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Water Quality Trading in the United States

Cynthia Morgan and Ann Wolverton

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U.S. Environmental Protection Agency
National Center for Environmental Economics
1200 Pennsylvania Avenue, NW (MC 1809)
Washington, DC 20460
http://www.epa.gov/economics

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Cynthia Morgan and Ann Wolverton

Correspondence:

Cynthia Morgan
1200 Pennsylvania Ave
Mail Code 1809T
Washington, DC 20460
202-566-2296
morgan.cynthia@epa.gov

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Abstract: This paper provides a systematic overview of water quality trading in the U.S. The primary source of information for this overview is a detailed database, collected and compiled by a team of researchers at Dartmouth College. This paper divides the trading programs discussed in the database into four categories: on-going offset/trading programs, one-time offset agreements, state and regional trading policies, and other projects and recent proposals that involve trading. Details discussed include: sources of the pollutant, types of pollutants traded, legal liability, main regulatory drivers, market structure, trading ratios, transaction and administrative costs, and difficulties encountered in trading. We find that trading has often been explored in the context of more stringent discharge limits, or watershed-wide caps (e.g. TMDL). The most common type of trading program in the United States is between point sources and non-point sources. Point sources are usually held liable for non-point source reductions. The pollutants most commonly traded in the U.S. are nutrients such as phosphorus and nitrogen, and almost all offset and trading programs focus on one pollutant only. However, market structures, trading ratios, and other details of the trading framework vary widely among programs.

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1. Introduction

The United States has used the concept of tradable pollution rights in the context of air since the 1980s, first as a way to make progress towards meeting existing emissions standards in regions that were in non-attainment with these standards and later as a way to offer firms a more flexible and cost-effective method for reducing emissions through "cap-and-trade" systems. Recently, interest has grown in applying the concept of trading to water pollution control for regulated, point sources and unregulated, non-point sources. In this paper, we provide a systematic overview of water quality trading in the U.S. by relying on a database that reports available details for forty water quality trading initiatives, six state water quality trading frameworks, and twenty-three other projects that are either exploring trading as one possible option for improving water quality or are in the early stages of developing a trading system.

The database we use as the primary source of information was collected and compiled by a team of researchers at Dartmouth College, led by Professor Karen Fisher-Vanden, on water-quality trading throughout the United States (Breetz 2004). This team of researchers relied on publicly available written information as well as telephone and email contact with persons knowledgeable of the programs.[1] Each trading program or offset agreement has a separate entry in the water quality database, organized alphabetically by state. In each case, information relevant to the program is divided into the general categories of program background, trade structure, outcomes, and information/ references. Program background includes information such as the

[1] The assemblage of the database was supported by the National Center for Environmental Economics at the U.S. Environmental Protection Agency and by the Rockefeller Center at Dartmouth College. The most recent version of the database may be found at http://www.dartmouth.edu/~kfv/.

pollutant traded, the geographic size of the program, the number of potential trading partners, and identification of regulatory drivers. Trade structure contains information such as trading ratios, market structure, allocation mechanisms, and liability or penalties. The outcomes category focuses on information such as the number of trades that have occurred, costs incurred, achievement of program goals, and potential cost savings.[2] For those that wish to track down further information than what is found in the database, the information/reference category contains website addresses and contact names. Some of this information is more amenable to study from the perspective of the economics discipline than others. It is on these factors that we concentrate. We leave it to experts in other areas to analyze important non-economic factors also included in the database (e.g. stakeholder involvement).

This paper divides the trading programs discussed in the database into four categories: on-going offset/trading programs, one-time offset agreements, state and regional trading policies, and other projects and recent proposals that involve trading.[3] In some cases, the way in which we categorize programs differs from the database. This is primarily due to a lack of detailed information in the database for some trading programs about important factors such as market structure and trading ratios that speak to the very nature of the trading or offset framework. In these cases an in-depth discussion is not possible, so the offset agreement or trading program has been re-

[2] While the database often reports cost savings from trading, we find this category difficult to discuss. The numbers reported are derived from a wide variety of sources that vary in estimation, quality, and completeness. We have therefore minimized any discussion of overall cost savings associated with trading in this paper. Given the difficulty of consistently and accurately measuring cost savings associated with the wide variety of trading programs in the US, this is an important topic for future research.

