Voluntary Approaches to Agricultural Water Pollution Reduction

A Summary of The Current State of Water Quality Trading and Adaptive Management Approaches and Frameworks

Linda Reid[1]

Benjamin Edelstein[2] Megan Kiplinger[3] Brittany Hebeler [4] Thomas McGue[5]

Farming is a valued part of American identity and remains an important part of the American economy. In 2019, agriculture and its related industries contributed $1.109 trillion to the U.S. gross domestic product.[6] Together, the food and agriculture sectors are responsible for about one-fifth of the economy and more than 13 percent of U.S. employment.[7] At the same time, however, agricultural

---

[1] JD, 1995, University of Arkansas School of Law; BS, 1997, Mount Senario College.

[2] JD Candidate, 2022, Marquette University Law School; MA, 2018, University of Wisconsin-Milwaukee; BA, 2015, University of Wisconsin-Milwaukee.

[3] JD, 2021, Marquette University Law School; BS, 2015, Grand Valley State University.

[4] JD, 2020, Marquette University Law School; BA, 2013, Northern Illinois University.

[5] JD, 2021, Marquette University Law School, BS, 2018, Indiana University.

[6] *Ag and Food Sectors and the Economy*, USDA, https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/ag-and-food-sectors-and-the-economy/ (last updated June 2, 2021).

[7] *See* FEEDING THE ECONOMY, U.S. FOOD AND AG INDUSTRIES ECONOMIC IMPACT IN THE UNITED STATES (2021), *available at* http://feedingtheeconomy.com/#

sources of pollution are contributing to water quality problems in rivers and streams.[8] These sources of pollution have also contributed to water quality impacts in the nation's lakes, ponds, and reservoirs.[9] However, pollution from agriculture and other nonpoint sources has proven difficult to regulate under the Clean Water Act.

Agriculture has been referred to as the "Rubik's Cube of environmental policy."[10] Environmental regulation in the United States is a highly developed body of law.[11] However, existing approaches to limiting the environmental effects of agriculture are costly and have questionable long-term benefits.[12] Furthermore, uncertainty exists regarding what form environmental regulations would take.[13] As a result, agriculture has never had coherent environmental protection programs, and "no significant environmental controls have been placed on farm practices even where agricultural activities are a primary cause of pollution problems."[14]

This report summarizes the current state of agricultural water pollution reduction in the United States, focusing on voluntary rather than regulatory approaches. We begin with an overview of how agricultural sources affect water quality and examine existing approaches to regulating water pollution from agriculture in the United States. Next, we provide an overview of two voluntary approaches to agricultural water pollution—water quality trading and adaptive management—and present case studies of states utilizing each approach. We then conclude and offer policy recommendations.

1. The Harm to Water Bodies Caused by Agricultural Water Pollution

As Professor Melissa Scanlan explains, "[t]he dilemma presented when trying to address agricultural water pollution is wrapped up in the breadth and diversity of the field level management practices and landscape factors that contribute to it."[15] Agricultural activities that impair water quality include "poorly located or managed animal feeding operations; overgrazing; plowing too often or at the wrong time; and improper, excessive or poorly timed application of pesticides, irrigation water and

---

[8] See, U.S. E.P.A., NATIONAL WATER QUALITY INVENTORY: REPORT TO CONGRESS 8 (August 2017), *available at https://www.epa.gov/waterdata/2017-national-water-quality-inventory-report-congress* [hereinafter NATIONAL WATER QUALITY INVENTORY]; FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, MORE PEOPLE, MORE FOOD, WORSE WATER? A GLOBAL REVIEW OF WATER POLLUTION FROM AGRICULTURE 4 (2018), *available at* http://www.fao.org/3/ca0146en/CA0146EN.pdf [hereinafter GLOBAL REVIEW OF WATER POLLUTION FROM AGRICULTURE].

[9] NATIONAL WATER QUALITY INVENTORY, *supra* note 7, at 11.

[10] J.B. Ruhl, *Agriculture and Ecosystem Services: Strategies for State and Local Governments*, 17 N.Y.U. ENVTL. L.J. 424, 425 (2008)

[11] J.B. Ruhl, *Farms, Their Environmental Harms, and Environmental Law*, 27 ECOLOGY L.Q. 263, 265 (2000); *see also* Robinson Meyer, *How the U.S. Protects the Environment, From Nixon to Trump*, THE ATLANTIC (Mar. 29, 2017), https://www.theatlantic.com/science/archive/2017/03/how-the-epa-and-us-environmental-law-works-a-civics-guide-pruitt-trump/521001/.

[12] *See* David E. Ervin, *Shaping a Smarter Environmental Policy for Farming*, 14 ISSUES IN SCI. & TECH. 73 (1998).

[13] *Id*. at 74 ("Although it is high time to deal with agriculture's contribution to water pollution, the damage is very uneven in scope and severity; it tends to occur where farming is extensive and fresh water resources are vulnerable. Thus, blanket regulations would be unwise.")

[14] C. Ford Runge, *Environmental Protection from Farm to Market* in THINKING ECOLOGICALLY: THE NEXT GENERATION OF ENVIRONMENTAL POLICY 200, 200-01 (Marian R. Chertow & Daniel C. Etsy eds., 1997).

[15] Melissa K. Scanlan, *Adaptive Trading: Experimenting with Unlikely Partners*, 62 KAN. L. REV. 971, 976 (2014)

fertilizer."[16] Brief summaries of the most common types and sources of pollutants resulting from agricultural activities are provided below.

A. Sediment

"Sediment is, by weight, the greatest pollutant of water resources."[17] Four to five billion tons of sediment reach United States surface waters each year.[18] It is measured in water as total suspended solids (TSS), which are waterborne particles that exceed 2 microns in size.[19] Anything smaller than 2 microns is considered a dissolved solid. Sediment is a mixture of organic matter and minerals that settle at the bottom of a body of water.[20] Stormwater collects and transports soil as sediment, pesticides, and other potentially toxic pollutants before draining into water bodies.[21] Sediment can destroy habitats, choke streams, and reduce useful storage volume in reservoirs, affecting irrigation schemes and reducing water supplies.[22] It can also affect tourism and other industries, resulting in economic losses.[23]

B. Nutrients

When nutrients are not fully utilized by the crops after application or applied at rates greater than they are fixed by soil particles or exported from the soil profile, they leach into groundwater or move via surface runoff into waterways.[24] When excess nutrients such as nitrogen and phosphorus drain into rivers, lakes, and streams, they can cause eutrophication and accelerate the growth of algal blooms.[25] The algal decomposition process reduces oxygen, which causes hypoxic conditions that are unsuitable for sustaining aquatic life.[26] Furthermore, nutrient pollution and harmful algal blooms create toxins and compounds that are dangerous to human health.[27]

C. Concentrated Animal Feeding Operations

---

[16] *Protecting Water Quality from Agricultural Runoff*, U.S. E.P.A. (Mar. 2005), https://www.epa.gov/sites/production/files/2015-09/documents/ag_runoff_fact_sheet.pdf.

[17] G. ALLAN BURTON, JR., & ROBERT E. PITT, STORMWATER EFFECTS HANDBOOK – A TOOLBOX FOR WATERSHED MANAGERS, SCIENTISTS, AND ENGINEERS 32 (2002).

[18] *See* Virginia Department of Environmental Quality, *Erosion and Sediment Control Principles, Practices, and Costs* in VIRGINIA EROSION AND SEDIMENT CONTROL HANDBOOK II-5 (3d ed. 1992); Gerald Willet, *Urban Erosion* in NATIONAL CONFERENCE ON URBAN EROSION AND SEDIMENT CONTROL: INSTITUTIONS AND TECHNOLOGY EPA 905/9-80-002 51 (January 1980).

[19] *See What is Total Suspended Solids (TSS)?*, WATER AND WASTES DIGEST (Apr. 16, 2021), https://www.wwdmag.com/suspended-solids-monitors/what-total-suspended-solids-tss.

[20] GLOBAL REVIEW OF WATER POLLUTION FROM AGRICULTURE, *supra* note 7, at 111.

[21] *Protecting Water Quality from Agricultural Runoff*, *supra* note 15.

[22] DAVID E. WALLING, THE IMPACT OF GLOBAL CHANGE ON EROSION AND SEDIMENT TRANSPORT BY RIVERS: CURRENT PROGRESS AND FUTURE CHALLENGES 1 (2009).

[23] F. Benavides & J.N. Veenstra, *The Impost of Tropical Deforestation on River Chemical Pollution*, 7 GLOBAL NEST J. 180, 186 (2005).

[24] GLOBAL REVIEW OF WATER POLLUTION FROM AGRICULTURE, *supra* note 7 at 53.

[25] *Id.* at 53-54

[26] *Id.*

[27] *Id*.

The majority of farms in the United States use animal feeding operations (AFOs) to efficiently maintain and feed livestock.[28] In animal feeding operations, feed is brought to animals living in confined areas rather than the animals grazing.[29] The USDA estimates that these operations produce about 500 million tons of manure annually.[30] Runoff from poorly managed AFOs can carry pathogens such as bacteria and viruses, nutrients, and oxygen-demanding organics and solids that pollute water bodies.[31]

D. Overgrazing

Since the 1970s, the total number of livestock has more than tripled.[32] Overgrazing exposes soils, increases erosion, and encourages invasion by undesirable plants.[33] Moreover, livestock destruction of streambanks and floodplain vegetation harms fish habitats and impedes natural filtration.[34]

E. Irrigation

There has also been a marked increase in farmland irrigation.[35] Farmers apply irrigation water to supplement natural precipitation and to protect crops against freezing or wilting.[36] Irrigation is a source of water pollution because the evaporation of irrigation water used concentrates salts.[37] Inefficient or excessive irrigation can cause erosion and transport nutrients, pesticides, and heavy metals to nearby surface waters.[38]

F. Pesticides

Improperly selected and managed pesticides contribute to poor water quality.[39] Pesticides enter and contaminate water through direct application, runoff, and atmospheric deposition.[40] Once in the

---

[28] *See, e.g.*, OFFICE OF ENFORCEMENT AND COMPLIANCE ASSURANCE, EPA, COMPLIANCE ASSURANCE IMPLEMENTATION PLAN FOR CONCENTRATED ANIMAL FEEDING OPERATIONS 2 (1998); Mark Peters & David Kesmodel, *Livestock Waste Lands Iowa in Hot Water: With Runoff from Farms Blamed for Fouling Drinking Water*, WALL ST. J., March 15, 2013, at A3.

