeau, 2003). The specific types of depressional GIWs found in the southeastern U.S. are described below.

Carolina bay wetlands

A Carolina bay is an elliptical depression that occurs throughout the southeastern Coastal Plain from New Jersey to northern Florida, but is most abundant in southeastern North Carolina and mid-coastal South Carolina (Sharitz, 2003). They have a unique geomorphic structure and hydrology is dominated by precipitation inputs and evapotranspiration losses (Sharitz, 2003). Water levels fluctuate seasonally and among years, depending on rainfall and groundwater water levels. Thus, while some bays may have surface waters at all times, other bays may appear dry most of the time (Sharitz, 2003).

In addition to precipitation, bays can also obtain water from artesian wells, shallow groundwater and runoff during periods of high rainfall (Wells and Boyce, 1953; Lide et al., 1995; Sharitz, 2003). There is uncertainty regarding the extent to which Carolina bays are connected to groundwater, but it is generally understood that some bays seem to be influenced

[1] converted from reported 721,222 hectares

[2] Please note that not all wetlands that fall in the categories below are GIWs. Some are located adjacent to other covered waters.

by subsurface lateral flows (Lide et al., 1995). Typically, intact Carolina bays have no natural drainages and overland surface flows are minimal. However, a few Carolina bays have small creeks flowing into them and a few form the headwaters of perennial streams. For example, Lake Waccamaw, the largest Carolina Bay, drains into the Waccamaw River in North Carolina. Additionally, some Carolina bays have natural stream drainages, which lead to other bays at lower elevations (Sharitz, 2003). More commonly, Carolina bays are connected to other waters through man-made ditches designed to either drain uplands into the bay or drain the bay itself (Bennett and Nelson, 1991). In fact, Bennett and Nelson, 1991 found ditches in about 65% of the 2,651 bays in South Carolina.

Carolina bays range in size from less than 1 ha to over 3,600 ha (Sharitz, 2003). Generally, they are distinguished by a southeastern sand rim. It is estimated that approximately 10,000-20,000 Carolina bays currently exist. Carolina bays occur in areas of sandy surficial sediments across elevations ranging from several meters above sea level to more than 200m above sea level. Soils range from highly organic to mineral, and some larger bays in eastern North Carolina have peat layers up to 4.5m thick (Ingram and Otte, 1981). Temperatures fluctuate with the seasons, ranging from lows near freezing to highs of 31-33°C during the summer, creating a highly variable and unique habitat (Sharitz and Gibbons, 1982). There are 11 main types of Carolina bays based on vegetation associations: lakes, small depression ponds, vernal pools, pond cypress ponds, non-alluvial swamps, pond cypress savannas, depression meadows, low and high pocosins, small depression pocosins, pond pine woodlands, and bay forests (Sharitz, 2003).

Sinkhole wetlands

Sinkhole wetlands are typical of karst landscapes where the collapse of land surface creates distinct basins (Tiner, 2003). All six southeastern states of interest have karstlands, which are characterized by sinkholes, caves, and springs. Some of these wetlands receive groundwater discharge from underlying limestone deposits, while others occur in basins formed by dissolution of underlying limestone (Tiner, 2003). An underground network of fissures moves water rapidly through the system, and surface water entering the system can impact groundwater quality on a rapid time scale (Tiner, 2003).

Upland swamps

Upland swamps generally occur from Maryland to South Carolina (Fleming and Patterson, 2004). They are primarily found in small, shallow basins in upland settings where water pools due to limited soil drainage (Fleming and Patterson, 2004). Most upland swamps are found over mafic (a mineral group rich in magnesium and iron) bedrock (NatureServe, 2017). Shallow, seasonal flooding is induced by perched water tables during the winter and spring months (NatureServe, 2017). Hydroperiods are irregular and unpredictable (NatureServe, 2017).

Canopy cover in upland swamps ranges from open to complete cover (Fleming and Patterson, 2004). Upland swamps in northern Virginia typically have pin oak, swamp white oak, and red maple canopies, while those found in the Southern Piedmont usually have willow oak, sweetgum, and overcup oak canopies (Fleming and Patterson, 2004). In these wetlands, the central depression with standing water is surrounded by a ring of shrubs, and an exterior ring of trees (NatureServe, 2017).

2.2.2 Slope wetlands

Slope wetlands occur on slopes where groundwater discharges reach the surface of a slope. Typically these wetlands do not have the capacity for surface water storage (U.S. EPA, 2002). Geographically isolated slope wetlands found in the southeastern U.S. include hillside seeps, Southern Appalachian seepage wetlands, and fens.

Hillside seeps

Hillside seeps are small patch ecosystems found on moist to wet slopes in sandy terrain. These wetlands are most common from Texas to southwestern Georgia (Harper et al.,1998). Hillside seeps represent natural groundwater discharge points. They may be dominated by shrubs or herbs (including pitcher plants), with scattered trees such as pond, slash, or longleaf pine (McMillan et al., 2002). Most seeps in the state of Georgia are fire-suppressed. Fire exclusion in hillside seeps can allow woody species to invade (Harper et al.,1998).

The soils of hillside seeps are saturated by discharge of groundwater between an overlaying permeable sandy layer and relatively impermeable lower layer (Harper et al.,1998). Soils are generally acidic and nutrient poor (Harper et al.,1998). They are hydrologically unique in that they are nearly constantly saturated but never inundated (Bridges and Orzell, 1989).

Southern Appalachian seepage wetland

This distinctive wetland is found where groundwater discharges on gentle slopes in the Southern Appalachians (NatureServe, 2017b). They tend to be small and can be found over wide elevational range, but generally lacking from flat valley bottoms (NatureServe, 2017b). At higher elevations, these wetlands are typically associated with headwater streams (U.S. EPA, 2008). Vegetation varies from low to high elevation ranging from forb-dominated to moss- or sedge-dominated, respectively (NatureServe, 2017b).

Fens

Fens are distinguished by a strong connection to groundwater and often occur where groundwater becomes surface water (Bedford and Godwin, 2003). Southeastern fens are groundwater-fed wetlands richer in nutrients and less acidic than bogs, typically with a slow internal drainage through seepage on a gradual slope (Richardson and Gibbons, 1993). Fens are generally found in the southern Appalachian region of the southeastern U.S.

Fens develop where a relatively constant supply of groundwater to the plant rooting zone maintains saturated conditions and water chemistry reflects the mineral content of surrounding soils and geological materials (Bedford and Godwin, 2003). The degree to which groundwater dominates fen water budgets is a continuum, but in all cases the influence of groundwater exceeds that of precipitation and surface water (Bedford and Godwin, 2003). These wetlands rarely flood creating a unique environment that supports highly diverse vegetation and many uncommon fauna, including many federally listed endangered species (Bedford and Godwin, 2003). Fens tend to be isolated from other surface waters, but can feed headwaters (Bedford and Godwin, 2003). When connected to surface waters the flow is predominately unidirectional out

of the fen (Bedford and Godwin, 2003). Botanists distinguish fens from bogs by their vegetation, especially the presence of indicator species (Bedford and Godwin, 2003).

2.2.3 Flats wetlands

Flats wetlands are found in areas of low topographic relief, such as large floodplain terraces, with precipitation as the main source of water (U.S. EPA, 2002). Geographically isolated flats wetlands in the southeastern U.S. include pocosins and highland bogs.

Pocosins

Pocosin is an Algonquin Indian word meaning "swamp on a hill" (Richardson, 2003). Pocosins are classified as palustrine wetland ecosystems since they are nontidal wetlands and trees, shrubs, persistent emergent, and emergent mosses or lichens cover 30% of more of their area (Richardson, 2003). Pocosins are generally restricted to the southeastern coastal plain, occurring in broad, shallow basins, drainage basin heads, or on interfluves which are narrow plateau-like landforms between two valleys (Tiner, 2003). They occur from Virginia to northern Florida, but 70% of pocosins are in North Carolina and they comprise more than 50% of North Carolina's freshwater wetlands (Tiner, 2003). Pocosin vegetation consists of evergreen trees and broad-leaved evergreen shrubs (Tiner, 2003) .

Pocosins are distinguished by long wet and dry periods, ephemeral surface water, periodic burning and sandy humus, muck or peat soils (Richardson, 2003). Most pocosins are seasonally connected to drainageways leading to estuaries or contiguous with other wetlands that drain into perennial rivers, streams, or estuaries (Tiner, 2003). However, there are some isolated pocosins including small depressional pocosins and those located in the Sandhills of the Carolinas or seasonally saturated interfluves (Weakley and Schafale, 1991; Tiner, 2003). One of the major functions of pocosins is to temporarily hold water that would otherwise run off the land more quickly into adjacent estuaries (Tiner et al., 2002; Tiner, 2003).

Highland bogs

Bogs are defined by their nutrient-poor, acidic and saturated soils, and are usually found in low-lying areas filled by precipitation (Brinson, 1993). Mosses and shrubs flourish while mature trees are rare. They are distinguished by the presence of Sphagnum species or peat moss (Brinson, 1993). Found in the southern Appalachian region of the southeastern U.S., bogs are saturated with water for most of the year.

Bog wetlands in Tennessee are associated with flat sites in the Southern Blue Ridge and Cumberland Mountains (TN Wildlife Action Plan Team, 2015). These sites occur at elevations below 1,220 m in poorly drained bottomlands on soils which are often saturated (TN Wildlife Action Plan Team, 2015). Vegetation is a mixture of partially open vegetative zones, with herbaceous-dominated areas as well as shrub thickets and forested zones (TN Wildlife Action Plan Team, 2015).

2.3 Streams

A stream is defined as a visible, natural channel that contains a relatively small volume of flowing water, where the subsurface water flows in the same direction as the surface water. The water in a stream can spread out beyond its channel and flow laterally as well. The lateral flows connect streams to floodplains and riparian areas (U.S. EPA, 2015; Naiman and Bilby, 1998). A channel is a natural or constructed passageway or linear depression that conveys water and materials from higher to lower elevations, and is defined by continuous bed and bank structures or a permeable, uninterrupted bottom and lateral boundaries (U.S. EPA, 2015).

Under pre-2015 regulatory definitions of the Clean Water Act, tributaries of all defined waters of the U.S. are within Army Corps of Engineers jurisdiction (U.S. EPA, 2015). This standard includes "relatively permanent" streams, and those which are not relatively permanent but possess a "significant nexus" to traditional navigable waters (Grumbles and Woodley, 2008).

2.3.1 Intermittent and Ephemeral Streams

Different flow duration classes include perennial, intermittent, and ephemeral streams. The classes can be distinguished by the duration and magnitude of baseflow (U.S. EPA, 2015). Baseflow sustains streamflow between hydrologic events and originates from groundwater discharge or seepage.

Perennial streams have baseflow year round and streambed elevation is below surrounding groundwater elevation, that is, the groundwater table is higher than the bottom of the channel (U.S. EPA, 2015). In a representative southeastern U.S. watershed, the Chattooga River basin, perennial streams comprise approximately 19% of total headwater stream length (Hansen, 2001). Intermittent streams have seasonal baseflow and may or may not maintain a groundwater connection. Continuous flow occurs only at wetter times of the year, while at other times portions of an intermittent stream can be dry. In these systems, flow is derived from seasonal precipitation, ground-water or surface water sources and typically surface flow has a low residence time (U.S. EPA, 2015). Unlike intermittent streams, ephemeral streams lack baseflow and are above the water table at all times. These systems flow briefly (hours to days) during and immediately following hydrologic events such as precipitation or snowmelt leading to stormflow (Brooks, 2009; U.S. EPA, 2015). In practice, these two stream types are often combined for the purposes of research and reporting and termed "ephemeral streams."

These definitions are consistent in U.S. regulatory agency reports and the peer-reviewed, scientific literature.

When considering the legal protection of intermittent and ephemeral streams compared to those that are perennial, it is important to recognize that the flow duration class of a stream may change through time, and is subject to human impacts. For example, the Upper Kansas River Basin lost 21% of its stream length from 1950 to 1980 as the presumed result of extensive groundwater pumping and climate change (Perkin et al., 2017). Furthermore, losses of streams or changes in the flow duration class of streams are consistently underestimated because drainage networks are mapped at a coarse scale that overlooks a large proportion of small streams (Meyer and Wallace, 2001). For example, the USGS's best maps estimate the Upper Little Tennessee River drainage density at 1.23 $km\ km^{-2}$, however newer modeling techniques estimate the drainage density at 3.88 $km\ km^{-2}$ (Benstead and Leigh, 2012). This three fold difference in drainage density is most likely due to the inclusion of small streams; some of which are intermittent and ephemeral (Benstead and Leigh, 2012).

Traditional map-based approaches are potentially producing under-estimates of intermittent and ephemeral streams ecosystem services, especially biogeochemical regulating service since reach length is essential to calculating the service (Benstead and Leigh, 2012). This underscores the notion that legal protection of streams based solely on flow duration class risks haphazard and inconsistent overall stream protection.

2.3.2 Headwaters

Headwater streams are defined by agencies and peer-reviewed literature as low order streams (0-3) which are visible at the 1:100,000 map or image scale (Freeman et al., 2007; Nadeau and Rains, 2007; Meyer et al., 2007). Headwater streams comprise 50-70% of total stream length in the U.S. and can encompass all categories of streams (Nadeau and Rains, 2007). Approximately 50% of headwaters are considered intermittent or ephemeral (Nadeau and Rains, 2007). Headwaters are likely the most studied type of intermittent or ephemeral waters in the Southeast, therefore this review will draw heavily from this literature on headwaters and their restoration. Where possible, this review will distinguish between research conducted explicitly on ephemeral or intermittent headwaters and non-headwaters.

3 Definition of Ecosystem Services

The concept of an ecosystem service first emerged in the 1970s as a way to demonstrate human dependence on the environment (Gómez-Baggethun et al., 2010). In one of the first iterations, ecosystem services were defined as the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life (Daily, 1997). The ecosystem services concept uses a utilitarian framing of ecosystem functions that are beneficial to human well-being in order to promote conservation (Braat and de Groot, 2012) and the concept transcends boundaries, reaching the non-profit, private, and public sectors (Gómez-Baggethun et al., 2010). An analysis completed in 1997 estimated that the global value of ecosystem services was approximately $33 trillion USD annually in 1995 USD values (about $46 trillion USD based on values in 2007; Costanza et al., 1997). As of 2017, Costanza et al., 1997, the paper reporting this first global ecosystem service valuation analysis, has been cited over 18,000 times. An updated estimate values global ecosystem services at between $125-145 trillion USD annually (based on 2007 values), much of which is not captured in the GDP (Costanza et al., 2014).

The Millennium Ecosystem Assessment (MEA) was a four-year study with input from 1,300 scientists. Its release in 2005 put ecosystem services on the policy agenda (Gómez-Baggethun et al., 2010; Costanza et al., 2014). The MEA divided ecosystem services into four different categories: *supporting services*, *provisioning services*, *regulating services*, and *cultural services*. Supporting services refer to those services that are necessary to produce other ecosystem services, like nutrient cycling and soil formation (MEA, 2005). Provisioning services represent products that are directly obtained from ecosystems, like food and freshwater (MEA, 2005). Regulating services are benefits obtained from the regulation of ecosystem processes, like water purification (MEA, 2005). Lastly, cultural services are nonmaterial benefits from ecosystems, like recreation, ecotourism, and education opportunities (MEA, 2005). Changes in any of these service

types affect human well-being, both directly and indirectly, by impacting health, security, and more (MEA, 2005). The assessment further found that 60% of global ecosystem services are being degraded or used unsustainably, including freshwater and fisheries services (MEA, 2005).

4 Methods

Articles for this literature review were collected from the Web of Science citation database and Google Scholar search engine. Specific search terms are listed in the subsections below. This approach is a widely accepted method for identifying literature to be included in a review. The returned citations were then filtered for geographical appropriateness.

4.1 Wetlands

The literature synthesized for the wetlands portion of this review was found using the search terms "geographically isolated wetlands," "geographically isolated wetlands ecosystem services," and "isolated wetlands ecosystem services." Additionally, the Wetlands 2003 Special Issue on geographically isolated wetlands was used to identify important researchers in the field and is cited throughout this study (Nadeau and Leibowitz, 2003). Citations of this special issue were also tracked to find more recent relevant research on GIWs.

4.2 Streams

The search terms "ephemeral streams," "intermittent streams," "headwater streams," and "south-east US intermittent streams" were used to collect citations for this review. The 2007 Headwaters Hydrology featured collection of the Journal of American Water Resources Association was also important for identifying research on intermittent and ephemeral streams.

4.3 Spillover effects

In this review of the literature, special attention has been paid to spillover effects. Spillover effects refer to functions that occur in one location (e.g., within a geograpically isolated wetland) but have consequences that extend beyond that specific location. Many of the ecosystem services described in Section 5 and Section 7 can be thought of as spillover effects, and these effects are largely attributable to the connectivity of water across landscapes. Water found within geographically isolated wetlands, ephemeral streams, or intermittent streams, as well as the energy, material, and organisms associated with it, is unequivocally connected to larger downstream waters via groundwater and surface flows (U.S. EPA, 2015). Therefore, impacts to water within these temporary waterbodies can have profound effects on downstream wetlands, rivers, and lakes. These spillover effects can be found within each category of ecosystem service defined in Section 3. Thus, while examples of spillover effects are not always labeled as such in the followings sections, we have endeavored to highlight these spillover effects in our review of the ecosystem services of temporary waterways.

5 Ecosystem Services of Wetlands including Geographically Isolated Wetlands (GIWs)

5.1 Overview

The ecosystem services provided by GIWs directly and indirectly benefits humans (Costanza et al., 1997; MEA, 2005). The designation of "geographically isolated wetland" implies the wetland is separated from the landscape, and is misleading. Wetlands provide many ecosystem services such as providing habitat for species; retaining nutrients, sediments and pollutants; storage of floodwaters; recharging groundwater that eventually feed river baseflows; regulating the freshwater flow into estuaries; and providing recreational areas and supporting tourism. In all of these cases, GIWs differ from non-geographically isolated wetlands only in the amount of an ecosystem service provided. However, GIWs also provide unique services such as providing habitat for endemic and threatened species (Section 5.2.1); and the cultural significance of pre-historic and historic settlements found near Coralina bays (Section 5.5.2).

The amount of services provided per area differs by wetland characteristics including hydroperiod (duration filled with water), duration of surface water connectivity, size, shape and location. Wetland characteristics' impact on supporting services can be used as an example. Wetlands lacking surface water connection are often more efficient (ie. yield more human benefits per area) at retaining nutrients than similar wetlands with surface water connection to traditional navigable waters. For example, GIWs are often able to sequester more carbon when compared to wetlands with a surface water connection (see Section 5.2.3). Within GIWs, smaller wetlands are more efficient at retaining phosphorus, while larger wetlands are more efficient at retaining nitrogen (Marton et al., 2015). Many of the bioremediation supporting services provided are a function of the GIWs' perimeter to area ratio, rather than total volume or area, and are cheaper than constructing waste water treatment plants (see Section 5.2.2).

The landscape surrounding a GIW also impacts the ecosystem services provided. The small effects of individual wetlands accumulate over space and time to impact downstream waters (see Section 5.3). For example, downstream nutrient concentrations are both a function of biogeochemical processes within a GIW and the connections between waters that allow transport of nutrients (Fritz et al., 2018; Leibowitz et al., 2018; Goodrich et al., 2018; Lane et al., 2018).

A variety of wetlands, including those lacking surface water connections, need to be preserved to maintain the current level of services provided given the impact of wetland characteristics on the magnitude of ecosystem services.

The case studies for the geographically isolated wetlands section will focus on the ecosystem services provided by first reviewing preserved or intact GIWs (see Section 6.1). The second section focuses the ecosystem services gained through the more recent restoration of previously drained GIWs (see Section 6.2). These case studies are designed to highlight the timescale that ecosystem services are provided during the restoration process. Some services, like flood control, return almost immediately, while other services, like sequesting carbon in above ground biomass, have a longer lag time. Based on these case studies highlighting the resumption of ecosystem services gained from restoration we can inferr the adverse consequences of draining, and landuse conversion. In other words we assume that filling previously drained geographically

isolated wetlands, and draining geographically isolated wetlands have an equal but opposite effect on any ecosystem service.

5.2 Supporting services

5.2.1 Biodiversity

Geographically isolated wetlands provide greater habitat diversity on the landscape compared to non-isolated wetlands due to the inherent variability of GIWs. GIWs can be large or small, have wet and dry years, and long and short hydroperiods (Sharitz, 2003). Decision-makers tend to assume that larger wetlands are more important, but in fact smaller wetlands can be more valuable for maintaining biodiversity as populations depend on a landscape covered by a variety of wetlands. Further, the source and sink dynamic of isolated wetlands is crucial to the regional survival of species (Semlitsch and Bodie, 1998).

GIWs contribute to the larger landscape, providing a network of energy and chemical interactions for organisms that depend on the presence of surface water during some part of the year (Gibbons, 2003). Many species are highly dependent on GIWs for all of their life requirements including wetland plants and breeding amphibians (Kirkman et al., 1999). The habitat diversity of GIWs can support a range of habitat specialists that can lead to high species richness within and between wetlands (Leibowitz, 2003). GIWs increase biodiversity at multiple scales by contributing an aquatic feature in a terrestrial matrix (Calhoun et al., 2017). These aquatic features act as "stepping stones" within the matrix and provide a source of food and resting habitat for migrating species (Calhoun et al., 2017). For instance, the bullfrog spends winter months in deep-water habitats but migrates to ephemeral wetlands for both reproduction and feeding (Mushet et al., 2015). Mammals and birds use vegetation and wildlife (e.g., algae, invertebrates, amphibian eggs, etc.) in GIWs to supplement their diet (Calhoun et al., 2017). GIWs can also serve as important habitats for specific lifestages of animals: wetlands that act as nurseries for birds or fish may influence adult populations at other locations or times (Hoehn et al., 2003).

Isolation contributes to regional biodiversity by supporting connected populations or metapopulations of upland species (Leibowitz, 2003). Metapopulation dynamics consist of local extinctions of populations within certain habitat patches and subsequent recolonization from neighboring patches through dispersal (Leibowitz, 2003). Proposed changes to Clean Water Act jurisdiction could substantially increase the distance between isolated wetlands. As distance increases between wetlands, the potential for migration and recolonization decreases reducing the chances of a healthy population rescuing a neighboring declining population (Semlitsch and Bodie, 1998). Wetland mitigation often proposes to replace multiple, small wetlands with one big wetland but research on the topic specifically demonstrates that one 20 *ha* wetland does not equal 20 1-*ha* wetlands in terms of function (Semlitsch and Bodie, 1998).

GIWs are important because they provide habitat for a variety of species, ranging from mammals to plants to amphibians. Pocosins serve as refuges for mammals such as black bears, white-tailed deer, bobcats, marsh rabbits, and gray squirrels (NCASI, 2008). In one study conducted in 1985, scientists either trapped or observed 40 different mammal species in pocosins and Carolina bays (Clark et al., 1985; NCASI, 2008). *Lindera melissifolia*, a federally endangered shrub, is endemic to isolated wetlands of the southeast (Beckley and Gramling, 2013). Unfortunately, habitat availability

is declining steeply for the species due to wetland conversion to other land uses (Beckley and Gramling, 2013).

Amphibians and reptiles

GIWs provide valuable habitat for a multitude of amphibian and reptile species. Particularly, the southeastern U.S. is a global hotspot of amphibian biodiversity, many of these species are endemic and inhabit ephemeral wetlands (Duellman, 1999). The southeastern U.S. is also a hotspot for freshwater turtle diversity and richness (Mittermeier et al., 2015). Many of these species are as dependent on the terrestrial habitat surrounding GIWs for some aspect of their life cycle as they are on the wetlands themselves (Gibbons, 2003). Thus, the integrity of the associated uplands with geographically isolated wetlands is important from a biodiversity standpoint (Gibbons, 2003). Research shows that the survival of amphibian eggs, larvae and breeding adults is more likely if a wetland is isolated (Gibbons, 2003). More than 1,500 adult amphibians were observed in a 0.2 ha Alabama sinkhole wetland, including 527 mole salamanders, 127 eastern tiger salamanders, 269 gopher frogs, 241 southern leopard frogs, and 191 ornate chorus frogs (Tiner, 2003).

Within the southeastern Coastal Plain, GIWs provide breeding or primary habitat for 36 different amphibian species (Liner et al., 2008). A study by Liner et al., 2008 found that GIWs in Georgia had a mean species richness of 12.7 $\pm$ 0.5 species. The maximum species richness measured, 25 species, is similar to the most diverse wetlands in the southeast and across the U.S. (Liner et al., 2008). GIWs can also support extremely dense amphibian populations. For example, Ellenton Bay, a GIW in Atkin, South Carolina, has an estimated 38,612 individuals per hectare (Gibbons et al., 2006). The same study also estimated 159 $kg\ ha^{-1}\ year^{-1}$ of amphibian biomass was transferred from the wetland to surrounding uplands showing that GIWs can substantially contribute to overall productivity of the surrounding terrestrial systems (Gibbons et al., 2006). The position of GIWs among upland habitat is critical to supporting such high reptile and amphibian populations. Many species of amphibians in the southeastern Coastal Plain exhibit life histories that require both terrestrial and aquatic habitat. Adult salamanders and anurans migrate to GIWs for mating and egg deposition but return to upland habitats for the remainder of the year (Russell et al., 2002). The eggs hatch as aquatic larvae that develop in wetlands until metamorphosis (Russell et al., 2002). Survival rates of pond-breeding amphibian eggs and tadpoles in GIWs are higher than wetlands with surface water connections (Werner et al., 2009). The higher survival rate is a function of the GIWs lack of surface water connections, which prevent colonization of predatory fish species (Werner et al., 2009). After metamorphosis, juveniles head to adjacent terrestrial habitats where they stay until reproductive maturity. Associated uplands provide nesting habitat for freshwater turtles and snakes. Turtles also use terrestrial sites for hibernation or periods of dormancy (Russell et al., 2002; Gibbons, 2003). Many species live in underground caves associated with southeastern karst wetlands, like Georgia blind salamanders, cave shrimp, cave isopods, and cave amphipods (Tiner, 2003). Looking forward, several amphibian species associated with GIWs are ranked as most vulnerable to changes in climate through 2100 (Barrett et al., 2014). These species include the federally listed threatened frosted flatwoods salamander (Endangered and Threatened Wildlife and Plants; Final Rule To List the Flatwoods Salamander as a Threatened Species, 64 Red. Reg. 15,691, [15,691] (April 1, 1999)), currently petitioned for federal listing gopher frogs (Endangered and Threatened Wildlife and Plants; 90-Day Findings on 31 Petitions, 80 Fed. Reg. 37,568, [37,569] (July 1, 2015)), state-listed

striped newt, and the eastern tiger salamander which is of special concern in Georgia (GA DNR, 2015).

Carolina Bays

The shifting hydroperiods of Carolina bays create a variable environment, allowing for a diverse collection of plants and animals (Burbage, 2004). The large variation in plant communities among bays themselves and the presence of rare, endangered, and endemic species in Carolina bays contribute greatly to the biodiversity of the southeastern U.S. (Semlitsch and Bodie, 1998; Burbage, 2004; Leibowitz, 2003; Altman-Goff, 2016). In fact, Carolina bays exhibit levels of endemism that rival many global biodiversity hotspots (Altman-Goff, 2016). Bennett and Nelson, 1991 identified 23 different species within Carolina bays in South Carolina that are considered rare, threatened, or endangered. Thousands of amphibians were counted in a 1-ha Carolina bay at the Savannah River site in 1979 (Tiner, 2003). Over a two-year period, researchers collected over 72,000 amphibians from the same bay, including 9 species of salamanders and 16 species of frogs (Tiner, 2003). Kirkman and Sharitz, 1994 reported 56-105 species per bay from a sample of four Carolina bays at the Savannah River Site in Atkin, South Carolina. A study in 2000 found 27 species of frogs, toads, salamanders in the 0.5 ha Rainbow Bay in South Carolina, which represents one of the highest species diversities for amphibians in the region (Semlitsch and Bodie, 1998). This study recorded breeding activity of 41,776 females and production of 216,251 metamorphosing juveniles. Juvenile recruitment is generally higher in wetlands that seasonally dry out (Semlitsch and Bodie, 1998). Species richness in Carolina bays on the coastal plain of South Carolina ranged from 14 to 56 species per bay (Altman-Goff, 2016).

The Carolina bay seed bank, with an estimated 72,600 seedlings m^{-2}, is larger than reported for most other freshwater wetlands (Kirkman and Sharitz, 1994). The isolated nature of Carolina bays excludes aquatic predators that require permanent water, creating a sanctuary for prey species (Burbage, 2004; Richardson and Gibbons, 1993). A study comparing an undisturbed Carolina bay, a partially drained Carolina bay and a man-made pit found that fewer individuals metamorphosed at the pit compared to the undisturbed bay, with the lowest number at the partially drained bay (Pechmann et al., 1989).

Carolina bays have been recognized for extraordinary zooplankton diversity (Mahoney et al., 1990). In 1987, 23 Carolina bays on the upper coastal plain in South Carolina were sampled for zooplankton. These wetlands demonstrated remarkably rich zooplankton communities, including 44 species of cladocerans and seven species of calanoid copepods (Mahoney et al., 1990). Cladoceran richness was related to both bay size and hydroperiod. A comparison between zooplankton species richness in undisturbed and disturbed bays showed no differences, suggesting either that zooplankton communities are resistant to disturbance or that the bays had adequate time for recovery (Mahoney et al., 1990).

Research shows that bat activity is higher over undrained Carolina bays (Menzel et al., 2005). Furthermore, there is significantly more bat activity after bay restoration compared to prior, suggesting that Carolina bay restoration can have an immediate positive impact on bat activity (Menzel et al., 2005). Carolina bays are also important to bird species; bird species richness is greater in pine forests with Carolina bays than those without during winter months (Czapka and Kilgo, 2011). In 2012, NatureServe gave a global conservation rank of G1 (critically imperiled) or G2

(imperiled) to 27 different community associations found within Carolina bays, indicating the extent to which Carolina bays provide habitat for vulnerable organisms (Altman-Goff, 2016).

Pocosins

Like Carolina bays, pocosins also contribute to regional biodiversity in the southeastern U.S. At least 24 mammal, 48 reptile and amphibian, and 145 bird species occur in typical pocosin habitats (Zeveloff, 1983). Pocosins provide wildlife habitat for many animals including rare species like the Hessel's hairstreak butterfly, the federally endangered pine barrens tree frog, and the specialized swallowtail (Tiner, 2003; Richardson, 2003). The North Carolina state-endangered eastern diamondback rattlesnake and American alligator are found in pocosins (Richardson, 2003). Pocosins provide refuges for big game species like black bears and white-tailed deer. The federally endangered red-cockaded woodpecker inhabits mature pond pines in pocosins as well (Richardson, 2003). Pocosins are also important wintering places for migratory birds because of their location along migratory corridors and the availability of open, unfrozen water (Zeveloff, 1983). Pocosins can provide the large areas needed for breeding populations of neotropical migrant birds (Zeveloff, 1983).

In general, the loss of GIW habitats impacts a wide array of fauna, both permanent residents and passersby, and most prominently, turtles, amphibians, birds, and small mammals, many of which are threatened or endangered (Cohen et al., 2016). Southeastern GIWs are highly threatened habitats, receiving little legal protection and high levels of development pressure (Tiner, 2003). There is a need for realistic wetland conservation and restoration strategies in order to maintain southeastern biodiversity into the future (Liner et al., 2008).

5.2.2 Bioremediation and phytoremediation

Wetlands are commonly referred to as "nature's kidneys" because they provide a similar function by absorbing waste products from the environment. The physical and chemical properties of wetlands provide many positive attributes for remediating contaminants (Williams, 2002). High primary production and anaerobic soils allow for the retention of metals, nutrients, and pesticides in organic matter (Cohen et al., 2016). Phytoremediation, or the use of living plants to treat contaminants in soil and water, can be an effective, low-cost option for areas of moderate contamination (Weis and Weis, 2004). Wetland plant tissue uptakes elements that then become immobilized within the tissue (Weis and Weis, 2004). The large rhizosphere of wetland plant species provides an enriched culture zone for microbes involved in degradation, and redox conditions in the soil further enhance degradation pathways (Williams, 2002). Further, GIWs tend to have higher perimeter-to-area ratios than non-GIWs because GIWs tend to be smaller than non-GIWs (Cohen et al., 2016). This higher ratio leads to increases in reactivity, or the processes that can lead to remediation of contaminants (Cohen et al., 2016).

In general, elemental uptake by wetland plants varies among species, and is related to rooting depth and plant life form (Collins et al., 2010). Typha, Phragmites, Eichhornia, Azolla, Lemna, and other aquatic macrophytes are some of the most effective wetland plants for heavy metal removal (Rai, 2008). Research shows that seed germination for many wetland species occurring in Carolina bays is not responsive to contaminant exposure.

In some areas, wastewater treatment systems use depressional wetlands to treat water (Ewel, 1997). In particular,

cypress wetlands have demonstrated a potential for treating secondary wastewater, however, disposal of raw sewage can decrease tree productivity (Lemlich and Ewel, 1984). The Carolina Bay Natural Land Treatment Program in Horry County, South Carolina uses four natural Carolina bays to treat tertiary wastewater (U.S. EPA, 1993). The use of wetlands significantly lowers the cost of wastewater treatment, and because of the project, these four bays will be protected and represent one of the largest public holdings of Carolina bays in South Carolina. The only side effect found was an increase in plant productivity due to the influx of nutrients (U.S. EPA, 1993).

The Savannah River Site (SRS) in Aiken, South Carolina, is active in promoting both phytoremediation and bioremediation as low cost, natural remediation strategies (Schwitzguébel et al., 2002). One study at SRS showed that four common species of southeastern wetlands (*Myriophyllum aquaticum*, *Nymphaea odorata*, *Juncus effuses*, *Pontederia cordata*) can accumulate phosphorus and metals in their biomass for at least two growing seasons, demonstrating their potential to remove these elements from coal runoff waters (Collins et al., 2010). Another SRS wetlands study on uptake of chlorinated ethenes showed that bald cypress, tupelo, and loblolly pine contained the highest concentrations of trichloroethene (TCE), with lesser amounts in nearby oak and sweet gum (Vroblesky et al., 1999).

GIWs can be used as cost-effective means to immobilize uranium. Research in SRS shows that uranium may be strongly bound to wetland sediments under both reducing and oxidizing conditions (Li et al., 2014). These findings indicate that uranium is much less likely to be released as a result of seasonal changes in the oxidation state of the wetlands, indicating sustained uranium retention under a range of environmental conditions (Li et al., 2014). Vegetated wetlands can help remediate acidic, metal-contaminated water, but on occasion there can be undesirable side effects like lower pH and greater iron and manganese concentrations in effluent (Collins et al., 2005).

5.2.3 Biogeochemical cycles

GIWs are integral to biogeochemical processing on the landscape and thus to maintaining the integrity of U.S. waters (Marton et al., 2015). GIWs can act as hotspots for sediment deposition, nutrient retention and transformation, organic matter cycling and storage, and metal and pesticide immobilization (Mitsch and Gosselink, 2000; Walbridge and Lockaby, 1994; Cohen et al., 2016). GIWs typically have large, complex perimeters relative to their overall size, which means that a substantial portion of most GIWs are subjected to wet-dry cycles that enable high rates of biogeochemical processing (Marton et al., 2015). As a result, GIWs greatly influence the delivery of reactive nitrogen, phosphorus and other pollutants to downstream navigable waters, an important spillover effect (Marton et al., 2015). Long residence times due to seasonal or slow connections facilitate kinetically-limited reactions, like phosphorus sorption, and increase GIW sink functions (Cohen et al., 2016). No direct surface connection is required for GIWs to have a biogeochemical effect on downstream waters, and in fact hydrologic connection can reduce nutrient retention (Marton et al., 2015). Both GIWs' intermittent connectivity and high potential for biogeochemical processing lead to a significant reduction in nutrient delivery downstream (Marton et al., 2015; Freeman et al., 2007; Alexander et al., 2007).

Spatial and temporal processes drive variability in the biogeochemical processes of isolated wetlands (Marton et al., 2015). Smaller wetlands are more effective at phosphorus retention, while larger wetlands are more effective at nitrogen retention

due to an increase in water retention time. The shape of a wetland's perimeter can influence biogeochemical processes as well, as rates of water loss from GIWs vary with the length of shoreline per unit area, causing variation in wetland water levels (Marton et al., 2015). The frequency of wetting and drying is greater in concave profile wetlands. This is important because wetting and drying increases leaching and desorption of phosphorus from sediment organic matter, and can also increase denitrification and export of nitrate (Marton et al., 2015).

The position of a GIW in the watershed also influences biogeochemistry. Upper reach GIWs are better at removing sediment (Marton et al., 2015). Midreach GIWs are better at retaining phosphorus, while lower reach wetlands are better at removing nitrogen (Marton et al., 2015). GIWs with steep slopes and shallow soils are likely to receive more nutrients from runoff and thus have higher water quality improvement potential. Lastly, the number of GIWs can increase the potential to remove nutrients. When 2-7% of a watershed is wetland cover, there are noticeable improvements in water quality (Marton et al., 2015).

Sediment accumulation can be similar or even greater in GIWs compared to other wetlands. Craft and Chiang, 2002 measured sediment accumulation rates of 951 $g\ sediment\ m^{-2}yr^{-1}$ in depressional wetlands and 1,289 $g\ sediment\ m^{-2}yr^{-1}$ in floodplain wetlands in southwestern Georgia (Marton et al., 2015). In areas where plant production exceeds decomposition, GIWs can become filled with peat (Whigham and Jordan, 2003). The intensity of nearby agricultural land use is a main determinant of biogeochemical processes through increased sediment and excessive drainage that can accelerate organic matter decomposition (Craft et al., 2017). Draining or filling in a wetland creates drier environments like uplands, which can decrease the processing ability of wetlands and impair carbon, nitrogen and phosphorus accumulation (Cabezas et al., 2014; Lane and Autrey, 2017). Altering hydrology in this way can bypass wetland processing and send nutrient-loaded waters to ditches and other waterways with negative downstream impacts (Lane and Autrey, 2017).

Carbon

Carbon sequestration is an important process due to its role in regulating global climate change (MEA, 2005). Depressional wetlands are capable of sequestering enormous amounts of carbon, significantly impacting landscape carbon dynamics when wetlands are abundant (Lane and Autrey, 2017). Carbon enters wetlands through plants, leaf litter, and in the form of suspended organic sediment from runoff (Gala and Young, 2015). It is retained due to wet, anaerobic conditions that slow decomposition rates (Gala and Young, 2015). This potential is threatened, however, by changes in land use. For example, converting a wetland to agriculture can reduce the soil carbon pool or carbon sequestration by 20-40% (Neely, 2008).

Lane et al., 2012 mapped nearly 1.2 million ha of GIWs in southeastern states, estimating that this quantity of wetlands has the potential to sequester 0.25–3.8 teragrams (Tg; equivalent to one billion kg) of organic carbon (C) annually. The Dougherty Plain in southeastern Georgia has approximately 43,000 ha of mapped GIWs representing cumulative carbon storage rates of 0.023 Tg per year (Marton et al., 2015). Coastal plain wetlands have average accumulation rates of 43.4 $\pm$ 39.0 $g\ C\ m^{-2}yr^{-1}$ (Lane and Autrey, 2017). Watt and Golladay, 1999 found that litterfall productivity—the quantity of leaves produced annually—in GIWs in South Georgia was among the highest reported for wetland systems, but that

these systems efficiently processed and accumulated the organic material from these leaves. Dissolved organic carbon (DOC) concentrations, another measurement of carbon sequestration in these wetlands ranged from 10 to 40 $mg\ C\ L^{-1}$ and were comparable to those measured in other wetland types such as cypress swamps and bogs (Opsahl, 2005).

Pocosins are noted for sequestering carbon in organic soils and accreting peat, providing protection from sea level rise (Steven and Lowrance, 2011). The restoration of pocosins has the potential to store enormous amounts of carbon in soil and biomass (Neely, 2008). A study in Ohio showed that GIWs had higher organic content ($146 \pm 4.2\ g\ C\ kg^{-1}$) than riverine ones ($50.1 \pm 6.9\ g\ C\ kg^{-1}$; Bernal and Mitsch, 2012). Soil carbon was 98-99% organic in isolated depressional wetland communities and 85-98% organic in riverine wetlands (Bernal and Mitsch, 2012). Further, the depressional wetlands sequestered more carbon annually ($317 \pm 93\ g\ C\ m^{-2}yr^{-1}$) than riverine wetlands ($140 \pm 16\ g\ C\ m^{-2}yr^{-1}$; Bernal and Mitsch, 2012). These differences in carbon sequestration abilities highlight the importance of recognizing wetland type when determining the role of wetlands in the global carbon budget.

Nitrogen

GIWs contribute to nitrogen removal and limit the exposure of downstream systems to nitrogen (N). Wetlands with a high supply of nitrogen and phosphorus may have elevated denitrification rates which suggests an important role for GIWs in agricultural and urban landscapes (Lane et al., 2012; Marton et al., 2015). Denitrification services provide improved water quality and downstream system integrity (Lane et al., 2012). Small wetlands, like many GIWs, play a disproportionately large role in landscape-level nutrient processing. A study by Cheng and Basu, 2017 showed that 50% of nitrogen removal globally occurred in wetlands smaller than 0.1 acres.

Southeastern GIWs can denitrify from 0.0095–0.063 Tg of nitrogen per year (Marton et al., 2015). Nitrogen retention capacity of pocosins ranges from 22 to 89% percent of total nonpoint source inputs (Walbridge and Lockaby, 1994), indicating that areas adjacent and downstream to these wetlands can benefit immensely. Within pocosins, biological processes like plant uptake (15 to 51.8 $kg\ N\ ha^{-1}yr^{-1}$) and microorganism absorption (16.2 to 87.0 $kg\ N\ ha^{-1}yr^{-1}$) are important aspects of nitrogen services of wetlands (Walbridge and Lockaby, 1994). Studies show that drained wetlands have greater concentrations of nitrite (NO_2) and nitrate (NO_3) in surface runoff compared to restored and reference Carolina bays (Miller et al., 2017). The Dougherty Plain in Georgia has approximately 43,000 ha of mapped GIWs representing cumulative nitrogen storage rates of 0.0020 Tg per year (Marton et al., 2015).

A study in southwest Georgia found that GIWs store a disproportionate amount of nitrogen compared to upland soils (Craft and Chiang, 2002). The studied depressional wetlands were islands of nitrogen in the nitrogen-poor southeastern coastal plain landscape. Researchers found 2 $mg\ cm^{-3}$ organic nitrogen in the wetlands, and observed higher C:N ratios in uplands compared to wetlands indicating the nitrogen limitation of plant growth in upland areas (Craft and Chiang, 2002). It is likely that the saturation of soil in the wetland areas favors the sequestration of organic forms of nitrogen (Craft and Chiang, 2002). Waterlogged soils favor a higher proportion of nitrogen to phosphorus ratio, creating a gradient from nitrogen limited upland soils to phosphorus limited wetland soils (Craft and Chiang, 2002). GIW soils saturated with water also encourage the sequestration nitrogen and phosphorus in an organic or non-biologically

available form (Craft and Chiang, 2002). There are limits to GIWs nutrient sequestering abilities, and occur when in agricultural landscape. Carolina bays adjacent to fields where poultry litter was used as fertilizer had N_2O emissions of 1.8 $mg\ m^{-2}day^{-1}$ (Miller et al., 2017).

Phosphorus

The limited surface water connections to GIWs provides a service to downstream waters by retaining phosphorus (P; Lane and D'Amico, 2010). GIWs store a higher quantity of total phosphorus compared to the uplands that surround them, most which is in soil rather than plant biomass or litter (Lane and Autrey, 2017; Dunne et al., 2007). Phosphorus fluxes from wetland soils to the water column depend on various factors, including physical and chemical characteristics of the soil and changes in soil redox conditions (Bhadha et al., 2011). These factors determine whether wetland soils act as a sink or source of phosphorus to the system. Biological processes like phosphorus uptake by plants (0.2 to 3.8 $kg\ P\ ha^{-1}yr^{-1}$) and microorganism absorption (6.6 to 40.0 $kg\ P\ ha^{-1}yr^{-1}$) are important parts of the phosphorus cycling services provided by pocosins on the southeastern Coastal Plain (Walbridge and Lockaby, 1994). Southeastern GIWs store between 0.00012–0.059 Tg of phosphorus (Marton et al., 2015).

The Dougherty Plain in Georgia has approximately 43,000 ha of mapped GIWs representing phosphorus storage rates of 3.4×10−5 Tg P per year (Marton et al., 2015). Annual phosphorus accumulation rates for the Atlantic Coastal Plain are approximately 0.01 ± 0.01 $g\ P\ m^{-2}yr^{-1}$ (Lane and Autrey, 2017). Generally, wetlands along lower order streams have lower rates of phosphorus deposition in sediment (1.6 to 3.0 $kg\ P\ ha^{-1}yr^{-1}$) compared to wetlands along higher order streams (13.6 to 36.0 $kg\ P\ ha^{-1}yr^{-1}$; Walbridge and Lockaby, 1994). A study in southwest Georgia found an increase of phosphorus in GIWs soils compared to adjacent upland areas (Craft and Chiang, 2002).

5.3 Regulating services

5.3.1 Water and material storage

Water storage is crucial for flood control. Nearly 2 billion people live in high flood risk areas, a risk that will increase if wetlands are lost or degraded (MEA, 2005). GIWs support numerous watershed functions, including hydrologic regulation, because of their variability in hydrologic connection and disconnection (Rains et al., 2016). GIWs are important for reducing peak floodwater flows, contributing to groundwater recharge and providing stream base flow (Calhoun et al., 2017). A watershed composed of at least 30% wetlands can reduce flood water levels by 60-80% (NRCS, 2006), and rainfall retention by wetlands can reduce flooding at separate geographical locations (Brinson, 1991). GIWs provide "spill and fill" and "spill and merge" functions on the landscape (Calhoun et al., 2017). "Spill and fill" refers to intermittent surface water connections (Leibowitz et al., 2016). "Spill and merge" occurs when wetland ponds merge or when two adjoining wetlands overlap (Leibowitz et al., 2016).

Carolina bays are sinks for runoff and groundwater discharge, especially during the spring and summer when the depressions are more empty which is an important spillover effect within the southeastern Coastal Plain, especially after large storm events in the late summer months (Sun et al., 2006). In regions dominated by GIWs, like the Carolina bays

of the upper coastal plain of South Carolina, the regulatory ecosystem service on downgradient waters is produced by the combined effect of all GIWs rather than single GIW (Rains et al., 2016). This implies that many Carolina bays need to be maintained in order to preserve the ecosystem function (Rains et al., 2016). Within the lower Neuse River Basin, North Carolina as the average distance of GIWs, mostly Carolina bays, in a subbasin to a stream increases so does GIWs streamflow contributions (Golden et al., 2016). This seemingly counter intuitive pattern is strongest in winter months, when Carolina bays can significantly contribute to streamflow (Golden et al., 2016). This seasonal pattern could be explained by more distant GIWs impacting streamflow over longer time periods (i.e. seasons or annually) compared to GIWs closer to the stream (Golden et al., 2016).

Pocosins, regardless of "isolation" status, play a similar role attenuating peak rates of surface runoff during storms given their abundant retention storage (Daniel, 1981). Pocosins are comprised of porous, organic soils with a high capacity for stormwater retention (Daniel, 1981). The importance of this service is apparent when pocosins are connected to estuaries that require time to assimilate freshwater runoff in order to avoid sudden, detrimental changes in salinity (Tiner, 2003). For example, substantial decreases in estuarine salinity levels as a result of heavy rains and compromised pocosins are factors suspected in reduced harvests of North Carolina brown shrimp, the state's most valuable shrimp species (Street and McClees, 1981). When a pocosin is ditched or drained, it loses its buffering capacity, and consequently contributes more and oftentimes enriched water to streamflow (Tiner, 2003).

There are direct economic benefits related to the water storage services of GIWs. Stormwater management costs directly affect local economies in terms of flood damage and degradation of drinking water (Lane and D'Amico, 2010). U.S. FEMA estimated annual property damage from all types of flooding averages $2 billion USD a year (as cited by Lane and D'Amico, 2010). Constructing artificial retention basins can ameliorate flooding events but are significantly costlier than maintaining natural wetlands. For example, the Natural Resources Council estimates costs from $100-3000 per acre for wetland construction for water storage, and estimated that stormwater and sediment control adds $1500-9000 to the cost of new homes in North Carolina (NRC, 2009; Lane and D'Amico, 2010). Overall, maintaining wetlands on the landscape can limit flooding impacts and cut down on costs related to flooding.

GIWs buffer aquifer dynamics. GIWs provide water storage in the landscape that reduces water table changes in response to rainfall (McLaughlin and Cohen, 2013). Regular sink-source reversals buffer aquifer dynamics by limiting aquifer variation, in turn stabilizing the regional drainage network (McLaughlin and Cohen, 2013). Evapotranspiration varies seasonally in GIWs, causing water table fluctuations that release water slowly in saturated conditions and provide rainwater storage after dry periods (Steven and Lowrance, 2011). Adjacent to coastal areas, these controlled releases are important for regulating salinity in estuarine habitats (Steven and Lowrance, 2011).

5.3.2 Water purification and filtering

The degradation of water quality can increase the prevalence of disease and limit access to water for drinking and other human uses (MEA, 2005). Numerous studies demonstrate the importance of freshwater wetlands for maintaining water quality by remediating nonpoint runoff (Craft and Richardson, 1997; Knox et al., 2008; Atkinson et al., 2011). When

groundwater flows are consistent, GIWs can serve as stable sources of potable water (Hoehn et al., 2003). Further, episodic reversals in the direction of groundwater exchange increase biogeochemical reaction rates and improve water quality (McLaughlin et al., 2014).

All wetlands assimilate nutrients from runoff through uptake in plant biomass and subsequent deposition in sediments, or through microbial denitrification in wetland soils (Atkinson et al., 2011). Generally, GIWs like fens, swamps and forested wetlands have high microbial biomass (Gala and Young, 2015). Aerobic and anaerobic microbes attack nutrients and chemically transform them into harmless substances (Gala and Young, 2015). The effectiveness of this process varies across wetland types and is influenced by a wetland's degree of connectivity with the surrounding landscape (Craft and Casey, 2000; Marton et al., 2015). The ability of a GIW to provide water quality services depends on factors such as water residence time, the proportion of the watershed composed of wetlands, and the types of interaction between wetlands and the surrounding landscape (Marton et al., 2015). Even in the absence of a surface water connection, a GIW can still provide functions to improve the water quality of navigable waters (Marton et al., 2015). GIWs process pollutants at rates similar to or higher than those of wetlands with apparent hydrologic connectivity (Whigham and Jordan, 2003; Marton et al., 2015). Deghi and Ewel, 1984 found that GIWs that received wastewater inputs removed more than 90% of incoming nutrients.

The water quality of GIWs can be very sensitive to adjacent land use (Yu et al., 2015). Episodic flows generated in agricultural fields often flow through GIWs before entering perennial waters, especially in the agriculturally dominated landscapes of the southeast (Deemy et al., 2015). One study conducted at Ichauway in southwest Georgia found evidence of greater planktonic cell numbers in GIWs influenced by agriculture (Knox et al., 2008). These higher numbers are likely crucial to the assimilation and cycling of nutrients (Knox et al., 2008). Another study at Ichauway found evidence of improvement of water quality as water moved between and through GIWs in Georgia's Dougherty Plain (Deemy et al., 2015). Improvement across biological, chemical, and physical water quality parameters demonstrates a crucial spillover effect of GIWs for the water quality of more permanent waterbodies in the region (Deemy et al., 2015). Thus, particularly in highly disturbed agricultural landscapes, isolated wetlands can provide valuable water quality services for the landscape as a whole (Atkinson et al., 2011).

Pocosins are a significant source of freshwater in the southeastern coastal plain where they cover large geographic areas (Richardson, 2003); consequently, the conversion of pocosins to agricultural fields or plantation forests is predicted to decrease downstream water quality via increased nutrient export (Walbridge and Richardson, 1991). The water quality of Carolina bays and pocosins depend on the degree of connection between the wetland and the underlying substrate (Whigham and Jordan, 2003). Generally, water quality in "short" pocosins, which are marked by shrubby vegetation and a thick peat layer, is similar to water quality in ombrotrophic, "cloud-fed" bogs (Whigham and Jordan, 2003). By contrast, "tall" pocosins, characterized by taller vegetation and little-to-no peat, have water quality similar to ground water (Whigham and Jordan, 2003). Data shows that water quality is seasonally variable in southeastern GIWs (Whigham and Jordan, 2003).

5.3.3 Erosion and flood control

The erosion control services of GIWs are attributed to the storage of runoff during rainstorms (Gala and Young, 2015). Wetland vegetation impedes the downstream momentum of floodwaters by slowing the water's momentum and allowing it to be stored in the underlying soils. Roots ensure that soils stay in place and stabilize wetland edges (Gala and Young, 2015). By lowering the frequency of high water table conditions, GIWs reduce downstream vulnerability to overland flows and associated hazards like stream bank erosion (McLaughlin et al., 2014). Thus, wetlands protect downstream landowners from both flood and erosion damage to crops and infrastructure (Gala and Young, 2015). Furthermore, by storing floodwater, wetlands enable evapotranspiration (Gala and Young, 2015).

5.3.4 Groundwater recharge

Groundwater is a vital source of water for domestic use (Gala and Young, 2015); in 2010 an estimated 130 million people, or one-third of the population, in the U.S. rely on groundwater for drinking water (DeSimone et al., 2014). The Northern Atlantic Coastal Plain aquifer system which spans coastal Virginia and North Carolina is particularly vulnerable to manmade contaminants like nitrate, pesticides, and volatile organic compounds (DeSimone et al., 2014). While the Upper Floridan Aquifer is naturally protected from manmade contaminates, supply wells in South Carolina, Georgia, and Alabama can increase the aquifer's vulnerability to contaminates by pulling shallow groundwater into the deep aquifer (DeSimone et al., 2014). Each day 80 billion gallons of water is pumped from aquifers in the U.S. (DeSimone et al., 2014). As the population continues to increase, groundwater will become an increasingly more important resouce (DeSimone et al., 2014). This is especially the case in areas with limited surface water supplies (DeSimone et al., 2014).

Groundwater recharge is defined as a change in water table height caused by water percolating through the vadose zone to the zone of saturation (Williams et al., 2014). GIWs impact groundwater dynamics through subsurface exchanges with surrounding uplands (McLaughlin et al., 2014). Pyzoha et al., 2008 found that a Carolina bay was hydraulically connected to surrounding uplands during wet periods and during the onset and end of droughts. The volume of this exchange is controlled by wetland perimeter, not area; thus, the magnitude of groundwater recharge that occurs within several, small wetlands will be greater than that of a single, large wetland of comparable size (McLaughlin et al., 2014).

Groundwater recharge rates are spatially and temporally dynamic, but generally, wetlands recharge groundwater at rates ranging from 0.03 $cm\ day^{-1}$ to 1.1 $cm\ day^{-1}$ (Gala and Young, 2015). Research shows higher groundwater exchange occurs in areas with coarse, upland soil, like those in the Atlantic Coastal Plain, compared to finer soils (McLaughlin et al., 2014). Coes et al., 2007 found summer recharge rates of 0.054 $cm\ day^{-1}$[3] and winter rates of 0.036 $cm\ day^{-1}$ [4] in a North Carolina pocosin. Williams et al., 2014 found GIW recharge rates of 3.29 $cm\ day^{-1}$, and did not find a significant difference between recharge rates of GIWs compared to riverine wetlands in South Carolina. The groundwater recharge rate from GIWs can be increased if regional groundwater pumping lowers hydraulic heads through

[3] converted from reported 20 $cm\ yr^{-1}$
[4] converted from reported 13 $cm\ yr^{-1}$

water removal (Rains et al., 2016).

5.4 Provisioning services

Among the provisioning services of GIWs, the most important is likely the direct provisioning of water for myriad human uses, including drinking water, which has been described in detail in Section 5.3.1 and Section 5.3.2. Wetlands also provide livelihoods for over a billion people globally via fishing, tourism, transport, and other activities. Specifically, GIWs support domestic animal farming by providing foraging resources during periods of drought (Gala and Young, 2015). GIWs also have documented impacts on fisheries, and can influence habitat quality in geographically-separate nursery areas for fish and shellfish (Brinson, 1991). Pocosin wetlands regulate drainage in a way that protects estuarine wetlands from sudden changes in salinity, which can diminish shrimp recruitment (see Section 5.3.1; Swallow, 1994). Each acre of pocosin wetland converted to other uses can cost the shrimp industry up to $3.73 USD per year in nearby estuaries (Swallow, 1994). The substantial economic impact of GIWs generated through their recreational use is highlighted in Cultural services (Section 5.5.1).

5.5 Cultural services

5.5.1 Human recreation

Wetlands provide many recreational opportunities, including hunting, fishing, boating, birdwatching, and wildlife photography (Gala and Young, 2015). Between 35–45 million people take part in recreational fishing in the United States, spending a total of $24–37 billion USD each year on their hobby (MEA, 2005), and this opportunity is supported by the presence of wetlands. Birdwatching, a recreational activity that generated nearly $107 billion USD in total industry output in 2011 (Carver, 2013), is also reliant on the presence of intact wetland habitat for many bird species. When found in densely populated areas, wetland habitat provides important open space amenities (Hoehn et al., 2003). Wetlands can be important cultural heritage sites for indigenous groups and provide diverse educational opportunities (Gala and Young, 2015). An Iowa study showed that willingness to pay for wetland visits per year was more than two and half times the willingness to pay derived from resident's actual visits and travel costs ($264.65 USD versus $99.61 USD; Boyer and Polasky, 2004).

Across the southeastern U.S., wetlands provide many opportunities for recreation. Table 2 shows 2011 wildlife-related expenditures in the Southeast, including activities like fishing and hunting, which total over $16 million USD (U.S. DOI, 2011). Most southeastern states have a statewide comprehensive outdoor recreation plan (SCORP), with sections highlighting the importance of wetlands to recreation (Tummons and Marshall, 2009; SC ADC, 2013; VA DCR, 2013; SC DPRT, 2014; NC DENR, 2015; Parks, 2016). Georgia's SCORP makes note of anticipated population growth, particularly for areas adjacent to wetlands, and mentions a need to prioritize landscape-level wetland areas for development of wetland mitigation banks or other wetland restoration activities (Parks, 2016). The Virginia SCORP explicitly states that wetlands are among the most important natural resources in Virginia's landscape (VA DCR, 2013). The Tennessee SCORP highlights the state's Wetland Acquisition Fund administered by the Tennessee Wildlife Resources Agency

(Tummons and Marshall, 2009). South Carolina's SCORP identified species of greatest conservation concern that rely on isolated ponds and wetlands, including 19 amphibians, 4 freshwater fishes, and 7 varieties of crayfish (SC DPRT, 2014).

Table 2: Wildlife related expenditures and number of people fishing or hunting in 2011 for Alabama, Georgia, North Carolina, South Carolina, Tennessee, and Virginia (U.S. DOI, 2011)

State	Total wildlife related expenditures[a]	Fishing and hunting expenditures[a]	Sportspersons (in thousands)
AL	2,665,172	1,930,968	1,732
GA	4,556,286	2,753,862	3,058
NC	3,294,423	2,364,762	3,497
SC	2,019,749	1,552,496	1,729
TN	2,868,103	1,925,532	2,584
VA	3,542,179	2,583,572	3,269

[a]Reported in thousands of dollars, USD

North Carolina is home to six different wildlife refuges that contain GIWs (Alligator River, Pocosin Lakes, Cedar Island, Mattamuskeet, Roanoke River, Swanquarter). Pocosin Lakes National Wildlife Refuge contains 100,000 acres of wetlands, forests and swamps (Edgell, 2016) and is known for providing black bear tours; birdwatching and wildlife photography are also popular at the refuge (Edgell, 2016). Pocosin Lakes receives 34,000 visitors annually, and about 1,500 anglers use the refuge for recreational fishing (U.S. FWS, 2010). The North Carolina State Park System offers wetland features like Dismal Swamp, Goose Creek, Hammock Beach, Lake Waccamaw, Merchants Mill Pond, and Pettigrew State Park (NC DENR, 2015).

Within the state of Alabama, both residents and nonresidents spent $2.2 billion on wildlife recreation in 2006, including almost $700 million in fishing related expenses. More than 1 million Alabama residents participated in wildlife watching; 600,000 fished and 310,000 hunted (U.S. DOI, 2006). Over the last decade, Alabama has experienced an increased use of wetlands associated with the river system for trail development, environmental education, and interpretive sites (SC ADC, 2013). Approximately 40 wetland sites across the state offer birding opportunities and scenic appreciation (SC ADC, 2013). Alabama's SCORP includes strategies for the use of wetland areas for purposes like education, mitigation, and ongoing wetland trend studies (SC ADC, 2013).

5.5.2 Cultural significance

Some Carolina bays are sites of archaeological research which reveal pre-historic and historic settlement patterns. These wetlands have dense and diverse artifact assemblages (Brooks et al., 2010). For example, Oak Bay in South Carolina, a GIW, has evidence of a Sewee shell ring that was used to make a dam over 4000 years ago (Middaugh, 2013).

5.6 Ecosystem service tradeoffs

Understanding the value of any wetland involves prioritizing among the many services it provides (McLaughlin and Cohen, 2013). The augmentation of some functions (like carbon sequestration) may be at the expense of others (like habitat), demonstrating a trade-off between ecosystem services (McLaughlin and Cohen, 2013). For

instance, high water levels lower CO_2 emissions and increase bird habitat, whereas low water levels improve grazing, reduce floods and reduce methane emissions (Maltby and Acreman, 2011).

Considering tradeoffs between ecosystem services is important for ecosystem managers. Management decisions on wetlands often involve tradeoffs between services, like flood releases from reservoirs causing changes in water levels (Maltby and Acreman, 2011). Tradeoffs are not recognized with current wetland regulation and mitigation, which shows preference for habitat integrity and underestimates the value of "working wetlands" (McLaughlin and Cohen, 2013). This is particularly relevant when considering wetlands in disturbed areas, like those found in urban or agricultural settings. Often, these wetlands have reduced habitat functions, but other services like water storage and water quality improvements may be present and perhaps more important due to the greater need to ameliorate the disturbances of a human-dominated landscape (McLaughlin and Cohen, 2013).

6 GIWs Case Studies

6.1 Preserved GIWs

The following case studies highlight the ecosystem services provided by GIWs that have been intact since the late 1970's or earlier. These systems have been allowed to flourish, and are maintained for research or conservation purposes. Given the 40 plus years of recovery, the biodiversity of plants and animals in these case studies are quite impressive.

6.1.1 Ellenton Bay, South Carolina

Ellenton Bay is a semi-permanent, open-water herbaceous Carolina bay located within the Department of Energy (DOE) Ellenton Bay set-aside (Davis and Janecek, 1997). The DOE's Set-Aside Program is a system of reserve areas on DOE facilities that provide reference sites for human impacts on the environment (Davis and Janecek, 1997). Ellenton Bay was originally set aside in the 1960's, after being selected for study by University of Georgia scientists, and gained recognition for being the site of Eugene Odum's prominent research on old-field succession and energy flow (Davis and Janecek, 1997). The set-aside itself is about 580 acres, and is one of few set asides that allows for manipulative studies (Davis and Janecek, 1997).

Ellenton Bay is an acidic, softwater system dominated by aquatic and marsh vegetation. The Carolina bay itself is 27 acres and remains inundated throughout most of the year, drying to small pools only during exceptionally dry summers (Gibbons and Coker, 1977). Dominant plants include water lilies, switch cane, sedges, willow and Panicum grass. The bay is ringed by blackberries and pine trees (Davis and Janecek, 1997). The bay has a maximum water depth of 2 meters and mosquito fish are seasonally abundant (Gibbons, 1970; Davis and Janecek, 1997). A road embankment divides the bay into two main sections (Davis and Janecek, 1997). Gibbons et al., 2006 detected the presence of 24 species in the bay. These included sensitive species like the eastern tiger salamander, the Carolina gopher frog, the American alligator, the southern hognose snake, the Carolina swamp snake, and the bobcat. Ellenton Bay is one of the most biodiverse wetland habitats in the nation (Davis and Janecek, 1997; Gibbons et al., 2006).

Ellenton Bay is a site of ongoing research on the life histories of various reptile and amphibian species

(Davis and Janecek, 1997). In 1997, 250 publications and reports had been published based on research from the Ellenton Bay Set Aside (Davis and Janecek, 1997).

The site has infrastructure in place for research, including an amphibian call recording device and box installations for studying wood ducks (Davis and Janecek, 1997). Prominent research themes include the use of radioactive tracers to study energy flow and food webs, life histories of freshwater turtles, ecology and reproductive biology of wood ducks, the relationship between structure and function in old-field communities, the effects of gamma radiation on the reproduction and survival of small mammals, life histories of salamanders, amphibian disease dynamics, reptile metapopulations, and more (Davis and Janecek, 1997).

Research on freshwater turtles in Ellenton Bay has shown the importance of long term studies to reveal ecological phenomena in animal populations (Congdon and Gibbons, 1983). Further study on freshwater turtles has shown that critical life cycle stages, including nesting and hibernation, occur beyond wetland boundaries. Freshwater turtles require a 275-m upland buffer zone to protect all of their nesting and hibernation sites (Burke and Gibbons, 1995), demonstrating the equal importance of wetlands and adjacent uplands habitat to the survival of turtles. Work in Ellenton Bay on reptile metapopulations has also shown the necessity of studies of sufficient duration to allow for meaningful results, as demonstrated by a 26-year long mark-recapture study on slider turtles (Burke et al., 1995).

A 2014 study examined the value of reptile and amphibian species found in Ellenton Bay. Researchers determined the values of the different species using commercial values listed in peer reviewed literature, pet trade companies, and biological supply companies (DeGregorio et al., 2014). They estimated that the 392,605 individuals, representing 17 species, captured at Ellenton Bay over the span of a year were worth $3,605,848 (DeGregorio et al., 2014). This estimate is likely low because it does not include the aesthetic value of the species, but it does highlight the importance of the Bay's biodiversity. According to the researchers, the value of Ellenton Bay ($360,085 ha^{-1}) exceeds that of agriculture ($24,000 ha^{-1}) by two orders of magnitude (DeGregorio et al., 2014).

6.1.2 Green Swamp, North Carolina

The Green Swamp Preserve is located in the southeastern corner of the North Carolina Coastal Plain and covers an area of 6,700 *ha*. Much of the preserve was owned and managed by the Federal Paper Board until the company donated it to The Nature Conservancy in 1977. The Preserve is mostly shrub-dominated pocosin scattered amongst savanna (Palmquist et al., 2014). Periodic droughts occur in the region and can result in the temporary loss or dormancy of species that depend on moist soils (Palmquist et al., 2014). Soils are generally poorly drained, and the water table is within 25 cm of the soil surface for several months of the year (Palmquist et al., 2014).

Green Swamp Preserve is noted for its incredible biodiversity. It is home to a black bear population (Drewry et al., 2013) and many rare animals including the American alligator, the fox squirrel, Henslow's sparrow, Bachman's sparrow, and Hessel's hairstreak butterfly (TNC, 2017). The preserve is also habitat for the venus flytrap, a vulnerable species on the conservation list, and the endangered red-cockaded woodpecker (TNC, 2017). Despite their worldwide renown, venus flytraps are in fact found only in few areas in North Carolina and South Carolina.

Beyond its animal diversity, Green Swamp is also renowned for its high diversity of herbaceous species with more than 30 species m^{-2}, including endemic species like the rough-leaf loosestrife (Walker and Peet, 1984). This level of diversity surpasses all other North American plant communities. In a study looking at over 20,000 plots in temperate North American forests, species richness never exceeded 17 species m^{-2}, and in studies of tall-grass prairie, richness averaged 18 m^{-2} and never exceeded 28 m^{-2} (Peet et al., 1983; Walker and Peet, 1984). Frequent fires are critical to maintaining this diversity (Bucher and High, 2002), with highest richness in sites with high fire frequency near the middle of the moisture gradient (Walker and Peet, 1984).

Green Swamp also contains threatened longleaf pine savannas and many rare orchid species, including the Spiranthes orchid. Since becoming a preserve in 1977, it has been a site for research on prescribed burns (Reardon et al., 2007; Palmquist et al., 2014) and on species richness (Rome, 1988), demonstrating the importance of the pocosin wetlands.

6.2 Recent restoration of GIWs

The restoration of GIWs can lead to the provision of previously lost or impaired ecosystem services. Reestablishing wetland hydrology is often cited as the most important component to wetland restoration success (Bruland et al., 2003) and can be easily achieved by plugging drainage ditches (Barton et al., 2008). Regional interest in restoration of longleaf pine habitats in the southeast could provide an opportunity to promote GIWs restoration as well, since these wetlands compose a significant part of the longleaf pine ecosystem (Kirkman et al., 1999). Determining the suitability of a wetland for restoration generally involves an assessment of disturbance level, location, and accessibility (Barton et al., 2008).

6.2.1 Barra Farms Regional Wetland Mitigation Bank, North Carolina

Barra Farms Regional Wetland Mitigation Bank is a Carolina bay complex in North Carolina. The complex was cleared and ditched beginning in the 1960's (Bruland et al., 2003). The establishment of drainage ditches changes hydrologic dynamics by lowering the water table, which leads to rapid drainage and continuous surface water flow (Bruland et al., 2003). These artificial conditions lead to soil erosion and the loss of organic matter. Furthermore, the use of this area for agriculture exacerbated changes, causing the compaction of wetland soils, changes in pH, and increases in decomposition (Bruland et al., 2003).

In order to reverse some of these negative impacts, 250 *ha* at the southern end of the site were restored to wetland in 1997-1998 (Bruland et al., 2003). The restoration consisted of filling ditches and planting native seedlings (Bruland et al., 2003). The filling of ditches almost immediately restored wetland hydrology despite years of artificial drainage (Bruland et al., 2003), leading to the return of flood control services (Bruland and Richardson, 2006). Beyond these benefits, the restoration actions also provided water quality services. The outflow from the restored wetland had less phosphorus and nitrogen when compared to outflow from agricultural sites (Bruland et al., 2003). This reduction has impacts downstream, and research shows that the water quality of nearby Harrison Creek and Cape Fear River has improved in response to the restoration actions (Flanagan and Richardson, 2010).

6.2.2 Pocosin Lakes National Wildlife Refuge, North Carolina

The U.S. Fish and Wildlife Service aims to increase climate change resilience by restoring the hydrology of carbon-rich wetlands like those found at the 59,305 acre [5] Pocosin Lakes National Wildlife Refuge (NWR) based on science showing that rewetting peatland can sequester greenhouse gases (Ward and Settelmeyer, 2014). Prior to being a wildlife refuge, this span of pocosins in North Carolina was drained for agricultural and peat mining operations, leading to releases of carbon to the atmosphere and nearby water sources (U.S. FWS, 2010). The drainage of organic soils like those found in pocosins promotes aerobic decomposition, CO_2 emissions can eventually lead to land subsidence (U.S. FWS, 2010). Further, it can cause an increase in severity and frequency of peat fires due to the significant changes in moisture regime (Poulter et al., 2006). A 1985 pocosin fire in the area led to the estimated release of 1 to 3.8 teragrams Carbon (1 Tg is equivalent to one billion kg) (Poulter et al., 2006).

When this area became a national wildlife refuge in 1990, managers aimed to implement restoration efforts in order to decrease fire frequency and sequester carbon. Restoration efforts were two-fold: restore hydrology and reforest native vegetation (U.S. FWS, 2010). A hydrology restoration plan was created in 1994 that involved the installation of water control structures to raise the water table (Ward and Settelmeyer, 2014). Over 14 miles of roads were raised to encourage the return of natural sheetflow. This led to the rewetting of 9,500 acres of pocosin (U.S. FWS, 2010). Reforestation was also a key part of the project at Pocosin Lakes. About 100,000 trees of Atlantic white-cedar, pond pine, and bald cypress were planted in April 1995 (U.S. FWS, 2010).