[3] The Appendix contains the name of each trading program sorted by category and the page number where information about the program may be found in the database.

categorized under "other projects and recent proposals." We provide a brief definition for each of the four categories below.

Ongoing Offset/Trading Programs: This category includes trading programs that are already active and those that, while not yet trading, have developed a trading framework with the intent of encouraging trades between sources in a watershed.[4] The trading programs in this category take many forms – the allowed participants, rules for trading, market structure, allocation mechanisms, monitoring requirements, and certification may differ widely.

Typically, a total maximum daily load (TMDL) or a watershed-based limit acts as a cap on total pollutant discharges for a given watershed. It is possible to have trading without a TMDL if point sources can only trade within the constraints of limits set by their individual National Pollution Discharge Elimination System (NPDES) permits. Since NDPES permits can only be issued to point sources, however, projects undertaken by non-point sources must be evaluated to determine the pollution reduction credits generated (i.e. no permit limit exists from which to measure surplus reductions). Likewise, an offset project must be evaluated to determine how much reduction can be credited to the project (via various estimation or measurement techniques) and therefore how much it offsets emission increases.

One-Time Offset Agreements: Due to permit limits, discharges by point sources into a watershed are capped. To accommodate expansion of existing sources (or a new source) in the watershed, the source must permanently offset any increase in discharges with a decrease at another source. When a trading framework does not

[4] In some cases, a well-developed trading framework is in place, but delays in TMDL development or in the implementation of the trading program has prevented the occurrence of authorized trading.

exist, this offset is created through the funding and/or oversight of a one-time project or set of projects negotiated to eliminate another source of discharges equivalent to the increase.

Regional and State Trading Policies: State and regional policies aim to establish a framework or set of rules under which trading is authorized to take place within the state or region. A trading program that is developed in a state should follow the developed guidance or adhere to the adopted trading rules.[5]

Other Projects and Recent Proposals: This category includes projects or proposals that are still in the proposal stage and have not yet fleshed out a framework for trading (for instance, case or feasibility studies, or instances where trading was considered but never implemented). For many of these entries, the database includes only a brief project or proposal background, and a list of contacts and references.[6] Also included may be a few cases where a trading framework has been completed but information is unavailable.

Using these four categories, we find that there are 19 ongoing offset/trading programs and eight one-time offset agreements in the U.S. for which we have detailed information. In addition, there are nine state or regional trading programs (six of which are in the database),[7] and 35 recent projects or proposals related to water

[5] The US EPA issued a water quality trading policy in January 2003 that offers general guidance on when and how trading should occur, consistent with existing legislation. All state guidance and policy also should be consistent with EPA policy. The US Water Quality Trading Policy is available at: http://www.epa.gov/owow/watershed/trading/finalpolicy2003. html.

[6] We do not consider the programs in Tampa Bay, FL (page 90), Santa Rosa, CA (page 320), and Providence, RI (page 330) as trading or offset programs and therefore do not include them in this paper. The Tampa Bay Estuary Program is an ecosystem management approach to nitrogen reductions that are collaboratively determined and coordinated between sources. The Santa Rosa program is a wastewater reuse program that resembles a subsidy program to farmers. The Providence program is a subsidy for the use of non-sodium road deicing alternatives.

[7] Three states issued their trading policies after or near the time of the release of the database.

quality trading in the U.S. (21 of which are categorized this way in the database).[8] According to the database, trading most often is explored in the context of more stringent discharge limits, or watershed-wide caps (e.g. TMDL). The most common type of trading program in the United States occurs between point sources (PS) and non-point sources (NPS). Of the 27 offset or trading agreements for which we have detailed information from the database (both one-time and ongoing), 23 involve trading between point sources and non-point sources. Six of the ongoing offset/trading programs that allow trading between point and non-point sources also allow trading between point sources. Three programs pertain solely to trades between point sources. There also are two trading programs that allow trades between non-point sources. Most of the state and regional policies that have been developed consider trades between point sources as well as trades between point and non-point sources. Point sources usually are held liable for non-point source reductions.