[29] USDA & EPA UNIFIED NATIONAL STRATEGY FOR ANIMAL FEEDING OPERATIONS § 2.1 (Mar. 9, 1999) (Stating that Animal Feeding Operations "congregate animals, feed, manure, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures.").

[30] National Pollution Discharge Elimination System Permit Regulations and Effluent Limitation Guidelines and Standards for Concentrated Animal Feeding Operations (CAFOs), 68 Fed. Reg. 7,180 (Feb. 12, 2003) (to be codified at 40 C.F.R. parts 9, 122, 123, 412).

[31] *See* JoAnn Burkholder et al., *Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality*, 115 ENVTL HEALTH PERSPECTIVES 308, 308-309 (Feb. 2007).

[32] GLOBAL REVIEW OF WATER POLLUTION FROM AGRICULTURE, *supra* note 7 at 2.

[33] *Protecting Water Quality from Agricultural Runoff*, *supra* note 15, at 2.

[34] *Id*.

[35] GLOBAL REVIEW OF WATER POLLUTION FROM AGRICULTURE, *supra* note 7 at 2.

[36] *Protecting Water Quality from Agricultural Runoff*, *supra* note 15, at 2.

[37] *Id*.

[38] *Id*.

[39] GLOBAL REVIEW OF WATER POLLUTION FROM AGRICULTURE, *supra* note 7 at 13.

[40] *Id*.

waters, pesticides can harm fish and wildlife, contaminate food sources, impact habitats, and impair drinking water.[41]

Table I provides examples of negative impacts on human health, the environment, and the economy due to water pollution.

Table I: Negative Impacts of Water Pollution

Impacts on	Examples of impacts
Health	▪ Increased burden of disease due to reduced drinking water quality ▪ Increased burden of disease due to reduced bathing water quality ▪ Increased burden of disease due to food contamination
Environment	▪ Decreased biodiversity ▪ Eutrophication and dead zones ▪ Visual impacts such as landscape degradation ▪ Diminished recreational opportunities ▪ Increased greenhouse gas emissions
The Economy	▪ Reduced industrial productivity ▪ Reduced agricultural productivity ▪ Reduced number of tourists in polluted areas ▪ Reduced fish and shellfish catches, or reduced market value of fish and shellfish

Source: Adapted from FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, MORE PEOPLE, MORE FOOD, WORSE WATER? A GLOBAL REVIEW OF WATER POLLUTION FROM AGRICULTURE 4 (2018)

2. The Clean Water Act and Regulating Agricultural Water Pollution

The federal government is generally authorized to act in the public's interest to protect the quality of the nation's waters. In 1972, Congress passed the Federal Water Pollution Control Act, commonly referred to as the Clean Water Act (CWA).[42] The objective of the CWA is "to restore and

[41] *Id.*

[42] For an overview of events leading up to the CWA, see William L. Andreen, *The Evolution of Water Pollution Control in the United States—State, Local, and Federal Efforts*, 1789-1972: Part I, 22 STANFORD ENVTL. L. J. 145 (2003), and Part II, 22 STANFORD ENVTL. L. J. 215 (2003). For a retrospective of the CWA and a discussion of its

maintain the chemical, physical, and biological integrity of the Nation's waters."[43] To accomplish this goal, the CWA prohibits any unpermitted discharge of a pollutant. The CWA defines the phrase "discharge of a pollutant" to mean "any addition of any pollutant to navigable waters from any point source."[44]

The CWA employs both technology-based effluent limitations and water quality standards to protect water quality.[45] Technology-based effluent limitations restrict the number of specific pollutants that certain sources can discharge into the nation's waters.[46] The CWA also requires states to establish water quality standards that define a water body's intended uses and set criteria to protect those uses.[47]

A. Technology-Based Effluent Limitations

Point sources must obtain a National Pollutant Discharge Elimination System (NPDES) permit before discharging pollutants into navigable waters.[48] NPDES permits set "effluent limitations" that restrict the amount of specific pollutants discharged by a municipality.[49] Qualified states administer this permit system, and about three-quarters of states have been qualified.[50] States with NPDES permits must meet their effluent limits using pollution-control technologies.[51] These technologies are specific to the industry of each discharger. [52]These limits can take the form of technology-based effluent limitations (TBELs) or water quality-based effluent limitations (WQBELs). Generally, industrial and municipal facilities must get a permit to discharge pollutants into surface waters.

B. Water Quality Standards

The CWA also requires states to identify waterways where the technology-based effluent limitations are insufficient to achieve the desired water quality standards.[53] For these waterways, states must determine the Total Maximum Daily Loads (TMDLs), which calculate "the maximum amount of a specific pollutant that a waterbody can receive while still safely meeting water quality standards."[54] For the first quarter century after enactment of the CWA, TMDLs rarely came into play.[55] However, a series of lawsuits in the 1980s and 1990s led the EPA to be more vigilant about TMDL compliance. Today, for each water body that does not meet water quality standards, the EPA requires that states factor nonpoint sources into the TMDL calculations.[56] However, the "Clean Water Act does not require

---

limitations see William L. Andreen, S*uccess and Backlash: The Remarkable (Continuing) Story of the Clean Water Act*, 4 GEO. WASH. J. OF ENERGY & ENVTL. L. 25 (Winter 2013).

[43] 33 U.S.C. § 1251 *et seq.*

[44] 33 U.S.C. § 1362(12).

[45] *See* CLAUDIA COPELAND, CONG. RSCH. SERV., RL30030, CLEAN WATER ACT: A SUMMARY OF THE LAW (2016)

[46] 33 U.S.C. § 1311.

[47] 33 U.S.C. § 1313(c)(2)(a)

[48] 33 U.S.C. §§ 1311 & 1342.

[49] 33 U.S.C. § 1342.

[50] 33 U.S.C. 1251(b); 33 U.S.C. § 1342(b); *see also* BARTON H. THOMPSON, JR. ET AL., LEGAL CONTROL OF WATER RESOURCES: CASES AND MATERIALS 1166 (6th ed. 2018).

[51] 33 U.S.C. § 1311.

[52] *Id.*

[53] 33 U.S.C. § 1313(c)(2)(A).

[54] 40 C.F.R. § 130.2(i).

[55] THOMPSON, JR. ET AL., *supra* note 49, at 1186.

[56] Scanlan, *supra* note 14, at 978.

states to regulate nonpoint pollution to meet the TMDLs and water quality standards, nor does the Clean Water Act compel EPA to do so in the absence of state action."[57]

C. Nonpoint Source Regulation

When it was created, the CWA distinguished between point sources and nonpoint sources. A point source is "any discernible, confined, and discrete conveyance from which pollutants are or may be discharged."[58] Nonpoint source pollutants are "not traceable to a discrete, identifiable origin, but generally result from land runoff, precipitation, drainage, or seepage."[59] Unfortunately, Congress did not address nonpoint source pollution when it created the CWA, leaving nonpoint source regulation mainly up to the states.[60] The CWA has been very successful in controlling point source pollution.[61] However, nonpoint sources remain largely unregulated.[62] In fact, agricultural nonpoint sources were exempted from the Act's point source controls.[63]

Congress has attempted to address nonpoint pollution via CWA section 208 and CWA section 319, but these provisions are widely viewed as unsuccessful.[64] Section 208 of the CWA provides a federal funding mechanism to fund state programs developed to control nonpoint source pollution.[65] However, it proved to be unreliable and ineffective, and although it is still part of the CWA, all federal funding for the program ended in 1981.[66]

Section 319 of the CWA requires states to develop nonpoint source pollution management programs.[67] First, each state must submit an assessment report identifying waters impaired by nonpoint source pollution.[68] Then, each state must develop a state management program that identifies "best management practices," sets up implementation programs, and establishes a schedule of milestones.[69] Federal grants are available to help implement programs in states with assessment reports and management plans approved by the EPA, but these have been insufficient to encourage voluntary state

---

[57] THOMPSON, JR. ET AL., *supra* note 49, at 1187.

[58] *Id.* § 1362(14).

[59] 40 C.F.R. § 35.1605-4.

[60] Scanlan, *supra* note 14, at 971; Scott Yager & Mary-Thomas Hart, *The Tipping Point Source: Clean Water Act Regulation of Discharges to Surface Water Via Groundwater, and Specific Implications for Nonpoint Source Agriculture*, 23 DRAKE J. AGRIC. L. 429, 431-32 (2018)

[61] *See* Lara D. Guercio, *The Struggle Between Man and Nature—Agriculture, Nonpoint Source Pollution, and Clean Water: How to Implement the State of Vermont's Phosphorous TMDL Within the Lake Champlain Basin*, 12 VT. J. ENVTL. L. 456, 459-60 (2011).

[62] *Id.*; *see also*, OLIVER A. HOUCK, THE CLEAN WATER ACT TMDL PROGRAM: LAW, POLICY, AND IMPLEMENTATION 60 (2d ed. 2002).

[63] 33 U.S.C. § 1362 (14).

[64] *See* Jan G. Laitos & Heidi Ruckriegle, *The Clean Water Act and the Challenge of Agricultural Pollution*, 66 VT. L. REV. 1033, 1041-1046 (2013) ("Both Section 208 and 319 programs have failed to reduce pollution from [nonpoint source] runoff.")

[65] 33 U.S.C. § 1288.

[66] Laitos & Ruckriegle, *supra* note 63, at 1042.

[67] 33 U.S.C. § 1329.

[68] *Id.* § 1329(a)(1)(A).