Estimates have been made for the carbon sequestration benefits of the restoration project. These estimates are based on amount of carbon retained in peat soils, the amount retained that would otherwise be lost, and the amount sequestered in aboveground biomass (Ward and Settelmeyer, 2014). The rewetting benefits at Pocosin Lakes are estimated to be 1080 metric tons of CO_2 equivalents per acre over 100 years. Ultimately this will result in over 21 million tons of CO_2 equivalents for the total 20,000 acres of restoration efforts (U.S. FWS, 2010; Ward and Settelmeyer, 2014). Furthermore, studies show that restoration did not increase N_2O emissions, which have the potential to counteract carbon sequestration (Kluber et al., 2014).

Pocosin restoration also improves water quality. When pocosins are drained, soils become oxidized, mobilizing mercury and other nutrients that can become contaminants delivered downstream (U.S. FWS, 2010). The restoration project will improve aquatic habitat and provide connections for migratory fish like herring, shad, and striped bass (U.S. FWS, 2010). Improvements in water quality will also benefit fish reproduction. Improvements in terrestrial habitat due to reforestation will help support Pocosin Lake's black bear population and the endangered red wolf that was re-introduced to the area in 1987 (Tredick et al., 2007; Kindall and Manen, 2007; Karlin et al., 2016).

Pocosin restoration will reduce wildfire impacts by decreasing the frequency and intensity of fires (U.S. FWS, 2010). The restoration project will help improve resiliency to climate change. Restoration allows for biomass and soil accumulation, and this increase in soil provides a mechanism to combat sea level rise (U.S. FWS, 2010). Local livelihoods will also benefit. The economic development of this area in North Carolina depends on sustainable conservation of natural resources,

[5] converted from reported 24,000 hectares

many people come to the area for ecotourism, hunting, and fishing (U.S. FWS, 2010).

6.2.3 Juniper Bay, North Carolina

The Juniper Bay Mitigation Site is a Carolina bay located in Robeson County, North Carolina encompassing 728.5 acres (Environmental Services, Inc., 2009). Juniper Bay was cleared and ditched in 1966 and used for agricultural production until being purchased by the North Carolina Department of Transportation in January 2000 (Environmental Services, Inc., 2009). Historical information from maps and photos helped to identify problem areas for restoration of the Carolina bay for mitigation purposes (Ewing et al., 2005). The restoration of Juniper Bay is being used to provide compensatory wetland mitigation credits in the Lumber River Basin with a goal to restore hydrologic function and revegetate the site with wetland species (Ewing et al., 2005; Environmental Services, Inc., 2009).

In order to restore hydrology, efforts were made to plug and backfill the ditch network to increase water storage capacity and retention (Environmental Services, Inc., 2009). Reforestation goals were to establish two Carolina bay community types: the peatland Atlantic White Cedar Forest and the Pond Pine Bay Forest (Environmental Services, Inc., 2009). The project set five-year goals for each aspect of the project. Successful hydrology restoration required the soil to be saturated within 12 inches of the surface for at least 12.5% of the growing season during non-drought years (Environmental Services, Inc., 2009). During the 2006 monitoring period, 86% of the monitoring gauges met this criterion (Environmental Services, Inc., 2009). The vegetation restoration required 320 surviving stems per acre; in 2006, 11/20 plots met this criterion (Environmental Services, Inc., 2009).

The establishment of this vegetation appears to have reduced soil temperature and the rate of carbon mineralization (Taggart et al., 2011). Furthermore, previous wetland restoration projects in agricultural areas have experienced phosphorus release to nearby surface waters, but the Juniper Bay restoration project did not result in this phosphorus export (Vepraskas et al., 2016). These results seem to suggest that Carolina bays are ideal sites for future wetland restoration projects due to minimal negative impacts on nearby surface water (Vepraskas et al., 2016).

7 Ecosystem Services of Intermittent and Ephemeral Streams

7.1 Overview

Although they function temporarily as waterways, intermittent and ephemeral streams serve as permanent ecosystems that moderate biogeochemical cycles, support diverse biota, and protect valuable water resources. Intermittent and ephemeral streams provide critical ecosystem services locally and downstream both when they are flowing and when they are not. In many cases, the unique cycling of wet and dry periods produce benefits that cannot be met by streams with continuous flow. Wet periods can transport nutrients and organisms downstream which stabilize downstream aquatic communities, while dry periods allow for the accumulation of nutrients (see Sections 7.2.1 and 7.2.3). Many of the ecosystem services presented below maybe underestimates given the tendency of map-based estimates of drainage networks tend to overlook small streams (see Section 2.3.1; Benstead and Leigh, 2012).

The southern Appalachians, spanning the southeastern states of this review, are among the oldest mountainous ecosystems on Earth since they escaped glaciation (Bernhardt and Palmer, 2011. This allowed the southern Appalachians to become the biodiversity hotspot it is today (Bernhardt and Palmer, 2011. Today, the intermittent and ephemeral streams of the southern Appalachians are buried during mountain top mining, destroying many of the ecosystem services provided by intermittent and ephemeral streams, or dry channels (for examples see Sections 7.2.1, 7.2.2, and 7.4). Mountain top mining in the region is common; the footprint is an estimated 2,278 square miles [6] in 74-county 32,046 square mile [7] area of Central Appalachia spanning West Virginia, Kentucky, Tennessee, and Virginia (Pericak et al., 2018).

In regions undergoing development, intermittent and ephemeral streams are often piped (Elmore and Kaushal, 2008). In these cases, the stream looses energy inputs from the sun, and the water-sediment boundary. Sunlight is required for most primary production which is essential for many supporting, regulating, and cultural ecosystem services (see Sections 7.2, 7.3, and 7.5; respectively). The water-sediment boundary is just as crucial for providing ecosystem services. This boundary is where many of the reactions associated in biogeochemical cycles of supporting services (see Section 7.2.3). These reactions should not be overlooked given the potentially disproportionate by area contribution made to the watershed's services provided. For example, within a watershed, 23% of sequestered carbon can be found in the headwaters despite the headwaters comprising less than 1% of the watershed by area (Wohl et al., 2012).

The case studies for the intermittent and ephemeral streams section will focus on the impact of stream burial given it is such a threat to the ecosystem services provided by intermittent and ephemeral streams (see Section 8). The first section will focus on the impact of unrestored or impaired buried streams on ecosystem services (see section 8.1). The second section focuses the ecosystem services gained through the restoration or daylighting of previously buried streams (see Section 8.2). Based on these case studies highlighting the resumption of ecosystem services gained from restoration we can inferred the adverse consequences of backfilling, burying, or piping drainages. In other words we assume that restoring impacted waters, and impacting waters have an equal but opposite effect on any ecosystem service.

7.2 Supporting services

7.2.1 Biodiversity

The southeastern United States is a hotspot for endemic or highly localized species of plants and animals, containing some of the most species-rich amphibian, reptilian, and freshwater fish communities in North America (Jenkins et al., 2015). Freshwater biodiversity in this region is the highest in the nation. Alabama alone supports 38% of native freshwater fish species and 60% of native mussel species (Lydeard and Mayden, 1995).

In general, biodiversity of commonly studied taxonomic groups (i.e., insects, fish, algae, and plants) is higher in perennial than in intermittent or ephemeral streams (Soria et al., 2017). However, the species found in intermittent and ephemeral streams are often specialized for those systems and dependent upon the unique hydrologic flow patterns found in these systems (Delucchi and Peckarsky, 1989; Williams, 1996; Wood et al., 2005). The biodiversity of intermittent and

[6] converted from reported 5,900 km^2
[7] converted from reported 83,000 km^2

ephemeral streams has significant, positive impacts on downstream and terrestrial ecosystem services through the upstream and downstream movement of aquatic species (Meyer et al., 2007). As climate change progresses and urban centers grow, intermittent and ephemeral streams may become more prevalent due to increased drying events (Soria et al., 2017).

Invertebrates

Ephemeral and intermittent streams are habitat for a diverse macroinvertebrate community, including mollusks, snails, and insects (Grubbs, 2011). Small streams can support a wider range of aquatic insects (Meyer et al., 2007), harboring distinct communities of certain functional groups (Grubbs, 2011). Indeed, much of the diversity in aquatic insects of the Southeast can be found in small streams (Morse et al., 1993). Additionally, select macroinvertebrate species are only found in ephemeral streams (Feminella, 1996), including some crayfish (Yarra and Magoulick, 2017). As the larval habitat for emergent insects (Wohl, 2017), ephemeral streams play an important role in linking aquatic and terrestrial ecosystems. Dry river beds also provide unique ecosystems for insects and other arthropods (Steward et al., 2012; Datry et al., 2014).

Vertebrates

Headwater streams in the Southeast support the most biodiverse and imperiled freshwater fish communities in North America (Jenkins et al., 2015), including both game and nongame species. Often, species in ephemeral and intermittent headwaters are a subset of the species found downstream. For example, brook trout (*Salvelinus fontinalis*) are found in both perennial and intermittent Appalachian streams (Courtwright and May, 2013; Hudy et al., 2008). In other cases, the species assemblages of ephemeral headwaters are unique when compared to downstream assemblages (Paller, 1994; Paller et al., 2016). These unique assemblages boost regional fish diversity and are typically comprised of small-bodied, insectivorous fishes. Alternatively, some fish use headwater streams specifically for spawning (Meyer et al., 2007). Several species of Southeast darters use seepage streams and ephemeral streams for reproduction, including the trispot darter (*Etheostoma trisella*) that spawns in tiny creeks flowing out of ephemeral ponds (Ryon, 1986). Beyond fish, headwater streams support an array of amphibians like salamanders (Meyer and Wallace, 2001).

Plants

Southeastern intermittent streams can provide habitat for a wide variety of plants including macroalgae, bryophytes, and angiosperms (Everitt and Burkholder, 1991). In North Carolina, headwater streams support a diverse algal community, dominated by diatoms with low abundance of cyanobacterial and chlorophytic groups (Greenwood and Rosemond, 2005). Riparian zones of ephemeral streams in Georgia serve as habitat for 120 flora species ranging from hardwood trees to loblolly pines (Jolley, 2008). Appalachian streams in multiple states also harbor an array of non-vascular plants like bryophytes and mosses (Glime, 1968).

7.2.2 Bioremediation and phytoremediation

Intermittent and ephemeral streams are important locations for the remediation of waste and toxins by biota. Flowing periods enable the processing and retention of contaminants such as pesticides, which have been shown to be sequestered in temporary waterways through the sorption of pesticides to bed sediments and deeper soils (Dages et al., 2015). During dry phases, precipitation and runoff passes through soil and bed material, providing further opportunities for filtration and purification before entering groundwater and downstream waterways (Datry et al., 2017). Additionally, riparian vegetation can augment the filtration services that take place within intermittent and ephemeral streams (Gilliam, 1994). However, intermittent and ephemeral streams do not possess a limitless capacity to sequester and remediate toxins; therefore, it is important that these waterbodies are protected from needless contamination, which can result in degradation of downstream waterbodies. Ephemeral streams often experience the strongest influx of pollutants from mountaintop mines and other environmental disturbances (Bernhardt and Palmer, 2011), and these impacts propagate downstream to perennial waters (Meyer et al., 2007). For example, mine waste deposited in headwaters has led to metal contamination within the sediment, floodplains, and organisms more than 250 miles downstream (Hornberger et al., 2009).

7.2.3 Biogeochemical cycles

Downstream waterways are intrinsically linked to the biogeochemical processes that occur in upper stream reaches (Vannote et al., 1980). From decomposition to carbon storage and nitrogen transformation, ephemeral and intermittent streams lay the biogeochemical foundation upon which the entire aquatic ecosystem is built. Thus, maintaining the health of these streams is critical for protecting and preserving water resources.

Carbon

Ephemeral streams transform and store carbon before transporting remaining compounds downstream, and therefore play an important role regulating both downstream biological activity (Fritz et al., 2018) and global climate change (MEA, 2005). Headwater reaches contribute significantly to downstream processing of organic matter, breaking down leaf litter and other organic matter. Approximately 50% of the organic matter entering forested headwater streams is leaf litter (Benfield, 1997), and yet less than 2% of the exported organic matter is in this form (Fritz et al., 2018), as microbes and invertebrates decompose leaves, assimilating carbon into their tissue and exporting dissolved carbon downstream. In one North Carolina stream, invertebrates in ephemeral streams processed up to 74% of particulate organic matter (Romito et al., 2010). In ephemeral streams, provisioning of carbon to downstream waters is unique in that leaves and organic matter accumulate during dry periods (Fritz et al., 2010) and are then released downstream in pulses during storm events (Datry et al., 2014). These pulses are an important source of carbon for downstream animals (Bunn et al., 2006). Ephemeral streams also play a role in carbon sequestration, a process in which carbon is stored in sediment or taken up by organisms rather than being released into the atmosphere where it contributes to climate change. In one study, headwater streams and their valleys were estimated to store an out-sized percentage of the organic carbon within their watersheds—up to 23%—despite comprising less than 1% of watershed area; much of this carbon will remain sequestered for hundreds of

years in the form of floodplain sediment and coarse wood (Wohl et al., 2012). In the southeast, ephemeral streams store greater stocks of carbon in the form of coarse benthic organic carbon than perennial waterways (Fritz et al., 2010).

Nitrogen

Biological activity in ephemeral streams plays an important role in regulating the downstream transport of nutrients such as nitrogen, one of the main ingredients in fertilizers. The processing of nitrogen within small streams is important because it decreases the loading of nitrogen to larger downstream waters, an important spillover effect (Meyer et al., 2007). Excess nitrogen exported downstream can cause impairments such as increased harmful algal growth, decreased light penetration, and reduced dissolved oxygen levels, collectively known as eutrophication. Approximately 40% of the nitrogen in small to medium navigable waters originates in small streams, including ones that are ephemeral (Alexander et al., 2007). Therefore, any impact that diminishes nitrogen processing within small streams—such as stream burial—is expected to increase the amount of nitrogen that is transported to downstream, navigable waters (Mulholland et al., 2008).

Small streams process nitrogen in several ways. For example, biological activity in headwater streams can rapidly transform inorganic nitrogen inputs (like the nitrate and ammonia found in fertilizer) to dissolved organic forms (Johnson et al., 2013), some of which are less likely to promote harmful algal growth downstream compared to nitrate or ammonia (Lewis et al., 2011). Ephemeral streams can also promote the microbial conversion of nitrate into harmless nitrogen gas, a process known as denitrification; nitrogen loads in downstream waters have been reduced by up to 8% as a result of denitrification in headwater streams (Alexander et al., 2007). Denitrification primarily occurs when channel sediments are wet (Welter and Fisher, 2016), so impacts like stream piping that reduce the residence time of water in streams will lead to lower denitrification rates there. Finally, nitrogen in ephemeral streams can be taken up and retained in the biomass of plants and animals living there; riparian trees, for example, can remove substantial amounts of nitrate from water and retain it in their roots (O'Neill and Gordon, 1994). The loss of intact riparian plant communities in ephemeral streams would therefore be expected to cause increased exports of nitrogen and other nutrients to downstream waters.

Phosphorus

Uptake of phosphorus in intermittent and ephemeral streams can reduce the export of this potent nutrient to downstream waters, where it frequently causes harmful eutrophication, the most common impairment of surface waters in the U.S. (Carpenter et al., 1998). In forested headwater streams, phosphorus concentrations in the water are reduced through the binding of phosphorus to stream sediment (Meyer and Likens, 1979). The replacement of small headwater streams with pipes, as frequently occurs in urban settings (Elmore and Kaushal, 2008), has been predicted to greatly reduce phosphorus uptake: in a North Carolina headwater catchment, a modeling exercise indicated that the rate of phosphorus export would increase by 179% if pipes were to replace headwater streams (Meyer and Wallace, 2001). In the field, evidence of reduced phosphorus uptake with stream piping has been observed: an urban headwater stream in New Hampshire showed no uptake of phosphorus in the piped sections, whereas phosphorus uptake was detected in an unpiped reach

at a relatively high rate (Hope et al., 2014). Piped streams receive no light, a necessity if plants and algae are to grow and take up nutrients like phosphorus (Hope et al., 2014). However, even unpiped urban headwaters do not appear to provide the same phosphourus uptake services as intact, forested headwaters: the speed at which phosphorus was taken up in degraded, urban headwater streams in Georgia was reduced compared to streams in forested catchments (Meyer et al., 2005), indicating that increased phosphorus loads will be exported to downstream waters when streams are impaired. This may be related to the retention of leaves and wood in forested headwater streams, which act as important substrates and food sources for stream food webs (Wallace et al., 1997). The presence of this detritus drives the uptake and retention of phosphorus by microbes as they decompose the organic matter (Meyer et al., 2005). In degraded urban streams, a lack of leaf and wood inputs leads to reduced phosphorus demand by microbes, further contributing to the export of excess phosphorus to downstream waters (Aldridge et al., 2009).

While the uptake of phosphorus within headwaters can play an important role in reducing downstream nutrient pollution, some river and coastal systems rely on periodic phosphorus inputs from ephemeral streams during periods of flowing water. For example, the ephemeral Santa Clara River in California provides nutrients such as phosphorus to coastal waters during the winter, a season in which nutrient concentrations from ocean upwelling are lowest (Warrick et al., 2005). This represents another example of the importance of predictable pulses of water and nutrients from ephemeral and intermittent streams to downstream waterbodies that rely on these inputs.

7.3 Regulating services

7.3.1 Water and material storage and transport

Intermittent and ephemeral streams serve as important links connecting water and materials between upper catchments and downstream waterbodies. An estimated 55% of the annual water volume in large rivers originates in first-order streams, the majority of which only flow intermittently (Alexander et al., 2007; Acuña et al., 2014). Within intermittent and ephemeral streams, water may be transferred downstream in the form of surface water during periods of hydrologic connectivity. However, water may also be delivered downstream via infiltration into groundwater and eventual reemergence in springs or lower reaches, where it can be an important source of baseflow, energy, and nutrients (Fisher and Grimm, 1985). The substantial contribution of small streams to the overall water volume in a watershed is a function of the high percentage of total stream length that headwater streams comprise (Nadeau and Rains, 2007), and also the higher elevation of most headwater streams within catchments. This feature of small streams leads to greater accumulation of precipitation and more isolated rain events compared to downstream reaches.

In addition to water transport, intermittent and ephemeral streams accumulate debris and nutrients during dry phases, producing highly concentrated pulses of organic matter once rewetting occurs (Datry et al., 2014). In the Southeast, many headwater, intermittent, and ephemeral streams occur in steep mountainous landscapes which are prone to bank slope failure and erosion during precipitation events (Gomi et al., 2002). These erosive processes create sediment, nutrients, and organic matter that are important for channel formation and food web processes downstream (Gomi et al., 2002). Impairment of intermittent and ephemeral streams can reduce overall hydrological connectivity in watersheds, disrupting

the flow of crucial water and material from intermittent and ephemeral streams to downstream waterbodies that rely on these inputs (Gomi et al., 2002).

7.3.2 Water purification and filtering

Small streams, regardless of flow permanence, improve water quality downstream through the on-site filtration, sequestration, storage and accumulation of toxins by microorganisms, algae, plants, and animals (Datry et al., 2017). When intermittent and ephemeral streams are piped, buried, or otherwise degraded, the intrinsic capacity of these stream reaches to purify and filter water is compromised, which can lead to declines in downstream water quality. The magnitude of these filtration processes is so substantial that having intact headwater streams is more predictive of downstream water quality than downstream factors such as local land use or riparian cover (Dodds and Oakes, 2008; Alexander et al., 2007).

Furthermore, intermittent and ephemeral streams perform a large proportion of this ecosystem service due to the high prevalence of these flows in headwater streams. One study estimated that 69% percent of small streams below 60° latitude (i.e. south of Juneau, Alaska) flow only intermittently (Acuña et al., 2014). In much of the Southeast, the relative proportion of intermittent and ephemeral streams may exceed these estimates; in the Chattooga watershed in Georgia, North Carolina, and South Carolina, for example, 72% of the stream miles within a watershed were classified as intermittent or ephemeral streams (Hansen, 2001). The ubiquity of intermittent and ephemeral streams and the necessity of the functions that they perform underscore the crucial role that intermittent and ephemeral streams play in maintaining water quality, particularly for large waterbodies upon which humans rely.

7.3.3 Erosion and flood control

Intermittent and ephemeral streams play a crucial role in erosion and flood mitigation. By enabling the infiltration of water into dry sediments and groundwater supplies, intermittent and ephemeral channels buffer against large stormflows (Datry et al., 2017). Compared to reaches that are paved over or otherwise compacted, intact headwater streams and intermittent and ephemeral streams can reduce storm flows by 200-500% (Freeman et al., 2007). The infiltration and slowing of storm pulses reduce the likelihood of flows overtopping riverbanks, which often damage human infrastructure and agriculture. By reducing the volume and velocity of water following precipitation, infiltration within intermittent and ephemeral streams reduces the erosive capacity of storm flows, preventing the transport of excess sediment into downstream portions of watersheds. Excess sediment is considered the foremost pollutant of streams and rivers (Cooper, 1993), and is detrimental to municipal and industrial water supplies, dam longevity, and the health of aquatic organisms (Wenger, 1999).

Riparian vegetation associated with intact intermittent and ephemeral streams also helps mitigate floods and erosion. First, the presence of riparian vegetation decreases stormflow volumes via evapotranspiration. Areas maintained in forests promote enhanced evaporation of water from soil and leaf surfaces compared to land converted to other uses (Calder et al., 1995). Second, intact riparian vegetation associated with functioning intermittent and ephemeral streams slows the momentum of water moving across the land surface. This not only helps moderate potentially catastrophic pulses of water downstream, it enables sediment to settle out of water and remain on land, and limits stream bank erosion

and collapse (Wenger, 1999).

7.3.4 Groundwater recharge

Intermittent and ephemeral streams replenish aquifers that are crucial sources of human water (Boulton, 2014). In many basins, the infiltration of water from intermittent and ephemeral streams constitutes a primary source of groundwater recharge (Pool, 2005; Amiaz et al., 2011). Ephemeral streams, by definition, always flow above the groundwater table. Therefore, during periods of flow, some surface water, solutes and organic matter are transferred to underground aquifers (McDonough et al., 2011). The role of intermittent and ephemeral streams can be especially important in porous, karstic systems, which are topographies characterized by the presence of sinkholes and caves (Katz et al., 1998). Karst topography predominates in parts of the Southeast, most notably in the areas of southern Alabama, Georgia and South Carolina that comprise the Floridan aquifer system (Katz et al., 1998; DeSimone et al., 2014). Among the most important aquifer systems nationwide, the Upper Floridan aquifer is the primary source of water for more than 10 million people and has supported water withdrawals of nearly 2 billion gallons per day for irrigation purposes in recent years (Marella and Berndt, 2005). With demand for water resources projected to expand rapidly in the coming decades as a result of agricultural, human population growth, and climate change (Carter et al., 2014), intermittent and ephemeral streams will become increasingly important in replenishing aquifers and thus human water sources.

7.4 Provisioning services

Riparian zones supported by intermittent and ephemeral streams serve as an important source of plant materials for livestock as well as habitat for economically valuable wildlife. Riparian zones around intermittent and ephemeral streams generally support more substantial vegetation than areas not adjacent to streams, particularly in drier regions. This vegetation can provide forage for livestock, as well as timber products (Steward et al., 2012). These riparian zones also represent important habitat for wildlife, including valuable game species such as deer (Compton et al., 1988). As hunting is a large driver of economic activity in the southern U.S., responsible for over $10 billion in expenditures in 2011 (Poudel et al., 2016), conservation of important wildlife habitats, such as intermittent and ephemeral streams, provides important benefits in terms of sustaining this valuable industry.

The importance of intermittent and ephemeral streams has also been demonstrated for many fish, including commercially and recreationally valuable salmon and trout species (Wigington et al., 2006). Brook trout, an important and iconic sportfish in mountainous portions of the South, often utilize isolated pools within intermittent streams for critical summer habitat (Hudy et al., 2008; Courtwright and May, 2013). Furthermore, brook trout that occupy isolated intermittent streams in summer rely heavily on surrounding riparian areas for food; in one study, terrestrial invertebrates comprised 54% of brook trout diet despite representing only 7% of potential food resources (Courtwright and May, 2013). Therefore, alterations to riparian habitat that disrupt the input of terrestrial invertebrates to intermittent streams can have negative impacts on brook trout. Trout fishing has direct economic benefits for the Southeast, with an estimated economic value of $130.3 million in Georgia in 2012 (Dorison, 2012), and approximately $174 million in economic output generated annually

in North Carolina (NC WRC, 2013). A considerable percentage of the streams that comprise the historic range of trout in Virginia and North Carolina are intermittent or ephemeral (37% and 7%, respectively; Trout Unlimited, 2014).

7.5 Cultural services

Flowing and dry periods within intermittent and ephemeral streams provide cultural benefits to diverse groups through scientific, educational, entertainment, and aesthetic engagement (Datry et al., 2017). During flowing phases, ephemeral streams play roles within society similar to the cultural, recreational, and spiritual roles played by perennial streams. When flows cease, dry riverbeds can serve as areas to hike, camp, and enjoy the natural world (Steward et al., 2012). Moreover, ephemeral streams contribute to overall human well-being through the other ecosystem services they provide (Boulton, 2014).

More broadly, the ecosystem services supplied by intermittent and ephemeral streams are crucial for the cultural value of downstream waterbodies. Lakes and rivers treasured for swimming, fishing, and other forms of outdoor recreation rely on intact networks of intermittent and ephemeral streams for their overall water quality and quantity, as illustrated in Section 7.2 and 7.3. Without these services, problems with water quality and quantity can greatly diminish the cultural value of large waterbodies, with impacts ranging from swimming restrictions to eutrophication-driven fish kills.

Intermittent and ephemeral streams also have a place in indigenous American culture. Native Zuni Americans used dams on ephemeral streams to strategically and periodically irrigate their crops in adjacent floodplains (Norton et al., 2002). These streams have also subtly pervaded American culture, written about by the likes of American poet Robert Frost in "Hyla Brook" in the early 20th century (Frost, 1920).

8 Case Studies of Stream Burial

8.1 Impaired, unrestored buried streams

Streams, of any type, are not pipes that merely transport water downstream; they instead function as active transformers of solutes and habitat for fish, invertebrates, and microbes. They mitigate floods, maintain water quality, and provide cultural benefits. These services are largely derived from the interactions between groundwater and surface water, which is especially true for intermittent and ephemeral streams (Cerling et al., 1990). However, piping streams underground and disrupting intact riparian environments can eliminate these ecosystem services (Beaulieu et al., 2014). Burial results in a loss of riparian and groundwater connection, which provides the foundation for many of those critical stream benefits (Groffman et al., 2002).

Streams in the southeastern U.S. are especially imperiled due to both modification of streams in urban areas and mountaintop mining which results in burial of streams, especially intermittent and ephemeral streams (Bernhardt and Palmer, 2011). Streams in urban areas experience many negative effects due to human activity including increased erosion, sedimentation, elevated nutrient concentrations, elevated conductivity, increased bacterial concentrations, and harmful algal blooms (Walsh et al., 2005; Wenger et al., 2009). One study in the Chesapeake Bay found that 20 percent of all streams are

buried, with some catchments experiencing burial rates of up to 70% of all headwaters (Elmore and Kaushal, 2008). In sum, burial to streams occurs in the Southeast for primarily two reasons: urbanization and valley fills from mountaintop mining.

8.1.1 Urbanization

Urbanization threatens the health, function, and biodiversity of intermittent and ephemeral streams. Around 60 percent of the world's population will reside in an urban area by 2030 (UN, 2016), and the fast-growing Southeastern U.S. is expected to see similar urbanization increases (Terando et al., 2014). Cities and urbanization are not developed in isolation; much of their environmental footprint has external repercussions. Anthropogenically-altered landscapes load high nitrogen concentrations into streams (Vitousek et al., 1997), transforming urban streams into large contributors of nitrogen (nitrate and ammonia) exports (Walsh et al., 2005), which can lead to eutrophic conditions and contribute to harmful algal blooms in downstream ecosystems (Howarth et al., 2002). Via the taming and domestication of urban waters, streams are hydrologically modified disconnected from their floodplains and increasingly channelized or buried (Grimm et al., 2005; Vietz et al., 2014; Elmore and Kaushal, 2008). As towns and cities grow, streams are often paved over and placed in corrugated steel pipes or concrete culverts so development can occur where the streams once ran, altering key ecosystem services (Paul and Meyer, 2001). Burial entails a loss of groundwater-surface water interaction and a subsequent loss of critical sediment and processing, a loss of light, and complete riparian disconnection. These modifications impair microbial processing (Beaulieu et al., 2014), lower stream productivity (Pennino et al., 2014), and reduce or eliminate key habitats for fish and wildlife. The most critical loss of services following burials comes in the form of a loss of nutrient pollution reduction, which is essential to the maintenance of water quality (Beaulieu et al., 2014). The reduction of nitrogen retention as a result of burial exacerbates nitrate export (Pennino et al., 2014), decreases a stream's ability to remove nitrogen (Beaulieu et al., 2014; Grimm et al., 2005), and ultimately lowers stream metabolism (Pennino et al., 2014), which has been increasingly used as a metric for stream health (Young et al., 2008). These supporting services, which craft the foundation for the remaining ecosystem services, are not the only components impacted by stream burial.

Regulating services are similarly affected. The gravel that forms the bottom of many intermittent streams contributes to sediment retention (Cerling et al., 1990). The absence of this ecosystem service can impair water quality and aquatic habitat, while increasing the likelihood of downstream floods and poorer water quality (Buchholz and Younos, 2007). Piping and burying streams stunts the natural ability of a stream to follow its more uniform course. The culverts often act as a dam that spreads the stream's water out beyond its natural floodplain and thereby inundate adjacent riparian areas. This can lead to blockages, backups, and uncontrolled overflow before the piped reach (Wild et al., 2011). Additionally, stream burial is a maintenance liability, and often more expensive to operate than open water counterparts (Wild et al., 2011), due to difficult access and aging, leaky infrastructure (Kaushal et al., 2015).

Stroubles Creek, Blacksburg, Virginia

Stroubles Creek is a 14,336-acre sub-watershed of the New River watershed in Montgomery County, southwest Virginia. It flows for 9.2 miles through a gradient of development and urbanization, including rolling agricultural hills, pastures, urban landscapes, and forested areas, before draining into the New River (Buchholz and Younos, 2007; Hession, 2017). The catchment includes most of the Virginia Polytechnic Institute (Virginia Tech) campus and the Town of Blacksburg. The watershed can be split into Upper and Lower Stroubles catchments. The Upper Stroubles watershed is 6,119 acres and drains the large urban area claimed by the Town of Blacksburg and Virginia Tech campus (Benham et al., 2003). It is characterized as a pool-riffle channel (Buchholz and Younos, 2007), where pools provide opportunities for fish habitat and nutrient retention, and riffles serve as microhabitats for macroinvertebrates. Due to changes in land use, Stroubles Creek receives an influx of fine sediment and nutrient pollution derived from fertilizers and livestock, and has been buried beneath much of the town.

This headwater stream, formed via tributaries that are often expanding and contracting seasonally and with precipitation, was the driver behind the founding of the Town of Blacksburg in 1798 in its current location (Parece et al., 2010). Currently, the stream has been relegated to subterranean flow in favor of development. Contamination from cultivated fields, pastures, campus and town development, and coal mining increased (Buchholz and Younos, 2007), with impairments such as burial inhibiting the natural ability of the stream to mitigate this pollution. Contamination, coupled with rapid residential growth and the expanding local university (Parece et al., 2010), have influenced stormwater management initiatives along the creek (Buchholz and Younos, 2007). As development continues, water quality issues persist and multiply as more stream segments are buried and surrounded by impervious surfaces, including those intermittent and ephemeral tributaries (Buchholz and Younos, 2007).

Stroubles Creek has been designated as "impaired" by the Virginia Department of Environmental Quality because of the decline of critical benthic macro-invertebrate populations in the stream due to agricultural and urban pollution (Benham et al., 2003). Stream burial can inhibit the mitigation and filtration of nutrients and pollutants (Beaulieu et al., 2014), likely contributing to the impairment designation. The EPA approved a Total Mass Daily Load plan for Stroubles in 2004 (Buchholz and Younos, 2007), which limits the incoming sediment load to a stream. Approximately 27% of sediment loading came from bank erosion (Buchholz and Younos, 2007), which can be catalyzed by burial (Elmore and Kaushal, 2008).

The burial of intermittent, ephemeral, and perennial headwater streams of Stroubles Creek has contributed to widespread environmental degradation including the loss of macroinvertebrate populations, declines in stream health, impairment of water quality, and an excessive export of pollutants. Blacksburg community leaders have emphasized the historical importance of Stroubles, and called for the exploration of daylighting to restore this stream and surrounding ecosystem (Town of Blacksburg, 2016).

8.1.2 Mountaintop mining

Mountaintop mining presents the largest threat to Appalachian watersheds. The rock waste from mountain ridge and summit explosions are disposed of in adjacent valleys and create fills that bury headwater streams under up to hundreds of cubic meters of waste (Bernhardt and Palmer, 2011). Mountaintop mining is the largest driver of land use change in the central Appalachian ecoregion (Townsend et al., 2009), where hundreds of headwater streams have been impacted, and more than 1,180 miles [8] of stream miles have been buried beneath coal mining waste (Bernhardt et al., 2012; Palmer and Hondula, 2014).

Mountaintop mining fills heavily reduce, if not entirely destroy, biodiversity and function in the areas where streams are covered by fill. The streams below the fill also experience reduced biodiversity and function. Valley fills impair stream salamander abundance in streams that flow downstream of fills, likely due to serious degradation of water quality (Wood and Williams, 2013; Price et al., 2016). Fish species distributions are also negatively influenced by valley fills (Hopkins and Roush, 2013). Additionally, macroinvertebrate communities are also detrimentally impacted when located downstream of valley fills (Pond et al., 2014). The impediments to the streams from valley fills represent both an elimination of habitat from physical obstruction due to waste and impairment due to degraded water quality (Palmer et al., 2010).

Streams buried by mountaintop mining waste release alkaline mine drainage into the bodies of water that receive them, as well as greater concentrations of cations and anions that can exceed toxicity requirements (Bernhardt et al., 2012; Lindberg et al., 2011; U.S. EPA, 2011). Burying streams beneath mountaintop removal waste increases pH, specific conductance, chloride, sulfate, and total dissolved solids, all of which negatively impact the ecological health of the system (Wood and Williams, 2013). Macroinvertebrate communities, for instance, have been extremely impacted by mountaintop mining practices (Pond et al., 2014). Conductivity levels of streams impacted by mountaintop mining commonly exceed 300 $\mu S\ cm^{-1}$, which is the level the EPA has determined to be harmful to aquatic life (Lindberg et al., 2011). Reclamation of mine land has had limited success (Hopkins et al., 2013), suggesting that preemptive conservation of streams may be the best course of action to preserve stream health and water quality near mountaintop mining activities.

8.2 Restored streams following daylighting

8.2.1 Little Sugar Creek, Charlotte, North Carolina

Little Sugar Creek begins as intermittent, headwater tributaries in Mecklenburg County, North Carolina and flows for about 20 miles through uptown Charlotte to the South Carolina state line (Arendt, 2015). It is a major tributary of the Catawba River (Arendt, 2015). The name of Little Sugar Creek comes from the indigenous tribe Sugartree, which roughly translates to either "group of huts" or "people of the river of water which is unfit to drink" (Mecklenburg County, 2003). In the 1980s, Little Sugar Creek was one of the most polluted waterways in North Carolina. Additionally, two 100-year floods occurred within two years in 1995 and 1997 (Mecklenburg County, 2003), creating millions of dollars in damage and spurring the county to create a restoration plan to reestablish floodplains (Arendt, 2015).

[8] converted from reported 1,900 km

Restoration entailed the removal of about 1,500 feet of concrete from atop the creek by removing parking lots from strip retail lots (Arendt, 2015). An estimated 6,000 feet of streambed was restored, with approximately 6,300 feet of greenway built alongside (Arendt, 2015). Four rain gardens were created, two wetlands constructed in the floodplains, and one pedestrian footbridge was built (Caplanides, 2014). Over 7 miles of trails were created, and over 3,000 acres of riparian and adjacent floodplains were restored (Arendt, 2015).

The goals of restoration and construction of the greenway alongside unearthed, restored sections were to improve water quality and create miles of trails to serve as hotspots for cultural services, yielding increased tourism and more recreational opportunities (Burroughs, 2002; Caplanides, 2014). Additional goals of restoration included creating signature parks, presenting alternative transportation routes, and generating economic opportunity (Mecklenburg County, 2003). Every dollar spent on the greenway (an estimated $42 million) is projected to yield at least $3 of private development. The potential payback is approximately $82 million (Caplanides, 2014).

8.2.2 Shoal Creek, Dekalb, Georgia

Shoal Creek rises in Dekalb, Georgia and is a 11.94 mile long tributary of the Soque River, which flows into the Chattahoochee River. The Dekalb County Parks Department installed a culvert over a 200m reach of a tributary of the creek. It is likely that the stream was ephemeral or intermittent (Pinkham, 2000). The culvert that the Parks Department installed caused sinkholes over the next decade (Pinkham, 2000). The 200 foot long culvert was removed in 1994 and the stream was daylighted (Pinkham, 2000). For this stream and others, the maintenance of culverted or piped streams can be costlier than the resources required for managing open systems (Wild et al., 2011). This is especially true when Clean Water Act grants are available to perform such projects. In the end, the town ended up with a less expensive and more ascetically pleasing fix (Pinkham, 2000). The riparian areas planted along the stream banks flourished, and serves as a successful example of daylighting for those advocating further stream restoration activities in the Atlanta area (Pinkham, 2000).

8.2.3 Rocky Branch, Raleigh, North Carolina

Rocky Branch is a headwater stream rising in Raleigh, North Carolina, and eventually draining into the Neuse River (Doll, 2010). It runs through more than a mile of North Carolina State University's (NC State) campus (Doll, 2010), and its watershed is comprised of 260 *ha* that drain the entire campus (Jennings, 2003). In recent years, a burst of development and construction of impervious surfaces has created artificial perennial headwaters on parking lots and gutter systems (Bratt et al., 2017). These alterations eliminate potential for riparian retention (Groffman et al., 2002) and increase nutrient pollution and sediment load (Elmore and Kaushal, 2008). Impervious areas, coupled with stream burial, cause channel incision downstream (Elmore and Kaushal, 2008), where erosion along the streambanks was so severe that it caused concern among adjacent businesses who thought that the banks might collapse (Duda and Lenat, 1979). Burial also contributed to high sediment concentrations, even in the absence of ongoing construction (Duda and Lenat, 1979).

The North Carolina Division of Water Quality classified Rocky Branch as one of North Carolina's most polluted streams

in 1978 (Doll, 2010). Algal blooms occurred seasonally, and the creek was found to be devoid of macroinvertebrates, indicative of pollution to a toxic level (Duda and Lenat, 1979; Jennings, 2003). Due to water quality impairment, the North Carolina Sea Grant and NC State formed a partnership to restore Rocky Branch. They implemented an extensive stream restoration project, including the daylighting of a significant portion that runs through campus. The restoration has enabled further growth and connection of the town's Capital Area Greenway System (Doll, 2010), a network of interconnected trails for recreation, including walking, jogging, picnicking, hiking, and bird watching (Raleigh Parks and Resources, 2017).

To daylight part of Rocky Branch, the project participants exhumed 235 feet of buried stream (Doll, 2010). The stream was taken out of culverted pipes, and the floodplain and streambed were reconstructed (Doll, 2010). The ultimate project goals included restoring floodplain accessibility, vegetated riparian buffers, and a habitable streambed of riffles and pools (Doll, 2010). Once culverts were removed, the bed of the stream was elevated to access adjacent floodplains (Jennings, 2003), restoring potential for riparian mitigation of nutrients (Groffman et al., 2002).

Below is a list of the most relevant peer-reviewed studies, books, government publications, and non-government publications that we found discussing the functions and values, prevalence, and importance of geographically isolated wetlands and intermittent and ephemeral streams.

Resources

Peer-Reviewed Sources

[Acuña et al., 2014] Acuña, V., Datry, T., Marshall, J., Barceló, D., Dahm, C. N., Ginebreda, A., McGregor, G., Sabater, S., Tockner, K., and Palmer, M. A. (2014). Why Should We Care About Temporary Waterways? *Science*, 343(6175):1080–1081.

[Aldridge et al., 2009] Aldridge, K. T., Brookes, J. D. and Ganf, G. G. (2009). Rehabilitation of Stream Ecosystem Functions through the Reintroduction of Coarse Particulate Organic Matter. *Restoration Ecology*, 17(1):97–106.

[Alexander et al., 2007] Alexander, R. B., Boyer, E. W., Smith, R. A., Schwarz, G. E., and Moore, R. B. (2007). The Role of Headwater Streams in Downstream Water Quality. *Journal of the American Water Resources Association*, 43(1):41–59.

[Ameli and Creed, 2017] Ameli, A. A. and Creed, I. F. (2017) Quantifying Hydrologic Connectivity of Wetlands to Surface Water Systems. *Hydrology and Earth System Sciences*, 21(3):1791–1808.

[Amiaz et al., 2011] Amiaz, Y., Sorek, S., Enzel, Y., and Dahan, O. (2011). Solute Transport in the Vadose Zone and Groundwater during Flash Floods. *Water Resources Research*, 47(10):W10513.

[Atkinson et al., 2011] Atkinson, C. L., Golladay, S. W., and First, M. R. (2011). Water Quality and Planktonic Microbial Assemblages of Isolated Wetlands in an Agricultural Landscape. *Wetlands*, 31(5):885–894.

[Barrett et al., 2014] Barrett, K., Nibbelink, N.P., and Maerz, J.C. (2014). Identifying Priority Species and Conservation Opportunities Under Future Climate Scenarios: Amphibians in a Biodiversity Hotspot. *Journal of Fish and Wildlife Management*, 5(2):282–297.

[Barton et al., 2008] Barton, C. D., Andrews, D. M., and Kolka, R. K. (2008). Evaluating Hydroperiod Response in Restored Carolina Bay Wetlands Using Soil Physicochemical Properties. *Restoration Ecology*, 16(4):668–677.

[Beaulieu et al., 2014] Beaulieu, J. J., Mayer, P. M., Kaushal, S. S., Pennino, M. J., Arango, C. P., Balz, D. A., Canfield, T. J., Elonen, C. M., Fritz, K. M., Hill, B. H., Ryu, H., and Domingo, J. W. S. (2014). Effects of Urban Stream Burial on Organic Matter Dynamics and Reach Scale Nitrate Retention. *Biogeochemistry*, 121(1):107–126.

[Beckley and Gramling, 2013] Beckley, A. C. and Gramling, J. M. (2013). Description and Classification of Lindera melissifolia Habitat in the Southeastern Coastal Plain. *Castanea*, 78(4):277–289.

[Bedford and Godwin, 2003] Bedford, B. L. and Godwin, K. S. (2003). Fens of the United States: Distribution, Characteristics, and Scientific Connection Versus Legal Isolation. *Wetlands*, 23(3):608–629.

[Benfield, 1997] Benfield, E. F. (1997). Comparison of Litterfall Input to Streams. *Journal of the North American Benthological Society*, 16(1):104–108.

[Benstead and Leigh, 2012] Benstead, J. P, and Leigh, D. S. (2012) An Expanded Role for River Networks. *Nature Geoscience*, 5:678–679.

[Bernal and Mitsch, 2012] Bernal, B. and Mitsch, W. J. (2012). Comparing Carbon Sequestration in Temperate Freshwater Wetland Communities. *Global Change Biology*, 18(5):1636–1647.

[Bernhardt et al., 2012] Bernhardt, E., Lutz, B., S King, R., Fay, J., E Carter, C., Helton, A., Campagna, D., and Amos, J. (2012). How Many Mountains Can We Mine? Assessing the Regional Degradation of Central Appalachian Rivers by Surface Coal Mining. *Environmental Science & Technology*, 46:8115–8122.

[Bernhardt and Palmer, 2011] Bernhardt, E. S. and Palmer, M. A. (2011). The Environmental Costs of Mountaintop Mining Valley Fill Operations for Aquatic Ecosystems of the Central Appalachians. *Annals of the New York Academy of Sciences*, 1223:39–57.

[Bhadha et al., 2011] Bhadha, J. H., Jawitz, J. W., and Min, J.-H. (2011). Phosphorus Mass Balance and Internal Load in an Impacted Subtropical Isolated Wetland. *Water, Air, & Soil Pollution*, 218(1-4):619–632.

[Boulton, 2014] Boulton, A. J. (2014). Conservation of Ephemeral Streams and Their Ecosystem Services: What Are We Missing? *Aquatic Conservation: Marine and Freshwater Ecosystems*, 24(6):733–738.

[Boyer and Polasky, 2004] Boyer, T. and Polasky, S. (2004). Valuing Urban Wetlands: A Review of Nonmarket Valuation Studies. *Wetlands*, 24(4):744–755.

[Braat and de Groot, 2012] Braat, L. C. and de Groot, R. (2012). The Ecosystem Services Agenda: Bridging the Worlds of Natural Science and Economics, Conservation and Development, and Public and Private Policy. *Ecosystem Services*, 1(1):4–15.

[Bratt et al., 2017] Bratt, A. R., Finlay, J. C., Hobbie, S. E., Janke, B. D., Worm, A. C., and Kemmitt, K. L. (2017). Contribution of Leaf Litter to Nutrient Export during Winter Months in an Urban Residential Watershed. *Environmental Science & Technology*, 51(6):3138–3147.

[Bridges and Orzell, 1989] Bridges, E. L. and Orzell, S. L. (1989). Additions and Noteworthy Vascular Plant Collections from Texas and Louisiana, with Historical, Ecological and Geographical Notes. *Phytologia (USA).*

[Brinson, 1991] Brinson, M. M. (1991). Landscape Properties of Pocosins and Associated Wetlands. *Wetlands*, 11(1):441–465.

[Brooks et al., 2010] Brooks, M. J., Taylor, B. E., and Ivester, A. H. (2010). Carolina Bays: Time Capsules of Culture and Climate Change. *Southeastern Archaeology*, 29(1):146–163.

[Brooks, 2009] Brooks, R. T. (2009). Potential Impacts of Global Climate Change on the Hydrology and Ecology of Ephemeral Freshwater Systems of the Forests of the Northeastern United States. *Climatic Change*, 95(3-4):469–483.

[Bruland et al., 2003] Bruland, G. L., Hanchey, M. F., and Richardson, C. J. (2003). Effects of Agriculture and Wetland Restoration on Hydrology, Soils, and Water Quality of a Carolina Bay Complex. *Wetlands Ecology and Management*, 11(3):141–156.

[Bruland and Richardson, 2006] Bruland, G. L. and Richardson, C. J. (2006). Comparison of Soil Organic Matter in Created, Restored and Paired Natural Wetlands in North Carolina. *Wetlands Ecology and Management*, 14(3):245–251.

[Bunn et al., 2006] Bunn, S. E., Thoms, M. C., Hamilton, S. K., and Capon, S. J. (2006). Flow Variability in Dryland Rivers: Boom, Bust and the Bits in Between. *River Research and Applications*, 22(2):179–186.

[Burke and Gibbons, 1995] Burke, V. J. and Gibbons, J. W. (1995). Terrestrial Buffer Zones and Wetland Conservation: A Case Study of Freshwater Turtles in a Carolina Bay. *Conservation Biology*, 9(6):1365–1369.

[Burke et al., 1995] Burke, V. J., Greene, J. L., and Gibbons, J. W. (1995). The Effect of Sample Size and Study Duration on Metapopulation Estimates for Slider Turtles (Trachemys scripta). *Herpetologica*, 51(4):451–456.

[Cabezas et al., 2014] Cabezas, A., Pallasch, M., Schönfelder, I., Gelbrecht, J., and Zak, D. (2014). Carbon, Nitrogen, and Phosphorus Accumulation in Novel Ecosystems: Shallow Lakes in Degraded Fen Areas. *Ecological Engineering*, 66:63–71.

[Calder et al., 1995] Calder, I. R., Hall, R. L., Bastable, H. G., Gunston, H. M., Shela, O., Chirwa, A., and Kafundu, R. (1995). The Impact of Land Use Change on Water Resources in Sub-Saharan Africa: a Modelling Study of Lake Malawi. *Journal of Hydrology*, 170(1):123–135.

[Calhoun et al., 2017] Calhoun, A. J. K., Mushet, D. M., Bell, K. P., Boix, D., Fitzsimons, J. A., and Isselin-Nondedeu, F. (2017). Temporary Wetlands: Challenges and Solutions to Conserving a 'Disappearing' Ecosystem. *Biological Conservation*, 211:3–11.

[Carpenter et al., 1998] Carpenter, S. R., Caraco, N. F., Correll, D. L., Howarth, R. W., Sharpley, A. N. and Smith, V. H. (1998). Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen. *Ecological Applications*, 8(3):559–568.

[Cerling et al., 1990] Cerling, T. E., Morrison, S. J., Sobocinski, R. W., and Larsen, I. L. (1990). Sediment-Water Interaction in a Small Stream: Adsorption of 137cs by Bed Load Sediments. *Water Resources Research*, 26(6):1165–1176.

[Cheng and Basu, 2017] Cheng, F. Y. and Basu, N. B. (2017). Biogeochemical Hotspots: Role of Small Water Bodies in Landscape Nutrient Processing. *Water Resources Research*, 53(6):5038–5056.

[Clark et al., 1985] Clark, M. K., Lee, D. S., and Funderburg, J. B. (1985). The Mammal Fauna of Carolina Bays, Pocsins, and Associated Communities in North Carolina: An Overview. *Brimleyana.*, 11:1–38.

[Coes et al., 2007] Coes, A. L., Spruill, T. B., and Thomasson, M. J. (2007). Multiple-Method Estimation of Recharge Rates at Diverse Locations in the North Carolina Coastal Plain, USA. *Hydrogeology Journal*, 15(4):773–788.

[Cohen et al., 2016] Cohen, M. J., Creed, I. F., Alexander, L., Basu, N. B., Calhoun, A. J. K., Craft, C., D'Amico, E., DeKeyser, E., Fowler, L., Golden, H. E., Jawitz, J. W., Kalla, P., Kirkman, L. K., Lane, C. R., Lang, M., Leibowitz, S. G., Lewis, D. B., Marton, J., McLaughlin, D. L., Mushet, D. M., Raanan-Kiperwas, H., Rains, M. C., Smith, L.,

and Walls, S. C. (2016). Do Geographically Isolated Wetlands Influence Landscape Functions? *Proceedings of the National Academy of Sciences*, 113(8):1978–1986.

[Collins et al., 2005] Collins, B. S., Sharitz, R. R., and Coughlin, D. P. (2005). Elemental Composition of Native Wetland Plants in Constructed Mesocosm Treatment Wetlands. *Bioresource Technology*, 96(8):937–948.

[Collins et al., 2010] Collins, K. A., Lawrence, T. J., Stander, E. K., Jontos, R. J., Kaushal, S. S., Newcomer, T. A., Grimm, N. B., and Cole Ekberg, M. L. (2010). Opportunities and Challenges for Managing Nitrogen in Urban Stormwater: A Review and Synthesis. *Ecological Engineering*, 36(11):1507–1519.

[Compton et al., 1988] Compton, B. B., Mackie, R. J., and Dusek, G. L. (1988). Factors Influencing Distribution of White-Tailed Deer in Riparian Habitats. *The Journal of Wildlife Management*, 52(3):544–548.

[Congdon and Gibbons, 1983] Congdon and Gibbons, J. W. (1983). Relationships of Reproductive Characteristics to Body Size in Pseudemys scripta). *Herpetologica*, 39(2):147–151.

[Cooper, 1993] Cooper, C. M. (1993). Biological Effects of Agriculturally Derived Surface Water Pollutants on Aquatic Systems—A Review. *Journal of Environmental Quality*, 22(3):402–408.

[Costanza et al., 1997] Costanza, R., d'Arge, R., Groot, R. d., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., and Belt, M. v. d. (1997). The Value of the World's Ecosystem Services and Natural Capital. *Nature*, 387(6630):253–260.

[Costanza et al., 2014] Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S. J., Kubiszewski, I., Farber, S., and Turner, R. K. (2014). Changes in the Global Value of Ecosystem Services. *Global Environmental Change*, 26:152–158.

[Courtwright and May, 2013] Courtwright, J. and May, C. L. (2013). Importance of Terrestrial Subsidies for Native Brook Trout in Appalachian Intermittent Streams. *Freshwater Biology*, 58(11):2423–2438.

[Craft et al., 2017] Craft, C., Vymazal, J., and Kröpfelová, L. (2017). Carbon Sequestration and Nutrient Accumulation in Floodplain and Depressional Wetlands. *Ecological Engineering*.

[Craft and Casey, 2000] Craft, C. B. and Casey, W. P. (2000). Sediment and Nutrient Accumulation in Floodplain and Depressional Freshwater Wetlands of Georgia, USA. *Wetlands*, 20(2):323–332.

[Craft and Chiang, 2002] Craft, C. B. and Chiang, C. (2002). Forms and Amounts of Soil Nitrogen and Phosphorus Across a Longleaf Pine–Depressional Wetland Landscape. *Soil Science Society of America Journal*, 66(5):1713–1721.

[Craft and Richardson, 1997] Craft, C. B. and Richardson, C. J. (1997). Relationships between Soil Nutrients and Plant Species Composition in Everglades Peatlands. *Journal of Environmental Quality*, 26(1):224–232.

[Czapka and Kilgo, 2011] Czapka, S. and Kilgo, J. (2011). Importance of Carolina Bays to the Avifauna of Pinelands in the Southeastern United States. *Southeastern Naturalist*, 10(2):321–332.

[Dages et al., 2015] Dages, C., Samouëlian, A., Negro, S., Storck, V., Huttel, O., and Voltz, M. (2015). Seepage Patterns of Diuron in a Ditch Bed During a Sequence of Flood Events. *Science of The Total Environment*, 537:120–128.

[Datry et al., 2017] Datry, T., Boulton, A. J., Bonada, N., Fritz, K., Leigh, C., Sauquet, E., Tockner, K., Hugueny, B., and Dahm, C. N. (2017). Flow Intermittence and Ecosystem Services in Rivers of the Anthropocene. *Journal of Applied Ecology*, 55:353–364.

[Datry et al., 2014] Datry, T., Larned, S. T., and Tockner, K. (2014). Intermittent Rivers: A Challenge for Freshwater Ecology. *BioScience*, 64(3):229–235.

[DeGregorio et al., 2014] DeGregorio, B. A., Willson, J. D., Dorcas, M. E., and Gibbons, J. W. (2014). Commercial Value of Amphibians Produced From an Isolated Wetland. *The American Midland Naturalist*, 172(1):200–204.

[Delucchi and Peckarsky, 1989] Delucchi, C. M. and Peckarsky, B. L. (1989). Life History Patterns of Insects in an Intermittent and a Permanent Stream. *Journal of the North American Benthological Society*, 8(4):308–321.

[Dodds and Oakes, 2008] Dodds, W. K. and Oakes, R. M. (2008). Headwater Influences on Downstream Water Quality. *Environmental Management*, 41(3):367–377.

[Drewry et al., 2013] Drewry, J. M., Van Manen, F. T., and Ruth, D. M. (2013). Density and Genetic Structure of Black Bears in Coastal South Carolina. *The Journal of Wildlife Management*, 77(1):153–164.

[Dunne et al., 2007] Dunne, E. J., Smith, D. B., Clark, M. W., Jawitz, J. W., and Reddy, K. R. (2007). Phosphorus Storages in Historically Isolated Wetland Ecosystems and Surrounding Pasture Uplands. *Ecological Engineering*, 31: 16–28.

[Elmore and Kaushal, 2008] Elmore, A. J. and Kaushal, S. S. (2008). Disappearing Headwaters: Patterns of Stream Burial due to Urbanization. *Frontiers in Ecology and the Environment*, 6(6):308–312.

[Euliss et al., 2004] Euliss, N. H., LaBaugh, J. W., Fredrickson, L. H., Mushet, D. M., Laubhan, M. K., Swanson, G. A., Winter, T. C., Rosenberry, D. O., and Nelson, R. D. (2004). The Wetland Continuum: A Conceptual Framework for Interpreting Biological Studies. *Wetlands*, 24(2):448–458.

[Everitt and Burkholder, 1991] Everitt, D. T. and Burkholder, J. M. (1991). Seasonal Dynamics of Macrophyte Communities from a Stream Flowing over Granite Flatrock in North Carolina, USA. *Hydrobiologia*, 222(3):159–172.

[Ewing et al., 2005] Ewing, J. M., Vepraskas, M. J., and Zanner, C. W. (2005). Using Historical Records of Land Use to Improve Wetland Mitigation. *Southeastern Geographer*, 45(1):25–43.

[Feminella, 1996] Feminella, J. W. (1996). Comparison of Benthic Macroinvertebrate Assemblages in Small Streams along a Gradient of Flow Permanence. *Journal of the North American Benthological Society*, 15(4):651–669.

[Fisher and Grimm, 1985] Fisher, S. G. and Grimm, N. B. (1985). Hydrologic and Material Budgets for a Small Sonoran Desert Watershed during Three Consecutive Cloudburst Floods. *Journal of Arid Environments*, 9(2):105–118.

[Flanagan and Richardson, 2010] Flanagan, N. E. and Richardson, C. J. (2010). A Multi-Scale Approach to Prioritize Wetland Restoration for Watershed-Level Water Quality Improvement. *Wetlands Ecology and Management*, 18(6):695–706.

[Freeman et al., 2007] Freeman, M. C., Pringle, C. M., and Jackson, C. R. (2007). Hydrologic Connectivity and the Contribution of Stream Headwaters to Ecological Integrity at Regional Scales1: Hydrologic Connectivity and the Contribution of Stream Headwaters to Ecological Integrity at Regional Scales. *Journal of the American Water Resources Association*, 43(1):5–14.

[Fritz et al., 2010] Fritz, K. M., Fulton, S., Johnson, B. R., Barton, C. D., Jack, J. D., Word, D. A., and Burke, R. A. (2010). Structural and Functional Characteristics of Natural and

Constructed Channels Draining a Reclaimed Mountaintop Removal and Valley Fill Coal Mine. *Journal of the North American Benthological Society*, 29(2):673–689.

[Fritz et al., 2018] Fritz, K. M., Schofield, K. A., Alexander, L. C., McManus, M. G., Golden, H. E., Lane, C. R., Kepner, W. G., LeDuc, S. D., DeMeester, J. E., and Pollard, A. I. (2018). Physical and Chemical Connectivity of Streams and Riparian Wetlands to Downstream Waters: A Synthesis. *Journal of the American Water Resources Association*, 54(2):323–345.

[Gala and Young, 2015] Gala, T. S. and Young, D. (2015). Geographically Isolated Depressional Wetlands – Hydrodynamics, Ecosystem Functions and Conditions. *Applied Ecology and Environmental Sciences, Applied Ecology and Environmental Sciences*, 3(4):108–116.

[Gibbons, 1970] Gibbons, J. W. (1970). Terrestrial Activity and the Population Dynamics of Aquatic Turtles. *The American Midland Naturalist*, 83(2):404–414.

[Gibbons, 2003] Gibbons, J. W. (2003). Terrestrial Habitat: a Vital Component for Herpetofauna of Isolated Wetlands. *Wetlands*, 23(3):630–635.

[Gibbons and Coker, 1977] Gibbons, J. W. and Coker, J. W. (1977). Ecological and Life History Aspects of the Cooter,*Chrysemys floridana* (Le Conte. *Herpetologica*, 33(1):29–33.

[Gibbons et al., 2006] Gibbons, J. W., Winne, C. T., Scott, D. E., Willson, J. D., Glaudas, X., Andrews, K. M., Todd, B. D., Fedewa, L. A., Wilkinson, L., Tsaliagos, R. N., Harper, S. J., Greene, J. L., Tuberville, T. D., Metts, B. S., Dorcas, M. E., Nestor, J. P., Young, C. A., Akre, T., Reed, R. N., Buhlmann, K. A., Norman, J., Croshaw, D. A., Hagen, C., and Rothermel, B. B. (2006). Remarkable Amphibian Biomass and Abundance in an Isolated Wetland: Implications for Wetland Conservation. *Conservation Biology*, 20(5):1457–1465.

[Gilliam, 1994] Gilliam, J. W. (1994). Riparian Wetlands and Water Quality. *Journal of Environmental Quality*, 23(5):896–900.

[Glime, 1968] Glime, J. M. (1968). Ecological Observations on Some Bryophytes in Appalachian Mountain Streams. *Castanea*, 33(4):300–325.

[Golden et al., 2014] Golden, H. E., Lane, C. R., Amatya, D. M., Bandilla, K. W., Kiperwas, H. R., Knightes, C. D., and Ssegane, H. (2014). Hydrologic Connectivity between Geographically Isolated Wetlands and Surface Water Systems: A Review of Select Modeling Methods. *Environmental Modelling & Software*, 53:190–206.

[Golden et al., 2016] Golden, H. E., Sander, H. A., Lane, C. R., Zhao, C., Price, K., D'Amico, E., and Christensen, J. R. (2016). Relative Effects of Geographically Isolated Wetlands on Streamflow: A Watershed-Scale Analysis. *Ecohydrology*, 9(1):21–38.

[Gomi et al., 2002] Gomi, T., Sidle, R. C., and Richardson, J. S. (2002). Understanding Processes and Downstream Linkages of Headwater Systems. *BioScience*, 52(10):905–916.

[Goodrich et al., 2018] Goodrich, D. C., Kepner, W. G., Levick, L. R., and Wigington, P. J. (2018). Southwestern Intermittent and Ephemeral Stream Connectivity. *Journal of the American Water Resources Association*, 54(2):400–422.

[Greenwood and Rosemond, 2005] Greenwood, J. L. and Rosemond, A. D. (2005). Periphyton Response to Long-Term Nutrient Enrichment in a Shaded Headwater Stream. *Canadian Journal of Fisheries and Aquatic Sciences*, 62(9):2033–2045.

[Grimm et al., 2005] Grimm, N. B., Sheibley, R. W., Crenshaw, C. L., Dahm, C. N., Roach, W. J., and Zeglin, L. H. (2005). N Retention and Transformation in Urban Streams. *Journal of the North American Benthological Society*, 24(3):626–642.

[Groffman et al., 2002] Groffman, P. M., Boulware, N. J., Zipperer, W. C., Pouyat, R. V., Band, L. E., and Colosimo, M. F. (2002). Soil Nitrogen Cycle Processes in Urban Riparian Zones. *Environmental Science & Technology*, 36(21):4547–4552.

[Grubbs, 2011] Grubbs, S. A. (2011). Influence of Flow Permanence on Headwater Macroinvertebrate Communities in a Cumberland Plateau Watershed, USA. *Aquatic Ecology*, 45(2):185–195.

[Gómez-Baggethun et al., 2010] Gómez-Baggethun, E., de Groot, R., Lomas, P. L., and Montes, C. (2010). The History of Ecosystem Services in Economic Theory and Practice: From Early Notions to Markets and Payment Schemes. *Ecological Economics*, 69(6):1209–1218.

[Hansen, 2001] Hansen, W. F. (2001). Identifying Stream Types and Management Implications. *Forest Ecology and Management*, 143(1-3):39–46.

[Hoehn et al., 2003] Hoehn, J. P., Lupi, F., and Kaplowitz, M. D. (2003). Untying a Lancastrian Bundle: Valuing Ecosystems and Ecosystem Services for Wetland Mitigation. *Journal of Environmental Management*, 68(3):263–272.

[Hope et al., 2014] Hope, A. J., McDowell, W. H. and Wollheim, W. M. (2014). Ecosystem Metabolism and Nutrient Uptake in an Urban, Piped Headwater Stream. *Biogeochemistry*, 121(1):167–187.

[Hopkins et al., 2013] Hopkins, R. L., Altier, B. M., Haselman, D., Merry, A. D., and White, J. J. (2013). Exploring the Legacy Effects of Surface Coal Mining on Stream Chemistry. *Hydrobiologia*, 713(1):87–95.

[Hopkins and Roush, 2013] Hopkins, R. L. and Roush, J. C. (2013). Effects of Mountaintop Mining on Fish Distributions in Central Appalachia. *Ecology of Freshwater Fish*, 22(4):578–586.

[Hornberger et al., 2009] Hornberger, M. I., Luoma, S. N., Johnson, M. L., and Holyoak, M. (2009). Influence of Remediation in a Mine-Impacted River: Metal Trends over Large Spatial and Temporal Scales. *Ecological Applications*, 19(6):1522–1535.

[Howarth et al., 2002] Howarth, R. W., Sharpley, A., and Walker, D. (2002). Sources of Nutrient Pollution to Coastal Waters in the United States: Implications for Achieving Coastal Water Quality Goals. *Estuaries*, 25(4):656–676.

[Hudy et al., 2008] Hudy, M., Thieling, T. M., Gillespie, N., and Smith, E. P. (2008). Distribution, Status, and Land Use Characteristics of Subwatersheds within the Native Range of Brook Trout in the Eastern United States. *North American Journal of Fisheries Management*, 28(4):1069–1085.

[Jenkins et al., 2015] Jenkins, C. N., Houtan, K. S. V., Pimm, S. L., and Sexton, J. O. (2015). U.S. Protected Lands Mismatch Biodiversity Priorities. *Proceedings of the National Academy of Sciences*, 112(16):5081–5086.

[Johnson et al., 2013] Johnson, L. T., Tank, J. L., Hall Jr., R. O., Mulholland, P. J., Hamilton, S. K., Valett, H. M., Webster, J. R., Bernot, M. J., McDowell, W. H., Peterson, B. J., and Thomas, S. M. (2013). Quantifying the Production of Dissolved Organic Nitrogen in Headwater Streams Using ^{15}N Tracer Additions. *Limnology and Oceanography*, 58(4):1271–1285.

[Karlin et al., 2016] Karlin, M., Václavík, T., Chadwick, J., and Meentemeyer, R. (2016). Habitat Use by Adult Red Wolves, *Canis rufus*, in an Agricultural Landscape, North Carolina, USA. *Mammal Study*, 41(2):87–95.

[Katz et al., 1998] Katz, B. G., Catches, J. S., Bullen, T. D., and Michel, R. L. (1998). Changes in the Isotopic and Chemical Composition of Ground Water Resulting from a Recharge Pulse from a Sinking Stream. *Journal of Hydrology*, 211(1):178–207.

[Kaushal et al., 2015] Kaushal, S. S., McDowell, W. H., Wollheim, W. M., Johnson, T. A. N., Mayer, P. M., Belt, K. T., and Pennino, M. J. (2015). Urban Evolution: The Role of Water. *Water*, 7(8):4063–4087.

[Kindall and Manen, 2007] Kindall, J. L. and Manen, F. T. V. (2007). Identifying Habitat Linkages for American Black Bears in North Carolina, USA. *The Journal of Wildlife Management*, 71(2):487–495.

[Kirkman et al., 1999] Kirkman, L. K., Golladay, S. W., Laclaire, L., and Sutter, R. (1999). Biodiversity in Southeastern, Seasonally Ponded, Isolated Wetlands: Management and Policy Perspectives for Research and Conservation. *Journal of the North American Benthological Society*, 18(4):553–562.

[Kirkman and Sharitz, 1994] Kirkman, L. K. and Sharitz, R. R. (1994). Vegetation Disturbance and Maintenance of Diversity in Intermittently Flooded Carolina Bays in South Carolina. *Ecological Applications*, 4(1):177–188.

[Kluber et al., 2014] Kluber, L. A., Miller, J. O., Ducey, T. F., Hunt, P. G., Lang, M., and S. Ro, K. (2014). Multistate Assessment of Wetland Restoration on CO_2 and N_2O Emissions and Soil Bacterial Communities. *Applied Soil Ecology*, 76:87–94.

[Knox et al., 2008] Knox, A. K., Dahlgren, R. A., Tate, K. W., and Atwill, E. R. (2008). Efficacy of Natural Wetlands to Retain Nutrient, Sediment and Microbial Pollutants. *Journal of Environmental Quality*, 37(5):1837–1846.

[Lane and Autrey, 2017] Lane, C. R. and Autrey, B. C. (2017). Sediment Accretion and Accumulation of P, N and Organic C in Depressional Wetlands of Three Ecoregions of the United States. *Marine and Freshwater Research*, 68(12):2253–2265.

[Lane and D'Amico, 2016] Lane, C. R. and D'Amico, E. (2016). Identification of Putative Geographically Isolated Wetlands of the Conterminous United States. *Journal of the American Water Resources Association*, 52(3):705–722.

[Lane and D'Amico, 2010] Lane, C. R. and D'Amico, E. (2010). Calculating the Ecosystem Service of Water Storage in Isolated Wetlands using LiDAR in North Central Florida, USA. *Wetlands*, 30(5):967–977.

[Lane et al., 2012] Lane, C. R., D'Amico, E., and Autrey, B. (2012). Isolated Wetlands of the Southeastern United States: Abundance and Expected Condition. *Wetlands*, 32(4):753–767.

[Lane et al., 2018] Lane, C. R., Leibowitz, S. G., Autrey, B. C., LeDuc, S. D., and Alexander, L. C. (2018). Hydrological, Physical, and Chemical Functions and Connectivity of Non-Floodplain Wetlands to Downstream Waters: A Review. *Journal of the American Water Resources Association*, 54(2):346–371.

[Leibowitz, 2003] Leibowitz, S. G. (2003). Isolated Wetlands and Their Functions: An Ecological Perspective. *Wetlands*, 23(3):517–531.

[Leibowitz et al., 2016] Leibowitz, S. G., Mushet, D. M., and Newton, W. E. (2016). Intermittent Surface Water Connectivity: Fill and Spill Vs. Fill and Merge Dynamics. *Wetlands*, 36(2):323–342.

[Leibowitz and Nadeau, 2003] Leibowitz, S. G. and Nadeau, T. L. (2003). Isolated Wetlands: State-of-the-Science and Future Directions. *Wetlands*, 23(3):663–684.

[Leibowitz et al., 2018] Leibowitz, S. G., Wigington, P. J., Schofield, K. A., Alexander, L. C., Vanderhoof, M. K., and Golden, H. E. (2018). Connectivity of Streams and Wetlands to Downstream Waters: An Integrated Systems Framework. *Journal of the American Water Resources Association*, 54(2):298–322.

[Lemlich and Ewel, 1984] Lemlich, S. K. and Ewel, K. C. (1984). Effects of Wastewater Disposal on Growth Rates of Cypress Trees. *Journal of Environmental Quality*, 13(4):602–604.

[Lewis et al., 2011] Lewis, W. M., Wurtsbaugh, W. A., and Paerl, H. W. (2011). Rationale for Control of Anthropogenic Nitrogen and Phosphorus to Reduce Eutrophication of Inland Waters. *Environmental Science & Technology*, 45(24):10300–10305.

[Li et al., 2014] Li, D., Seaman, J. C., Chang, H.-S., Jaffe, P. R., Koster van Groos, P., Jiang, D.-T., Chen, N., Lin, J., Arthur, Z., Pan, Y., Scheckel, K. G., Newville, M., Lanzirotti, A., and Kaplan, D. I. (2014). Retention and Chemical Speciation of Uranium in an Oxidized Wetland Sediment from the Savannah River Site. *Journal of Environmental Radioactivity*, 131:40–46.

[Lide et al., 1995] Lide, R. F., Meentemeyer, V. G., Pinder, J. E., and Beatty, L. M. (1995). Hydrology of a Carolina Bay Located on the Upper Coastal Plain of Western South Carolina. *Wetlands*, 15(1):47–57.