The pollutants most commonly traded in the U.S. are nutrients such as phosphorus and nitrogen (22 of the 27 one-time and ongoing offset and trading programs discussed). Two trading programs in the U.S. consider trading for heavy metals, while there are single programs dedicated to trading sediments, selenium, temperature, and waterflow. One program also proposes trading to clean-up orphan mining sites that impair water quality. Almost all of the offset and trading programs focus on one pollutant only. Six of the 27 programs target more than one pollutant, four of which concentrate on nitrogen and phosphorus. The state and regional trading policies almost always pertain to nutrients. In some cases, additional pollutants also

[8] We categorize fourteen other programs this way because the programs are in the development stage so the database contains very few details.

are considered (e.g. temperature, metals, BOD). Market structures, trading ratios, and other details of the trading framework vary widely among these programs.

The rest of this paper discusses the main trends evident for key economic variables from the database for each of the four categories of offset agreement and trading program. Section 2 describes ongoing offset/trading programs. One-time offset agreements are discussed in Section 3. Section 4 describes state and regional trading policies. Section 5 discusses other projects and recent proposals related to trading, and Section 6 concludes.

2. Ongoing Offset/Trading Programs

There are 19 programs that we classify as ongoing offset/trading programs.[9] Five of these programs are in the state of Colorado; three are in Wisconsin; and two are in North Carolina. The remaining nine programs are scattered throughout various states: California, Connecticut, Idaho, Massachusetts, Michigan, Nevada, New Jersey, New York, and Ohio.

All but three of the 19 trading programs allow trading with non-point sources (see Table 1). Of these, 15 programs focus on trades between point sources and non-point sources. One program – the Grassland Area Farmers Tradable Loads Program in California – only allows trading between non-point sources. However, farmers are arranged into irrigation and drainage districts and trades occur among districts as

[9] Not counted in this total is a set of water-based trading simulations conducted in Pennsylvania (see page 251 in the database). Four simulation exercises were conducted; in each case these simulations were based on characteristics of impaired waters in Pennsylvania. Simulations examined trades between point sources, between point sources and non-point sources, and between non-point sources for a variety of pollutants: CBOD, phosphorus, nitrogen, suspended solids, ammonia, acid, and metals. The simulations demonstrated that trading opportunities were limited by a number of important factors, depending on the watershed, including regulatory constraints, economic viability, TMDL requirements, and trading opportunities. Pennsylvania continues to investigate trading options as part of a TMDL.

opposed to individual farms. The Lake Dillon trading program in Colorado is the only other program that allows trading between non-point sources; it also allows for point sources to trade with non-point sources.

In many cases, point sources are liable for all trades with non-point sources. For instance, in the Cherry Creek trading program in Colorado if a non-point source control funded by a point source fails to reduce phosphorus by the amount agreed upon, it is the point source that is held liable for exceeding its load allocation. However, there are exceptions. In the Kalamazoo River program, point sources enter into service agreements with non-point sources. If a non-point source fails to comply, the Steering Committee that administers the fund for the installation of a non-point source control is notified and the non-point source has 60 days to correct the problem. If the problem is not solved, the non-point source must refund the money to the fund within 90 days. In the Tar-Pamlico trading program in North Carolina, the point source is not liable once it purchases an offset from a non-point source. The North Carolina Agriculture Cost-Share Program is responsible for funding and insuring compliance of non-point sources with best management practices. If a non-point source does not comply, then the state is liable for the offset, and the non-point source is required to return its cost-share funding.

Of the 19 ongoing offset/trading programs, 14 target one pollutant, while two focus on heavy metals and four focus on multiple pollutants (see Table 1). Most trading programs concentrate on nutrients. The most common pollutant traded is phosphorus (thirteen programs trade phosphorus, three of which also trade nitrogen), followed by nitrogen (two programs trade only nitrogen). Two programs – Clear

Creek and Passaic Valley Sewerage Commission Pretreatment Trading (PVSC) – trade heavy metals; Clear Creek allows trading with non-point sources while PVSC only allows point sources to trade.[10] Other pollutants traded include selenium (Grassland Area Farmers Tradable Loads Program in California), water flow (Charles River in Massachusetts), and total dissolved solids (Truckee River in Nevada).