[69] *Id.* § 1329(b)(2)(A)-(C).

compliance.[70] Moreover, EPA cannot use its enforcement authority to compel control over nonpoint source pollution.[71]

D. Additional Agricultural Water Pollution Reduction Tools

Additional regulatory tools exist to address agricultural water pollution. There are grants, including some under the CWA, which help farmers implement pollution management practices.[72] The promise of this grant money helps incentivize farmers to adopt specific tools or techniques, or modify existing ones, to better achieve water pollution reduction goals. Additionally, "many programs funded by the U.S. Department of Agriculture and states provide cost-share, technical assistance, and economic incentives" to farms to implement management practices that assist in reducing agricultural pollution.[73]

However, due to the lack of federal enforcement power, states play a critical role in addressing agricultural water pollution. Many states rely on legal approaches mandating farmers to adopt specific practices to reduce water pollution. Most states have enacted laws and regulations requiring "nutrient management plans" that document the nutrients entering and exiting the soil and contain individualized steps to ensure that the farm is not a major contributor to water pollution.[74] Several states have "application restrictions," which are laws and regulations placing physical restrictions on the amount of nutrients that can be applied to crops.[75] Lastly, some states have "applicator certification" laws and regulations requiring certification for those individuals who use agricultural nutrients.[76]

3. Water Quality Trading

Despite the impacts agriculture and other nonpoint sources have on water quality, these sources have been harder to regulate than point sources.[77] Recognizing this regulatory gap, the EPA issued a water quality trading (WQT) policy in 2003.[78] The overall goal of WQT is to "reduce the amount of pollution discharged into bodies of water by using a market-based system to identify and maximize the most cost-effective pollution controls and save the most money."[79] This is done by establishing a market for pollution reduction efforts and assigning a dollar value to each effort.[80] Within this

---

[70] Laitos & Ruckriegle, *supra* note 63, at 1041-46.

[71] 33 U.S.C. § 1309.

[72] *Protecting Water Quality from Agricultural Runoff*, *supra* note 15, at 1.

[73] *Id.*

[74] PENN STATE COLLEGE OF AGRICULTURAL SCIENCES, NUTRIENT MANAGEMENT PLANNING: AN OVERVIEW 1 (2003), *available at* https://extension.psu.edu/nutrient-management-planning-an-overview.

[75] Ellen Essman & Micah Brown, *Mandatory Legal Approaches to Agricultural Nutrient Management*, Nat'l Agric. L. Ctr. (2020), *available at* https://nationalaglawcenter.org/state-compilations/nutrientmanagement/.

[76] *Id.*

[77] *See* Cy Jones, *An Introduction to Water-Quality* Trading, *in* WATER-QUALITY TRADING: A GUIDE FOR THE WASTEWATER COMMUNITY 2. 8 (2006) ("The CWA provides direct regulation of point sources but only weak and indirect regulation, at best of nonpoint sources."); Jennifer Pence, *The Murky Waters of Water Quality Credit Trading in the Ohio River Basin*, 6 J. ANIMAL AND ENVTL. L. 171 178 (2015) ("In contrast to point sources, nonpoint sources remain virtually unregulated under the CWA.").

[78] OFFICE OF WATER, EPA, FINAL WATER QUALITY TRADING POLICY I (Jan. 13, 2003).

[79] *Id.* at 4.

[80] *Id.*at 1.

established market, pollution reduction is treated as a commodity that the emitter can trade.[81] Thus, polluters with a lower cost of pollution emissions have the option to sell their extra credits to polluters who have higher costs of establishing a pollution reduction strategy (i.e., technology upgrades).[82] This results in an overall lower amount of pollutants being discharged into a body of water.[83]

A. EPA Water Quality Trading Policy

The EPA views water quality trading as an essential tool for addressing contemporary problems in major watersheds. In its 2008 water quality trading evaluation, the EPA asserts that "increased understanding of the design of water quality trading programs results in States developing trading frameworks and TMDL developers adopting TMDLs that embrace water quality trading."[84] According to the EPA,"[w]ater quality trading can provide greater flexibility on the timing and level of technology a facility might install, reduce overall compliance costs, and encourage the voluntary participation of nonpoint sources within the watershed."[85] Existing water quality programs can be grouped into four general categories: (1) cap-and-trade, (3) case-by-case, (3) open market, (3) not established.

The most common type of program is a cap-and-trade program, commonly referred to as a "closed market" system.[86] This approach "impose[s] a ceiling on the combined quantity of a pollutant that participating facilities may release." A regulatory agency establishes the limits to maintain environmental quality standards.[87] In a closed market program, "emissions permits create the scarcity that drives trading in the market for pollution rights."[88]

A case-by-case approach is "commonly used for one-time, site-specific trades but can also apply to programs that may include multiple trades."[89] In this type of program, all trades must be reviewed and preapproved by an overseeing authority.[90]

Open market programs "are used to maintain or potentially improve the environmental quality of a trading area while also allowing for economic growth and development."[91] In an open market system, "[t]here is no mandatory systemwide cap in which all participants have a defined and limited initial allocation; participation is usually voluntary. Facilities can trade, and often bank credits, or use them internally to achieve compliance."[92]

---

[81] *Id.* at 2; *see also* JOHN LEATHERMAN, CRAIG SMITH, & JEFFREY PETERSON, *AN INTRODUCTION TO WATER QUALITY TRADING*, DEPARTMENT OF AGRICULTURAL ECONOMICS, KANSAS STATE UNIVERSITY at 2 (2004)

[82] *Id.* at 1.

[83] *Id.*

[84] U.S. EPA, WATER QUALITY TRADING EVALUATION: FINAL REPORT 1-5 (2008), *available at* https://www.epa.gov/npdes/water-quality-trading-evaluation [hereinafter EPA 2008 REPORT];

[85] *Water Quality Trading*, U.S. EPA, https://www.epa.gov/npdes/water-quality-trading (last updated Oct. 8, 2020).

[86] EPA 2008 REPORT, *supra* note 83, at 2-6.

[87] Ann Sorensen and Benjamin Maloney, *Financial, Environmental, and Social Effects of Water Quality Trading*, *in* ADVANCES IN WATER QUALITY TRADING AS A FLEXIBLE COMPLIANCE TOOL 67 (Water Environment Federation ed. 2015)

[88] Pence, *supra* note 76 at 185.

[89] *Id.*

[90] *Id.*

[91] Sorensen and Maloney, *supra* note 86, at 67.

[92] EPA 2008 REPORT, *supra* note 83, at 2-6.

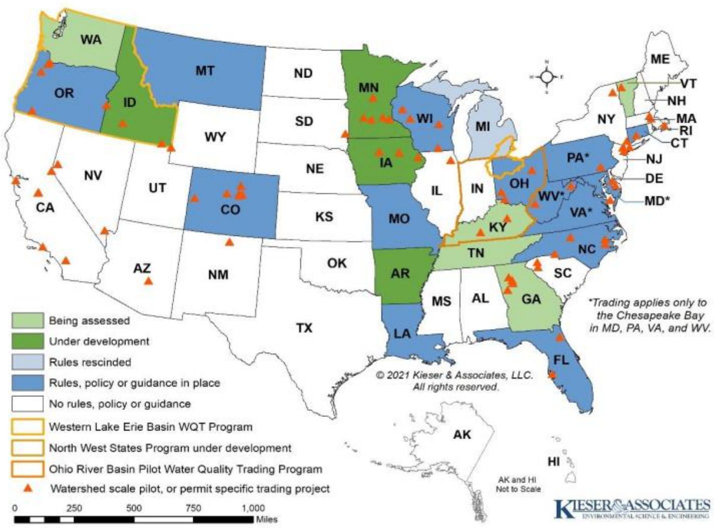
Finally, several states have not adopted any type of water quality trading program. Table II summarizes each type of water quality trading program. Figure 1 provides an overview of water quality trading programs.

Table II: Water Quality Trading Programs

Program	Description
Cap-and-trade	A pollution limit is put in place (therefore creating a "closed" market), typically by governments or other market managers. Pollution discharge allocations are allocated to participants, who then trade these allocations with each other
Case-by-case	All trades must be reviewed and preapproved by an overseeing authority.
Open Market	A system of rules is put in place, and participants can trade freely among themselves without preapproval from regulators or a mandatory program-wide cap.
Not established	No specific trading mechanisms are articulated during program creation.

Figure 1: Water Quality Trading in the United States

.



Source: The Environmental Trading Network, http://www.envtn.org/water-quality-trading/state-programs.

B. Water Quality Trading Policy Guidance

The EPA guides states, interstate agencies, and tribes on establishing a water quality trading program that complies with the CWA and its regulations. The EPA offers a toolkit for water quality trading permit writing.[93] The toolkit's release was significant because it recognized the critical role of permitting authorities in implementing and managing trading programs.[94] Furthermore, the toolkit helps generate support for water quality trading by educating regulatory agencies and permit writers about the benefits of trading programs.[95]

After the toolkit's initial release in 2007, water quality trading policy and guidance were sparse. In February 2019, however, the EPA released a memorandum affirming its support for water quality trading and other market-based programs to reduce water pollution.[96] It promoted the adoption of these programs and provided additional guidance and policy options to stakeholders for developing and

---

[93] U.S. EPA, WATER QUALITY TRADING TOOLKIT FOR PERMIT WRITERS (2009), *available at* https://www.epa.gov/sites/production/files/2016-04/documents/wqtradingtoolkit.pdf.

[94] WATER ENVIRONMENT FEDERATION, *supra* note 86 at 38.

[95] *Id.*

[96] U.S. E.P.A., MEMORANDUM UPDATING THE ENVIRONMENTAL PROTECTION AGENCY'S WATER QUALITY TRADING POLICY TO PROMOTE MARKET-BASED MECHANISMS FOR IMPROVING WATER QUALITY 1 (Feb. 6, 2019), *available at* https://www.epa.gov/nutrient-policy-data/water-quality-trading-memos.

implementing market-based programs[97] To achieve these goals, the memorandum identified six market-based principles to reduce water pollution:

(1) States, tribes, and stakeholders should consider implementing water quality trading and other market-based programs on a watershed scale.

(2) The EPA encourages the use of adaptive management strategies for implementing market-based programs.