[Lindberg et al., 2011] Lindberg, T. T., Bernhardt, E. S., Bier, R., Helton, A. M., Merola, R. B., Vengosh, A., and Giulio, R. T. D. (2011). Cumulative Impacts of Mountaintop Mining on an Appalachian Watershed. *Proceedings of the National Academy of Sciences*, 108(52):20929–20934.

[Liner et al., 2008] Liner, A. E., Smith, L. L., Golladay, S. W., Castleberry, S. B., and Gibbons, J. W. (2008). Amphibian Distributions within Three Types of Isolated Wetlands in Southwest Georgia. *The American Midland Naturalist*, 160(1):69–81.

[Lydeard and Mayden, 1995] Lydeard, C. and Mayden, R. L. (1995). A Diverse and Endangered Aquatic Ecosystem of the Southeast United States. *Conservation Biology*, 9(4):800–805.

[Mahoney et al., 1990] Mahoney, D. L., Mort, M. A., and Taylor, B. E. (1990). Species Richness of Calanoid Copepods, Cladocerans and Other Branchiopods in Carolina Bay Temporary Ponds. *The American Midland Naturalist*, 123(2):244–258.

[Maltby and Acreman, 2011] Maltby, E. and Acreman, M. C. (2011). Ecosystem Services of Wetlands: Pathfinder for a New Paradigm. *Hydrological Sciences Journal*, 56(8):1341–1359.

[Marton et al., 2015] Marton, J. M., Creed, I. F., Lewis, D. B., Lane, C. R., Basu, N. B., Cohen, M. J., and Craft, C. B. (2015). Geographically Isolated Wetlands are Important Biogeochemical Reactors on the Landscape. *BioScience*, 65(4):408–418.

[McLaughlin and Cohen, 2013] McLaughlin, D. L. and Cohen, M. J. (2013). Realizing Ecosystem Services: Wetland Hydrologic Function along a Gradient of Ecosystem Condition. *Ecological Applications*, 23(7):1619–1631.

[McLaughlin et al., 2014] McLaughlin, D. L., Kaplan, D. A., and Cohen, M. J. (2014). A Significant Nexus: Geographically Isolated Wetlands Influence Landscape Hydrology. *Water Resources Research*, 50(9):7153–7166.

[McMillan et al., 2002] McMillan, P. D., Peet, R. K., Porcher, R. D., and Sorrie, B. A. (2002). Noteworthy Botanical Collections from the Fire-Maintained Pineland and Wetland Communities of the Coastal Plain of the Carolinas and Georgia. *Castanea*, 67(1):61–83.

[Menzel et al., 2005] Menzel, J. M., Menzel, M. A., Kilgo, J. C., Ford, W. M., and Edwards, J. W. (2005). Bat Response to Carolina Bays and Wetland Restoration in the Southeastern U.S. Coastal Plain. *Wetlands*, 25(3):542–550.

[Meyer and Likens, 1979] Meyer, J. L., and Likens, G. E. (1979). Transport and Transformation of Phosphorus in a Forest Stream Ecosystem. *Ecology*, 60(6):1255–1269.

[Meyer et al., 2005] Meyer, J. L., Paul, M.J. and Taulbee, W.K. (2005). Stream Ecosystem Function in Urbanizing Landscapes. *Journal of the North American Benthological Society*, 24(3):602–612.

[Meyer et al., 2007] Meyer, J. L., Strayer, D. L., Wallace, J. B., Eggert, S. L., Helfman, G. S., and Leonard, N. E. (2007). The Contribution of Headwater Streams to Biodiversity in River Networks. *Journal of the American Water Resources Association*, 43(1):86–103.

[Middaugh, 2013] Middaugh, D. P. (2013). Evidence of An Archaic Dam In A Carolina Bay: The Sewee Shell Ring, South Carolina. *Journal of North Carolina Academy of Science*, 129(1):9–19.

[Miller et al., 2017] Miller, J. O., Ducey, T. F., Brigman, P. W., Ogg, C. O., and Hunt, P. G. (2017). Greenhouse Gas Emissions and Denitrification within Depressional Wetlands of the Southeastern US Coastal Plain in an Agricultural Landscape. *Wetlands*, 37(1):33–43.

[Mittermeier et al., 2015] Mittermeier, R.A., van Dijk, P.P., Rhodin, A.G.J., and Nash, S.D. (2015). Turtle Hotspots: An Analysis of the Occurrence of Tortoises and Freshwater Turtles in Biodiversity Hotspots, High-Biodiversity Wilderness Areas, and Turtle Priority Areas. *Chelonian Conservation and Biology*, 14(1):2–10.

[Morse et al., 1993] Morse, J. C., Stark, B. P., and Patrick McCafferty, W. (1993). Southern Appalachian Streams at Risk: Implications for Mayflies, Stoneflies, Caddisflies, and other Aquatic Biota. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 3(4):293–303.

[Mulholland et al., 2008] Mulholland, P. J., Helton, A. M., Poole, G. C., Hall, R. O., Hamilton, S. K., Peterson, B. J., Tank, J. L., Ashkenas, L. R., Cooper, L. W., Dahm, C. N., Dodds, W. K., Findlay, S. E. G., Gregory, S. V., Grimm, N. B., Johnson, S. L., McDowell, W. H., Meyer, J. L., Valett, H. M., Webster, J. R., Arango, C. P., Beaulieu, J. J., Bernot, M. J., Burgin, A. J., Crenshaw, C. L., Johnson, L. T., Niederlehner, B. R., O'Brien, J. M., Potter, J. D., Sheibley, R. W., Sobota, D. J., and Thomas, S. M. (2008). Stream Denitrification Across Biomes and its Response to Anthropogenic Nitrate Loading. *Nature*, 452(7184):202–205.

[Mushet et al., 2015] Mushet, D. M., Calhoun, A. J. K., Alexander, L. C., Cohen, M. J., DeKeyser, E. S., Fowler, L., Lane, C. R., Lang, M. W., Rains, M. C., and Walls, S. C. (2015). Geographically Isolated Wetlands: Rethinking a Misnomer. *Wetlands*, 35(3):423–431.

[Nadeau and Leibowitz, 2003] Nadeau, T. L. and Leibowitz, S. G. (2003). Isolated Wetlands: An Introduction to the Special Issue. *Wetlands*, 23(3):471–474.

[Nadeau and Rains, 2007] Nadeau, T. L. and Rains, M. C. (2007). Hydrological Connectivity Between Headwater Streams and Downstream Waters: How Science Can Inform Policy1: Hydrological Connectivity Between Headwater Streams and Downstream Waters:

How Science Can Inform Policy. *Journal of the American Water Resources Association*, 43(1):118–133.

[Norton et al., 2002] Norton, J., Bowannie Jr., F., Peynetsa, P., Quandelacy, W., and Siebert, S. (2002). Native American Methods for Conservation and Restoration of Semiarid Ephemeral Streams. *Journal of Soil and Water Conservation*, 57(5):250 – 258.

[O'Neill and Gordon, 1994] O'Neill, G. J. and Gordon, A. M. (1994). The Nitrogen Filtering Capability of Carolina Poplar in an Artificial Riparian Zone. *Journal of Environmental Quality*, 23(6):1218–1223.

[Opsahl, 2005] Opsahl, S. P. (2005). Organic Carbon Composition and Oxygen Metabolism across a Gradient of Seasonally Inundated Limesink and Riparian Wetlands in the Southeast Coastal Plain, USA. *Biogeochemistry*, 76(1):47–68.

[Paller, 1994] Paller, M. H. (1994). Relationships between Fish Assemblage Structure and Stream Order in South Carolina Coastal Plain Streams. *Transactions of the American Fisheries Society*, 123(2):150–161.

[Paller et al., 2016] Paller, M. H., Prusha, B. A., Fletcher, D. E., Kosnicki, E., Sefick, S. A., Jarrell, M. S., Sterrett, S. C., Grosse, A. M., Tuberville, T. D., and Feminella, J. W. (2016). Factors Influencing Stream Fish Species Composition and Functional Properties at Multiple Spatial Scales in the Sand Hills of the Southeastern United States. *Transactions of the American Fisheries Society*, 145(3):545–562.

[Palmer et al., 2010] Palmer, M. A., Bernhardt, E. S., Schlesinger, W. H., Eshleman, K. N., Foufoula-Georgiou, E., Hendryx, M. S., Lemly, A. D., Likens, G. E., Loucks, O. L., Power, M. E., White, P. S., and Wilcock, P. R. (2010). Mountaintop Mining Consequences. *Science*, 327(5962):148–149.

[Palmer and Hondula, 2014] Palmer, M. A. and Hondula, K. L. (2014). Restoration As Mitigation: Analysis of Stream Mitigation for Coal Mining Impacts in Southern Appalachia. *Environmental Science & Technology*, 48(18):10552–10560.

[Palmquist et al., 2014] Palmquist, K. A., Peet, R. K., and Weakley, A. S. (2014). Changes in Plant Species Richness Following Reduced Fire Frequency and Drought in One of the Most Species-Rich Savannas in North America. *Journal of Vegetation Science*, 25(6):1426–1437.

[Paul and Meyer, 2001] Paul, M. J. and Meyer, J. L. (2001). Streams in the Urban Landscape. *Annual Review of Ecology and Systematics*, 32(1):333–365.

[Pechmann et al., 1989] Pechmann, J. H. K., Scott, D. E., Gibbons, J. W., and Semlitsch, R. D. (1989). Influence of Wetland Hydroperiod on Diversity and Abundance of Metamorphosing Juvenile Amphibians. *Wetlands Ecology and Management*, 1(1):3–11.

[Pennino et al., 2014] Pennino, M. J., Kaushal, S. S., Beaulieu, J. J., Mayer, P. M., and Arango, C. P. (2014). Effects of Urban Stream Burial on Nitrogen Uptake and Ecosystem Metabolism: Implications for Watershed Nitrogen and Carbon Fluxes. *Biogeochemistry*, 121(1):247–269.

[Pericak et al., 2018] Pericak A. A, Thomas C. J., Kroodsma D. A., Wasson M. F., Ross M.R.V., Clinton NE, et al. (2018). Mapping the Yearly Extent of Surface Coal Mining in Central Appalachia Using Landsat and Google Earth Engine. *PLoS ONE* 13(7): e0197758. https://doi.org/10.1371/journal.pone.0197758.

[Perkin et al., 2017] Perkin, J. S., Gido, K. B., Falke, J. A., Fausch, K. D., Crockett, H., Johnson, E. R., and Sanderson, J. (2017). Groundwater Declines Are Linked to Changes in Great Plains Stream Fish Assemblages. *Proceedings of the National Academy of Sciences*, 114(28):7373–7378.

[Pond et al., 2014] Pond, G. J., Passmore, M. E., Pointon, N. D., Felbinger, J. K., Walker, C. A., Krock, K. J. G., Fulton, J. B., and Nash, W. L. (2014). Long-Term Impacts on Macroinvertebrates Downstream of Reclaimed Mountaintop Mining Valley Fills in Central Appalachia. *Environmental Management*, 54(4):919–933.

[Pool, 2005] Pool, D. R. (2005). Variations in Climate and Ephemeral Channel Eecharge in Southeastern Arizona, United States. *Water Resources Research*, 41(11):W11403.

[Poudel et al., 2016] Poudel, J., Henderson, J. E., and Munn, I. A. (2016). Economic Contribution of Hunting Expenditure to the Southern United States of America. *International Journal of Environmental Studies*, 73(2):236–254.

[Poulter et al., 2006] Poulter, B., Christensen, N. L., and Halpin, P. N. (2006). Carbon Emissions from a Temperate Peat Fire and its Relevance to Interannual Variability of Trace Atmospheric Greenhouse Gases. *Journal of Geophysical Research: Atmospheres*, 111(D6):D06301.

[Price et al., 2016] Price, S. J., Muncy, B. L., Bonner, S. J., Drayer, A. N., and Barton, C. D. (2016). Effects of Mountaintop Removal Mining and Valley Filling on the Cccupancy and Abundance of Stream Salamanders. *Journal of Applied Ecology*, 53(2):459–468.

[Pyzoha et al., 2008] Pyzoha, J. E., Callahan, T. J., Sun, G., Trettin, C. C., and Miwa, M. (2008). A Conceptual Hydrologic Model for a Forested Carolina Bay Depressional Wetland on the Coastal Plain of South Carolina, USA. *Hydrological Processes*, 22(14):2689–2698.

[Rai, 2008] Rai, P. K. (2008). Heavy Metal Pollution in Aquatic Ecosystems and its Phytoremediation using Wetland Plants: An Ecosustainable Approach. *International Journal of Phytoremediation*, 10(2):133–160.

[Rains et al., 2016] Rains, M. C., Leibowitz, S. G., Cohen, M. J., Creed, I. F., Golden, H. E., Jawitz, J. W., Kalla, P., Lane, C. R., Lang, M. W., and McLaughlin, D. L. (2016). Geographically Isolated Wetlands Are Part of the Hydrological Landscape. *Hydrological Processes*, 30(1):153–160.

[Reardon et al., 2007] Reardon, J., Hungerford, R., and Ryan, K. (2007). Factors Affecting Sustained Smouldering in Organic Soils from Pocosin and Pond Pine Woodland Wetlands. *International Journal of Wildland Fire*, 16(1):107–118.

[Richardson, 2003] Richardson, C. J. (2003). Pocosins: Hydrologically Isolated or Integrated Wetlands on the Landscape? *Wetlands*, 23(3):563–576.

[Rome, 1988] Rome, A. (1988). Vegetation Variation in a Pine-Wiregrass Savanna in the Green Swamp, North Carolina. *Castanea*, 53(2):122–131.

[Romito et al., 2010] Romito, A. M., Eggert, S. L., Diez, J. M., and Wallace, J. B. (2010). Effects of Seasonality and Resource Limitation on Organic Matter Turnover by Chironomidae (Diptera) in Southern Appalachian Headwater Streams. *Limnology and Oceanography*, 55(3):1083–1092.

[Russell et al., 2002] Russell, K. R., Hanlin, H. G., Wigley, T. B., and Guynn, D. C. (2002). Responses of Isolated Wetland Herpetofauna to Upland Forest Management. *The Journal of Wildlife Management*, 66(3):603–617.

[Ryon, 1986] Ryon, M. G. (1986). The Life History and Ecology of *Etheostoma trisella* (Pisces: Percidae). *The American Midland Naturalist*, 115(1):73–86.

[Schwitzguébel et al., 2002] Schwitzguébel, J.-P., Lelie, D. v. d., Baker, A., Glass, D. J., and Vangronsveld, J. (2002). Phytoremediation: European and American Trends Successes, Obstacles and Needs. *Journal of Soils and Sediments*, 2(2):91–99.

[Semlitsch and Bodie, 1998] Semlitsch, R. D. and Bodie, J. R. (1998). Are Small, Isolated Wetlands Expendable? *Conservation Biology*, 12(5):1129–1133.

[Sharitz, 2003] Sharitz, R. R. (2003). Carolina Bay Wetlands: Unique Habitats of the Southeastern United States. *Wetlands*, 23(3):550–562.

[Soria et al., 2017] Soria, M., Leigh, C., Datry, T., Bini, L. M., and Bonada, N. (2017). Biodiversity in Perennial and Intermittent Rivers: A Meta-Analysis. *Oikos*, 126(8):1078–1089.

[Steven and Lowrance, 2011] Steven, D. D. and Lowrance, R. (2011). Agricultural Conservation Practices and Wetland Ecosystem Services in the Wetland-Rich Piedmont-Coastal Plain Region. *Ecological Applications*, 21(3) Supplement:S3–S17.

[Steward et al., 2012] Steward, A. L., von Schiller, D., Tockner, K., Marshall, J. C., and Bunn, S. E. (2012). When the River Runs Dry: Human and Ecological Values of Dry Riverbeds. *Frontiers in Ecology and the Environment*, 10(4):202–209.

[Sun et al., 2006] Sun, G., Callahan, T. J., Pyzoha, J. E., and Trettin, C. C. (2006). Modeling the Climatic and Subsurface Stratigraphy Controls on the Hydrology of a Carolina Bay Wetland in South Carolina, USA. *Wetlands*, 26(2):567–580.

[Swallow, 1994] Swallow, S. K. (1994). Renewable and Nonrenewable Resource Theory Applied to Coastal Agriculture, Forest, Wetland, and Fishery Linkages. *Marine Resource Economics*, 9(4):291–310.

[Taggart et al., 2011] Taggart, M. J., Heitman, J. L., Vepraskas, M. J., and Burchell, M. R. (2011). Surface Shading Effects on Soil C Loss in a Temperate Muck Soil. *Geoderma*, 163(3):238–246.

[Terando et al., 2014] Terando, A. J., Costanza, J., Belyea, C., Dunn, R. R., McKerrow, A., and Collazo, J. A. (2014). The Southern Megalopolis: Using the Past to Predict the Future of Urban Sprawl in the Southeast U.S. *PLOS ONE*, 9(7):e102261.

[Tiner, 2003] Tiner, R. W. (2003). Geographically Isolated Wetlands of the United States. *Wetlands*, 23(3):494–516.

[Townsend et al., 2009] Townsend, P. A., Helmers, D. P., Kingdon, C. C., McNeil, B. E., de Beurs, K. M., and Eshleman, K. N. (2009). Changes in the Extent of Surface Mining and Reclamation in the Central Appalachians Detected Using a 1976–2006 Landsat Time Series. *Remote Sensing of Environment*, 113(1):62–72.

[Tredick et al., 2007] Tredick, C. A., Vaughan, M. R., Stauffer, D. F., Simek, S. L., and Eason, T. (2007). Sub-sampling Genetic Data to Estimate Black Bear Population Size: A Case Study. *Ursus*, 18(2):179–188.

[Vannote et al., 1980] Vannote, R. L., Minshall, G. W., Cummins, K. W., Sedell, J. R., and Cushing, C. E. (1980). The River Continuum Concept. *Canadian Journal of Fisheries and Aquatic Sciences*, 37(1):130–137.

[Vietz et al., 2014] Vietz, G. J., Sammonds, M. J., Walsh, C. J., Fletcher, T. D., Rutherfurd, I. D., and Stewardson, M. J. (2014). Ecologically Relevant Geomorphic Attributes of Streams are Impaired by Even Low Levels of Watershed Effective Imperviousness. *Geomorphology*, 206:67–78.

[Vitousek et al., 1997] Vitousek, P. M., Aber, J. D., Howarth, R. W., Likens, G. E., Matson, P. A., Schindler, D. W., Schlesinger, W. H., and Tilman, D. G. (1997). Human Alteration of the Global Nitrogen Cycle: Sources and Consequences. *Ecological Applications*, 7(3):737–750.

[Vroblesky et al., 1999] Vroblesky, D. A., Nietch, C. T., and Morris, J. T. (1999). Chlorinated Ethenes from Groundwater in Tree Trunks. *Environmental Science & Technology*, 33(3):510–515.

[Walbridge and Lockaby, 1994] Walbridge, M. R. and Lockaby, B. G. (1994). Effects of Forest Management on Biogeochemical Functions in Southern Forested Wetlands. *Wetlands*, 14(1):10–17.

[Walbridge and Richardson, 1991] Walbridge, M. R. and Richardson, C. J. (1991). Water Quality of Pocosins and Associated Wetlands of the Carolina Coastal Plain. *Wetlands*, 11(1):417–439.

[Walker and Peet, 1984] Walker, J. and Peet, R. K. (1984). Composition and Species Diversity of Pine-wiregrass Savannas of the Green Swamp, North Carolina. *Vegetatio*, 55(3):163–179.

[Wallace et al., 1997] Wallace, J. B., Eggert, S. L., Meyer, J. L. and Webster, J. R. (1997). Multiple Trophic Levels of a Forest Stream Linked to Terrestrial Litter Inputs. *Science*, 277(5322):102–104.

[Walsh et al., 2005] Walsh, C. J., Roy, A. H., Feminella, J. W., Cottingham, P. D., Groffman, P. M., and Morgan, R. P. (2005). The Urban Stream Syndrome: Current Knowledge and the Search for a Cure. *Journal of the North American Benthological Society*, 24(3):706–723.

[Warrick et al., 2005] Warrick, J. A., Washburn, L., Brzezinski, M. A. and Siegel, D. A. (2005). Nutrient Contributions to the Santa Barbara Channel, California, from the Ephemeral Santa Clara River. *Estuarine, Coastal and Shelf Science*, 62(4):559–574.

[Watt and Golladay, 1999] Watt, K. M. and Golladay, S. W. (1999). Organic Matter Dynamics in Seasonally Inundated, Forested Wetlands of the Gulf Coastal Plain. *Wetlands*, 19(1):139–148.

[Weakley and Schafale, 1991] Weakley, A. S. and Schafale, M. P. (1991). Classification of Pocosins of the Carolina Coastal Plain. *Wetlands*, 11(1):355–375.

[Weis and Weis, 2004] Weis, J. S. and Weis, P. (2004). Metal Uptake, Transport and Release by Wetland Plants: Implications for Phytoremediation and Restoration. *Environment International*, 30(5):685–700.

[Wells and Boyce, 1953] Wells, B. W. and Boyce, S. G. (1953). Carolina Bays: Additional Data on their Origin, Age and History. *Journal of the Elisha Mitchell Scientific Society*, 69(2):119–141.

[Welter and Fisher, 2016] Welter, J. R. and Fisher, S. G. (2016). The Influence of Storm Characteristics on Hydrological Connectivity in Intermittent Channel Networks: Implications for Nitrogen Transport and Denitrification. *Freshwater Biology*, 61(8):1214–1227.

[Wenger et al., 2009] Wenger, S. J., Roy, A. H., Jackson, C. R., Bernhardt, E. S., Carter, T. L., Filoso, S., Gibson, C. A., Hession, W. C., Kaushal, S. S., Martí, E., Meyer, J. L., Palmer, M. A., Paul, M. J., Purcell, A. H., Ramírez, A., Rosemond, A. D., Schofield, K. A., Sudduth, E. B., and Walsh, C. J. (2009). Twenty-six Key Research Questions in Urban Stream Ecology: An Assessment of the State of the Science. *Journal of the North American Benthological Society*, 28(4):1080–1098.

[Werner et al., 2009] Werner, E. E., Relyea, R. A., Yurewicz, K. L., Skelly, D. K. and Davis, Christopher J. (2009). Comparative Landscape Dynamics of Two Anuran Species: Climate-driven Interaction of Local and Regional Processes. *Ecological Monographs*, 79(3):503–521.

[Whigham and Jordan, 2003] Whigham, D. F. and Jordan, T. E. (2003). Isolated Wetlands and Water Quality. *Wetlands*, 23(3):541–549.

[Wigington et al., 2006] Wigington, P., Ebersole, J., Colvin, M., Leibowitz, S., Miller, B., Hansen, B., Lavigne, H., White, D., Baker, J., Church, M., Brooks, J., Cairns, M., and Compton, J. (2006). Coho Salmon Dependence on Intermittent Streams. *Frontiers in Ecology and the Environment*, 4(10):513–518.

[Wild et al., 2011] Wild, T. C., Bernet, J. F., Westling, E. L., and Lerner, D. N. (2011). Deculverting: Reviewing the Evidence on the 'daylighting' and Restoration of Culverted Rivers. *Water and Environment Journal*, 25(3):412–421.

[Williams et al., 2014] Williams, C., Flite, O., Wilson, A., and Tufford, D. (2014) Groundwater Recharge Rates in Isolated and Riverine Wetlands: Influencing Factors. *Journal of South*

Carolina Water Resources, 2(1):86–92.

[Williams, 1996] Williams, D. D. (1996). Environmental Constraints in Temporary Fresh Waters and Their Consequences for the Insect Fauna. *Journal of the North American Benthological Society*, 15(4):634–650.

[Williams, 2002] Williams, J. B. (2002). Phytoremediation in Wetland Ecosystems: Progress, Problems, and Potential. *Critical Reviews in Plant Sciences*, 21(6):607–635.

[Winter and LaBaugh, 2003] Winter, T. C. and LaBaugh, J. W. (2003). Hydrologic Considerations in Defining Isolated Wetlands. *Wetlands*, 23(3):532–540.

[Wohl, 2017] Wohl, E. (2017). The Significance of Small Streams. *Frontiers of Earth Science*, 11(3):447–456.

[Wohl et al., 2012] Wohl, E., Dwire, K., Sutfin, N., Polvi, L., and Bazan, R. (2012). Mechanisms of Carbon Storage in Mountainous Headwater Rivers. *Nature Communications*, 3:1263.

[Wood and Williams, 2013] Wood, P. B. and Williams, J. M. (2013). Impact of Valley Fills on Streamside Salamanders in Southern West Virginia. *Journal of Herpetology*, 47(1):119–125.

[Wood et al., 2005] Wood, P. J., Gunn, J., Smith, H., and Abas-Kutty, A. (2005). Flow Permanence and Macroinvertebrate Community Diversity within Groundwater Dominated Headwater Streams and Springs. *Hydrobiologia*, 545(1):55–64.

[Yarra and Magoulick, 2017] Yarra, A. N. and Magoulick, D. D. (2017). Stream Permanence is Related to Crayfish Occupancy and Abundance in the Ozark Highlands, USA. *Freshwater Science*, 37(1):54–63.

[Young et al., 2008] Young, R. G., Matthaei, C. D., and Townsend, C. R. (2008). Organic Matter Breakdown and Ecosystem Metabolism: Functional Indicators for Assessing River Ecosystem Health. *Journal of the North American Benthological Society*, 27(3):605–625.

[Yu et al., 2015] Yu, X., Hawley-Howard, J., Pitt, A. L., Wang, J.-J., Baldwin, R. F., and Chow, A. T. (2015). Water Quality of Small Seasonal Wetlands in the Piedmont Ecoregion, South Carolina, USA: Effects of Land Use and Hydrological Connectivity. *Water Research*, 73:98–108.

[Zeveloff, 1983] Zeveloff, S. I. (1983). Island Biogeographic Considerations for Pocosin Wildlife Conservation. *Journal of the Elisha Mitchell Scientific Society*, 99(3):69–77.

Books and Book Chapters

[Arendt, 2015] Arendt, R. (2015). *Rural by design: planning for town and country.* American Planning Association, Planners Press, Chicago, second edition.

[Carter et al., 2014] Carter, L. M., Jones, J. W., Berry, L., Burkett, V., Murley, J. F., Obeysekera, J., Schramm, P. J., and Wear, D. (2014). Southeast and the Carribbean. In Melillo, J. M., Richmond, T. C., and Yohe, G. W., editors, *Climate Change Impacts in the United States: The Third National Climate Assessment*, pages 396–417. U.S. Global Change Research Program.

[Daily, 1997] Daily, G. C., editor (1997). *Nature's services: societal dependence on natural ecosystems*, pages 1–10. Island Press, Washington, DC.

[Daniel, 1981] Daniel, C. C. (1981). Hydrology, geology, and soils of pocosins: a comparison of natural and altered systems. In Richardson, C. J., editor, *Pocosin Wetlands*, pages 66–108. Hutchinson Ross Publishing Co., Stroudsburg, PA.

[Deemy et al., 2015] Deemy, J., Hepinstall-Cymerman, Kirkman, L. K., and Rasmussen, T. (2015). Water Quality of Episodic Flow through Isolated Wetlands Embedded in a Long Leaf Pine/Wiregrass Ecosystem. In *Proceedings of the 2015 Georgia Water Resources Conference*, Athens, GA.

[Deghi and Ewel, 1984] Deghi, G. S. and Ewel, K. C. (1984). Simulated effect of wastewater application on phosphorus distribution in cypress domes. In Ewel, K. C. and Odum, H. T., editors, *Cypress Swamps*, pages 102–111. University Press of Florida, Gainesville, FL.

[Duellman, 1999] Duellman W.E. (1999). Global Distribution of Amphibians: Patterns, Conservation, and Future Challenges. In Duellman WE, editor. *Patterns of Distribution of Amphibians*, pages 1—31. John Hopkins University Press, Baltimore, MD.

[Edgell, 2016] Edgell, D. L. (2016). *Managing sustainable tourism: a legacy for the future*, pages 124–125. Routledge, London; New York, second edition.

[Ewel, 1997] Ewel, K. (1997). Water quality improvement by wetlands. In Daily, G. C., editor, *Nature's Services: Societal Dependence on Natural Ecosystems*, pages 329–344. Island Press, Washington, DC.

[Frost, 1920] Frost, R. (1920). Hyla Brook. In *Mountain Interval*. Henry Holt and Company, New York.

[Ingram and Otte, 1981] Ingram, R. L. and Otte, L. J. (1981). Peat in North Carolina wetlands. In Richardson, C. J., editor, *Pocosin Wetlands*, pages 125–134. Hutchinson Ross Publishing Co., Stroudsburg, PA.

[Jennings, 2003] Jennings, G. D. (2003). Stream Restoration Case Studies in North Carolina. In *Proceedings of the 2003 Georgia Water Resoruces Conferences*, University of Georgia, Athens, Georgia.

[McDonough et al., 2011] McDonough, O. T., Hosen, J. D., and Palmer, M. A. (2011). Temporary streams: the hydrology, geography, and ecology of non-perennially flowing waters. In Elliot, H. S. and Martin L. E., editors, *River Ecosystems: Dynamics, Management and Conservation*, pages 259–289. Nova Science, New York.

[Meyer and Wallace, 2001] Meyer, J. L. and Wallace, J. B. (2001). Lost linkages and lotic ecology: rediscovering small streams. In Press, M. C., Huntly, N. J., and Levin, S. A., editors, *Ecology: achievement and challenge*, pages 295–317. Blackwell Science, Oxford; Malden, MA.

[Mitsch and Gosselink, 2000] Mitsch, W. J. and Gosselink, J. G. (2000). *Wetlands*, pages 399–406. Wiley, New York, third edition.

[Naiman and Bilby, 1998] Naiman, R. J. and Bilby, R. E. (1998). River Ecology and Management in the Pacific Coastal Ecoregion. In Naiman, R. J. and Bilby, R. E., editors, *River ecology and management*, pages 1–10. Springer, New York.

[NRC, 2009] National Research Council. (2009). *Urban Stormwater Management in the United States*, page 445. The National Academies Press, Washington, DC.

[Peet et al., 1983] Peet, R. K., Glenn-Lewin, D. C., and Wolf, J. W. (1983). Prediction of man's impact on plant species diversity. A challenge for vegetation science. In Holzner, W., Werger, M. J. A., and Ikusima, I., editors, *Man's impact on vegetation*, pages 41–54. W. Junk, The Hague; Boston; Hingham, MA.

[Richardson and Gibbons, 1993] Richardson, C. J. and Gibbons, J. (1993). Pocosins, Carolina bays, and mountain bogs. In Martin, W. H., Boyce, S. G., and Echternacht, A. C., editors, *Biodiversity of the southeastern United States: Upland Terrestrial Communities*, pages 257–310. Wiley, New York.

[Street and McClees, 1981] Street, M. W. and McClees, J. D. (1981). North Carolina's coastal fishing industry and the influence of coastal alterations. In Richardson, C. J., editor, *Pocosin Wetlands*, pages 66–108. Hutchinson Ross Publishing Co., Stroudsburg, PA.

Technical Reports

— Federal Publications —

[Brinson, 1993] Brinson, M. M. (1993). A Hydrogeomorphic Classification for Wetlands. Technical Report WRP-DE-4, U.S. Army Engineer Waterways Experiment Station, Washington, DC.

[Bucher and High, 2002] Bucher, M. and High, M. (2002). Fire Management and Research for Biodiversity in the Green Swamp. In: Ford, W.M., Russell, K.R., Moorman, C.E., eds. Proceedings: the role of fire for nongame wildlife management and community restoration: traditional uses and new directions. Technical report NE-288, pages 111–115. U.S. Department of Agriculture, Forest Service, Northeastern Research Station, Newtown Square, PA.

[Carver, 2013] Carver, E. (2013). Birding in the United States: A Demographic and Economic Analysis: Addendum to the 2006 National Survey of Fishing, Hunting, and Wildlife-associated Recreation. Technical Report 2011-1, U.S. Department of Interior, U.S. Fish and Wildlife Service, Division of Economics, Washington, DC.

[Cowardin et al., 1979] Cowardin, L., Carter, V., Golet, F., and LaRoe, E. (1979). Classification of Wetlands and Deepwater Habitats of the United States. Technical Report FWS/OBS-79/31, U.S. Department of Interior, U.S. Fish and Wildlife Service, Office of Biological Services, Washington, DC.

[DeSimone et al., 2014] DeSimone, L. A., McMahon, P. B., and Rosen, M. R. (2014). The Quality of Our Nation's Waters - Water Quality in Principal Aqyuifers of the United States, 1991-2010. U.S. Geological Survey Circular 1360, 151 p.,http://dx.doi.org/10.3133/cir1360.

[Grumbles and Woodley, 2008] Grumbles, B. H. and Woodley, Jr., J. P. (2008). Clean Water Act Jurisdiction Following the U.S. Supreme Court's Decision in Rapanos v. United States & Carabell v. United States [Memorandum]. Technical report, U.S. Environmental Protection Agency, Department of the Army, Washington, DC.

[Harper et al.,1998] Harper, M.G., Trame, A., and Hohman, G. (1998). Management of Herbaceous Seeps and Wet Savannas for Threatened and Endangered Species. Technical Report USACERL-TR98/70, U.S. Army Construction Engineering Research Laboratories, Champaign, IL.

[Marella and Berndt, 2005] Marella, R. L. and Berndt, M. P. (2005). Water Withdrawals and Trends from the Floridan Aquifer System in the Southeastern United States, 1950-2000. Technical Report 1278, U.S. Geological Survey.

[NRCS, 2006] NRCS (2006). Ecologically Isolated Wetlands. Technical Report 38, U.S. Department of Agriculture, Washington, DC.

[Sharitz and Gibbons, 1982] Sharitz, R. R. and Gibbons, J. (1982). The Ecology of Southeastern Shrub Bogs (Pocosins) and Carolina Bays: a Community Profile. Technical Report FWS/OBS-82/04, U.S. Fish and Wildlife Service, Division of Biological Services Program, Washington, DC.

[Tiner et al., 2002] Tiner, R. W., Bergquist, G., DeAlessio, G., and Starr, M. (2002). Geographically isolated wetlands a preliminary assessment of their characteristics and status in selected areas of the United States. Technical report, U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.

[U.S. DOI, 2006] U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S.Census Bureau (2006). National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Technical report.

[U.S. DOI, 2011] U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau (2011). 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Technical report.

[U.S. EPA, 1993] U.S. Environmental Protection Agency (1993). Carolina Bays: A Natural Wastewater Treatment Program. Technical Report EPA832-R-93-005a; EPA/832/R-93/005A, U.S. Environmental Protection Agency, Office of Water, Washington, DC.

[U.S. EPA, 2002] U.S. Environmental Protection Agency (2002). Methods for Evaluating Wetland Condition: Wetlands Classification. Technical Report EPA-822-R-02-017, Office of Water, U.S. Environmental Protection Agency, Washington, DC.

[U.S. EPA, 2008] U.S. Environmental Protection Agency (2008). Methods for Evaluating Wetland Condition: Wetland Hydrology. Technical Report EPA-822-R-08-024, U.S.

Environmental Protection Agency, Office of Water, Washington, DC.

[U.S. EPA, 2015] U.S. Environmental Protection Agency (2015). Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence (Final Report. Technical Report EPA/600/R-14/475F, U.S. Environmental Protection Agency, Washington, DC.

[U.S. EPA, 2011] U.S. Environmental Protection Agency (2011). The Effects of Mountaintop Mines and Valley Fills on Aquatic Ecosystems of the Central Appalachian Coalfields (2011 final). Technical Report EPA/600/R-09/138F, U.S. Environmental Protection Agency, Washington, DC.

[U.S. FWS, 2010] U.S. Fish and Wildlife Service (2010). Benefits of Wetland Hydrology Restoration in Historically Ditched and Drained Peatlands: Carbon Sequestration Implications of the Pocosin Lakes. Technical report, U.S. Department of Interior, U.S. Fish and Wildlife Service, Washington, DC.

— State Publications —

[Benham et al., 2003] Benham, B., Brannan, K., Dillaha, T., Mostaghimi, S., Wagner, R., Wynn, J., Yagow, G., Zeckoski, R., Hill, J., Devlin, G., and Lazarus, D. (2003). Benthic TMDL for Stroubles Creek in Montgomery County, Virginia. Technical report, Virginia Department of Environmental Quality, Virginia Department of Conservation and Recreation, Montgomery County, VA.

[Bennett and Nelson, 1991] Bennett, S. and Nelson, J. (1991). Distribution and Status of Carolina Bays in South Carolina. Technical Report 1, South Carolina Wildlife and Marine Resources Department, Columbia, SC.

[Environmental Services, Inc., 2009] Environmental Services, Inc. (2009). Juniper Bay Wetland Mitigation Site. Technical report, North Carolina Department of Environment and Natural Resources, Ecosystem Enhancement Program, Raleigh, NC.

[Fleming and Patterson, 2004] Fleming, G. and Patterson, K. (2004). Natural community inventory of selected areas in the Northern Virginia Culpeper Basin, Fairfax, Loudoun, Prince William, Fauquier, and Culpeper counties. Technical Report Natural Heritage Technical Report 04-07, Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA.

[GA DNR, 2015] Georgia Department of Natural Resources (2015). High Priority Species and Habitats Summary Data. In *Georgia State Wildlife Action Plan* (pg A2-A3). Social Circle, GA: Georgia Department of Natural Resources.

[NC DENR, 2015] NCDENR (2015). North Carolina Outdoor Recreation Plan 2015-2020. Technical report, North Carolina Department of Environment and Natural Resources, Division of Parks and Recreation.

[NC WRC, 2013] NCWRC (2013). North carolina trout resources management plan. Technical report, Division of Inland Fisheries, North Carolina Wildlife Resources Commission, Raleigh, NC.

[Parks, 2016] Parks, G. S. (2016). Georgia Plan for Outdoor Recreation 2017-2021. Technical report, Georgia State Parks, Stockbridge, GA.

[SC DPRT, 2014] SCDPRT (2014). South Carolina State Comprehensive Outdoor Recreation Plan (SCORP. Technical report, South Carolina Department of Parks, Recreation and Tourism, Columbia, SC.

[TN Wildlife Action Plan Team, 2015] Tennessee State Wildlife Action Plan Team (2015). Tennessee State Wildlife Action Plan 2015. Technical report, Tennessee Wildlife Resources Agency, Nashville, TN.

[Tummons and Marshall, 2009] Tummons, M. and Marshall, A. (2009). Tennessee 2020: Vision for Parks, People, and Landscapes. Technical report, Tennessee Department of Environment & Conservation, Nashville, TN.

[VA DCR, 2013] Virginia Department of Conservation and Recreation (2013). Virginia Outdoors Plan. Technical report, Richmond, VA.

— County and City Publications —

[Caplanides, 2014] Caplanides, L. (2014). Facts and Figures: Urban Little Sugar Creek Greenway. Technical report, Mecklenburg County Parks and Recreation, and Chralotte-Mecklenburg Storm Water Services, Mecklenburg County, NC.

[Mecklenburg County, 2003] Mecklenburg County (2003). Little Sugar Creek Greenway Master Plan. Technical report, Mecklenburg County Park and Recreation Department, Mecklenburg County, NC.

[Raleigh Parks and Resources, 2017] Raleigh Parks, R. and Resources, C. (2017). Capital Area Greenway System.

[Town of Blacksburg, 2016] Town of Blacksburg (2016). Blacksburg Comprehensive Plan: 2016 Update. Technical report, Town of Blacksburg, Blacksburg, VA.

— **Non-Government Publications** —

[Buchholz and Younos, 2007] Buchholz, T. and Younos, T. (2007). Urban Stream Daylighting Case Study Evaluations. Technical report, Virginia Water Research Center, Virginia Tech, Blacksburg, VA.

[Comer et al., 2005] Comer, P. J., Goodin, K., Tomaino, A., Hammerson, G., Kittel, G., Menard, S., Nordman, C., Pyne, M., Reid, M., Sneddon, L., and Snow, K. (2005). Biodiversity values of geographically isolated wetlands in the United States. Technical report, NatureServe, Arlington, VA.

[Davis and Janecek, 1997] Davis, C. and Janecek, L. (1997). DOE Research Set-Aside Areas of the Savannah River Site. Technical report, Savannah River Site, Aiken, SC.

[Doll, 2010] Doll, B. (2010). Rocky Branch Stream Restoration and Greenway Project. Technical Report UNC-SG-10-04.

[Hession, 2017] Hession, C. (2017). Reducing Sediment in Stroubles Creek, Blacksburg, VA. Technical report, Biological Systems Engineering, Virginia Tech, Blacksburg, VA.

[MEA, 2005] Millenium Ecosystem Assessment (2005). Ecosystems and Human Well-being: Wetlands and Water Synthesis. Technical report, World Resources Institute, Washington, DC.

[NCASI, 2008] National Council for Air and Stream Improvement, Inc. (NCASI). Biodiversity response to stand structural features in southern pine forests: A literature review. Technical Report Technical Bulletin No. 958, National Council for Air and Stream Improvement, Inc., Research Triangle Park, NC.

[TNC, 2017] The Nature Conservancy (2017). Green Swamp Preserve.

[Parece et al., 2010] Parece, T., DiBetitto, S., Sprague, T., and Younos, T. (2010). The Stroubles Creek Watershed: History of Development and Chronicles of Research. Technical Report SR48-2010, Virginia Water Research Center, Virginia Tech, Blacksburg, VA.

[Pinkham, 2000] Pinkham, R. (2000). Daylighting: new life for buried streams. Technical report, Rocky Mountain Institute, Old Snowmass, CO.

[SC ADC, 2013] SCADC (2013). Alabama Statewide Comprehensive Outdoor Recreation Plan 2013-2018. Technical report, Montgomery, AL.

[Trout Unlimited, 2014] Trout Unlimited (2014). Rising to the challenge: how anglers can respond to threats to fishing in America. Technical report, Arlington, VA.

[UN, 2016] United Nations Department of Economic and Social Affairs, Population Division (2016). The World's Cities in 2016 – Data Booklet. Technical report, United Nations, New York, NY.

[Vepraskas et al., 2016] Vepraskas, M., White, J., Richter, D., and Moorberg, C. (2016). Phosphorus Fluxes in a Restored Carolina Bay Wetland Following Eight Years of Restoration. Technical Report 481, Water Resources Research Institute of The University of North Carolina, Raleigh, NC.

[Ward and Settelmeyer, 2014] Ward, S. and Settelmeyer, S. (2014). Special Focus: Coastal Blue Carbon. *Coastal Blue Carbon*, 36(1):5.

[Wenger, 1999] Wenger, S. J. (1999). A review of the scientific literature on riparian buffer width, extent and vegetation. Technical report, Office of Public Service and Outreach, Institute of Ecology, University of Georgia, Athens, GA.

Miscellaneous

[64 Red. Reg. 15,691] Endangered and Threatened Wildlife and Plants; Final Rule to List the Flatwoods Salamander as a Threatened Species, 64 Fed. Reg. 62 (April 1, 1999). Federal Register: The Daily Journal of the United States. Web. 1 April 1999.

[80 Fed. Reg. 37,568] Endangered and Threatened Wildlife and Plants; 90-Day Findings on 31 Petitions, 80 Fed. Reg. 126 (July 1, 2015). Federal Register: The Daily Journal of the United States. Web. 1 July 2015.

[Altman-Goff, 2016] Altman-Goff, K. (2016). An examination of plant community composition in six Carolina Bays on the coastal plain of South Carolina. Master's thesis, Coastal Carolina University, Conway, SC.

[Burbage, 2004] Burbage, L. (2004). Environmental Gradients and Plant Distributions in Carolina Bays. Master's thesis, University of Georgia, Athens, GA.

[Burroughs, 2002] Burroughs, L. (2002). Little Sugar Creek Greenway Brochure. URL https://www.mecknc.gov/ParkandRec/Greenways/LittleSugarCreekGreenway/Documents/LSC_Brochure.pdf

[Dorison, 2012] Dorison, A. M. (2012). Estimating the economic value of trout angling in Georgia: a travel cost model approach. Master's thesis, University of Georgia, Athens, GA.

[Duda and Lenat, 1979] Duda, A. M. and Lenat, D. (1979). Water Quality Degradation in Urban Streams of the Southeast: Will Nonpoint Source Controls Make any Difference. University of Kentucky, Lexington, Kentucky.

[Jolley, 2008] Jolley, R. (2008). *Effects of sedimentation on productivity, nutrient cycling and community composition in riparian forests associated with ephemeral streams at Ft. Benning, GA, USA*. Ph.D., Auburn University, Auburn, AL.

[Neely, 2008] Neely, H. (2008). Restoring Farmland to Wetlands: The Potential for Carbon Credits in Eastern North Carolina. Master's thesis, Duke University, Durham, NC.

[NatureServe, 2017] NatureServe (2017). NatureServe Explorer: An online encyclopedia of life. Ecological System Comprehensive Report: Piedmont Upland Depression Swamp. NatureServe, Arlington, VA. URL:http://explorer.natureserve.org/servlet/NatureServe?searchSystemUid=ELEMENT_GLOBAL.2.723169

[NatureServe, 2017b] NatureServe (2017). NatureServe Explorer: An online encyclopedia of life. Ecological System Comprehensive Report: Southern Appalachian Seepage Wetland. NatureServe, Arlington, VA. URL:http://explorer.natureserve.org/servlet/NatureServe?searchSystemUid=ELEMENT_GLOBAL.2.723181

Exhibit B

Proposed Changes to the Waters of the United States (WOTUS) Definition – Summary of M&N Conclusions

Presented to:

Geoff Gisler, Southern Environmental Law Center (SELC)
Chapel Hill, NC

April 7, 2019

Prepared by:

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1. Introduction:

What follows is a technical analysis of the proposed definition of "Waters of the United States" (WOTUS), 84 Fed. Reg. 4154 (Feb. 2019). These comments were prepared by current environmental consultants and retired state and federal employees with more than 100 years of combined regulatory experience, largely related to Sections 404/401 permitting, wetland and stream delineation, and stream determinations for riparian buffer rules (Appendix 1). These comments are based on the authors' extensive field and regulatory experience. While much of this experience relates to work in North Carolina, our experience can be extrapolated to other Southeastern states with similar geography and hydrology. Where supported by the scientific literature, these comments have also been extrapolated to other areas within the United States. This report evaluates different scenarios raised by the proposed rule and requests for comment.

2. Overall Conclusions About the Proposed Rule with a Focus on the Southeastern U.S.: Compliance with Clean Water Act

The primary objective of the Clean Water Act (CWA) (33 U.S.C. § 1251) is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. However, the current administration has proposed a new definition of WOTUS, which delineates the scope of federal regulatory authority under the CWA and fails to achieve this objective. The proposed rule would limit regulated WOTUS, by definition, to traditional navigable waters, only tributaries that contribute perennial or intermittent flow to traditional navigable waters, and only wetlands that abut or have a direct hydrological surface connection to other WOTUS in a typical year as well as some other water features. The proposed rule focuses only on the presence or absence of flow of a water body or the proximity of that water body to traditional navigable waters and fails to recognize the other critical functional aspects specifically defined in the Act, namely, the physical, biological, and chemical functions necessary for clean water and the integrity of the Nation's waters.

The EPA Connectivity Report (US EPA. 2015) made the following point very clear: "The scientific literature clearly shows that wetlands and open waters in riparian areas (transitional areas between terrestrial and aquatic ecosystems) and floodplains are **physically**, **chemically,** and **biologically** integrated with rivers via functions that improve downstream water quality" (emphasis added). Further, the Connectivity Report specifically identifies the key role of interconnectivity in protecting water quality in keeping with Clean Water Act objectives: "Variations in the degree of connectivity are determined by the **physical, chemical,** and **biological** environment, and by human activities. These variations support a range of stream and wetland functions that affect the integrity and sustainability of downstream waters" (emphasis added). Contrary to statements made in the proposed rule's supporting documentation (e.g., 84 Fed. Reg. at 4176, 4187), the proposed rule ignores the Connectivity Report. For example, the proposed rule categorically excludes ephemeral streams and requires that any wetland connection to a WOTUS be by intermittent or perennial channels contrary to science, as documented in the Connectivity Report. In fact, the proposed rule fails to incorporate science at all.

By failing to recognize science and the full range of functions provided by small streams and wetlands, the proposed rule does not comply with the CWA. In general, the proposed rule does not preserve and restore the chemical, physical, and biological integrity of the Nation's waters. The much narrower proposed definition of WOTUS will remove CWA protections from many highly functional wetlands and ephemeral streams, as detailed in the analysis below. At-risk wetlands provide the essential functions of water quality improvement, groundwater recharge, low flow augmentation for nearby streams, floodwater storage, aquatic life habitat, and, in some cases, habitat for threatened and endangered aquatic species, such as amphibians. Wetlands often provide these benefits *because* they lack permanent surface water connections to intermittent or perennial streams, characteristics that could eliminate existing protections under the proposed rule. The scientific literature (as described below) demonstrates that ephemeral streams, especially in the Southwestern US, provide important hydrological functions and habitat. Therefore, in our opinion, the CWA's overall goal to protect and restore the Nation's waters cannot be accomplished with the rule as proposed. To the extent the final rule goes even farther, excluding, for example, intermittent streams, which provide significant water quality, water storage, and aquatic life functions, the result on water quality would be even more detrimental.

3. General Comments on the Specific Categories of Waters in the Proposed Rule

3.1. Tributaries (Streams)

The following discussion addresses the proposal's impact on ephemeral, intermittent, and perennial streams. The differences between these types of streams generally relate to rate and source of flow: 1) ephemeral streams carry stormwater and are not connected to the local ground water table, 2) intermittent streams carry stormwater and are connected to the local ground water table seasonally (usually in the winter in the Southeastern US), and 3) perennial streams carry stormwater and are connected to the local ground water table continuously during a year of normal rainfall. These definitions are generally consistent with the definitions presented in the proposed rule.

In general, the rule as proposed would result in the loss of jurisdiction over ephemeral channels but retain jurisdiction over most intermittent and perennial tributaries. However, the agencies are soliciting comment on whether the definition of "tributary" should be limited to perennial waters only as well as whether a minimum flow limit should be set. These scenarios are discussed below.

Scenario 1: Removal of Ephemeral Stream Jurisdiction

The critical role that ephemeral streams play in the Southwestern US has been well documented in the scientific literature as summarized by a 2008 EPA report by Levick, et al. (2008) who stated that "ephemeral and intermittent stream systems comprise a large portion of southwestern watersheds, and contribute to the hydrological, biogeochemical, and ecological health of a watershed." In addition, in the Southeastern US ephemeral streams can have important aquatic life and hydrology functions during periods of protracted rainfall and related high local water tables. Ephemeral streams are also important because they connect many wetlands in the North Carolina Piedmont and Inner

Coastal Plain with physical, chemical, and biological functions to downstream WOTUS (see discussion below).

Scenario 2: Removal of Intermittent Stream Jurisdiction

If the final rule is modified to remove jurisdiction from intermittent channels, this would result in a significant loss of channel length in watersheds across the country. As described below, we have conducted an analysis in various Level IV ecoregions[1] of North Carolina demonstrating the significance of those streams. In general, intermittent streams are ecologically important because these streams have significant aquatic life functions (Eaton and Vander Vorste. 2012) as well as contribute to nutrient removal and water transport. Intermittent streams are also important because they connect many wetlands in the North Carolina Piedmont and Inner Coastal Plain with physical, chemical, and biological functions to downstream WOTUS.

The attached M&N Stream report based on field-collected stream origin data in 19 Level IV ecoregions of North Carolina (Moffatt & Nichol. 2019- Appendix 2) demonstrates the prevalence of the intermittent streams with the greatest amounts of intermittent streams in the Atlantic Southern Loamy Plains (96%), Mid-Atlantic Flatwoods (53%), Sand Hills (46.5%), and Triassic Basins (35.3%) ecoregions. Based on a weighted average of the percentage of intermittent streams by the area of each Level IV ecoregion, we estimate that intermittent streams make up at least 27% of the state's stream length.

3.2. Wetlands

Under the proposed rule, "wetlands that abut or have a direct hydrologic surface connection to otherwise jurisdictional waters" are jurisdictional. 84 Fed. Reg. at 4187. This definition is one more example of the agencies' effort to create certainty which ends up creating significant confusion instead. The term ''abut'' in the proposed definition, means ''to touch at least at one point or side of'' a jurisdictional water. 84 Fed. Reg. 4187. Based on the information provided in the proposed rule, it appears that a "direct hydrologic surface water connection" would have to qualify as a tributary to result in a wetland being jurisdictional. Therefore, all wetlands would be required to "abut" a jurisdictional water. The proposed rule, however, highlights a situation where a wetland would have a "direct hydrologic surface connection" but not "abut" a jurisdictional water: where "Surface water from a wetland that overtops a berm and connects the wetland to a jurisdictional water or connections from a wetland to a jurisdictional water through upland or through a barrier as mediated by a culvert, tide gate, or similar structure would constitute direct hydrologic surface connections so long as such connections are perennial or intermittent as defined in this proposal and occur in a typical year." 84 Fed. Reg. at 4188. If such flow exists for long enough to create an intermittent connection, it appears likely that the connection will meet the definition of a tributary, which would also abut the connected wetland.

[1] There are 27 Level IV ecoregions (Griffith, et al. 2002) in North Carolina that represent areas of "general similarity in ecosystems and in the type, quality, and quantity of environmental resources".

Wetlands at Risk Due to the Narrowed Definition of WOTUS

There would likely be a major overall reduction in regulated wetlands as a result of the proposed rule, but, in North Carolina, that reduction will vary greatly by physiographic region and wetland type (Table 1). These results are based on (1) extensive knowledge of wetlands in North Carolina; (2) analysis of a relatively new database on reference wetlands gathered for the ATLAS effort (North Carolina Department of Transportation, 2019); and (3) analysis of field data on 34 headwater forest wetlands in the piedmont and coastal plain of North Carolina which were used to calibrate the North Carolina Wetland Assessment Method (NC WAM) model for this wetland type (Savage and Baker, 2010; Dorney, et al. 2015).

In this section, we evaluate the impact of four scenarios outlined in the proposed rule or derived from the agencies' requests for comments. The first three scenarios evaluated include the loss of protection for wetlands that require a surface water connection to a WOTUS via (a) an intermittent or perennial stream, (b) a perennial stream; or (c) a stream with a flow rate of greater or equal to 5 cubic feet per second. The fourth scenario evaluated wetlands that may be part of a "complex of wetlands," jointly connected to a jurisdictional water via a direct hydrologic connection, but are beyond 500 feet from the jurisdictional water. These scenarios would have differing implications for wetland jurisdiction as shown below in Tables 1 and 2, and in the text. Finally, the risks to endangered and threatened species posed by the wetland loss is also presented.

Overall, wetland losses in North Carolina would likely be greatest in the Piedmont and Inner Coastal Plain mainly since many wetlands in these ecoregions are connected by ephemeral streams or ditches to downstream WOTUS or are connected by intermittent streams to downstream WOTUS. Losses would be somewhat less in the Middle Atlantic Coastal Plain (Outer Coastal Plain) mainly since large parts of this landscape are wetlands that are continuously connected to downstream waters. Since the mountains in North Carolina have a very high density of perennial streams, the change in extent in this physiographic region would probably be less than in the rest of the state.

Table 1: Estimated Losses of wetlands[2]if, for jurisdiction, intermittent or perennial connections are required (Scenario 1(a)) or perennial connections are required (in ***bold and italics***) ***(Scenario 1(b))*** **See Appendix 5 for discussion of these wetland types.**

NC WAM Type	Outer Coastal Plain (Middle Atlantic Coastal Plain)	Inner Coastal Plain (Southeastern Plains)	Piedmont	Mountains	Statewide
Salt/Brackish Marsh	None ***None***	n/a	n/a	n/a	None ***None***
Estuarine Woody Wetland	None ***None***	n/a	n/a	n/a	None ***None***
Tidal Freshwater Marsh	None ***None***	n/a	n/a	n/a	None ***None***
Riverine Swamp Forest	None ***Some***	Few ***Some***	Most ***Most***	Some ***Some***	Some ***Some***
Seep	Few ***Few***	Few ***Few***	Most ***Most***	Most ***Most***	Most ***Most***
Hardwood Flat	Some ***Most***	Most ***Most***	n/a	n/a	Some ***Most***
Non-Riverine Swamp Forest	Some ***Most***	Most ***Most***	n/a	n/a	Most ***Most***
Pocosin	Some ***Most***	Most ***Most***	n/a	n/a	Some ***Most***
Carolina Bays[3]	Some ***Most***	Most ***Most***	n/a	n/a	Most ***Most***
Pine Savanna	Some ***Most***	Most ***Most***	n/a	n/a	Most ***Most***
Pine Flat	Some ***Most***	Most ***Most***	n/a	n/a	Most ***Most***
Basin	All	All	All	All	All
Bog	n/a	n/a	n/a	Many ***Most***	Many ***Most***
Non-tidal Freshwater Marsh	Few ***Some***	Few ***Some***	Some ***Many***	Some	Some ***Some***
Floodplain pool	Some ***Some***	All ***All***	All ***All***	All ***All***	Most ***Most***
Headwater forest	Some ***Most***	Some ***Most***	Some ***Most***	Most ***Most***	Some ***Most***
Bottomland Hardwood Forest	Some	Some ***Most***	Most ***Most***	Most ***Most***	Many ***Most***

[2] *Assumptions for Table 1 are that 1) an intermittent or perennial connection is required to downstream waters, and 2) if the wetland is directly connected to downstream intermittent or perennial waters by a continual, unbroken wetland (i.e., "a complex of wetlands," 84 Fed. Reg. at 4189), then all those wetlands would still be jurisdictional.*

[3] Carolina Bays are generally a subset of pocosins in the NC WAM method. However, they are separated here since they are formed by different geologic and hydrologic processes and would be affected differently under the proposed rule.

The pending high loss of floodplain wetlands (such as floodplain pools, bottomland hardwood forest, riverine swamp forest, and headwater forest in NC WAM and in the above table) associated with ephemeral versus intermittent/perennial connections to nearby waters or only a perennial connection reflects the landscape ecology of streams in the Piedmont (Trimble 1974, 2008 (see Appendix 6 for a figure). Most Piedmont streams are deeply incised due to the fairly recent downcutting of the channels from the mid-1900s following widespread land abandonment and subsequent reforestation from the 1930s. Since then, piedmont streams have downcut through these legacy sediments which were deposited in the floodplains from before the 1930s with the result that piedmont streams are usually deeply incised. Piedmont wetlands tend to be located behind the natural, upland levees adjacent to channels or behind dredge spoils (especially in urban areas where stream channelization has been more common). These Piedmont wetlands are located in the floodplains of larger streams but only receive overbank flow during larger flow events (normally thunderstorms, tropical storms, and hurricanes). During normal stream flow, Piedmont wetlands are connected by localized drainages that are not incised deeply enough to contain perennial or intermittent flow but generally have ephemeral flow. If these connections were deep enough to have intermittent or perennial flow, the adjacent floodplain would most likely drain more quickly and therefore reduce the likelihood of wetland presence. Therefore, in many instances in the Piedmont, these floodplain wetlands exist only because the drainages from them contain ephemeral flow.

Based on the proposed rule, a large portion of the Piedmont wetlands would no longer be protected. The same condition is present along many streams in North Carolina's Inner Coastal Plain; accordingly, many floodplain wetlands would no longer be jurisdictional in this physiographic province, even though these systems are in very close proximity to jurisdictional waters and provide significant functional benefits such as storing significant amounts of local stormwater and overbank stormwater during higher flows (thus decreasing floods downstream), removing significant amounts of sediment and other pollutants such as nutrients, and providing aquatic life habitat.

Scenario 1A: Assumes that an intermittent or perennial stream connection is required for wetland jurisdiction and that ephemeral connections and most ditches[4] do not provide a jurisdictional connection. This scenario is outlined in the proposed rule.

i. *Summary by Wetland Type*

Wetlands lost under Scenario 1A will vary by wetland type. For North Carolina and other similar states in the Southeast (e.g., Virginia, South Carolina), the greatest losses will likely occur in floodplain pools, seeps, non-riverine swamp forest, pine savanna, pine flat, headwater forest, bog, and bottomland hardwood forest communities (Table 1). These specific wetland community types are most at risk because they are often connected by ephemeral drainages or ditches to downstream jurisdictional

[4] These include all ditches that do not meet the proposed definition of WOTUS. See 84 Fed. Reg. at 4179 (ditches are jurisdictional if they (1) are traditional navigable waters; (2) are constructed in a tributary and also satisfy the conditions of the tributary definition; or (3) are constructed in an adjacent wetland and also satisfy the conditions of the tributary definition).

waters rather than by intermittent or perennial streams, and/or do not immediately abut systems with intermittent or perennial flow

ii. *Closer look at Headwater Forests*

To more accurately estimate the extent of loss for headwater forests, an analysis was conducted on a dataset of 34 sites (16 sites in the Piedmont and 18 sites in the Coastal plain) used to calibrate the NC WAM for this wetland type (Dorney, et al. 2015) to determine which types of streams (ephemeral, intermittent or perennial) provided a downstream connection to a WOTUS (Table 2) (Personal communication, Rick Savage and Virginia Baker, March 27, 2019). This analysis revealed that an estimated 29% of these sites would no longer be jurisdictional if ephemeral connections are not sufficient to determine jurisdiction. The percentage of headwater forests no longer jurisdictional is a little higher in the Piedmont (31%) than the Coastal plain (28%). Headwater forests provide critical water quality protection for downstream waters since they are located in the landscape at the head of tributaries and therefore filter pollutants from the immediate watershed before they enter the tributary channel (Appendix 5). In addition, these wetlands store large amounts of floodwaters and release them slowly thereby reducing downstream flooding. Finally, they provide habitat for a wide variety of amphibians (Savage and Baker 2010). Therefore, the loss of jurisdiction of these wetlands would have result in significant increases in downstream pollution including nutrient delivery to downstream eutrophic waters and increased flooding risks.

Table 2: Summary of Changes in Headwater Forest Jurisdiction based on the Proposed Rule

	Headwater Forest Wetlands Lost because Ephemeral Connection Only	Headwater Forest Wetlands Lost because of Ephemeral or Intermittent Connection Only
Coastal Plain	5 out of 18 will no longer be jurisdictional (28%)	14 out of 18 will no longer be jurisdictional (78%)
Piedmont	5 out of 16 will no longer be jurisdictional (31%)	12 out of 16 will no longer be jurisdictional (75%)
Total	10 out of 34 no longer jurisdictional (29%)	26 out of 34 no longer jurisdictional (76%)

iii. *Case Studies*

The proposed rule acknowledges the shortcomings of existing data bases (84 Fed. Reg. at 4201). To further evaluate the impacts of the rule, we examined eight large public and private project sites in Virginia, North Carolina, and South Carolina. From this dataset, we identified three projects that contain wetland maps and stream flow information sufficient to allow a comparison to the proposed rule. This analysis (Appendix 3) was done for one project in Virginia and two in North Carolina. To summarize:

- The project in the Virginia mountains (Doe Branch Mine) would lose jurisdiction over 100% of the site's wetlands, while the project in North Carolina's Inner Coastal Plain (Global TransPark) would lose jurisdiction over 76% of the site's wetlands.

- The project in North Carolina's Outer Coastal Plain (PCS Phosphate) would lose jurisdiction over 8% of the site's wetlands. The lower rate of loss for the Outer Coastal Plain site reflects the fact that wetlands in this much flatter landscape tend to be directly and continuously connected by broad swaths of wetlands to downstream perennial streams. The loss for the PCS Phosphate site would be significantly greater, however, if the agency were to set a distance limit beyond which wetlands within the "complex of wetlands" (84 Fed. Reg. at 4189) are no longer jurisdictional, an issue solicited for comment in the agency's proposal.

iv. NC WAM Reference Wetland Database Analysis

An intensive effort was undertaken statewide on public property during the summer of 2018 to locate at least two reference-quality examples (defined as wetlands that rate high for Hydrology, high for Water Quality, and high for Habitat (using NC WAM (NC Wetland Functional Assessment Team 2016)) in each of seven focus areas across the state. These wetlands will be used for training purposes and serve as a database of some of the highest quality wetlands in the state. The NC WAM reference wetland database was examined to determine what percentage of sites would no longer be regulated based on the proposed rule since the sites were known to be connected only by ephemeral tributaries or nonjurisdictional ditches based on field visits during the summer of 2018 (Table 3). In the coastal plain, jurisdiction would be lost over 18.2% of the site wetlands, while in the piedmont, jurisdiction would be lost over 62.9% of the site wetlands, and in the mountains, jurisdiction would be lost over 29.2% of the site wetlands. Overall, at least 30.6% of the NC WAM Reference wetland sites would no longer be jurisdictional.

Table 3: NC WAM Reference Wetland Database – summary by physiographic region

Level III Ecoregion	Still Regulated	No Longer Regulated	Uncertain	Total
Coastal Plain	72	16	2	90
Piedmont	13	22	12	47
Mountains	17	7	2	26
Total	102	45	16	163

Scenario 1B: Assumes that only a perennial stream can provide a connection for wetland jurisdiction and that ditches[5], and intermittent or ephemeral connections, do not provide a jurisdictional connection. This scenario is presented in the proposed rule in the request for comment on whether to limit jurisdiction to only perennial tributaries.

[5] These include all ditches that do not meet the proposed definition of WOTUS, as described above.

If only perennial streams connections are covered, then as shown on Table 1, the vast majority of freshwater wetland types in NC would experience a loss of jurisdiction with the greatest losses likely to be for floodplain pools, seeps, non-riverine swamp forest, pine savanna, pine flat, headwater forest, bog, bottomland hardwood forest communities, hardwood forests, pocosins, and Carolina bays.

The extent of the loss for headwater forests in the 34-site dataset described above is further shown on Table 2. From this database, 76% of the headwater forests would no longer be jurisdictional with similar loss rates in the piedmont and coastal plain. For the same reasons as outlined above in section 1A(ii), this loss of jurisdiction would have major implications for downstream water quality and flooding.

Scenario 1C: Assumes that only streams with a flow of at least 5 cubic feet per second (cfs) or more could provide a connection for wetland jurisdiction (as solicited for comment) (84 Fed. Reg. at 4178)

This scenario would eliminate from jurisdiction connections by intermittent or ephemeral streams as well as many smaller perennial streams because this flow rate is much higher than the normal flow in most of perennial streams. Therefore, the losses of jurisdiction by wetland type shown in Table 1 above would even be more severe. There would likely be a loss of jurisdiction over all the headwater forests shown in Table 2 because, although connected by perennial streams, those perennial streams have flows much less than 5 cfs.

Scenario 2: This scenario assumes that a specific distance (for instance 500 feet) is used in the final rule. (Comments on the use of a distance is sought in the proposed rule (84 Fed. Reg. at 4189))

Presumably wetlands beyond the set distance would no longer be regulated regardless of their physical, chemical, or biological connection to any WOTUS. Given the overall low level of accuracy for wetland mapping in North Carolina, it is impossible to quantify the effect of a limit. However, based on our extensive field experience, most wetlands are found at distances well beyond 500 feet from a perennial or intermittent stream or other WOTUS[6].

The proposed rule provides no support for setting a specific distance beyond which wetlands would not be jurisdictional. Most wetlands have at least portions of them that go beyond 500 feet. If this distance were used as a hard cutoff to eliminate jurisdiction over a portion of hydrologically connected wetlands, and therefore ignore the obvious connection of wetlands to WOTUS, it would not have a scientific basis.

To the extent any distance limitation is coupled with a requirement that further narrows jurisdiction (i.e., perennial connection required, perennial or intermittent connection required, or flow greater than 5 cfs required), the outcome would ignore the scientific importance of these waters and would

[6] Although there are instances where ditches intersect non-adjacent wetlands, these ditches would only rarely if ever satisfy the proposed definition of a jurisdictional ditch.

make it impossible to protect the chemical, physical, and biological integrity of downstream navigable waters.

Federally Listed Threatened and Endangered Species Found in NC Wetland Types most affected by the Proposed WOTUS Rule

To illustrate the implications of the proposed rule change on listed species, we identified some of the federally threatened and endangered species that rely on bogs, pine savanna, floodplain pools, basin wetlands, and headwater forests in North Carolina (Table 4). A full analysis is provided in Appendix 4.

In general, wetland types at-risk in North Carolina provide important habitat for identified federally and threatened endangered species, so loss of Section 404 jurisdiction would present a major challenge to the federally approved recovery plans for the species as well as continued existence of these species.

Table 4: Federal threatened (T) and endangered (E) species present in North Carolina wetland types that are likely to have the largest loss of extent under the proposed WOTUS rule.

Bog	Pine Savanna	Floodplain Pool	Basin Wetland	Seep	Headwater Forests
Bog Turtle (T(S/A), Green Pitcher Plant (E), Mountain Sweet Pitcher Plant (E)	Red-Cockaded Woodpecker (E), Canby's Dropwort (E), Cooley's Meadowrue (E), Golden Sedge (E)	Canby's Dropwort(E), Cooley's Meadowrue (E), Golden Sedge (E), Pondberry (E)	Canby's Dropwort (E), Pondberry (E)	Bunched Arrowhead (E), Green Pitcher Plant (E), Small-Anthered Bittercress (E)	Dwarf-Flowered Heartleaf (T), Small-Anthered Bittercress (E)

3.3. Ditches

In general, the proposed rule would exclude ditches unless the ditch currently meets the tributary definition (has a perennial/intermittent flow and direct surface water connection to WOTUS) and was initially constructed in (1) a jurisdictional tributary (perennial/intermittent flow and direct surface water connection to WOTUS); or (2) an adjacent jurisdictional wetland (adjacent to or abutting WOTUS). This is true even for those ditches that have an OHWM.

The proposed rule ignores the fact that ditches that drain wetlands such as wet flats, hardwood and pine flats, pocosins, or Carolina bays downslope to intermittent or perennial streams. By the very nature of their direct connection to downstream waters, these ditches provide essential hydrology and water quality functions to downstream waters. Without jurisdictional protection, wetlands such as wet flats, pocosins, or Carolina bays could readily be drained and developed, and become sources of waters for downstream flooding and water quality degradation due to uncontrolled nutrient input into already eutrophic waters. This is a critical reason to continue to regulate ditches that provide water quality functions.

In addition, the proposed rule discusses intermittent versus perennial ditches, but it is very difficult (impossible in many cases) to determine the flow duration of a ditch. Water quality in ditches is invariably poor, and the aquatic community is usually insufficient to determine if a ditch has ephemeral, intermittent, or perennial flow. None of the existing flow duration methods for streams that are discussed below (Section 4 ¶ 3 of this report) address the determination of flow duration in ditches because they use the OHWM indicator. The EPA and USACE would need to develop a process to make this determination before proposing a final rule that considers flow duration in ditches.

4. Specific Comments on Additional Issues Raised by the Proposed WOTUS Rule[7]

The following comments are in response to issues solicited by the agencies for comment and represent best professional judgement and an analysis of jurisdictional systems undertaken in North Carolina with extrapolation to South Carolina and Virginia.

1. **Appropriate treatment of natural or man-made breaks in jurisdictional tributaries (84 Fed. Reg. at 4177).** Interruptions in flow are commonly found in small headwater streams in North Carolina and the Southeastern U.S. and should not alone be enough to break jurisdiction; the proposed rule as written is also too vague and subject to interpretation. We suggest that the existing protocols for dealing with these breaks in jurisdiction be used, namely that evidence of continuous surface flow is sufficient to establish connectivity for continued jurisdiction and/or suggest that the USACE use other tools to determine continuity of jurisdiction (such as the use of non-toxic dye to show connection beneath a debris field).

2. **Definition of intermittent, specifically the effect of:**

   i. **Requiring 6 months of flow (84 Fed. Reg. at 4178).** If the final rule is changed and suggests more than three months of flow for intermittent streams, this would greatly reduce the amount of intermittent streams that are regulated since research by Williams (2005) shows that intermittent streams in North Carolina generally flow (or contain water) for about three months.

   ii. **Relying on groundwater monitoring to evaluate flow (84 Fed. Reg. at 4178).** Groundwater monitoring would be impractical and very costly since it would require installation of shallow groundwater wells in transects parallel to the channel with a sufficient number of wells monitored for months or longer, in a "typical" (rainfall) year, to demonstrate the flow regime. Any such study plan would need to be approved by the appropriate agencies (which is not a quick process). Groundwater monitoring is simply not realistic during a typical delineation process.

