Adaptive Trading:
Experimenting with Unlikely Partners

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INTRODUCTION

When Congress created the Clean Water Act it distinguished between point sources, "discernible, confined, and discrete conveyance[s]" like paper mills and sewage treatment plants that discharge pollutants,[1] and nonpoint sources[2] of diffuse runoff pollution (like farms and city streets). Congress did not address diffuse nonpoint source pollution with the same prescriptive standards and permits it required for point sources; instead, Congress relegated runoff to a largely voluntary, state-led approach.[3]

The results are not particularly surprising. After more than 40 years of implementing the Clean Water Act, diffuse runoff is the single biggest

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1. 33 U.S.C. § 1362(14) (2006).

2. 40 C.F.R. § 35.1605–4 (2014).

3. In the 1987 Clean Water Act Amendments, Congress attempted to address nonpoint source pollution by adding the section 319 Nonpoint Source Management Program, 33 U.S.C. § 1329, and the 1990 Coastal Zone Act Reauthorization Amendments, which added the Coastal Nonpoint Pollution Program, 16 U.S.C. § 1455b. The Nonpoint Source Management Program authorizes the EPA to provide grants to states implementing management programs to reduce nonpoint source pollution in navigable waterways. 33 U.S.C. § 1329(h)–(i) (2006). To receive funding, states must identify waterways that require a reduction in nonpoint source pollution to achieve and maintain water quality; identify categories of significant nonpoint source pollutants; outline the process for identifying best management practices; and identify state and local programs for addressing nonpoint source pollution. § 1329(h)(1)(i), (a)(1). Similarly, the Coastal Nonpoint Pollution Control Program provides grants to states implementing management programs to reduce nonpoint source pollution in coastal waters. 16 U.S.C. § 1455b(f) (2006). To receive funding under this program, states must identify coastal waters and adjacent areas threatened by "reasonably foreseeable increases in pollution" and land uses contributing to the degradation of coastal waters and implement and continually revise management measures necessary to achieve and maintain water quality. § 1455b(b)(1)–(3).

source of water quality problems in the United States.[4] Agriculture is the leading contributor to water quality problems in streams and rivers, making nutrients and sediments the most common pollutants fouling U.S. waters.[5]

Now, the EPA, some states, and regulated point sources are pushing to bridge this regulatory gap by setting up water quality trading programs.[6] In theory, trading would allow regulated industries and municipal sewage plants (point sources) to pay largely unregulated farms (nonpoint sources) to reduce nutrient pollution in lakes, rivers and streams.

However, to date, water quality trading has produced more smoke than fire.[7] Although the EPA has been promoting trading for almost

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4. According to the EPA:

> The United States has made tremendous advances in the past 25 years to clean up the aquatic environment by controlling pollution from industries and sewage treatment plants. Unfortunately, we did not do enough to control pollution from diffuse, or nonpoint, sources. Today, nonpoint source (NPS) pollution remains the Nation's largest source of water quality problems. It's the main reason that approximately 40 percent of our surveyed rivers, lakes, and estuaries are not clean enough to meet basic uses such as fishing or swimming.

Nonpoint Source Pollution: The Nation's Largest Water Quality Problem, EPA, http://water.epa.gov/polwaste/nps/outreach/point1.cfm (last visited Feb. 28, 2014) [hereinafter *Nonpoint Source Pollution*].

See also U.S. E.P.A., NATIONAL WATER QUALITY INVENTORY: REPORT TO CONGRESS: 2004 REPORTING CYCLE EPA 841-R-08-001, at 14–15, 18, 22 (2009), *available at* http://water.epa.gov/lawsregs/guidance/cwa/305b/upload/2009_01_22_305b_2004report_2004_305Breport.pdf [hereinafter NATIONAL WATER QUALITY INVENTORY]. Of the assessed bodies of water, 44% of the miles of streams and rivers, 64% of lakes, and 30% of bays and estuaries were impaired. *Id.* at 13, 16, 22. Sources of pollution categorized as diffuse runoff have been ranked as the top impairment causes. Nutrients and sediments are in the top ten "causes" of river and stream impairments, with nutrients impairing 38,632 miles and sediments impairing 35,177 miles. *Id*. at 15. Agriculture ("crop production, grazing, and animal feeding operations") is the number one "cause" of stream and river impairment and the third highest source of impairment for lakes. *Id*. at 15–16, 19. Agricultural runoff impairs 94,182 stream and river miles, 1,670,513 lake acres, and 792 square miles of estuaries. *Id.* at 15–16, 19, 23. In reality, the scope of impairment is likely much larger, considering that 84% of the total U.S. river and stream miles, 61% of the total U.S. lakes, and 71% of the total bays and estuaries are unassessed. *Id.* at 13, 17, 20.

5. NATIONAL WATER QUALITY INVENTORY, *supra* note 4, at 16. However, the EPA has consistently ranked municipal point sources as another leading source of impairment. *Nonpoint Source Pollution*, *supra* note 4.

6. This push in the area of water quality trading is just a subset of a larger emphasis on markets as a solution to achieving environmental goals, which has existed for the last three decades. Joseph W. Dellapenna, *Climate Disruption, the Washington Consensus, and Water Law Reform*, 81 TEMP. L. REV. 383, 399 (2008). Prof. Dellapenna laid bare the problems with water markets as a solution to water quantity problems, but did not address markets for trading water quality. *Id.* at 410–22.

7. *See* Karen Fisher-Vanden & Sheila Omstead, *Moving Pollution Trading from Air to Water: Potential, Problems, and Prognosis*, 27 J. ECON. PERSP. 147, 147 (2013), *available at* http://pubs.

three decades, the number of water quality trading programs with actual trading has been very small.[8] The EPA has had a water quality trading policy since 2003, allowing sources of pollution to buy and sell pollution reductions in order to manage the costs of pollution control.[9] Yet, only twenty-four programs have had any water quality trading.[10] Within these programs, only 100 facilities have taken part in water quality trading, and 80% of all trades in the U.S. have been in Long Island Sound.[11]

Notably, the trading activity has mainly taken place between regulated point sources.[12] Only ten programs have experienced any trading between point and nonpoint sources, and some of these involved only one exchange.[13] Trading nutrients with unregulated farms is so untested in the field that when Pennsylvania, a Chesapeake Bay state, approved a policy of point to nonpoint source water quality trading in December 2006, a Sea Grant report described this as the "first state to

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aeaweb.org/doi/pdfplus/10.1257/jep.27.1.147 ("While nearly three dozen water pollution trading programs have been established in the United States, many have seen no trading at all, and few are operating on a scale that could be considered economically significant."); Dennis M. King & Peter J. Kuch, *Will Nutrient Credit Trading Ever Work? An Assessment of Supply and Demand Problems and Institutional Obstacles*, 33 ENVTL. L. REV. 10352, 10352 (2003), *available at* http://www.envtn.org/uploads/ELR_trading_article.PDF (noting that "very few nutrient credit trades have actually taken place").

8. The first water quality trade was on Lake Dillon, Colorado, in 1986. *List of All Trading Programs*, U.S. ENVTL. PROT. AGENCY, http://water.epa.gov/type/watersheds/trading/upload/tradingprograminfo.xls (last visited Mar. 24, 2014) [hereinafter *List of All Trading Programs*]; *see generally* Hanna L. Breetz et al., *Water Quality Trading and Offset Initiatives in the U.S.: A Comprehensive Survey*, U.S. E.P.A. (2004), *available at* http://www.dep.state.fl.us/water/watersheds/docs/ptpac/DartmouthCompTradingSurvey.pdf (cataloguing development of trading programs).

9. EPA Water Quality Trading Policy, Issuance of Final Policy, 68 Fed. Reg. 1608-01, 1609 (Jan. 13, 2003).

10. *List of All Trading Programs*, *supra* note 8.

11. *EPA Water Quality Trading Evaluation*, U.S. E.P.A. at 1-2 (2008), *available at* http://www.epa.gov/evaluate/pdf/water/epa-water-quality-trading-evaluation.pdf [hereinafter *Water Quality Trading Evaluation*]. This low level of usage exists despite the EPA's provision of policy guidance (most recently updated in 2003), tools and guidance documents for states, training courses, and grants to state and local trading programs. *Id.* *See also List of All Trading Programs*, *supra* note 8.

12. *List of All Trading Programs*, *supra* note 8.

13. *Id.* In the EPA's 2008 water quality trading evaluation, it noted that twenty-five trading programs have been launched, but "relatively few trading programs have been scaled up from pilot projects to permanent programs, and even fewer can claim to have had a significant impact in improving water quality or reducing pollutant control costs." *Water Quality Trading Evaluation*, *supra* note 11, at 1-2. The ten programs that involve point to nonpoint source trading are: Red Cedar River, Wisconsin; Great Miami River, Ohio; NYC Phosphorus Offset Program; Southern Minnesota Beet Sugar Cooperative; Rahr Malting Company, Minnesota; Pinnacle (Vlasic Foods), Delaware; Lake Dillon Reservoir, Colorado; Cherry Creek, Colorado; Chatfield Reservoir, Colorado; and Bear Creek, Colorado. *List of All Trading Programs*, *supra* note 8.

embrace point–nonpoint source exchanges on a wide scale."[14] As of 2013, this Pennsylvania program has not yet produced any actual trades with nonpoint sources.