(3) Water quality credits and offsets may be banked for future use.

(4) The EPA encourages simplicity and flexibility in implementing baseline concepts.

(5) A single project may generate credits for multiple markets.

(6) Financing opportunities exist to assist with deployment of nonpoint source land use practices.[98]

C. Risks and Challenges

While water quality trading is seen as a way to provide cost-effective opportunities for controlling water pollution from agriculture and other nonpoint sources, the performance of existing water quality trading markets has been uneven.[99] While several programs have been successful, others have been fraught with barriers to trade.[100] A well-designed water quality trading program will ensure that participants are confident in the market and willing to engage in transactions.[101] As a result, regulated sources can meet their regulatory obligations at lower costs than traditional command and control approaches. [102] However, persistent concerns about whether credits represent real and equitable offsets to regulated loads, the behavior of participants, and the viability of markets can erode public trust and jeopardize cost-effectiveness.[103]

A study funded by the EPA identified several issues that contributed to unsuccessful programs, including inadequate trading partners, lack of sufficient regulatory drivers, legal and regulatory obstacles, high transaction costs, the availability of cheaper alternatives, and a lack of clarity regarding trading rules.[104] In addition, according to the World Resources Institute, impediments to program success include uncertainty about the performance and estimation of nonpoint source reductions themselves, uncertainty due to extreme events, buyer uncertainty about nonpoint source implementation, and seller uncertainty about market and regulatory dynamics.[105]

---

[97] *Id.*

[98] *Id.* at 3-5.

[99] *See* Hanna L. Breetz et. al., *Trust and Communication: Mechanisms for Increasing Farmers' Participation in Water Quality Trading*, 81 LAND ECON.170, 171-72.

[100] *See* Suzie Greenhalgh, & Mindy Selman, *Comparing Water Quality Trading Programs: What Lessons are There to Learn? 42* J. OF REG'L ANALYSIS & POL'Y 104, 106-107 (2012)

[101] SARA WALKER & MINDY SELMAN, ADDRESSING RISK AND UNCERTAINTY IN WATER QUALITY TRADING MARKETS 6 (World Res. Inst. eds., 2014).

[102] MINDY SELMAN ET AL., WATER QUALITY TRADING PROGRAMS: AN INTERNATIONAL OVERVIEW 15 (World Res. Inst. Eds., 2009).

[103] Walker & Selman, *supra* note 100, at 6.

[104] *See* HANNA L. BREETZ ET AL., WATER QUALITY TRADING AND OFFSET INITIATIVES IN THE UNITED STATES: A COMPREHENSIVE SURVEY (2004), *available at* https://nationalstormwater.com/wp/wp-content/uploads/2020/08/DartmouthCompTradingSurvey.pdf.

[105] Walker & Selman, *supra* note 100, at 8-10.

Limits on ways that trades can occur is a shortcoming from the perspective of both buyers and sellers. For example, under Wisconsin's trading program, there are restrictions on where transactions can occur.[106] Another issue that states face is the ability to track trades. For example, the Colorado Water Quality Control Division has stated explicitly that tracking trades has been challenging and needs to be addressed in its trading policy going forward.[107] Trades must be accurately and consistently tracked to ensure that the program achieves pollution reduction goals.

Another challenge is that municipalities are resistant to giving up the safety and certainty of complying with their permits through projects that they have built and operated in favor of agricultural practices that are less certain and not under their direct control. More technical data is needed to help potential traders feel confident in participating. Missouri is an example of a state that effectively and efficiently acquired this technical data without expending additional financial resources and time. According to the Missouri Department of Natural Resources, the state is in a unique position because it had to do research relating to its water quality standards after its proposed measures were not approved by the EPA in 2009.[108] Missouri's focus on developing a nutrient trading framework came from research relating to this litigation with the EPA.[109] To develop and implement a trading framework, the state DNR was challenged by various political constraints.[110] For example, many volunteer mayors struggled to accomplish different requirements because doing so required assistance from the DNR and municipal organizations.[111] There are also time constraints because developing water criteria, researching other watersheds to determine if there is an ability to reduce agricultural water pollution, and overall regulatory drivers take time.

Implementing an economically and environmentally successful trading program also requires incentivizing farmer participation. According to Chris Wieberg from the Missouri DNR, the state is not just reducing agricultural water pollution but essentially changing how the entire state produces food.[112] Therefore, farmers need incentives to grow food in an alternative way. For example, farmers may participate in different practices if the returns are higher in profits and yields.[113] According to the Iowa DNR, farmers need not only financial motivators to encourage participation (i.e., profitability software showing how much more money a farmer could make doing certain practices) but overall awareness.[114] If farmers are aware that they are contributing to the pollution of their primary water source, they will have a heightened interest in and incentive to reduce pollution.[115]

There is no single framework that every state can implement to achieve the desired outcomes. To succeed, programs must be tailored by the state to local water conditions and individual state needs. Thus, another challenge in developing and implementing trading programs is the need for creative thinking. The Upper Mississippi River Basin Association (UMRBA) serves as an example of this type of creative thinking. UMRBA is a regional interstate organization formed by Illinois, Iowa, Minnesota, Missouri, and Wisconsin governors to coordinate river-related programs and policies and work with

---

[106] Conversation with Attorney Paul Kent.

[107] Conversation with Joni Nuttle (July 24, 2020).

[108] Telephone interview with Chris Wieberg, Director of Water Protection Program, Missouri Department of Natural Resources, Chris Wieberg (July 24, 2020).

[109] *Id.*

[110] *Id.*

[111] *Id.*

[112] *Id.*

[113] *Id.*

[114] Video conference with Adam Schnieders, Iowa DNR (Aug. 11, 2020).

[115] *Id.*

federal agencies with river responsibilities. It aims to reduce nutrient pollution and increase incentive dollars that are put toward nonpoint source nutrient pollution.[116]

Another obstacle involves the need to conduct a nutrient technology evaluation. For example, implementing a nutrient trading program involves optimizing technology and understanding the costs of doing so.[117] A problem exists when the cost to a wastewater treatment facility to build infrastructure is less than buying credits.[118] In that case, a trading program would not be utilized because it would not be necessary.

A more significant, pragmatic risk in water quality trading is that it takes a biological issue and attempts to correct it with an economic solution.[119] For example, tradable credits might be used to address the water quality of a lake that has more nitrogen than phosphorus.[120] However, this mechanism cannot solve the biological problem because scientific data is needed.[121]

D. Water Quality Trading Case Studies

Ohio River Basin Water Quality Trading Program

The Ohio River Basin Water Quality Trading Program is one of the most extensive trading programs in the country. In 2012, representatives from Indiana, Kentucky, and Ohio signed an agreement to create a pilot program to allow farmers and industrial facilities to trade pollution credits to reduce fertilizer runoff and nutrient discharges.[122] The program aims to address nutrient pollution into the Ohio River — and ultimately, the Gulf of Mexico — by generating credits from conservation practices on agricultural land. Since its inception, the project has generated more than 200,000 verified water quality credits from agricultural conservation practices from about fifty farms.[123] It is entirely voluntary to participate Ohio River Basin Water Quality Trading Program. Trading provides permitted dischargers with flexibility in achieving their regulatory limits cost-effectively while providing financial incentives for selling credits and reducing pollution loads.[124] Currently, one credit equals one pound of total nitrogen (TN) or one pound of total phosphorus (TP). Each credit is associated with a specific vintage year, depending on the total volume purchased.[125]

Maryland

Maryland developed a water quality trading program to help meet TMDL limits in the Chesapeake Bay Watershed. Maryland's water quality trading guidance was released in January

---

[116] Telephone conference with Chris Wieberg, *supra* note 74.

[117] *Id.*

[118] *Id.*

[119] *Id.*

[120] *Id.*

[121] *Id.*

[122] *See* OHIO RIVER BASIN WATER QUALITY TRADING PROJECT, ELECTRIC POWER RESEARCH INST. 1-2 (Mar. 2014)

[123] Jessica Fox & Brian Brandt, *Protecting Ecosystems by Engaging Farmers in Water Quality Trading: Case Study from the Ohio River Basin*, *in* SOIL AND WATER CONSERVATION: A CELEBRATION OF 75 YEARS 88 (J.A. Delgado, G.F. Sassenrath & C.J. Gantzer eds. 2020).

[124] Selman et al., *supra* note 101, at 2.

[125] *Water Quality Credits: An Award-Winning Mechanism to Improve Water Quality in the Ohio River Basin*, FIRST CLIMATE (2021), https://www.firstclimate.com/en/water-quality-credits/.

2020.[126] The program is voluntary and relies on a market-based approach to offer economic incentives for pollutant reductions from point and nonpoint sources.[127] The guidance creates a public market for nitrogen, phosphorus, and sediment reductions. Both the Maryland Department of the Environment (MDE) and the Maryland Department of Agriculture (MDA) cooperate to enhance the restoration and protection of the Chesapeake Bay and its local waters.[128] The current types of credits used are stormwater/alternative credits, wastewater credits, and oyster aquaculture credits.[129] A program participant may only use credits generated and sold within the state to comply with applicable nitrogen, phosphorus, and sediment load or waste load allocations of the Maryland portion of the Chesapeake Bay TMDL, local TMDL, or NPDES permit requirements.[130]

Maryland's program is a leader because the state provides the infrastructure to support trading through online tools: The Maryland Nutrient Tracking Tool[131] (used by agricultural credit generators), The Central Registry, and the optional Marketplace. Under the state's WQT guidance, credits are not valid until they are certified.[132] Sellers can use the Water Quality Trading Market Board to post credits, find buyers, or find other credits for sale.[133] Maryland's Water Quality Trading Program homepage is easily navigable because it provides buyers and sellers with simple instructions for buying and selling credits.