   The definition of jurisdictional wetlands explicitly excludes consideration of groundwater, while the stream definitions explicitly use groundwater and the definition of lakes allows consideration of subsurface flows. This is inconsistent and should be reconciled in the final rule

[7] Unless otherwise noted, these comments relate to the application of the proposed rule in the Southeast.

to allow the use of groundwater and other subsurface flows in the wetland definition as has been done for many decades in the United States with the consideration of soil saturation in addition to flooding.

iii. **Requiring certain flow rates, specifically 5 cfs (84 Fed. Reg. at 4178).** This would be an extremely complex proposal and difficult to implement in the field since it would require installation of stream gauges, a very costly exercise that is impractical on small streams. The suggested flow of 5 cfs is very high and would likely eliminate all intermittent and many small perennial streams from jurisdiction in the Southeast. Most intermittent and small perennial streams have very low flow rates (except right after storms) and it is impossible to determine (or model) that flow.

iv. **Flow Duration:** The proposal also discusses the potential for a specific flow duration (30, 60, or 90 days) (**84 Fed. Reg. at 4178**). Again, this is impractical since it assumes some sort of continuous monitoring during a "typical" year. Such monitoring is extremely expensive to install and would greatly increase the cost of delineation and permitting.

3. **Determination of stream jurisdiction:** Presently, the U.S. Army Corps of Engineers (USACE) uses the easily observable presence of an Ordinary High Water Mark (OHWM) to determine stream jurisdiction. This rapid process, which normally takes seconds to conduct at each site, is based on long-standing regulatory guidance from USACE as captured in their 2005 Regulatory Guidance Letter (USACE 2005) as well as long-established training processes conducted by USACE across the United States (for example, see USACE 2014). It is very effective at defining the entire length of a tributary. The proposed rule, however, would require that the agencies separate each tributary into ephemeral, intermittent, and perennial sections. Although there are protocols for performing this analysis, they require more time and would involve extensive training.

   In North Carolina, these determinations have been made for the past two decades using the North Carolina Stream Identification Method (North Carolina Division of Water Quality 2010). The North Carolina Method is relatively rapid, requiring about 15 minutes per site to conduct the evaluation (Dorney and Russell. 2018). As outlined in the methodology, a total of 26 field metrics are observed and rated on a scale of absent, weak, moderate, or strong. The field metrics are separated into three major categories of geomorphology, hydrology, and biology including bank stability, bed composition, riparian canopy cover, and the existence of insects and amphibians. The overall purpose of the method is to identify the origins of intermittent and perennial streams and to characterize stream segments in terms of their flow duration.

   This proposed change from reliance on the OHWM to determination to flow duration will greatly increase the workload (and thereby permitting cost) for public and private projects since consultants and agencies will need to determine flow duration, which is a more complex, time consuming process than the simple, rapid, on-site determination of the presence of an OHWM.

   Contrary to what the rule proposes, the use of intermittent or perennial (or non-ephemeral) flow as opposed to the OHWM as currently used will not be simple for landowners to understand.

Indeed, determination of the OHWM is vastly simpler for consultants and landowners to determine in the field than flow duration, which requires specialized training and equipment.

Methodologies to identify stream flow duration only exist in North Carolina, Tennessee Department of Environment and Conservation, 2011), and Pacific Northwest (Washington, Oregon, and Idaho) (Dorney and Russell, 2018; Nadeau, 2018). Other locations would need to have methods developed and related training conducted. The North Carolina method has been successfully used in Virginia, South Carolina, and Georgia, but scientifically developed and vetted methods are certainly not available for the rest of the country. It takes at least two years to develop these methods and at least two years to train a critical mass of agency personnel to properly use the method. Therefore, accurate implementation of a flow duration-based regulatory program cannot be done quickly without massive inconsistencies in implementation in the field.

Under the proposed rule, each Corps district or each state would have to develop or adopt a protocol for determining where ephemeral streams begin and end. There are only three in the country—one used in NC, one used in TN, and one used in the Pacific Northwest. Two are described in Dorney, et al. (2018, Chapters 4.1.1 and 4.1.2). To develop a new protocol and provide the necessary training will take years. At the very least, the USACE and EPA need to provide guidance to the Districts who would develop and implement the methods. For instance, the rules could state that rapid methods be developed on a USACE District, USACE Division, or EPA Regional level to determine flow durations that are based on easily observable geomorphology, hydrology, and biological characteristics during a single site visit (i.e., bed, banks, OHWM). These methods need to be developed by a team of local experts and fully tested and validated before they are used (like the process that the EPA recently used in the Pacific Northwest – Nadeau 2018).

For instance, the North Carolina Stream Identification Method (North Carolina Division of Water Quality 2010) is a field-based, rapid assessment method which requires successful completion of a four-day training class which includes a written test and two field tests (Dorney and Russell. 2018). The method contains 26 metrics which must be carefully observed or evaluated in the field and requires use of a soil auger, Munsell soil chart, an aquatic insect sampling net (normally a “D net”) and white sorting pan. The method normally takes about 15 minutes per site in the field to properly evaluate a stream reach. In comparison, the current method used by the US Army Corps of Engineers to identify the OHWM at the upgradient terminus of an ephemeral stream takes about 10 seconds per field site. Therefore, use of ephemeral versus intermittent versus perennial tributary determinations are much more time intensive and require specialized training to implement consistently.

4. **Watershed Scale (84 Fed. Reg.at 4154, 4178-79):** The rule suggests the use of watershed scale as a way to determine stream flow duration. While watershed size is certainly a factor, so is slope, physiographic region, soils, vegetation cover, land use, etc. (Russell, et al. 2015). Watershed scale by itself is much too simple a criterion.

5. **Effect of limiting adjacency, such as setting a distance limitation for adjacent wetlands (84 Fed. Reg. 4154, 4189):** The agencies request comment on whether to use distance from another

jurisdictional water as the basis for asserting jurisdiction over wetlands; they also request comment on establishing a jurisdictional cut-off in a contiguous wetland. As described above, the scientific literature does not provide any scientifically supportable distance, so any distance chosen will be arbitrary (USEPA 2015). Also use of a distance invariably means that some wetlands beyond that distance will lose jurisdiction even though they are connected (hydrologically, functionally, etc.) to the wetland that happens to be within the distance. Because of their connection, this approach would hinder the water quality function of all the wetlands, whether jurisdictional or not, and of any adjacent or abutting jurisdictional waters.

6. **Requirement for an intermittent or perennial surface connection for wetlands coverage:** As noted above, the requirement for an intermittent or perennial connection will eliminate a large amount of highly functional riparian and non-riparian wetlands, especially in the piedmont and inner coastal plain (see Table 1 and Table 2), from jurisdiction including a large number of wetlands in floodplains which receive periodic overbank flow. The scientific literature (and EPA's connectivity report, US EPA 2015) strongly support the importance of all wetlands in floodplains but again the scientific literature and the connectivity report do not provide guidance on any specific distance.

7. **Trespassing will be required to implement this rule.** If a delineator needs to determine if a wetland has an intermittent or perennial connection or if a stream is an intermittent or perennial tributary to a Traditionally Navigable Water, additional field work often involves going off the property (and thereby trespassing) to determine connectivity. No existing data source is accurate enough to use in lieu of field work. As noted before, the USACE does not have the power of eminent domain and allowable trespass onto private property without owner consent which sets up an impossible process to implement.

   To make a jurisdictional determination, the rule also would require the delineator to determine if the stream or wetland is connected to a downstream WOTUS via an intermittent or perennial stream. This will also likely require going offsite and therefore trespassing onto adjacent property. Plus, additional field work will be needed which would likely consist of an additional field visit, which will then increase the cost of permitting. We expect that for public work (such as for the North Carolina Department of Transportation or a public utility), consultants would not be authorized to go outside the study area due to trespass concerns and therefore consultants or landowners may have difficulty in making a jurisdictional determination in these cases. The USACE would then have to make that determination later and address the trespass issue; however, USACE agency staff does not generally have trespass rights unless specifically provided by the property owner verbally or through application for a USACE permit.

8. **The rule discusses the use of State/Tribal/Federal geospatial databases** to make jurisdictional determinations, but these databases either do not exist or are wildly inaccurate. For instance, the rules suggest the use of LiDAR to determine stream flow duration. LiDAR is a very powerful tool and is widely used in North Carolina for a variety of purposes since it is available for the entire state. However, LiDAR cannot be used to determine stream flow duration; without additional extensive field work. Finally, statewide LiDAR is available in only a few locations in the U.S.

Therefore, these databases either do not exist or are not useable for the anticipated purposes. For example, the state of North Carolina has begun to develop and implement the so-called ATLAS project (NC DOT, 2019) to use the latest GIS tools to expedite the delineation process and especially expedite environmental screening for projects. However, even this very sophisticated product does not eliminate the need for site visits. These site visits are critical to make valid, scientifically-sound determinations of the existence of streams and wetlands in the landscape.

9. **Does the proposed rule provide clarity in determining jurisdiction?** No, despite the overall goal of the proposed rule is to develop "simple, understandable, and implementable terms" and "bright jurisdictional lines that are easily comprehensible and implementable" (84 Fed. Reg. 4197). For the reasons outlined above, this is simply not true. North Carolina has almost two decades of experience in determining stream flow duration with the original goal being a determination that could be made by a landowner/layperson. This was not achieved and cannot likely be achieved based on our extensive experience. Based on our two decades of experience in implementing the riparian buffer rules in North Carolina, the determination of ephemeral versus intermittent versus perennial flow requires specialized training and expertise. The new rule provides so little guidance that determining jurisdiction will be very difficult, even with expert guidance.

10. **Ponds**: Whether ponds are or were built in streams, they are jurisdictional. They should also be jurisdictional if they have a "significant nexus" to downstream waters of the United States. That is the only way to protect water quality in the downstream waters.

11. **Maps**: The rule requests information on maps of jurisdictional features. There are no maps of streams or wetlands with any accuracy for the Southeastern U.S. In fact, the more accurate stream map in North Carolina (the hard copy NRCS soil surveys) are not even digitized (North Carolina Division of Water Resources, 2019a; Colson, et al. 2008). The streams shown on the Web Soil Survey are completely misleading. There are modeling efforts underway (see Russell et al., 2015 and the NC ATLAS project (NC DOT 2019)) but those are not yet complete. Based on our extensive experience, field visits are essential.

5. References

Colson, T, J. Gregory, J. Dorney and P. Russell. 2008. Topographic maps do not accurately depict headwater stream networks. National Wetlands Newsletter 30(3): 25-28.

Dorney, J.R., L. Paugh, A.P. Smith, T. Allen, M.T. Cusack, R. Savage, E.B. Hughes and B. Munoz. 2015. The North Carolina Wetland Assessment Method (NC WAM): Development of a Rapid Wetland Assessment Method and Use for Compensatory Mitigation. Environmental Practice 17 (2):145-155.

Dorney, Savage, Tiner, and Adamus (eds). 2018. Wetland & Stream Rapid Assessments: Development, Validation, and Application. Elsevier Publishing.

Dorney and Russell. 2018. North Carolina Division of Water Quality Methodology for Identification of Intermittent and Perennial Streams and Their Origins. Chapter 4.1.1 Wetland & Stream Rapid Assessments: Development, Validation, and Application. Elsevier Publishing.

Eaton, L. and R. Vander Vorste. 2012. Final Report: Documenting Significant Nexus to Navigable Waters in the Southeast CD 95415609-0. NC Division of Water Quality, Raleigh, NC. Available at http://ofmpub.epa.gov/apex/grts/f?p=101:150:8728681756582::NO::P150_GRT_SEQ:100807#final. Accessed December 30, 2014.

Levick, L., J. Fonseca, D. Goodrich, M. Hernandez, D. Semmens, J. Stromberg, R. Leidy, M. Scianni, D. P. Guertin, M. Tluczek, and W. Kepner. 2008. The ecological and hydrological significance of ephemeral and intermittent streams in the Arid and Semi-Arid American Southwest. U.S. Environmental Protection Agency and USDA/ARS Southwest Watershed Research Center, EPA/600/R-08/134, AR/ 233046, 116 pgs.

Moffatt & Nichol. 2019. The Effect of a Revised Waters of the US (WOTUS) Definition on the Extent of Jurisdictional Streams in Selected Level IV Ecoregions in North Carolina. Available from Southern Environmental Law Center, Chapel Hill, North Carolina. Update from 2018 version.

Nadeau. 2018. A Rapid Assessment Method for Classifying Flow Permanence of Stream Reaches in the Pacific Northwest, United States. Chapter 4.1.2. Wetland & Stream Rapid Assessments: Development, Validation, and Application. Elsevier Publishing.

NC Department of Transportation. 2019. ATLAS project. NC WAM Reference Wetlands. Website pending later in 2019.

NC Administrative Code (NCAC) 2B .0233 (Neuse River Buffer Rules). The rule says the 2015 Rule may have failed to appropriately recognize that the EPA Connectivity report is “not [legally] dispositive” (page 158). In contrast, this rule totally ignores that report.

NC Division of Water Quality. 2010. Methodology for Identification of Intermittent and Perennial Streams and Their Origins. Version 4.11. September 1, 2010. Available at http://www.xerces.org/wp-content/uploads/2009/03/NC_2010_Methodology_identification_intermittent_perennial_streams.pdf.

NC Division of Water Resources. 2019a. Surface Water Identification Training and Certification Class (SWITC) Manual. Chapter 4 – Stream Maps.

NC Division of Water Resources. 2019b. North Carolina State Water Program Summary from the Association of State Wetland Managers report. Available at https://www.aswm.org/pdf_lib/state_summaries/north_carolina_state_wetland_program_summary_083115.pdf

NC Wetlands Functional Assessment Team. 2016. NC Wetland Assessment Manual, Version 5.0. Available at http://www.xerces.org/wp-content/uploads/2009/03/NC_2010_Methodology_identification_intermittent_perennial_streams.pdf

Russell, P. S. Gale, B. Munoz, J. Dorney and M. Rubino. 2015. A spatially explicit model for mapping headwater streams. Journal of the Water Resources Research Association 51(1): 226-239.

Savage, R. and V. Baker. 2010. Field verification of wetland functional assessment methods within local watershed planning areas- Draft report. Department of Environment and Natural Resources. NC Division of Water Quality, Raleigh, NC. EPA Final Report CD-996433105-01. Available at https://sewwg.rti.org/LinkClick.aspx?fileticket=iBF4Fd4cOHM%3d&tabid=60. Accessed on March 27, 2019.

Tennessee Department of Environment and Conservation, Division of Water Pollution Control. 2011. Guidance for Making Hydrologic Determinations. Version 1.4, May 2011. Available at https://www.tn.gov/content/dam/tn/environment/documents/guid_hydro_det.pdf.

Trimble, S. W. 1974, 2008. Man-Induced Soil Erosion on the Southern Piedmont, 1700-1970. Enhanced Edition with a new foreword by Andrew Goudie. Soil and Water Conservation Society, Ankeny, Iowa.

US Army Corps of Engineers. 2005. Regulatory Guidance Letter: Ordinary High Water Mark Identification. December 7, 2005. RGL 050-05.

U.S. Army Corps of Engineers. 2014. Ordinary High Water Mark (OHWM) Research, Development, and Training, Improving Corps regulatory practices. Available at: https://www.erdc.usace.army.mil/Media/Fact-Sheets/Fact-Sheet-Article-View/Article/486085/ordinary-high-water-mark-ohwm-research-development-and-training/. Accessed on March 26, 2019.

U.S. EPA. Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence (Final Report). 2015. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-14/475F, 2015. Available at https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=296414

Williams, N.B. 2005. Relationship between flow regime and aquatic macroinvertebrate abundance in headwater streams in the piedmont region of North Carolina. MS Thesis. North Carolina State University, Natural Resources, Hydrology.

6. Appendices

Appendix 1: Author Biographies

John Dorney – Mr. Dorney has been employed by Moffatt & Nichol since March 2014 after working three years with another private consulting firm and working with the Water Quality Section of the NCDivision of Water Quality for about twenty-nine years. At Moffatt & Nichol, he is responsible for doing environmental permitting as well as being involved in stream and wetland functional assessment. When Mr. Dorney started at the Division of Water Quality, he spent three years working on water quality standards. After that he was the supervisor of the Special Projects Group in Water Quality Planning for three additional years. From 1990 to

2004, Mr. Dorney was responsible for the 401 Water Quality Certification Program in North Carolina and was supervisor of the Wetlands/401 Unit that is responsible for regulatory review of development projects to ensure compliance with the state's wetland and buffer regulations. From 2004 to 2011, he oversaw the Wetlands Program Development Unit which is responsible for developing and implementing new or modified wetland regulatory policies including developing policy for cumulative and indirect impact as well as FERC permitting and watershed monitoring. Previously Mr. Dorney worked for environmental consulting firms in Wisconsin and Ontario, for local governments and a Native American tribe doing land use and recreational planning and at a research lab at NC State University.

Mr. Dorney has a BS degree in Biology, an MS degree in Botany, and an MS degree in Civil Engineering. He has prepared numerous government agency reports and has published scientific articles concerning wetlands and water quality. In addition, he has been an expert witness for wetlands and water quality for several court cases. He has also done numerous presentations on water quality issues and wetland/buffer regulations for various groups. Recently, he was the main editor on a book published by Elsevier entitled "Wetland & Stream Rapid Assessments: Development, Validation, and Application" edited by John Dorney, Rick Savage, Ralph Tiner, and Paul Adamus (2018).

Jerry McCrain – Dr. McCrain has a background in wetland ecology, permitting, mitigation banking, environmental policy development, watershed planning, and complex project management. With 44 years of highly diversified experience in the environmental field, including 30 years of progressive consulting experience, Dr. McCrain has managed several hundred environmental projects throughout the Southeast US, Africa, and the Caribbean in the past 15 years. He is a Certified Environmental Professional through the Academy of Board of Certified Environmental Professionals and a Professional Wetland Scientist.

His current and previous experience is directly related to this work. As principal-in-charge and senior project manager for a $3 million, three-year contract for policy-level support at EPA headquarters, his work involved support for economic and regulatory impact analysis under the Clean Water Act, Section 404 permitting program, as well as reviewing and evaluating direct, secondary, and cumulative impacts associated with proposed alternatives; compliance with Section 404(b) (1) guidelines; stakeholder involvement; technical assessments; and QA/QC review of technical reports.

He managed a $4.7 million oyster reef project for the NC Division of Mitigation Services involving design, engineering, and environmental services. The 42-acre reef structure will be located in Pamlico Sound and will be one of the largest artificial reef projects in the US once constructed.

Most recently, Jerry has served as the environmental, safety, social, and sustainability lead review consultant to International Finance Corporation/World Bank for a $1.5 billion port project in Tema, Africa – the largest infrastructure project on the continent. His work includes

site visits; analysis of submitted environmental, social, and safety documentation; and stakeholder interactions to insure compliance with World Bank performance standards.

Ken Jolly – Mr. Jolly graduated from NC State University with a B.S. in Wildlife Biology in 1977. He has 34 years of experience with all aspects of the USACE Regulatory Program in Wilmington District, performing all technical duties from Regulatory Specialist to Regulatory Chief. As the Wilmington District Regulatory Chief from 2002 to 2012, he planned, directed, monitored, and executed the Wilmington District throughout North Carolina, leading a staff of 54 technical and administrative personnel. During the period January to June 2010, he completed a developmental assignment with the Assistant Secretary of the Army for Civil Works, serving as liaison with Headquarters-level staff of all federal agencies, including USACE; tribal representatives; congressional, senate, and state government staff; and the public on policy matters involving national USACE Civil Works issues. From 1987 to 2001, he served as the Section/Field Office Chief for the Raleigh Regulatory Field Office, managing and executing the Regulatory Program throughout a 30-county area of North Carolina while leading a staff of 7 technical and administrative staff. As Field Office Chief, he worked as the senior technical Regulatory specialist, interacting daily with state and federal agency representatives, local government representatives, and the public regarding Regulatory issues and concerns. From May to September 2017, he served as a Regulatory Project Manager/Supervisor Mentor with Alaska District USACE, assisting in preparation and review of NEPA documentation for controversial projects with significant, major impacts on the human environment.

Adam Efird – Mr. Efird is a senior environmental scientist at Moffatt & Nichol with 10 years of experience and expertise in the areas of wetland and wildlife ecology, species modeling, GIS, natural resource management, urban ecology, air quality analysis, traffic noise modeling, NEPA/SEPA, and environmental permitting. He has a BS in Biology from Campbell University, and a Master of Natural Resources from Virginia Tech.

Rebeckah Hollowell – Ms. Hollowell is an environmental scientist at Moffatt & Nichol. She has a BS in Biological Sciences and MS in Plant and Environmental Sciences from Clemson University. She has been with Moffatt & Nichol almost two years. Her expertise includes wetland and stream ecology, natural resource management, environmental planning, NEPA/SEPA, GIS, stream restoration, mitigation, and environmental permitting. Ms. Hollowell provides GIS support for various environmental, planning, and project development tasks.

Appendix 2: The Effect of a Revised Waters of the US (WOTUS) Definition on the Extent of Jurisdictional Streams in Selected Level IV Ecoregions in North Carolina with Extrapolations to Virginia, South Carolina, and Georgia

Final Report

The Effect of a Revised Waters of the US (WOTUS) Definition on the Extent of Jurisdictional Streams in Selected Level IV Ecoregions in North Carolina with Extrapolations to Virginia, South Carolina, and Georgia

Presented to:

Geoff Gisler, Southern Environmental Law Center (SELC)
Chapel Hill, NC

April 7, 2019

Prepared by:

Moffat & Nichol

1. Legal Background

The definition of Waters of the United States (WOTUS), especially in the context of the 404 Permit Program, has been the subject of three main US Supreme Court cases (Riverside Bayview, Solid Waste Authority of Northern Cook County [SWANCC], and most recently, the Rapanos/Carabell case in 2006). As a result of the Rapanos/Carabell decision (Rapanos v. United States, 547 U.S. 715), the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (USACE) have used either the "relatively permanent" test outlined by the opinion of Justice Scalia (described below) or the "significant nexus" test outlined by the opinion of Justice Kennedy. In 2008, the agencies issued guidance interpreting the Rapanos decision (2008 Guidance). In most situations, the significant nexus test has been used by USACE since it is the broader definition, with strong reliance on the 1987 Manual and its Regional Supplements.

In 2011, the Obama Administration began a formal process to define WOTUS based on the significant nexus test. This process involved an in-depth examination of the scientific literature, as well as proposed rulemaking and public comment. After this lengthy process, the Obama Administration formally published the new definition of WOTUS on June 29, 2015. A day before the final rule became effective on August 28, 2015, it was stayed in 13 states by a district court. On October 9, 2015 the U.S. Court of Appeals for the Sixth Circuit stayed the Clean Water Rule nationwide. The Sixth Circuit directed EPA and USACE to use the 2008 Guidance to make jurisdictional determinations. On February 28, 2017 the Trump Administration issued an Executive Order directing EPA to repeal and then replace the CWR with a new rule consistent with the Scalia test. On July 27, 2017 EPA issued a proposed rule that would repeal the CWR. On February 14, 2019, EPA proposed a new definition of WOTUS.

The new proposed definition is largely consistent with the test for making jurisdictional determinations articulated by Justice Scalia in the Rapanos case. Under the proposed WOTUS definition, federal jurisdiction under the Clean Water act would be limited to "relatively permanent flowing and standing waterbodies that are traditional navigable waters in their own right or that have a specific connection to traditional navigable waters, as well as wetlands abutting or having a direct hydrologic surface connection to those waters." Revised Definition of "Waters of the United States", 84 Fed. Reg. 4154, 4170 (Feb. 14, 2019). The proposed rule expressly excludes ephemeral streams. It also requests comments on numerous ways jurisdiction could be narrowed, including on whether intermittent streams should be jurisdictional.

The work described in this report examined the potential effect of a "relatively permanent" definition of waters with respect to streams in Level IV ecoregions of North Carolina where field data exist to conduct the analysis. For this analysis, we assume that "relatively permanent" is synonymous with perennial flow.

2. Purpose of this Work

The purpose of this work is to gather and analyze data on intermittent and perennial stream origins and their lengths from field-collected data in selected Level IV ecoregions in North Carolina. These origins have been collected using the most current (at the time of data collection) version of the NC

Stream Identification Method (NC Division of Water Quality, 2010). These data were then analyzed by Level IV ecoregion (Griffith et al., 2002) to estimate the percent of stream length in these ecoregions that is intermittent and the percent of steam length in these ecoregions that is perennial. Conclusions were then made as to whether these results could be extrapolated to the same ecoregions in Virginia, South Carolina, and Georgia. Note that various technical issues with these data are described in Appendix 1 of this report.

3. Scientific Background

Most studies of stream flow duration involve either simple mapping exercises or mapping of stream types in selected watersheds rather than comprehensive analyses over a large geographic region. Very few studies have been published on the distribution of stream flow in larger geographic areas, such as states or countries.

It is well known that analyses using existing maps to determine the distribution of ephemeral, intermittent, or perennial channels are problematic due to the low level of accuracy of the underlying maps (Colson, et al. 2008). Other studies use more accurate field determinations of stream origins often in association with GIS models of stream networks derived from field-determined origins (Russell, et al. 2015; Fritz, et al. 2013.; Williamson, et al. 2015; Caruso 2014) based on the analysis of selected (usually relatively undisturbed) watersheds. For instance, Russell, et al. (2015) reported that 35% of the streams in North Carolina's Triassic basin were intermittent, while Caruso (2014) reported that about 50% of the streams in his western Colorado study area were ephemeral, about 13% were intermittent, and about 37% were perennial. From an analysis of data presented by Fritz, et al. (2013) – Table 3), of intermittent and perennial steams in various selected study watersheds in the eastern U.S., an average of 57.9% were intermittent and 42.1% were perennial, but the percentage of streams that were intermittent ranged from zero to 82.6% depending on the watershed. It also has been shown that the percentage of ephemeral and intermittent streams is generally highest in arid climates (Levick, et al. 2008). In general, the ratio of intermittent to perennial streams varies considerably based on climate, geology, and past land use.

The analysis reported in this document examines the state of North Carolina, which has diverse physiography, from flat, sandy Coastal Plain, to rolling, clayey Piedmont, to steep mountain terrain of the Appalachian Mountains (and their foothills). In addition, because some of these ecoregions also occur in the neighboring states of Virginia, South Carolina, and Georgia, these results can be extrapolated to the same ecoregion in adjacent states. As far as we can determine, this is the first comprehensive analysis of stream flow duration on a statewide scale in the United States, which is especially notable in a state like North Carolina with greatly varying physiography.

4. Data Sources

4.1. Level IV Ecoregions

The EPA and respective state cooperating agencies have prepared maps of (the larger) Level III and (the smaller) Level IV ecoregions. The North Carolina ecoregion map dates to 2002 (Griffith, et al.

2002) and contains four Level III ecoregions (Middle Atlantic Coastal Plain, Southeastern Plains, Piedmont, and Blue Ridge Mountains) as well as 27 Level IV ecoregions (see Figure 2). Ecoregions are defined as areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources (Griffith et al., 2002). Ecoregions are designed to serve as a framework for research, assessment, management, and monitoring of ecosystems and are based on consideration of geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. As such, these Level IV ecoregions serve as an ideal framework to collect stream origin data and have been used by the NC Division of Water Resources as the framework for the data collection and modeling efforts used in this report.

4.2.NC Stream Identification

4.2.1.**Stream Definitions –** According to the NC Stream Identification Method (NC Division of Water Quality, 2010) and the underlying NC Riparian Buffer Rules (NC Environmental Management Commission, 2007), there are three basic types of streams ephemeral, intermittent, and perennial. Intermittent and perennial streams are discussed in this report. North Carolina's definitions for these streams, which differ slightly from the agencies' proposed definitions as described below, were used to collect data analyzed in this report. In addition, the NC rules contain definitions of "ditches" and "modified natural streams" that are not included in this analysis since these systems are not natural features and are only jurisdictional if they were originally constructed in another jurisdictional water.

4.2.1.1. **Ephemeral Streams:** The NC method is not used to determine the origin of ephemeral streams. Therefore, data on the length of ephemeral channels (which may or may not have an OHWM) is not available in NC or the surrounding states. However, based on our extensive field experience, the portion of ephemeral streams with Ordinary High Water Marks is located immediately upslope of the intermittent origin.

4.2.1.2. **Intermittent Streams:** "Intermittent stream means a well-defined channel that contains water for only part of the year, typically during winter and spring when the aquatic bed is below the water table. The flow may be heavily supplemented by stormwater runoff. An intermittent stream often lacks the biological and hydrological characteristics commonly associated with the conveyance of water. [15A NCAC 02B .0233(2)(g)]." (NC Division of Water Quality, 2010).

Generally, in North Carolina and the southeastern U.S., intermittent streams are connected to the local high groundwater table usually in the winter (when evapotranspiration is limited) and have flowing water for three to four months during that time (Williams, 2005). In our experience, these channels always have OHWMs and are therefore considered jurisdictional by the USACE under the existing 404 permit program. These streams also include protected buffers where State riparian regulatory programs exist.

4.2.1.3. **Perennial Streams:** "Perennial stream means a well-defined channel that contains water year-round during a year of normal rainfall with the aquatic bed located below the water table for most of the year. Groundwater is the primary source of water for a perennial stream, but it also carries stormwater runoff. A perennial stream exhibits the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water. [15A NCAC 02B .0233(2)(i)]." (NC Division of Water Quality, 2010).

Generally, in North Carolina and the southeastern U.S., perennial streams are connected to the local high groundwater table year around during a year of normal rainfall and have flowing or ponded water during that entire time. In our experience, these channels always have OHWMs and are therefore considered jurisdictional by the USACE for the 404 permit program and have protected buffers where State regulatory programs exist.

5. The NC Stream Identification Method (NC Division of Water Quality, 2010)

The NC Stream Identification Method was first developed in 1999 as a tool for state staff and the regulated public to use to determine the presence of intermittent and perennial streams for the Neuse River Riparian Buffer Rules (NC Environmental Management Commission, 2007). This program has since been expanded to be used throughout the state for buffer rules in other river basins and the definitions listed above have been adopted for determining and defining intermittent and perennial streams. The method has been updated several times and the most current version is the 4.11 version dated September 1, 2010. A modified version of the method has been used in the Chesapeake Bay area for the determination of buffers (DeBerry and Crayosky, 2018). A validation study on the method was published by Fritz et al. (2013).

The method uses 26 metrics that are usually scored from 0 to 3 (zero indicates that a respective metric is usually “absent” while three is usually “strong”). This methodology is designed to be a rapid assessment and completed on a uniform, selected stream reach in about 15 minutes, which includes time for sampling aquatic macroinvertebrates with a net as well as soil sampling with a soil auger.

If the system scores at least 19 points, this waterbody is generally considered intermittent while if the channel scores 30 points, it is generally considered perennial (absent unusual or extenuating circumstances judged on a case-by-case basis). The perennial determination can also be made based on the presence of specific aquatic life (including aquatic macroinvertebrates) which require permanent water for survival as listed in the Manual.

6. Peer-reviewed Literature in North Carolina

Russell et al. (2015) published the results of an analysis of stream origins in the Triassic basin in NC. Data were collected from 157 intermittent and perennial stream origins across seven rural watersheds

in the Triassic basin. "Stream origins" are defined as those locations on the ground where the stream type changes from ephemeral to intermittent (an intermittent origin) or from intermittent to perennial (a perennial origin). Statistical models were then developed to predict the origins of intermittent and perennial streams in this Level IV ecoregion. Data from this publication were used in Table 1 to characterize the percentage of intermittent and perennial streams in North Carolina's Triassic basins.

7. Data Collection

The NC Division of Water Resources (DWR – formerly the NC Division of Water Quality) has had an active program of locating intermittent and perennial stream origins in selected watersheds within Level IV ecoregions of the state since 2005. The purpose of this work is to gather field data to develop statistically valid, linear regression models of stream origins and then use those models to produce statistically valid maps of these intermittent and perennial streams for each of the 27 Level IV ecoregions of the state. As of the end of 2018, the DWR had gathered stream origin data from 173 watersheds in 19 Level IV ecoregions (personal communication, Andrew Kiley, NC Division of Water Resources, February 18, 2019). For this project, electronic copies of these data were obtained from the DWR under a Public Records request and then analyzed as described below. The critical assumption in this analysis (as in Russell, et al. 2015) is that the watersheds where the data were collected represent the Level IV ecoregion where they were collected.

8. Data Analysis

Data were separated either by project name/location or by Level IV ecoregion. DWR staff are actively engaged in organizing the data to analyze using the latest version of the state's LiDAR data. Therefore, the data as of the end of 2018 were in various states of being organized. Some data had already been sorted and updated by DWR staff, while other data contained raw data sets.

Stream-specific data were obtained from the state files and organized by ecoregion. For each ecoregion, a new ArcGIS map was created showing origin points for all identified stream systems and break points between ephemeral and intermittent, intermittent to perennial, etc. for each specific field verified watershed (see Figure 1 on the following page for an example). Each stream length, by type (intermittent, perennial, excluding ephemeral reaches), was measured and quantified. Data were tallied to provide an overall – and consistent – assessment of each stream type. Note that since the NC stream data set only contains locations for the origins of intermittent or perennial streams, that the length of ephemeral reaches is unknown and is not included in this dataset.

Analysis results were then copied into an Excel spreadsheet based on Level IV ecoregion where the size of the watershed, total length of stream, percent length of intermittent stream and percent length of perennial stream, as well as the number of intermittent and perennial origins, were recorded. This was completed for 13 separate Level IV Ecoregions and 66 distinct watersheds. In addition, the seven watersheds for the Triassic basin ecoregion from Russell, et al. (2015) were included in this analysis.

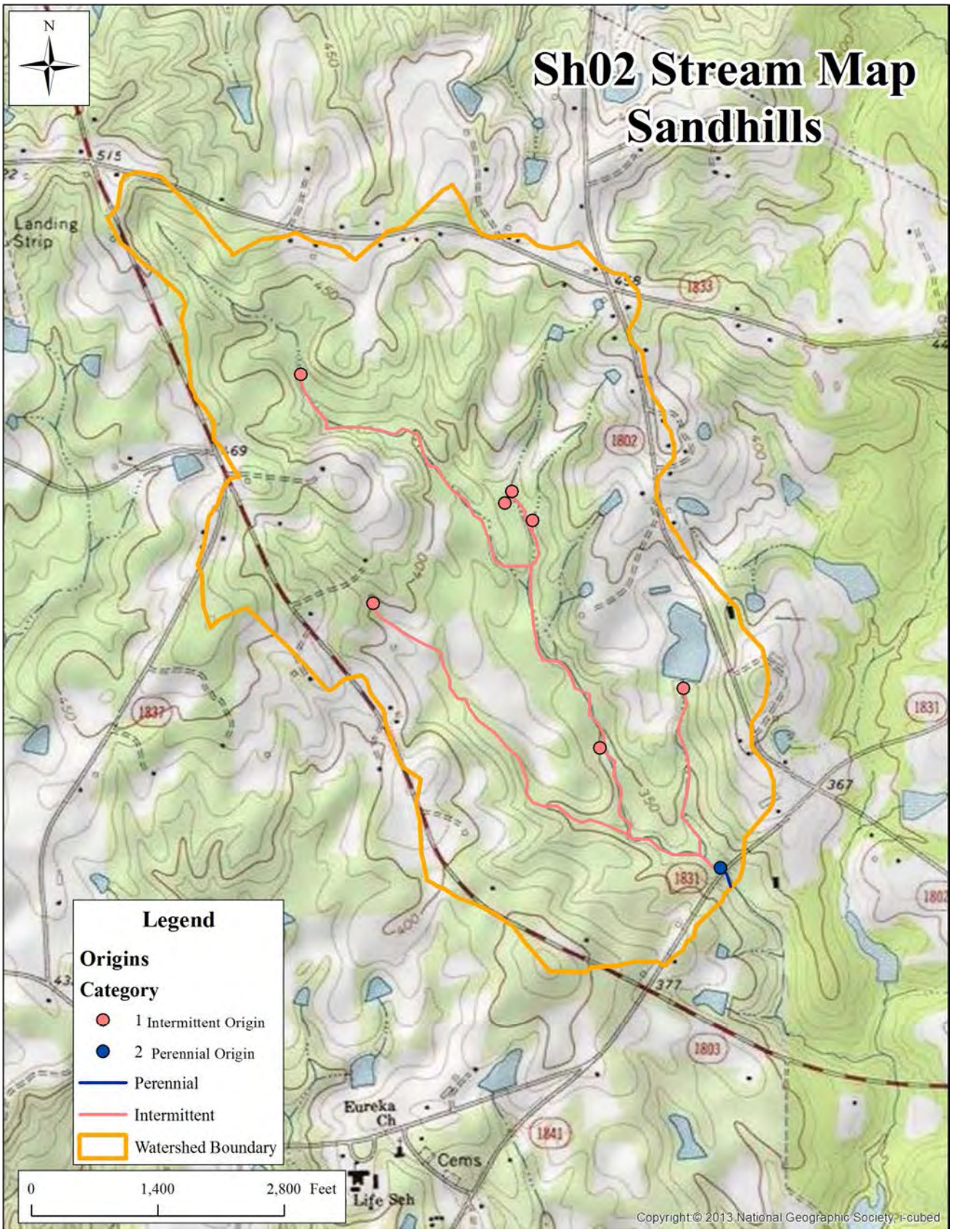


Figure 1: Example of Local Watershed showing locations of intermittent and perennial stream origins

9. Summary of Results by NC Ecoregion – Percentages of Intermittent versus Perennial Streams

The stream origin data gathered from 173 watersheds located in 19 separate Level IV ecoregions across North Carolina, totaled 141.4 square miles of watersheds with a total of 454.6 miles of streams. A total of 1,154 intermittent stream origins and 1,127 perennial stream origins were examined from this data set (Table 1, Figure 2).

Nineteen of the 27 Level IV ecoregions present in the state are represented in this analysis (three ecoregions from the Middle Atlantic Coastal Plain, three ecoregions from the Southeastern Plains, six ecoregions from the Piedmont, and seven ecoregions from the Blue Ridge Mountains) (Table 1). In general, the sample has good representation for the Blue Ridge Mountains (seven of nine ecoregions), the Piedmont (six of seven ecoregions), and the Southeastern Plains (three of the four ecoregions), while it has fair representation for the Middle Atlantic Coastal Plain (only three ecoregions out of seven).

The other eight of the 27 Level IV ecoregions do not have stream origin data in the NC DWR database. These are in the Middle Atlantic Coastal Plain (Nonriverine Swamps and Peatlands, Virginian Barrier Islands and Coastal Marshes Carolinian Barrier Islands and Coastal Marshes); in the Southeastern Plains (Southeastern Floodplains and Low Terraces); in the Piedmont (Kings Mountain); and in the Blue Ridge (Southern Sedimentary Ridges and the Sauratown Mountains). Most of these are fairly small ecoregions in NC.

In general, ecoregions in the Coastal Plain have watersheds containing anywhere from 20.9% to 39.4% intermittent streams based on length (Figure 3). A notable exception is the Sand Hills region with an average of 46.5% intermittent streams and the Atlantic Southern Loam Plains with an average of 96% intermittent streams. In the Sand Hills, this probably reflects the highly porous sandy soil in this ecoregion, which acts as a drain to groundwater rather than allowing surface water to accumulate in smaller valleys. The result is a higher percentage of intermittent streams in this particular ecoregion. In the South Atlantic Loam Plains, undisturbed streams were very difficult to find (Sandy Smith, Axiom Environmental, personal communication, March 18, 2019) which may have affected these results since disturbance (mostly ditching) makes is difficult to determine the undisturbed flow duration

Watersheds in the Piedmont ecoregions range from 19.7% to 24.8% intermittent streams. The Triassic Basin is an exception with intermittent streams averaging 35.3% of the stream length in this area. This probably reflects the relatively impervious soils in the Triassic Basin which severely restrict groundwater infiltration and results in lower local water tables.

Watersheds in the mountains seem to be bimodal in terms of their distribution of the percent intermittent streams. Many mountain ecoregions have percentages of intermittent streams in the single digits (ranging from 0% to 1.8%), but flatter areas (such as the Broad Basins where Asheville, Brevard, and Hendersonville are located) average 20.3% intermittent streams. The Eastern Blue Ridge Foothills ecoregion also averages 20.5%, but of the four watersheds in the sample, there were highly variable percentages of intermittent streams (respectively 2.32%, 4.95%, 33.26%, and 39.76%). This

appears to reflect a highly varied terrain in this particular ecoregion with higher percentages of intermittent streams in local watersheds of flatter relief and lower percentages in steeper terrain. The Amphibolite Mountains and New River Plateau ecoregions also average around 20% intermittent streams. One important caveat is that seeps are very common in the uppermost ends of small valleys in the mountains. These features are often delineated as small wetlands rather than streams but commonly have biota more characteristic of perennial streams such as presence of benthic macroinvertebrates (immature salamanders, larvae of stoneflies, caddisflies and mayflies). Since seeps are not normally delineated as streams, there may be additional small lengths of perennial or intermittent channels within these seeps that are not captured in the data for mountain stream length.

Overall, data for the percent of intermittent versus perennial streams account for about 93% of the land area of North Carolina based on data from these 19 Level IV ecoregions.

With respect to the average length of intermittent stream segments by Level IV ecoregion, in general the Coastal Plain (especially the Sand Hills at 1,378.3 feet and the Chesapeake-Pamlico Lowlands and Tidal Marshes at 1,940.8 feet) had the longest average lengths of intermittent streams while the steep mountainous ecoregions had the shortest average length. The Piedmont and the less steep mountains generally have intermediate average lengths of intermittent streams. The New River Plateau, part of the Blue Ridge Level III ecoregion, had an average lengths of intermittent streams with 1391.72 feet. In the Southeastern Loam Plains, the ecoregion with one of the greatest average lengths of intermittent streams was the Atlantic Southern Loam Plains, with an average of 1876.29 feet.

With respect to the percentage of streams that are first order (defined as either intermittent or perennial streams that do not have another stream draining into them), the data showed wide ranges between ecoregion with percentages ranging from 84.0% (Mid-Atlantic Flatwoods), to 52.8% (Sand Hills), to 35.4% (Slate Belt). The High Mountains ecoregion was less (16.2%) but since this represents only one watershed, it is unclear whether this is an accurate assessment of this particular ecoregion. There was no clear pattern between the Level III ecoregions as there was with the average length of intermittent streams, discussed above. Finally, Russell, et al. (2014) did not present this statistic so average stream length was not calculated for this particular ecoregion.

Table 1: Summary of local watershed data by Level IV ecoregion

Level III Ecoregion	Level IV Ecoregion	Number of Watersheds	Range of Watershed Sizes (mi2)	Average Watershed Size (mi2)	Average Number of Intermittent Origins per Watershed	Average Number of Perennial Origins per Watershed	Average % Intermittent Length per Watershed	Average % Perennial Length per Watershed	Average Length Intermittent Streams (feet)	Percent of Length of First Order Streams	Data Source	Ecoregion in VA?	Ecoregion in SC?	Notes
Middle Atlantic Coastal Plain	Carolina Flatwoods	5	1.0 - 6.1	2.9	9.4	8.8	20.9%	79.1%	665.6	46.8%	DWR 2017	No	Yes	
	Cheaspeake - Pamlico Lowlands and Tidal Marshes	11	n/a	n/a	3.18	2.27	39.4%	60.6%	1940.8	72.0%	DWQ 2006	Yes	No	Cannot determine watershed sizes due to mining disturbance in the watershed.
	Mid-Atlantic Flatwoods	41	2.91 to 339.4 acres	35.94	1	1	54.0%	46.0%	514.75	84.0%	DWR 2018	Yes	No	
	Mid-Atlantic Floodplains and Low Terraces	4	14.65 to 64.71 acres	35	2	1	40.0%	60.0%	643.91	66.0%	DWR 2018	No	Yes	
Southeastern Plains	Sand Hills	5	0.8 - 2.6	1.6	5	3.6	46.5%	53.50%	1378.3	52.8%	DWR 2017	No	Yes	
	Rolling Coastal Plain	7	2.73 to 6.32	4.0	18.3	10.6	26.6%	73.4%	665.6	47.5%	DWR 2017	Yes	No	
	Atlantic Southern Loam Plains	18	13.93 to 222.1 acres	97.77	1	0	96.0%	4.0%	1876.29	67.0%	DWR 2018	No	Yes	
Piedmont	Southern Inner Piedmont	19	7.54 to 477.39 acres	106.39	2	2	22.0%	78.0%	601.58	53.0%	DWR 2018	No	Yes	
	Southern Outer Piedmont	4	0.77 to 2.41	1.4	21.5	20.5	19.7%	80.3%	366.0	47.8%	DWR 2017	No	Yes	
	Carolina Slate Belt	5	1.2 to 6.2	2.8	16.6	13	24.8%	76.2%	644.6	35.4%	DWR 2017	Yes	Yes	
	Northern Inner Piedmont	7	0.74 to 2.88	1.8	30.4	18.1	20.0%	80.0%	367.9	36.9%	DWR 2017	Yes	No	
	Northern Outer Piedmont	6	0.65 to 2.39	1.3	14.3	9.3	19.9%	80.1%	366.0	47.1%	DWR 2017	Yes	No	
	Triassic	7	0.42 to 1.85	1.1	15	7.4	35.3%	64.7%	169.8	Unknown	Russell, et al. 2014. JAWRA	Yes	Yes	
Blue Ridge	Southern Crystalline Ridges and Mountains	2	5.0 to 10.9	7.9	18	98	1.8%	98.2%	211.7	39.1%	DWR 2017	Yes	Yes	Small number of watersheds
	Southern Metasedimentary Mountains	4	0.12 to 0.5	0.26	0.5	21.2	1.8%	98.2%	351.8	46.6%	DWR 2017	No	No	
	High Mountains	1	1.1	1.1	0	16	0%	100%	0.0	16.2%	DWR 2017	No	No	Small number of watersheds
	Broad Basins	5	0.4 to 2.5	1	13.4	13	20.3%	79.7%	554.4	46.7%	DWR 2017	No	No	
	Eastern Blue Ridge Foothills	4	1.1 to 2.8	2.1	25.5	25.8	20.5%	79.5%	576.8	49.0%	DWR 2017	No	No	Need more watersheds - two watersheds with <5% and two watersheds with > 30%. Average is misleading.
	Amphibolite Mountains	7	69.52 to 465.17 acres	245.95	2	3	18.0%	82.0%	1391.72	49.0%	DWR 2018	No	No	
	New River Plateau	11	10.98 to 89.03 acres	52.3	2	3	19.0%	81.0%	370.33	58.0%	DWR 2018	Yes	No	

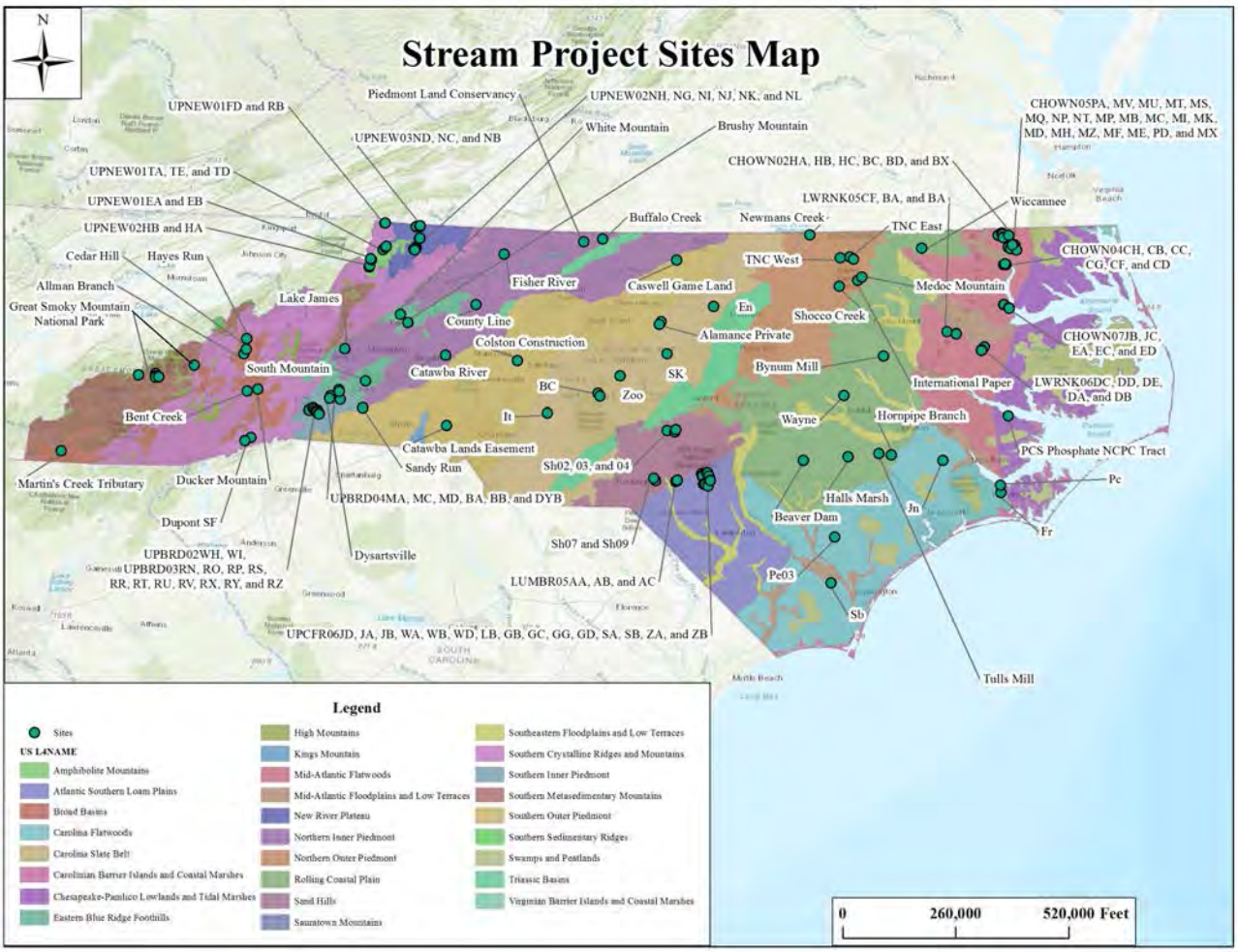


Figure 2: Watersheds studied by Level IV ecoregion in North Carolina

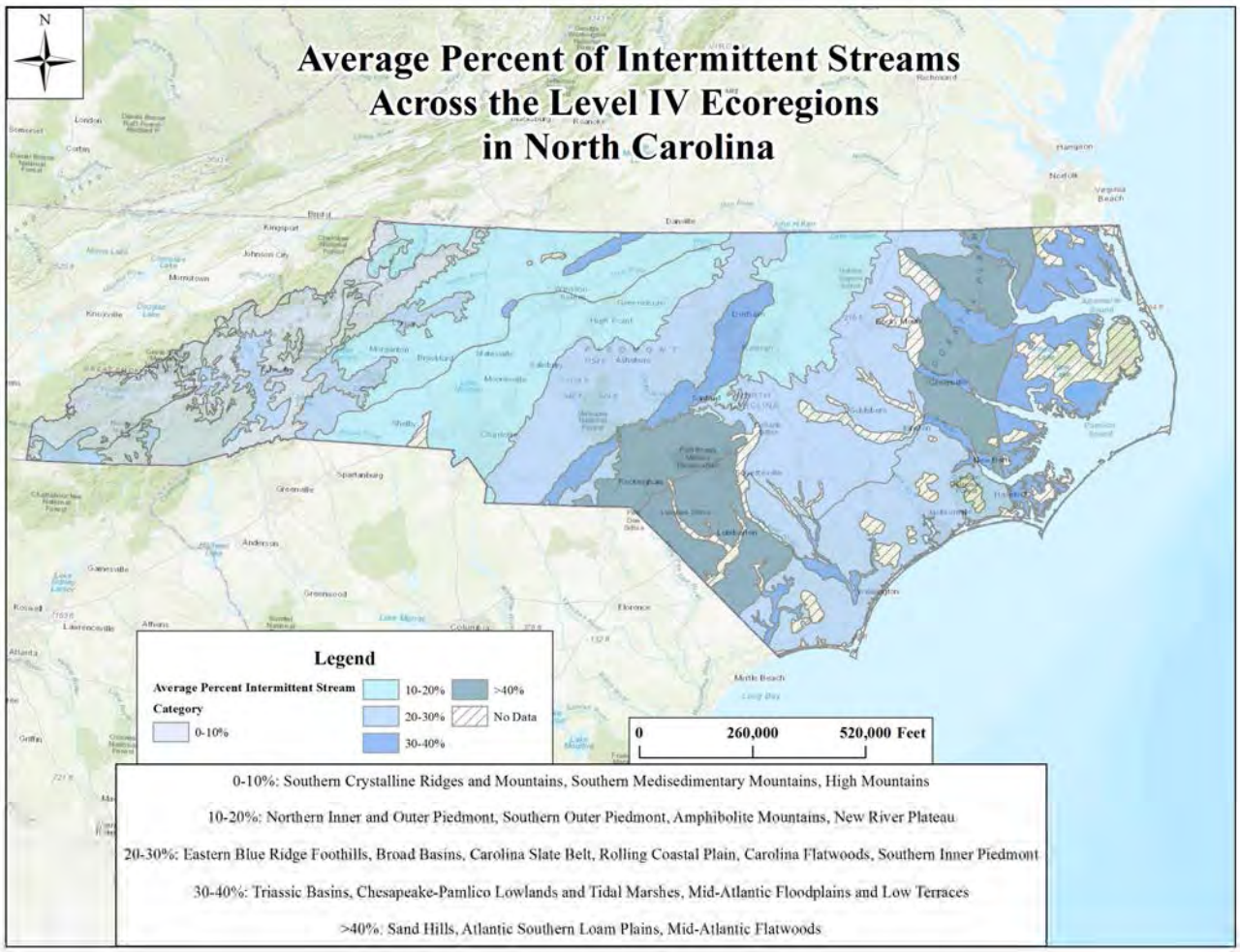


Figure 3: General Distribution of the Percent of Intermittent Stream Length by Level IV ecoregion in North Carolina

10. Extrapolation of Results to Similar Ecoregions in Virginia, South Carolina, and Georgia

Based on an initial examination of topography, soils, ecoregion descriptions, and our personal knowledge of some of the ecoregions, we believe that the percentage of intermittent and perennial streams would likely be similar across the same Level IV ecoregions among the three states (shown as "yes" in Table 1). However, to make a more definitive and quantitative conclusion, further data mining and analysis (grey literature or peer-reviewed literature) and/or field validation in these Level IV ecoregions in these three states would be required. Figure 4 shows the extrapolated average percent of intermittent streams across the Level IV ecoregions in Virginia, while Figure 5 depicts those streams in South Carolina. Finally, Figure 6 depicts those steams in Georgia. In summary, these data predict the intermittent stream percentage for 54% of Virginia, 88% of South Carolina, and 52% of Georgia.

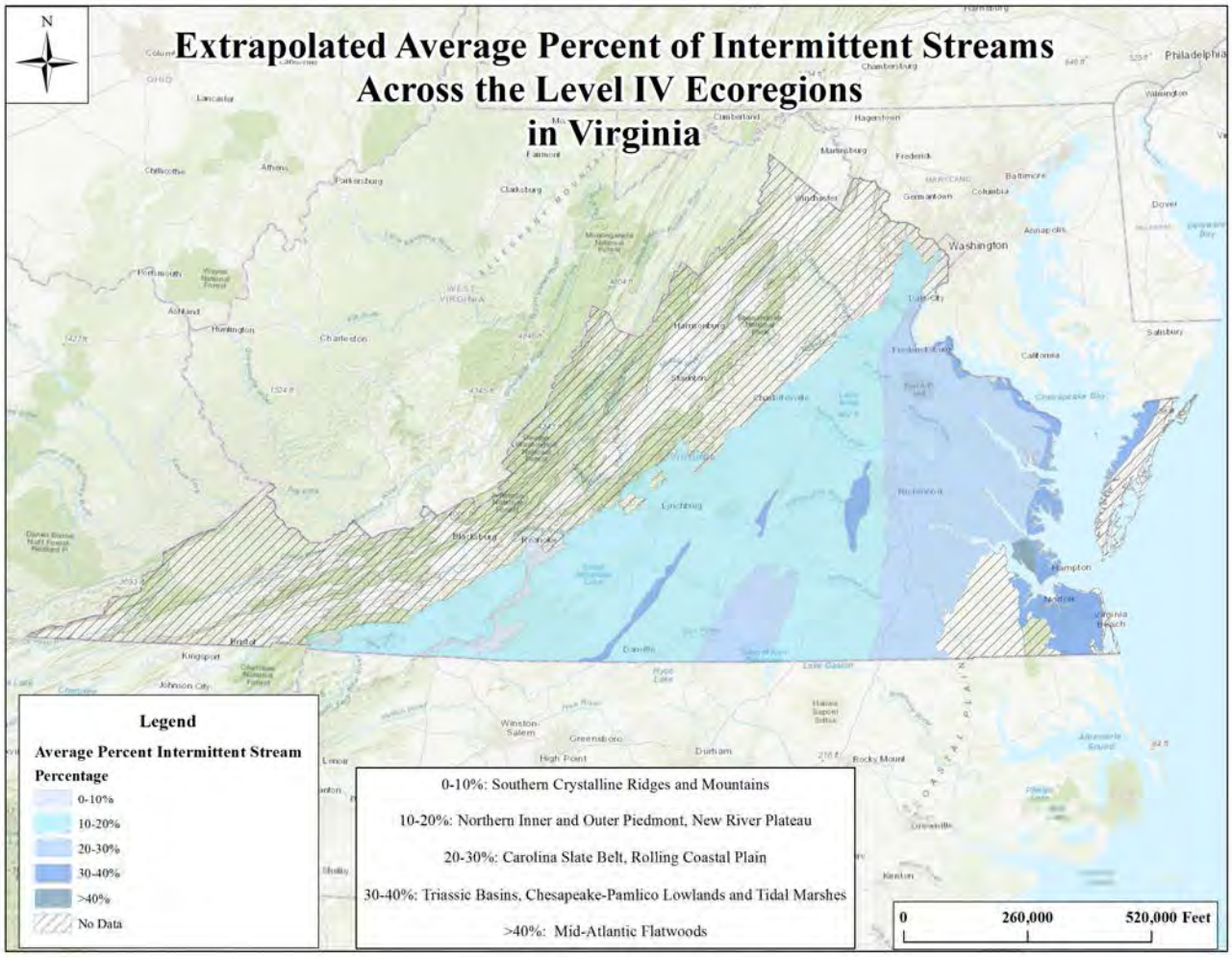


Figure 4: General Distribution of the Percent of Intermittent Stream Length by Level IV ecoregion in Virginia

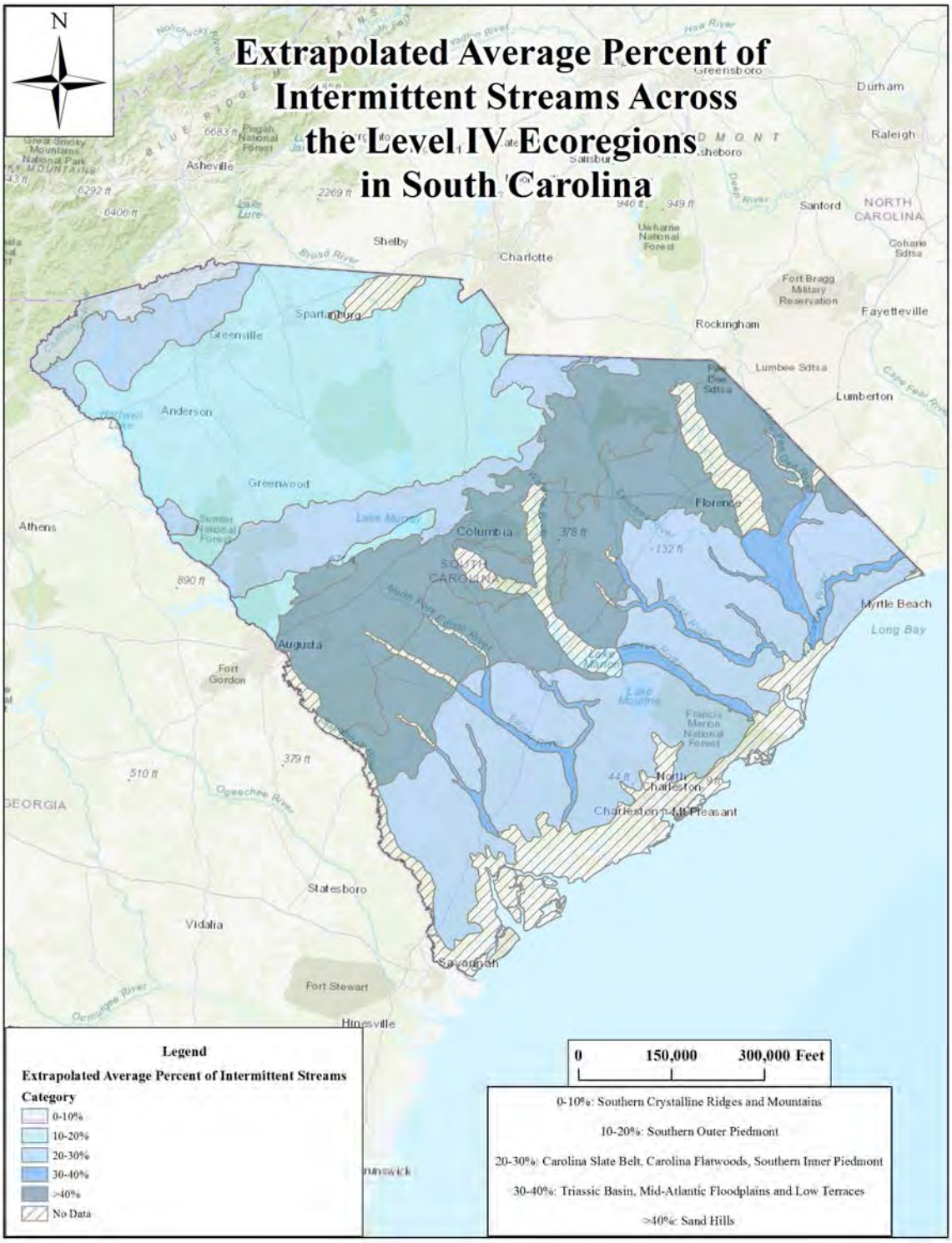


Figure 5: General Distribution of the Percent of Intermittent Stream Length by Level IV ecoregion in South Carolina

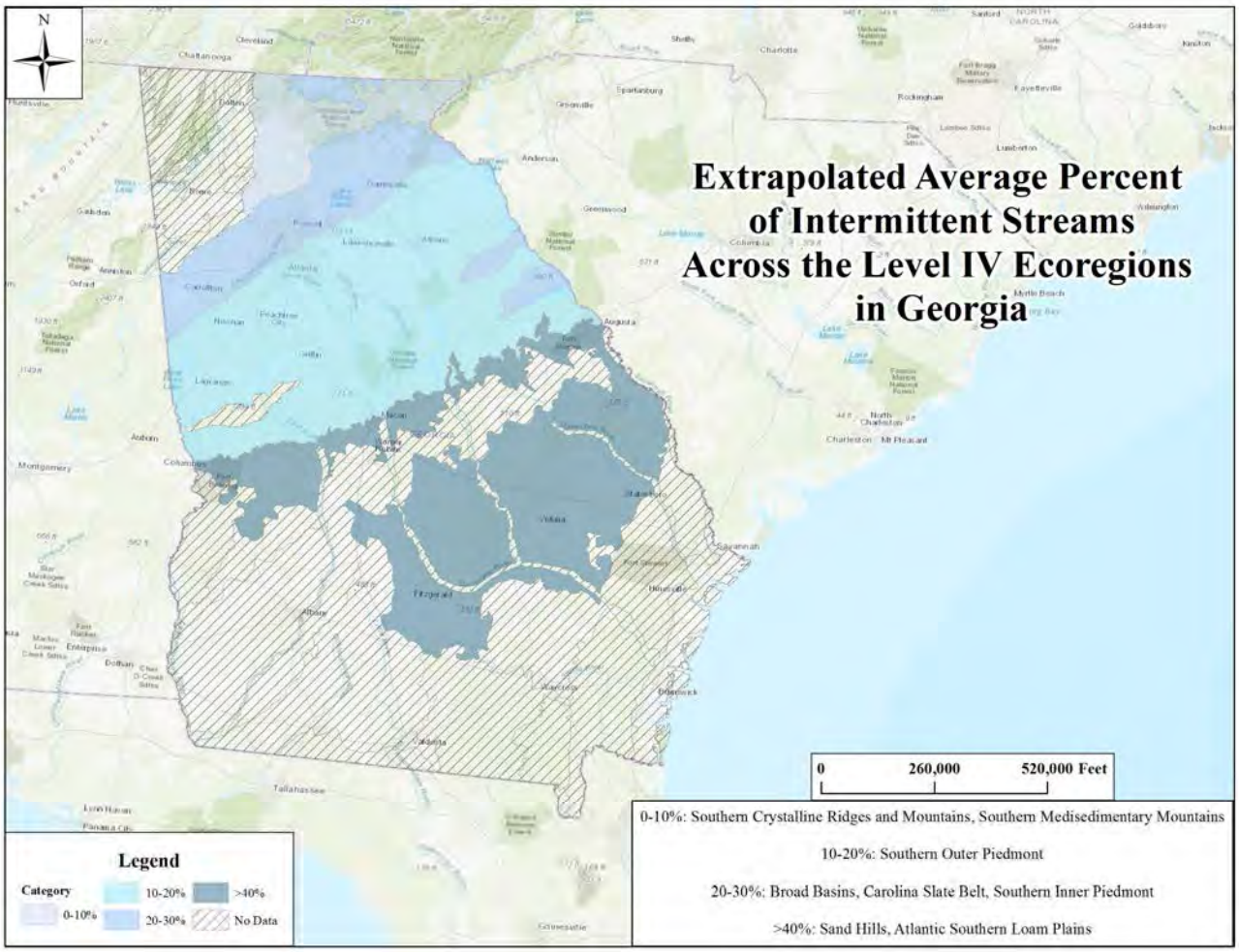


Figure 6: General Distribution of the Percent of Intermittent Stream Length by Level IV ecoregion in Georgia

11. Conclusions

This information about the extent of intermittent and perennial stream length shows that the impact of any potential change in the definition of WOTUS with respect to streams will vary across the state and by Level IV ecoregion. The implications of the change in stream jurisdiction, which could greatly affect the jurisdictional status of ephemeral and intermittent systems, appears to be greatest in the Atlantic Southern Loam Plains, Mid-Atlantic Flatwoods, Sand Hills, Chesapeake – Pamlico Lowlands and Tidal Marshes (data from the PCS Phosphate study – NC DWQ 2006), and Triassic Basin (Russell, et al. 2015) ecoregions and less in the steeper mountainous terrain. Since the NC data do not include ephemeral stream length, this estimate of the extent of streams no longer jurisdictional is a conservative estimate. Based on a weighted average of the percentage of intermittent streams by the area of each Level IV ecoregion, an approximate statewide estimate of 27% was calculated for intermittent streams statewide.

12. References/Citations

Caruso, B.S. 2014. GIS-based stream classification in a mountain watershed for jurisdictional evaluation. Journal of the American Water Resources Association 50(5):1304-1324.

Colson, T., J. Gregory, J. Dorney, and P. Russell. 2008. Topographic and soil maps do not accurately depict headwater streams. National Wetlands Newsletter 30(3):25-29.

DeBerry, D.A. and T.W. Crayosky. 2018. Qualitative Indicators for Perennial Stream Determinations in Virginia. Publication pending in "Wetland and Stream Rapid Assessments: Development, Validation, and Application. Edited by John Dorney, Rick Savage, Ralph Tiner, and Paul Adamus". Elsevier Publishing. London, England.

Federal Register. 2015. Clean Water Rule: Definition of "Waters of the U.S."; Final Rule. Federal Register 80(124): 37054-37126.

Fritz, K.M., W.R. Wenerick, and M.S. Kostich. 2013. A Validation Study of a Rapid Field-Based Rating System for Discriminating Among Flow Permanence Classes of Headwater Streams in South Carolina. Environmental Management 52(5): 1286-1298.

Fritz, K.M., E. Hagenbuch, E. D'Amico, M. Reif, P. J. Wigington Jr., S.G. Leibowitz, R.L. Commeleo, J.L. Ebersole, and T-L. Nadeau. 2013. Comparing the extent and permanence of headwater streams from two field surveys to values from hydrographic databases and maps. Journal of the American Water Resources Association 49(4):867-882.

Gallen, S.F., Webmann, K.W, Frankel, K.L. Hughes, S., Lewis, R.Q., Lyons, N, Paris, P., Ross, K., Bauer, J.B., and Witt, A.C. 2011. Hillslope response to knickpoint migration for the Southern Appalachians: implications for the evolution of post-orogenic landscapes. Earth Surface Processes and Landforms 36: 1254-1267.

Griffith, G.E., Omernick, J.M., Comstock, J.A., Schafale, M.P., McNab, W.H., Lenat, D. R., and MacPherson, T.F. 2002. Ecoregions of North Carolina. US Environmental Protection Agency. Corvallis, OR (map scale 1:1,500,000).

Kerrow, A.J., Williams, D.G., and Collazo, J.A. 2006. The North Carolina Gap Analysis Project. Final Report. Biodiversity and Spatial Information Center, North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University, Raleigh, NC. Page 21 of 788. Available at http://www.basic.ncsu.edu/ncgap/NCFinal%20Report.pdf. Accessed on November 21, 2017.

Levick, L., J. Fonseca, D. Goodrich, M. Hernandez, D. Semmens, J. Stromberg, R. Leidy, M. Scianni, D. P. Guertin, M. Tluczek, and W. Kepner. 2008. The Ecological and Hydrological Significance of Ephemeral and Intermittent Streams in the Arid and Semi-arid American Southwest. U.S. Environmental Protection Agency and USDA/ARS Southwest Watershed Research Center, EPA/600/R-08/134, ARS/233046, 116 pp. Available at https://www.epa.gov/sites/production/files/2015-03/documents/ephemeral_streams_report_final_508-kepner.pdf. Accessed on February 27, 2018.

National Land Cover Database (NLCD). 2011. NLCD 2011 Product Data Downloads. Available at: https://www.mrlc.gov/nlcd11_data.php. Accessed November 8, 2017.

N.C. Division of Water Quality. 2006. Stream Origin Assessment: South Creek, NC (PCS Phosphate Company). December 7, 2016 report. Available at https://files.nc.gov/ncdeq/Water%20Quality/Surface%20Water%20Protection/401/Policies_Guides_Manuals/StreamOriginAssessmentforSouthCreek.pdf. Accessed on January 9, 2018.

NC Division of Water Quality. 2010. Methodology for Identification of Intermittent and Perennial Streams and Their Origins. Version 4.11, September 1, 2010. Raleigh, NC. Available at http://portal.ncdenr.org/web/wq/swp/ws/401/waterresources/streamdeterminations, Accessed on January 26, 2016.

NC Division of Water Resources. 2017. Data from the NC Stream Mapping Program, provided in response to a Public Records request. Andrew Kiley and Ernest Hahn. October 25, 2017 and November 7, 2017.

N.C. Environmental Management Commission. 2007. Neuse River Basin Protection and Maintenance of Existing Riparian Buffers. 15A NCAC 02B.0233. Available at: http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2002%20-%20environmental%20management/subchapter%20b/15a%20ncac%2002b%20.0233.pdf. Accessed November 1, 2017.