Table 1: Ongoing Offset Trading Programs by Type of Trade and Pollutant

Program Name	Type of Trade	Pollutant
Grassland Area Farmers Tradable Loads Program, CA	NPS-NPS	Selenium
Bear Creek, CO	PS-PS	Phosphorus
Chatfield Reservoir, CO	PS-PS, PS-NPS	Phosphorus
Cherry Creek, CO	PS-PS, PS-NPS	Phosphorus
Clear Creek, CO	PS-NPS	Heavy metals
Lake Dillon, CO	PS-NPS, NPS-NPS	Phosphorus
Long Island Sound, CT	PS-PS	Nitrogen
Lower Boise River, ID	PS-NPS	Phosphorus
Charles River, MA	PS-NPS	Water flow
Kalamazoo River, MI	PS-NPS	Phosphorus
Truckee River Quality Settlement Agreement, NV[11]	PS-PS, PS-NPS	Phosphorus, nitrogen, total dissolved solids
Passaic Valley Sewerage Commission Pretreatment Trading, NJ	PS-PS	Heavy metals
New York City Watershed Offsets Pilot Program, NY	PS-PS, PS-NPS	Phosphorus
Neuse River Basin, NC	PS-NPS	Nitrogen
Tar-Pamlico Basin, NC	PS-NPS	Phosphorus, nitrogen
Great Miami River Watershed Trading Pilot Program, OH	PS-NPS	Phosphorus, nitrogen
Fox-Wolf Basin, WI	PS-PS, PS-NPS	Phosphorus
Red Cedar River, WI	PS-NPS	Phosphorus
Rock River, WI	PS-PS, PS-NPS	Phosphorus

[10] The Clear Creek program is designed to clean-up unregulated "orphan sites" in return for credits that could be used for water or non-water quality purposes while the PVSC program allows industrial permitees flexibility in meeting new local pretreatment standards.

[11] The Truckee River Program actually trades water rights rather than water quality. The TMDL sets pollutant limits by mass instead of concentration.

Fourteen of the 19 trading programs are still active (see Table 2). In other words, the underlying trading framework is still available for sources in those watersheds to use for trading purposes. The oldest program – Bear Creek in Colorado – was started in 1992 and is still active. Ten programs are pilot programs designed to investigate the feasibility of using trading as a longer-term method to improve water quality. Five of these are still active while five have been completed.

Most of the trading programs in Table 2 have a Total Maximum Daily Load (TMDL) in place or under development for the watershed. A TMDL indicates the maximum amount of a pollutant that a watershed can receive and still meet Federal water quality standards, and it allocates this load among the sources of this pollutant in the watershed, both specific point sources and non-point sources as a group. Trading is one possible way to ensure that a TMDL is met; the prevalence of TMDLs points to one possible regulatory reason why many of these trading programs have been implemented. The rivers in Wisconsin do not yet have TMDLs but are listed as impaired rivers. A state code that mandates phosphorus discharge limits for point sources is the primary regulatory driver for these rivers.

Table 2: Offset/Trading Programs by Year, Status, and Existence of a TMDL

Program Name	Yr. Program Introduced	Pilot?	Active?	TMDL?
Grassland Area Farmers Program, CA	1998		Yes	Yes
Bear Creek, CO	1992		Yes	
Chatfield Reservoir, CO	1993		Yes	Yes
Cherry Creek, CO	1997		Yes	Yes
Clear Creek, CO	1998	Yes	No	No
Lake Dillon, CO	1984		Yes	Yes
Long Island Sound, CT	2002		Yes	Yes
Lower Boise River, ID	1998	Yes	No	In development*

Program Name	Yr. Program Introduced	Pilot?	Active?	TMDL?
Charles River, MA			No	In development
Kalamazoo River, MI	1996	Yes	Yes	Yes
Truckee River Quality Settlement Agreement, NV	1996		Yes	Yes
Passaic Valley Sewerage Commission Pretreatment Trading, NJ	1996	Yes	Yes	
New York City Watershed Program, NY	1997	Yes	Yes	Yes
Neuse River Basin, NC	2002		Yes	Yes
Tar-Pamlico Basin, NC	1990		Yes	Yes
Great Miami River Watershed Program, OH	2004	Yes	No	In development
Fox-Wolf Basin, WI	1997	Yes	No	No
Red Cedar River, WI	2000	Yes	Yes	No
Rock River, WI	2000	Yes	Yes	No