Despite the lack of success in controlling agricultural pollution through trading, the EPA and some states are presenting trading as a key tool for addressing contemporary problems in major watersheds, such as the Chesapeake Bay,[15] the Ohio River Basin,[16] and the Great Lakes.[17] Indeed, in the EPA's overall plan for trading, the agency envisions states adopting nutrient criteria and Total Maximum Daily Loads (TMDLs) that "embrace" water quality trading as a way to ultimately meet water quality goals.[18]

The governmental push for water quality trading in these and other watersheds is sometimes accompanied by an encouragement to use adaptive management; however, programs provide little detail about implementation of this approach. Even so, water quality trading programs could benefit from adaptive management, given the reliance on trading as an antidote to persistent nutrient and sediment impairment and the fact that trading is still in its experimental phase. Taking an adaptive approach to trading between point and nonpoint sources could increase the likelihood of understanding system dynamics and creating the transparency essential to deciding whether this regulatory tool is capable

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14. Stephanie Showalter & Sarah Spigener, *Pennsylvania's Nutrient Trading Program: Legal Issues and Challenges* 2 (Nat'l Sea Grant Law Ctr., White Paper, 2007), *available at* http://nsglc.olemiss.edu/WQT.pdf.

15. *Chesapeake Bay TMDL* 10.3–10.4, U.S. E.P.A. (2010), *available at* http://www.epa.gov/reg3wapd/pdf/pdf_chesbay/FinalBayTMDL/CBayFinalTMDLSection10_final.pdf; *id.* at 8-27 (allowing trading in Pennsylvania), *available at* http://www.epa.gov/reg3wapd/pdf/pdf_chesbay/FinalBayTMDL/CBayFinalTMDLSection8_final.pdf; *id.* at 8-32 (allowing trading in West Virginia). This follows an earlier tributary strategy in Pennsylvania that identified a 27,000 pound phosphorus shortfall in nonpoint source reductions in the Susquehanna Basin and proposed nutrient credit trading by Publicly Owned Treatment Works to make up the difference. Showalter & Spigener, *supra* note 14, at 5.

16. Brydon Ross, *IN, KY, and OH Sign Largest Credit Trading Program for Water Pollution*, KNOWLEDGE CTR., COUNCIL FOR STATE GOV'TS (Aug. 9, 2012, 3:55 PM), http://knowledgecenter.csg.org/kc/content/ky-and-oh-sign-largest-credit-trading-program-water-pollution.

17. *See generally* Nancy Frank & Sahana Goswami, *Our Waters: Water Quality Trading* (Se. Wis. Watersheds Trust, Inc., White Paper, 2012), *available at* http://www.scribd.com/doc/137233107/Water-Quality-Trading-White-Paper-June-2012 (reviewing the status of water quality trading in Wisconsin). The water quality trading approach allows producers of nonpoint source pollutants to choose between reducing the end-of-pipe pollutant concentrations and entering into trade agreements with other producers in the watershed to achieve the same result. *Id*. at 2.

18. *See Water Quality Trading Evaluation*, *supra* note 11, at 1–4.

of solving the problem presented by unregulated nonpoint source pollution. However, implementation of adaptive management in the trading context raises a variety of complexities. Without clearly sorting through those issues, adaptive management becomes "magic words" that fail to deliver an improvement in water quality.

This article discusses how adaptive management could be applied to nutrient trading programs to satisfy the informational needs of policy makers charged with advancing water quality. Section I frames the agricultural nonpoint source water pollution dilemma within the context of the Clean Water Act. It outlines the range of possible solutions, and the EPA's focus on water quality trading. Section II discusses the use of the term "adaptive management" in conjunction with water quality trading programs in the Chesapeake Bay, Ohio River, Wisconsin (impacting waters that empty into the Great Lakes and Mississippi River), Rogue River, Willamette River, and Lower Boise River. This section highlights the lack of specificity about how to apply adaptive management. Section III, adaptive trading, identifies the information necessary for nutrient trading involving nonpoint sources and suggests a more defined approach to applying adaptive management.

I. NONPOINT AGRICULTURAL POLLUTION DILEMMA

A. Extent of Water Pollution from Agriculture and Clean Water Act Approach

Congress distinguished point from nonpoint sources of pollution when it created the Clean Water Act (CWA). Section 502(14) of the CWA defines "point source" as readily identifiable sources of pollution, such as discharge pipes.[19] Point sources are regulated with the National Pollution Discharge Elimination System (NPDES) or state equivalent permits that apply water quality and technology standards, among other requirements, and impose legal liability for violations.[20]

By contrast, Congress defined "nonpoint source" as "any source of

19. Specifically, a "point source" is "any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. *This term does not include agricultural stormwater discharges and return flows from irrigated agriculture*." 33 U.S.C. § 1362(14) (2006) (emphasis added).

20. *National Pollution Discharge Elimination System (NPDES)*, U.S. E.P.A., http://cfpub.epa.gov/npdes/cwa.cfm?program_id=45 (last visited Mar. 2, 2014) (citing CWA sections relating to the NPDES Permit Program).

water pollution that does not meet the definition of 'point source' in section 502(14)".[21] This is diffuse runoff from land, and can include manure, fertilizer, oil and grease, salt, bacteria, sediment, and other pollutants.[22]

Nonpoint source pollution is the largest persistent category of water pollution in the U.S., which by definition is diffuse, varied, and unregulated at the federal level.[23] According to the EPA, agricultural nonpoint source pollution is the leading cause of impairments to surveyed rivers and streams.[24] Hence, agriculture is key to the nonpoint source pollution problem, which is to say *the* water pollution problem, and the solution to that problem.

The 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. The agricultural activities that lead to these impairments 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 fertilizer."[25] Add to that the fact that these activities are taking place on more than 330 million acres of U.S. land.[26] Unlike applying an end-of-pipe technology to

21. *What Is Nonpoint Source Pollution?*, U.S. ENVTL. PROT. AGENCY, http://water.epa.gov/polwaste/nps/whatis.cfm (last visited Mar. 2, 2014).

22. *Id.*

23. NATIONAL WATER QUALITY INVENTORY, *supra* note 4, at 14–15, 18, 22. Of the assessed stream and river miles, 44% are impaired. *Id.* at 13. Agriculture ("crop production, grazing, and animal feeding operations") is the number one "cause" of stream and river impairment, impairing 94,182 miles. *Id.* at 15–16. For assessed lakes, a much higher percentage than rivers and streams were impaired: 64%. *Id.* at 16. Agriculture is the third highest source of impairment, impairing 1,670,513 lake acres. *Id.* at 19. Of the assessed bays and estuaries, 30% are impaired. *Id.* at 20. Unlike lakes, rivers and streams, agriculture is the ninth source of estuary/bay impairment, impairing 792 square miles. *Id.* at 23.

According to the findings of the National Research Council,

> The Clean Water Act has been effective in addressing point sources of water pollutants. Notably, however, the Clean Water Act addresses nonpoint source pollution only in a limited, indirect manner. This is a crucial difference given the significance of nonpoint source water pollution throughout the nation and its special importance to Mississippi River and northern Gulf of Mexico water quality.

Nat'l Research Council Comm. on the Mississippi River and Clean Water Act, *Mississippi River Water Quality and Clean Water Act: Progress, Challenges, and Opportunities*, at 6 (2008), available at http://www.nap.edu/openbook.php?record_id=12051&page=1.

24. *Agriculture*, U.S. E.P.A., http://water.epa.gov/polwaste/nps/agriculture.cfm (last updated Sept. 9, 2013). However, this EPA statement is based on data reported in 2000 and a survey of a minority of all water bodies in the U.S., which may not accurately reflect the reality of the problem.

25. *Id.*

26. *Id.*

control point source water pollution, these polluting activities involve farm management practices, which will have varying impacts based on a variety of local environmental and landscape factors.

In contrast to the prescriptive approach applied to point sources, which sets pollution limits and requires permits, neither state nor federal government have applied similar regulatory methods to nonpoint source agricultural pollution.[27] According to the National Research Council, in its study of impairments to the massive Mississippi River Basin, the "Clean Water Act contains no authorities that directly regulate nonpoint sources . . . ."[28] Instead, of regulating these sources, the EPA points out that "[t]here are many government programs available to help farmers and ranchers design and pay for management approaches to prevent and control [nonpoint source] pollution."[29]

Despite Congress's express commitment in the Clean Water Act to control water pollution, the act's language fails to ensure effective control of nonpoint source pollution.[30] Initially, the Clean Water Act focused on municipal and industrial point sources. Section 208 of the Act addressed nonpoint source pollution by requiring states to create comprehensive water quality plans;[31] but Section 208 failed to require implementation, making the plans largely ineffective.[32]

The 1987 amendments to the Clean Water Act created the Nonpoint Source Management Program, authorizing the EPA to provide grants to states implementing programs to reduce nonpoint source pollution in

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27. Clean Water Act, Section 319, establishes the federal nonpoint water pollution program. 33 U.S.C. § 1329 (2006). The program requires states to report on nonpoint source pollution, and those states that comply with the reporting requirement then become eligible to apply for federal grants to implement their nonpoint source management programs. *Id.* These grants to states, territories and tribes fund "a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific nonpoint source implementation projects." *Clean Water Act Section 319*, U.S. E.P.A., http://water.epa.gov/polwaste/nps/cwact.cfm (last visited Mar. 2, 2014).