Wisconsin

As early as 1997, legislative action in Wisconsin created three pilot programs for water quality trading in the Red Cedar River Watershed, the Fox and Wolf River Basin, and the Rock River Basin.[134] The Red Cedar River Watershed was deemed a success for phosphorus trading.[135] In 2011, the state legislature expanded water quality trading throughout Wisconsin and provided the basic framework for the existing program.[136] Under Wisconsin's program, WQT "may be used by municipal and industrial permit holders to demonstrate compliance with water quality-based effluent limitations."[137] An example of a current WQT project is the Devil's Lake project, which focuses on generating credits from agricultural nonpoint sources by converting cropland into recreational areas and expanding the

---

[126] *Water Quality Trading Guidance*, MD. DEP'T OF ENV'T, https://mde.maryland.gov/programs/Water/WQT/Pages/guidance.aspx. (last visited July 23, 2021).

[127] MD. CODE REGS. 26.08.11.01 (2020).

[128] *Water Quality Trading Guidance*, *supra* note 119.

[129] *Id.*

[130] *Id.*

[131] *See Maryland Nutrient Tracking/Trading Tool (MNTT)*, MARYLAND DEPARTMENT OF THE ENVIRONMENT, http://www.mdnutrienttrading.com/ (last visited July 23, 2021)

[132] MD. CODE REGS. 6.08.11.07 (2020).

[133] *Water Quality Trading Program Frequently Asked Questions*, MD. DEP'T OF ENV'T (Jan. 2020), *available at* https://mde.maryland.gov/programs/Water/WQT/Documents/Guidance%20PDFs/General%20Questions%20WQT.pdf.

[134] *Adaptive Management and Water Quality Trading Project Locations*, WIS. DEP'T OF NAT. RES., https://dnr.wisconsin.gov/topic/Wastewater/AmWqtMap.html (last visited July 23, 2021).

[135] *Id.*

[136] *Id.*; WIS. STAT. § 283.84.

[137] *Adaptive Management and Water Quality Trading Project Locations*, *supra* note 133.

park.[138] Another example is WE Energies' Paris Generating Station project, which generates phosphorus credits by converting agricultural land into native prairie vegetation.[139]

Minnesota

Minnesota has a long history of successfully applying water quality trading as a means of compliance.[140] In 1997 and 1999, Minnesota created two water quality trading projects under the legal framework of NPDES permits in the Minnesota River Basin.[141] "This legal arrangement was well suited to the two projects, as both involved trading between a single point source and multiple point sources."[142] These projects have been highly successful and have generated hundreds of transactions.[143] Methods used to generate reductions include soil erosion best management practices, cattle exclusion, rotational grazing with cattle exclusion, and cover cropping.[144] Trading credit evaluation procedures are detailed in permits. A unique feature of the Minnesota program is the trust fund set up by each point source and devoted to the trading program to accomplish the required nutrient load reductions. This fund provides financial viability to the program and ensures sufficient credits to offset pollution loads.

Missouri

Missouri is an example of a state collecting data to produce a viable trading program utilizing credits.[145] The state secured grant money to study three different watersheds to determine whether it would reduce agricultural water pollution.[146] Once the state has gained more data, it can develop a clearinghouse or a bank of credits.[147] The Missouri DNR can then sell those credits to point sources. The objective is to use those dollars to focus on specific watersheds and implement more conservation work.[148]

---

[138] WISCONSIN DEPARTMENT OF NATURAL RESOURCES, WATER QUALITY TRADING PLAN: WISCONSIN DNR DEVIL'S LAKE STATE PARK (2016), *available at* https://dnr.wi.gov/topic/Surface-Water/documents/AmWqt/DevilsLakeWQTPlan.pdf.

[139] *Adaptive Management and Water Quality Trading Project Locations*, WISCONSIN DEPARTMENT OF NATURAL RESOURCES, https://dnr.wi.gov/topic/wastewater/AmWqtMap.html (last visited July 23, 2021).

[140] *See* James Klang, *Minnesota*, *in* ADVANCES IN WATER QUALITY TRADING AS A FLEXIBLE COMPLIANCE TOOL 204-212 (Water Environment Federation ed. 2015); Karen Fisher-Vanden & Sheila Olmstead, *Moving Pollution Trading from Air to Water: Potential, Problems, and Prognosis*, 27 J. ECON. PERSP. 147, 151-154 (Winter 2013).

[141] MARK S. KAISER & FEND FANG, ECONOMIC AND ENVIRONMENTAL BENEFITS OF WATER QUALITY TRADING – AN OVERVIEW OF U.S. TRADING PROGRAMS 8 (Environmental Trading Network & Kaiser & Associates eds., 2004).

[142] Feng Feng, K. William Easter & Patrick L. Brezonik, *Point-Nonpoint Source Water Quality Trading: A Case Study in the Minnesota River Basin*, 41 J. AM. WATER RESOURCES ASS'N 645, 655 (2005).

[143] MINNESOTA POLLUTION CONTROL AGENCY, WATER QUALITY TRADING GUIDANCE 26 (Jan. 2021), *available at* https://www.pca.state.mn.us/sites/default/files/wq-gen1-15.pdf.

[144] *Id*. at 34.

[145] *See* MISSOURI DEPARTMENT OF NATURAL RESOURCES, MISSOURI WATER QUALITY TRADING FRAMEWORK (2016), *available at* https://dnr.mo.gov/env/wpp/cwforum/docs/4-11-16-wq-trading-framework.pdf.

[146] *See* MISSOURI DEPARTMENT OF NATURAL RESOURCES, MISSOURI NUTRIENT LOSS REDUCTION STRATEGY (2020), *available at* https://dnr.mo.gov/env/wpp/mnrsc/documents/missouri-nutrient-reduction-strategy-2020-update.pdf.

[147] *Id*.

[148] *Id*.

Iowa

Iowa is using a cooperative approach to reduce nutrient pollution.[149] The state does not currently have regulations requiring it to reduce nutrient pollution. However, cities and stakeholders have recently taken an interest in creating frameworks to manage watersheds because of the recognized need to protect the state's primary source of water (the Mississippi River).[150] As a result, the Iowa League of Cities secured a water quality trading grant for a Nutrient Reduction Exchange database developed by the Corps called the Regulatory In-Lieu Fee and Bank Information Tracking System database.[151] The Corps created the database to track wetland credits.[152] The Iowa DNR currently has Memorandums of Understanding that are used as guidance for nutrient reduction strategies.[153] As of 2020, Iowa was in the process of developing rule language to create a registry of nonpoint source nutrient reduction practices installed by facilities that have NPDES permits.[154] Practices registered in the database may then be eligible for future regulatory incentives.[155] The Iowa DNR will track and maintain the registry.[156]

Montana

The Montana Department of Environmental Quality has a water quality trading policy (Circular DEQ-13). Montana has completed trades under the Septic Trading Method described in DEQ-13, but agricultural sources have not generated credits. There may be some limited opportunities for trading from nonpoint sources to point sources. [157] The Watershed Protection Section continues to look for opportunities to facilitate trades from nonpoint sources to point sources. Recently, a wastewater treatment plant (WWTP) provided funding to a stream fencing project funded primarily through 319 projects. While the WTTP did not apply for or receive trading credits, relationships were developed that may be helpful in the future.

Colorado

Colorado has a dated trading policy from 2004 called the Colorado Pollutant Trading Policy.[158] The approach primarily focused on nutrients because toxic pollutants were not considered appropriate for trading.[159] There has not been a lot of active trading in Colorado. This may be because the state only started to adopt nutrient standards recently.[160] Trading in Colorado has primarily occurred under

---

[149] Video conference with Adam Schnieders, *supra* note 113.

[150] *Id.*

[151] *Id.*

[152] Tyler Marshall, I*owa's Innovative Approach to Nutrient Loading: The Nutrient Reduction Exchange*, WATER AND WASTE DIGEST (Jan. 13, 2020), https://www.wwdmag.com/iowa-nutrient-reduction-exchange-address-algae-blooms.

[153] Web conference with Adam Schnieders, *supra* note 113.

[154] *Id.*

[155] *Id.*

[156] *Id.*

[157] Morrison Maierle, Inc and Kieser & Associates, *Water Quality Trading Business Case for Montana*, http://deq.mt.gov/Portals/112/Water/WQPB/Standards/NutrientWorkGroup/PDFs/WaterQualityTradingBusinessCaseMontana.pdf (Dec. 31, 2014).

[158] Email Conversation with Joni Nuttle, COLORADO WATER QUALITY CONTROL DIVISION (July 24, 2020).

[159] *Id.*

[160] *Id.*

the state's reservoir control regulations that focus on total phosphorus loading to certain reservoirs.[161] Examples include Regulation 71 (Dillon Reservoir Control Regulation), Regulation 72 (Cherry Creek Reservoir Control Regulation), Regulation 73 (Chatfield Reservoir Control Regulation), and Regulation 74 (Bear Creek Watershed Control Regulation).[162] These control regulations include trading programs.[163] However, the trading program in Cherry Creek Reservoir Control Regulation 72 was removed when the rule was changed to a concentration-based management approach.[164] Several decades ago, the state's Water Quality Control Commission adopted site-specific nutrient standards for the reservoirs listed above. For a long time, these were the only nutrient standards in Colorado.[165] Currently, both point-to-point source trades and nonpoint-to-point source trades have occurred.[166] In 2020, a nonpoint-to-point source phosphorus trade was executed under Chatfield Reservoir Control Regulation 73.[167] As of 2017, Colorado's Water Quality Control Division recognized fewer than a dozen trades as "active."[168] There have been two trades under Regulation 71, three under Regulation 73, and one under Regulation 74.[169] The most recent trade occurred in 2020 under Regulation 73.[170]

4. Adaptive Management

In the 1970s, adaptive management emerged as a scientific response to the management of complex systems.[171] Adaptive management refers to using structured, consistent decision-making in the face of uncertainty to develop new and effective techniques.[172] The goal is to create feedback loops that allow programs to learn to achieve their goals by incorporating new information.[173] This approach "emphasizes that dynamic systems are better served by management that collects, tests, and applies information."[174]

Unlike water quality trading, adaptive management is not a direct offset to a permit limit; instead, it involves employing various tools to achieve water quality goals, regardless of the distinction between point and nonpoint sources. The contents of the water are measured using either TMDL compliance or water quality criteria. While not simply a trial-and-error approach to agricultural practices, states are given flexibility in the mechanisms they employ to reach the ultimate water quality goal. Adaptive management tools typically focus on improving water quality so that the applicable

---

[161] *Id.*

[162] *Id.*

[163] *Id.*

[164] *Id.*

[165] *Id.*

[166] *Id.*

[167] *Id.*

[168] *Id.*

[169] *Id.*

[170] *Id.*

[171] Rachel Eberhard et al., *Adaptive Management for Water Quality Planning – From Theory to Practice*, 60 MARINE AND FRESHWATER RSCH. 1189, 1189 (2009)

[172] *What is Adaptive Management?*, U.S. DEPARTMENT OF INTERIOR, https://www.doi.gov/sites/doi.gov/files/migrated/ppa/upload/TechGuide.pdf.