Experts in the literature often argue that the extent to which trading occurs depends, in part, on market size. A thin market, one in which there are fewer buyers and sellers, may offer fewer opportunities for trading. While teasing out the relationship between market size and the number of trades that occur is beyond the scope of this paper, Table 3 offers two indicators of market size for offset/trading programs: geographic size, and the number of sources in the watershed that can potentially trade. The geographic size of the watersheds ranges from 3,200 acres to 4.1 million acres. For the 18 programs for which information is available, the average size is 1.5 million acres. Most of the trading programs that allow trading with non-point sources have a large quantity of potential non-point traders (in the hundreds). The exception to this is in cases where non-point sources have been aggregated into irrigation districts that then trade. The Grassland Area Farmers Tradable Loads Program in California has seven irrigation districts, while the Lower Boise River in Idaho has eight irrigation districts. The number of point sources in a trading program

ranges from four to 314. For the 16 programs for which we have information, seven have fewer than 20 point sources and four have more than 100 point sources.

Table 3: Geographic and Market Size of US Offset/Trading Programs

Program Name	**Size of Watershed**[12]	**Sources**
Grassland Area Farmers Tradable Loads Program, CA	97,000 acres	7 irrigation and drainage districts
Bear Creek, CO	83,700 acres	14 PSs
Chatfield Reservoir, CO	1.92 million acres	7 PSs, many NPSs
Cherry Creek, CO	243,000 acres	6 PSs, many NPSs
Clear Creek, CO	Not available	Not available
Lake Dillon, CO	3,200 acres	4 PSs; 1,000 NPSs
Long Island Sound, CT	Approx. 3.5 million acres	79 PSs, many NPSs
Lower Boise River, ID	41,000 acres	10 PSs; 8 irrigation districts
Charles River, MA	197,000 acres	Not available
Kalamazoo River, MI	1.28 million acres	50 PSs, many NPSs
Truckee River Quality Settlement Agreement, NV	Approx. 1.4 million acres	3 PSs, many NPSs
Passaic Valley Sewerage Commission Pretreatment Trading, NJ	534,000 acres	260 PSs
New York City Watershed Offsets Pilot Program, NY	1.26 million acres	100+ WWTPs, many NPSs
Neuse River Basin, NC	3.96 million acres	22 PSs, many NPSs
Tar-Pamlico Basin, NC	2.88 million acres	16 PSs; many NPSs
Great Miami River Watershed Trading Pilot Program, OH	2.56 million acres	314 PSs, many NPSs
Fox-Wolf Basin, WI	4.1 million acres	100s of PSs, many NPSs
Red Cedar River, WI	1.92 million acres	18 PSs, many NPSs
Rock River, WI	1.15 million acres	60 PSs, many NPSs

The database specifies a market structure for each offset trading program. Two of these market structures are defined in Woodward and Kaiser (2002). In a bilateral negotiation, the terms of trade are negotiated and information on the product

[12] When possible, the size listed in the database has been converted to a consistent measure. For instance, when size is described in terms of square miles, it has been converted to acres.

is obtained through personal contact between the buyer and the seller. This type of market structure is common when there are a wide variety of sellers from which a buyer may choose, and when the goods available for purchase are heterogeneous. In a clearinghouse, the state or some other entity pays for pollution reductions and then sells generated credits at a fixed price to polluters; buyers and sellers interact only with the intermediary and not with each other. A clearinghouse works best when the impacts of pollution discharges are similar enough to allow for the transfer of rights between a large number of buyers and sellers in the watershed. In addition, the database distinguishes a third category referred to as a third-party broker – usually this is a broker in a bilateral negotiation used to identify potential parties interested in either purchasing or selling credits (depending on who has procured the service).[13]

Table 4 lists the market structures for each offset/trading program in the US. Six trading programs rely solely on bilateral negotiations. Another six programs rely on bilateral negotiations in conjunction with some other market structure. Four programs are classified as clearinghouses. Another four programs use clearinghouses along with one or more market structures. Only two programs rely solely on a third party broker to facilitate trades; another five programs allow the use of a third party broker along with some other market structure.