RAPANOS et ux., et al. v. UNITED STATES. 2006. US Supreme Court. 547 U.S. 715. No. 04–1034.

Roy, A.H., Dybas, A.L., Fritz, K.M. and Lubbers, H.R. 2009. Urbanization affects the extent and hydrologic permanence of headwater streams in a midwestern US metropolitan area. Journal of the North American Benthological Society, 2009, 28(4):911–928.

Russell, P.P., Gale, S.M., Muñoz, B., Dorney, J. R. and Rubino, M.J. 2015. A Spatially Explicit Model for Mapping Headwater Streams. Journal of the American Water Resources Association. 51(1): 226-239.

US Army Corps of Engineers. 2005. Regulatory Guidance Letter Number 05-05. Subject: Ordinary High-Water Mark. Dated December 7, 2005. Available at http://www.nap.usace.army.mil/Portals/39/docs/regulatory/rgls/rgl05-05.pdf. Accessed on November 2, 2017.

Williams, N. B. 2005. Relationship between flow regime and aquatic macroinvertebrate abundance in headwater streams in the Piedmont Region of North Carolina. M. S. Thesis. North Carolina State University College of Natural Resources and the Department of Forestry and Environmental Resources. Raleigh, NC.

Williamson, T.N., C.T. Agouridis, C.D. Barton, J.A. Villines, and J.G. Lant. 2015. Classification of ephemeral, intermittent, and perennial steam reaches using a TOPMODEL-Based approach. Journal of the American Water Resources Association 51(6):1739-1759.

13. Appendix 1

General technical issues with the use of these data to predict the extent of jurisdictional streams and WOTUS – There are several issues to consider when comparing these data to the jurisdictional extent of streams for the 404 Permit Program of the USACE:

13.1.1. The State methodology employed in this study would not include ephemeral stream segments that have Ordinary High-Water Marks (OHWM) and are therefore jurisdictional streams for the 404 Permit Program. These ephemeral stream lengths are normally short and probably a very small percentage of the total stream length in any particular watershed. The change in 404 jurisdiction to the use of a "relatively permanent" definition would certainly exclude these ephemeral channels. Therefore, the reduction in jurisdiction predicted from the data on intermittent streams is a conservative estimate since these ephemeral channels also would no longer be regulated.

13.1.2. These stream data are gathered (with few exceptions) from rural (often dominated by agricultural land use or forested areas with active silviculture in some locations in the coastal plain) rather than urban watersheds. These watersheds were chosen by the State for data collection and model development since they are less disturbed for these Level IV ecoregions. The effect of urbanization on stream type in North Carolina and/or the Southeastern U.S. has not been documented. However, in an urban watershed in Cincinnati, Ohio ephemeral and intermittent streams were lost due to culverting of these channels as the area developed while the length of perennial streams increased due to higher base flows which probably converted some of the intermittent streams to perennial flow (Roy et al., 2009). Assuming similar changes may occur with urbanization in North Carolina, we believe that the impact of such stream changes in the context of this analysis is relatively minor since urban areas (urban, industrial and low density residential) make up only 3% of the North Carolina land use/land cover categories statewide (Kerrow, et al. 2006).

13.1.3. Results of the NC Stream Identification Method as compared to stream delineation by the USACE for 404 Permits. The USACE uses the presence of an OHWM to determine if a channel is jurisdictional for the 404 Permit program (US Army Corps of Engineers, 2005). Although the NC Stream Identification Method does not explicitly use this criterion, extensive field experience across the state has shown that intermittent and perennial streams in North Carolina always have OHWMs. Therefore, the intermittent and perennial streams identified by the NC Stream Identification Method are always jurisdictional streams for the USACE under the Section 404 Permit program under the 2005 guidance described above. In addition, there may be relatively short lengths of ephemeral streams upslope of the intermittent origin that have OHWMs that may be subject to permitting under Section 404 of the Clean Water Act. However, this assessment has relied on State stream definitions and ephemeral segments would not be included in the following analysis.

13.1.4. Mountain physiographic region – There are two technical issues relative to data on streams from the Mountain ecoregions as described below.

13.1.4.1. Seeps – Seeps are very common in the uppermost ends of small valleys in the mountains where groundwater comes to the surface. These features are often delineated

as small wetlands rather than streams but often have biota more characteristic of perennial streams such as presence of benthic macroinvertebrates (immature salamanders, larvae of stoneflies, caddis flies and mayflies). Since seeps are not normally delineated as streams, there may be additional small lengths of perennial or intermittent channels within these seeps that are not captured in the data for stream length in the mountains.

13.1.4.2. The effect of small, relict landslides – Many small valleys in the mountains still show signs of relict landslides and small slumps that occurred many decades ago when the North Carolina mountains were heavily logged; often resulting in local erosion and relict landslide deposits (Gallen, et al. 2011). Many of these localized slumps and landslides have stream flow above and below them with little or no evidence of surface flow in the buried stream segment even though flow does occur beneath these slumps and landslides. Jurisdictional determinations (by USACE or the State) usually ignore these areas. A mapping or delineation effort of finer detail might depict some of these non-stream segments.

13.1.5. Level IV ecoregions were selected as the primary sampling framework for the data collection described in this report with the assumption that these areas provide landscapes of fairly uniform characteristics which should result in consistent stream forming conditions. Indeed, through the analysis in this report, the watersheds within a particular Level IV ecoregion (except one ecoregion as described below) have similar percentages of intermittent and perennial streams which supports this assumption of uniformity. However, the Eastern Blue Ridge Foothills ecoregion is unusual because of the four watersheds that have been mapped, two have a percentage of intermittent streams less than 10% and two have a percentage of intermittent streams greater than 30% with an overall average of 20.5% After a desktop review of topography for these watersheds, this appears to reflect a rather wide diversity of topography and soils in this particular ecoregion.

13.1.6. The stream data show the origins of perennial streams based on the NC Stream Identification Method which has been calibrated using long term flow data from eight locations of long monitoring (18 months) from relatively undisturbed sites in the central piedmont of NC (Williams, 2005). Whether these locations are the start of "relatively permanent" flow in the meaning of the Scalia opinion is unclear. For this analysis, we assume that "relatively permanent" is synonymous with perennial flow.

Appendix 3: Analysis of selected large projects for analysis under the proposed WOTUS definition (February 26, 2019, Version 1.0)

A total of eight large development sites were selected by the SELC staff (Figure 1) for detailed study from a list of 35 preliminary sites in the three states prepared by Moffatt & Nichol staff (6 in NC, 16 in SC, and 13 in VA). Of the eight sites, only three sites (Table 3) could be analyzed to determine the likely extent of wetlands under the new proposed WOTUS definition since they included wetland and stream maps with the stream maps showing stream flow duration. The other five sites only had summary data from the permitting process available or maps that did not show stream flow duration. These sites are located in the mountains (Doe Branch Mine in Virginia), the Inner Coastal Plain (Global TransPark and rail spur) in North Carolina, and Outer Coastal Plain (PCS Phosphate) in North Carolina. Since maps depicting intermittent versus perennial streams were available for the two NC sites, an analysis was made of the extent of wetland jurisdiction when intermittent streams would no longer be jurisdictional. However due to the small size of the sample, it is impossible to determine if these sites are representative of these physiographic regions in the Southeast. The results of this analysis are summarized below.

6.1. Doe Branch Mine, Virginia

This project is a proposed mountain top removal coal mine in the Virginia mountains that would impact approximately 1,100 acres of land (USACE, Norfolk District, 2013). The USACE reported that 1,980 feet of perennial, 9,670 feet of intermittent, and 4,680 feet of ephemeral streams would be impacted, along with 2.42 acres of jurisdictional wetlands. A FOIA was completed and submitted to the Norfolk District to gather information to help determine which of these wetlands would be regulated under the “continuous surface connection” to “relatively permanent” waters definition. The Environmental Assessment (EA) for the project reported that there were 2.42 acres of wetlands to be impacted that were subject to 404 Permitting and an additional 5.89 acres of isolated wetlands subject to permitting only by the Virginia Department of Environmental Quality.

This analysis revealed that none of the 2.42 acres of jurisdictional wetlands would still be jurisdictional under the proposed WOTUS definition since these non-isolated wetlands are not connected by intermittent or perennial streams to downstream waters.

6.2. Global TransPark and Rail Spur, North Carolina

This site is located in Lenoir County near Kinston, in the Rolling Coastal Plain Level IV ecoregion (Griffith et al., 2002). This is a 5,775-acre site with an additional 730 acres for the associated rail spur extension project. Wetlands, streams, and ditches were delineated and approved by the USACE. Stream origins were available from the NC Division of Water Resources whose staff determined stream origins for the riparian buffer rules.

This analysis revealed that 482.86 acres of the total 1,972.21 acres of wetlands on the site would still be jurisdictional under the proposed WOTUS definition. The wetlands no longer

regulated are mostly hardwood and pine flats and are not connected by intermittent or perennial streams to downstream waters. Note that most of the wetlands associated with the rail spur are believed to still be connected by an intermittent stream to downstream waters, but no recent field verification was done to test this assumption.

6.3. PCS Phosphate, North Carolina

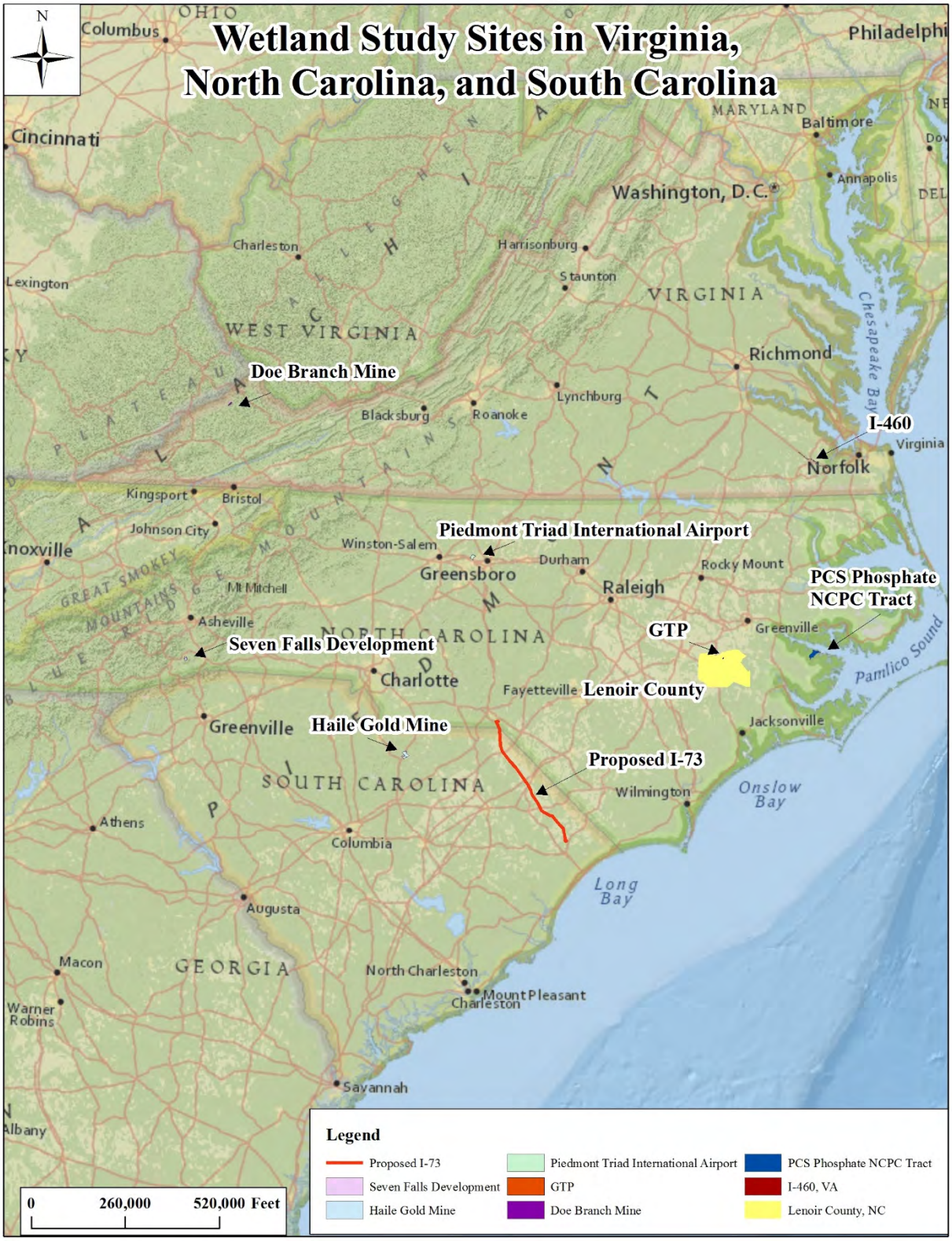
The PCS Phosphate mine is located in the Outer Coastal Plain (mostly in the Chesapeake-Pamlico Lowlands and Tidal Marshes and the Nonriverine Swamps and Peatlands, Level IV ecoregions) near Aurora. The NCPC tract is one of three large areas proposed for expansion of the mine. PCS Phosphate is a large, open pit phosphate mine that applied for an expanded mining permit with a Public Notice in 2008. This analysis focused on the NCPC tract which is bordered by the then existing mine, South Creek, and Pamlico River. The USACE confirmed the wetland and stream delineations in 2008 and this wetland analysis is based on the information contained in the final EIS (USACE, 2008). Stream lengths were derived after georeferencing the map of intermittent and perennial stream origins as prepared by consultants to PCS Phosphate and then field-verified by staff from the NC Division of Water Quality in 2006 (NC Division of Water Quality, 2006).

This analysis revealed that 2,346.57 acres of the total 2,544.74 acres of wetlands on the site would still be jurisdictional under the proposed WOTUS definition since these wetlands are connected by intermittent or perennial streams to downstream waters. Most of the no longer regulated wetlands are hardwood or pine flats with no direct connection to intermittent or perennial steams or with connections disrupted by roads with culverts (when present) only carrying ephemeral flow.

Table 3: Summary of selected large projects for analysis under the proposed WOTUS definition

Project	Wetlands under Pre-2015 Rule (acres)	Wetlands under Obama Rule (acres)	Wetlands under Proposed Rule (acres)	Wetlands Lost (percentage)
Doe Branch Mine, VA	2.42	2.42	0.00	100%
Global TransPark and Rail Spur, NC – intermittent and perennial streams jurisdictional	1972.21	1972.21	482.86	75.5%
Global TransPark and Rail Spur, NC- only perennial streams jurisdictional	1972.21	1972.21	463.24	76.5%
PCS Phosphate, NC — intermittent and perennial streams jurisdictional	2544.74	2544.74	2346.57	7.8%
PCS Phosphate, NC - only perennial streams jurisdictional	2544.74	2544.74	2246.31	11.7%

Figure 1: Selected large projects for analysis



Appendix 4: An Analysis of Federally Threatened (T) and Endangered Species (E) Presence in North Carolina Wetlands Types with Predicted Large Rates of Loss from the Proposed WOTUS Rule

Bog	Pine Savanna	Floodplain Pool	Basin Wetland	Seep	Headwater Forests
Bog Turtle (T(S/A), Green Pitcher Plant (E), Mountain Sweet Pitcher Plant (E)	Red-Cockaded Woodpecker (E), Canby's Dropwort (E), Cooley's Meadowrue (E), Golden Sedge (E)	Canby's Dropwort(E), Cooley's Meadowrue (E), Golden Sedge (E), Pondberry (E)	Canby's Dropwort(E), Pondberry	Bunched Arrowhead (E), Green Pitcher Plant €, Small-Anthered Bittercress (E)	Dwarf-Flowered Heartleaf (T), Small-Anthered Bittercress (E)

Bogs are typically the appropriate habitat for Bog Turtles *(Glyptemys muhlenbergii)* (Federally Threatened) in Western North Carolina. Bog turtles live in the mud, grass, and sphagnum moss of bogs, swamps, and marshy meadows. These wetlands are usually fed by cool springs flowing slowly over the land, creating the wet, muddy soil needed by the turtles. Throughout their range they are known to occur to nearly 4,500 feet in elevation in North Carolina. There are two major threats to its continued existence – habitat loss due to the draining and filling of wetlands for farming and development; and the illegal collection of bog turtles for the pet trade. The species is considered threatened due to similarity of appearance. The southern population in Western North Carolina has not experienced the same level of habitat loss as the northern population in New York to Maryland.

The Green Pitcher Plant *(Sarracenia oreophila)* (Federally Endangered) is found in Clay County, North Carolina, and typical habitat includes mountain bogs, seeps, as well as boggy stream side areas. The Green Pitcher Plant also can be found in some upland habitats that have been maintained by fire.

Mountain Sweet Pitcher Plant *(Sarracenia rubra ssp. Jonesii)* (Federally Endangered) is a species that is more specifically dependent upon bogs for suitable habitat. Mountain Sweet Pitcher Plant is typically limited to wetlands and is not found in upland areas. The most serious threat to mountain sweet pitcher plant is the destruction or degradation of its small wetland habitat in Western North Carolina.

Red-cockaded woodpeckers (Federally Endangered) are typically found in mature pine forests – specifically those with longleaf pines averaging from 80 to 120 years old and loblolly pines averaging 70 to 100 years old. Although many woodpeckers are usually found in more upland pine savannas, it is possible that cavity trees could be located in or near wet pine savannas. The primary threat to red-cockaded woodpeckers is loss of suitable mature pine savanna habitat.

Canby's dropwort *(Oxypolis canbyi)* (Federally Endangered) has been found in a variety of coastal plain habitats, including natural ponds dominated by pond cypress, grass-sedge dominated Carolina bays, wet pine savannas, floodplain pools, shallow pineland ponds, basin wetlands, and cypress-pine swamps or sloughs. The largest and healthiest populations have been found in open bays or ponds that are wet throughout most of the year, but which have little or no canopy cover. Soils where

Canby's dropwort are found typically are sandy loams or acidic peat mucks underlain by clay layers which, along with the slight gradient of the areas, result in the retention of water. The primary threat to Canby's dropwort is the loss or degradation of wetland habitat in which it occurs. Extensive ditching and draining of wetlands for agricultural and silvicultural purposes has altered the groundwater table in many areas of the mid-Atlantic coastal plain where Canby's dropwort historically occurred.

Cooley's meadowrue *(Thalictrum cooleyi)* (Federally Endangered) occurs on circumneutral soils in grass-sedge bogs, floodplain pools, wet pine savannahs, and savannah-like areas. It may also grow along fire plow lines, in roadside ditches, woodland clearings, and powerline rights-of-way, and needs some type of disturbance such as fire or mowing to maintain suitable habitat. Plants often found growing with Cooley's meadowrue include tulip poplar growing with bald cypress and/or Atlantic white cedar. Cooley's meadowrue is threatened by loss of habitat, ecological succession, clearing for agriculture, forestry, herbicide application to power line corridors, development and road maintenance, and construction projects.

Golden sedge (Carex lutea) (Federally Endangered) grows in floodplain pools and partially shaded savannas/swamps where occasional to frequent fires favor an herbaceous ground layer and suppressed shrub dominance. The species is found in sandy soils overlying coquina limestone deposits, where the soil pH is unusually high for this region, typically between 5.5 and 7.2. Soils supporting the species are very wet to periodically shallowly inundated. The species prefers the ecotone (narrow transition zone between two diverse ecological communities) between the pine savanna and adjacent wet hardwood or hardwood/conifer forest. In eastern North Carolina, this habitat can often include floodplain pools. At most sites, Golden sedge shares its habitat with Cooley's meadowrue (Thalictrum cooleyi), another federally endangered plant species, and with Thorne's beakrush (Rhynchospora thornei), a species of concern. The remaining populations of Golden sedge are currently threatened by habitat alteration including fire suppression, conversion of its limited habitat for residential, commercial, or industrial development, highway and utility expansion, herbicidal applications to rights-of-way, and drainage activities associated with silviculture, agriculture and development projects.

Pondberry *(Lindera melissifolia)* (Federally Endangered) is associated with wetland habitats such as bottomland and hardwoods in the interior areas, and the margins of sinks, ponds, and other depressions in the more coastal sites. Pondberry can be found in floodplain pools as well as basin wetlands in North Carolina. The plants generally grow in shaded areas but may also be found in full sun. In North Carolina, one population exists in Sampson County and one in Cumberland County. In addition, one collection was recently made in Onslow County, but plants haven't been found again since the original collection. The most significant threats are drainage ditching and subsequent conversion of its habitat to other uses. Even ditching without later conversion of land use can alter the water regime in a manner that reduces the plant's vigor or eliminates it from the site.

Bunched arrowhead *(Sagittaria fasciculata)* (Federally Endangered) is usually found in undisturbed sites that are typically located just below the origin of slow, clean, continuous seeps on gently sloping terrain in deciduous woodlands. In North Carolina, bunched arrowhead is only known to occur in

Henderson County, though it was historically known from Buncombe County as well. The primary factor determining the rarity of bunched arrowhead is the current rarity of its required habitat. The seepage habitat in which bunched arrowhead occurs is extremely threatened and remaining bunched arrowhead populations are threatened by residential and industrial development, conversion to pasture, and invasive exotic species.

Small-anthered bittercress *(Cardamine micranthera)* (Federally Endangered) is found in seepages, headwater forests, wet rock crevices, stream banks, sandbars, and wet woods along small streams, in fully to partially-shaded areas. It is known only from the Dan River basin in north-central North Carolina (Stokes County) and south-central Virginia (Patrick County). With a very limited range, and found in close association with water, the plant is threatened by stream impoundments, channelization, water contamination, as well increased stormwater runoff which can abnormally increase the volume and velocity of stream flows, eroding stream banks and beds.

Dwarf-flowered heartleaf *(Hexastylis naniflora)* (Federally Threatened) grows in acidic soils along bluffs and adjacent slopes, in boggy areas next to streams and creek heads, in headwater forests, and along the slopes of nearby hillsides and ravines. It is found in the upper piedmont region of Western North Carolina and upstate South Carolina. The greatest threat to dwarf-flowered heartleaf is conversion of habitat to agricultural, residential, commercial, and industrial uses. Habitat may also be eliminated through the construction of reservoirs, which floods habitat.

References

https://www.fws.gov/asheville/htmls/listed_species/Green_pitcher_plant.html

https://www.fws.gov/raleigh/species/es_mtn_sweet_pitcher_plant.html

https://www.fws.gov/endangered/esa-library/pdf/woodpecker.pdf

https://www.fws.gov/raleigh/species/es_canbys_dropwort.html

https://www.fws.gov/raleigh/species/es_cooleys_meadowrue.html

https://www.fws.gov/raleigh/species/es_golden_sedge.html

https://www.fws.gov/raleigh/species/es_pondberry.html

https://www.fws.gov/asheville/htmls/listed_species/Bunched_arrowhead.html

https://www.fws.gov/asheville/htmls/listed_species/Small_anthered_bittercress.html

https://www.fws.gov/raleigh/species/es_dwarf-flowered_heartleaf.html

Appendix 5: NC WAM Wetland Functions

The following descriptions of the general functions provided by wetland according to the 16 NC WAM types used in this report. This information was drawn from the NC WAM User Manual Version 5 (NC Wetland Functional Assessment Team. 2016 and. additional information was also provided by Carolina Wetlands Association available at: (http://carolinawetlands.org/index.php/other-resources/wetlands-101/types-of-wetlands/)

6.4. Salt/Brackish Marsh

6.4.1. Hydrology – Salt/Brackish marshes provide an area that can be subjected to regular or occasional flooding by tides, with some reduction of wave heights. These help to alleviate tidal flooding and protect coastal shoreline from erosional forces. These marshes also store floodwaters during storms such as hurricanes or northeasters.

6.4.1.1. Water quality – These wetlands can handle saline waters, providing a transitory zone between ocean and inlets, with roots of vegetation that help to trap sediments. Oysters commonly inhabit this wetland type and help improve water quality through their filtering capabilities. In addition, the wetland itself removes sedimentation through settling. These wetlands provide organic matter via tidal export for aquatic food chains in the adjacent estuary.

6.4.1.2. Habitat – These wetlands are made of predominantly herbaceous vegetation of varied plant species, which can inhabit a variety of animals. Growth of vegetation helps increase land elevation to alleviate flooding impacts. These wetlands also provide nursery habitat for many species of fish, crabs, shrimp and feeding grounds for tidal birds.

6.4.2. Estuarine Woody Wetland

6.4.2.1. Hydrology – Estuarine woody wetlands provide an area that can be subjected to regular or occasional flooding by tides and/or marshes, with some reduction of wave height.

6.4.2.2. Water quality – These wetlands can handle mildly saline waters, providing as escape for erratic tidal flood and saline levels from storm surges. In addition, the wetland itself removes sedimentation through settling.

6.4.2.3. Habitat – These wetlands are readily adapted to disturbance. Dominant organisms are mostly a subset of the salt/brackish marsh or adjacent uplands.

6.4.3. Tidal Freshwater Marsh

6.4.3.1. Hydrology – Tidal freshwater marshes provide an area that can be subjected to regular or occasional flooding by tides, with the majority of

the time being saturated as well by estuaries and lower reaches of streams and rivers. These wetlands also store floodwaters during storms such as hurricanes or northeasters.

6.4.3.2. Water quality – These wetlands can handle mildly saline water. The wetland itself also removes sedimentation and nutrients as well as other contaminants mainly through settling.

6.4.3.3. Habitat – These marshes support a large diversity of mostly herbaceous plant species, with many water-loving birds relying on these areas for critical habitat along with associated mammalian species.

6.4.4. Riverine Swamp Forest

6.4.4.1. Hydrology – Riverine swamp forests are characterized by seasonal to semi-permanent inundation, with overland and groundwater being important sources of water, as are over bank and tidal flooding. Beaver impact has an effect on water level; many riverine swamp forests especially in the mountains and piedmont are formed due to beaver activity. Storage of stormwater is an important function of these wetlands.

6.4.4.2. Water quality – These wetlands are important in reducing pollution from stormwater that comes from overland flow.

6.4.4.3. Habitat – These wetlands have large woody hydrophilic trees that inhabit most often like oaks, elms, ashes, etc. Present hollow trees provide space for animals like bats and swifts to inhabit as well. Nesting habitats are also provided for many bird species in these forests. Amphibians, reptiles, and fish also rely on these areas for habitat.

6.4.5. Seep

6.4.5.1. Hydrology – Groundwater is discharged to the surface on a slope, not in a geomorphic floodplain or a natural topographic crenulation, to form a seep, therefore making these wetlands semi-permanently to permanently saturated by groundwater. These do not typically have long term surface water. Seeps provide water during low flow periods to downstream waters though.

6.4.5.2. Water quality – moves water slowly on hillslopes down to the floodplain of streams. Some filtration of local stormwater runoff occurs as well.

6.4.5.3. Habitat – relatively open centers with herbaceous vegetation, may be surrounded by trees that could also shade the wetland if it is small enough. Many rare plant species exist in seeps due to their aspect and

saturation. Salamanders and other amphibians commonly inhabit this wetland type as well.

6.4.6. Hardwood Flat

6.4.6.1. Hydrology – Hardwood flats are found in poorly drained, interstream flats mostly in the Coastal Plain. These wetlands are usually seasonally saturated or intermittently to seasonally inundated by a high water table or by poor drainage. The primary source of water is a high water table from precipitation and overland runoff.

6.4.6.2. Water quality – Recharging groundwater is the main water quality-related function of wet flats. Filtration of local runoff can also occur in some flats.

6.4.6.3. Habitat – Mineral soils and vegetation is dominated by hardwood trees such as oaks, tulip poplar, sweetgum, etc. that drop their leaves in the fall providing habitat for a variety of mammals and birds.

6.4.7. Non-Riverine Swamp Forest

6.4.7.1. Hydrology – Non-riverine swamp forests occur primarily in the embayed region on poorly drained, interstream flats not contiguous with streams, rivers, or estuaries. They are seasonally to semi-permanently inundated with hydrology driven by groundwater discharge, overland runoff, and/or precipitation instead of flooding.

6.4.7.2. Water quality – These wetlands provide good water storage due to the hummocky ground present.

6.4.7.3. Habitat – These wetlands are dominated by forest vegetation like bald cypress, black gum, tulip poplar, etc. providing important habitat for amphibians as well as mammals and birds.

6.4.8. Pocosin/Carolina Bays

6.4.8.1. Hydrology – Pocosins and Carolina Bays occur primarily on poorly drained, interstream flats and other basins with peat or muck soils. These wetlands are seasonally saturated or inundated by a high or perched water table. The primary source of water is a high water table following precipitation and due to slow drainage. Occasionally these can be flooded with ground water. Pocosins and Carolina Bays provide recharge for downstream waters and help maintain low flow. They also store waters and reduce downstream flooding. Some intermittent or perennial stream origins occur at the edge of the pocosin or Bay.

6.4.8.2. Water quality – Filtration of local runoff occurs in some pocosins or Bay. Pocosins and Carolina Bays also store carbon in their organic soils.

6.4.8.3. Habitat – Dominated by waxy evergreen shrubs and woody vine vegetation makes these wetlands good provision of food for migrating birds and black bears. These wetlands also provide good wildlife habitat and protection due to their inaccessibility by people.

6.4.9. Pine Savanna

6.4.9.1. Hydrology – Pine savannas occur primarily on poorly drained, interstream flats in the Coastal Plains ecoregions. These wetlands are usually seasonally saturated by a high water table or by poor drainage. Little water surface storage due to the relatively flat ground surface is typical of these wetlands. Groundwater recharge is an important function of pine savannas.

6.4.9.2. Water quality – Filtration of local runoff can occur in some pine savannas.

6.4.9.3. Habitat – Long-leaf pine and pond pine are dominant in these wetlands with some low shrubs like wax-myrtle, creeping blueberry, etc. Typically, a more open canopy and shrub layer is present. The ground layer can be very diverse though. These wetlands are home to the Venus Fly Trap, a carnivorous plant endemic to North Carolina. Red-cockaded woodpeckers also are common due to the provision of mature pine trees where nests in cavities can occur.

6.4.10. Pine Flat

6.4.10.1. Hydrology – Pine flats occur primarily on poorly drained, interstream flats in the Coastal Plains ecoregions. These wetlands are usually seasonally saturated or intermittently to seasonally inundated by a high water table or due to poor drainage. The primary source of water is a high water table due to precipitation and overland runoff. Groundwater recharge is an important function of pine flats.

6.4.10.2. Water quality – Filtration of local runoff can occur in some flats.

6.4.10.3. Habitat – These wetlands are dominated by forest, early successional forest/shrub species, or can be found on managed pine plantations. Since this type is successional in nature, it is fairly open and has low species diversity and structural complexity. These areas provide habitat for a variety of birds and mammals mainly due to their relatively large size.

6.4.11. Basin Wetland

6.4.11.1. Hydrology – Basin wetlands are seasonally to semi-permanently inundated but may lose surface hydrology during later portions of the growing season. Sources of water are perched groundwater, groundwater discharge, overland runoff, and precipitation. These wetlands occur in

natural depressions that are surrounded by uplands or occur on the edges of small lakes/ponds. Typically, these are only wet for part of the year and experience dryness during warmer months. In addition, they can store significant amounts of stormwater and thereby reduce downstream flooding. Finally, they recharge groundwater and thereby provide low flow to nearby streams during drought periods.

6.4.11.2. Water quality – Basins provide treatment of stormwater from localized overland flow.

6.4.11.3. Habitat – Habitat of basin wetlands varies greatly from a dominant forest in mafic depressions and ephemeral pools, to primarily herbaceous or emergent vegetation in lime sinks, man-excavated depressions, and along shorelines of small open waters. These wetlands provide important breeding ground for many amphibian species like frogs and salamanders.

6.4.12. Bog

6.4.12.1. Hydrology – Bogs occur in geomorphic floodplains or natural topographic crenulations and are typically located on flat or gently sloping ground mainly in the mountains and foothills of NC. These are formed by a poorly understood combination of groundwater seepage and/or blocked overland runoff, making it at least semi-permanently saturated, but typically not inundated. When they are impacted by beaver activity, longer inundation periods can result. Release of water to adjacent streams during low flow conditions is an important function of bogs.

6.4.12.2. Water quality – Filtration of local stormwater and removal of pollutants is common as is water storage.

6.4.12.3. Habitat – Generally these wetlands are transitional in nature and may be found in a variety of forms such as supporting a closed canopy to lacking canopy trees, with sparse ground cover to dense mats of herbs and moss. These wetlands provide important habitat for rare animal and plant species like the Bog Turtle, Alder Flycatcher, Four-Toed Salamander and a variety of orchids.

6.4.13. Non-Tidal Freshwater Marsh

6.4.13.1. Hydrology – Non-tidal freshwater marshes are found in geomorphic floodplains, in natural topographic crenulations, or contiguous with open waters that are large. These wetlands are subject to semi-permanent inundation or saturation, but not typically subject to flooding by tides. Beaver activity is a common cause for the creation of these wetlands.

6.4.13.2. Water quality – These can also develop in areas of disturbance by humans and thus helps to reduce the impacts of erosion and sedimentation as

well as removal of other pollutants. Their water storage capacity can also reduce downstream flooding as well as provide water for low flow conditions in nearby streams.

6.4.13.3. Habitat – Habitat tends to be predominantly herbaceous vegetation in transition. Many species of wildlife, such as waterfowl and other birds, use this type of wetland for breeding, wintering and migrating.

6.4.14. Floodplain Pool

6.4.14.1. Hydrology – Floodplain pools are found in geomorphic floodplains. These wetlands occur due to abandoned stream or river channels, like oxbows that have been cut off, or in localized depressions near the toe of slopes. These pools are semi-permanently inundated. Sources of water are primarily groundwater, precipitation, and sometimes overbank flooding.

6.4.14.2. Water quality – Storage of floodwaters is an important function of floodplain pools as well as removal of pollutants from nearby, adjacent stormwater runoff.

6.4.14.3. Habitat – These wetlands are usually dry at some points of the year, thus providing important habitat for amphibians to breed. Vegetation typically is located on the fringe of these and lacking in the middle, being dominated by herbaceous vegetation like ferns, sedges, etc.

6.4.15. Headwater Forest

6.4.15.1. Hydrology – Headwater forests are found in geomorphic floodplains of first-order streams or smaller and in topographic crenulations without streams. Groundwater seepage and diffuse surface flow are important sources of waters. Typically, these have surface flow only due to precipitation. These wetlands have little water storage though because of the relatively flat ground surface. Headwater forests are intermittently inundated by surface water or seasonally saturated to semi-permanently saturated, thus providing flow to streams during droughts.

6.4.15.2. Water quality – Source of stormwater treatment (filtering pollutants) from overland flow that serve as natural drainage features in the landscape towards actual stream channels, most often reducing the flow of the water to downstream waters, especially in urban settings.

6.4.15.3. Habitat – These wetlands are dominated by hardwood tree and shrub species like oaks, sycamores, maples, etc. providing important habitat for many amphibian species like frogs and salamanders.

6.4.16. Bottomland Hardwood Forest

6.4.16.1. Hydrology – Bottomland hardwood forests are found in geomorphic floodplains of second-order or greater streams. Generally, these wetlands are intermittently to seasonally inundated. Overbank flooding is an important source of water as is groundwater and surface runoff. In addition, this wetland can store significant amounts of stormwater water during floods and thereby reduce downstream flooding.

6.4.16.2. Water quality – Stormwater treatment from overland flow is an important water quality function of this wetland type. These wetlands can receive sediments and nutrients from overbank flooding along brownwater streams and treat these reducing their potential harmful effects.

6.4.16.3. Habitat – Habitat within this wetland type is dominated by hardwood trees like oaks, ashes, maples, etc. providing important habitat for a variety of birds and mammals.

Appendix 6: History of Stream Dynamics in the Southeastern Piedmont (from Trimble 1974).

STANLEY W. TRIMBLE

MAN-INDUCED SOIL EROSION ON THE SOUTHERN PIEDMONT

1700–1970

ENHANCED EDITION

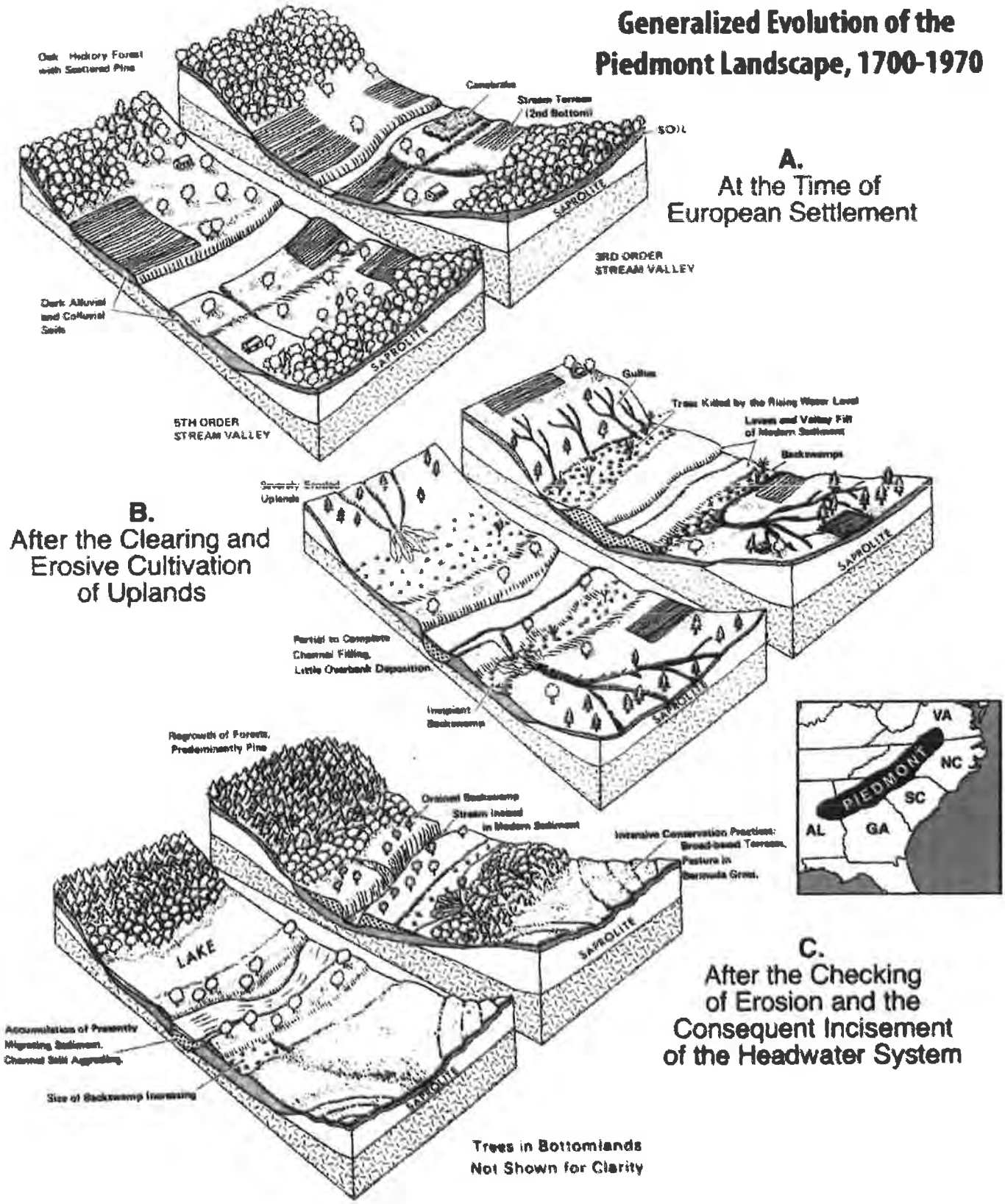
WITH A NEW FOREWORD BY ANDREW GOUDIE

SOIL AND WATER CONSERVATION SOCIETY

Soil and Water Conservation Society
Ankeny, Iowa

(c) SWCS. For Individual Use Only.

FIG. 29



(c) SWCS. For Individual Use Only.

Exhibit C

Comments on "Economic Analysis for the Proposed Revised Definition of 'Waters of the United States'" (EPA-Army 2018)

Prepared by John C. Whitehead for the Southern Environmental Law Center

April 9, 2019

Introduction

The U.S. Environmental Protection Agency and U.S. Department of the Army (EPA-Army 2015) estimated the total quantified benefits of the Clean Water Rule (CWR) to range from a low of $339 million to a high of $350 million (2014 dollars). The largest component of these benefits was due to wetland mitigation, which was estimated at $306 million (using the "original number of ORM2 other waters records" scenario). EPA-Army (2015) concluded that the benefits of the CWR exceed the costs.

In the repeal rule, EPA-Army (2017) stated that the "largest and most uncertain estimates from the[ir] 2015 CWR ... [economic analysis] are associated with the benefits of the CWA 404 program." The agencies argue that the wetland mitigation benefits are uncertain for several reasons. In response to this uncertainty the agencies choose to dismiss the monetized benefits presented in their 2015 analysis, instead presenting them as qualitative benefits in EPA-Army (2017). They justify this decision by stating that they "believe the cumulative uncertainty in this context is too large to include quantitative estimates in the main analysis for this proposed rule". In the "low end" scenario (Tables 1, p. 9) the $314 million (2016 dollars) in wetland mitigation benefits from EPA-Army (2015) are replaced by "$B". This, in effect, places a value of zero on wetland benefits as can be seen in the bottom line total in Table 1 (p. 9).[1]

The agencies have taken three different approaches to evaluate wetland mitigation benefits. In EPA-Army (2015), the agencies used only the point estimate of $306 million without sensitivity analysis around this estimate, ignoring the uncertainty. In EPA-Army (2017), the agencies again choose to avoid sensitivity analysis but this time they moved to an extreme position and avoided quantitative measurement of the benefits. In EPA-Army (2018), the agencies take a different approach than in the two previous economic analyses. That analysis adopted the most conservative, worst case scenario aggregate benefit assumption from EPA-Army (2015). The aggregate wetland benefit point estimate is $59.4. This aggregate benefit estimate is biased downward, significantly underestimating wetland benefits.

The aggregate wetland benefit is the product of willingness to pay per wetland acre and the

[1] EPA-Army refers to the CWA 404 wetland benefits as "foregone benefits" in the 2017 and 2018 economic analyses. Benefits set forth in the CWR (EPA 2015) are referred to as costs in EPA-Army (2017, 2018) and costs set forth in CWR (EPA 2015) are referred to as benefits in EPA-Army (2017, 2018). Throughout these comments I will refer to the CWA 404 wetland benefits without the "foregone" modifier to avoid confusion.

number of households who enjoy this benefit. There is one clear reason for the downward bias in the aggregate wetland benefit estimate as EPA-Army moves from the (2015) study to the (2018) study. This is the overly conservative definition of the "geographic extent of the market" (i.e., the number of households who enjoy the wetland benefit per acre). In this context, "conservative" means that the analysis errs on the side of underestimating wetland benefits. Specifically, the agencies limit benefit estimates by state boundaries—ignoring wetland benefits to households in neighboring states, the region, or nation. The economic literature demonstrates that wetland benefits are not limited by political boundaries.

It is less clear why the willingness to pay per wetland acre is lower relative to the 2015 CWR analysis, which is a significant flaw in the 2018 analysis. Several assumptions made by EPA-Army (2018) may be conservative, driving aggregate benefits down still further. Considering the uncertainty in both the estimates of the willingness to pay per acre and the number of households the appropriate approach requires a relaxation of the conservative assumptions and development of a range of benefit estimates and the completion of formal sensitivity analysis.

<u>EPA-Army (2018) relies on an inappropriately defined geographic extent of the market</u>

Smith (1993) was the first to emphasize that the "geographic extent of the market", in other words the aggregation rule, can be a more important consideration than research that fine tunes willingness to pay estimates. The aggregation rule for any given analysis is simply the method used to determine which households benefit from wetland protection and therefore should be considered in the willingness-to-pay analysis. The aggregation rule in EPA-Army (2015) was to adopt a "blended approach" between state and regional level aggregation. This blended approach is still a superior point estimate for the CWA 404 wetland benefits, as explained below. EPA-Army (2018) inappropriately restricts attention to the state-level aggregation. Standard benefit-cost analysis under uncertainty would consider the range of benefit estimates between the state level and the regional level approaches to be an appropriate approach. I will turn to the appropriate treatment of uncertainty in the last section of these comments.

EPA-Army (2018) (pp. 62-65) argues that since the primary valuation studies take a state-level approach then it is inappropriate to expand the value estimates beyond state borders. For example, consider a mean willingness to pay per acre estimate for state j, WTP_j. In this case, when aggregating willingness to pay estimates the "geographic extent of the market" is limited to the political jurisdiction by assumption. If B is the aggregate wetland benefit, then $B_j = \sum_{i=1}^{n_j} WTP_{ij} \times A_j$, where n_j is the household population of state j and A_j is the wetland acreage of state j. This aggregation rule, by assumption, constrains the aggregate wetland benefit estimate. This constraint on wetland benefits results in a downward bias because willingness to pay for wetlands spills across state lines. In their 2018 economics analysis, EPA-Army has reversed their decision from 2015 and no longer consider the value of benefits to residents of households outside the borders of the state where a wetland is located.

The critical flaw in that analysis is that willingness to pay for natural resources is not constrained

by political jurisdictions. There is evidence that wetland benefits spill across state lines. This evidence is embodied in the "distance-decay" contingent valuation literature. Conceptually, the distance-decay relationship is $WTP = \alpha + \beta D$, where D is distance and α, β are parameters to be estimated. The "distance-decay" relationship is found when the parameter on distance is estimated to be negative. Willingness to pay declines as the individual or household lives further from the natural resource site. The economic jurisdiction, in contrast to the political jurisdiction, is determined from this data-driven model and not by assumption. The estimated distance over which willingness to pay should be aggregated is found by solving for the distance that drives willingness to pay to zero, $\widehat{D} = -\alpha/\beta$. With this definition of the geographic extent of the market aggregate, wetland benefits in state j are $B_j = \sum_{i=1}^{n_{\widehat{D}k}} WTP_i \times A_j$, where $n_{\widehat{D}k}$ is the population with positive willingness to pay for wetlands in state j. This aggregation rule considers all households who would benefit.

There is economic theory to support the empirical distance-decay relationship for use values and passive use values.[2] In terms of use values, Whitehead (1994, 1995a) uses the fact that the implicit price of recreational use of the resource is a function of distance (and resource quality). In the Whitehead (1994) paper, I work out the theoretical relationship between willingness to pay for a quality improvement and the implicit price of recreation. The theory shows that there should be a negative relation between willingness to pay and the implicit price of recreation, and the parameter on price provides a measure of the additional recreation trips that would be taken with the improvement in resource quality. Whitehead (1995b) shows how this relationship can be used to differentiate between use and passive use values. Huang, Haab, and Whitehead (1997) show that this relationship in the contingent valuation data is consistent with the recreation data.

Considering passive use values, Whitehead and Blomquist (1991a) develop a model that suggests a pathway from observable behavior to the formation of passive use value. The logic begins with the well-known negative relationship between site-specific outdoor recreation and distance to the site. Recreation and other past observable behaviors is a necessary condition for information about the natural resource. Then logically, information about the natural resource is a necessary condition for valid passive use values. Whitehead and Blomquist (1991a) find empirical evidence for this theory with the Whitehead and Blomquist (1991b) wetland benefit data used in EPA-Army (2018).

The distance-decay relationships described above, $WTP = \alpha + \beta D$, is a reduced-form model of these more theoretical relationships between distance and willingness to pay. The reduced form distance-decay model is better adapted to determination of the geographic extent of the market. Consideration of the distance-decay model leads to a significantly more accurate method of estimating aggregate wetland benefits relative to the political jurisdiction constrained approach

[2] The total economic value of a natural resource is the sum of use value and passive use value. Use value results from the on-site experience of a natural resource. Passive use value results from the enjoyment obtained from a natural resource while off-site. See Smith (1987).

adopted by EPA-Army (2018).

There is much evidence in the empirical contingent valuation literature that the aggregate benefits of natural resources will be biased downwards if willingness to pay is aggregated over political jurisdictions, as in EPA-Army (2018). Sutherland and Walsh (1985) and Silberman, Gerlowski and Williams (1992) were the first to demonstrate the empirical distance-decay effect. Loomis (1996) was the first to show how this relationship could affect aggregation of benefits for policy analysis. Loomis (1996) conducts Washington state-wide and national contingent valuation surveys for the value of removing two dams on the Elwha River. The empirical model suggests that willingness to pay falls by $0.01 for each mile the survey respondent is removed from the river. The mean willingness to pay is $78 in Washington State. Using the distance-decay empirical model the willingness to pay is $58 two thousand miles away. Loomis (1996) estimates that 97% of the total benefits are out-of-state.

Of the wetland valuation studies used in EPA-Army (2018), the Loomis et al. (1991) data exhibits a distance-decay effect as demonstrated by Pate and Loomis (1997). The authors present a willingness to pay function for their wetland improvement scenario of $WTP = 372 - 33 \times \ln(D)$. With this functional form, willingness to pay falls by $150 for the first 100 miles away from the wetland area but the remaining distance-decay is relatively flat, falling by $100 from 100 to 2000 miles away. Loomis (2000) shows that limiting aggregation to the state population would underestimate benefits by 82%.

This brief review of the literature suggests that the state level aggregation rule used by EPA-Army (2018) leads to an underestimate of the aggregate benefits.[3] The state level aggregation rule is, at best, a lower bound on the aggregate benefits. Presentation of the lower bound as the preferred aggregate benefit point estimate is inappropriate and cannot serve as the basis for a proper benefit-cost analysis.

Willingness to pay per acre estimates

Benefit transfer is defined as the use of a benefit estimate developed from a study site at a policy site for which no benefit estimate is available. A study site is the location where benefits have been estimated. A policy site is the location where a benefit estimate is needed for a benefit-cost analysis. No primary benefit study has been conducted at the policy site

There are two types of benefit transfers, both of which are used in EPA-Army (2018), though without adequate information provided to fully understand the willingness to pay per acre estimate used in the benefit-cost analysis. A unit value transfer involves the use of a willingness to pay estimate with little ability to adjust it for local conditions.[4] In contrast, a benefit function

[3] See Johnston et al. (2017) for reference to other more recent studies that investigate the distance-decay link.

[4] Note that it is possible to adjust for differences in income from the study site to the policy site with assumptions about the income elasticity of willingness to pay.

transfer is possible when the benefit estimate at the study site is a function of site and study characteristics. When the benefit estimate is transferred to the policy site, differences in the site and study characteristics can be accounted for. EPA-Army (2018) employs unit value transfer and a meta-analysis benefit function transfer.

Unit value transfer

EPA-Army (2018) describes a unit value transfer analysis but is overly cautious when interpreting the benefit transfer literature. EPA-Army (2018) asserts that a unit value transfer analysis cannot be conducted if there are significant differences in the study site and policy site. That has been shown to be incorrect. Whitehead, Morgan and Huth (2015), in the context of benefit transfer with the contingent valuation method, point out that this restrictive condition is rarely met in real world policy analysis and assess the level of error that might be experienced if benefit transfer is conducted in a less than ideal situation.

In an empirical application, Whitehead, Morgan and Huth (2015) find that unit value and benefit function value estimates across states are not statistically different, indicating the potential for valid benefit transfer. The average benefit transfer error across each of the comparison methods is 25% which is lower than most of the transfer error estimates from the contingent valuation benefit transfer studies in the literature. Kaul et al. (2013) find that the mean transfer error is 36% with a range of 20% to 125%.

The unit value transfer exercise completed by EPA-Army (2018) assigns $0 value to states that are more dissimilar than states with existing wetland benefit estimates (Table III-4). This approach is not appropriate unless the agencies believe that the value of wetlands is equal to $0 in those states. An appropriate approach would be to transfer wetland benefits to states without estimates using the best available estimate. In other words, EPA-Army (2018) should fill in the blanks in the "Unit Value Transfer Foregone Benefits" column in Table III-9 with the necessary caveats. Estimates of transfer errors from the literature could be applied in a sensitivity analysis.

Meta-analysis function transfer

Meta-analysis function transfer may be preferred to unit value transfer. Differences in study sites and study characteristics can be incorporated in a valuation model and used to develop estimates for different sites and situations. EPA-Army (2018) relies on a literature review and a meta-analysis regression model (Moeltner et al., 2018) to conduct their national level aggregate benefit analysis. The literature review describes a different set of primary benefit studies relative to that used by EPA-Army (2015).[5] The effect of the use of a different set of primary benefit studies on the willingness to pay per acre estimate is not made clear in EPA-Army (2018).

Moeltner et al. (2018) describe in detail how the meta-analysis function can be used to assign per

[5] The studies are described in a December 10, 2018 memo from Besedin and Moeltner to the EPA.

acre wetland values in a case study. In contrast, EPA-Army (2018) provides relatively little detail about the decisions made when predicting willingness to pay per acre values (pp. 73-74). The aggregate benefit estimate in EPA-Army (2018) is $59.4 million with a 95% confidence interval of $238 thousand and $122 million. The point estimate is a 38% reduction from the comparable $96.5 million unit value transfer estimate described in Table 1 below. There is no explanation given for why the meta-analysis function transfer estimate is so much lower than the estimate adjusted from EPA-Army (2015), other than the potential effect of a different set of primary studies (but, as stated above, this is not made clear).

EPA-Army (2018) uses the same meta-analysis model as in Moeltner et al. (2018) but does not provide enough detail to assess the differences in the predicted willingness to pay per acre estimates. This raises six questions, the answers to which are needed to understand the willingness to pay per acre estimates that lead to the $59.4 million wetland benefit estimate in EPA-Army (2018):

[1] Moeltner et al. (2018) describe how to estimate the mean benefit estimate from the meta-analysis regression when the natural log of willingness to pay is the dependent variable. In general, the median willingness to pay is the exponential of the natural log: $\widetilde{WTP} = exp(lnWTP)$. The mean willingness to pay is $\overline{WTP} = exp(lnWTP + 0.5\sigma^2)$, where σ^2 is the variance of $lnWTP$. Moeltner et al. (2018) describe how to predict the mean with "error effects" and empirically shows that the median willingness to pay estimate is significantly lower than the mean willingness to pay. While Table III-9 describes "mean WTP" in the headings it is not clear if the inclusion of the second term in the parenthetical of the mean *WTP* equation has been included in the calculation. The question for the agencies is: Is the mean WTP or median WTP estimate used in the meta-analysis function transfer analysis? If the median is used then the aggregate wetland benefit estimate is biased downward since the mean willingness to pay is more appropriate for benefit-cost analysis. This is because the median is the willingness to pay where one-half of respondents are willing to pay less and the other half are willing to pay more. Conceptually, it is the amount that would generate a 50% vote in favor of a policy referendum. If the willingness to pay distribution is skewed right, the mean will be greater than the median. If the median is aggregated over the population it will be lower than the mean aggregated over the population. The mean willingness to pay aggregated over the population is the total benefit, which is the appropriate measure of willingness to pay required for benefit-cost analysis.

[2] Moeltner et al. (2018) set the lump sum variable equal to zero in order to simulate annual benefits. This variable differentiates the studies that use a one-time (i.e., lump sum) payment versus an annual payment in the contingent valuation scenarios. The mean parameter on the lump sum variable is positive, as predicted by theory (i.e., respondents will pay more if they are asked to pay a certain amount of money one time relative to being asked to pay the same amount annually). How do the Agencies handle the lump sum variable? My suggestion would be to set lump sum equal to zero as in Moeltner et al. (2018) to simulate annual payments.

[3] Moeltner et al. (2018) give equal weight to the voluntary and coercive (e.g., an income tax)

payment vehicles. This decision downwardly biases the willingness to pay per acre estimates, which would result in an underestimate of aggregate benefits if this assumption is adopted by EPA-Army (2018). Carson and Groves (2006) show that a coercive payment vehicle is one which contributes to the consequentiality of the contingent valuation scenarios. Consequential surveys more accurately measure true benefits because respondents have an incentive to answer a contingent valuation question truthfully if their responses might affect policy. There is a small empirical literature assessing how consequentiality affects benefit estimates (Vossler and Watson 2013, Groothuis et al. 2017). The early evidence suggests respondents who feel the survey is inconsequential report downwardly biased (and invalid) willingness to pay estimates. For the purposes of mimicking a consequential survey and producing a more valid wetland benefit estimate the voluntary variable should be set equal to zero. It is not clear how the Agencies handled this variable in the EPA-Army (2018) analysis.

[4] Moeltner et al. (2018) report separates estimates for all four combinations of local and forested wetlands (i.e., local/forested, local/non-forested, non-local/forested and non-local/non-forested. The EPA-Army (2018) reports one willingness to pay per acre estimate without discussion. How do the agencies handle the local and forested variables? Note that the mean parameter on the local variable is positive, providing some evidence of the distance-decay relationship described above. One way to simulate the distance-decay effect is to set the local variable equal to one for the state-level willingness to pay estimates and zero for the regional willingness to pay estimates.

[5] The meta-analysis function includes variables for three wetland functions equal to one if the function is captured in the primary study and zero otherwise: cultural ("nonextractive recreation"), provisioning ("fishing, hunting") and regulating ("water filtration, flood control"). The Moeltner et al. (2018) model includes estimated parameters which allow a description of the monetary contribution of these functions relative to the willingness to pay baseline. The provisioning function has a relatively large negative parameter, the regulating function has a relatively large positive parameter and the cultural function has a relatively small negative parameter. When conducting the benefit transfer, setting the provisioning and cultural function variables to one would lower willingness to pay. Setting the regulating function variable to one would have a positive effect on willingness to pay.

Moeltner et al. (2018) estimate willingness to pay per acre that only include cultural values by setting the cultural variable equal to one. Do the agencies follow Moeltner et al. (2018) and set the cultural variable equal to one? How are the provisioning and regulating variables handled? These decisions should be explained in order to better communicate the types of willingness to pay values being transferred. Since the Moeltner et al. (2018) approach is only an example, it should not be followed for the current analysis. The input variables should be tailored to fit the characteristics of the wetlands at the state level as closely as possible. For example, if a percentage of a state's wetlands support the wetland function then that percentage could be used as the input variable (e.g., 0.45 instead of zero or 1). In the absence of this sort of information, using the means of these variables would be preferred with sensitivity analysis to determine the

impact of these decisions.

[6] Moeltner et al. (2018) set the study year variable (lnyear) equal to the "log of (2018-1988). This simulates the willingness to pay estimated in a 2018 study. Since the mean parameter on study year is positive, any simulation of a study year earlier than 2018 will result in a lower willingness to pay per acre estimate. How does the EPA-Army (2018) handle the study year variable?

Since the aggregate wetland benefit estimate is significantly lower than previous estimates, the role of each of these features of the meta-analysis model should be clearly explained and documentation provided for public review.

Inadequate Treatment of Uncertainty

Uncertainty is inherent in any economic analysis. Statistical uncertainty is captured in confidence intervals that result from the statistical properties of the central tendency of a benefit estimate (i.e., variance around the mean). Another type of uncertainty results from assumptions made during the analysis. The EPA-Army (2018) addresses the former but not the latter.

Statistical uncertainty

The agencies account for statistical uncertainty by developing confidence intervals for the lower bound state-level willingness to pay estimates (based on the meta-analysis) and these are presented in Table III-9 (pp. 78-79). The aggregate benefit estimate is $59.4 million with a 95% confidence interval of $238 thousand and $122 million.

While the statistical uncertainty is presented, it is not utilized in the analysis. For example, consider a comparison with the CWA 404 category cost estimates. The range of potential annual avoided costs in the CWA 404 category in the baseline scenario is $86 million to $206 million presented in Table 1 of EPA-Army (2017, p. 10). Considering these two numbers as standards (without confidence intervals), the aggregate benefit estimate is not statistically different from the lower cost estimate at the p=.05 level. The aggregate benefit estimate is statistically different from the high cost estimate at the p=.05 level. Since the 95% threshold is an arbitrary standard, especially considering its use in policy analysis, the agencies should develop estimates of the probabilities (p-values) at which the estimated benefits are less than the costs to assess the statistical uncertainty.

Uncertainty and assumptions

The major assumption made by the EPA-Army (2018) is that the state political jurisdiction is the appropriate geographic extent of the market. This assumption results in a conservative aggregation rule, i.e. one that excludes households that would benefit.

Farrow (2013), in his article "How (not to) lie with benefit cost analysis" suggests that "Act(ing)

as if a number is certain" is "lie #4." EPA-Army (2018) presents their aggregation rule as the most defensible and does not formally consider others in their analysis. This is inappropriate considering the uncertainty about their state-level aggregation assumption given the evidence from the distance-decay literature. Farrow suggests that reviewers:

> *Ask "Does there seem to be a false level of precision in this analysis?" and "Are we told whether the results change if reasonable changes are made to the analysis?"*

The answers to these questions for EPA-Army (2018) are "yes" and "no," respectively. Considering Farrow (2013), the appropriate method for presenting aggregate benefits is with a sensitivity analysis considering how benefits change if reasonable changes are made. For example, a reasonable change considering the distance-decay literature is to re-consider the regional aggregation rule used in EPA-Army (2015). For simplicity, suppose that the upper bound of the aggregate benefit estimate is the regional aggregate benefit estimate from EPA-Army (2015) (using the "original number of ORM2 other waters records" scenario) since this number can be easily calculated. This upper bound number is not presented in EPA-Army (2015) but the state level aggregation number is reported in EPA-Army (2018) on page 67 (rounded to three significant digits). The state-level benefit estimate and the blended state-regional estimate allows calculation of an upper bound regional benefit estimate. The blended approach is described by the EPA-Army (2015, p. 50) as:

> *Instead, on a region by region basis, EPA has taken a blended approach, using the simple average of the WTP applied at the regional level and the weighted average WTP applied at the state level for the states in that region, and applied this blended WTP to the acreage estimated for that region.*

Assuming that this approach is roughly the midpoint between the state and regional estimates allows an estimate of the regional aggregate benefit estimate to be developed as $Regional\ Benefit = 2 \times Blended\ Benefit - State\ Benefit$. The state, blended, and regional wetland benefit estimates using the 2015 study assumptions of a 50-year time horizon and a different willingness to pay per-acre are presented in Table 1.[6]

[6] The calculations are described in EPA-Army (2018) but not in EPA-Army (2015).

Table 1. Annual Wetland Benefits			
	Aggregation Rule ($millions)		
Study	State	"Blended"	Regional
2015	107	306	505
2018	96.5	276	456

The regional aggregate wetland benefit estimate of $505 million is not inconsistent with the Loomis (2000) result that over 82% of the wetland benefits are enjoyed by out of state residents in the Loomis et al. (1991) study. In other words, if only a state level estimate were available, assuming that 18% of the total benefits accrued at the state level and the regional benefits are the total, the regional benefits would be: $Regional\ benefit = State\ benefit/(1 - .82)$. Applying this benefit transfer logic to the 2015 state level benefit estimate of $107 million in Table 1, the regional benefit would equal $594 million.

Consider the second row of benefits in Table 1. EPA-Army (2018) employs a more conservative approach to estimating willingness to pay per acre, using (a) a different set of wetland benefit studies and (b) a 20 year time horizon instead of a 50 year time horizon to develop a present value of the stream of annual benefits (which is then annualized). The changes in part (a) may be justified as the excluded studies appear to be less valid than the remaining studies (Moeltner et al. 2018). But the effect on willingness to pay per acre of this change is not made explicit. The change in (b) requires even further justification by the Agencies. A 20 year time horizon will yield lower present values than a 50 year horizon and it is not clear why this change was made. These two changes combined yield a state-level aggregation rule annual wetland benefit estimate of $96.5 million which is slightly more than 90% of the estimate from the 2015 study. Scaling the "blended" and regional estimates down by the same factor yields a benefits range of $96.5 million to $456 million with a midpoint of $276 million.

Sensitivity analysis

EPA-Army (2015) recognizes the overly conservative position taken in the state-level aggregation assumption. Considering the state-level aggregation rule (pp. 49-50):

> *Benefits from wetland losses now being compensated for via compensatory mitigation may also be assumed to accrue at the state level. This approach assumes that only residents within a state's boundaries receive benefits from wetland losses offset within that state. This calculation for benefits may be overly conservative as wetlands can provide services and benefits to downstream waters beyond a state's boundaries, but it serves as a useful point of comparison.*

I agree with the assessment that the state-level aggregation rule is "overly conservative". EPA-Army (2018) also agrees that the state-level approach is "overly conservative" (p. 67) and yet still presents the estimates from the state-level aggregation rule as their preferred point estimate of aggregate wetland benefits: $96.5, as set forth in Table 1. This is not defensible given the

tools of sensitivity analysis available for benefit-cost analysis (Boardman et al. 2017, Farrow 2018).

Considering the regional approach, EPA-Army (2015) states (p. 49):

> *However, aggregating benefits using the wetland region requires ascribing benefits over a large geographic area and there are not data available to allow for examination of the effect distance from the resource being valued has on* [household willingness to pay] *for wetlands.*

EPA-Army (2018) states (p. 67):

> *"... the regional approach is inappropriate for a benefit transfer exercise because the extent of the market considered in the majority of the original studies was narrower (e.g., state population).*

The approach taken in EPA-Army (2018) is not a defensible position given the estimates of distance-decay parameters that are available in the economic literature (e.g., Pate and Loomis 1997 for the wetlands data used in Loomis et al. 1991). The logic of using the distance-decay parameter from the literature as a validity check on the regional benefit estimate is similar to the logic of using benefit estimates in a benefit transfer exercise. When the time and money resources are not available to conduct the appropriate distance-decay study then the necessary components of the analysis can be borrowed "off-the-shelf" to assess the potential impact of the assumption of the state-level aggregation rule.

Considering the wide range of aggregate benefit estimates over the state and regional aggregation rules, EPA-Army (2015) states (p. 50):

> *There are no clear boundaries determining to whom benefits should accrue. Though both approaches are described above as appropriate, estimating mitigation benefits using both and presenting the results as a range would introduce more variation to the analysis than is warranted.*

I disagree with this statement. When there is significant uncertainty in an estimate in benefit-cost analysis, in this case the aggregation rule, a range of estimates from the lowest defensible amount to the highest defensible amount is exactly what should be presented. Formal textbook sensitivity analysis is available to better understand the comparison of benefits and costs.[7]

If the distribution of benefits across the range is assumed to be uniform, with each dollar value equally likely, then a best/worst case analysis should be conducted. In a best/worst case analysis two net benefit estimates are calculated. In the worst case scenario (described as such supposing the policy, e.g., the CWR, is pursued) the lowest benefit estimate is compared to the highest cost

[7] See Chapter 11 of Boardman et al. (2017).

estimate. In the best case scenario, the highest benefit estimate is compared to the lowest cost estimate. These two net benefit ($Net\ benefit = benefit - cost$)) estimates give two extreme pictures of the potential outcomes. If the best case scenario generates negative net benefits then the policy should not be pursued. If the worst case scenario generates positive net benefits then the policy should be pursued. If the best and worst case net benefit estimates disagree, in other words if the best case scenario has positive net benefits and the worst case scenario has negative net benefits, then the decision-maker must consider the magnitude of the difference and the degree of societal risk-aversion when making the policy decision.

It is the role of the analyst to present the range of uncertainties in benefit-cost estimates to the decision maker. In effect, EPA-Army (2018) is solely conducting a worst case scenario analysis by comparing what may be the most conservative willingness to pay per acre estimates aggregated over the smallest number of households (i.e., the state-level aggregation rule) which they acknowledge is too conservative (EPA-Army 2015, pp. 49-50 quoted above). The conduct of a worst case analysis, in isolation, is inappropriate in a benefit-cost analysis under uncertainty.

If each dollar value across the range is not equally likely then best/worst case analysis is less appropriate. This conclusion is implicit in the statements made by EPA-Army (2015, 2018) quoted above. According to the EPA-Army (2015, 2018) it is defensible to assume that the state-level aggregation rule yields downward biased wetland benefits and the regional-level aggregation rule yields upward biased aggregate benefits.

The agencies in EPA-Army (2018) should address the uncertainty embodied in these ranges of estimates using standard, textbook methods. Once a benefit-cost analyst has developed a reasonable and defensible range of estimates, there are a number of methods available to consider how to assess the impact of the range of uncertainty. If the midpoint of the range, or other measure of central tendency (e.g., the "blended" benefit estimate from EPA-Army 2015), is considered most likely then the distribution could be assumed to be normal with standard deviation equal to the range divided by 6 (by the empirical rule) or a triangular distribution could be assumed with the minimum and maximum equal to the upper and lower bounds of benefits. Both of these distributions put little to no weight on the likelihood of the extreme values affecting the analysis. Similar assumptions could be applied to the range of cost estimates. With these statistical distributions Monte Carlo simulation should be employed by EPA-Army to determine the mean net benefit, error bands and the probability that the net benefit over the simulated statistical distributions is positive or negative.

Other issues

There are three other issues that deserve mention. These are the Federalism scenarios, unquantified benefits and the case studies.

Federalism Scenarios

EPA-Army (2018) develops "Federalism" scenarios in which they predict the state response to regulatory rollback. This is an interesting analysis but not appropriate for this benefit-cost analysis. First, there is no empirical evidence provided that this sort of state response will be forthcoming. On the other hand, there is historical evidence that the state response will be weaker than the Federal response for a variety of reasons (e.g., see Stanton and Whitehead, 1994). There is nothing in the EPA Guidelines for Economic Analysis (NCEE 2014) that suggests that this analysis is appropriate.

The Federalism scenario analysis is a highly speculative and not a defensible component of this economic analysis. If there is precedent for this sort of Federalism analysis in Federal benefit-cost analysis then it should be cited. If not, the Federalism scenarios should be discarded.

Unquantified Benefits

The benefits of four policy categories (CWA 301 Compliance, CWA 401 Administration, CWA 402 Pesticide General Permit Implementation and CWA 404 Mitigation – Streams) are unquantified and replaced with the $B placeholder. This, in effect, places a value of zero on these benefits. Instead of this treatment of unquantified benefits, there should be a separate breakeven analysis for this component of the benefit-cost analysis. A breakeven analysis projects the unquantified benefits from zero to the point at which the net benefits are zero. In this simple case, the breakeven benefits are equal to the costs. The Agencies should then present analysis considering the probabilities that these benefits will be greater than or less than the breakeven point. Without this analysis, the naïve policy maker will look to the bottom line estimates of benefits and costs and assume that the unquantified benefits are equal to zero. In the current compilation of benefits and costs, this will bias the decision towards less protection of wetlands.

Case Studies

The case studies rely on the willingness to pay estimates from Blomquist and Whitehead (1998). This study produces a conservative willingness to pay estimate for two reasons. First, it uses a voluntary contribution payment vehicle which is conservative for theoretical reasons (Carson and Groves 2007). Brouwer et al. (1999) estimates that an income tax payment vehicle generates larger willingness to pay estimates in a wetlands meta-analysis. This result could be applied to the benefit estimates in the case studies to improve accuracy.

Second, Blomquist and Whitehead (1998) use the median willingness to pay which, as described above, is lower than the mean willingness to pay estimate and biases downward aggregate benefits. In my own re-analysis of these data, the mean willingness to pay is $15.25 while the median is $4.69. The mean willingness to pay estimate is (at least) 3.25 times larger than the

published median willingness to pay estimates.[8] In other words, using the median willingness to pay from Blomquist and Whitehead (1998) instead of the mean willingness to pay biases the aggregate benefits downward by a substantial amount. The mean is the most conceptually appropriate measure of willingness to pay for use in benefit-cost analysis.

In order to develop annual estimates of wetland benefits, the agencies use the annual willingness to pay estimates and aggregate these for each of 20 years considering the potential population growth. The present value is then annualized using the formula presented in the EPA guidelines for economic analysis (NCEE 2014). It is not clear why a time horizon of only 20 years is chosen. The EPA-Army (2018) reports that EPA-Army (2015) used a time horizon of 50 years. A 20 year time horizon will generate lower willingness to pay estimates than a 50 year time horizon. This is another potential area that sensitivity analysis is needed as both of these decisions may be defensible.