[173] Scanlan, *supra* note 14, at 987.

[174] *Id.*

phosphorus compliance requirements are met. The end goal is an acceptable in-stream phosphorus concentration.[175]

A. Adaptive Management as a Framework for Pollution Reduction

Like water quality trading, adaptive management allows permittees to work with nonpoint or other point sources of pollution in a watershed to reduce the overall pollutant load to a given water body.[176] However, adaptive management and water quality trading utilize different measures of compliance.[177] Trading requires facilities to purchase enough credits to offset their pollutant load.[178] Adaptive management focuses exclusively on improving water quality to meet water quality standards.[179] In other words, water quality trading focuses on compliance with a discharge limit (offsetting the amount of phosphorus in the effluent), while adaptive management focuses on compliance with P criteria (meeting an acceptable in-stream phosphorus concentration).[180]

Though a variety of descriptions of adaptive management theory and practice exist, Professor Bradley C. Karkkainen offers four core principles of adaptive management:

> (1) treating present ecological models, understandings, and the management interventions predicated upon them as provisional; (2) designing interventions as testable hypotheses where possible; (3) carefully and systematically monitoring and evaluating the results; and (4) adjusting our models, understandings, and management interventions in accord with what we have learned through experience.[181]

Adaptive management provides a way for point source discharges to work with nonpoint sources and other facilities to reduce pollution in their watershed without having to implement expensive technologies.[182] According to the Wisconsin Department of Natural Resources, adaptive management has many benefits:

> (1) Permit compliance through adaptive management may be economically preferable to other compliance options.
>
> (2) Point sources, and the nonpoint sources that work cooperatively with them, can demonstrate their commitment to the community and the environment by protecting and restoring local water resources.
>
> (3) Dischargers receive less restrictive interim phosphorus limits while they work with partners to improve water quality. These less stringent [pollutant] limits may become permanent if adaptive management is successful and phosphorus water quality standards are restored.

---

175 *Guidance for Implementing Water Quality Trading in WPDES Permits*, WISCONSIN DNR, https://dnr.wisconsin.gov/topic/Wastewater/WaterQualityTrading.html.

176 WISCONSIN DEPARTMENT OF NATURAL RESOURCES, ADAPTIVE MANAGEMENT TECHNICAL HANDBOOK, A GUIDANCE DOCUMENT FOR STAKEHOLDERS 10 (2013) [hereinafter WDNR ADAPTIVE MANAGEMENT HANDBOOK].

177 CLEAN WISCONSIN, A GUIDE TO THE ADAPTIVE MANAGEMENT OPTION FOR PHOSPHOROUS IN Wisconsin 10 (2013) [hereinafter CLEAN WISCONSIN ADAPTIVE MANAGEMENT GUIDE].

178 *Id*.

179 *Id*.

180 WDNR ADAPTIVE MANAGEMENT HANDBOOK, *supra* note 175, at 10.

181 Bradley C. Karkkainen, *Bottlenecks and Baselines: Tackling Information Deficits in Environmental Regulation* 86 TEX. L. REV. 1409, 1443 (2008)

182 CLEAN WISCONSIN ADAPTIVE MANAGEMENT GUIDE, *supra* note 176 at 10.

(4) Adaptive management provides flexibility for permittees and partners to learn from each other and adapt with experience.[183]

B. Agricultural Best Management Practices

Best management practices (BMPs) have been developed as tools for avoiding, controlling, and trapping water pollution. Below is an overview of the most common BMPs.[184]

Cover Crops

Cover crops have been used for many years to limit water pollution resulting from agricultural runoff.[185] This technique involves growing another type of crop during the offseason. For example, a farmer may grow corn during the year and use barley as a cover crop in the offseason. The cover crop is used to suppress weed growth, manage soil erosion, help build and suppress fertility, improve the quality of the soil, control pests and diseases, and promote biodiversity. Cover crops help to limit pollution from agricultural runoff because farmers do not have to use pesticides and fertilizers to control pests and maintain the control quality by using cover crops.

In contrast to fertilizers and pesticides, cover crops do not wash away with rain and become agricultural runoff. Additionally, cover crops are helpful to farmers because they act to make money during the offseason. For example, farmers can grow barley and either sell it or use it to produce craft beer as an alternative source of income.[186]

No-Till Farming

Another adaptive management technique that has been effective in several states is the use of no-till farming. No-till farming is an agricultural technique used for growing crops without disturbing the soil through tillage.[187] Essentially, the farmer does not turn over the soil. This keeps the banks stable and decreases the amount of soil erosion. It also reduces the number of fertilizers that need to be added to the soil every year. As a result, the amount of agricultural runoff can be significantly decreased.

Biopesticides

Biopesticides are a method that can be employed to limit the amount of chemicals that enter waterways. Pesticides are used to prevent insects and other pests from damaging crops. Chemical pesticides are the traditional method for getting rid of these pests.[188] These pesticides are sprayed onto agricultural fields, and when it rains, the pesticides are washed into a nearby water source, contaminating the water.

Drainage Ditches

---

[183] WDNR ADAPTIVE MANAGEMENT HANDBOOK, *supra* note 175, at 11.

[184] For a more detailed list of BMPs, see MINNESOTA DEPARTMENT OF AGRICULTURE, THE AGRICULTURAL BMP HANDBOOK FOR MINNESOTA (Sept. 2012), *available at* https://wrl.mnpals.net/islandora/object/WRLrepository%3A2749/datastream/PDF/view.

[185] *Cover Crops for Agricultural Nonpoint Source Pollution*, U.S. EPA, https://www.epa.gov/nps/cover-crops-agricultural-nonpoint-source-pollution-control.

[186] *Finding Success with Specialty Crops, Iowa-Nebraska Equipment Dealers Association*, INDEA (May 15, 2016), https://ineda.com/blog/2016/05/15/finding-success-with-specialty-crops/.

[187] *Conservation Tillage*, U.S. EPA, https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=1370 (last visited July 23, 2021).

[188] *Biopesticides*, U.S. EPA, https://www.epa.gov/pesticides/biopesticides (last visited July 23, 2021).

Drainage ditches are another potentially effective adaptive management technique that has been used nationally. However, unlike conventional drainage ditches, farmers have been using agricultural drainage ditches that have a two-stage ditch or shatto ditch. The two-stage ditch creates a natural floodplain, which returns channelized streams to their historical contours.[189] During this process, the drainage ditch's benches trap sediment, blunt storm surges, and collect much of the nitrate, suspended solids, and phosphorus before being washed into the waterways.

Grazing Management

Grazing management involves intentionally controlling the area where livestock grazes and the amount consumed.[190] This method stops livestock from standing or grazing next to water sources. Furthermore, it prevents livestock from walking on banks or depositing solid waste into rivers, streams, or lakes. Grazing management also involves limiting the number of livestock on each section of property. This is important because excess livestock in one area leads to manure overload in the field. When it rains, the excess manure is carried into nearby water sources. Manure contains excess nutrients that are harmful to aquatic life. The amount of manure can be limited by rotating which grazing fields are used. As a result, no single grazing field becomes overwhelmed with manure and is not subject to overgrazing. However, having several grazing fields limits the overall crop yield because a field previously used for the crop may have to be sacrificed as an extra grazing field.

C. Risks and Challenges

Specific economic challenges are generally applicable to each of the identified BMPs. The availability of adequate resources stands as a barrier to the more widespread adoption of adaptive management techniques. As an initial step to implementing adaptive management practices, it is "necessary to know the current status of water quality and the spatial and temporal distribution patterns of any contaminant emissions, loads and concentrations in water environments."[191] If this data is not available, it may be expensive to obtain. Furthermore, the process of gathering data to determine whether a particular method is effective can be both time-consuming and costly because the process requires diligent data collection.

Additionally, variables in the collection process may unintentionally skew the results. Eliminating all possible variables may be a time consuming and expensive process, if possible at all. Certain variables, such as climate, will yield different results throughout the country. For example, a method that is effective in South Carolina may not be effective in Maine or Arizona because of the different climates. Additionally, even with adequate research proving the environmental efficacy of a specific tool, it may not be implemented if those implementing it find that it is more expensive than their current practice.[192]

The implementation of adaptive management tools also faces social challenges. Without mandatory laws and regulations forcing compliance, voluntary approaches require sufficient local

---

[189] Rona Kobell, *Two-Stage Ditch Design and Cover Crops Absorb a lot of Excess Nutrients Before They Can Enter Waterways*, BAY JOURNAL (Mar. 30, 2015), https://environmentalchange.nd.edu/news-events/news/farmers-reduce-pollution-after-ditching-old-way-of-handling-runoff/.

[190] *See, e.g.*, GRAZING LIVESTOCK AND WATER QUALITY, FARM*A*SYST N.C. (Noah N. Ranells et al. eds., 2001), *available at* https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_046596.pdf.

[191] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, WATER POLLUTION FROM AGRICULTURE: A GLOBAL REVIEW – EXECUTIVE SUMMARY 20 (2017), *available at* http://www.fao.org/3/i7754e/i7754e.pdf.