28. Nat'l Research Council Comm., *supra* note 23, at 7. "The Clean Water Act specifically exempts agricultural stormwater discharges and return flows from irrigated agriculture from being regulated as point source discharges and does not address agricultural nonpoint source pollution except as it leaves all nonpoint source pollution management to the states . . . . *Id.*

29. *Agricultural Nonpoint Source Fact Sheet*, U.S. E.P.A., http://water.epa.gov/polwaste/nps/agriculture_facts.cfm (last visited Mar. 2, 2014). Section 319 Clean Water Act grants, cost-share, technical assistance, and other economic incentives are available for farms. *Id.*

30. Chelsea H. Congdon et al., *Economic Incentives and Nonpoint Source Pollution: A Case Study of California's Grassland Regions*, 14 HASTINGS W.-NW J. ENVTL. L. & POL'Y 215, 221 (2008).

31. *Id.* at 220.

32. *Id.*

navigable waterways.[33] To receive funding, states must identify waterways that require a reduction in nonpoint source pollution to achieve and maintain water quality; identify categories of significant nonpoint source pollutants; outline the process for identifying Best Management Practices (BMPs); and identify state and local programs for addressing nonpoint source pollution.[34] BMPs require farmers to adopt specific technology or management practices to decrease runoff pollution.[35] "These BMPs are, of necessity, less specific than technology-based requirements for point sources and are intended to allow for site-specific adaptation."[36] However, BMPs tend to be too general to impose accountability on pollutant dischargers and only require dischargers to comply with the BMPs, regardless of whether more efficient methods of pollution exist.[37]

Additionally, the Clean Water Act requires states to establish Total Maximum Daily Loads (TMDLs). TMDLs set the amount of pollution that can be discharged into a specific waterbody in order to attain water quality.[38] For each body of water that does not meet water quality standards, nonpoint sources must be factored into the TMDL calculations.[39] However, the federal law still has not taken the next step to require states to implement the nonpoint source program, nor does it authorize the EPA to step in and promulgate a federal program in the absence of an effective state nonpoint source program.[40]

B. Range of Solutions to Water Pollution from Agriculture

Proposals to address the problem of excessive water pollution from agriculture can be better understood against the backdrop of existing law. The range of plausible solutions include creating regulations that require farms to implement BMPs, funding to pay for BMPs on farms causing water quality impacts, and encouraging water quality trading between point sources and farms. The EPA, states, and regulated point sources are calling for greater use of water quality trading, allowing regulated

33. 33 U.S.C. § 1329(h)–(i) (2006).
34. § 1329(h), (a)(1).
35. Congdon et al., *supra* note 30, at 227.
36. *Id.* at 255.
37. *Id.* at 227, 255.
38. 33 U.S.C. § 1313(d)(1)(c) (2006).
39. Congdon et al., *supra* note 30, at 220.
40. *Id.* at 221.

point sources to purchase less expensive reductions in nutrients and sediments from farms in order to bridge the regulatory gap Congress created with the Clean Water Act. Assessing the range of plausible solutions explains the support for this particular solution.

Much scholarship has centered on this debate over how to control agricultural nonpoint sources of water pollution. Most scholars recognize that the Clean Water Act's current regulatory framework is inadequate to control nonpoint source pollution.[41] They disagree, however, about whether the best method would be to continue a system based on local and voluntary efforts or to initiate a federal and more prescriptive approach.

Some scholars argue that states are better suited to address nonpoint sources because land use regulation belongs exclusively to state and local governments.[42] Furthermore, variations in crops, soil, climate, topography, hydrology, and other conditions may preclude a national one-size-fits-all approach.[43] As such, proponents of state-level nonpoint source management find voluntary, incentive-based programs more flexible, efficient, and cost-effective and, thus, more amenable to the diverse needs of farmers.[44]

Local or state-based methods of pollution control include after-the-fact litigation and preventive measures, like local land use controls. Pollution-related litigation frequently involves common law nuisance claims and the public trust doctrine. Public nuisance claims may arise

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41. *See, e.g.*, Robert W. Adler, *Agriculture and Water Quality: A Climate-Integrated Perspective*, 37 VT. L. REV. 847, 847 (2013) ("While control programs have resulted in success stories for some kinds of impacts on a local or even regional scale, from a broad national perspective the effects of agriculture on water quality have not changed significantly."); Jan G. Laitos & Heidi Ruckriegle, *The Clean Water Act and the Challenge of Agricultural Pollution*, 37 VT. L. REV. 1033, 1040 (2013) ("Continued high pollution levels from agricultural sources reflect the states' failure [under the Clean Water Act's state management programs] to effectively regulate agricultural nonpoint source . . . pollution."); Douglas R. Williams, *When Voluntary, Incentive-Based Controls Fail: Structuring a Regulatory Response to Agricultural Nonpoint Source Water Pollution*, 9 WASH. U. J.L. & POL'Y 21, 25 (2002) ("The increased attention given to controlling nonpoint source pollution [under the Clean Water Act and other federal and state programs] has not yet . . . translated into either widespread demonstrable results or clearly defined, coherent regulatory programs.").

42. *See* Robin Kundis Craig, *Local or National? The Increasing Federalization of Nonpoint Source Pollution Regulation*, 15 J. ENVTL. L. & LITIG. 179, 182 (2000) (noting that "[o]pponents of increased federal regulation to protect the environment have recently challenged the constitutionality of federal environmental enforcement that they perceive as reaching 'too far' into local land use affairs").

43. Adler, *supra* note 41, at 848.

44. *See* Congdon et al., *supra* note 30, at 217 (noting that a regulatory program that requires farmers to adopt best management practices and apply for individual permits would be difficult to apply to "a highly diverse group of individual farms").

when agricultural activities unreasonably interfere with the use and enjoyment of one's property.[45] Nonpoint source pollution that impairs water quality and adversely affects human health and the property rights of others "may be abatable under state nuisance laws."[46] The public trust doctrine provides that the state has a legal duty to hold navigable waters in trust for the benefit of the public and may allow injured parties to bring suit against the state for failing to control nonpoint source pollution of those waters.[47] A litigation approach, however, is by its nature piece meal, after-the-fact, and relies on the existence of litigants with standing and the resources to protect a common pool resource like shared waters. In short, it serves a different purpose than a more forward looking regulatory or even market approach.

Preventative measures, like local land use controls, cluster zoning and transferable development rights, may also reduce the harmful effects of nonpoint source pollution by directing agricultural pollution away from waterways and other environmentally sensitive areas.[48] However, lack of consistency between local governments undermines the effectiveness of land use controls to address chronic and widespread agricultural nonpoint pollution. Where there is no state standard, local controls vary too much to adequately address the scale of nonpoint source agricultural pollution, which follows watershed and not political boundaries.

On a larger scale, agricultural nonpoint source pollution may be addressed through stronger federal regulation. Many scholars argue that the federal government relies too heavily on voluntary participation[49] and should take a more active role in establishing water quality standards and enforcing state compliance.[50] Proponents of a federal control program contend that the technology for addressing nonpoint source pollution is available, but that policy concerns—e.g., the protection of agricultural interests—are preventing a strong federal response.[51]

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45. Laitos & Ruckriegle, *supra* note 41, at 1066–67.

46. *Id*. Note, however, the limits imposed by many states that have "Right to Farm" laws protecting farms against these types of lawsuits.

47. Véronique Jarrell-King, *Wildlife, Water Quality, and the Public Trust Doctrine: A Means of Enforcing Agricultural Nonpoint Source Pollution Management Plans*, 23 VILL. ENVTL. L.J. 1, 4, 23 (2012).

48. Laitos & Ruckriegle, *supra* note 41, at 1067–69.

49. *E.g.*, Williams, *supra* note 41, at 27.

50. *See id.* at 112–13 (arguing for minimum national water quality and monitoring standards, a stronger TMDL program, and the elimination of the Clean Water Act's exemptions for agriculture).

51. Adler, *supra* note 41, at 871.

Suggestions for federal regulatory improvements include creating minimum national water quality and monitoring standards,[52] creating mandatory BMPs,[53] strengthening the TMDL program,[54] eliminating the Clean Water Act's agricultural exemption,[55] and extending the Clean Water Act's citizen suit provision to nonpoint sources that violate state water quality standards.[56] However, there is significant pressure from the Farm Bureau and their supporters to avoid any form of federal water pollution regulation.[57] As a result, none of these regulatory reforms have gained traction over the years.

Additionally, agricultural pollution could be addressed through more robust and targeted incentive programs. Dating back to early farm bills, farm participation in such voluntary programs has been incentivized through income or price support and payments for specific actions.[58] The USDA has established programs that pay farmers to implement conservation practices, such as the Conservation Reserve Program (CRP), Environmental Quality Incentive Program (EQIP), and Conservation Security Program (CSP).[59] However, not all farms contribute equally to the problem of polluted runoff so "[b]asing conservation and land use decisions across a watershed primarily on incentive-based payments to enlist voluntary actions does not ensure efficient use of resources designed to reduce nutrient and sediment loadings."[60] The National Research Council also recommends targeting these programs to fund farms undertaking BMPs in areas with higher pollutant loading into waterways.[61] Other scientific research similarly

52. Williams, *supra* note 41, at 112–15.

53. Congdon et al., *supra* note 30, at 255.

54. Williams, *supra* note 41, at 115–18.

55. *Id.* at 119–20. The Clean Water Act explicitly exempts "return flows from irrigated agriculture" from the federal permitting system. 33 U.S.C. § 1342(l)(1) (2006).