Increasing future benefits by increasing population is appropriate in the case studies. It would also be appropriate in the Phase I national analysis. This does not appear to have been done. This is another potential area that sensitivity analysis is needed as the constant population assumption is likely too conservative.

Conclusion

The agencies have used a number of inappropriate approaches that tend to understate the potential benefits of wetland protection. The agencies adopt an aggregation rule that understates the number of households over which to sum the household willingness to pay per acre estimate. The aggregation rule presented in EPA-Army (2018) is overly conservative (as acknowledged by the authors of the report). In effect, EPA-Army (2018) is calculating the lowest possible wetland benefits by aggregating willingness to pay per acre over the smallest number of households (i.e., the state-level aggregation rule). There is one clear reason for the downward bias in the aggregate wetland benefit estimate as EPA-Army moves from the (2015) study to the (2018) study. This is the conservative definition of the "geographic extent of the market." A brief review of the distance-decay literature shows that contingent valuation studies that limit benefit transfer to state boundaries significantly underestimates the benefits.

There are potentially other reasons for why the aggregate benefit estimate is too conservative (i.e., low), primarily considering the implementation of the meta-analysis transfer function. There are a number of unexplained elements of the current analysis that could change the

[8] I am using only the more conservative dichotomous, relative to polychotomous, choice data ($n = 222$) in Blomquist and Whitehead (1998). The mean willingness to pay estimate is derived using the nonparametric Turnbull estimator which is a lower bound, conservative estimate of mean willingness to pay. Note that the Blomquist and Whitehead (1998) article was written as a test of the validity of the contingent valuation method and not for use in a benefit-cost analysis. The mean willingness to pay from the re-analysis of these data is more appropriate for benefit-cost analysis.

calculation of the household willingness to pay per acre. Too few details are provided to allow an adequate assessment of the methods used to arrive at the willingness to pay per acre estimate. As presented, the willingness to pay per acre analysis conducted by the EPA-Army (2018) is a black box that may be biasing the aggregate benefit estimate downward.

Whereas the EPA-Army (2017) report threw up its hands and implicitly assigned a zero value to aggregate benefit estimates in the face of uncertainty, the correct approach in benefit-cost analysis is to account for ALL uncertainties in the appropriate manner (Boardman et al. 2017, Farrow 2018). It is the role of the analyst to present the range of uncertainties in benefit and cost estimates to the decision maker. The appropriate incorporation of all uncertainties will likely lead to a very wide range of potential aggregate wetland benefits of the 2015 CWR (and equally wide ranges of reversing that rule). Considering the wide range of possible aggregate benefit estimates and the amount of statistical uncertainty, it may be difficult to develop a benefit-cost analysis that has clear recommendations for the decision maker. But, without a primary benefit estimation study designed for the 2015 CWR, the EPA-Army (2018) report with inclusion of the recommendations in these comments is likely to be the best that the tools of benefit-cost analysis can do. In other words, a good benefit-cost analysis does not necessarily produce a clear answer to a complicated policy question.

References

Boardman, Anthony E., David H. Greenberg, Aidan R. Vining, and David L. Weimer. Cost-benefit analysis: concepts and practice. Cambridge University Press, 5th edition, 2017.

Brouwer, Roy, Ian H. Langford, Ian J. Bateman, and R. Kerry Turner. "A meta-analysis of wetland contingent valuation studies." Regional Environmental Change 1, no. 1 (1999): 47-57.

Carson, Richard T., and Theodore Groves. "Incentive and informational properties of preference questions." Environmental and Resource Economics 37, no. 1 (2007): 181-210.

Farrow, Scott. "How (not) to lie with benefit-cost analysis." The Economists' Voice 10, no. 1 (2013): 45-50.

Farrow, Scott. "Simulation: Incorporating Uncertainty," Chapter 19 in Teaching Benefit-Cost Analysis: Tools of the Trade, edited by Scott Farrow, Edward Elgar Publishing, 2018.

Groothuis, Peter A., Tanga M. Mohr, John C. Whitehead, and Kristan Cockerill. "Endogenous Consequentiality in Stated Preference Referendum Data: The Influence of the Randomly Assigned Tax Amount." Land Economics 93, no. 2 (2017): 258-268.

Huang, Ju-Chin, Timothy C. Haab, and John C. Whitehead. "Willingness to pay for quality improvements: should revealed and stated preference data be combined?" Journal of environmental economics and management 34, no. 3 (1997): 240-255.

Johnston, Robert J., Kevin J. Boyle, Wiktor Adamowicz, Jeff Bennett, Roy Brouwer, Trudy Ann Cameron, W. Michael Hanemann et al. "Contemporary guidance for stated preference studies." Journal of the Association of Environmental and Resource Economists 4, no. 2 (2017): 319-405.

Kaul, Sapna, Kevin J. Boyle, Nicolai V. Kuminoff, Christopher F. Parmeter, and Jaren C. Pope. "What can we learn from benefit transfer errors? Evidence from 20 years of research on convergent validity." Journal of Environmental Economics and Management 66, no. 1 (2013): 90-104.

Loomis, John B. "Vertically summing public good demand curves: an empirical comparison of economic versus political jurisdictions." Land Economics (2000): 312-321.

Loomis, John B. "How large is the extent of the market for public goods: evidence from a nationwide contingent valuation survey." Applied economics 28, no. 7 (1996): 779-782.

National Center for Environmental Economics, Office of Policy, U.S. Environmental Protection Agency, "Guidelines for Preparing Economic Analyses," December 17, 2010 (updated May 2014).

Pate, Jennifer, and John Loomis. "The effect of distance on willingness to pay values: a case study of wetlands and salmon in California." Ecological economics 20, no. 3 (1997): 199-207.

Silberman, Jonathan, Daniel A. Gerlowski, and Nancy A. Williams. "Estimating existence value for users and nonusers of New Jersey beaches." Land Economics (1992): 225-236.

Sutherland, Ronald J., and Richard G. Walsh. "Effect of distance on the preservation value of water quality." Land Economics 61, no. 3 (1985): 281-291.

Smith, V. Kerry. "Nonuse values in benefit cost analysis." Southern Economic Journal (1987): 19-26.

Smith, V. Kerry. "Nonmarket valuation of environmental resources: an interpretive appraisal." Land Economics (1993): 1-26.

Stanton, Timothy J., and John C. Whitehead. "Special interests and comparative state policy: an analysis of environmental quality expenditures." Eastern Economic Journal 20, no. 4 (1994): 441-452.

U.S. Environmental Protection Agency and U.S. Department of the Army, "Economic Analysis of the EPA-Army Clean Water Rule," May 20, 2015.

U.S. Environmental Protection Agency and U.S. Department of the Army, "Economic Analysis for the Proposed Definition of 'Waters of the United States' – Recodification of Pre-existing Rules, June 2017.

U.S. Environmental Protection Agency and U.S. Department of the Army, "Economic Analysis for the Proposed Revised Definition of 'Waters of the United States'", December 14, 2018.

Vossler, Christian A., and Sharon B. Watson. "Understanding the consequences of consequentiality: Testing the validity of stated preferences in the field." Journal of Economic Behavior & Organization 86 (2013): 137-147.

Whitehead, John C., and Glenn C. Blomquist. "A link between behavior, information, and existence value." Leisure Sciences 13, no. 2 (1991a): 97-109.

Whitehead, John C., and Glenn C. Blomquist. "Measuring contingent values for wetlands: effects of information about related environmental goods." Water resources research 27, no. 10 (1991b): 2523-2531.

Whitehead, John C., Thomas J. Hoban, and William B. Clifford. "Specification bias in contingent valuation from omission of relative price variables." Southern Economic Journal (1994): 995-1009.

Whitehead, John C. "Willingness to pay for quality improvements: comparative statics and interpretation of contingent valuation results." Land economics (1995a): 207-215.

Whitehead, John C. "Differentiating use and non-use values with the properties of the variation function." Applied Economics Letters 2, no. 10 (1995b): 388-390.

Whitehead, John C., O. Ashton Morgan and William L. Huth, "Benefit Transfers with the Contingent Valuation Method," Chapter 9 in Johnston, Robert J., John Rolfe, Randall S. Rosenberger, and Roy Brouwer, eds.. Benefit Transfer of Environmental and Resource Values. Vol. 14. Springer, 2015.

Biography

Dr. John C. Whitehead is a professor in the Department of Economics at Appalachian State University. He received his BA in economics from Centre College and PhD in economics from the University of Kentucky. His teaching includes courses in environmental and natural resource economics, benefit-cost analysis, microeconomics and business statistics. Dr. Whitehead's research includes nonmarket valuation, primarily in the context of recreation, water quality and sports. He has published over 100 peer reviewed articles and book chapters and co-edited two books. He is an associate editor at Marine Resource Economics and successfully completed one-term as an associate editor at the Journal of Environmental Management. He is currently on the editorial council of the Journal of the Association of Environmental and Resource Economists. He is a member of the Socioeconomic Panel (SEP) of the Statistics and Scientific Committee (SSC) of South Atlantic Fishery Management Council. He has served on review panels for the USEPA, NMFS, NSF and Sea Grant. Previously he served on the Board of Directors of the Association of Environmental and Resources Economists and as president of the Socioeconomics Section of the American Fisheries Society. He is a member of the American Economic Association, Association of Environmental and Resource Economists, North American Association of Fisheries Economists, North American Association of Sports Economists and the Southern Economic Association. He was presented with the 2007 Research Award from the Walker College of Business and the 2008 Distinguished Economist Award by the Kentucky Economic Association.

Exhibit D

Final Review of the 2018 EPA Economic Analysis for the Proposed Revised Definition of "Waters of the United States"

PREPARED FOR
Southern Environmental Law Center

PREPARED BY
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April 11, 2019

Executive Summary

In December 2018, the EPA and the Army published an Economic Analysis for the Proposed Revised Definition of "Waters of the United States" (hereafter referred to as the "December 2018 EA"). The proposed, revised definition to WOTUS evaluated in the December 2018 EA was formally proposed in 2019 and is referred to as the 2019 Rule, hereafter. The December 2018 EA takes a two-stage approach to evaluating the annual avoided costs and foregone benefits of implementing the 2019 Rule. Breaking the analysis into two stages rather than evaluating the proposed rule change as a single action has implications for the results, as do several subjective yet critical parameter choices, especially the baseline acreage.

Stage 1 of the December 2018 EA uses the May 2015 EA as a baseline to estimate the annual foregone benefits and avoided costs of rescinding the 2015 Rule, thereby returning to the pre-2015 WOTUS definition. For CWA 404 provisions, Stage 1 also includes documentation of a meta-analysis for evaluating annual foregone benefits of rescinding the 2015 Rule. The meta-analysis estimates household (HH) willingness to pay (WTP) for preserving a given number of wetland acres. These estimates are then translated into state-level WTP per HH per wetland acre.

Stage 2 of the December 2018 EA estimates the annual avoided costs and foregone benefits of implementing the proposed 2019 Rule after the 2015 Rule has been rescinded. In other words, Stage 2 estimates the annual avoided costs and foregone benefits of the proposed 2019 Rule with the pre-2015 Rule as the baseline. Stage 2 conducts several watershed-level case studies, but ultimately uses the results from the Stage 1 meta-analysis to estimate the annual avoided costs and foregone benefits at the national level.

This two-stage approach I call "rescind-and-replace." It is clear the proposed 2019 Rule is meant to be the final and immediate regulatory outcome. In other words, the proposed 2019 Rule is meant to replace the 2015 Rule, not to revert back to the pre-2015 Rule WOTUS definition for some unspecified but meaningful period of time before implementing the proposed 2019 Rule. As such, breaking the analysis into two separate stages is inappropriate.

Both stages of the December 2018 EA examine 4 scenarios related to the extent the protections reduced under the proposed 2019 Rule are replaced by equivalent state-level protections: Scenario 0, 1, 2, and 3. Scenario 0 assumes no states adopt standards more protective than the proposed 2019 Rule; the subsequent scenarios increase the number of states adopting new protections in light of the proposed rule.

The meta-analysis has several important issues of concern. First and foremost, despite extensive attempts to do so, the results presented in Table III-9 (p. 77) and Table F-5 (p.285) could not be replicated using the mean variable values and model coefficient estimates presented in Table III-6 (p. 72), Table III-7 (p. 73), and Table III-8 (p. 74). This should be a straight-forward exercise. The lack of replicability raises the possibility that the December 2018 EA is missing important information. The agencies need to demonstrate how Tables III-6, -7, and -8 are used to generate Table III-9 and Table F-5.

A second concern relates to the data. One of the most important factors in the analysis is the change in the number of wetland acres that would be affected by the various Rule changes. The Stage 2 analysis uses permitting activity from 2011 through 2015 to estimate the number of affected acres. As such, it is likely to have under-estimated the number of acres impacted by moving from the pre-2015 Rule to the 2019 Rule. This is because, in addition to actual permit

applications, the permitting and mitigation costs may have deterred some wetland conversion activity, activity that may arise under the proposed 2019 Rule. While the Stage 2 analysis likely under-estimates the number of affected acres, the December 2018 EA does not explain how the affected acres in the Stage 1 analysis (moving from the 2015 Rule to the pre-2015 Rule) were established. This is a critical parameter for their analysis, the estimation of which needs to be explained and justified. As with the Stage 2 analysis, if the number of affected acres is based on previous permitting activity, then it is likely to generate an under-estimate.

Another data concern related to acres has to do with the baseline acres. To apply the results of the meta-analysis to each state, the December 2018 EA says it assumes the baseline acres of wetlands for each state is 10,000 acres (p. 73), although it appears the real assumption is 40,000 acres. Either way, every state does not have the same number of baseline wetland acres. This is evident from Table A-1 of the appendix. The December 2018 EA argues that the National Wetland Inventory (NWI) is not a regulatory database. While that may be true, it does shed some light on how wetland acres vary across the states, and how likely 40,000 acres is to be an appropriate baseline. The average number of NWI wetland acres reported in Table A-1 is 2.4 million, with a minimum of 57,000 and a maximum of 12.2 million. The baseline acreage is an exceptionally influential parameter in the meta-analysis' estimation of foregone benefits – an increase in baseline acreage results in larger foregone benefits. If the December 2018 EA were conducted exactly the same as presented in that document but the baseline acres were set to 220,000 instead of 40,000 for Stage 1, the annual foregone benefits would increase from $59.4 million to $204.8 million for Scenario 0, from $16.7 million to $74.9 million for Scenario 1, from $14.3 million to $64.6 million for Scenario 2, and from $1.2 million to $5.1 million for Scenario 3. For Stage 2 the annual foregone benefits would increase from $135.6 million to

$567.9 million for Scenario 0, from $46.8 million to $200.3 million for Scenario 1, from $41.7 million to $179.4 million for Scenario 2, and from $6.9 million to $24.7 million for Scenario 3. Using a low level of baseline acres systematically under-estimates the annual foregone benefits of both rescinding the 2015 Rule and implementing the proposed 2019 Rule. Coupling the single regulatory action issue discussed above with the baseline acreage issue compounds the under-estimation of annual foregone benefits.

A separate data concern has to do with the CPI-U values used to inflate dollar values from earlier years to 2017-dollar levels. The CPI-U values employed for the meta-analysis are lower than the values reported by the Census Bureau. This leads to a systematic under-estimate of WTP/HH, and annual foregone benefits of the Rule changes in both Stage 1 and Stage 2.

A third concern relates to the selection and robustness of the econometric model used in the meta-analysis. Wetland functions are divided into four general categories: regulating, supporting, provisioning, and cultural. The econometric model includes three of these functions, but not the "supporting" function. Omission of this variable would likely bias the results. Why the supporting function was not included in the model needs to be explained and justified. The counter-intuitive signs and lack of statistical significance for several of the model coefficients brings the model results further into question. The potential effects of these issues can be seen in the exceptionally wide range for the state-level 95% confidence intervals of annual foregone benefits presented in Table III-9 (p. 78) and Table F-5 (p. 285).

A fourth concern is the scope of the meta-analysis. On page 69, the report states, "Wetland benefits are, in general, a more local commodity." This may be true for some of the functions wetlands serve, but for other functions the value of a wetland may have significant geographic

scope. For example, the Prairie Pothole Region (PPR) of the northern plains serves as an important breeding ground for migratory game birds. Duck hunters in Pennsylvania, thousands of miles from the PPR derive direct benefits from those wetlands (see, for example, Kinnell et al., 2002). Ironically, North Dakota, in the heart of the PPR, is projected to lose the most wetland acres of any state in the nation if the 2015 Rule is rescinded. Yet the agencies explicitly assume the benefits of wetland preservation in a given state are restricted to residents of that state; households outside of that state are assumed to have WTP/HH = 0. This leads to further systematic under-estimation of foregone benefits. If, rather than assuming foregone benefits are restricted to residents of a given state, the residents of neighboring states are also assumed to value the benefits in that given state – an assumption employed earlier in the December 2018 EA – the Stage 1 conclusions of Scenario 0 (p. 222), and Scenarios 1, 2, and 3 (pp. 81-83) as well as the Stage 2 conclusions of Scenarios 0, 1, 2, and 3 (pp. 207-208) are all undermined. Specifically, the Stage 1 CWA 404 foregone benefits in Scenario 0 increase from $59.4 million to $216.6 million; from $16.7 million to $90.4 million for Scenario 1; from $14.3 million to $56 million in Scenario 2; and from $1.2 million to $11.8 million in Scenario 3. The Stage 2 CW 404 foregone benefits in Scenario 0 increase from $135.4 million to $419.5 million; from $46.8 million to $233.9 million for Scenario 1; from $41.7 million to $193.4 million in Scenario 2; and from $6.9 million to $74.3 million in Scenario 3. (Also note that Pennsylvania is not adjacent to North Dakota.)

In summary, the meta-analysis and subsequent calculations used to estimate foregone benefits in both Stage 1 and Stage 2 of the December 2018 EA suffer from systematic under-estimation of the benefits, lack of transparency in the determination of the number of affected acres (Stage 1 only) and the calculation of state-level benefits, a highly consequential and dubious assumption

related to baseline acres, insufficient scope of benefits, and demonstrable evidence of the model's lack of precision. In addition, the two-stage approach employed by the December 2018 EA leads to lower annual foregone benefits than a single stage approach would. A two-stage approach would only be appropriate if the proposed 2019 Rule actually constitutes a "rescind-and-replace" action that results in the pre-2015 WOTUS definition being in effect for a significant period of time. The agencies need to explain the extent to which the proposed 2019 Rule will result in the pre-2015 WOTUS definition being in effect and justify why the two-stage is appropriate in that circumstance.

1. Overview of the December 2018 EA, Stage 1 Analysis

The December 2018 EA evaluates a 2-stage process that one could call "rescind-and-replace." Stage 1 estimates the annual avoided costs and foregone benefits of rescinding the 2015 Rule thereby returning to the pre-2015 Rule (hereafter referred to as rescinding the 2015 Rule). Stage 2 estimates the annual avoided costs and foregone benefits of moving from the pre-2015 Rule to the proposed 2019 Rule. This section focuses on the Stage 1 analysis.

One of the fundamental differences between the June 2017 EA and the December 2018 EA is the development of a set of scenarios for examining state-level responses to the Rule changes. The Army and EPA argue in the December 2018 EA that even though some waters will no longer be regulated under the CWA as "waters of the United States" with either the pre-2015 Rule or the 2019 Rule, the change in the WOTUS definition will not affect the definition of "waters of the State" for many states. In fact, some states currently have more stringent regulatory requirements related to waters of the State than the 2015 Rule. Other states, however, have specific language that automatically adopts the prevailing WOTUS definition for waters of the State. As a result, the change in the definition of WOTUS will have different regulatory implications in different states.

Four categories of state-level response related to dredge/fill activities and three categories related to surface water discharges are created. These categories are then used to develop state-level response scenarios to evaluate the annual avoided costs and foregone benefits of the 2017 Rule.

1.1 Lack of Replicability

<u>Main Conclusions:</u> Despite extensive attempts to do so, the results presented in Table III-9 (p. 77) could not be replicated using the mean variable values and model coefficient estimates

presented in Table III-6 (p. 72), Table III-7 (p. 73), and Table III-8 (p. 74). This should be a straight-forward exercise. The lack of replicability raises the possibility that the December 2018 EA is missing important information. It is incumbent upon the agencies to explicitly detail how the coefficient estimates from the meta-analysis are used to generate the results of Table III-9.

Detailed Discussion: Section III.C.2.2.3.2 of the December 2018 EA presents a new meta-analysis for estimating the foregone benefits of rescinding the 2015 Rule. A meta-analysis is, in effect, a "study of studies"; it uses the results of prior empirical research (called "primary studies") to identify over-arching results from the empirical literature. As with all econometric studies, the meta-analysis estimated a specific mathematical relationship between a "dependent variable" and a set of "explanatory variables." The dependent variable in the meta-analysis was WTP/household/year estimated by a given primary study, and the explanatory variables were defining characteristics of that study. Specific variables included in the analysis are shown in Table III-6 (p. 72) of the December 2018 EA and reprinted in Table 1.1 below.

The general form of the model presented in the December 2018 EA is shown as Equation (1)

$$(1)\ y_s = X_s\beta + \ln\left(\gamma^{-1}\left(exp(\gamma q_{1,s}) - exp(\gamma q_{0,s})\right)\right) + \varepsilon_s$$

where y_s is the natural log of WTP (per household per year) from study s, X_s is a vector of variables describing the context of the study s, $q_{1,s}$ is the post-policy wetland area, and $q_{0,s}$ is the baseline wetland area. As such, $(q_{1,s} - q_{0,s})$ is the number of wetland acres affected by the policy. The estimates of the econometric coefficients (β's, and γ) are presented in Table III-7 (p. 73) of the December 2018 EA, and reprinted here in Table 1.2.

Table 1.1: Variables in the December 2018 Meta-Analysis

	Description	Mean	Min	Max
Lnwtp	log(total wtp in 2017 dollars)	3.56	1.05	6.06
Lnyear	log(year of data collection - oldest year +1)	1.57	0.00	2.89
Lninc	log(income in 2017 dollars)	10.97	10.64	11.48
Sagulf	1 = S-Atlantic/Gulf (AL,GA,SC,LA)	0.19	0.00	1.00
Nema	1 = NE/mid-Atlantic,(DE,MD,NJ,PA,RI)	0.14	0.00	1.00
Nmw	N/Mid-West (KY,MI,NE,OH,WI)	0.57	0.00	1.00
Local	1 = target population at sub-state level	0.33	0.00	1.00
Prov	1 = provisioning function affected	0.24	0.00	1.00
Reg	1 = regulating function affected	0.52	0.00	1.00
Cult	1 = cultural function affected	0.76	0.00	1.00
Forest	1 = forested wetland	0.52	0.00	1.00
q0	baseline acres (1000s)	40	0	220
q1	policy acres (1000s)	51	1	220
Volunt	1 = payment mechanism = voluntary contribution	0.43	0.00	1.00
lumpsum	1 = payment frequency = lump sum (single payment)	0.43	0.00	1.00
Ce	1 = elicitation method = choice experiment	0.14	0.00	1.00
Nrev	1 = study was not peer-reviewed	0.24	0.00	1.00
median	1 = wtp estimate = median	0.33	0.00	1.00

Table 1.2: Parameter Estimates for the Meta-Analysis

	mean	std.	p(> 0)[1]
Constant	-0.546	3.097	0.430
context-specific			
Lnyear	-0.359	0.667	0.281
Lninc	0.211	0.363	0.723
Sagulf	-0.406	1.743	0.405
Nema	-0.784	1.538	0.295
Nmw	-1.073	1.556	0.244
Local	3.130	0.895	0.999
Prov	-2.273	0.876	0.009
Reg	1.632	0.850	0.970
Cult	-0.317	1.563	0.413
Forest	1.118	0.726	0.937
Moderators			
Volunt	-0.016	1.038	0.495
lumpsum	1.486	0.771	0.968
Υ	0.008	0.007	0.883
σ_{ϵ}^2	0.474	0.260	1.000

The first column of Table 1.2, above, reports all of the explanatory variables used in the final meta-analysis. The second column reports the mean estimated value of the coefficient for each variable. Using those results, we can re-write the general equation (1) as the estimated equation (2). Equation (2) was used to generate the WTP/HH/acre for each state presented in Table III-9 (pp. 77-78).

$$(2)\ \ln(WTP) = -0.546 - 0.359 * \ln(year) + 0.211 * \ln(inc) - 0.406 * Sagulf - 0.784 * Nema - 1.073 * Nmw + 3.130 * Local - 2.273 * Prov + 1.632 * Reg - 0.317 * Cult + 1.118 * Forest - 0.016 * Volunt + 1.486 * Lumpsum + \ln(0.008^{-1} * (\exp(0.008 * q_1) - \exp(0.008 * q_0)))$$

The variables Sagulf, Nema and Nmw indicate whether a state is located in a particular region. The values of these variables for each state are presented in Table III-8 (pp. 74-75). That table also presents values for the other state-specific explanatory variables: log of average income ln(inc), proportion of forested acres (Forest), and change in wetland acres ($q_1 - q_0$).

The variables ln(year), local, volunt, and lumpsum are related to how the original empirical studies used in the meta-analysis were conducted. Those variables are not state-specific but, because they show up in the estimated equation, i.e., equation (2), a value must be assumed for each in order to generate an estimate of the dependent variable. In situations such as this, the mean value of the variable is conventionally used. The mean values are reported in Table 1.1, above.

The variables Prov (provisioning), Reg (regulating), and Cult (cultural) describe the functions of the wetlands affected by the policy change in the original empirical studies. Ideally, these would

be state-specific variables, identifying the extent to which the wetlands affected by rescinding the 2015 Rule perform those functions. The December 2018 EA, however, does not provide any information about the functions of the affected wetlands. Therefore, one is left to assume the mean value for each of those variables was used for every state to estimate the dependent variable. The December 2018 EA also states, "the mean value for baseline acres from the primary studies is used for q_0 which is 10,000 acres…The value for q_1 for each state is 10,000 acres plus the expected change in jurisdictional wetland acres for each state." (pp. 73-74). Using the state-specific values in Table III-8 (p. 74) for Alabama along with the mean values for the other variables, equation (2) can be used to estimate ln(WTP) for Alabama as in equation (3).

$$(3)\ \ln(WTP) = -0.546 - 0.359 * 1.57 + 0.211 * 47{,}221 - 0.406 * 1 - 0.784 * 0 - 1.073 * 0 + 3.130 * 0.33 - 2.273 * 0.24 + 1.632 * 0.52 - 0.317 * 0.76 + 1.118 * 0.9632 - 0.016 * 0.43 + 1.486 * 0.43 + \ln(0.008^{-1} * (\exp(0.008 * 10{,}007.3) - \exp(0.008 * 10{,}000)))$$

Equation (3) provides an estimate of ln(WTP) for all of the affected acres. Taking the anti-log of that value and dividing by the number of affected acres (7.3 in the case of Alabama) will yield an estimate of WTP/household/acre. For Alabama, equation 3 yields a value of $0.037/HH/acre. This is different than the Mean WTP/household/acre reported in Table III-9 (pp. 77 and 78), which is $0.030. In fact, the estimate using equation (3) is different than the value reported in Table III-9 for every state.

One problem may be that the mean value for baseline acres reported in Table III-6 (p. 72) should be 40,000 acres, not 10,000 acres as stated. Changing the value of q_0 to 40,000 leads equation (3)

to generate estimates that are closer to those in Table III-9, but still considerably different. Digging deeper, the closest equation (3) can come to the estimated in Table III-9 is to have 40,000 baseline acres and assume values of zero for the variables Volunt and Lumpsum, although there are still up to *three-fold* differences for some states. If that is, in fact, what was done, a multitude of questions arise.

In short, there is no clear way to replicate the results of Table III-9 using the information presented in Section III.C.2.2.3.2 of the December 2018 EA. The agencies must explicitly demonstrate how the coefficient estimates from the meta-analysis are used to generate the results of Table III-9, and, if they did not use specific variables, clearly justify why.

1.2 Scope of the Analysis

Main Conclusion: Wetland values do not stop at the state border. Assuming household WTP = 0 for households outside of the state systematically under-estimates the foregone benefits of rescinding the 2015 Rule. Including adjacent states in the analysis leads foregone benefits to: (i) exceed "Low" avoided costs for the CWA 404 program across all scenarios (0, 1, 2, and 3); (ii) exceed "High" avoided costs in Scenario 3; (iii) nearly equal "High" avoided costs in Scenario 0 and Scenario 1; (iv) lie within 20% of the "High" avoided costs in Scenario 2. Considering this, plus the lack of precision regarding the estimated foregone benefits (see section 1.4 below) it is not at all clear that the avoided costs exceed the foregone benefits for any scenario. Additionally, ignoring economies of scale related to the costs of administering and enforcing regulations will lead to further under-estimation of the foregone benefits. (Also see critique of avoided cost estimates in Appendix Section 4.)

Detailed Discussion: The December 2018 EA meta-analysis employs a troubling assumption about the value of wetlands across state lines. On page 69, the report states, "Wetland benefits are, in general, a more local commodity." This may be true for some of the functions wetlands serve, but for other functions the value of a wetland may have significant geographic scope. For example, the Prairie Pothole Region (PPR) of the northern plains serves as an important breeding ground for migratory game birds. Duck hunters in Pennsylvania, thousands of miles from the PPR derive direct benefits from those wetlands (Kinnell et al., 2002). Ironically, North Dakota, in the heart of the PPR, is projected to lose the most wetland acres of any state in the nation if the 2015 Rule is rescinded. (Note: Pennsylvania is not adjacent to North Dakota)

Pate and Loomis (1997) also found residents in Oregon had non-zero willingness to pay for wetland preservation in California. In fact, one of the primary conclusions of that study is "…restricting benefits to just the political jurisdiction in which the site is located would understate the benefits…" (Pate and Loomis, 1997, p. 206). The notion that wetland benefits are restricted to residents of a state is especially difficult to conceive in densely populated corridors like the Northeast and Mid-Atlantic states that are relatively small in land area.

In the unit value transfer analysis presented in Table III-4 (p. 70), the annual foregone benefits for a state are estimated for that state alone, along with regional estimates that include the population of adjacent states. Applying the same scope of adjacent states to the meta-analysis leads to considerably different results for Scenario 0 (Table B-1, p. 222), and Scenarios 1, 2, and 3 (Tables III-10 through III-12, pp. 81-83).

Table 1.3, below, presents the "Low" and "High" annual avoided costs, as well as the annual foregone benefits for each of these scenarios, focusing exclusively on the CWA 404 program.

Oddly, the "Low" and "High" annual foregone benefits reported in Tables III-10 through III-12, as well as in Table B-1, are all based on the mean estimate of foregone benefits from Table III-9 (pp. 77-78). This is despite the fact that Table III-9 also presents an upper 95th estimate of foregone benefits, which would serve as a logical "High" annual foregone benefit estimate. Therefore, these "High" annual foregone benefits are also presented in Table 1.3.

The final two columns of Table 1.3 show the mean and upper 95th of annual foregone benefits for the CWA 404 under the adjacent state scope. The WTP/household/acre for adjacent states are generated using the elasticity of WTP with respect to income estimated by the meta-analysis (technical details available upon request).

The following points can be made using the results of Table 1.3:

- Using the upper 95th WTP/household/acre estimates more than doubles the annual foregone benefits, compared to the mean, under all four scenarios and both scopes of analysis.
- Expanding the scope of the analysis to include adjacent states increases annual foregone benefits by *three*- to *ten*-fold, under all four scenarios and both foregone benefits levels.
- Expanding the scope of analysis to include adjacent states and using mean WTP/household/acre, leads to annual foregone benefits that are
    - greater than the low avoided cost levels across all scenarios
    - greater than the high avoided cost in Scenario 3
    - nearly equal to the high avoided cost in Scenarios 0, 1, and 2
- Using the upper 95th WTP/household/acre estimates and expanding the scope of the analysis to include adjacent states leads to annual foregone benefits that are more than

double the high annual avoided costs across all scenarios, and more than *eight*-times the low avoided costs.

Table 1.3: Stage 1 Annual Avoided Costs and Annual Foregone Benefits by Scenario and Scope, (q_0 = 40,000 acres)

2017$ millions	Annual Avoided Costs[a]		Annual Foregone Benefits		Annual Foregone Benefits	
			Scope = Single State		Scope = Adjacent States	
Scenario 0	Low	High	Mean[b]	High[c]	Mean[d]	High[e]
Permit	$29.8	$74.7				
Mitigation	$57.4	$159.7				
CWA 404 Total	$87.2	$234.4	$59.4	$121.4	$216.6	$445.8
Scenario 1	Low	High	Mean	High	Mean	High
Permit	$15.7	$39.5				
Mitigation	$37.7	$57.6				
CWA 404 Total	$53.4	$97.1	$16.7	$38.6	$90.4	$207.7
Scenario 2	Low	High	Mean	High	Mean	High
Permit	$10.2	$25.5				
Mitigation	$26.7	$42.1				
CWA 404 Total	$36.9	$67.6	$14.3	$33.1	$56.0	$127.3
Scenario 3	Low	High	Mean	High	Mean	High
Permit	$1.5	$3.8				
Mitigation	$2.3	$2.9				
CWA 404 Total	$3.8	$6.7	$1.2	$2.8	$11.8	$26.5

a: As reported in Tables III-10 through III-12 and Table B-1.
b: As reported in Tables III-10 through III-12 and Table B-1.
c: Uses Upper 95th WTP/household/acre from Table III-9; assumes WTP=0 for residents outside of the state.
d: Uses mean WTP/household/acre from Table III-9; includes WTP>0 for residents outside of the state.
e: Uses Upper 95th WTP/household/acre from Table III-9; includes WTP>0 for residents outside of the state.

With respect to costs to states that continue to regulate waters that are no longer protected by the 2015 Rule (Category 4 dredge/fill states), the December 2018 EA assumes there are no costs or benefits from the Rule change. While it is true that there would be no foregone benefits generated by wetlands in such states – the same set of waters would continue to be regulated – the assumption implies that the presence of federal regulations has no impact on the regulatory costs at the state level. This is unlikely to be true. States may require significant additional resources to fill the regulatory void left by the federal government. Additionally, there are likely to be economies of scale related to regulatory scope so that the total regulatory costs of a federal regulation are lower than the sum of the regulatory costs of implementing the same regulation at the state level in every state. In other words, there is likely to be an economy of scale with respect to the regulating entity. The increase in regulatory costs to states that continue to implement the 2015, therefore, is a foregone benefit which, if excluded, will lead to further underestimation of the foregone benefits of rescinding the 2015 Rule.

1.3 Data Issues: CPI, Affected Acres

Main Conclusions: The CPI used to inflate WTP values for the meta-analysis are too low, leading to a systematic under-estimation of annual foregone benefits. Considering the central nature of affected acres to the analysis, it is essential the agencies fully explain and justify the methodology used to estimate that parameter for each state. Basing the number of acres affected by rescinding the 2015 Rule on previous permitting activity will likely under-estimate affected acres. And finally, assuming a baseline acreage of 10,000 acres (or is it 40,000 as noted in section 1.2 above?) for every state is absurd and leads to further under-estimation of the foregone benefits.

Detailed Discussion: Table III-3 (p. 69) appears to have used the wrong inflation factor for adjusting the values from the Blomquist and Whitehead 1998 study. In that paper, the WTP estimates are reported in 1990$'s. The inflation factor for 1990 to 2017 reported in the US Census Bureau CPI-U-RS table (https://www.census.gov/topics/income-poverty/income/guidance/current-vs-constant-dollars.html) is 1.82. The December 2018 EA uses four values from that study. In the original paper those values are $1.69, $4.69, $3.68, and $11.12 in 1990$'s ($3.08, $8.53, $6.70, and $20.40, respectively in 2017$'s). The values used in the December 2018 EA's meta-analysis, as reported in Table III-5 (p. 71), are all lower than these values. In fact, all of the WTP values reported in Table III-5 are lower than the values reported in the original papers inflated to 2017$'s using the CPI-U-RS inflation factors. As a result, the WTP estimates generated by the meta-analysis used in the December 2018 EA are systematically under-estimated. This needs to be reconciled.

The agencies use the estimates from the meta-analysis to generate state-level estimates of the foregone benefits that would occur if the 2015 Rule were to be rescinded. They do this by multiplying WTP/household/acre by the number of households and the number of impacted acres. There is, however, no explanation in the December 2018 EA of how the number of impacted acres was estimated at the state-level. On page 18, the agencies state, "fewer wetlands would be considered jurisdictional under the proposed Rule for this category of wetlands, but the agencies are not able to quantify this change." This is a critical parameter for their analysis, the estimation of which needs to be fully justified. If it is based on permitting activity under the 2015 Rule, then it is likely to systematically under-estimate the number of acres impacted by returning to the pre-2015 Rule. This is because, in addition to actual permit applications, the permitting costs may have deterred some wetland conversion activity, activity that may arise -

under the pre-2015 Rule. It is essential for the agencies to address how such an important component of the analysis was established.

More importantly, the December 2018 EA assumes 10,000 acres as the baseline (q_0) for every state. This variable has an exceptional influence on the estimated annual foregone benefits. Wetland acres certainly vary by state, and most states have considerably more than 10,000. Table A-1 (pp. 219-221) of the appendix reports the wetlands acres by state from the National Wetland Inventory (NWI). The agencies argue that the NWI is not a regulatory database and should not be used to set the baseline acreage for the December 2018 EA. Accepting that, the NWI does provide significant information about the appropriateness of using 40,000 acres as a baseline for every state. The NWI wetland acres range from 57,000 acres in West Virginia up to 12.2 million acres in Florida, with an average of 2.4 million acres across all states.

The December 2018 EA explains the 10,000-acre baseline is used to avoid out-of-sample prediction. Considering the vast difference in NWI acres across states and the fact that all states have NWI acreage greater than 10,000 acres (and greater than 40,000 acres), it is inappropriate to use such a low value for the baseline acreage. The agencies could partly rectify this situation and still comply with their out-of-sample prediction concerns by simply using the maximum number of baseline acres (q_0) reported in Table III-6 (p. 72) as the baseline acreage for every state. This would still likely underestimate the annual foregone benefits, but it would be a step in the right direction.

Table 1.4 presents the results of changing the baseline acreage (q_0) from 40,000 to 220,000 acres.

Table 1.4: Stage 1 Annual Avoided Costs and Mean Annual Foregone Benefits by Scenario and Scope and Baseline Acreage

2017$ millions	Annual Avoided Costs[a]		Annual Foregone Benefits		Annual Foregone Benefits	
			Scope = Single State		Scope = Adjacent States	
Scenario 0	Low	High	Mean 40[b]	Mean 220[c]	Mean 40[d]	Mean 220[e]
Permit	$29.8	$74.7				
Mitigation	$57.4	$159.7				
CWA 404 Total	$87.2	$234.4	$59.4	$204.8	$216.6	$754.6
Scenario 1	Low	High	Mean 40	Mean 220	Mean 40	Mean 220
Permit	$15.7	$39.5				
Mitigation	$37.7	$57.6				
CWA 404 Total	$53.4	$97.1	$16.7	$74.9	$90.4	$389.0
Scenario 2	Low	High	Mean 40	Mean 220	Mean 40	Mean 220
Permit	$10.2	$25.5				
Mitigation	$26.7	$42.1				
CWA 404 Total	$36.9	$67.6	$14.3	$64.6	$56.0	$240.9
Scenario 3	Low	High	Mean 40	Mean 220	Mean 40	Mean 220
Permit	$1.5	$3.8				
Mitigation	$2.3	$2.9				
CWA 404 Total	$3.8	$6.7	$1.2	$5.1	$11.8	$48.5

a: As reported in Tables III-10 through III-12 and Table B-1.
b: As reported in Tables III-10 through III-12 and Table B-1.
c: Re-estimates mean WTP/household/acre with baseline acreage set to 220,000; assumes WTP=0 for residents outside of the state.
d: Uses mean WTP/household/acre from Table III-9; includes WTP>0 for residents outside of the state.
e: Re-estimates mean WTP/household/acre with baseline acreage set to 220,000; includes WTP>0 for residents outside of the state.

One way the variation in baseline acres across states could be addressed would be to use the relative number of wetland acres listed in the National Wetland Inventory as a proxy. It is imperative the agencies address this issue.

1.4 Model Robustness: Theoretical Consistency (Concavity of benefit function), Counter-Intuitive Signs, Statistically Insignificant Variables, Wide CIs, Variable Selection

Main Conclusion: There are fundamental questions about the robustness of the meta-analysis used to estimate the foregone benefits based on the reported statistics and estimated coefficients.

Detailed Discussion – Variable Selection: The meta-analysis used an econometric technique called stochastic search variable selection (SSVS) to select the combination of variables listed in Table 1.1, above, that lead to the best-performing model. The criteria used to select the model are not detailed in the December 2018 EA, but the model selection was most likely based on either the Bayesian Information Criterion (BIC) or the Akaike Information Criterion (AIC) – conventional methods for model selection. This should be explicitly noted.

The general form of the model presented in the December 2018 EA is shown as Equation (1)

$$(1)\ y_s = X_s\beta + \ln\left(\gamma^{-1}\left(exp\left(\gamma q_{1,s}\right) - exp\left(\gamma q_{0,s}\right)\right)\right) + \varepsilon_s$$

where y_s is the natural log of WTP (per household per year) from study s, X_s is a vector of variables describing the context of the study s, $q_{1,s}$ is the post-policy wetland area, and $q_{0,s}$ is the baseline wetland area. As such, $(q_{1,s} - q_{0,s})$ is the number of wetland acres affected by the policy. The estimates of the econometric coefficients (β's, and γ) are presented in Table III-7 (p. 73) of the December 2018 EA, and reprinted in Table 1.2, below.

Table 1.1: Variables in the December 2018 Meta-Analysis

	Description	Mean	Min	Max
Lnwtp	log(total wtp in 2017 dollars)	3.56	1.05	6.06
Lnyear	log(year of data collection - oldest year +1)	1.57	0.00	2.89
Lninc	log(income in 2017 dollars)	10.97	10.64	11.48
Sagulf	1 = S-Atlantic/Gulf (AL,GA,SC,LA)	0.19	0.00	1.00
Nema	1 = NE/mid-Atlantic,(DE,MD,NJ,PA,RI)	0.14	0.00	1.00
Nmw	N/Mid-West (KY,MI,NE,OH,WI)	0.57	0.00	1.00
Local	1 = target population at sub-state level	0.33	0.00	1.00
Prov	1 = provisioning function affected	0.24	0.00	1.00
Reg	1 = regulating function affected	0.52	0.00	1.00
Cult	1 = cultural function affected	0.76	0.00	1.00
Forest	1 = forested wetland	0.52	0.00	1.00
q0	baseline acres (1000s)	40	0	220
q1	policy acres (1000s)	51	1	220
Volunt	1 = payment mechanism = voluntary contribution	0.43	0.00	1.00
lumpsum	1 = payment frequency = lump sum (single payment)	0.43	0.00	1.00
Ce	1 = elicitation method = choice experiment	0.14	0.00	1.00
Nrev	1 = study was not peer-reviewed	0.24	0.00	1.00
median	1 = wtp estimate = median	0.33	0.00	1.00

Table 1.2: Parameter Estimates for the Meta-Analysis

	mean	std.	p(> 0)[1]
Constant	-0.546	3.097	0.430
context-specific			
Lnyear	-0.359	0.667	0.281
Lninc	0.211	0.363	0.723
Sagulf	-0.406	1.743	0.405
Nema	-0.784	1.538	0.295
Nmw	-1.073	1.556	0.244
Local	3.130	0.895	0.999
Prov	-2.273	0.876	0.009
Reg	1.632	0.850	0.970
Cult	-0.317	1.563	0.413
Forest	1.118	0.726	0.937
Moderators			
Volunt	-0.016	1.038	0.495
lumpsum	1.486	0.771	0.968
Υ	0.008	0.007	0.883
σ_{ϵ}^2	0.474	0.260	1.000

The variables listed in Table 1.2 are the same as in Table 1.1, but without the Ce, Nrev, and Median variables. In other words, the model selected by the SSVS procedure did not include those variables (i.e., they do not influence the dependent variable, WTP/household/year).

The Mean column of Table 1.2 shows the expected value of each of the coefficients in the model. These are the expected impact of a unit change in the value of the variable on y. Note that y was expressed as the natural log of WTP for the model estimation. Likewise, year and income were also expressed in natural logs. We'll set those aside for the moment.

Let's start with the regional variables (Sagulf, Nema, Nmw). The Mean estimate of the coefficient for each of these regional variables is a measure of how the natural log of WTP changes for households within those regions compared to households not in those regions. So, households in the South Atlantic/Gulf region on average have a natural-logged willingness-to-pay that is 0.406 less than (note the negative sign on the coefficient) households that are not in Sagulf or Nema or Nmw. We can convert this to an impact on WTP itself (as opposed to the natural log of WTP) by taking the exponential function of the parameter (exp(-0.406) = 0.6663). Now, it is important to remember that these coefficients represent differences under *ceteris paribus* (i.e., all other things remaining the same) conditions. So, if two households have the same income and are evaluating the same change in wetland acres in the same year, etc., and the only difference is that one of them is located in the South Atlantic/Gulf region and the other is not located in either the Sagulf, Nema, or Nmw, then the household in Sagulf is only willing to pay $0.6663 for every dollar that the other household is willing to pay. That is, the Sagulf household's WTP is 66.63% of the other household's WTP.

Similarly, households in NE/mid-Atlantic region on average have a natural-logged willingness-to-pay that is 0.784 less than households that are not in Sagulf or Nema or Nmw. That is Nema households are only willing to pay $0.4566 for every dollar a household outside of Sagulf, Nema, and Nmw is willing to pay. And, finally, households in N/Mid-West region on average have a natural-logged willingness-to-pay that is 1.073 less than households that are not in Sagulf or Nema or Nmw, which translates to $0.3420 for every dollar of households outside Sagulf, Nema, and Nmw are willing to pay.

Now let's look at the Forest coefficient (1.118). We have the same interpretation as above. Namely, we can take the exponential function of the coefficient and determine how willingness-to-pay is affected by the wetland acre being forested versus non-forested, *ceteris paribus*. Here exp(1.118)=3.0587, so households are willing to pay 3.0587 times as much for forested wetlands as for non-forested wetlands. This has considerable implications for the development of the state-level WTP per household per acre estimates presented in Table III-9 (pp. 77-78) of the December 2018 EA.

Local, Volunt, and lumpsum variables pertain to how a particular study was conducted, and the coefficients can all be interpreted in the same manner as above.

I have questions about the Lnyear variable. It is unclear what is meant by "oldest year," and there is no information about that variable in the meta-analysis data file titled EPA-HQ-OW-2018-0149-0087-1-Wetland Valuation Studies Meta-Data for Proposed Rule EA. The agencies need to explain how this variable was used in to generate the results in Table III-9.

According to Table 1.2 the Prov, Reg, and Cult variables take on a value of 1 (zero, otherwise) if provisioning, regulating, or cultural functions, respectively, are "affected." In the data file

referenced above, the description of those variables is that they take on a value of 1 if the study "describes" those functions to the respondent. These are very different things, and the inconsistency should be clarified. Nonetheless, the coefficient of the Prov variable is negative, meaning households value wetlands that directly provide services less (depending on the definition of Prov) than wetlands that do not. According to the coefficient estimate, provisioning wetlands are only worth 10.3% of the value of a non-provisioning wetland, *ceteris paribus.* This is a very counter-intuitive and brings into question the veracity of the results.

Similarly, wetlands that serve cultural functions are valued at only 72.83% of the value of wetlands that do not serve cultural functions, another counter-intuitive result. However, the counter-intuitive sign on the Cult coefficient is less troubling than the coefficient on Prov. To understand why, let's look at the last column of Table 1.2. That column shows the proportion of the distribution of the coefficient that lies above 0 on the number line.

It is important to recognize that the *estimated* coefficients (β's and γ) are random variables. As such, they have a mean (expected value) but also variation around that mean (std. in Table 1.2). The p(>0) values in Table 1.2 represent how confident we are that the true coefficient (not it's estimate) is greater than zero. So, the p(>0) value of 0.413 for the Cult variable means that we are 41.3% confident that the coefficient is positive, and 58.7% (100%-41.3%) confident that it is negative. Now, conventional confidence levels used in empirical analysis are 95% or 99%, and occasionally 90%. So, by conventional measures we would not be convinced that the Cult coefficient is positive, nor would we be convinced that it is negative. In other words, we are not convinced that it is not, in fact, equal to zero! A coefficient of zero would mean that wetlands that serve cultural functions do not affect a household's willingness to pay for wetlands. This may be unexpected, but it is easier to reconcile than a negative coefficient.

The p(>0) value for the Prov coefficient, however, is 0.009. In other words, we are 99.1% sure that the true coefficient for the Prov variable is negative. When a statistical analysis strongly suggests a counter-intuitive result, in the absence of a rationale or explanation to support the result, one begins to suspect that there may be something fundamentally wrong with the model used in the statistical analysis (for example bias associated with omitted variables).

In line with the explanation above, there is convincing evidence that the coefficients for the Local, Reg, Forest, and lumpsum variables are greater zero, and the Prov coefficient is less than zero. The other coefficients (including the regional variables discussed above), however, are not convincingly different than zero.

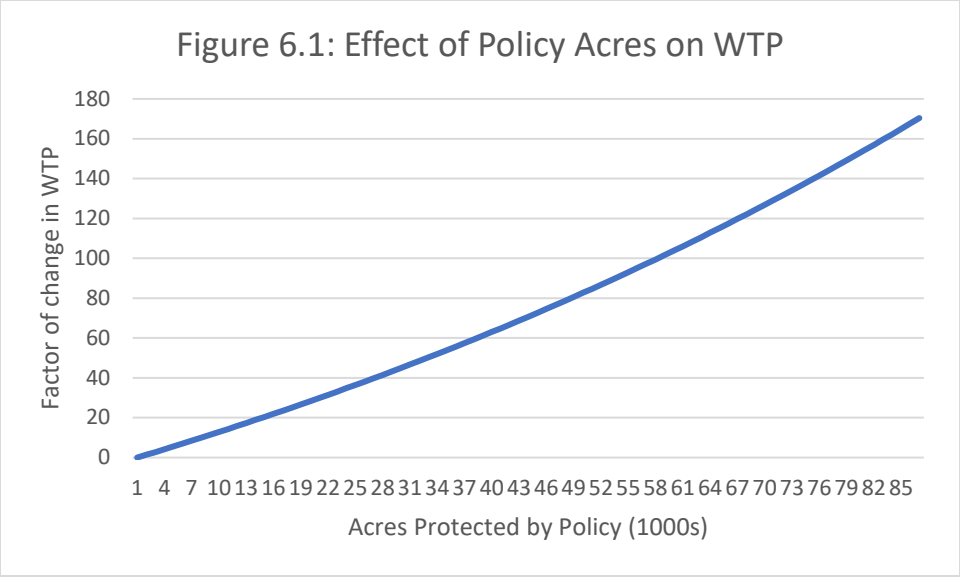
Nonetheless, let's look at the two remaining variables, Lninc and γ. The coefficient for Lninc has a special interpretation because Lninc, like y (WTP/household/year), is measured in natural logs. This means that the coefficient represents the percentage change in WTP due to a 1% change in household income. This relationship is known as an "elasticity" in economics. The estimated coefficient of 0.211 suggests that a 1% increase in household income will result in a 0.211% increase in WTP. This elasticity can be exploited to develop estimates of foregone benefits that include households in neighboring states, as presented in section 1.2, above. The technical details of that can be provided upon request. Let's discuss the γ parameter.

The γ parameter reflects how the scope of the policy (number of wetlands protected) affects a household's willingness-to-pay. Looking at the p(>0) value for this parameter, we are only 88% sure that it is not zero, outside of the least conservative conventional level, but close to it. If we accept that γ is positive, then as the number of acres affected by the policy increases, the willingness to pay for the policy also increases. This is perfectly intuitive and consistent with

economic theory (i.e., more of a good thing is preferred to less). On page 70, the December 2018 EA, however, states the following:

> "The study performs a Bayesian non-linear meta-regression that ensures the benefits function meets a set of utility theoretic validity criteria. Those criteria are: concavity of the benefits function over wetland acres…"

In lay terms, concavity of the benefits function means that benefits are increasing at a decreasing rate. In other words, the marginal benefits of regulating wetlands decline as the number of regulated acres increase. The December 2018 EA argues on page 55, "If the marginal benefits of regulating water decline as smaller waterbodies are regulated (which would be a common assumption of diminishing marginal benefits) then the benefits of the 2015 Rule and 2017 Proposal may be overstated." The curious thing is that the econometric model estimated in the meta-analysis is actually *convex* in the number of acres regulated, not concave. This can be shown mathematically by taking the anti-log of Equation (1), above, and then taking the derivative of the anti-log with respect to q_1, the post-policy number of protected wetland acres. The first derivative is strictly positive, regardless of the sign of γ. The sign of the second derivative, however, depends on the sign of γ. The meta-analysis estimates $\gamma = 0.008 > 0$. When γ is positive the second derivative is also positive, meaning the WTP for a policy is increasing at an *increasing* rate as the scope of the policy widens. In other words, the marginal benefits are increasing. The increasing marginal benefits can also be demonstrated numerically by choosing values for q_1, calculating the resulting y, and plotting the relationship between the two. This relationship is illustrated in Figure 1.1 below. This relationship is independent of the value of any other variables (Sagulf, Nema, Nmw, Prov, Forest, etc.).



The desire to model the benefit function as concave is rooted in the December 2018 EA identification of "potential biases" in the EAs of the 2015 Rule and proposed 2017 Rule. As noted above, one of the concerns is expressed on p. 55 of the December EA as follows:

> "If the marginal benefits of regulating water decline as smaller waterbodies are regulated (which would be a common assumption of diminishing marginal benefits) then the benefits of the 2015 Rule and 2017 Proposal may be overstated. If the costs of regulating increases as smaller water bodies are regulated (an assumption of increasing marginal costs) then the costs of these two actions would have been underestimated."

The problem with this statement is that the size of the waterbody is not used to establish a jurisdictional determination – none of the WOTUS Rules, including the proposed 2017 Rule and the proposed 2019 Rule, define WOTUS based on size – nor are the benefits of a waterbody solely a function of its size. The 2015 Rule may have brought waters of exceptional value under regulation. Because the 2015 Rule classifies new waters as WOTUS based on a variety of

factors, it is entirely plausible that the marginal benefit function could be increasing, i.e., the waters protected under the 2015 Rule are more valuable than the least valuable waters protected under the pre-2015 Rule. Similarly, the marginal cost curve may be negatively sloped. The odd thing is that the December 2018 EA first asserts that the marginal benefit function should be decreasing (i.e., a concave benefit function), then claims to estimate a benefit model that is concave but actually estimates a benefit function that is convex. The agencies need to address these contradictions and explain the implications of a convex benefit function for the analysis.

The income variable, measured in natural log, is important in the calculation of the of WTP per household per acre. As we see from Table 1.2, the p(>0) value is only 0.723, meaning we are only 72.3% sure it is positive. From a "statistical significance" perspective we would not be willing to conclude that it is, in fact, different from zero. That is, there is not convincing evidence that household income has an effect on household WTP.

As discussed above, I have been unable to replicate the results using the estimated coefficients. Nonetheless, the December 2018 EA claims, "Using the results of the meta-analysis to estimate a change in benefits for each state resulting from a change in wetland area requires the following state-specific variables: change in wetland acres because of CWA jurisdictional changes, average household income, number of households, proportion of changes in acres that is forested, and region of the United States" (p. 73). So, at the state level, the key drivers of the estimated WTP per household per acre are the region the state is located in, it's average household income, it's proportion of forested wetlands, and the number of acres affected by the policy change even though there is not convincing evidence that the region, income or number of acres actually influence WTP. (Actually, another important state-level parameter, as demonstrated in Table 1.4, is the baseline acreage parameter q_0.)

The effect of the uncertainty related to these variables in particular, and the model in general, can be seen in the confidence intervals for the WTP/household/acre. The lower bound of the 95% confidence interval is zero for many states, while the upper bound is generally more than twice as much as the mean. In other words, the meta-analysis lacks precision. This is reinforced when one looks at the 95% confidence interval for the annual foregone benefits, also presented in Table III-9. For California, for example, the lower bound of annual foregone benefits is just over $37,000 while the upper bound is more than $20.2 million! Given the lack of precision of the estimates from the meta-analysis, it is entirely inappropriate to treat the mean annual foregone benefit estimates as both the "Low" and "High" estimates in Scenarios 0, 1, 2, and 3. (See Section 1.2, Table 1.3, above.)

2. Critique of the December 2018 EA, Stage 2 Analysis

Stage 2 of the December 2018 EA focuses on the replace component of rescind-and-replace, i.e., the annual avoided costs and foregone benefits of moving from the pre-2015 Rule to the proposed 2019 Rule. For this analysis, the December 2018 EA conducted three watershed-level case studies. For each of the case studies, a single study from the empirical literature was used to generate estimates of the annual foregone benefits for a specific watershed. At the end of the day, however, the Stage 2 analysis utilizes the results of the meta-analysis from Stage 1 to generate the annual foregone benefits in each state and at the national level. As such, all of the criticisms of both the meta-analysis and the Stage 1 results discussed above also pertain to the Stage 2 analysis.

Tables 2.1 and 2.2 present the results for Stage 2 under the same conditions as Tables 1.3 and 1.4, respectively, with similar conclusions. Namely, that the scope of the analysis and the baseline acreage have dramatic effects on the estimated annual foregone benefits. Furthermore,

the annual foregone benefits can easily exceed the annual avoided costs under Scenarios that are equally plausible to the scenarios presented in the December 2018 EA.

Table 2.1: Stage 2 Annual Avoided Costs and Annual Foregone Benefits by Scenario and Scope, q_0 = 40,000 acres

2017$ millions	Annual Avoided Costs[a]		Annual Foregone Benefits		Annual Foregone Benefits	
			Scope = Single State		Scope = Adjacent States	
Scenario 0	Low	High	Mean[b]	High[c]	Mean[d]	High[e]
Permit[f]	$26.6	$26.2				
Mitigation[g]	$209.9	$470.0				
CWA 404 Total	$236.5	$496.6	$135.6	$300.3	$419.5	$898.3
Scenario 1	Low	High	Mean	High	Mean	High
Permit	$16.0	$16.0				
Mitigation	$118.6	$249.7				
CWA 404 Total	$134.6	$265.7	$46.8	$104.0	$233.9	$496.4
Scenario 2	Low	High	Mean	High	Mean	High
Permit	$10.6	$10.6				
Mitigation	$101.9	$204.3				
CWA 404 Total	$112.5	$214.9	$41.7	$92.7	$193.4	$408.3
Scenario 3	Low	High	Mean	High	Mean	High
Permit	$2.4	$2.4				
Mitigation	$25.3	$60.2				
CWA 404 Total	$27.6	$62.6	$6.9	$14.2	$74.3	$152.9

a: As reported in Table IV-61.
b: As reported in Table IV-62.
c: Uses Upper 95th WTP/household/acre from Table IV-62.
d: Uses mean WTP/household/acre from Table IV-62; includes WTP>0 for residents outside of the state.
e: Uses Upper 95th WTP/household/acre from Table IV-62; includes WTP>0 for residents in adjacent states.

Table 2.2: Stage 2 Annual Avoided Costs and Mean Annual Foregone Benefits by Scenario and Scope and Baseline Acreage

2017$ millions	Annual Avoided Costs[a]		Annual Foregone Benefits		Annual Foregone Benefits	
			Scope = Single State		Scope = Adjacent States	
Scenario 0	Low	High	Mean 40[b]	Mean 220[c]	Mean 40[d]	Mean 220[e]
Permit	$26.6	$26.2				
Mitigation	$209.9	$470.0				
CWA 404 Total	$236.5	$496.6	$135.6	$567.9	$419.5	$1,648
Scenario 1	Low	High	Mean	Mean 220	Mean	Mean 220
Permit	$16.0	$16.0				
Mitigation	$118.6	$249.7				
CWA 404 Total	$134.6	$265.7	$46.8	$200.3	$233.9	$905.7
Scenario 2	Low	High	Mean	Mean 220	Mean	Mean 220
Permit	$10.6	$10.6				
Mitigation	$101.9	$204.3				
CWA 404 Total	$112.5	$214.9	$41.7	$179.4	$193.4	$742.7
Scenario 3	Low	High	Mean	Mean 220	Mean	Mean 220
Permit	$2.4	$2.4				
Mitigation	$25.3	$60.2				
CWA 404 Total	$3.8	$6.7	$6.9	$24.7	$74.3	$266.6

a: As reported in Table IV-61.
b: As reported in Table IV-62.
c: Re-estimates mean WTP/household/acre with baseline acreage set to 220,000; assumes WTP=0 for residents outside of the state.
d: Uses mean WTP/household/acre from Table IV-62; includes WTP>0 for residents outside of the state.
e: Re-estimates mean WTP/household/acre with baseline acreage set to 220,000; includes WTP>0 for residents outside of the state.

8. A Single Action, Not a 2-Stage Process

The idea that the proposed 2019 Rule actually constitutes a two-stage process is difficult to believe. The goal of the proposed 2019 Rule is to change the WOTUS definition to something

less strict than the pre-2015 Rule. Breaking the December 2018 EA into two stages seems disingenuous, especially because the estimates of annual foregone benefits are affected by that approach. The reason for that is related to the convexity of the estimated benefit function and the baseline acres, discussed above. In particular, if the benefit function is convex and the proposed 2019 Rule actually constitutes a single rescind-and-replace action then treating the Stage 2 analysis as separate from the Stage 1 analysis will systematically under estimate the total effect of rescind-and-replace. To understand how, let's look at Florida. Table III-9 (p. 77) estimates 28.6 acres will be affected by rescinding the 2015 Rule. Table F-5 estimates the proposed 2019 Rule will affect an additional 439.5 acres. The December 2018 EA calculates Florida's mean WTP/household/acre to be $0.0190 in Stage 1 and $0.0195 in Stage 2, a 2.5% increase. As we can see, the WTP/household/acre is increasing in the number of affected acres. As such, treating the proposed 2019 Rule as a single rescind-and-replace action resulting in 468.1 affected acres will lead to an even larger WTP/household/acre and larger annual foregone benefits than treating the two actions separately. The systematic under-estimation of annual foregone benefits from using this two-stage is compounded by the low assumed value of the baseline acreage, again due to the convexity of the estimated benefit function.

Table 8.1 presents mean estimated annual foregone benefits for a single-stage analysis of the CWA 404 programs using 220,000 acres as the baseline. This is done for both the single-state scope as well as including adjacent states, as in the preceding analyses.

Table 8.1: Single Stage Annual Foregone Benefits by Scenario and Scope (q_0 = 220,000)

2017$ millions	Annual Foregone Benefits	
	Scope = Single State	Scope = Adjacent States
Scenario 0	$772.9	$2,403.4
Scenario 1	$275.2	$1,295.2
Scenario 2	$244.2	$984.1
Scenario 3	$29.8	$315.1

9. Conclusions

The December 2018 EA has some fundamental flaws, all of which lead to systematic under-estimation of the annual foregone benefits of rescinding the 2015 Rule and replacing it with the proposed 2019 Rule. Given these problems it is inappropriate to make a regulatory decision based on the benefits presented in the December 2018 EA.

The agencies are urged to do the following:

1. Provide an additional analysis estimating the annual foregone benefits of the CWA 404 programs as a single transition from the 2015 Rule to the proposed 2019 Rule.
2. Explicitly show how the results of the meta-analysis can be used to replicate Table III-9 and Table F-5.
3. Considering the fundamental importance of the baseline acreage, provide additional analyses using 220,000 acres as the baseline for each state.
4. Conduct sensitivity analysis around the affected acres parameters for each state, acknowledging the use of historical permitting data will under-estimate this important parameter.
5. Explain why the CPI-U values used in the December 2018 EA are not the same as those published by the Census Bureau.

6. Include “High” estimates of the annual foregone benefits for Stage 1.
7. Re-estimate the econometric model in the meta-analysis including the supporting function of wetlands as an explanatory variable.
8. Expand the scope of the benefits to include residents in adjacent states.

In summary, the meta-analysis and subsequent calculations used to estimate foregone benefits in both Stage 1 and Stage 2 of the December 2018 EA suffer from systematic under-estimation of the benefits, a highly consequential and dubious assumption related to baseline acres, and demonstrable evidence of the model’s lack of precision. In addition, the two-stage approach employed by the December 2018 EA leads to lower annual foregone benefits than a single stage approach would. A two-stage approach would only be appropriate if the proposed 2019 Rule actually constitutes a “rescind-and-replace” action that results in the pre-2015 WOTUS definition being in effect for a significant period of time. The agencies need to explain the extent to which the proposed 2019 Rule will result in the pre-2015 WOTUS definition being in effect and justify why the two-stage is appropriate in that circumstance.

References Cited

Kinnell, J., J. K. Lazo, D. J. Epp, A. Fisher, and J. S. Shortle. 2002. Perception and value for preventing ecosystem change: Pennsylvania duck hunters and the prairie pothole region. Land Economics 78:228–244.

Pate, J. and J. Loomis. 1997. The effect of distance on willingness to pay values: a case study of wetlands and salmon in California. Ecological Economics 20:199–207.

Appendix

A1. Introduction

The term "waters of the United States" (WOTUS) is used to determine whether a water body is governed by the requirements of the federal Clean Water Act (CWA). The exact scope of the term WOTUS has been in fluctuation since a 2001 Supreme Court decision and was further complicated by a subsequent Supreme Court case in 2006. In 2015, the Environmental Protection Agency (EPA) and the Department of the Army (Army) prepared a final Clean Water Rule (CWR) that sought to identify waters that are and are not WOTUS, thereby identifying which waters are subject to the CWA. EPA and the Army subsequently prepared a set of economic analyses to estimate the costs and benefits of implementing the new CWR, the most recent of which was completed in May 2015 (hereafter referred to as the "May 2015 EA").

In October of 2015, the U.S. Sixth Circuit Court of Appeals issued a stay on the new definition of WOTUS detailed by the 2015 CWR. As a result, the pre-2015 CWR definition of WOTUS is currently in effect.

In February 2017, President Trump signed Executive Order 13778 requiring the review of the "Waters of the United States Rule." In response, the EPA and the Army have initiated a two-step process to review and revise the definition of WOTUS established in the 2015 CWR. The first step entails re-codifying the definition of WOTUS to reflect the 2001 and 2006 Supreme Court decisions, overriding the definition promulgated by the 2015 CWR even if the current stay were lifted.

In June 2017, the EPA and the Army published an Economic Analysis for the Proposed Definition of "Waters of the United States" – Recodification of Pre-Existing Rules (hereafter

referred to as the "June 2017 EA"). The June 2017 EA uses the May 2015 EA as a baseline to estimate the foregone benefits and avoided costs of not implementing the 2015 CWR.

In December 2018, the EPA and the Army published an Economic Analysis for the Proposed Definition of "Waters of the United States" – Recodification of Pre-Existing Rules (hereafter referred to as the "December 2018 EA"). The December 2018 EA uses the May 2015 EA as a baseline to estimate the foregone benefits and avoided costs of not implementing the 2015 CWR.

Both the May 2015 EA and the June 2017 EA focused on four sections of the CWA: Sections 311, 401, 402, and 404. The only substantive difference between the results of those two analyses has to do with their treatment of the potential costs and benefits associated with Section 404. As such, this report focuses exclusively on the Section 404 cost and benefit estimates.

A2. Overview of the May 2015 EA

The May 2015 EA estimates the potential costs and benefits of implementing the 2015 CWR. These are the costs and benefits that are expected to be realized if the 2015 CWR were to take effect.

A2.1 Cost Estimation under CWA Section 404

The May 2015 EA breaks the potential costs of implementing the 2015 CWR that are attributable to CWA Section 404 into three categories: wetland mitigation costs, stream mitigation costs, and permit application costs. Wetland mitigation costs were estimated at the state level and calculated as the product of additional state-level mitigated wetland acres and state-level costs per mitigated wetland acre. To estimate the total wetland mitigation costs for the country, the state-level mitigation costs were summed over all 50 states and the District of Columbia. Data

from fiscal year 2009 (FY09) to FY14 were used to estimate the number of additional mitigated wetland acres due to the 2015 CWR, by state, as well as state-specific costs per mitigated wetland acre.

Stream mitigation costs were calculated in a similar manner. Utilizing data from FY13 and FY14 the number of additional linear feet of stream mitigation due to the 2015 CWR were estimated by state. This was then multiplied by a state-specific estimate of the mitigation cost per linear foot of stream, using the most up-to-date data available, to estimate the state-level total stream mitigation cost. The state-level costs were then summed to generate an estimated stream mitigation cost for the country.

There are two types of permits issued under CWA Section 404, general permits and individual permits. General permits are typically used to cover projects that are expected to have minimal impacts on WOTUS, and therefore require less documentation. Individual permits are required for projects that are expected to have more than minimal impacts. The individual permit application and review are more data-intensive and require significantly more documentation, and are typically more costly to obtain than general permits.

To estimate the additional permit application costs attributable to the 2015 CWR, the May 2015 EA used two different methodologies. In 1999, the US Army Corps of Engineers (USACE) conducted a review of permitting costs for "typical" projects up to three acres in size by interviewing Corps District staff and consulting firms that specialize in CWA Section 404 permit applications. This review resulted in a range of costs for a general permit ($3,00 - $10,000) and a range of costs for an individual permit ($10,000 - $24,000), both expressed in 1999 dollars. The 2015 EA provides some ad hoc rationale for using the upper value of these ranges – $10,000 for

a general permit, and $24,000 for an individual permit – and inflates those values to 2014 dollars for one estimate of the additional application costs per permit type. Multiplying the estimated number of additional general and individual permits by their respective additional permit costs due to the 2015 CWR gives one estimate of the CWA Section 404 total additional permitting costs. This is referred to as the Low scenario in both the May 2015 EA and the June 2017 EA.

The other methodology uses a set of estimates from Sunding and Zilberman (2002). That study relied on data from a 1999 survey of private developers and wetland consultants detailing application costs for both general and individual permits. The sample of 103 survey responses represented applications from across the country, and generally reflected the mix of applicants (private entities v. public agencies), types of activities (flood control, quarry expansion, school construction, etc.), project size, impacted acres, and regional distribution of wetland permits in the late 1990s (Sunding and Zilberman, 2002). That study reports several sample statistics, broken down by permit type, as reported in Table 1. While these statistics are of interest, it would be informative if the standard deviation were also reported. It would also be helpful to know how many of the sample observations were general versus individual permits. It is also unclear how many entities provided the data. A select few developers and consultants may have provided information on multiple applications to generate the 103 observations, or each developer/consultant may have provided a single observation. This is not documented in either Sunding and Zilberman (2002) or the May 2015 EA.

Table 1: Sample Statistics of Permit Application Costs from the Sunding and Zilberman Survey

Permit Type	Cost per Permit (1999 dollars)			
	Minimum	Maximum	Median	Mean
General	$2,000	$140,076	$11,800	$28,915
Individual	$7,000	$1,530,000	$155,000	$271,596

Sunding and Zilberman (2002) argue against using the sample mean as an estimate of the average cost of a permit because permit costs are likely to vary by the size of the project. They then report the barest results from a statistical analysis aimed at deconstructing permit costs into a fixed cost and a cost per acre of impact.