[192] Melissa J. Malott & Daniel T.S. Cook, *Wisconsin's Watershed Adaptive Management Option: A Novel Approach to Overcoming Barriers to Effective Watershed Management*, WATERSHED SCIENCE BULLETIN, Oct. 2012, at 29, 29-32.

community buy-in.[193] Understanding the incentives to deviate from traditional practices and implement adaptive management tools can be complicated. Thus, it becomes necessary to have relationships with local experts in the farming community.[194]

In addition to the generally applicable risks and challenges, there are specific issues with the various best management practices.

Cover Crops

While the economic and environmental benefits of cover crops have been established, "cover crops only make up about 2% of the overall landscape of the U.S. Midwest 'Corn Belt.'"[195] While many farmers recognize the long-term benefits of using cover crops, the primary obstacle is establishment and maintenance's short-term cost (actual or perceived). Farmers worry about the risk of a reduced yield in the immediate growing season.[196] With a smaller yield, farmers will be unable to sell as much product. Without raising the cost of sellable crops, farmers will have a smaller income than usual.

Additionally, farmers worry about covering the cost to implement or maintain cover crops during seasons where production costs are higher than usual.[197] A lower yield means less money to offset the heightened production costs. In addition to these structural barriers, "regional norms emphasize maximizing output."[198] Unproductive land does not align with this norm.

In addition to cost, the actual cover crop to be planted is a barrier to widespread adoption. Without a wide variety of seeds that can be used for cover crops, farmers face the uncertainty of not having the seeds available that they may need in times of shortage.[199] In addition to which seeds can be used to grow cover crops, concerns arise as to timing. A type of cover crop that can only grow during the busy growing season detracts from the land available to produce an economically viable crop in the short term.[200]

No-Till Farming

There are economic reasons that a farmer may be hesitant to adopt no-till farming practices. Like with cover crops, no-till farming may not best serve the short-term economic needs of the farmer. The economic and environmental benefits will not be immediately apparent because it takes time for the soil quality to improve. The initial costs of implementing no-till farming practices could disincentivize farmers from adopting this technique. However, "the money can be recouped through higher crop yields, labor savings, and selling off of old tillage equipment and downsizing tractors or eliminating extra tractors that are no longer needed." The overhead costs for machinery are typically

---

[193] *Id.*

[194] *Id.* at 31.

[195] Adrea Basche, *Cover Crop Challenges: A Reminder That In Agriculture, Even Small Changes Can Be Hard*, THE EQUATION (Mar. 17, 2017 3:03 PM), https://blog.ucsusa.org/andrea-basche/cover-crop-challenges-a-reminder-that-in-agriculture-even-small-changes-can-be-hard.

[196] *See* Gabrielle E. Roesch-McNally et. al., *The Trouble With Cover Crops: Farmers' Experiences with Overcoming Barriers to Adoption*, 33 RENEWABLE FOOD & AGRIC. FOOD SYS. 322 (Mar. 3, 2017).

[197] *Id.*

[198] *Id.*

[199] Rhonda Brooks, *Cover Crop Concerns*, FARM JOURNAL'S AGPRO (July 15, 2019 11:33 AM), https://www.agprofessional.com/article/cover-crop-concerns.

[200] Basche, *supra* note 194.

less than the cost for machinery that would otherwise be used.[201] Additionally, a farmer may see the "learning curve" as a risk.[202] Learning a new practice takes time, and the risk of error associated with learning is always present.

There are also environmental risks associated with no-till farming. For example, if "crop residue is not incorporated into the soil after harvest," crops in the next season could become infected if diseases are carried over.[203] Additionally, no-till farming has the potential to result in gullies forming "because the field isn't continually being smoothed with tillage."[204] Finally, while ultimately environmentally beneficial, no-till farming still requires the application of herbicides.[205] If improperly selected and applied, these herbicides can have negative impacts on the land, as discussed.

Biopesticides

Like many other adaptive management tools, the primary risk with biopesticides involves economic considerations. Using biopesticides results in a "slower rate of control" than traditional pesticides.[206] This presents a threat to crops if an outbreak poses an immediate risk to the crops. Additionally, biopesticides are less reliable than traditional pesticides, as they are more susceptible to adverse environmental conditions.[207] Despite an awareness of the environmental benefits of biopesticides, farmers may be hesitant to assume the heightened risk of not controlling pests that may destroy their crops. Finally, farmers may be unwilling to deviate from their traditional pesticides. There is a more significant learning curve when using biopesticides because they "are not as 'robust' as conventional pesticides."[208]

Drainage Ditches

The initial costs of implementing drainage ditches on farms may disincentivize farmers from using this adaptive management tool. Installing a drainage system is expensive and likely requires the help of a professional. Additionally, a farm may potentially need a permit for a drainage ditch to be installed.[209] The cost of the permit, in addition to the administrative hassles, may be unappealing. Beyond the initial installation costs, farmers may foresee the potential for continued maintenance and repair costs, as well as an increase in time spent monitoring the system to ensure that it is functioning properly. For a drainage ditch to achieve the desired goals, a farmer must "ensure that the outlet ditches . . . are free from blockages caused by sediment buildup," "check that debris does not seal the inlet covers," and replace broken drainage system tiles.[210]

In addition to economic risks associated with drainage ditches, potential environmental risks may dissuade environmentally motivated farmers from using this adaptive management tool. Without proper implementation and maintenance, drainage ditches can contribute to agricultural water

---

[201] *Advantages And Disadvantages Of No Till Farming*, NO TILL AGRIC. (2021), https://notillagriculture.com/no-till-farming/advantages-and-disadvantages-of-no-till-farming/.

[202] *Id.*

[203] *Id.*

[204] *Id.*

[205] *Id.*

[206] *Biopesticides: Pros & Cons*, WARWICK CROP CENTRE (June 4, 2017), https://warwick.ac.uk/fac/sci/lifesci/wcc/research/biopesticides/amberproject/biopesticide_uses.

[207] *See generally*, Suresh Kumar & Archana Singh, *Biopesticides for Integrated Crop Management: Environmental and Regulatory Aspects*, 5 J. BIOFERTIL. BIOPESTICI. 1 (2014).

[208] *Id.*

[209] *Id.*

[210] *Id.*

pollution.[211] Research has shown that agricultural drainage systems "carry nitrate through the drainpipes, channeling it directly into the bodies" of surface waters.[212]

Grazing Management

Various grazing management strategies can be implemented, but there are economic costs associated with each regardless of which one is used. Unlike with continuous grazing, any grazing management technique requires more fencing.[213] Even if temporary fencing is used, it still must be moved with each rotation. Additionally, grazing management often involves periods where certain grazing areas are unproductive because the livestock is not actively grazing in that area.[214] While this may be economically and environmentally preferable in the long-term, the immediate needs of the farmer may take precedence. Grazing management also requires more planning and labor on the part of the farmer. Unlike with continuous grazing, farmers must be more thoughtful in selecting food for livestock.[215] A smaller paddock may not have a water source. Installing pipes to bring water to the smaller grazing area requires time and money.[216] Farmers must develop and manage a rotation schedule and take the time to move the livestock.[217]

D. Adaptive Management Case Studies

Wisconsin

In Wisconsin, an adaptive management approach is used by the Wisconsin DNR to limit the amount of nonpoint source phosphorus so that it matches the water quality-based criteria.[218] The state DNR sets this criterion. One benefit of using an adaptive management process is that it may be an economically beneficial compliance option. The dischargers of the phosphorus will receive less restrictive interim phosphorus discharge limits while cooperating with other discharges to improve overall water quality.[219] If the adaptive management technique is successful and phosphorus water quality standards are restored, the less restrictive phosphorus limits may become permanent.[220] Adaptive management also allows for more flexibility between dischargers to learn from each other.[221] The adaptive management option can extend over 20 years.[222] This time is allowed so that the permittee can install phosphorus reduction practices, develop new partnerships, and measure the success of the

---

[211] *Id.*

[212] *Id.*

[213] *The Benefits of Managed Grazing Systems*, PENNSTATE EXTENSION (Apr. 28, 2015), https://extension.psu.edu/the-benefits-of-managed-grazing-systems.

[214] *Id.*

[215] *Id.*

[216] *Rotational vs. Continuous Grazing*, UNIV. KY. COLL. AGRIC., FOOD & ENV'T, https://grazer.ca.uky.edu/content/rotational-vs-continuous-grazing (last visited July 23, 2021).

[217] *The Benefits of Managed Grazing Systems*, *supra* note 214.

[218] *See* WDNR ADAPTIVE MANAGEMENT HANDBOOK, *supra* note 177, at 8.

[219] *Id.* at 11.

[220] *Id.*

[221] *Id.*

[222] Adaptive Management, WISCONSIN DEPARTMENT OF NATURAL RESOURCES, https://dnr.wisconsin.gov/topic/Wastewater/AdaptiveManagement.html (last visited July 23, 2021).

techniques.[223] Furthermore, adaptive management demonstrates a commitment to the community and the environment, which may benefit public relations.[224]

In 2010, the CWA TMDL requirements for phosphorus and sediment were adopted by South Central Wisconsin (Rock River Basin). Madison Metropolitan Sewerage District (MMSD) developed an adaptive management program in the Yahara Watershed to achieve the targets.[225] Within the Yahara Watershed, two out of every three acres is farmland.[226] A pilot project was initiated, called the Yahara Watershed Improvement Network or Yahara WINs.[227] An estimated $500,000 in funding was provided to the pilot program for "research, water quality monitoring, and phosphorus reducing practices, baseline inventories of agricultural land, and other initiatives."[228] Yahara Water Infrastructure Improvements for the Nations groups (WINs) worked with Yahara Pride Farms[229] and other stakeholders to "connect funding sources with farmers and urban entities."[230] With the funding from Yahara WINs, Yahara Pride Farms has successfully worked with farmers to cover crop seeding since 2011.[231] In 2013, Yahara Pride Farms developed a Farm Certification Program, which provides certification that a farmer or dairy operation has completed all aspects of the water quality program.[232]

The pilot program provided information on what challenges MMSD faced. For example, it was a challenge to develop a framework for a successful collaboration between a variety of stakeholders (e.g., there are different regulatory structures for each state and federal program for wastewater, stormwater, and agriculture interests because each city, town, and village have their own governmental and political interests).[233] Yahara Pride Farms helped facilitate appropriate dialogue with dairy farmers and other agricultural producers and changed the phosphorus dischargers' view from "someone else's concern" to a collaborative watershed issue, where it is the responsibility of all stakeholders.[234]

Within the Yahara Watershed, farmers cover the fields, which means keeping fields green after harvest to protect soil and reduce erosion.[235] Cover crops allow nutrients to stay on the field for future harvest and help to keep the water clear.[236] Farmers are also protecting waterways by adding buffer grass between crop fields and waterways to keep phosphorus out of waterways.[237] Farmers are also

---

[223] *Id.*

[224] *Id.*

[225] NATIONAL ASSOCIATION OF CLEAN WATER AGENCIES & IOWA AGRICULTURE WATER ALLIANCE, COLLABORATING FOR HEALTHY WATERSHEDS: HOW THE MUNICIPAL & AGRICULTURAL SECTORS ARE PARTNERING TO IMPROVE WATER QUALITY 6 (2015), *available at* https://www.iowaagwateralliance.com/pdf/CollaboratingForHealthyWatersheds.pdf

[226] *Agriculture*, CLEAN LAKES ALLIANCE, *https*://www.cleanlakesalliance.org/agriculture/ (last visited July 23, 2021).