56. Craig, *supra* note 42, at 232.

57. The Farm Bureau's statement about the "importance to the agricultural community" of its lawsuit challenging the TMDL for the Chesapeake Bay exemplifies this broad opposition: "To ensure that EPA cannot dictate how and when states choose to implement water quality goals, particularly where achieving those goals involves important land use and economic decisions." AM. FARM BUREAU FED'N, http://www.fb.org/index.php?fuseaction=legal.active (last visited Mar. 30, 2014).

58. Nat'l Research Council Comm., *supra* note 23, at 166.

59. *See id.* at 9 ("The EPA could assist the USDA to help improve the targeting of funds expended in the CRP, EQIP, and CSP.").

60. *Id.* at 178.

61. *Id.* at 8, 168–72, 188. Although EQIP is implemented by local conservation districts, it "does not effectively target working lands that produce the highest rates of nutrient and sediment pollutant loads." *Id.* at 169. CSP rewards farmers who install water quality and erosion control

finds that an approach that targets efforts on the most highly phosphorus-polluting fields *and* aggregates efforts within certain watersheds is the most effective in terms of producing measurable water quality improvements.[62]

A targeted approach requires stronger interagency coordination between the USDA and the EPA to direct these funds and work with conservation districts, extension agents, and farmers on water quality management and monitoring.[63] From a water quality perspective, it makes very little sense to have conservation programs that cannot be targeted based on proximity to water bodies. The National Research Council recommends that current USDA "programs aimed at reducing nutrient and sediment inputs should include efforts at targeting areas of higher nutrient and sediment deliveries to surface water."[64] However, some farm advocates oppose targeting funding in this way, and describe it as "unfair" because it excludes some producers from being able to receive conservation payments.[65] In order to advance this strategy, agencies would need to overcome this political pressure, which has so far stymied meaningful progress in this area.[66]

C. The EPA's Chosen Solution—Market Mechanism

Lastly, there is the market mechanism to address unregulated water pollution from farms. As noted, the EPA has concluded that "pollution sources not traditionally regulated, most notably non-point pollutants from agriculture, are the primary source of water quality impairment in many watersheds."[67] The EPA accepts the lack of agricultural regulation as the status quo, and asserts that water quality trading provides a "framework wherein pollutants can be voluntarily reduced by non-point sources more cost-effectively than imposing additional treatment controls on point sources."[68]

BMPs by increasing payments, but it is "operated with only a modest budget." *Id.* at 170.

62. Matthew W. Diebel et. al., *Landscape Planning for Agricultural Nonpoint Source Pollution Reduction I: A Geographical Allocation Framework*, 42 ENVTL. MGMT. 789, 798–800 (2008).

63. Nat'l Research Council Comm., *supra* note 23, at 171–72.

64. *Id.* at 188 (emphasis in original removed).

65. *Id.* at 178.

66. The National Research Council recognizes that targeting of USDA financial incentive programs has been stymied by political pressure; targeting is seen as "unfair" because it excludes some producers from being able to receive conservation payments. *Id.*

67. *Water Quality Trading Evaluation*, *supra* note 11, at ES-1.

68. *Id.*; *see also id.* at 1-1.

In environmental law and policy, there is an ongoing debate about whether the tool of command and control regulation is preferable to the market mechanism.[69] For the purposes of this Article, I provide a brief explanation and examples without repeating the critiques of these divergent approaches replete in the literature.[70]

Command and control regulations, which are prescriptive, take a uniform approach and require all members of a particular industrial or municipal category to reduce pollution. An example of this is the Clean Water Act's use of technology-based standards for a particular industry, which sets clear end-of-pipe discharge limits to be included in permits in every state in the United States and subjects violators to penalties and possible criminal liability.[71]

By contrast, the common example of a market mechanism is emission trading under the Clean Air Act:

> Emissions trading schemes allocate pollution rights within an industrial sector or geographic region based on the theory that firms that can reduce their emissions at a lower cost will be encouraged to do so by a market mechanism in which they can sell their excess allocation to firms for which such reductions would be more expensive. This presumably accomplishes the ultimate regulatory goal (which government still establishes) in the most efficient way.[72]

Because market mechanisms have been developed mainly as an alternative to uniform prescriptive regulation across an entire regulated industry, it is often pitted against regulations or presented as an "either or" scenario. The use of the market mechanism to reduce unregulated agricultural nonpoint source pollution falls somewhat outside the boundaries of the debate.[73]

The market mechanism is most commonly described in this context as allowing point sources of pollution to buy credits from agricultural nonpoint sources that have reduced pollution.[74] Water quality trading

69. Jody Freeman & Daniel A. Farber, *Modular Environmental Regulation*, 54 DUKE L.J. 795, 814–21 (2005).

70. *See, e.g.*, Adler, *supra* note 41; Laitos & Ruckreigle, *supra* note 41; Williams, *supra* note 41; Craig, *supra* note 42; Congdon et al., *supra* note 30; Jarrell-King, *supra* note 47.

71. *Clean Water Act*, U.S. E.P.A., http://cfpub.epa.gov/npdes/cwa.cfm?program_id =45.

72. Freeman & Farber, *supra* note 69, at 814.

73. *Id.* at 816. Although Freeman and Farber cite watershed-based effluent trading as an example of a market mechanism, it is important to tease out this distinction about trading with unregulated nonpoint sources a bit more.

74. Other market mechanisms for agricultural pollution, which are less widely discussed, are issuing traditional permits to agriculture and then using a cap and trade system between farms, or

between point and agricultural nonpoint sources occurs as a response to a regulatory driver, not as an alternative. It is a tool to control what are currently unregulated discharges of pollution from agriculture. For example, a state sets a prescriptive standard for phosphorus and a municipal wastewater treatment plant looks for a way to meet the new regulation. Finding a low cost way of complying with the new regulation creates the impetus for the point source to seek out an unregulated agricultural source with which it can enter a contract to secure reductions in phosphorus.

Additionally, the benefits for the environment may extend beyond reductions in the traded pollutant.

> [E]ven if phosphorus is the regulated target, installing Best Management Practices (BMPs) on a farm or in a subdivision reduce other pollutants as well, such as Total Suspended Solids that carry phosphorus in addition to petroleum residues and silt up streams. BMPs can prevent erosion, restore habitat, and sequester carbon.[75]

One place where the EPA is encouraging trading between point and nonpoint sources is in watershed clean-up plans or TMDLs.[76] A TMDL calculates the total amount of a pollutant a water body can receive and meet water quality standards.[77] As noted, this calculation includes load allocations from nonpoint and background sources and waste load allocations from point sources.[78]

However, trading between point and nonpoint sources in a TMDL setting is not squarely addressed in the Clean Water Act or related regulations. There is a vague recognition in the TMDL regulations that the "TMDL process provides for nonpoint source control tradeoffs."[79]

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imposing effluent fees. Congdon et al., *supra* note 30, at 259–60.

75. Frank & Goswami, *supra* note 17, at 3; *see also* Water Quality Trading Evaluation, *supra* note 11, at ES-1.

76. *What is a TMDL?*, U.S. E.P.A., http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/overviewoftmdl.cfm (last updated Mar. 11, 2013).

77. 33 U.S.C. § 1313(d)(1)C) (2006) ("(C) Each State shall establish for the waters identified in paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies under section 1314(a)(2) of this title as suitable for such calculation. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.").

78. 40 C.F.R. § 130.2(g)–(h) (2014).

79. 40 C.F.R. § 130.2(g)–(i) (2014) ("(g) Load allocation (LA). The portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. Load allocations are best estimates of the loading, which

One vein of thinking is that if a point source is going to "continue activities that give rise to pollutant loading, they must secure reductions from nonpoint sources in the watershed by paying the nonpoint sources to reduce their pollutant loading."[80] Courts are divided as to the legality of offsetting pollution sources.[81]

Despite the legal uncertainties, the EPA appears to present trading as *the* plausible solution to the problem of chronic unregulated agricultural runoff; it continues to emphasize water quality trading between point and nonpoint sources by encouraging incorporation of trading into TMDLs.[82] The 2003 EPA Trading Policy goes beyond the gaps in its regulations and "encourages the inclusion of specific trading provisions in the TMDL" as well as in National Pollutant Discharge Elimination System permits and watershed plans.[83] This policy is particularly applicable to chronic problems with agricultural runoff because nutrients and sediments are the primary pollutants the EPA Trading Policy targets.[84] Hence, the market mechanism *could* be a plausible tool to bring under control pollution sources that Congress has been unwilling to regulate using prescriptive requirements or targeted financial incentives.

Yet, there are multiple caveats and complicating factors to this

may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint source loads should be distinguished." (h) Wasteload allocation (WLA). The portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation. (i) Total maximum daily load (TMDL). The sum of the individual WLAs for point sources and LAs for nonpoint sources and natural background. If a receiving water has only one point source discharger, the TMDL is the sum of that point source WLA plus the LAs for any nonpoint sources of pollution and natural background sources, tributaries, or adjacent segments. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure. If Best Management Practices (BMPs) or other nonpoint source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent. *Thus, the TMDL process provides for nonpoint source control tradeoffs.*" (emphasis added)).

80. Thomas K. Ruppert, *Water Quality Trading and Agricultural Nonpoint Source Pollution: An Analysis of the Effectiveness and Fairness of EPA's Policy on Water Quality Trading*, 15 VILL. ENVTL. L.J. 1, 9–10 (2004).