> "The acreage of waters of the United States impacted by a project has a statistically significant effect on the cost of both the nationwide [general] and individual permit preparation costs. Utilizing the survey data, we determined a statistical relationship between these factors for both types of permits. For individual permits, application costs were measured as $43,687 plus $11,797 for each acre of impact. For nationwide [general] permits, costs were measured as $16,869 plus $9285 for each acre of waters of the United States impacted. Thus, permitting costs have statistically significant fixed and variable components and permits are more expensive to obtain for larger projects." (p. 74)

There is no information on the level of statistical significance of the fixed and per acre cost estimates by permit type. Nor is there any information about the statistical methods used to generate those estimates. The May 2015 EA uses these estimates in the following manner: the projected number of additional general permits due to the 2015 CWR (2,791) is multiplied by the fixed cost of a general permit ($16,869) to get a total general permit fixed cost; the average impacted acres per general permit (0.43) (based on FY13 data) is multiplied by the per acre cost of a general permit ($9,285) and by the number of additional general permits (2,791); these are then added together to estimate the total additional general permitting costs due to the 2015 CWR, and inflated to 2014 dollars. The same is done for individual permits using the projected additional individual permits (217), fixed individual permit cost ($43,687), individual permit average impacted acreage (5.94), and per acre cost of an individual permit ($11,797). These estimates are referred to as the High scenario in the May 2015 EA and the June 2017 EA.

A2.2 Benefit Estimation under CWA Section 404

Potential benefits of the 2015 CWR under CWA Section 404 result from the avoidance and minimization of project impacts as well as compensatory mitigation associated with the expansion of jurisdictional waters. The potential benefits of wetland impact avoidance and compensatory mitigation were estimated using the benefit transfer method in which the results from a study in one location are transferred to another study area, adjusting for differences in the characteristics of the two study areas. The potential benefits of stream impact avoidance and compensatory mitigation were not estimated.

Ten contingent valuation studies were used to develop willingness to pay (WTP) estimates per household per acre of wetland mitigation for the benefit transfer estimates. Four of those studies

were used to estimate per household per acre benefits for Freshwater Forested wetlands; six studies were used to estimate per household per acre benefits for Freshwater Emergent wetlands. The studies used were summarized in Appendix B of the May 2015 EA, and that information is reprinted here in the Appendix.

The benefit transfer analysis accounts for state and regional variation in the WTP per household per acre estimates as well as the expected number of mitigated acres by wetland type to generate regional WTP per household estimates for the increase in mitigated acres due to the 2015 CWR. These are then multiplied by the number of households in the region to estimate total regional benefits. Summing across all regions leads to total projected CWA Section 404 wetland mitigation benefits attributable to the 2015 CWR.

A3. Overview of the June 2017 EA

The June 2017 EA considers the same policy change as the May 2015 EA but from the perspective of rescinding the 2015 CWR, as opposed to implementing it. As a result, the June 2017 EA calculates the costs avoided and the benefits foregone from not implementing the 2015 CWR. The methodology used in the June 2017 EA to estimate the costs avoided for each of the relevant CWA Sections (311, 401, 402, and 404) is identical to the methodology used in the May 2015 EA, merely inflating those results to report them in 2016 dollars.

The methodology for estimating the foregone benefits is also the same in the June 2017 EA as that of the May 2015 EA, with one exception – the foregone benefits of wetland mitigation under CWA Section 404. For this line item in the economic assessment, the value is deemed larger than zero but not estimated. To justify this omission, the June 2017 EA states:

> "The 2015 CWR wetland benefits were derived through a benefit transfer exercise using 22 estimates from 10 studies, examining households' willingness to pay for wetland preservation. The studies were published between 1986 and 2000, although the agencies attempted to find more recent studies. More recent wetland studies were not available. The age of these studies introduces uncertainty…the limited number of studies available also restricts the application of common tests…necessary to validate the results." (p. 8-9)

A4. Critique of the June 2017 EA

The June 2017 EA effectively made one change to the May 2015 EA: it removed the estimates of the benefits of the 2015 CWR for CWA Section 404. It is, however, difficult to reconcile this omission while retaining the CWA Section 404 permit cost estimates from that study. There were four general rationales for the benefit estimate omission: it is based on too few studies, the data are old, the methodology may be insufficient, and there are no recent studies available. Each of these criticisms can be levied at the CW Section 404 permit cost estimates as well.

The benefit estimates were derived from 22 sets of results generated by 10 different studies. The cost estimates were based on results of 2 studies.

The data for the benefit estimates are from surveys conducted between 1986 and 1999. The data for both the Low and High cost scenario estimates are from surveys conducted in 1999.

The benefit estimates used for the benefit transfer exercise may not have been collected and analyzed under what currently constitute best practices. While this may be true of the data collection, there is no reason the analysis could not be updated to reflect current practice. On the cost side, however, the Low cost scenario estimates were selected in a completely arbitrary

manner, absent of any sound methodology. A range of cost estimates were solicited from USACE regulators for each permit type, and the highest value was selected to represent the Low cost scenario estimate. For the High cost estimates, the reported results are frustratingly opaque and prohibit any serious evaluation of their robustness or theoretical consistency. Sunding and Zilberman (2002) state that there is a "statistically significant" permit cost that is dependent on the impacted acres, but they do not state what the level of significance is. While the general convention for statistical significance is a p-value of 0.05, many studies highlight estimates as being statistically significant with p-values as high as 0.10. Because statistical significance is a subjective term, it is standard practice to report the p-value and/or the standard deviation of a parameter when claiming "statistical significance." Similarly, the authors report the range (min and max) of permit application costs from their survey as well as the mean and median by permit type, but they fail to report the standard deviations or the number of observations for each permit type. This omission prohibits investigating hypotheses related to the difference in the two means. Furthermore, it is left to the reader to assume that the fixed permit application cost estimates and the cost per impacted acre estimates were generated by a linear regression model. There is no mention of how those estimates were generated. Assuming it was through a linear regression model, there is no information about the functional form of the model or standard statistics regarding model performance such as R^2, F-statistic for the model, or t-statistics for the parameter estimates; neither is there any discussion of the other variables included in the model, results of tests for heteroskedasticity of the error term, or the potential for omitted variables bias. The authors report the results only for a linear relationship between permit application costs and impacted acres. It is, however, quite possible that a logarithmic relationship, quadratic or exponential relationship could perform better, and lead to dramatically different results.

While we have been unable to identify any new CWA Section 404 permit application cost studies since the two (based on 1999 survey data) mentioned above, there have been numerous peer-reviewed studies estimating the value of wetlands since 2000. These studies, referenced in Section 5, could certainly form the foundation for updating the benefits associated with wetland mitigation from the 2015 CWR.

A5. More Studies Related to Wetland Valuation

*Barbier, E.B., 2007. Valuing ecosystem services as productive inputs. *Economic Policy* 49: 178–229.

*Bin, O. 2005. "A semiparametric hedonic model for valuing wetlands," *Applied Economics Letters*, 12:10, 597-601.

*Carlsson F, P. Frykblom, and C. Lijenstolpe. 2003. "Valuing wetland attributes: an application of choice experiments," *Ecological Economics,* 47: 95–103.

*Costanza, R., O. Perez-Maqueo, M.L. Martinez, P. Sutton, S.J. Anderson, and K. Mulder. 2008. "The value of coastal wetlands for hurricane protection," *AMBIO: A Journal of the Human Environment*, 37(4):241-248.

*Gascoigne, W.R., D. Hoag, L. Koontz, B.A. Tangen, T.L. Shaffer, and R.A. Gleason. 2011. "Valuing ecosystem and economic services across land-use scenarios in the Prairie Pothole Region of the Dakotas, USA," *Ecological Economics*, 70:1715-1725.

*Jenkins, W.A., Murray, B.C., Kramer, R.A., Faulkner, S.P., 2010. "Valuing ecosystem services from wetlands restoration in the Mississippi Alluvial Valley," *Ecological Economics*, doi:10.1016/j.ecolecon.2009.11.022

*Kaffashi, S., Shamsudin, M. N., Radam, A., Rahim, K. A., and Yacob, M. R. (2015). "Users and non-users of wetland area: Willingness to pay and demand elasticity." J. Sustain. Develop., 8(8), 56–69.

*Yi, H., B. Güneralp, A.M. Filippi, U.P. Kreuter, and I. Güneralp. 2017, "Impacts of land change on ecosystem services in the San Antonio River Basin, Texas, from 1984 to 2010," *Ecological Economics* 135: 125-135.

*Turner, K.R., Georgiou, S., Fisher, B., 2008. Valuing ecosystem service: the case of multifunctional wetlands. Earthscan, London, UK.

*Moeltner, K. and R. Woodward. 2009. "Meta-functional benefit transfer for wetland valuation: making the most of small samples," *Environmental and Resource Economics*, 42:89-108.

*Liu, S., R. Costanza, A. Troy, J. D'Aagostino, and W. Mates. 2010. "Valuing New Jersey's Ecosystem Services and Natural Capital: A Spatially Explicit Benefit Transfer Approach," *Environmental Management*, 45:1271–1285.

*Mahan, B.L., S. Polasky, and R.M. Adams. 2000. "Valuing Urban Wetlands: A Property Price Approach," *Land Economics*, Vol. 76, No. 1, pp. 100-113.

*Johnston, R.J., J.J. Opaluch, M.J. Mazzotta, and G. Magnusson. 2005. Who Are Resource Nonusers and What Can They Tell Us About Nonuse Values? Decomposing User and Nonuser Willingness to Pay for Coastal Wetland Restoration. Water Resources Research 41(7): W07017.

*Costanza, R., R. deGroot, P. Sutton, S. van der Ploeg, S.J. Anderson, I. Kubiszewski, S. Farber, and R.K. Turner. 2014. "Changes in the global value of ecosystem services," *Global Environmental Change*, 26:152-158.

*Kubiszewski, I., R. Costanza, S. Anderson, and P. Sutton. 2017. "The future value of ecosystem services: Global scenarios and national implications," *Ecosystem Services*, 26:289-301.

*Frey, E.F., M.B. Palin, P.J. Walsh, and C.R. Whitcraft. 2013. "Spatial Hedonic Valuation of a Multi-use Urban Wetland in Southern California," *Agricultural and Resource Economics Review*, 42(2):387-402.

Baifu, X. 2007. "An hedonic analysis of southwest Louisiana wetland prices using GIS," *LSU Master's Theses.* 3475.

Frey, E.F., M.B. Palin, P.J. Walsh, and C.R. Whitcraft. 2013. "Spatial Hedonic Valuation of a Multi-use Urban Wetland in Southern California," *Agricultural and Resource Economics Review*, 42(2):387-402.

Lewis, S.E., J.S. Popp, L.A. English, and T.O. Odetola. 2017. "Willingness to Pay for Riparian Zones in an Ozark Watershed," *Journal of Water Resources Planning and Management*, 143(5).

*Petrolia, D., M.G. Interis, J. Hwang, M.K. Hidrue, R.G. Moore, and G.S. Kim. 2013. "America's Wetland? A National Survey of Willingness to Pay for Restoration of Louisiana's Coastal Wetlands," Final Project Report, Northern Gulf Institute, available at: https://www.americaswetland.com/photos/article/Report_4_1_13.pdf.

Brander, L., R.J.G.M. Florax, and J.E. Vermaat. 2006. "The empirics of wetland valuation: A comprehensive summary and a meta-analysis of the literature," *Environmental and Resource Economics*, 33: 223-250.

Woodward, R.T., and Y. Wui. 2001. "The economic value of wetland services: a meta-analysis," *Ecological Economics*, 37: 257-270.

Kreuter, Urs P., H.G. Harris, M.D. Matlock, and R.E. Lacey. 2001. "Change in ecosystem service values in the San Antonio area, Texas," *Ecological Economics,* 39: 333–346.

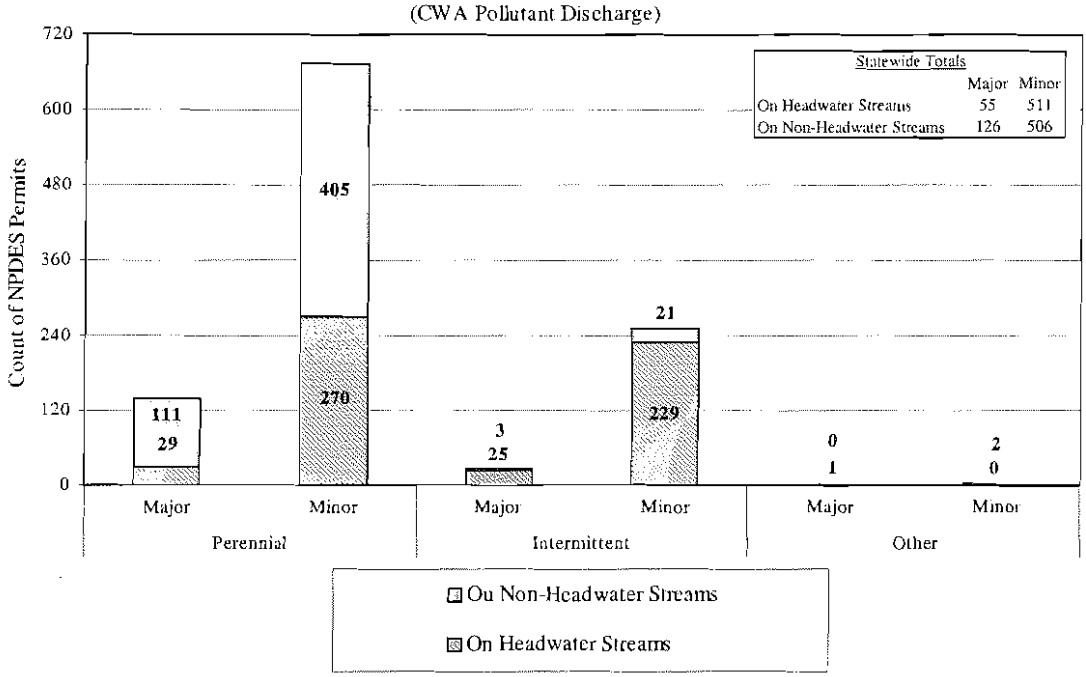
Dr. Mullen received his PhD. from Virginia Tech in 1999 and joined the faculty of the University of Georgia (UGA) in July of 2000. At UGA, he has focused his research on the interface between agricultural production and the environment, with particular emphasis on water resources. His work includes analyses of how agricultural water demand responds to public policy, climatic uncertainty, technology adoption, water scarcity, and land values. He also has extensive experience with non-market valuation in the context of environmental and human health risks.

In addition to his research, Dr. Mullen has taught a wide variety of graduate and undergraduate courses, including environmental economics, quantitative methods, econometrics, production economics, energy economics, and water resource economics.

Exhibit E

Location of Individual NPDES Permits on Alabama Streams

(CWA Pollutant Discharge)



Legend: Out of 1,587 total NPDES Individual permits statewide, 75% (1,198 permits) have location data. Of those with location data, 47% (566 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

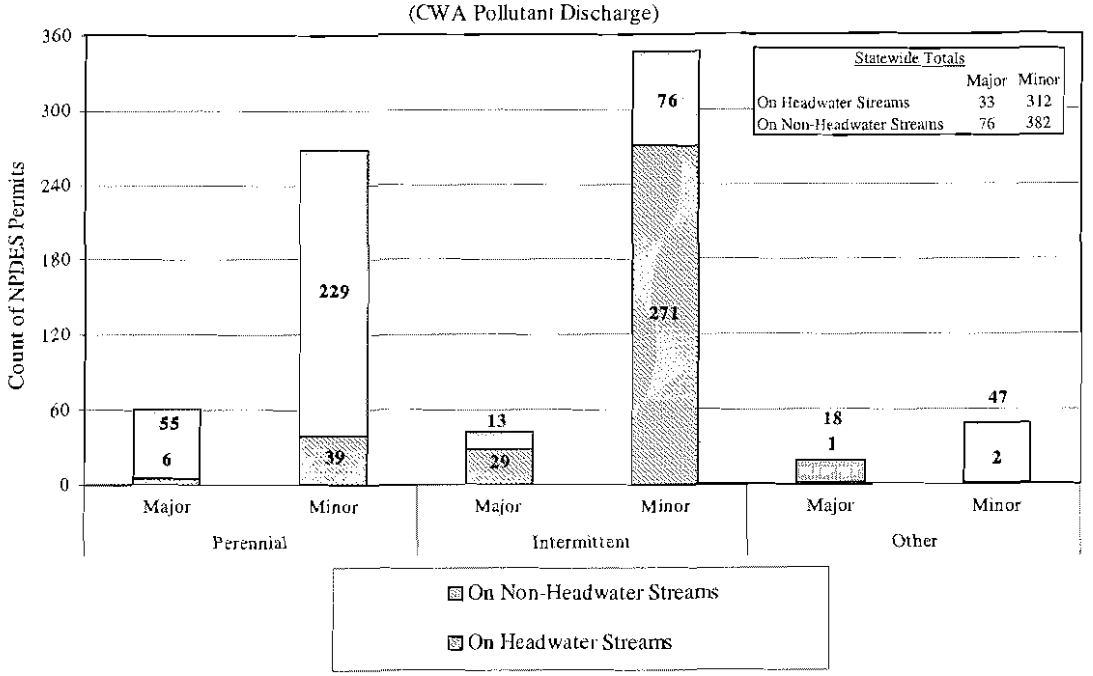
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Arkansas Streams

(CWA Pollutant Discharge)



Legend: Out of 815 total NPDES Individual permits statewide, 99% (803 permits) have location data. Of those with location data, 43% (345 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

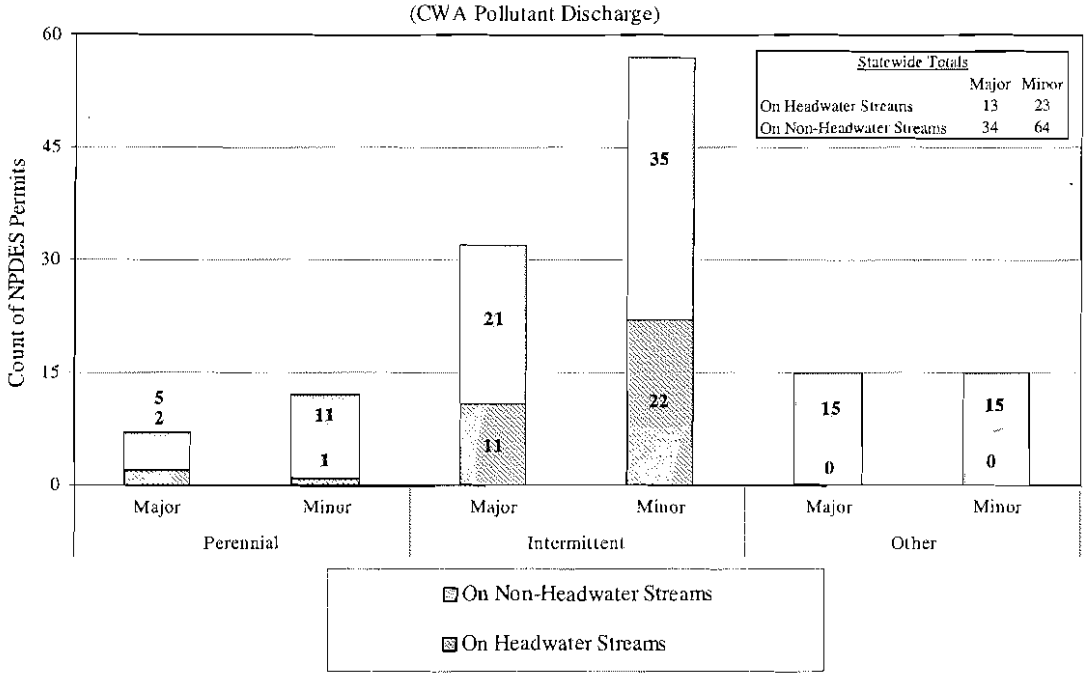
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Arizona Streams

(CWA Pollutant Discharge)



Legend: Out of 183 total NPDES Individual permits statewide, 73% (134 permits) have location data. Of those with location data, 27% (36 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

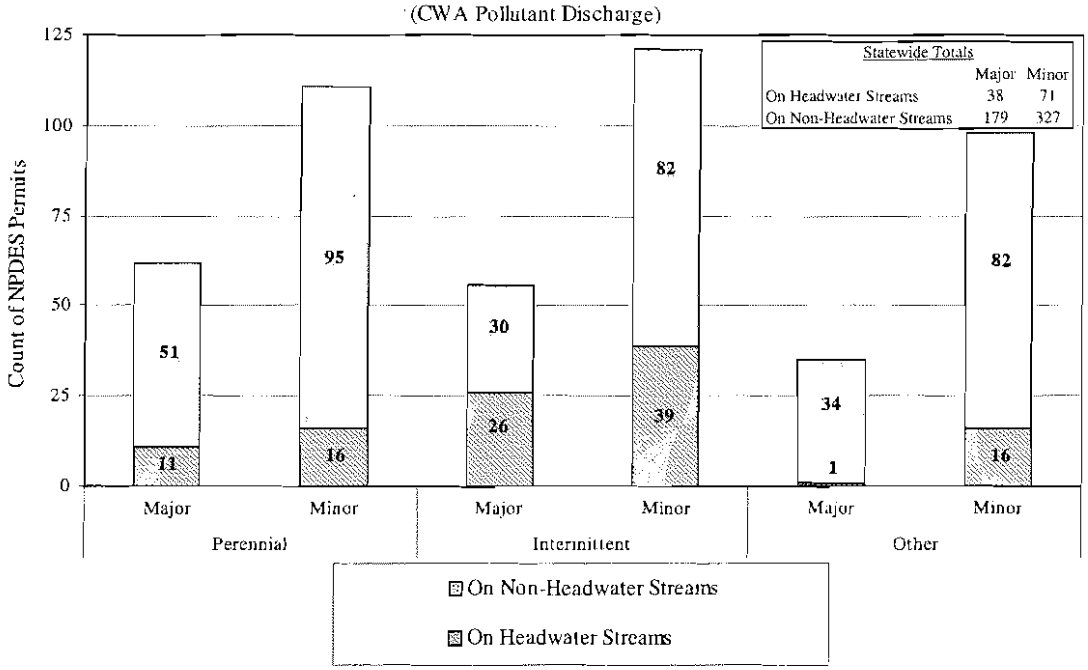
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on California Streams

(CWA Pollutant Discharge)



Legend: Out of 849 total NPDES Individual permits statewide, 72% (615 permits) have location data. Of those with location data, 18% (109 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

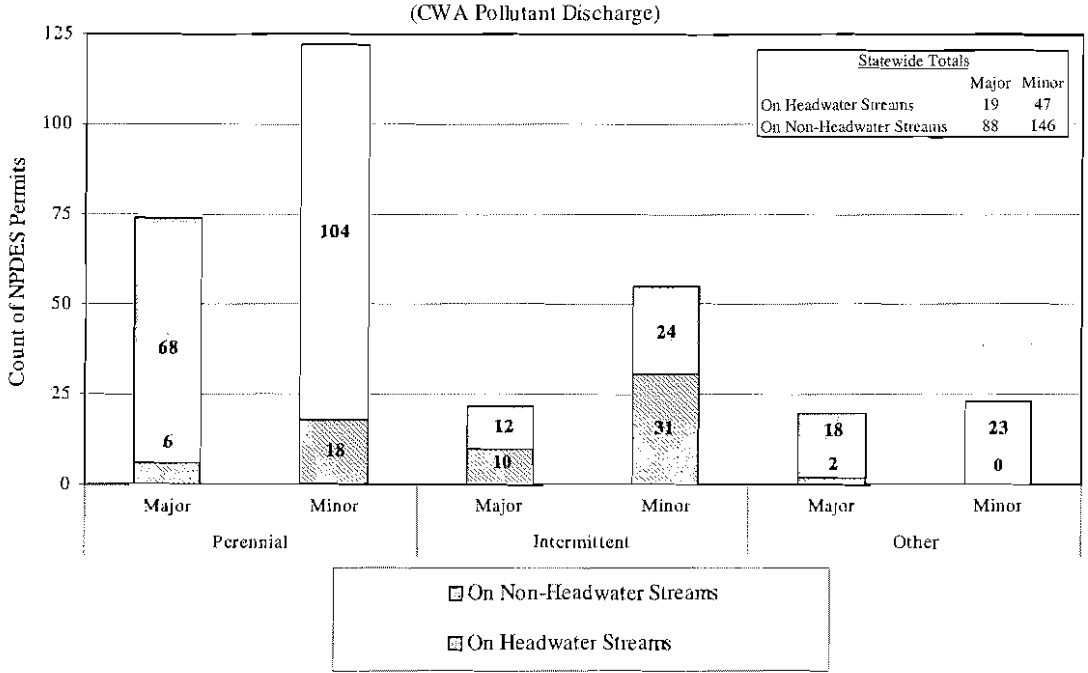
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Colorado Streams

(CWA Pollutant Discharge)



Legend: Out of 399 total NPDES Individual permits statewide, 75% (300 permits) have location data. Of those with location data, 22% (66 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

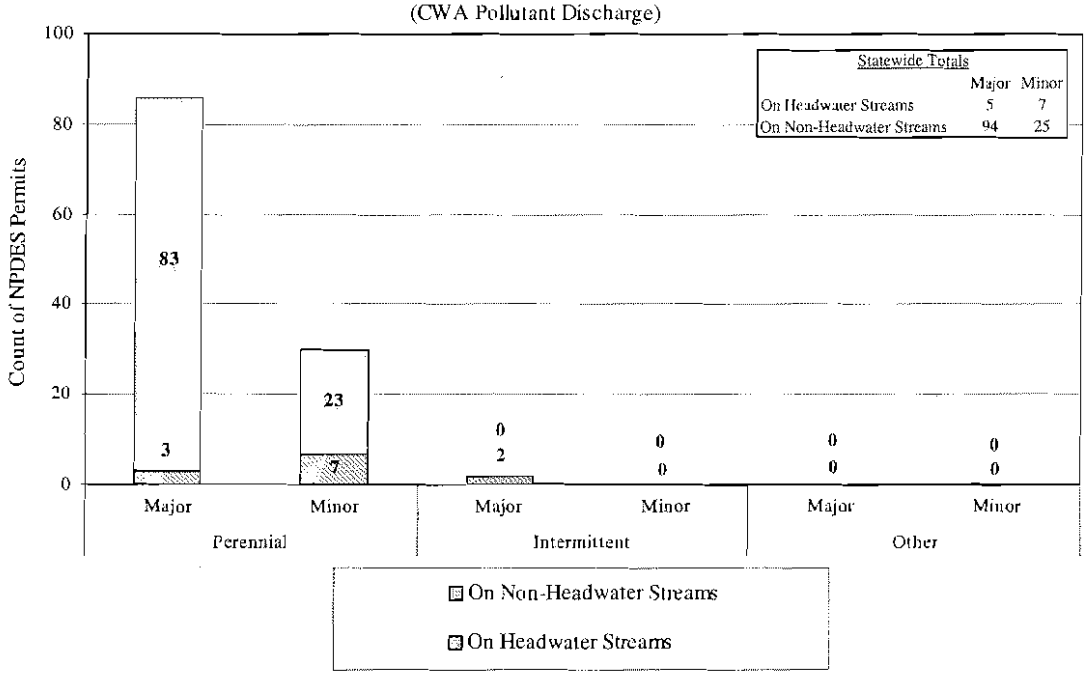
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Connecticut Streams

(CWA Pollutant Discharge)



Statewide Totals

	Major	Minor
On Headwater Streams	5	7
On Non-Headwater Streams	94	25

Legend: Out of 197 total NPDES Individual permits statewide, 66% (131 permits) have location data. Of those with location data, 9% (12 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

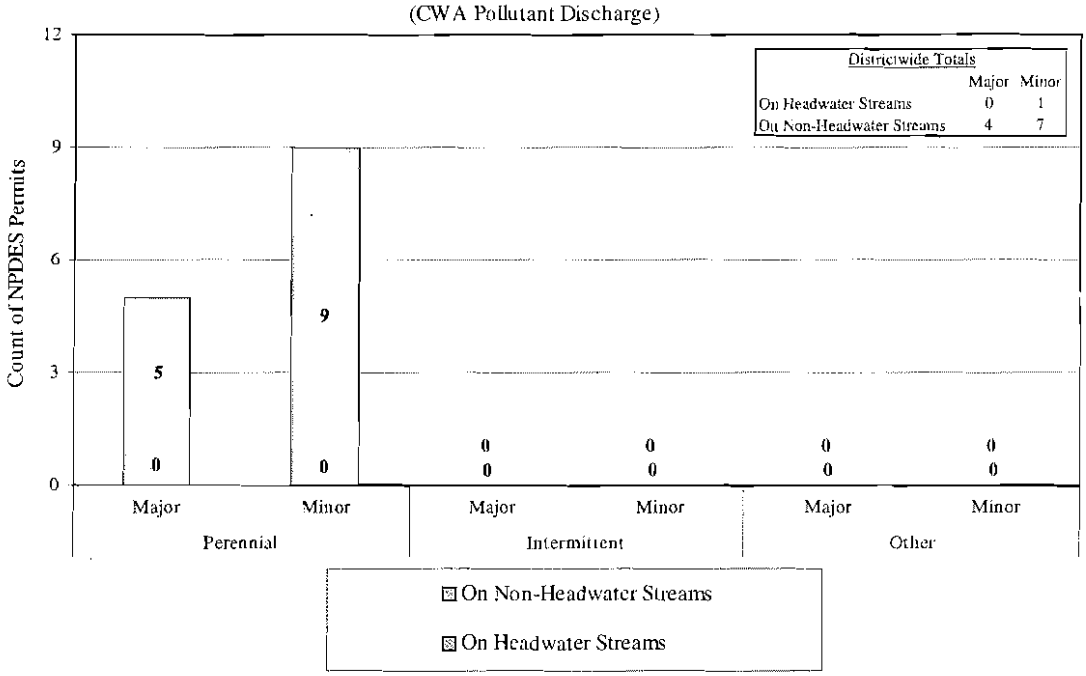
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and epbemeral streams grouped together.
- Washes in the arid western U.S. not consistently demareated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Washington, D.C. Streams

(CWA Pollutant Discharge)



Legend: Out of 15 total NPDES Individual permits districtwide, 80% (12 permits) have location data. Of those with location data, 8% (1 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

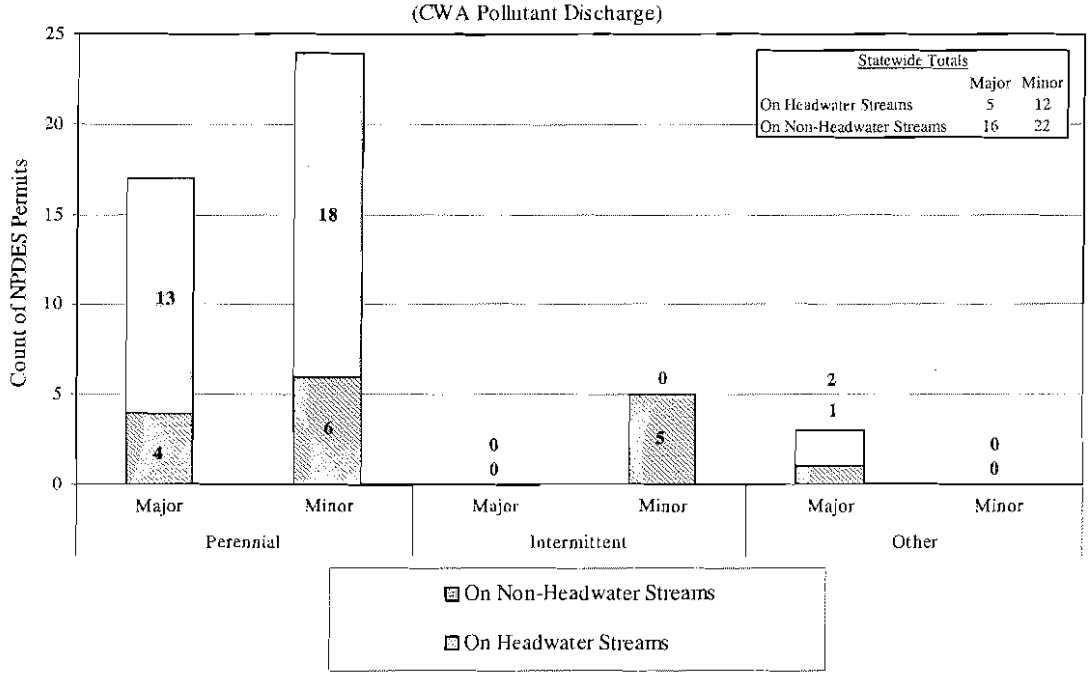
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Delaware Streams

(CWA Pollutant Discharge)



Legend: Out of 57 total NPDES Individual permits statewide, 96% (55 permits) have location data. Of those with location data, 31% (17 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

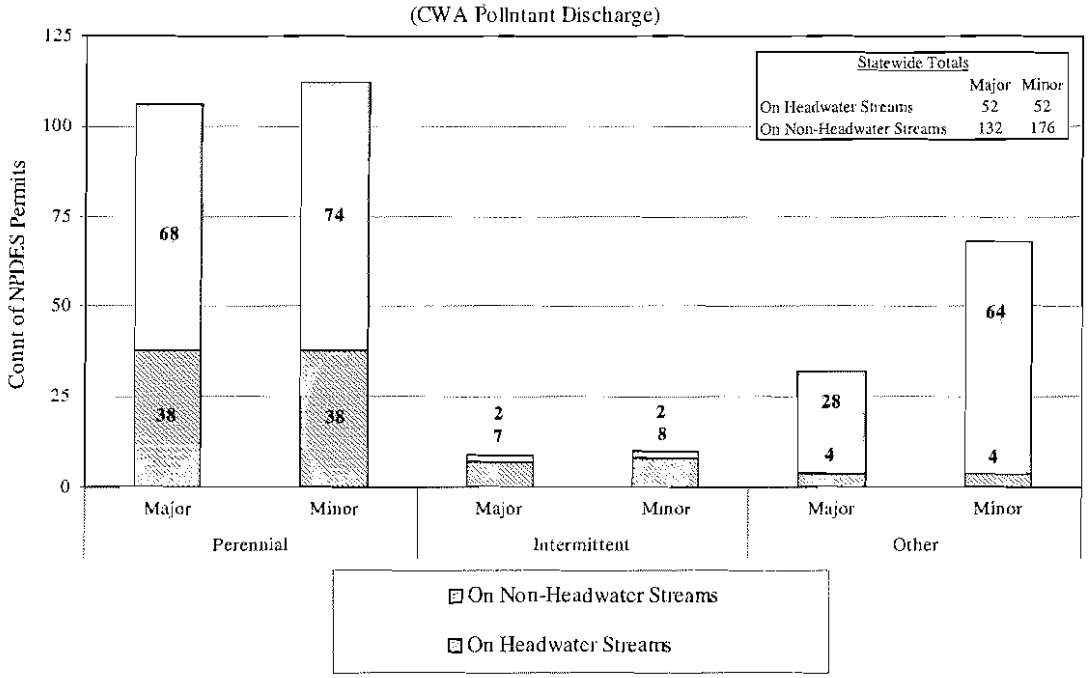
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Florida Streams

(CWA Pollutant Discharge)



Legend: Out of 493 total NPDES Individual permits statewide, 84% (412 permits) have location data. Of those with location data, 25% (104 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

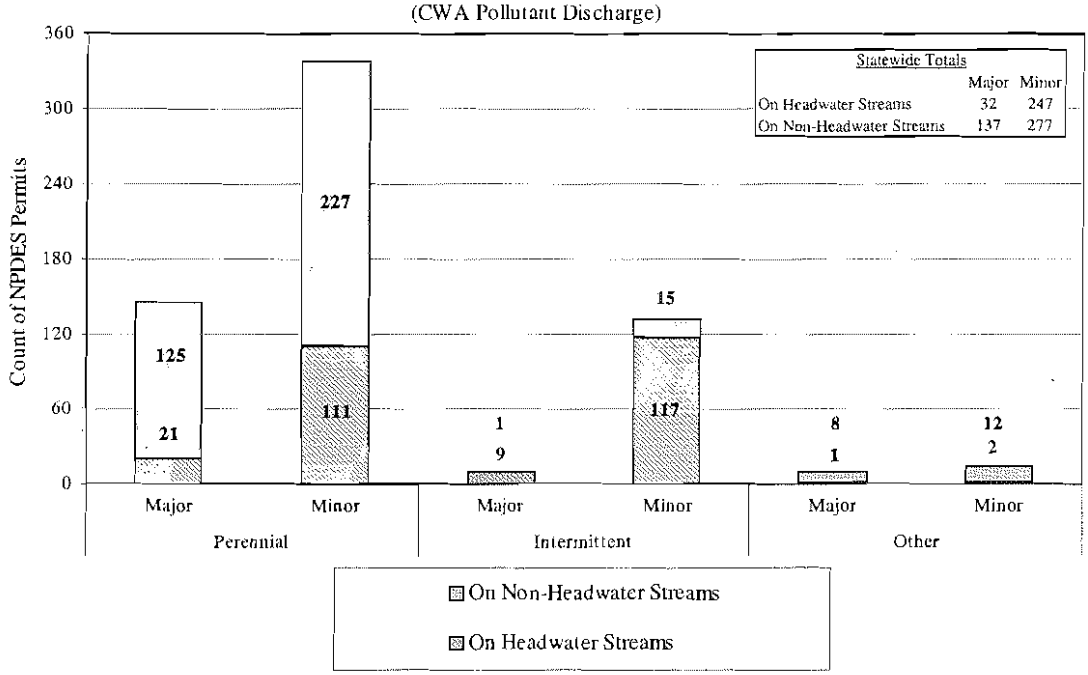
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Georgia Streams

(CWA Pollutant Discharge)



Legend: Out of 843 total NPDES Individual permits statewide, 82% (693 permits) have location data. Of those with location data, 40% (279 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

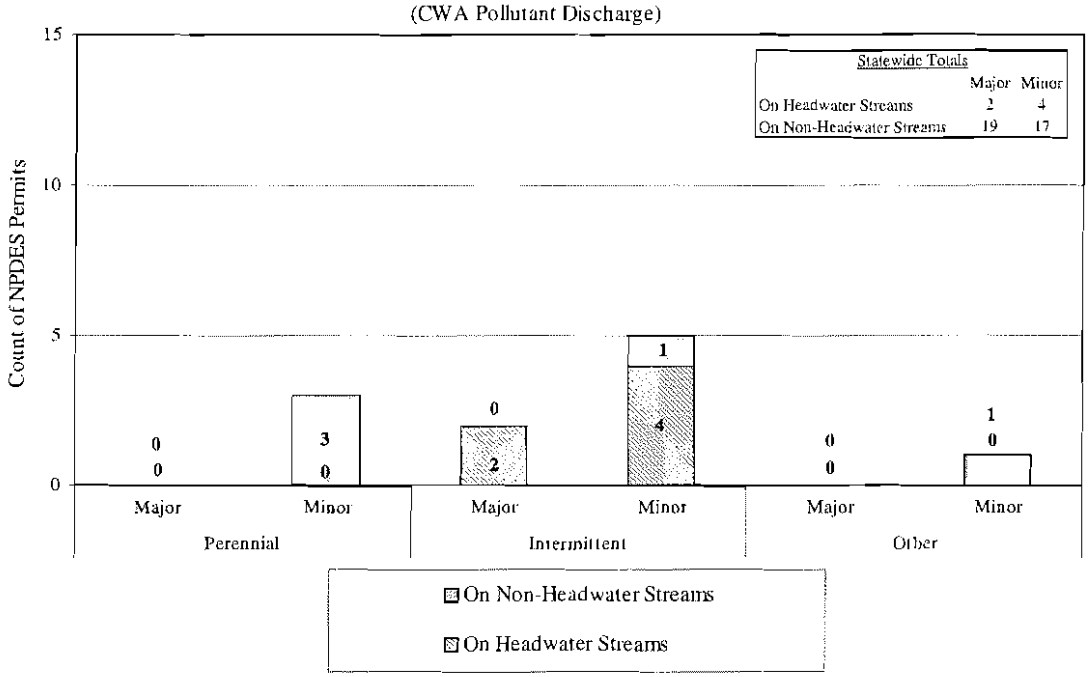
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Hawaii Streams

(CWA Pollutant Discharge)



Legend: Out of 79 total NPDES Individual permits statewide, 53% (42 permits) have location data. Of those with location data, 14% (6 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

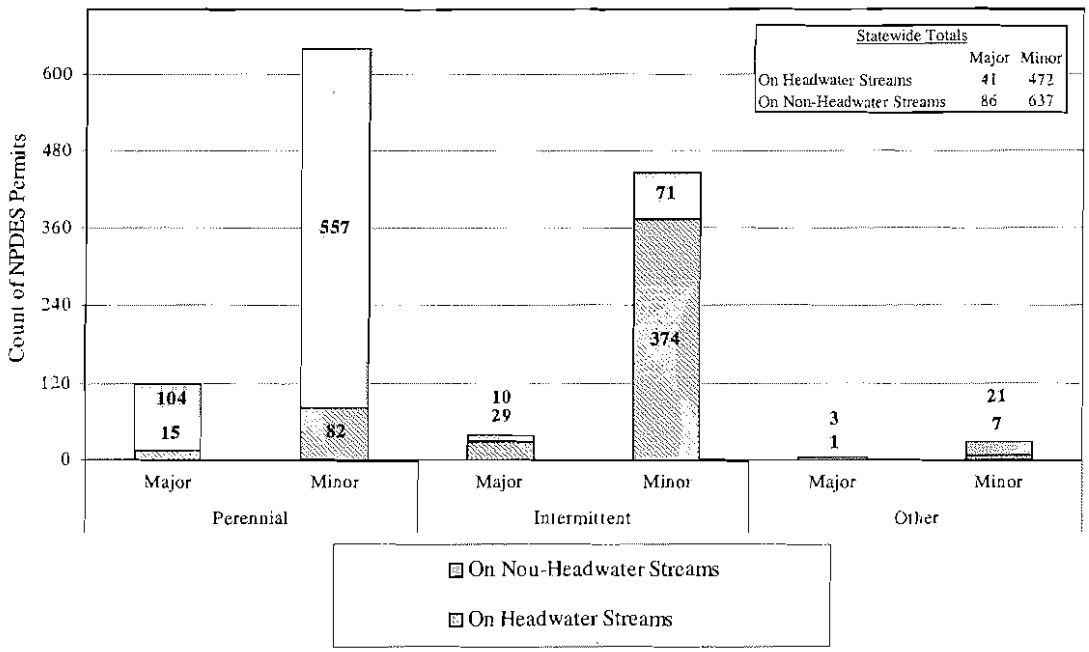
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Iowa Streams

(CWA Pollutant Discharge)



Legend: Out of 1,512 total NPDES Individual permits statewide, 82% (1,236 permits) have location data. Of those with location data, 42% (513 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

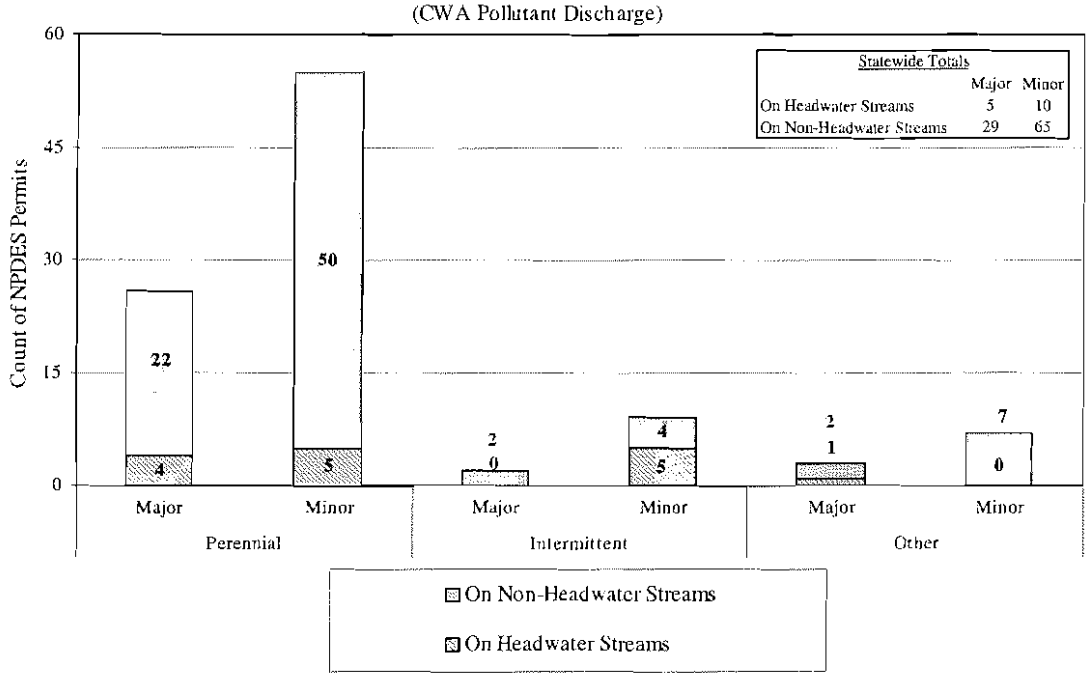
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Idaho Streams

(CWA Pollutant Discharge)



Legend: Out of 197 total NPDES Individual permits statewide, 55% (109 permits) have location data. Of those with location data, 14% (15 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

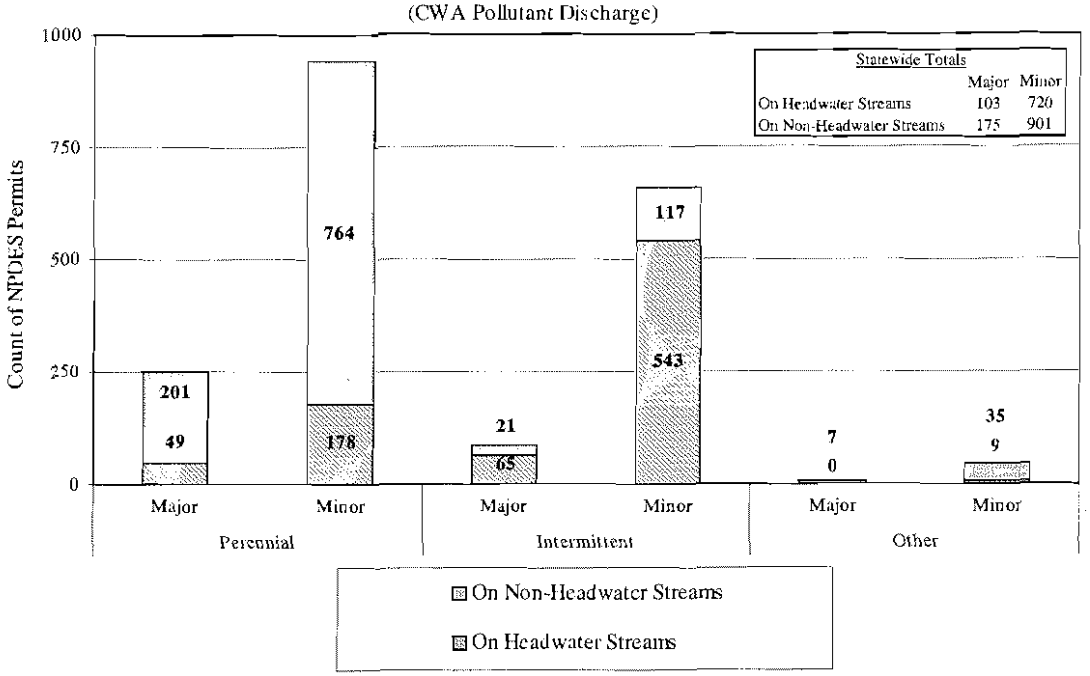
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Illinois Streams

(CWA Pollutant Discharge)



Legend: Ont of 1,966 total NPDES Individnal permits statewide, 97% (1,899 permits) have location data. Of those with location data, 43% (823 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

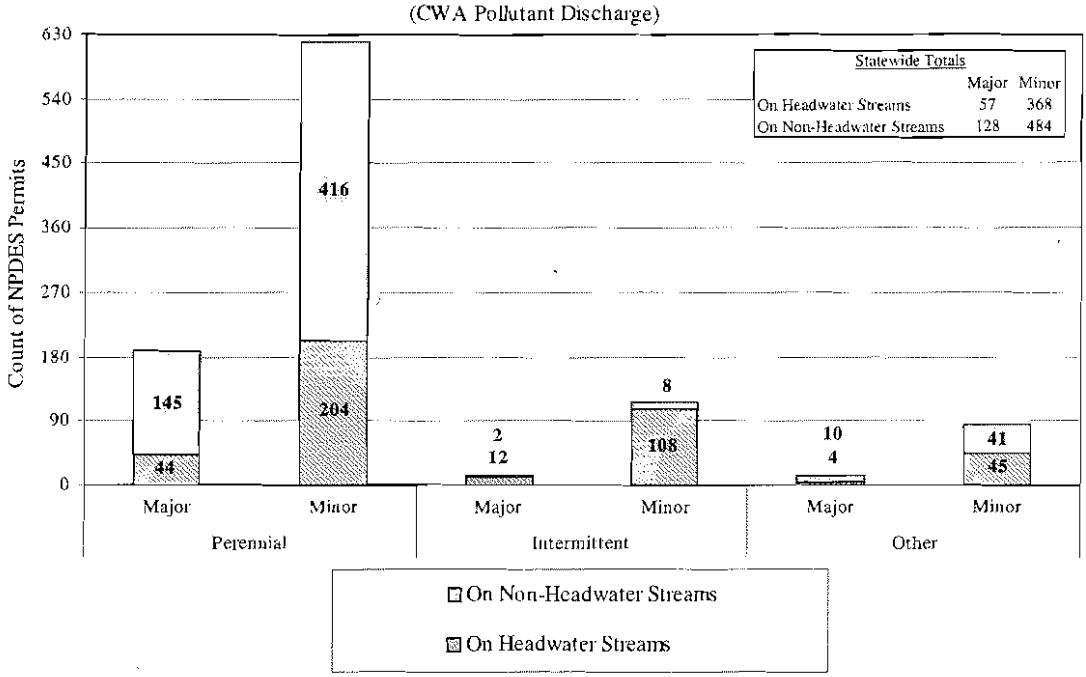
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermitteut aud ephemeral streams grouped together.
- Washes in the arid western U.S. uot consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) datahase, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" inclndes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in leugth.
- PCS facilities covered by storm water and non-storm water general permits are not included in this ehart.

Location of Individual NPDES Permits on Indiana Streams

(CWA Pollutant Discharge)



Legend: Out of 1,287 total NPDES Individual permits statewide, 81% (1,037 permits) have location data. Of those with location data, 41% (425 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

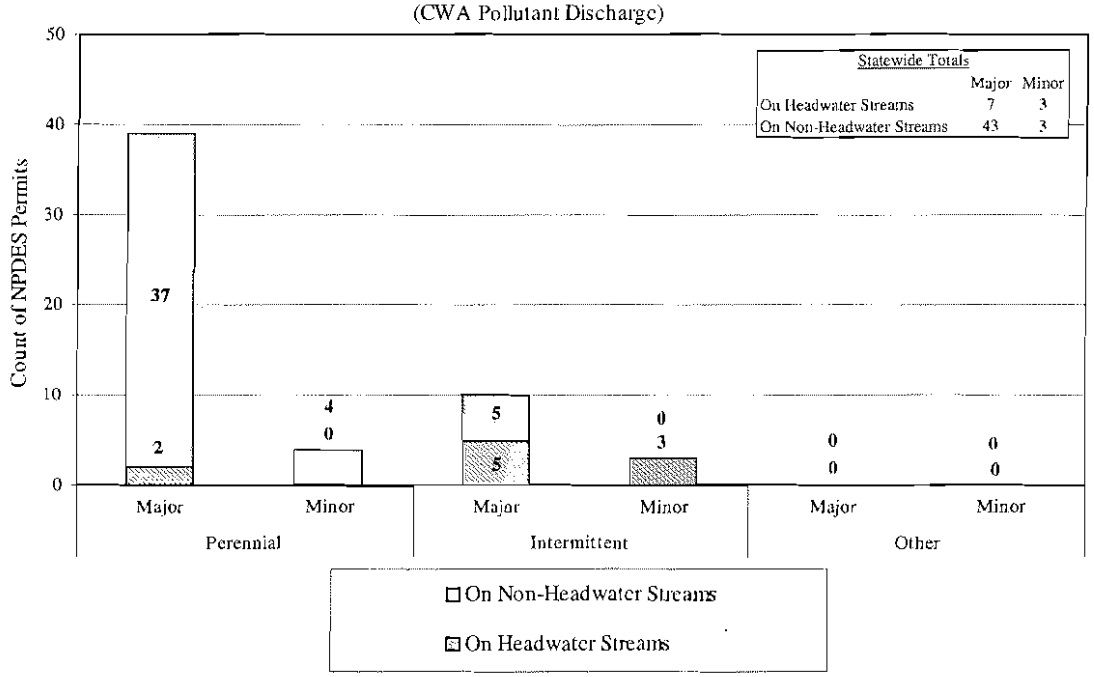
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Kansas Streams

(CWA Pollutant Discharge)



Legend: Out of 1,214 total NPDES Individual permits statewide, 5% (56 permits) have location data. Of those with location data, 18% (10 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

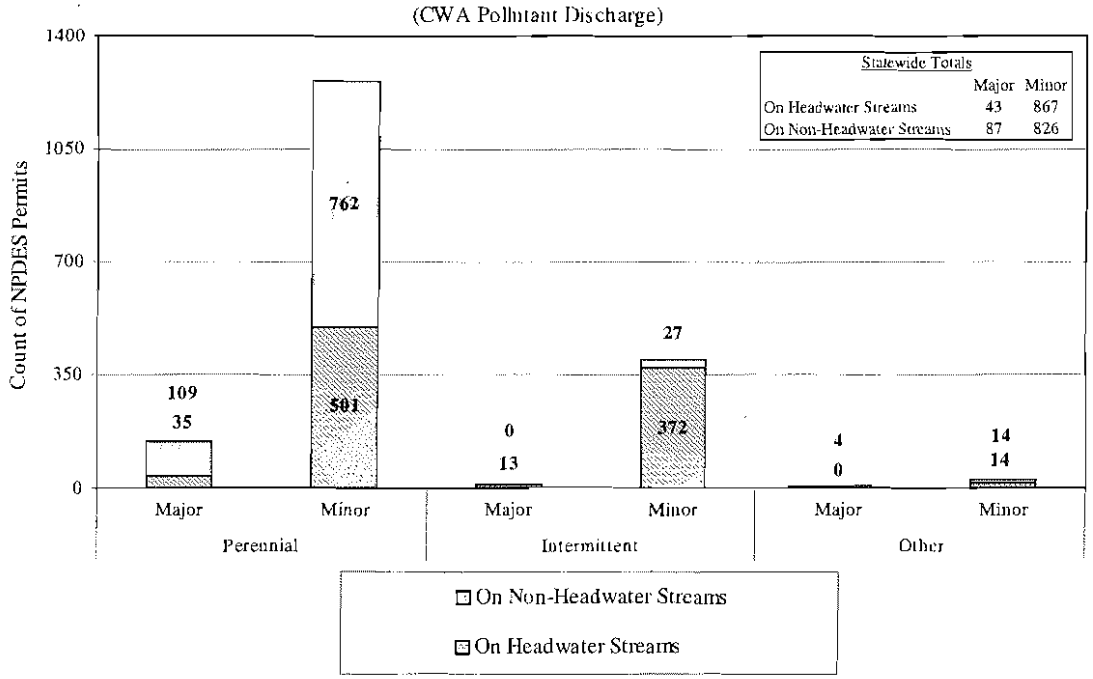
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Kentucky Streams

(CWA Pollutant Discharge)



Legend: Out of 1,847 total NPDES Individual permits statewide, 99% (1,823 permits) have location data. Of those with location data, 50% (910 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

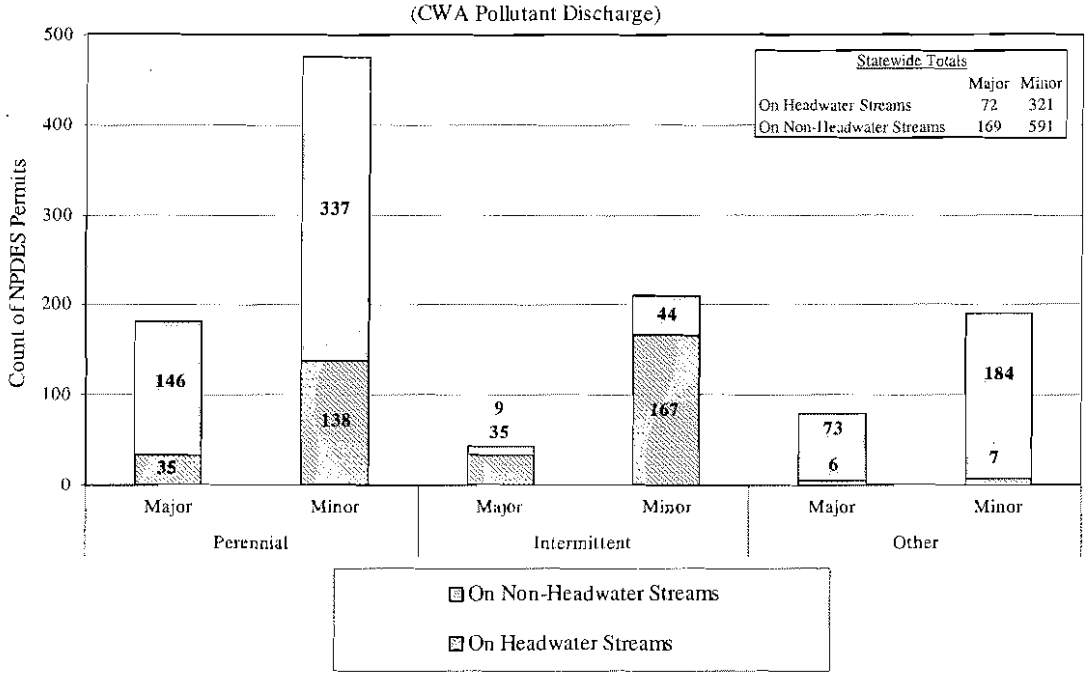
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Louisiana Streams

(CWA Pollutant Discharge)



Legend: Out of 1,707 total NPDES Individual permits statewide, 68% (1,153 permits) have location data. Of those with location data, 34% (393 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

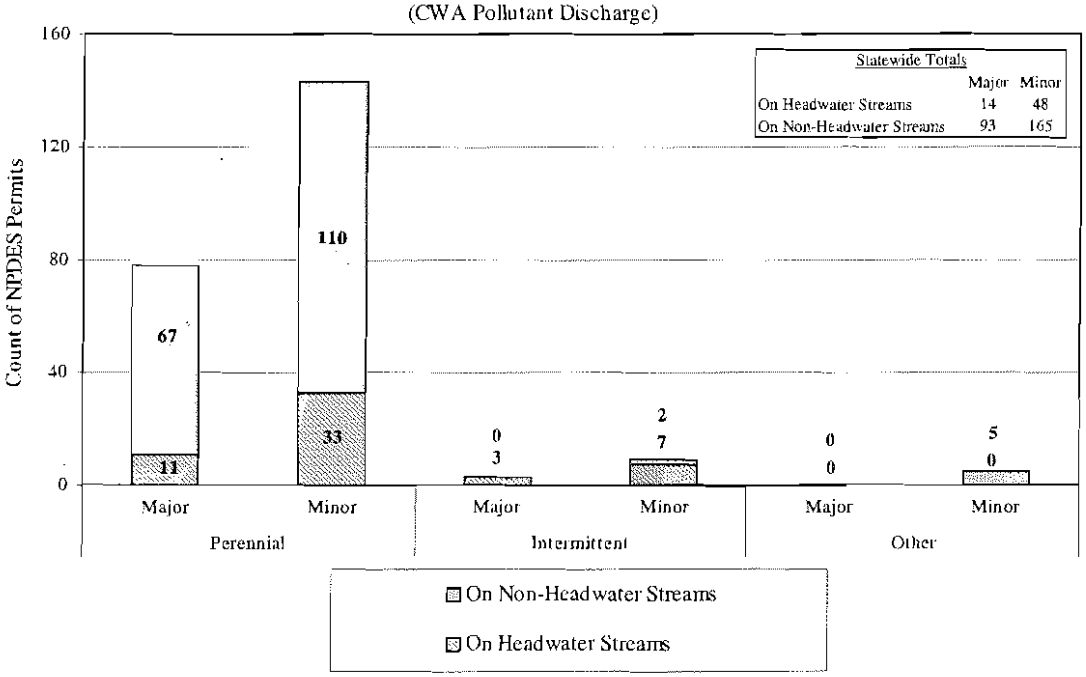
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Massachusetts Streams

(CWA Pollutant Discharge)



Legend: Out of 439 total NPDES Individual permits statewide, 73% (320 permits) have location data. Of those with location data, 19% (62 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

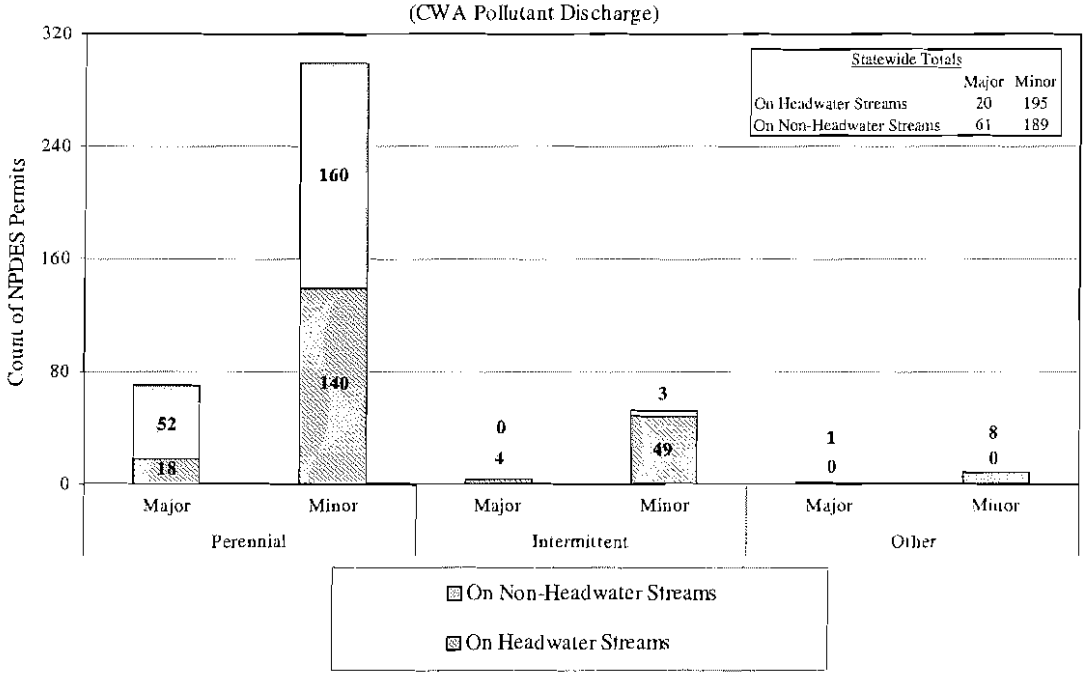
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Maryland Streams

(CWA Pollutant Discharge)



Legend: Out of 584 total NPDES Individual permits statewide, 80% (465 permits) have location data. Of those with location data, 46% (215 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

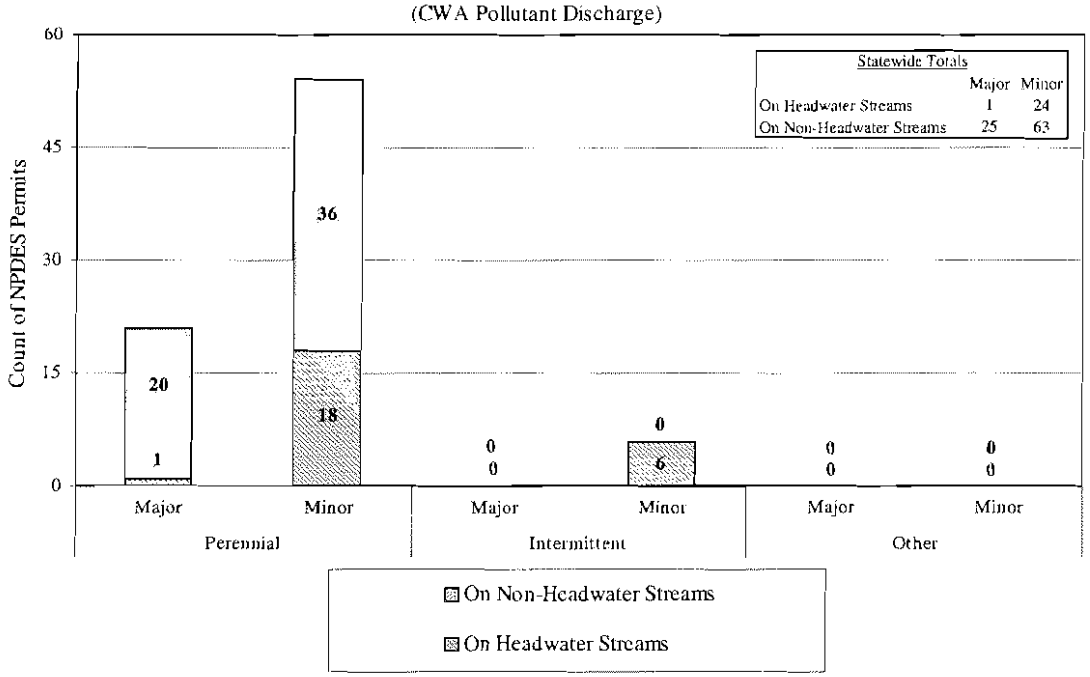
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Maine Streams

(CWA Pollutant Discharge)



Legend: Out of 353 total NPDES Individual permits statewide, 32% (113 permits) have location data. Of those with location data, 22% (25 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

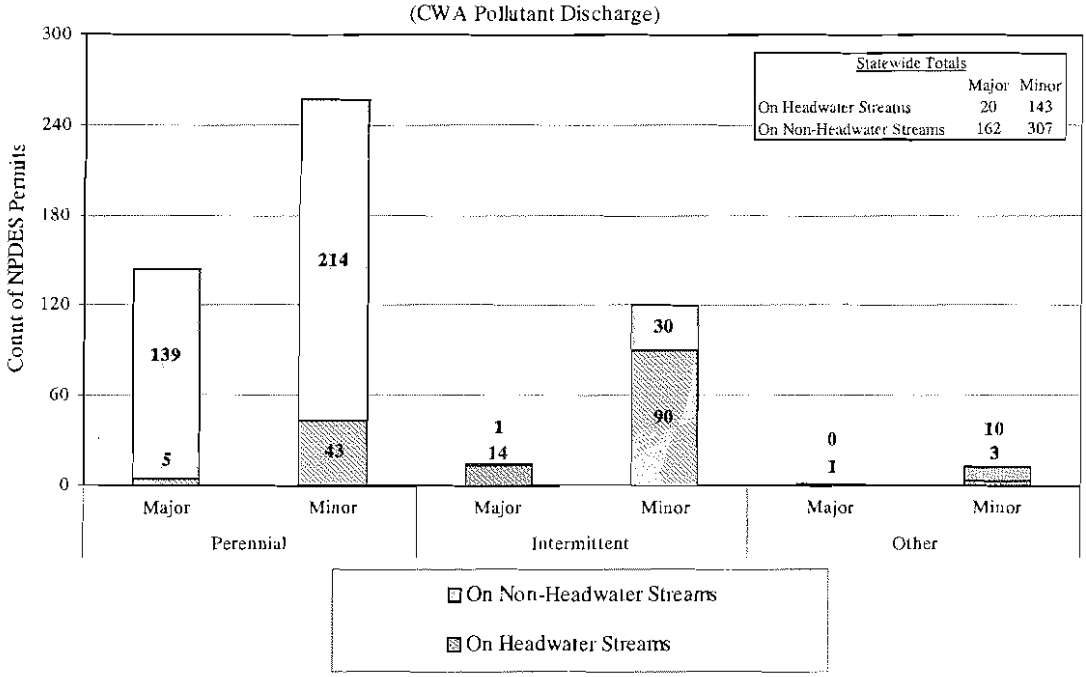
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Michigan Streams

(CWA Pollutant Discharge)



Legend: Out of 685 total NPDES Individual permits statewide, 92% (632 permits) have location data. Of those with location data, 26% (163 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

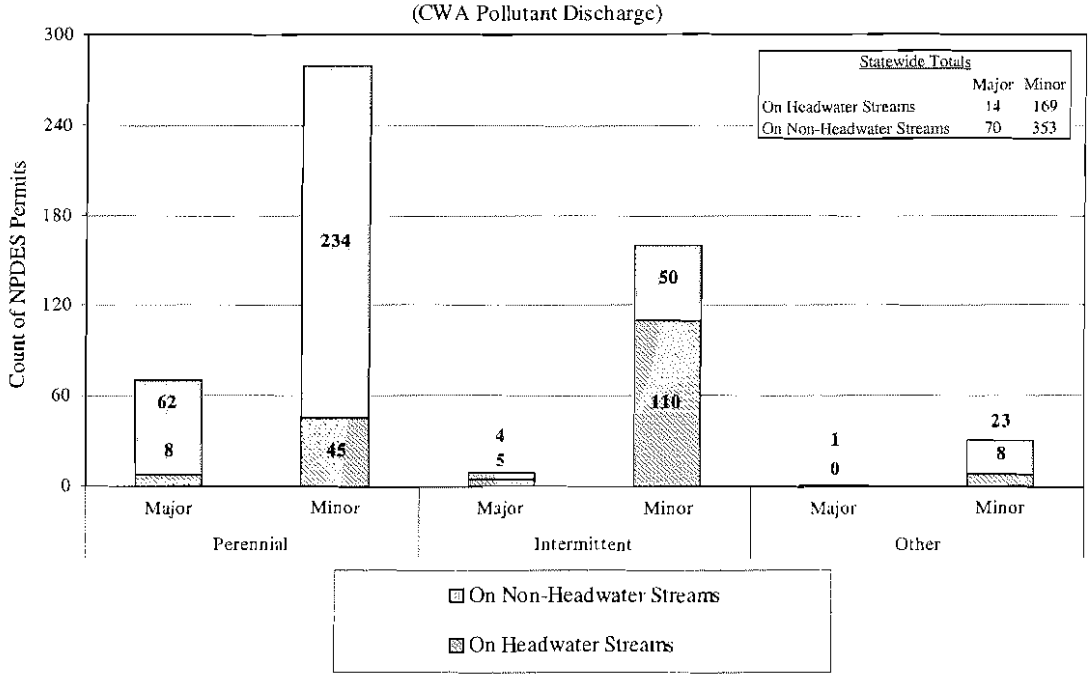
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Minnesota Streams

(CWA Pollutant Discharge)



Legend: Out of 925 total NPDES Individual permits statewide, 66% (606 permits) have location data. Of those with location data, 30% (183 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

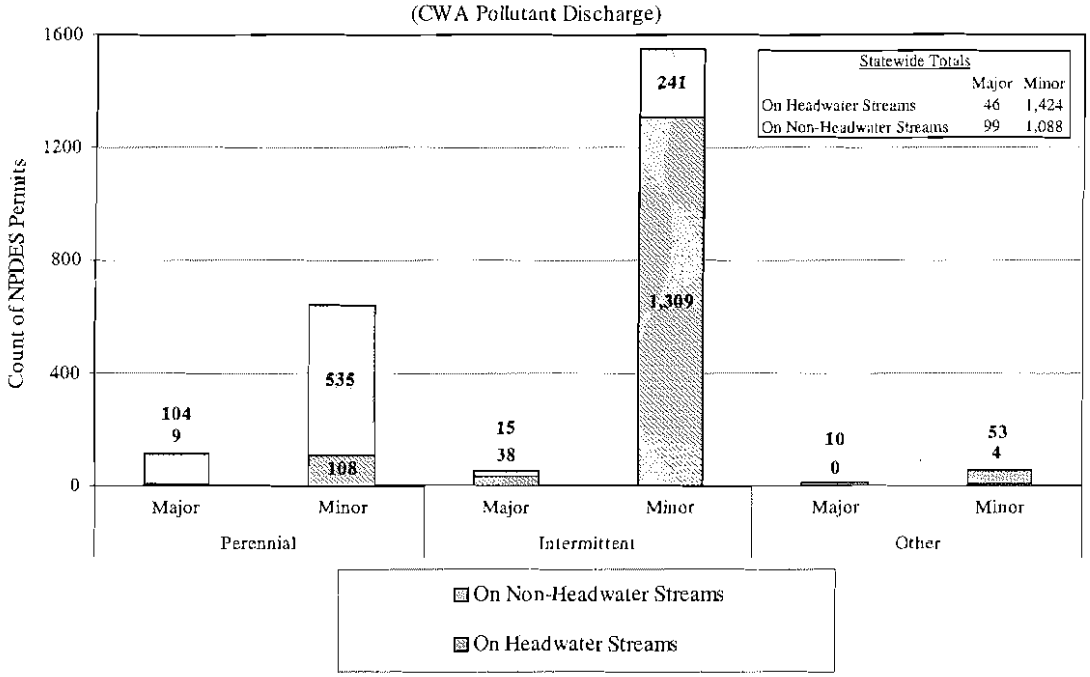
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermitteut and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Missouri Streams

(CWA Pollutant Discharge)



Legend: Out of 3,015 total NPDES Individual permits statewide, 88% (2,657 permits) have location data. Of those with location data, 55% (1,470 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

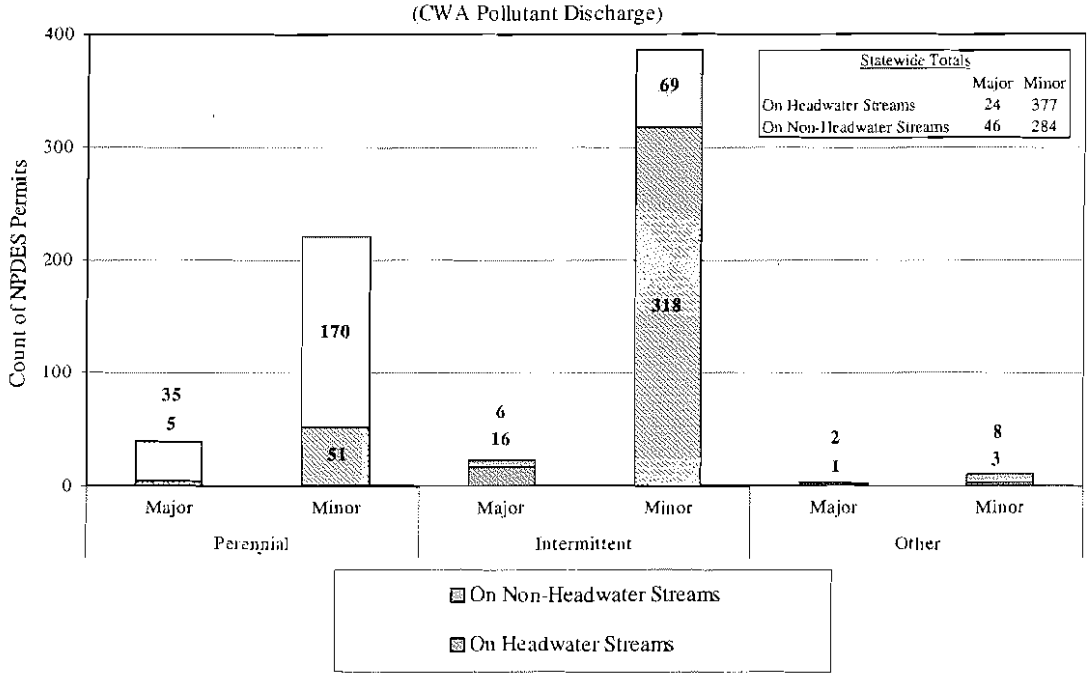
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Mississippi Streams

(CWA Pollutant Discharge)



Legend: Out of 1,748 total NPDES Individual permits statewide, 42% (731 permits) have location data. Of those with location data, 55% (401 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

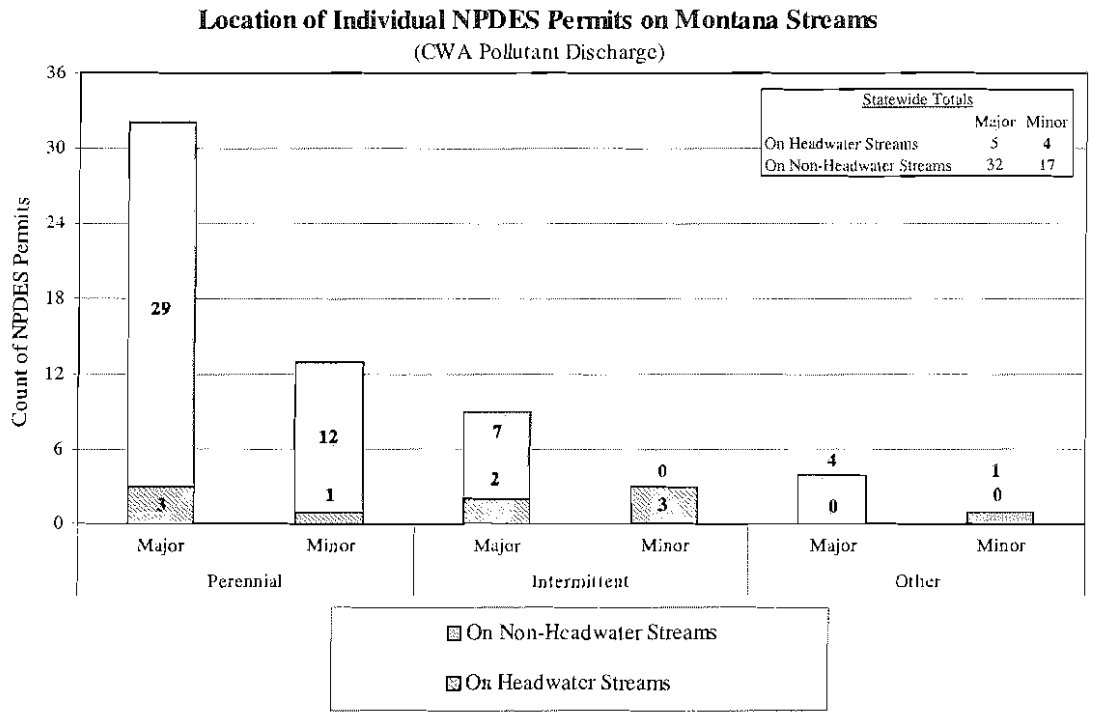
Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.