[227] *Id.*

[228] *Id.*

[229] Established in 2012, a farmer-led 501c(3) non-profit organization that strives to preserve agricultural heritage while simultaneously encouraging farmers to engage in proactive environmental stewardship within the Yahara Watershed.

[230] *Agriculture*, *supra* note 25.

[231] *Id.*

[232] *Id.*

[233] *Id.*

[234] *Id.*

[235] *Id.*

[236] *Id.*

[237] *Id.*

addressing manure management through a Nutrient Management Plan.[238] The plan consists of manure composting, manure digestion, and low-disturbance manure injection to allow farmers to address soil needs and manure transportation costs and storage.[239] Recently, Yahara Pride Farmers have reported a reduction of more than 18,000 pounds of phosphorus through its conservation practices.[240]

Maryland

In Maryland, the Chesapeake Bay Program has embraced adaptive management to enhance the overall management of its program and strengthen the scientific support for decision-making done by the organization. Beginning in 2005, the Government Accounting Office recommended that the Chesapeake Bay Program develop a coordinated implementation strategy to more effectively reach their targets with limited resources.[241] This reflects the understanding that many ecosystem management decisions are uncertain because they contain many variables.[242] Therefore, the most effective solution and methods can be discovered and implemented by continuous research and data collection.[243] In addition, the Chesapeake Bay Foundation (CBF) advocates for conservation programs such as stream buffers, cover crops, rotational grazing, and other BMPs.[244] CBF believes that BMPs are "the most cost-effective way to reduce nitrogen and phosphorus pollution in the Bay," and scientists estimate that these conservation practices could achieve almost two-thirds of the nitrogen and phosphorus reductions needed to restore the Bay.[245]

Iowa

In Iowa, private organizations, with the help of the Iowa DNR, have implemented a government-regulated program. For example, in the Rock Creek Watershed, landowners organized to improve water quality with the help of the Mitchell County Soil and Water Conservation District (SWCD) and the Iowa DNR.[246] They received a grant from the Walton Family Foundation to develop a plan. The product was the "Rock Creek Watershed Plan: A Roadmap for Improved Water, Soil and Habitat in the Rock Creek Watershed," which outlines a phased approach to ensure that continuous improvements are being made to protect the watershed. Although not directly labeled as an adaptive management plan, it emphasizes data measurement and monitoring to determine the effectiveness of various techniques. This plan is essentially a form of adaptive management. The results have helped find the best locations for conservation practices to be enacted to reduce the amount of pollutants

---

[238] *Nutrient Management Planning*, WISCONSIN DEPARTMENT OF NATURAL RESOURCES, https://dnr.wisconsin.gov/topic/CAFO/NutrientManagementPlan.html (last visited July 23, 2021).

[239] *Wisconsin Nutrient Management Basics*, WISCONSIN DEPARTMENT OF AGRICULTURE TRADE AND CONSUMER PROTECTION, https://datcp.wi.gov/Documents/NMBrochure.pdf (last visited July 23, 2021).

[240] *Farmers in Yahara Watershed dramatically reduce phosphorus delivery in 2017*, YAHARA PRIDE FARMS CONSERVATION BOARD, http://www.yaharapridefarms.org/farmers-in-yahara-watershed-dramatically-reduce-phosphorus-delivery-in-2017/ (last visited July 23, 2021).

[241] *Adaptive Management*, CHESAPEAKE BAY PROGRAM (2021), https://www.chesa-peakebay.net/what/adaptive_management.

[242] *Id.*

[243] *Id.*

[244] *Farmers Play a Critical Role in Keeping Our Waters Clean*, CHESAPEAKE BAY FOUNDATION, https://www.cbf.org/issues/agriculture/ (last visited July 23, 2021).

[245] *Id.*

[246] *Embracing Adaptive Management*, IOWA ENVIRONMENTAL COUNCIL (Jan. 19, 2016), https://www.iaenvironment.org/blog/iowa-environmental-voice/watershed-wedneday-embracing-an-adaptive-management-approach

flowing into watersheds. The long-term monitoring results are also being studied to continually identify and adopt proper conservation techniques. Overall, more than fifty landowners have signed up to apply new conservation practices, along with planting several thousand acres of cover crops.

Missouri

Missouri's adaptive management framework[247] is extensive because it has a sales tax that is collected and evenly split between state parks and the soil and water program.[248] The soil and water program involves putting approximately 40 million dollars of BMPs on the ground each year.[249] The conservation practices involve impoundment structures to trap sediments, wetlands, buffer strips, and cover crops.[250] The program's success has been nationally recognized and continues to receive support from state citizens each year.[251]

5. Conclusion and Policy Recommendations

While some states remain reluctant, many states are developing water quality trading and adaptive management programs. Approximately half a million tons of pesticides, twelve million tons of nitrogen, and four million tons of phosphorus fertilizer are applied annually to crops in the U.S., ultimately contributing to water quality impairment.[252] As a result, more focus and collaboration must be dedicated to reducing agricultural water pollution.

Many policymakers and regulators have embraced water quality trading as a means to cost-efficiently achieve pollution control. However, existing water quality trading programs have had only limited success. Successful programs have some fundamental similarities that should guide future program design. First, water quality trading requires robust regulatory drivers to generate demand.[253] Where regulatory drivers are present, programs must be designed to protect water quality and build efficient and credible markets for participants.[254] Also, stakeholder involvement is essential for a water quality trading program to be viable. Stakeholder engagement is crucial at every stage of program development and implementation. Lastly, transaction costs must be minimized to ensure that water quality trading programs are effective and that participants enter the market.

One recommendation for the future would be to create a space where water quality leaders and stakeholders from each state can gather to discuss water quality issues. For example, a portal where top leaders and stakeholders in water quality in each state can upload, discuss, and present current efforts to address pollution would be beneficial. A portal would be a quick and accessible way for leaders to identify who is in charge of water quality within a state and serve as a communication

---

[247] For more information on Missouri's framework, see Missouri Department of Natural Resources, *Parks, Soils & Water Sales Tax*, YOUTUBE (Sept. 11, 2015), https://youtu.be/Cv5aLxTzqTM.

[248] *Conserving Soil and Water for Future Generations: The Parks, Soil, and Water Sales Tax Brochure*, MISSOURI DNR (Feb. 2016), https://dnr.mo.gov/pubs/pub2166.pdf.

[249] *Id.*

[250] *Id.*

[251] *Id.*

[252] *Agricultural Contaminants*, USGS SCIENCE FOR A CHANGING WORLD, https://www.usgs.gov/mission-areas/water-resources/science/agricultural-contaminants?qt-science_center_objects=0#qt-science_center_objects (last visited July 23, 2021).

[253] Sara Walker, *Water Quality and Agriculture: Water Quality Trading in the Chesapeake Bay Watershed, USA*, WATER RES. INST., *available at* https://www.oecd.org/environment/resources/United-States-case-study-water-quality-and-agriculture-diffuse-pollution.pdf (last visited July 23, 2021).

[254] *Id.*

channel between leaders, a task that has proven itself challenging up until this point. By identifying ideas that have been unsuccessful in other states, states with similar ideas could then skip the trial-and-error phase and proceed to a new or more compelling idea. While each state has its characteristics that contribute to its water quality issues, awareness of other states' water quality issues will help leaders to make more informed decisions that will ultimately lead to better water quality for the entire nation.

An adaptive management program cannot succeed without the necessary funds and resources to support monitoring, data collection and analysis, and the implantation of management strategies. Additionally, it is important to acknowledge that there is no one-size-fits-all adaptive management strategy. Therefore, policymakers should tailor adaptive management programs to the problems they aim to address.[255] Management goals should be as unambiguous as possible.[256] Furthermore, "[a]daptive management is premised on the promise that management direction will be changed as needed to account for new information or altered circumstances."[257] Thus, a workable strategy should be established at the onset when developing a program. This involves setting clear benchmarks and processes for incorporating new information into a program.

Water quality trading and adaptive management are promising strategies for agricultural water pollution management. While these two approaches utilize different compliance measures, they both allow permittees to work with nonpoint or other point sources of pollution in a watershed to reduce the overall pollutant load to a given water body. However, both approaches have risks and challenges which must be adequately addressed. Otherwise, water quality trading and adaptive management are just buzz words that fail to deliver improvements in water quality.

---

[255] *See* Holly Dormes et al., *Making Good Use of Adaptive Management*, CTR. FOR PROGRESSIVE REFORM WHITE PAPER NO. 1104, 10 (Apr. 2011).

[256] *Id*. ("These goals are a function of social values, not of technical understanding. Adaptive management is the forum for technical experts with time to devote to a management problem. Management goals reflect values that may shift over time and should be subject to reconsideration in the appropriate political forum, exogenous to the adaptive management process.").

[257] *Id*. at 11.