81. The EPA lacks clear statutory authority to allow water quality trading. Showalter & Spigener, *supra* note 14, at 7–10; Friends of Pinto Creek v. EPA, 504 F.3d 1007, 1012 (9th Cir. 2007) (finding that 44 C.F.R. § 122.4(i) "is very clear that no permit may be issued to a new discharger if the discharge will contribute to the violation of water quality standards" and ultimately rejecting offsetting); *cf.* In re City of Annandale, 731 N.W. 2d 502 (Minn. 2007) (allowing state agency to consider offsets from other pollution sources while deciding whether to issue discharges from a new source would result in a violation of water quality standards).

82. *See* U.S. EPA, *supra* note 76 and accompanying text.

83. EPA Water Quality Trading Policy, Issuance of Final Policy, 68 Fed. Reg. 1608-01, 1610 (Jan. 13, 2003).

84. *Id.* at 1610.

proposition. In addition to the absence of clear statutory authority, the market mechanism cannot succeed without prescriptive regulations in some part of the system. It is precisely the prescription that drives the market for regulated point sources to trade with unregulated nonpoint sources of pollution.[85] The prescription goes hand in hand with the market mechanism rather than an alternative to a command and control system. At present that is dependent on states creating stringent nutrient standards or TMDLs for specific waterbodies so trading will be piecemeal in application. Furthermore, it is technically more difficult to measure runoff from a farm than emissions from a smokestack or discharges from a wastewater treatment plant.[86] This creates difficulties in accurately establishing tradable credits, verifying actual reductions as opposed to modeled ones, and knowing when the market tool is succeeding or failing.

So although plausible, the jury is out on whether the market mechanism of trading nonpoint for point source pollution will truly solve the problem of sediments and nutrients fouling the nation's waters. Assuming trading and offsets are permissible under the Clean Water Act, how the market mechanism is implemented will influence whether this approach results in measurable environmental improvements. Since watershed trading has generated more talk than actual trades, the tool is still largely experimental. Approaching watershed-based trading with an experimental mindset, like that envisioned by adaptive management theory, should improve the likelihood of measurable environmental improvements or provide enough information to change course if it is not delivering on the promise of cleaner water.

II. ADAPTIVE MANAGEMENT: MAGIC WORDS

The EPA and states have used the term "adaptive management" in conjunction with water quality trading programs in the United States, but they tend to lack specificity about how to apply the theory. Adaptive management holds the potential to create real improvements in water quality based on experimenting and incorporating new information.

85. James Salzmann & J.B. Ruhl, *Currencies and the Commodification of Environmental Law*, 53 STAN. L. REV. 607, 617–20 (2000).

86. Showalter & Spigener, *supra* note 14; *see also* Diebel et. al., *supra* note 62, at 800 (summing it up: "The use of agricultural conservation practices has no doubt benefited the environment. However, much environmental degradation is still caused by agriculture, and the benefits of conservation have been difficult to measure").

However, without measurable improvement to water quality, adaptive management becomes magic words that give the illusion of positive action. In this section, I highlight key examples where adaptive management and water quality trading are appearing together: Chesapeake Bay, Ohio River, Wisconsin (impacting waters that empty into the Great Lakes and Mississippi River), Rogue River, Willamette River, and Lower Boise River.

Adaptive management is an approach by which natural resource agencies are encouraged to learn as they implement their programs; the aim being to create feedback loops that allow programs to learn and come closer to achieving their goals by routinely incorporating new information.[87] Pioneered in the context of dynamic ecosystems in the 1970s, adaptive management emphasizes that dynamic systems are better served by management that collects, tests, and applies information.

Although there are a variety of descriptions of adaptive management theory and practice, one scholar has attempted to provide 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 models, understandings, and management interventions in accord with this new learning.[88]

At its core, adaptive management anticipates that agencies—either alone or in conjunction with stakeholders—actively seek new information and modify their management approaches in light of that new information.[89] With this brief explanation of adaptive management in mind, the following examples illustrate where adaptive management and water quality trading are appearing together.

The largest estuary in the United States, the Chesapeake Bay, has been at the center of watershed clean-up efforts, including adaptive management and trading.[90] The Chesapeake Bay TMDL includes a section entitled "Implementation and Adaptive Management." This

87. Melissa K. Scanlan & Stephanie Tai, *Marginalized Monitoring: Adaptively Managing Urban Stormwater*, 31 UCLA J. ENVTL. L. & POL'Y 1, 7–16 (2013).

88. *Id.* at 9–10 (citing Bradley C. Karkkainen, *Bottlenecks and Baselines: Tackling Information Deficits in Environmental Regulation*, 86 TEX. L. REV. 1409, 1443 (2008)).

89. *Id.* at 10.

90. Am. Farm Bureau Fed'n v. U.S. E.P.A., No 1:1–CV–0067, 2013 WL 5177530, at *5–9 (M.D. Penn. Sept. 13, 2013).

section describes offsets and trading anticipated by the TMDL, but does not detail the adaptive management approach indicated by the title of the section.[91] In one subsection addressing climate, the EPA commits itself "to take an adaptive management approach to the Bay TMDL and incorporate new scientific understanding of the effects of climate change into the Bay TMDL, in this case during the mid-course assessment."[92] However, the details of how this should be implemented are left undeveloped. Furthermore, there is no indication in the TMDL and its appendix on offsets and trading that an adaptive management iterative process will be used. The TMDL does not require any water quality monitoring to inform adjustments in individual trades or offsets, assess a bundle of trades on one segment of the watershed, or review the program as a whole.[93] By not requiring water quality monitoring in the TMDL and the accompanying appendix, the EPA has not used these tools to provide for uniform data collection to assess progress and provide feedback that informs possible land management changes. Taken together, the use of the term "adaptive management" in relation to trading in the Chesapeake Bay TMDL carries very little substantive meaning.

The Ohio River Basin is the subject of a pilot water quality trading program focused on agricultural nonpoint sources generating credits to trade with point sources.[94] The Ohio River pilot's use of adaptive management terminology is, like the Chesapeake Bay TMDL, devoid of clear steps laying out an experimental design and a continuous learning process for water managers. Like the Chesapeake Bay TMDL, this trading plan also offers little detail on implementing adaptive management. In its entirety the section addressing adaptive management reads: "An adaptive management approach will be used to periodically review and, if necessary, amend this Plan during the Pilot to achieve optimum effectiveness, efficiency, and environmental improvement.

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91. U.S. E.P.A., CHESAPEAKE BAY TOTAL MAXIMUM DAILY LOAD FOR NITROGEN, PHOSPHOROUS AND SEDIMENT §§ 10, 10.1.2, 10.2, 10.5 (2010), *available at* http://www.epa.gov/reg3wapd/tmdl/ChesapeakeBay/tmdlexec.html.

92. *Id.* §10.5.

93. *Id.* §§ 10.1.2, 10.2; app. S (Offsetting New or Increased Loadings of Nitrogen, Phosphorus, and Sediment to the Chesapeake Bay Watershed). The EPA describes that it reserves the authority to review individual offsets, but expects its role to primarily be one of reviewing offsets at the broader programmatic level. *Id.* § 10.1.4.

94. ELEC. POWER RESEARCH INST., PILOT TRADING PLAN 1.0 FOR THE OHIO RIVER BASIN INTERSTATE WATER QUALITY TRADING PROJECT (2011), *available at* www.farmland.org/documents/ORBTradingPlan8-6-12V2FINAL.pdf.

Public outreach will be a component of this adaptive management approach."[95]

Moreover, the Ohio River pilot aims to create a trading program in which nonpoint sources will generate credits to sell point sources.[96] Credits will be generated by a "scientifically-based" method of determining "ecologically-appropriate trade ratios."[97] Yet, the method is devoid of any monitoring of water quality. Instead, it relies entirely on two models, one to estimate nutrient reductions at the edge of the field where a BMP has been installed and another to estimate nutrient attenuation (reduction) from the edge-of-field to the point where the credits will be used.[98] The plan establishes a credit reserve in case of credit uncertainty or "failure,"[99] but verification of BMP installation and functioning does not include a requirement to monitor water quality.[100]

In Wisconsin, the phosphorus water quality standards for the state's more than 15,000 lakes and 80,000 miles of streams and rivers[101] include references to trading and adaptive management. However, the standards present trading and adaptive management as two different "compliance options."[102] The state agency guidance on the phosphorus rules describes these options as compliance options that give point sources "flexibility to achieve a phosphorus water quality based effluent limit (WQBEL) by controlling point and nonpoint phosphorus sources . . . ."[103] The guidance advises that a permittee may want to consider the adaptive management option when:

1. The WQBEL is stringent (generally 0.4 mg/L or less).
2. Achieving compliance would result in major facility modification even with the facility functioning at optimal conditions. If major facility modification is not required the applicant is not eligible for adaptive management.
3. Reducing nonpoint or other point sources is economically

95. *Id.* at 9.
96. *Id.* at 4–6.
97. *Id.* at 4.
98. *Id.* at 5–6. The field model is the EPA region 5's spreadsheet model, and the attenuation model is WARMF. *Id.*
99. *Id.* at 8–9.
100. *Id.* at E-7.
101. WIS. DEP'T OF NATURAL RES, 2010 WISCONSIN WATER QUALITY REPORT TO CONGRESS (2010), *available at* http://www.loonlakedistrict.org/pages/Attachment_A_2010_WQ_RptToCongress_FINAL _3-30-2010.pdf, at 12.
102. *Wisconsin's Adaptive Management*, WIS. DEPARTMENT OF NAT. RESOURCES, http://dnr.wi.gov/topic/SurfaceWater/adaptive management.html (last visited Mar. 27, 2014).
103. *Id.* at 6.

preferable.[104]

Wisconsin is not applying adaptive management to water quality trading, but presenting adaptive management as a less-stringent-than-trading compliance option.[105] Wisconsin offers an "adaptive management option" that allows an extended fifteen-year compliance schedule to point sources for meeting phosphorus WQBELs.[106] Wisconsin's guidance for a phosphorus adaptive management plan says it should include:

> 1. The amount of phosphorus that will be accounted for through adaptive management[,]
> 2. How the applicant will achieve compliance with interim and final WQBEL,
> 3. What strategies will be used to control the phosphorus contributions, and
> 4. Other implementation details including, but not limited to, partnership building capacities, funding sources, and monitoring plans.[107]

The plan can even allow applicants to pursue reductions in phosphorus by other sources that are not upstream of the point source.[108] There are no explicit water quality data collection requirements related to activities to reduce phosphorus by nonpoint sources in the adaptive management guidance.[109] Although there is indication that the point source will ultimately need to meet water quality at the discharge point, there is an allowance to use modeling to show "compliance with the intent of adaptive management" when actual water quality compliance is "infeasible."[110] Unlike the prior two examples, which simply lacked

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104. *Id.* at 85.