One factor that may affect the market structure utilized for trading is effective verification that non-point sources have carried out best-management practices

[13] Woodward and Kaiser (2002) note that substantial differences in transaction costs exist across market structures. For instance, transactions costs for bilateral negotiations are usually quite high because of search, information, negotiating, and contracting costs. Clearinghouses typically have substantially lower transaction costs because buyers and sellers only need to interact with the intermediary and face a fixed price that is not subject to negotiation.

(BMPs) or other activities to generate credits. The monitoring of non-point source controls among programs range from no monitoring to verification of all BMPs used to generate credits. Only two programs – Lower Boise and Red Cedar- verify and monitor all BMPs that generate non-point source credits. The Tar-Pamlico and Great Miami programs inspect between 5% and 10% of BMP credits. The Grassland program verifies non-point source credits by monitoring selenium loads as opposed to BMPs. Approval of a trade in the New York and Truckee programs is contingent on having a plan for monitoring and enforcement of non-point source controls.

The Chatfield, Cherry Creek, and Kalamazoo programs monitor water-quality to determine the effectiveness of non-point source controls. In the Kalamazoo River Water Quality Demonstration Project, for instance, a Steering Committee administers a fund for the installation of non-point source controls for phosphorus. Credits generated by non-point source controls are verified and then banked with the Steering Committee, and point sources receive credits in proportion to their contribution to the cost of these non-point source controls. Where possible, the Steering Committee follows up with water quality monitoring.

Trading ratios often are used as a mechanism to manage uncertainty associated with the effectiveness of non-point source controls. All programs use trading ratios, but these ratios vary considerably from program to program. Table 4 demonstrates that the most common trading ratio for programs that are trading nutrients between point and non-point sources is 2 to 1. In this case, a point source wishing to increase its discharges into the watershed must offset them at a non-point source by twice that amount. In contrast, point-source to point-source trades often have a trading ratio of 1

to 1. In other words, a point source offsets its increase in pollution with an equivalent decrease of that pollutant by another point source somewhere else in the watershed.

Trading ratios are also a way of accounting for differences in locations of sources in the watershed. The objective in this case is to ensure the equivalency of the potential environmental impact between a credit generated in one location and used in another location in the watershed. For example, in the Cherry Creek program the trading ratio may be adjusted up to 3 to 1 when the point source is further away from the Cherry Creek Reservoir than the non-point source. Two of the programs – Long Island Sound and the Lower Boise River – have a fixed set of ratios that relate pollution reductions from any source in the watershed to a particular location. The Lower Boise River program includes multiplicative ratios for river location, site location, and drainage delivery to relate the impact of phosphorus discharges anywhere in the watershed to the confluence of the Boise and Snake Rivers. In the Long Island Sound project, the trading ratios are based on locations of point sources and their impact on the Sound; the credits generated from reductions closer to the problem zone are more valuable than the credits generated further from the zone. The Rock River trading program starts with a base trading ratio and adds 0.125 to the ratio for each criterion met: the trade is not in the target area, the trade is not in the same "watershed,"[14] the trade is not "nearby", and credits are obtained from a downstream source. The ratios range from 1:1 to 1.5:1 for point-source to point-source trades and 1.75:1 to 3.6:1 for point-source to non-point-source trades.

Trading ratios also may be used to ensure that a net water quality benefit occurs with each trade. In the Passaic Valley program the trading ratio is 10 to 8 so

[14] The term "watershed" is defined by the Wisconsin Department of Natural Resources.

that 20% of the credits can be put aside to guarantee an overall reduction in the heavy metals loading. In the Great Miami River program trading ratios are higher (3:1) for sources discharging to impaired waters than those discharging into waters in attainment (2:1). The Grassland Area Farmers Tradable Loads Program chose to manage uncertainty using a different method: it made trading retroactive. Trades are based on measured selenium loads after the best-management practice (BMP) is in place rather than on a prediction of the BMP's effectiveness.