Legend: Out of 193 total NPDES Individual permits statewide, 30% (58 permits) have location data. Of those with location data, 16% (9 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

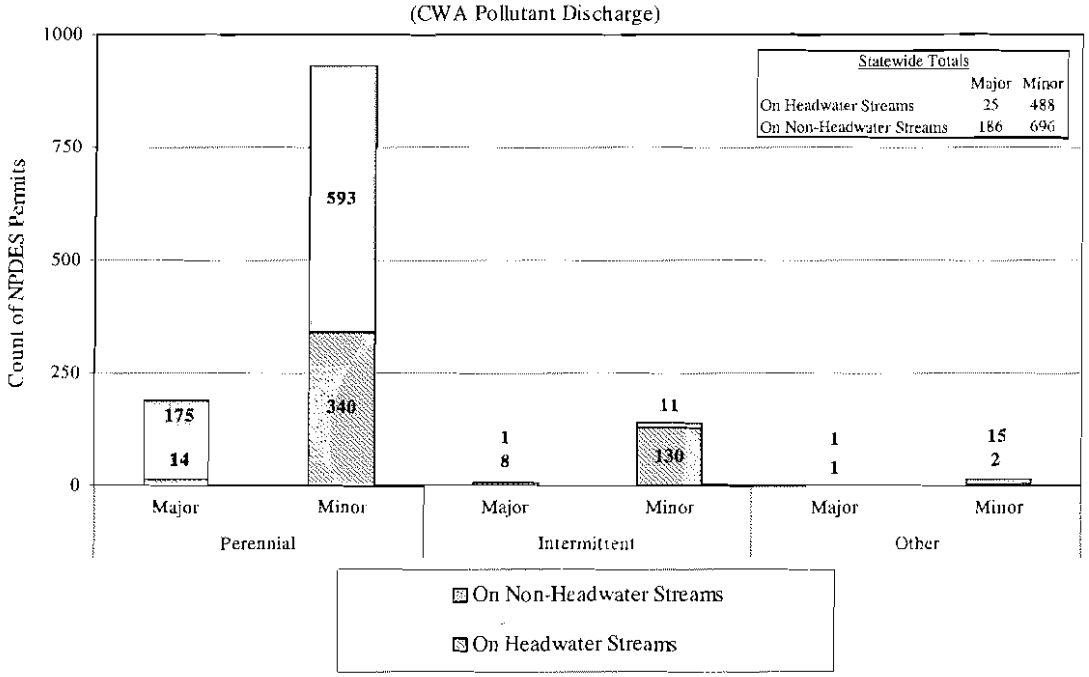
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demareated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on North Carolina Streams

(CWA Pollutant Discharge)



Legend: Out of 1,414 total NPDES Individual permits statewide, 99% (1,395 permits) have location data. Of those with location data, 37% (513 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

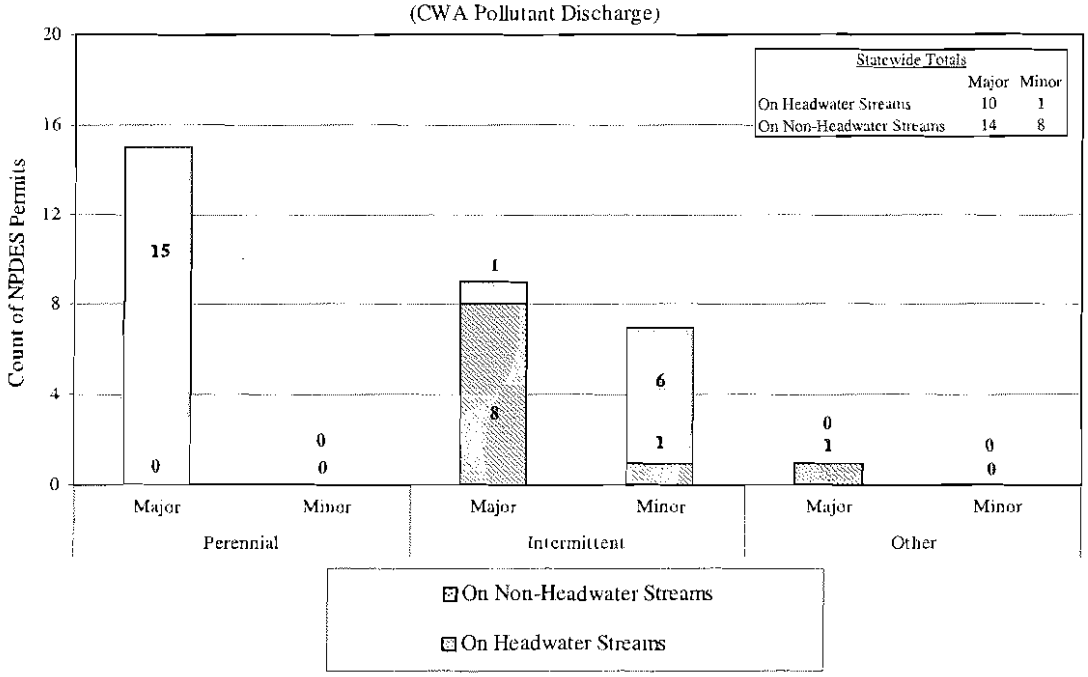
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on North Dakota Streams

(CWA Pollutant Discharge)



Legend: Out of 139 total NPDES Individual permits statewide, 24% (33 permits) have location data. Of those with location data, 33% (11 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

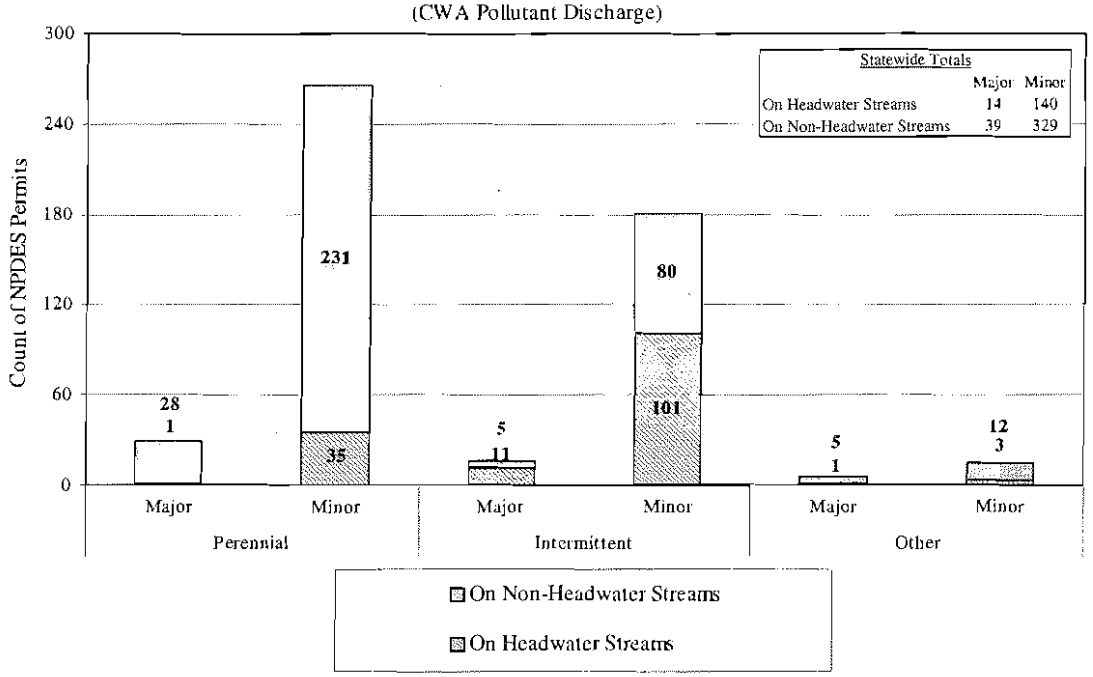
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Nebraska Streams

(CWA Pollutant Discharge)



Legend: Out of 736 total NPDES Individual permits statewide, 71% (522 permits) have location data. Of those with location data, 30% (154 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

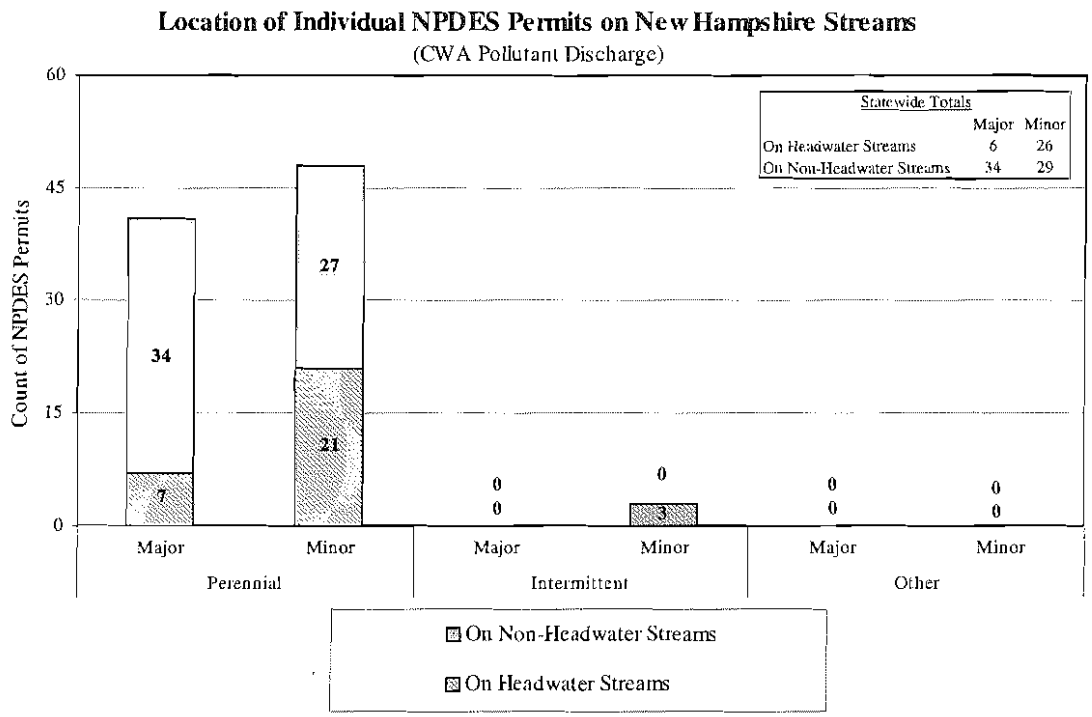
Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.



Legend: Out of 150 total NPDES Individual permits statewide, 63% (95 permits) have location data. Of those with location data, 34% (32 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

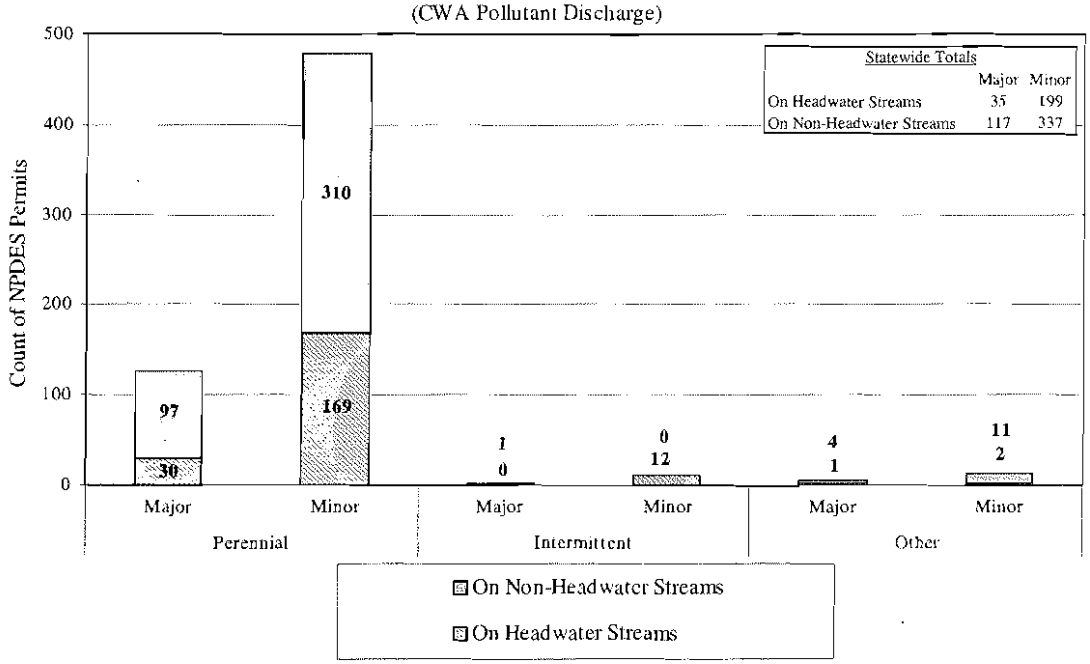
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on New Jersey Streams

(CWA Pollutant Discharge)



Legend: Out of 720 total NPDES Individual permits statewide, 96% (688 permits) have location data. Of those with location data, 34% (234 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

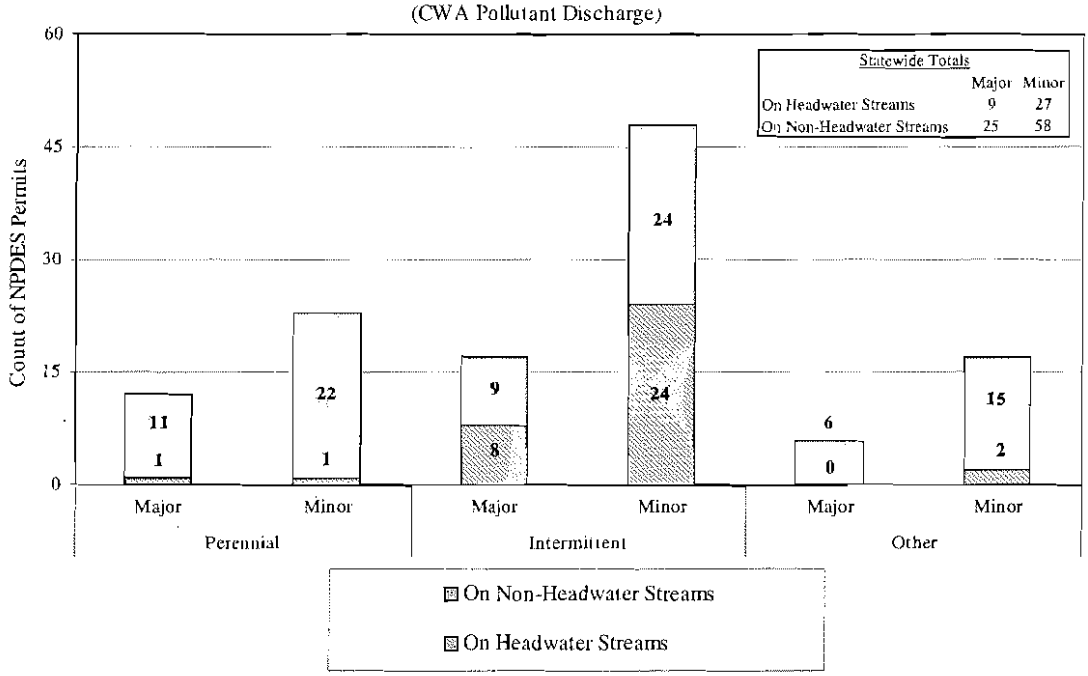
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on New Mexico Streams

(CWA Pollutant Discharge)



Legend: Out of 135 total NPDES Individual permits statewide, 88% (119 permits) have location data. Of those with location data, 30% (36 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

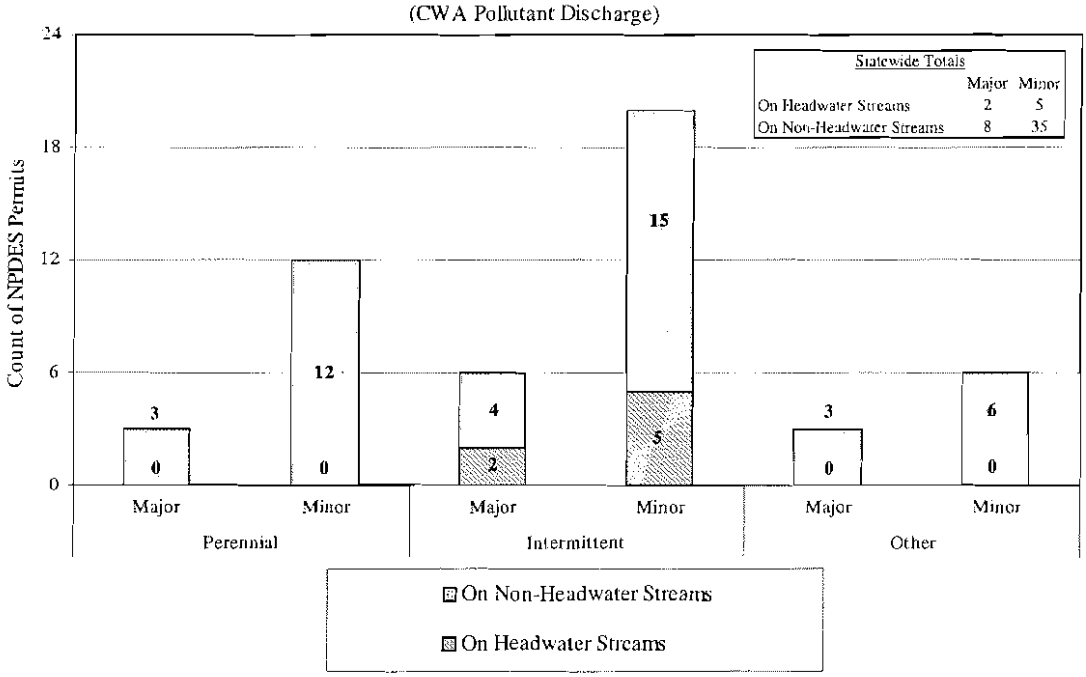
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and epbemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance Sysrem (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Nevada Streams

(CWA Pollutant Discharge)



Legend: Out of 75 total NPDES Individual permits statewide, 67% (50 permits) have location data. Of those with location data, 14% (7 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

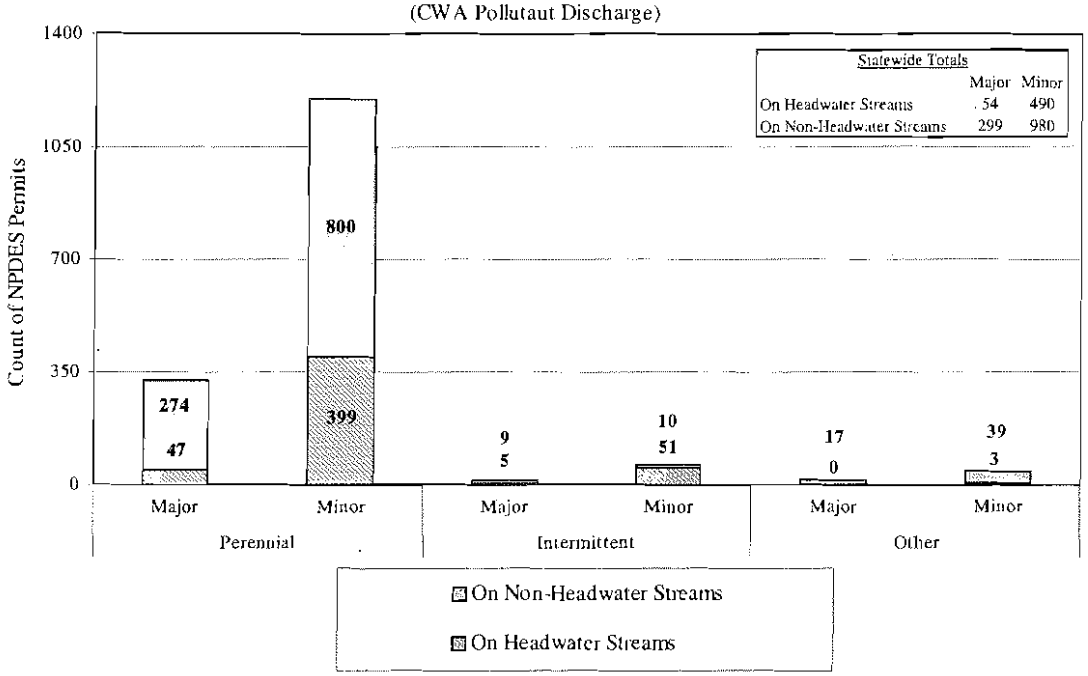
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on New York Streams

(CWA Pollutant Discharge)



Legend: Out of 1,867 total NPDES Individual permits statewide, 98% (1,823 permits) have location data. Of those with location data, 30% (544 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

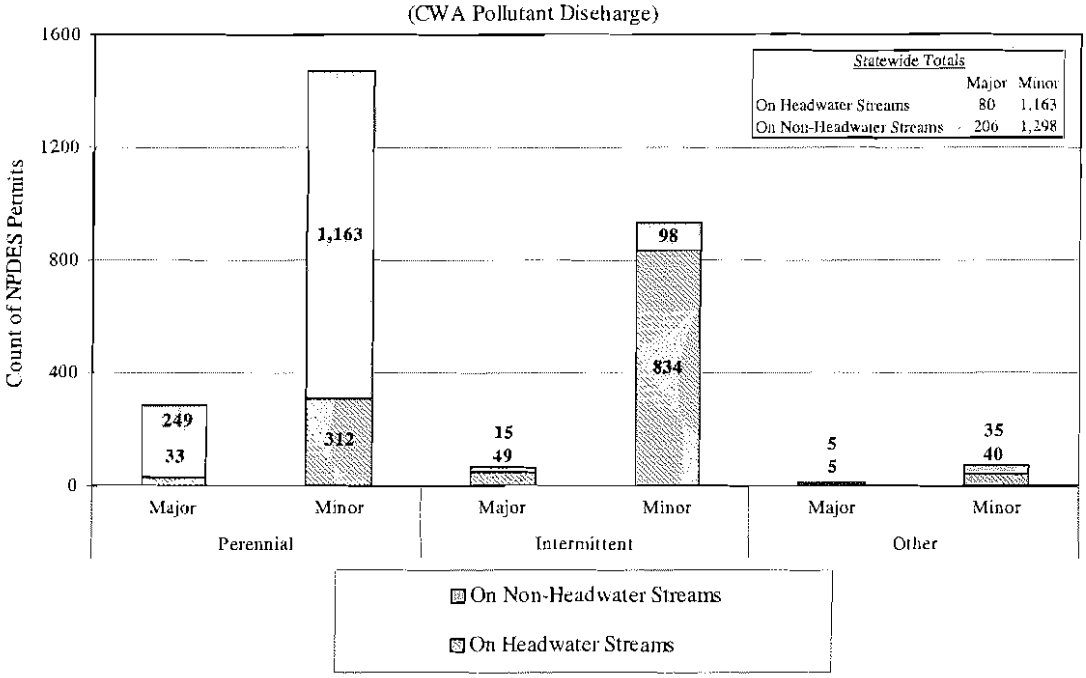
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Ohio Streams

(CWA Pollutant Discharge)



Legend: Out of 2,982 total NPDES Individual permits statewide, 92% (2,747 permits) have location data. Of those with location data, 45% (1,243 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

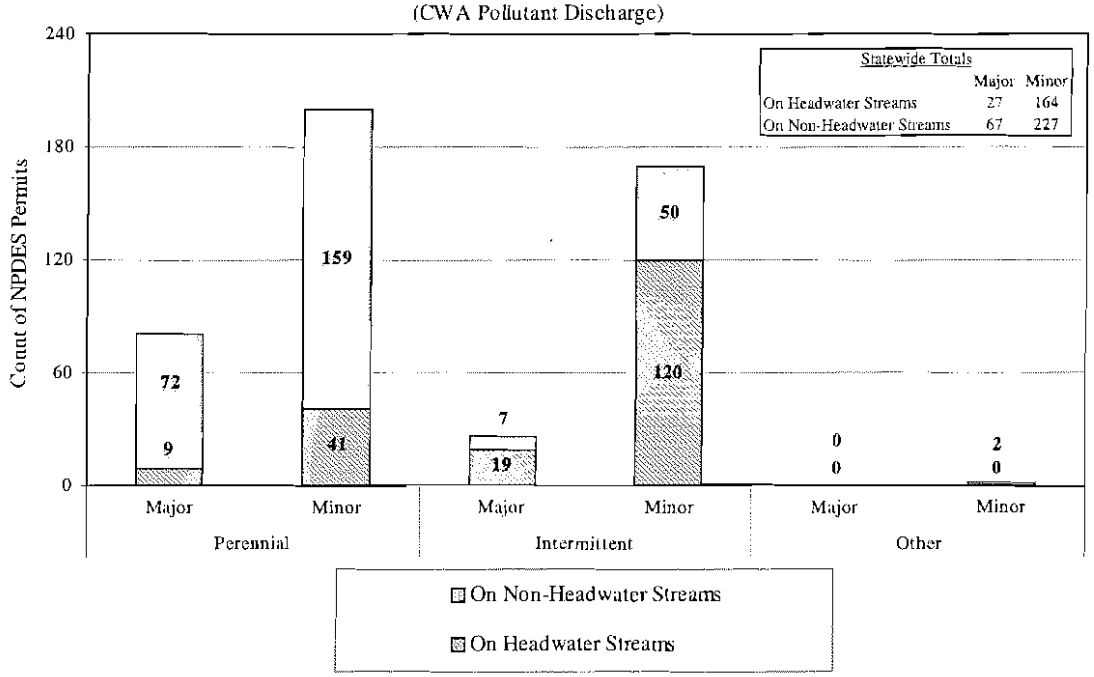
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Oklahoma Streams

(CWA Pollutant Discharge)



Legend: Out of 534 total NPDES Individual permits statewide, 91% (485 permits) have location data. Of those with location data, 39% (191 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

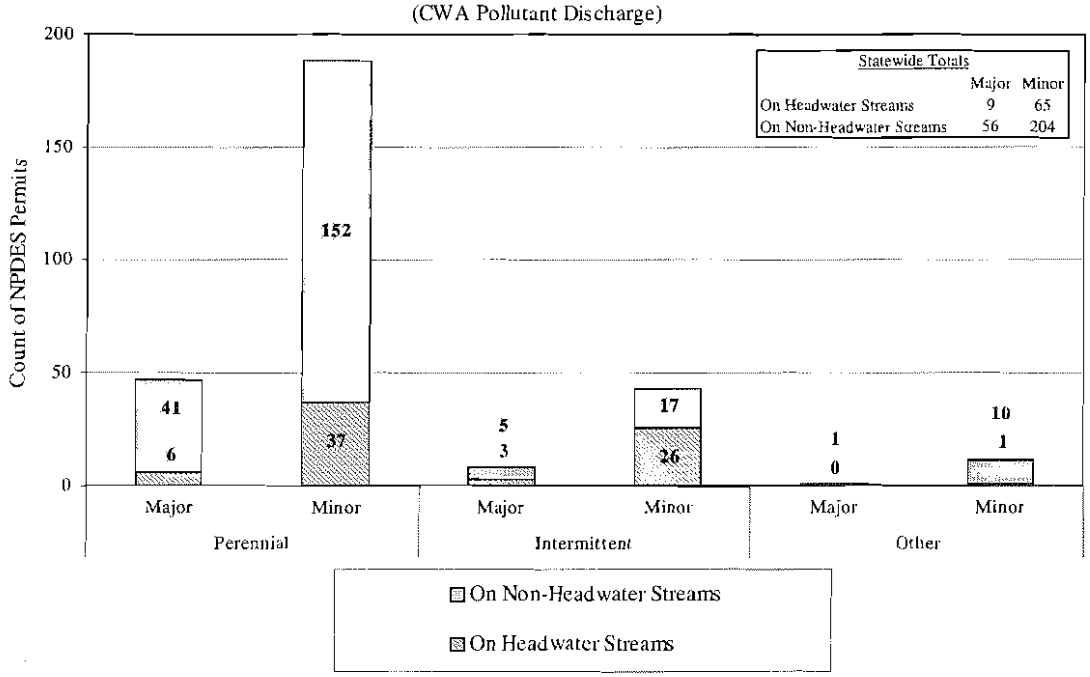
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Oregon Streams

(CWA Pollutant Discharge)



Legend: Out of 375 total NPDES Individual permits statewide, 89% (334 permits) have location data. Of those with location data, 22% (74 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

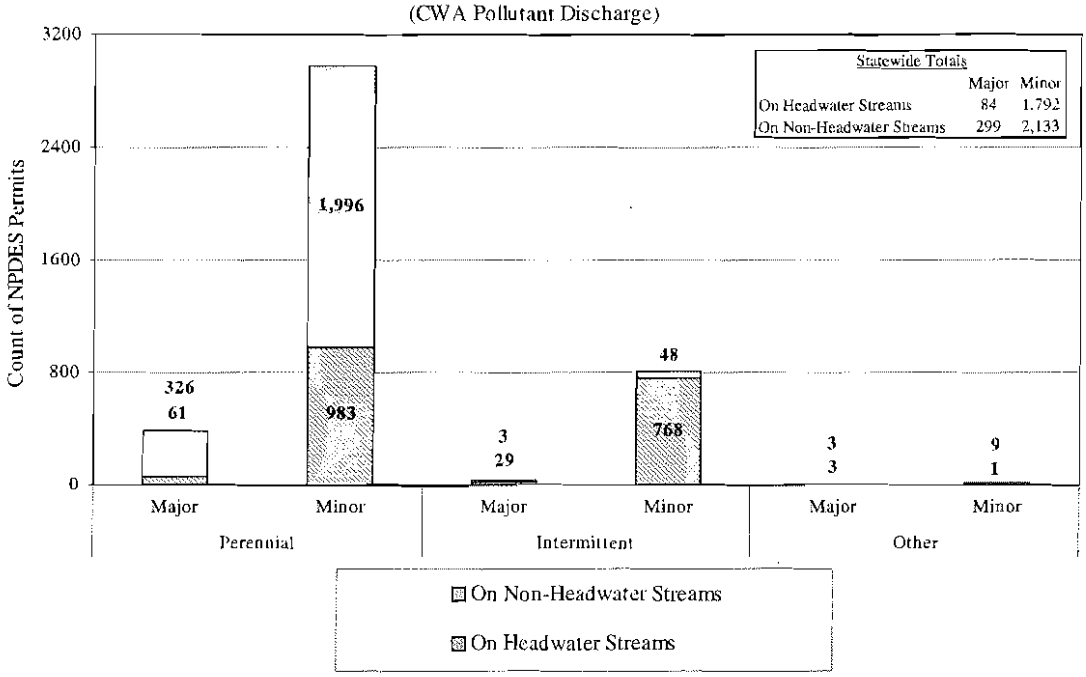
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Pennsylvania Streams

(CWA Pollutant Discharge)



Legend: Out of 4,575 total NPDES Individual permits statewide, 94% (4,308 permits) have location data. Of those with location data, 44% (1,876 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

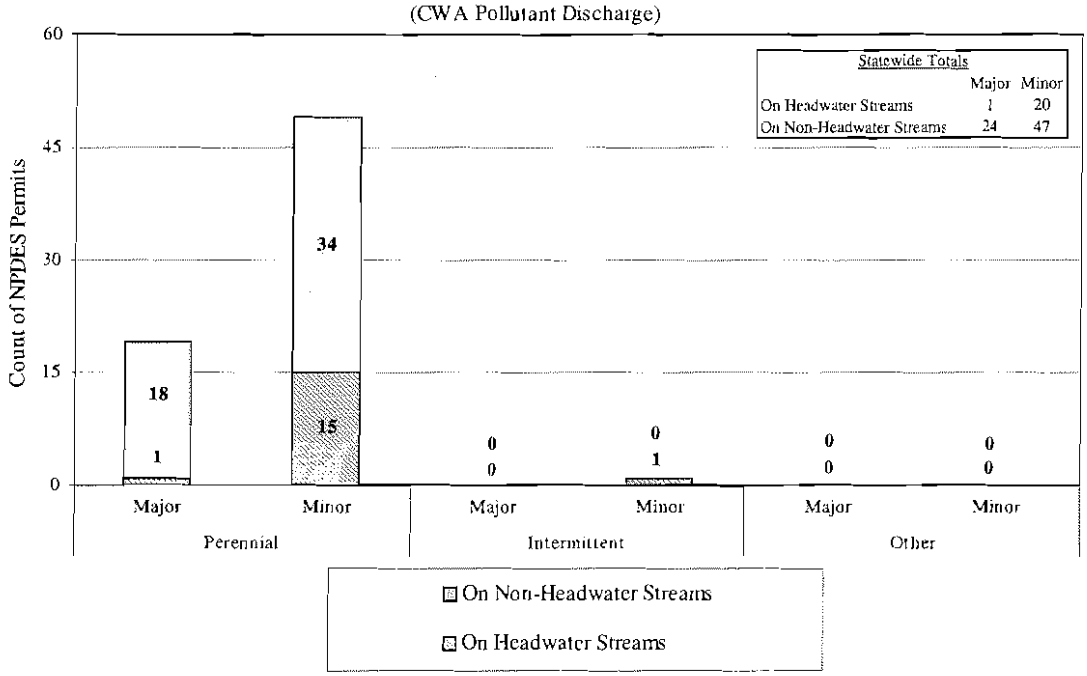
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Rhode Island Streams

(CWA Pollutant Discharge)



Legend: Out of 111 total NPDES Individual permits statewide, 83% (92 permits) have location data. Of those with location data, 23% (21 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

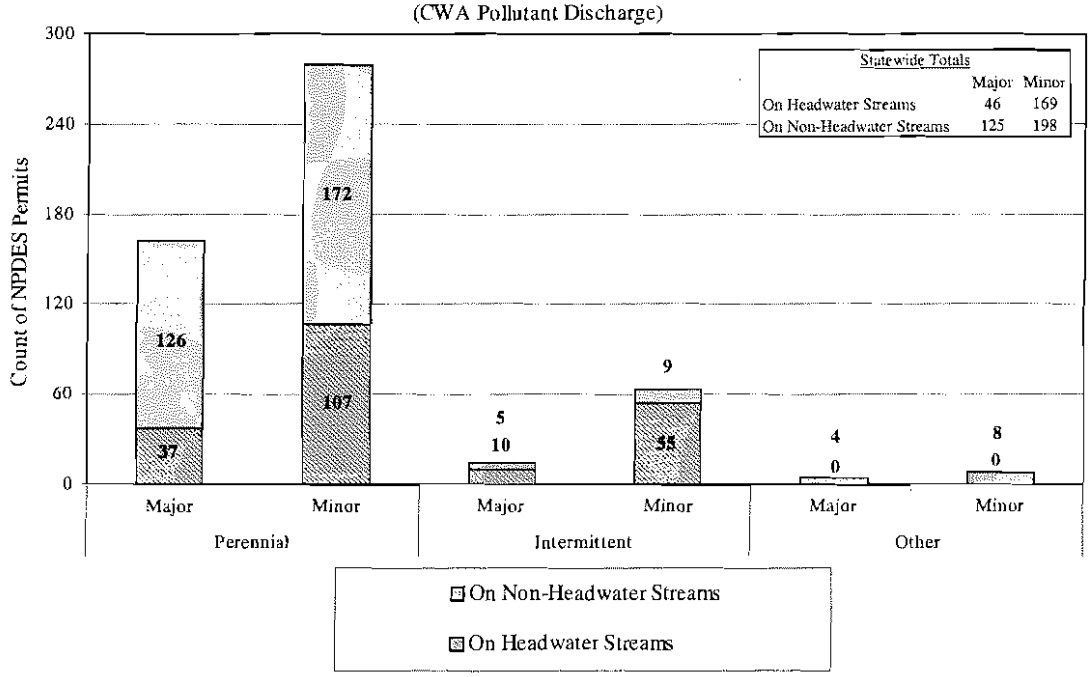
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on South Carolina Streams

(CWA Pollutant Discharge)



Legend: Out of 556 total NPDES Individual permits statewide, 97% (538 permits) have location data. Of those with location data, 40% (215 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

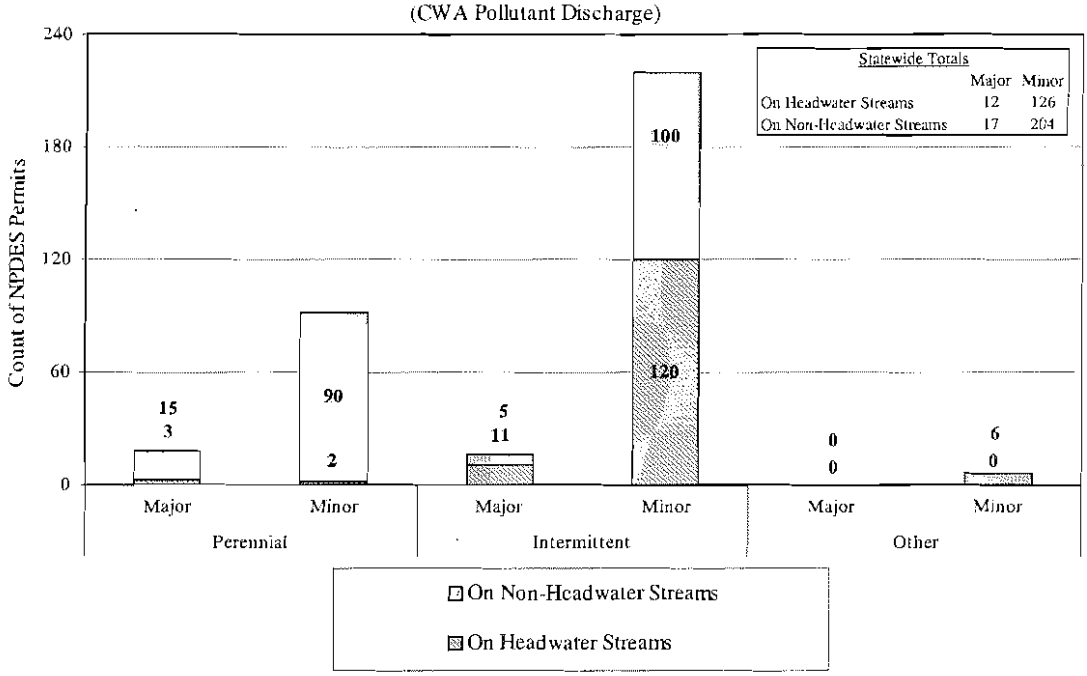
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on South Dakota Streams

(CWA Pollutant Discharge)



Legend: Out of 396 total NPDES Individual permits statewide, 91% (359 permits) have location data. Of those with location data, 38% (138 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

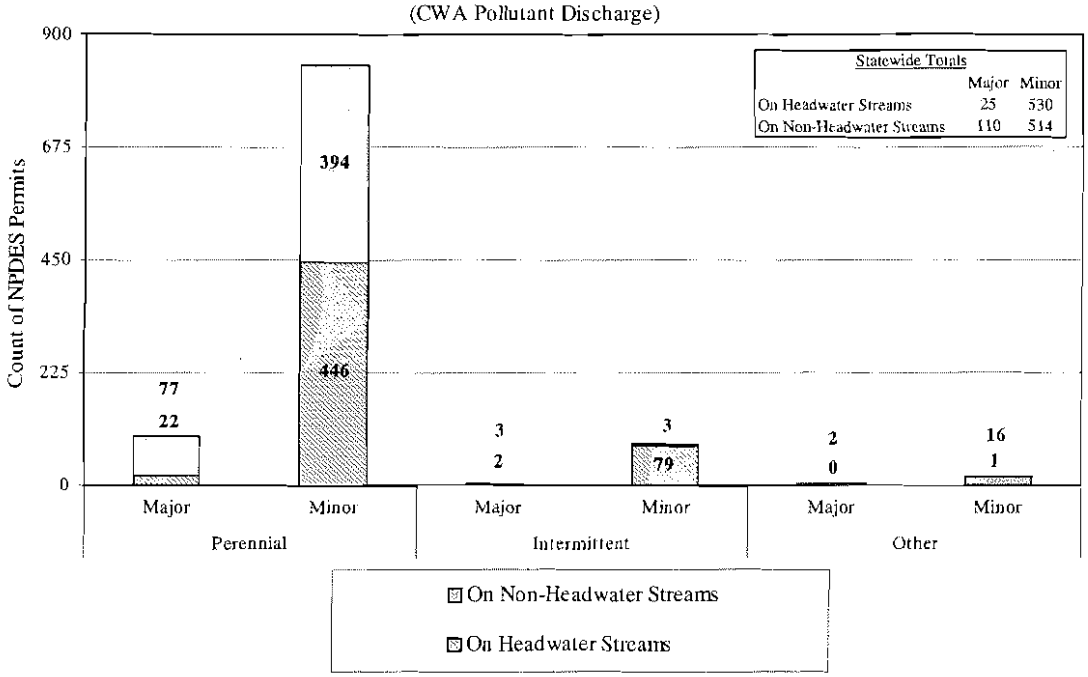
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Tennessee Streams

(CWA Pollutant Discharge)



Legend: Out of 1,441 total NPDES Individual permits statewide, 82% (1,179 permits) have location data. Of those with location data, 47% (555 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

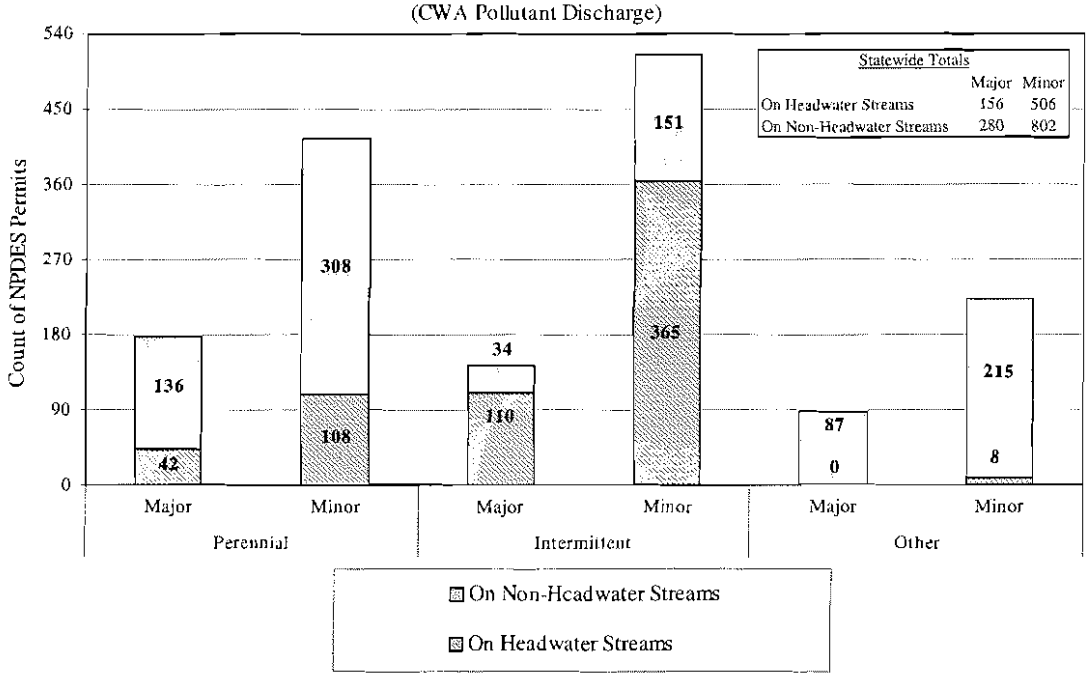
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Texas Streams

(CWA Pollutant Discharge)



Legend: Out of 2,994 total NPDES Individual permits statewide, 58% (1,744 permits) have location data. Of those with location data, 38% (662 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

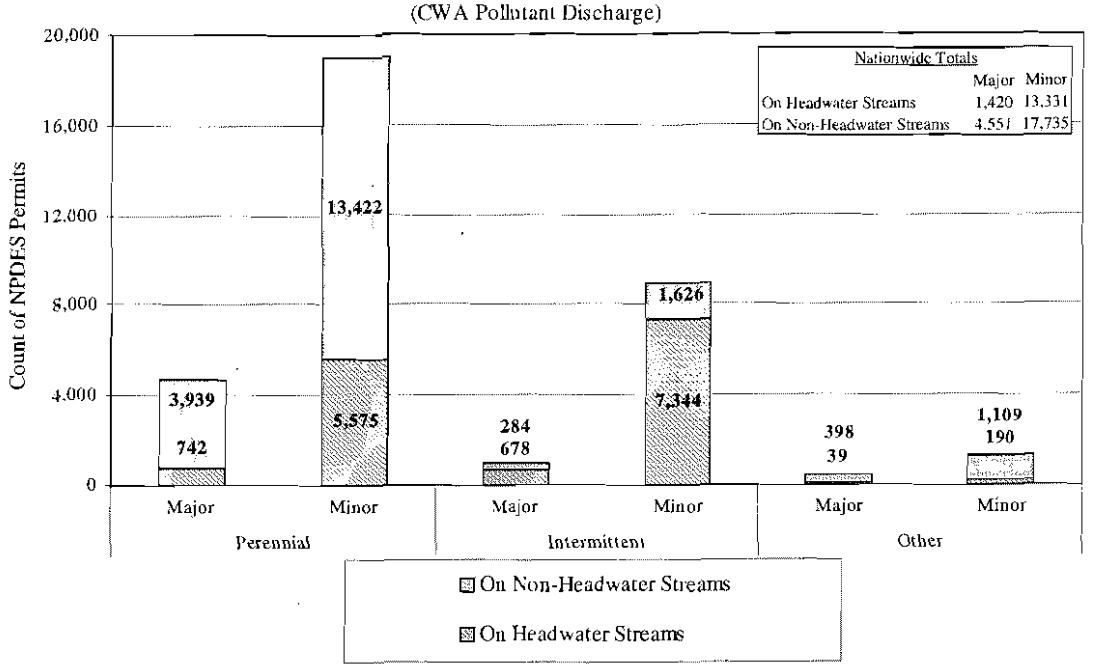
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on U.S. Streams

(CWA Pollutant Discharge)



Legend: Out of 43,507 total NPDES Individual permits nationwide, 85% (37,037 permits) have location data. Of those with location data, 40% (14,751 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the national table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the national table. Second, the national table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

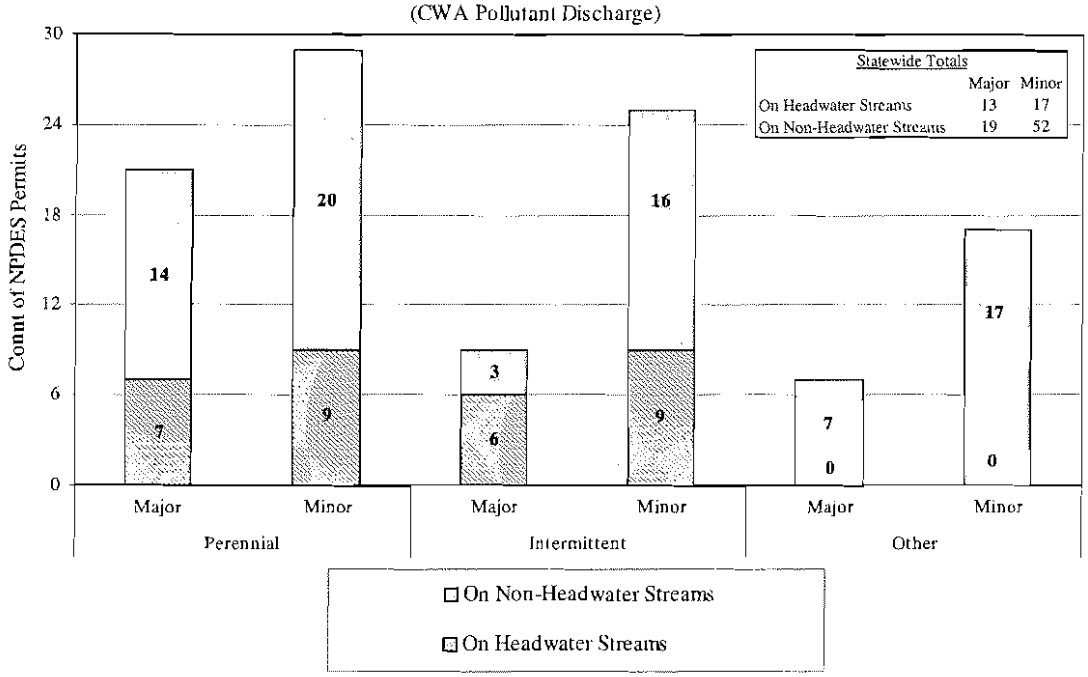
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Utah Streams

(CWA Pollutant Discharge)



Statewide Totals	Major	Minor
On Headwater Streams	13	17
On Non-Headwater Streams	19	52

Legend: Out of 123 total NPDES Individual permits statewide, 82% (101 permits) have location data. Of those with location data, 30% (30 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

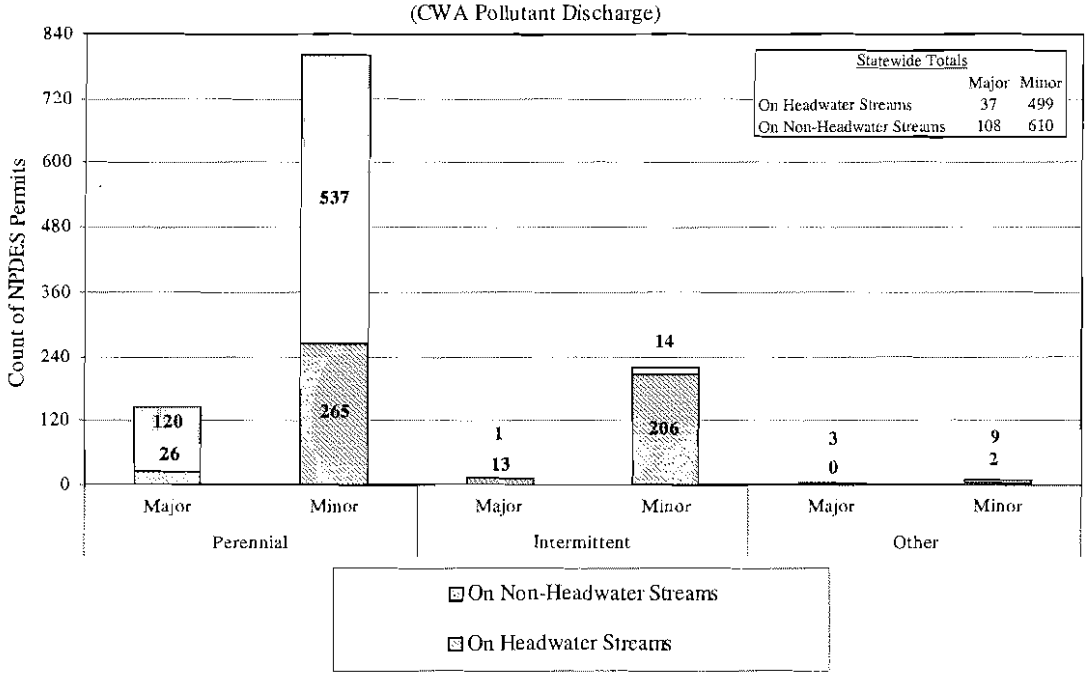
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Virginia Streams

(CWA Pollutant Discharge)



Legend: Out of 1,305 total NPDES Individual permits statewide, 96% (1,254 permits) have location data. Of those with location data, 43% (536 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, hnt only once in the statewide table. Second, the statewide table includes faeilities that have outfalls on stream categories uot represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

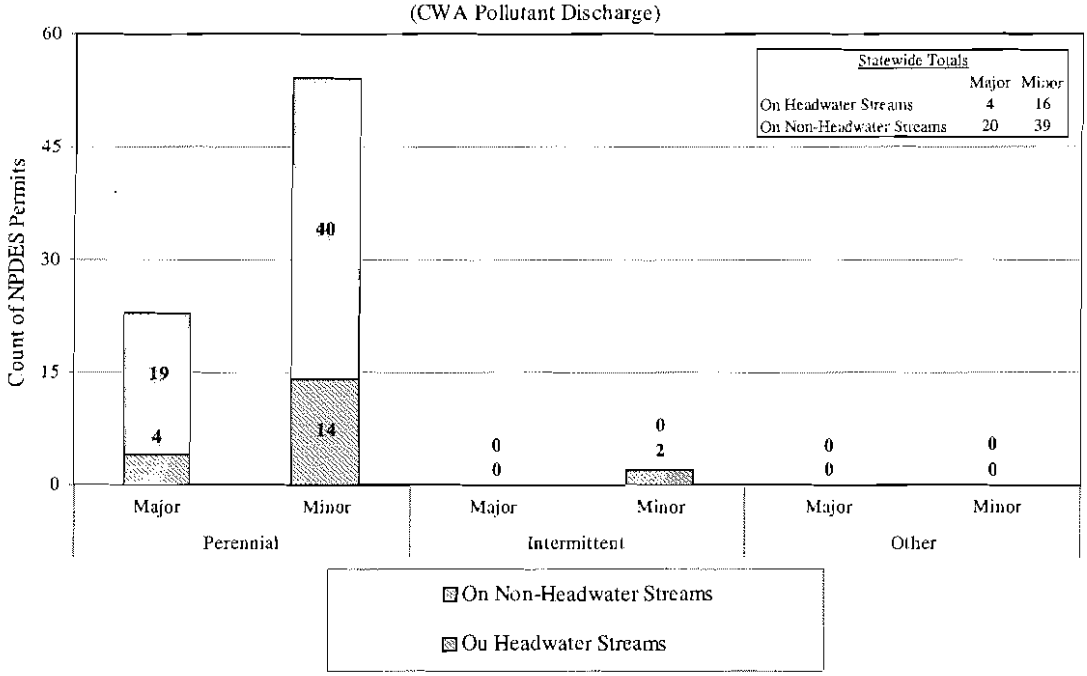
- NHD from Reaeh Address Database (RAD) v2.0 at 1:100,000 scale using 8 digir HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extraeted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities eovered by storm water and non-sroim water general permits are not ineluded in this chart.

Location of Individual NPDES Permits on Vermont Streams

(CWA Pollutant Discharge)



Legend: Out of 168 total NPDES Individual permits statewide, 47% (79 permits) have location data. Of those with location data, 25% (20 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

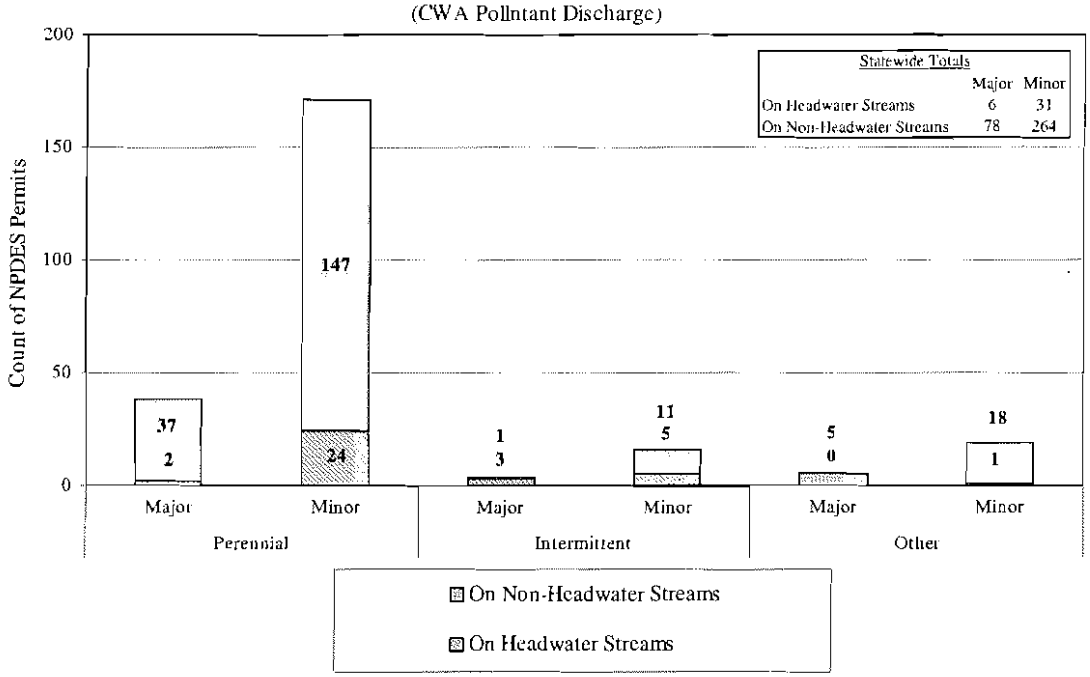
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Washington Streams

(CWA Pollutant Discharge)



Legend: Out of 551 total NPDES Individual permits statewide, 69% (379 permits) have location data. Of those with location data, 10% (37 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are *non-majors*.

Source Data:

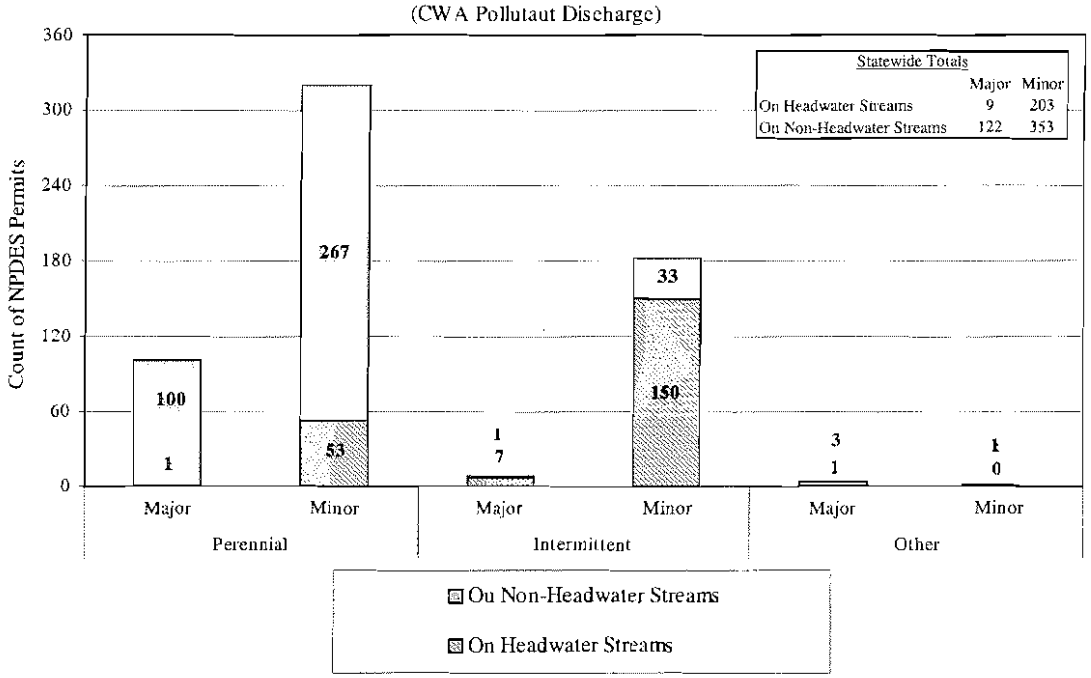
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Wisconsin Streams

(CWA Pollutant Discharge)



Legend: Out of 861 total NPDES Individual permits statewide, 80% (687 permits) have location data. Of those with location data, 31% (212 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

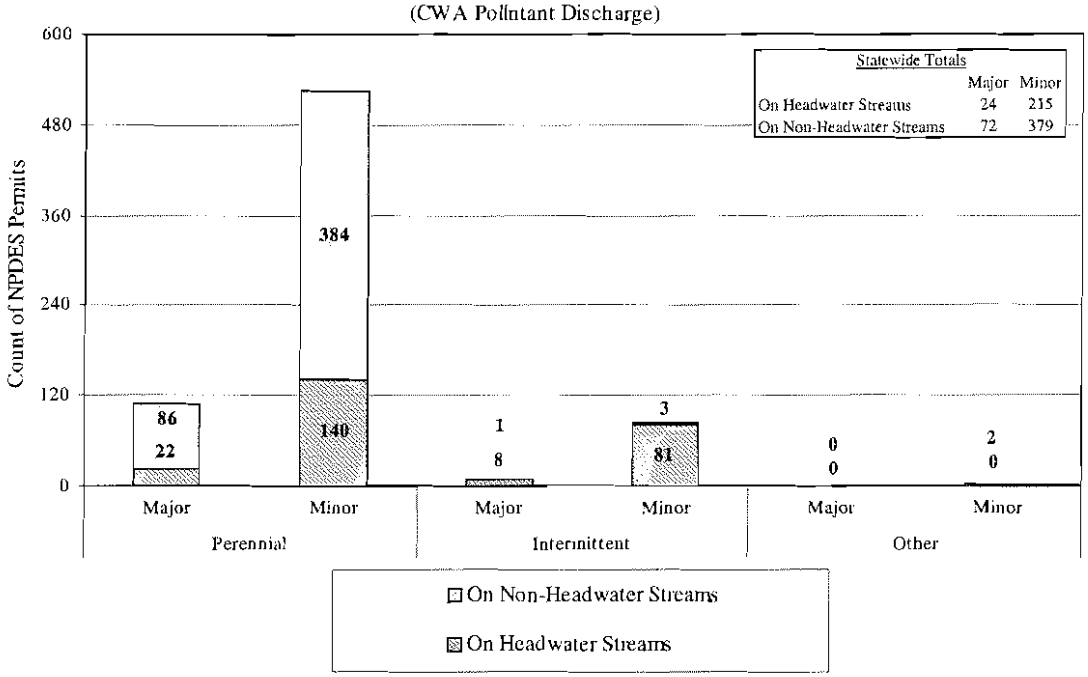
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on West Virginia Streams

(CWA Pollutant Discharge)



Legend: Out of 1,012 total NPDES Individual permits statewide, 68% (690 permits) have location data. Of those with location data, 35% (239 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

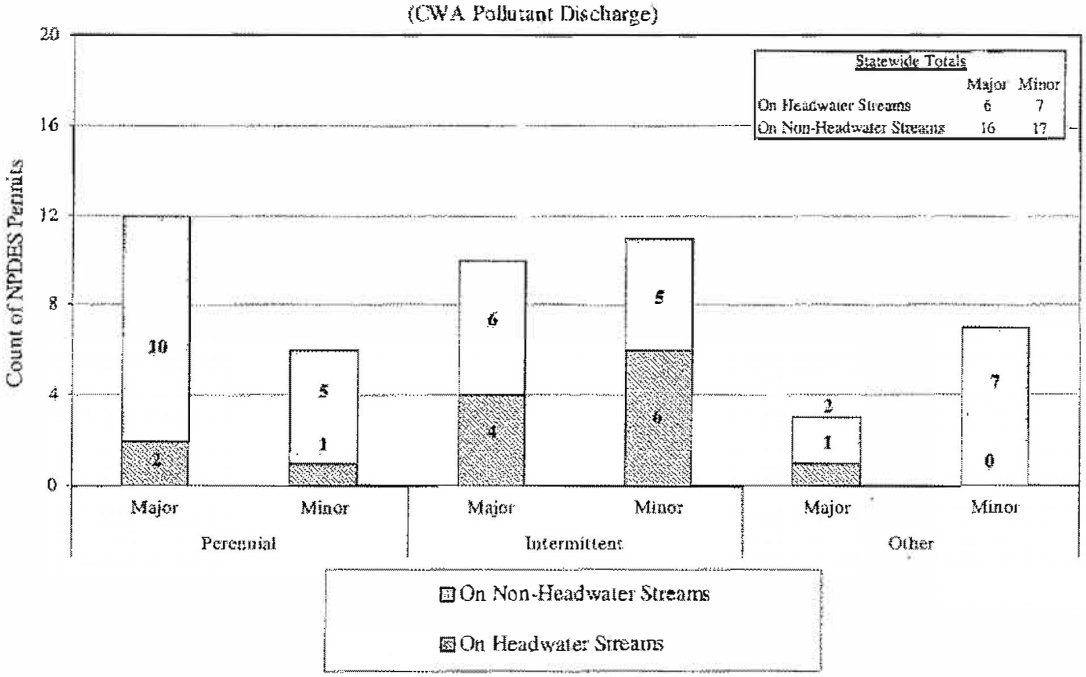
- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.

Location of Individual NPDES Permits on Wyoming Streams

(CWA Pollutant Discharge)



Legend: Out of 1,673 total NPDES Individual permits statewide, 3% (46 permits) have location data. Of those with location data, 28% (13 permits) are on headwaters. The counts as summed across chart columns may differ from the totals in the statewide totals table due to two factors. First, facilities with multiple outfalls on different stream categories are represented multiple times in the chart columns, but only once in the statewide table. Second, the statewide table includes facilities that have outfalls on stream categories not represented in the chart columns.

Generally, major municipal permittees have design flows >1 mgd or an approved pretreatment program. Major industrial permittees are determined based on specific ratings criteria such as flow, receiving water sensitivity, presence of toxic pollutants in the discharge, and others. Minors are non-majors.

Source Data:

- NHD from Reach Address Database (RAD) v2.0 at 1:100,000 scale using 8 digit HUC watersheds.
- Intermittent and ephemeral streams grouped together.
- Washes in the arid western U.S. not consistently demarcated.
- NPDES Permit Data from Permit Compliance System (PCS) database, extracted June 7, 2004.
- For the purposes of this analysis, a headwater stream is defined as a stream segment that has no other streams flowing into it (NHD start reach)
- "Other" includes ditches, connectors, and pipelines.

Caveats:

- NHD data generally do not capture streams under one mile in length.
- PCS facilities covered by storm water and non-storm water general permits are not included in this chart.