105. WIS. DEP'T OF NATURAL RES., ADAPTIVE MANAGEMENT TECHNICAL HANDBOOK: A GUIDANCE DOCUMENT FOR STAKEHOLDERS, Table 1, at 17 (Jan. 7, 2013), *available at* http://dnr.wi.gov/topic/surfacewater/documents/AdaptiveManagementHandbooksigned.pdf.

106. *Id.* at 86–88 ("WQBELs will be documented in the permit but will be held in abeyance pending the implementation of the adaptive management plan . . . . In other words, the WQBEL is included in the permit, but compliance is not required until the third permit term of the adaptive management plan or the water quality criteria has been attained, whichever comes first.").

107. *Id.* at 91.

108. *Id*.

109. The guidance includes water monitoring requirements at the point source and holds open the option of monitoring based on "plan requirements," but there are no specific requirements to monitor nonpoint or other sources that the permittee has solicited to make reductions under its adaptive management plan. *Id.* at 99–100.

110. *Id.* at 95 ("However, in some instances the contributions from other sources or the legacy

detail, this built-in compliance delay in Wisconsin's approach may thwart water quality improvements.[111]

The Rogue River Basin Water Quality Management Plan, which provides strategies for implementing the TMDL for that basin in Oregon, provides an approach that comes closer to the purpose of adaptive management.[112] The Rogue River TMDL encourages the use of trading thermal discharges.[113] Its section on adaptive management is instructive. It explicitly recognizes that TMDLs are based on models that are oversimplifications of complex processes and unlikely to exactly predict how waterbodies will respond to management practices.[114] Similarly, it acknowledges that technology for controlling nonpoint source pollution is in the development stages and that floods, drought, and other events may impair the expected functioning of BMPs.[115]

Oregon outlines expectations for adaptive management in this Water Quality Management Plan including a five-year review of TMDL implementation progress by the state agency, which involves assessing water quality standards; where implementation is inadequate, Oregon specifies that they should revise the plan to address the inadequacies.[116] By creating this simple iterative process, the plan provides a means for the agency to engage in learning and incorporate new information into their water management.

In another part of Oregon, the Willamette River Basin TMDL improves upon this articulated adaptive management process by specifying that it will have a plan for monitoring, data collection, data

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phosphorus in the receiving water makes achieving compliance with the criteria infeasible at the point of discharge within two permit terms. In these instances the applicant may use modeling to show compliance with the intent of adaptive management. In this case, model results/data should illustrate that water quality criteria would be attained if the residual phosphorus in the waterbody were removed."). *See also id.* at 97 ("Modeling may also be used to illustrate the effectiveness of the phosphorus reduction strategy and to illustrate compliance with the adaptive management plan.").

111. John Kennedy, Green Bay Metropolitan Sewerage District, powerpoint, *Water Quality Trading: A Permitee's Perspective*, at slide 18 (Nov. 14, 2011) ("Adaptive Management: Compliance Schedules (may get more time for ultimate compliance, but subject to DNR approval at each permit renewal. Trading – may offer incremental removal credits to avoid large capital expense.").

112. OR. DEP'T OF ENVTL. QUALITY, ROGUE RIVER BASIN TMDL, ch. 4, figure 4.2, at 4-2 (2008), *available at* http://www.deq.state.or.us/wq/tmdls/docs/roguebasin/Rogue/Chapter4WQMP .pdf.

113. *Id.* at 4-14.

114. *Id.* at 4-2.

115. *Id.* at 4-2, 4-3.

116. *Id.* at 4-3.

assessment, and making responsive revisions. If water quality standards are not being met, it envisions modifying "individual management strategies."[117]

Idaho's Lower Boise River's Implementation Plan for total phosphorus, which is described as "adaptive management," offers another template for creating an adaptive management approach. Plan developers explain that "the implementation schedule is designed to be flexible within an adaptive management framework. . . . The concept of adaptive management allows for on-the-ground implementation to proceed where uncertainty exists about how and when reduction targets will be met."[118] The plan emphasizes that "focused monitoring" is important for adaptive management, and that they are "committed to monitoring" specific reaches of the Lower Boise River to assess beneficial uses and phosphorus loading.[119] The plan calls for monitoring "at the mouth of key tributaries" to assess "how well nonpoint source improvements are performing."[120] It similarly requires monitoring of specific BMPs to assess whether they are "working as designed" and "reducing pollutant loading."[121]

The pollutant trading section of the Boise plan includes even more specific details about monitoring necessary for adaptive management. The plan says: "A rigorous monitoring plan and schedule is critical [to the TMDL]. There is no way to determine progress, define trends, fill data gaps or enlarge understanding without an understanding of the changes occurring in the system."[122]

As it relates to use of BMPs to reduce nonpoint source pollution, the Idaho plan states:

> BMP-specific monitoring will be included as part of specific treatment projects to verify that the BMPs are properly installed, maintained, and working as designed. Source groups constructing BMP projects should include budget allowances for a monitoring program. The results of the monitoring program will be used to recommend or discourage similar

117. Or. Dep't of Envtl. Quality, WILLAMETTE BASIN TMDL, 14–20 (2006), *available at* http://www.deq.idaho.gov/media/451497-_water_data_reports_surface_water_tmdls_boise_river_lower_lbr_total_phosphorus_plan_final.pdf . This TMDL also encourages trading for temperature. *Id.* at 14-34.

118. *Id.* at xxii.

119. *Id.* at xxiii.

120. *Id.*

121. *Id.*

122. *Id.* at 54.

> projects in the future.[123]

Some agricultural BMPs will have a "quantitative monitoring component as a means to better analyze the benefit in sediment or bacteria reduction."[124]

These examples show that the EPA and some states are interested in applying adaptive management to trading, as gauged by the use of both terms in emerging water restoration efforts. However, references to adaptive management are infrequently accompanied by guidance about how to structure an experimental approach. Oregon and Idaho's policies can be used as scaffolding for creating an adaptive management approach to trading that generates needed information. If the adaptive management approaches reflected current scientific advancements, data could be used to inform about the establishment of the trades, changes in management, modifications of permits or contracts, or assessments of whole water clean-up plans. The next section will explore some options for making water quality trading more adaptive.

III. ADAPTIVE TRADING: EXPERIMENTATION

The iterative monitoring and adjusting behavior core of the adaptive management approach appears to conflict with a prescriptive "command and control" system of regulations.[125] Some scholars also present an adaptive management approach to environmental problems as a counter to a market approach.[126] However, due to the flexibility of the market

123. *Id.* at 55.

124. *Id.* at 56.

125. Diebel et al., *supra* note 62, at 799–800. The command and control approach refers to the traditional method of controlling pollution through direct regulation. Winston Harrington & Richard D. Morgenstern, *Economic Incentive versus Command and Control: What's the Best Approach for Solving Environmental Problems?* 152 RESOURCES 13 (2004).

126. In response to the needs presented by climate disruption, Professor Dellapenna presents these as opposing approaches:

> Gene Stakhiv argues for adaptive management rather than an anticipatory strategy. By this, Stakhiv means that we should apply existing legal regimes with little or no change, counting on the flexibility he assumes is already built into such regimes to adapt gradually to the pressures induced by a combination of population growth, climate change, and technological innovation. Stakhiv argues against major changes in legal regimes to anticipate climate disruptions when the extent (and sometimes the precise nature) of the disruption is not known for certain. Others have suggested a turn to markets as a solution to adaptation to climate disruption in the face of massive uncertainty.

Joseph W. Dellapenna, *Climate Disruption, the Washington Consensus, and Water Law Reform*, 81 TEMP. L. REV. 383, 389 (2008) (internal citations omitted).

mechanism, it may be more amenable to incorporating an adaptive approach.

Additionally, since much is unknown about the efficacy of markets to solve intractable water quality problems, use of this policy tool would benefit from an experimental frame. Detractors will argue that recommending the application of adaptive management to water quality trading programs runs the risk of increasing the transaction costs of trading to the point that it negates the potential efficiencies gained by trading. Imposing a heavy information burden on those designing and implementing a trading program may increase the cost and discourage participation.[127] The challenge is whether adaptive management can be applied in a way that produces reliable information and flexibility to respond without increasing transaction costs to such an extent that trading partners will not enter the market. The markets' reliance on robust information raises another question: whether water quality trading markets can exist *without* the rich information that adaptive management could generate.[128]

In water quality trading, an adaptive management approach is potentially a useful tool for accounting for credit creation, uncertainty, compliance, and assessment of program efficacy. In an adaptive trading framework, monitoring and modeling of nonpoint source reductions and water quality improvements would be combined to provide robust information to inform these key issues.