Table 4: Market Structures and Trading Ratios for US Offset/Trading Programs

Program Name	Market Structure	Trading Ratio
Grassland Area Farmers Tradable Loads Program, CA	Bilateral	1:1; retroactive
Bear Creek, CO	Bilateral	1:1
Chatfield Reservoir, CO	Clearinghouse; bilateral; third party	2:1or less (case-by-case)
Cherry Creek, CO	Clearinghouse	Min. 2:1; may be adjusted up to 3:1
Clear Creek, CO	Third party	NA
Lake Dillon, CO	Bilateral	2:1 PS-NPS; 1:1 NPS-NPS
Long Island Sound, CT	Clearinghouse	Fixed ratio
Lower Boise River, ID	Bilateral; third party	Fixed ratio
Charles River, MA	Third party; clearinghouse	2:1 – 2.5:1
Kalamazoo River, MI	Clearinghouse; bilateral	2:1 to 4:1 PS-NPS; 1:1 PS-PS
Truckee River Quality Settlement Agreement, NV	Bilateral	1:1 PS-PS; PS-NPS not det.
Passaic Valley Sewerage Commission Pretreatment Trading, NJ	Bilateral; third party	10:8
New York City Watershed Offsets Pilot Program, NY	Bilateral	3:1
Neuse River Basin, NC	Clearinghouse	2:1
Tar-Pamlico Basin, NC	Clearinghouse	2.1:1
Great Miami River Watershed Trading Pilot Program, OH	Third party	Varies between 1:1 and 2:1
Fox-Wolf Basin, WI	Clearinghouse; bilateral	2:1; case-by-case up to 10:1

Red Cedar River, WI	Bilateral	2:1
Rock River, WI	Bilateral or third party	1:1 to 1.5:1 PS-PS; 1.75:1 to 3.6:1 PS-NPS

For many of the trading programs in the U.S., the database gives an indication of the transaction costs faced by sources when enacting a trade (see Table 5). Seven of the 19 programs have low transaction costs.[15] Low transaction costs result from mechanisms designed to facilitate trades such as arranging them at monthly or annual meetings or using a third party broker, and cost-sharing or government assumption of costs. Five of the trading programs have high transaction costs. Transaction costs are high in these cases because of the level of detailed information required as part of the application process, the length of the approval process, or the complications of negotiating an agreement. While Woodward and Kaiser (2002) point out that bilateral negotiations typically have high transaction costs (Rock River or Passaic Valley, for instance), there are exceptions. Because both the Grassland Area Farmers Tradable Loads and Bear Creek trading programs arrange all their trades at meetings that sources attend, transaction costs associated with bilateral negotiations are quite low. Transaction costs associated with clearinghouse market structures are typically low (Long Island Sound, for instance). However, the Kalamazoo River program requires a significant amount of information as part of the application process and has a long

[15] We categorize transaction costs as high, medium or low based on a combination of qualitative and quantitative information from the database. These categorizations are not meant to be definitive and are based on the information available, which is at times limited. As such, the reader should not interpret these categories as being associated with any distinct ranges of costs. The programs report costs in different ways, at times stating costs as high or low. Other times, the programs describe the range of activities underlying transaction costs, from which it is possible to determine their likely categorical level. Using these programs to establish "fuzzy" upper and lower bounds on transactions costs, we sort the programs that appear to have some costs (but not on the order of the highest costs) into the medium category.

approval process that results in high transaction costs. Likewise, rigorous application requirements in the Cherry Creek program result in high transaction costs despite a clearinghouse market structure.