However, the predominant water quality trading approach relies heavily on modeling without an additional monitoring follow up. In this section, I start by explaining the information challenges presented by using BMPs to reduce agricultural pollution, the use of models and monitoring in this context, and the EPA's Trading Policy on these issues. I then posit how adaptive management could be intentionally applied to water quality trading to produce adaptive trading.

When accounting for agricultural runoff, there are difficulties present both in measuring reductions in loading or pollutant concentration and accurately modeling those reductions.[129] Variables in soil, topography, distance to receiving water, and weather impact how much runoff will be

127. Salzmann & Ruhl, *supra* note 85, at 636 (recognizing the potential burdens posed by accounting for nonfungibilities across type, space, and time in environmental trading markets).

128. A lack of information can be a hurdle to robust trading. "This lack of information about the relative costs of pollution reduction often prevents realization of the full theoretical benefits that could arise from trading." Ruppert, *supra* note 80, at 12.

129. Ruppert, *supra* note 80, at 12–13.

reduced from a BMP.[130] One approach is to confirm installation of BMPs, which according to a model, should yield a specific reduction in pollutant loading. However, simply verifying installation of a BMP does not ensure that the expected pollutant loading reductions have occurred. Poor construction or heavy rainfall could result in it not functioning as estimated and modeled.[131] Similarly, less than expected rainfall or variation in some other environmental variable could mean the field on which the BMP was installed is yielding greater than modeled reductions in pollutant loading.

Modeling is fraught with difficulties. Although modeling allows for action in the face of uncertainty and lack of direct monitoring data, the results can vary based on adequacy of the data inputs as well as different interpretations of results.[132] Models are also subject to gaming. By slightly altering the many assumed values in equations, a modeler can often substantially change the outcome of the model with only minor and apparently reasonable changes to the variable assumptions. The dramatic changes in the result of complex equations due to miniscule changes in input information have been called "sensitive dependence on initial conditions."[133]

One way to address the myriad of uncertainties is to add a larger safety factor to reduce the calculation of loading reductions. Yet, this still does not provide a reliable way of knowing whether pollution reductions are actually being made to generate tradable credits. Another approach could be based on monitoring the receiving water body at the edge of the field where the individual BMP was used. However, this too may not show measurable improvements in water quality. Even though BMPs have been shown to be effective at reducing sediment and nutrient inputs to surface waters, these reductions "have rarely been found to act in concert to produce measurable, broad-scale improvements in water quality."[134] Despite the USDA spending $29.7 billion since 1987 to encourage farmers to implement conservation, they have generally not

130. Corey Longhurst, *Where is the Point? Water Quality Trading's Inability to Deal with Nonpoint Source Agricultural Pollution*, 17 DRAKE J. AGRIC. L. 175, 194 (2012).

131. Showalter & Spigener, *supra* note 14, at 11 ("A better method would be to require direct monitoring at the edge of the property and determine compliance based on actual reductions in loading."). This author then presumed the feasibility of monitoring was low, but did not cite any support for that presumption.

132. Ruppert, *supra* note 80, at 13.

133. *Id*.

134. Diebel et al., *supra* note 62, at 789.

produced measurable improvements in stream water quality.[135] One group of scientists found this is because "pollution control effort is often too sparsely distributed across the landscape to make an appreciable difference in any one place."[136]

According to the National Research Council, "The effectiveness of BMPs in agricultural settings is a subject of ongoing study."[137] In their report focused on the Mississippi River Basin, they highlight the need for water quality monitoring of different cropping practices. They also call for Mississippi River system-wide water quality monitoring to evaluate the water quality impacts of USDA funding programs for farmers to install BMPs.[138] For instance, for phosphorus BMPs, they note that the effectiveness is "difficult to evaluate at the farm field or local watershed level."[139] Because so much phosphorus is attached to soil particles, there is a lag time between changes in soil management and improvements in water quality. The council recognizes that meaningful evaluation of the water quality effectiveness of BMPs for phosphorus has been confounded by the "limited amount of long-term water quality data . . . ."[140] Likewise, a quantitative assessment of how much sediment is coming from a particular field is also challenging. Soil erosion from farming varies based on multiple factors that affect soil erosion, such as soil properties, fertilizer applications, slope of the land, location in relation to nearby streams, use of irrigation, and crop growth stage.[141]

The National Research Council's call for a system-wide monitoring effort is reinforced by research on nonpoint source pollution reductions in Wisconsin. The Wisconsin study shows that a targeted and aggregated approach is the most efficient way to see measureable improvements in water quality.[142] In other words, a program should target BMP installations to the largest sources of pollution and aggregate those efforts within watersheds. This is followed by monitoring to determine whether there is a water quality improvement in the receiving water body downstream from multiple installations of BMPs.[143]

135. *Id.* at 789–90.

136. *Id*. at 790.

137. Nat'l Research Council Comm., *supra* note 23, at 171.

138. *Id.* at 172.

139. *Id.* at 175.

140. *Id.*

141. The National Research Council states, "It would be impractical to monitor continuously the amount of sediments coming off each farm field." *Id.* at 176.

142. Diebel et al., *supra* note 62, at 789, 798–800.

143. Ruppert, *supra* note 80, at 16; Diebel et al., *supra* note 62, at 789.

The EPA's approach to trading embraces modeling and monitoring, but leans heavily on modeling, and does not reflect current scientific understanding of the need to target and aggregate efforts. The EPA Trading Policy includes several provisions on the topic of whether monitoring or modeling should be used for water quality trading. In the EPA Trading Policy's section on how trading aligns with the Clean Water Act, the policy asserts that NPDES permit-required sampling protocols and monitoring frequencies "should continue to be used where applicable for measuring compliance for point sources that engage in trading."[144] This is "necessary" to provide clear, consistent compliance measurements that provide sufficient information for enforcement.[145]

The EPA Trading Policy also sets forth "elements of credible trading programs."[146] The section on quantifying credits is particularly relevant to how compliance with the Clean Water Act will be demonstrated because if the credits do not accurately reflect reality, compliance will be frustrated.[147] The EPA's policy supports standard protocols to quantify pollutant loads, load reductions, and credits.

The EPA recognizes the "greater uncertainty" that exists for trades with nonpoint sources, and supports a variety of ways to "compensate" for this, including monitoring to verify load reductions; trading ratios; using performance values to estimate load reductions; and others.[148] Despite these different options, including monitoring for agricultural nonpoint sources, the policy heavily emphasizes estimating pollutant loading for agriculture.[149]

For instance, the result of a recent EPA and USDA collaboration is the Nitrogen Trading Tool, which is a model aimed at facilitating

144. EPA Water Quality Trading Policy, Issuance of Final Policy, 68 Fed. Reg. 1608-01, 1611 (Jan. 13, 2003).

145. *Id.*

146. *Id.* at 1611–12.

147. *Id.* at 1612.

148. *Id.*

149. *Id.* ("The site-specific procedures and protocols used in water quality trading programs that involve agriculture . . . should be developed by states and tribes in consultation with United States Department of Agriculture (USDA) agencies. Those *procedures should estimate* nutrient or sediment load delivery to the stream segment, water body or watershed where trading occurs." (emphasis added)). *Id.* ("[T]he Revised Universal Soil Loss Equation (RUSLE) may be used in some locations to *estimate* the sediment yield at the end of a slope in agricultural settings. The sediment yield at the end of a slope coupled with an appropriate method to *estimate* sediment delivery to the receiving waters can *provide a reasonable estimate* of sediment load and load reductions." (emphasis added)). *Id.* ("EPA and the USDA are working with other agencies to evaluate existing methods and to develop improved methods and procedures for *estimating loads* from agricultural . . ." (emphasis added)).

trading. This tool is a web-based interface that allows one to estimate nitrogen reductions due to implementing varying agricultural practices.[150] The idea is that the tool can be used to identify credits available to be traded or banked.[151] Its creators note that the design structure is generic enough that it could be adapted to other pollutants such as phosphorus and sediment.[152] They preface the tool by acknowledging that "[q]uantifying the loss mechanisms of nutrients such as nitrogen is difficult."[153]

However, this emphasis on estimating and modeling rather than monitoring actual results is at odds with another part of the EPA's Trading Policy related to compliance and enforcement. The compliance and enforcement section calls for "clear enforceable mechanisms consistent with NPDES regulations that ensure legal accountability for the generation of credits that are traded."[154] However, estimates of pollutant loading do not provide the type of clarity typically used in NPDES permit enforcement, such as discharge monitoring reports. Estimating, as opposed to actual monitoring, increases the uncertainty and legal risk for NPDES permit holders. If a nonpoint source fails to generate the agreed upon credits, the EPA, consistent with its Trading Policy, could require the NPDES permit holder to comply with more stringent permit limits that would have applied in the absence of a trade.[155]

Additionally, if a NPDES permit holder is not required to conduct water quality or BMP installation monitoring, third parties would have a greater need for information and could begin to monitor the receiving water. This data collected by third parties could be used to support citizen suits to enforce the more stringent NPDES permit terms that should apply where actual pollutant loading is higher than presumed by modeled estimates or water quality standards are violated. Since improvements to water quality are so difficult to measure, this puts the NPDES permit holders in a very difficult position.

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150. Christoph M. Gross et al., *Nitrogen Trading Tool to Facilitate Water Quality Credit Trading*, J. of Soil and Water Conservation, Vol. 63, No.2, at 44A (March/April 2008), *available at* http://naldc.nal.usda.gov/download/21718/PDF. The model used in the Nitrogen Trading Tool is the Nitrogen Loss and Environmental Assessment Package (NLEAP). *Id.*

151. *Id.*

152. *Id.* at 45A.

153. *Id.* at 44A.

154. EPA Water Quality Trading Policy, Issuance of Final Policy, 68 Fed. Reg. 1608-01, 1612 (Jan. 13, 2003).

155. *Id.*

In fact, lack of monitoring was part of the rationale for the recent legal challenge to the trading provisions in the TMDL for the Chesapeake Bay. According to the plaintiff's public statement about the case,

> the TMDL . . . allows for *unmonitored* 'nonpoint' sources of pollution, mainly agricultural operations, to claim *unverified* reductions in nitrogen and phosphorus discharges and sell these alleged reductions to 'point' source industries like power plants and wastewater treatment plants.[156]

Water quality monitoring in receiving water bodies allows one to identify a failure to create real water quality improvements.[157] However, the catch-22 is that even if BMPs are implemented and monitoring is required, the data may not show the hoped for improvements if BMP installations are too spread out over the landscape.

The National Research Council's report on the Mississippi River Basin included an evaluation of water quality trading as an option for addressing nonpoint agricultural pollution. Although it identified a variety of problems with water quality trading, it noted that the tool could "become more useful and widespread" as "monitoring improves" and stricter water quality criteria are adopted.[158] The report emphasized that in some situations nonpoint agricultural discharges can be "measured accurately" rather than simply estimated to determine whether BMPs comply with the program.[159] One example comes from the San Joaquin Valley, where measurements of selenium discharges are taken at the irrigation district level.[160] Although measuring diffuse runoff from fields is more difficult than measuring discharges from pipes draining irrigation tile systems, there are many fields lined with tiles and

156. *Advocacy Group Challenges National Water Pollution Trading Model*, FOOD AND WATER WATCH, http://www.foodandwaterwatch.org/pressreleases/nearing-40th-anniversary-of-the-clean-water-act-advocacy-groups-challenge-national-water-pollution-trading-model/ (last visited Mar. 19, 2014) (emphasis added) (discussing *Food and Water Watch v. EPA*, Civil Action No. 12-1639(RC), 2013 WL 6513826 (Dist. D.C. Dec. 13, 2013)). The case was recently dismissed for lack of standing without discussion of the merits of permitting trading. Food and Water Watch v. EPA, Civil Action No. 12-1639(RC), 2013 WL 6513826 (D.D.C. Dec. 13, 2013).

157. Ruppert, *supra* note 80, at 14.

158. Nat'l Research Council Comm., *supra* note 23, at 181–82. A caveat, however, is that: "Market-based approaches can become operative only if some enforceable regulatory standard provides the initial incentive to which market forces can respond. The institution providing the incentives also must have the appropriate geographical reach required to accomplish the pollution reduction goals and adequate enforcement authority." *Id.* at 184.

159. *Id.* at 182.

160. *Id.*

employing drainage pipes where runoff measurement could be possible.[161]

The Iowa Soybeans Association has also had success collaborating with farmers to increase productivity *and* measure and improve environmental performance. They are focusing on reducing nitrogen runoff and explicitly using adaptive management.[162] They plan at the watershed level and then work with a "majority of production acres across a given watershed in order to realize water quality gains."[163] Thus, they are targeting, aggregating, modeling and monitoring. They work "with farmers to help gather and evaluate water quality data to characterize waters, identify trends over time, identify emerging problems, assess the effectiveness of control programs, and direct pollution control activities to areas in which they will have the greatest effect."[164]

The Iowa Soybeans Association's approach could be adopted in water quality trading to make trading with nonpoint agricultural sources more adaptive. Such an approach to trading would involve setting up a monitoring program and a process for incorporating new information gained from experimentation into future management decisions. Adaptive trading should combine the use of modeling and monitoring to generate the information needed to inform the creation of credits and margins of safety to allow a market to function,[165] inform needed adjustments at the field or point source level, and assess overall water quality at the watershed scale.

Consistent with the EPA Trading Policy call for more "ambient monitoring" of water quality as part of an overall program evaluation, the EPA Policy supports studies "to quantify nonpoint source load reductions, validate nonpoint source pollutant removal efficiencies and determine whether the anticipated water quality objectives have been achieved."[166] The EPA's policy is compatible with adaptive trading because it envisions that these evaluations will inform changes to the

161. *Id.*

162. *Id.* at 186 (describing adaptive management as "integration of data into management decisions for continual improvement").

163. *Id.*

164. *Id.*

165. A lack of information can be a hurdle to robust trading. "This lack of information about the relative costs of pollution reduction often prevents realization of the full theoretical benefits that could arise from trading." Ruppert, *supra* note 80, at 12.

166. EPA Water Quality Trading Policy, Issuance of Final Policy, 68 Fed. Reg. 1608-01, 1612 (Jan. 13, 2003).

program to "ensure that water quality objectives" are achieved.[167]

Adaptive trading is based on the understanding that models, while useful, are oversimplifications subject to error, gaming, and over or under predicting due to weather. Adaptive trading also recognizes the variability inherent in reducing agricultural nonpoint source pollution, as well as the challenges presented by water quality monitoring. To incorporate adaptive management with water quality trading, there should be a multipart process that builds on the scientific findings about the need to target and aggregate reductions: 1) assess and rank the largest inputs of nutrients and sediment from nonpoint sources in a given watershed;[168] 2) allow trading between point sources and the largest sources of nonpoint source pollution in the same targeted watershed; and 3) create a defined and transparent plan for monitoring, data collection, data assessment, and taking responsive management actions.

Focused monitoring should be a priority, even if monitoring water quality and BMPs to ensure that they are installed, maintained, and working as designed may not be possible for all fields engaged in active agricultural runoff reduction. Agency scientists could identify monitoring sites downstream from aggregated BMP installations resulting from multiple trades. That means making a commitment to monitoring specific reaches of a river to assess loading from multiple sources over time.[169] It may also mean the agency identifies specific BMPs that should be monitored to assess whether they are working as designed and reducing pollutant loading.[170]

Adaptive trading requires a planned approach to information generation that raises the question of who is responsible for carrying out the monitoring program. Consistent with the balance struck by Congress and the EPA in placing monitoring responsibilities on point sources holding NPDES permits, monitoring required for adaptive trading could similarly be the responsibility of the point sources and sent into a central database maintained by the agency, just as is done for Discharge Monitoring Reports.

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167. *Id.*

168. For a useful four part process on delineating watersheds, ranking fields, and targeting BMPs, see Diebel et al., *supra* note 62, at 799.

169. This is the approach Idaho has taken on the Boise River. IDAHO DEP'T OF ENVTL. QUALITY, LOWER BOISE RIVER IMPLEMENTATION PLAN TOTAL PHOSPHOROUS xxiii (Dec. 2008), *available at* http://www.deq.idaho.gov/media/451497-_water_data_reports_surface_water_tmdls_boise_river_lower_lbr_total_phosphorus_plan_final.pdf.

170. *Id.*

Another decision with adaptive trading is how the information will be incorporated into management decisions. Oregon's adaptive management approach is to require a regular watershed level review by the state agency that assesses water quality standards. Oregon uses a five-year review period, which is consistent with the term of NPDES permits for point sources, and presents a logical timeframe for adaptive trading. If the information generated through monitoring shows that water quality standards are not being met, the agency needs to have the authority and duty, again preferably within a specific amount of time, to revise individual permits or contracts.[171]

IV. CONCLUSION

Agricultural nonpoint water pollution, which has been primarily addressed through state-led voluntary programs, will remain the largest source of water pollution in the U.S. unless an effective new approach is found. While more targeted funding and prescriptive approaches could yield more reliable water quality improvements, since these approaches have not been politically viable, the EPA has turned its attention to water quality trading between point and nonpoint sources. Water quality trading is still in an experimental phase and could benefit from applying adaptive management to create an intentional experimental design. Adaptive trading, as envisioned in this article, proposes the use of a multipart process: 1) assess and rank the largest inputs of nutrients and sediment from nonpoint sources in a given watershed; 2) allow trading between point sources and the largest sources of nonpoint source pollution in the same targeted watershed; and 3) create a defined and transparent plan for monitoring, data collection, data assessment, and taking responsive management actions. The use of adaptive trading, while not simple, will provide a means to determine water quality progress, define trends, and enlarge the understanding of complex systems. This level of detail is essential to determine whether water quality trading is solving chronic problems with agricultural runoff or whether the EPA should be championing a different solution.

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171. Oregon outlines that it will make revisions if standards are not met. OR. DEP'T OF ENVTL. QUALITY, WILLAMETTE BASIN TMDL 14–20 (2006), *available at* http://www.deq.state.or.us/wq/tmdls/willamette.htm; OR. DEP'T OF ENVTL. QUALITY, ROGUE RIVER BASIN TMDL, ch. 4, figure 4.2, at 4-3 (2008), *available at* http://www.deq.state.or.us/wq/tmdls/docs/roguebasin/Rogue/Chapter4WQMP.