Table 5: Estimated Transaction Costs for US Offset/Trading Programs

Program Name	**Transaction Costs**	**Explanation for Costs**
Grassland Area Farmers Tradable Loads Program, CA	Low	Trades arranged at monthly meetings
Bear Creek, CO	Low	Trades arranged at annual meetings
Chatfield Reservoir, CO	Low	$100 application fee assessed on PSs
Cherry Creek, CO	High	$2,500 application fee; extensive application
Clear Creek, CO	Not det	
Lake Dillon, CO	Low/Med	Varies; application required
Long Island Sound, CT	Low	No transaction fee; state assumes most transaction costs
Lower Boise River, ID	Medium	Approved BMP list to lower costs; need to identify & negotiate trades
Charles River, MA	Not det	
Kalamazoo River, MI	High	Long approval process; extensive application
Truckee River Quality Settlement Agreement, NV	Not det	
Passaic Valley Sewerage Commission Pretreatment Trading, NJ	High	Negotiation process requires much time and resources
New York City Watershed Offsets Pilot Program, NY	Not det	
Neuse River Basin, NC	Low	State assumes most transaction costs
Tar-Pamlico Basin, NC	Low	Cost-sharing fund to minimize transaction costs
Great Miami River Watershed Trading Pilot Program, OH	Low	Third party brokerage expected to minimize costs
Fox-Wolf Basin, WI	High	Negotiation process (no guidance)
Red Cedar River, WI	Not det	
Rock River, WI	High	Feasibility study required; monitoring

The database also provides an indication of government or third-party administrative costs for eleven of the trading programs.[16] Five of these programs have low administrative costs (see Table 6). Reasons for low administrative costs include the use of monitoring systems already in existence for other purposes, shifting of costs from government to point sources, and low levels of oversight and review of trades. Four programs have medium-level administrative costs, and two have high administrative costs.[17] Administrative costs are medium or high in these cases because of high monitoring costs, extensive review of applications for trading, oversight of non-point source implementation of approved best-management practices, and inspection costs.

Table 6: Administrative Costs for Offset/Trading Programs

Program Name	Administrative Costs	Reason for Costs
Grassland Area Farmers Tradable Loads Program, CA	Low	Uses existing monitoring and recordkeeping systems
Bear Creek, CO	Low	Data recorded and loaded; review of annual report by agency; annual meeting
Chatfield Reservoir, CO	Medium	Monitoring estimated at $58,500 annually
Cherry Creek, CO	High	Application considered before board; public hearing; written decision
Clear Creek, CO	Not det	
Lake Dillon, CO	Not det	

[16] Administrative costs are associated with program design and development, overall maintenance of the program, and costs per trade (e.g., monitoring and enforcing each trade). We categorize administrative costs as high, medium and low based on quantitative and qualitative information provided in the database. For instance, costs are high for the Red Cedar program because each BMP must be verified by the Land Conservation District and low for the Grassland program because that program is using existing monitoring and recordkeeping systems.

[17] We have characterized the administrative costs of the Tar-Pamlico Basin program as medium-level (assuming that a cost of 1% or 2% of the price would be considered a low administrative cost). However, we do not have enough information to know how this amount compares to how other programs have characterized their costs.

Program Name	Administrative Costs	Reason for Costs
Long Island Sound, CT	High	Administration of credit exchange
Lower Boise River, ID	Low	Most of identification of sources and evaluation is conducted by PSs
Charles River, MA	Not det	
Kalamazoo River, MI	Medium	Identifying and designing BMPs; oversee construction; calculate cost per lb generated
Truckee River Quality Settlement Agreement, NV	Not det	
Passaic Valley Sewerage Commission Pretreatment Trading, NJ	Low	Review final contract; drafts associated permit adjustments
New York City Watershed Offsets Pilot Program, NY	Not det	
Neuse River Basin, NC	Not det	
Tar-Pamlico Basin, NC	Medium	10% of price, animal waste systems inspected twice/yr; 5% of contracts inspected/yr
Great Miami River Watershed Trading Pilot Program, OH	Medium	Review proposals to generate credits; extensive monitoring; makes decisions on grants
Fox-Wolf Basin, WI	Not det	
Red Cedar River, WI	High	Almost as high as the costs of implementing the BMPs
Rock River, WI	Not det	

Trades have occurred in 11 of the offset/trading programs (see Table 7). Within these 11 programs, four programs have had only one trade, one program has had two trades, and two programs have had three trades since inception. The most successful programs in terms of the number of trades have been the Grassland Area Farmers Tradable Loads (39 trades over a two-year period), Long Island Sound (63 trades over a two-year period), Truckee River (33 trades over an eight-year period), and the Red Cedar River (22 trades each year since 2001) programs. However, in the case of the Grasslands program no trades occurred after the first two years that the program was in place because a drainage recycling project obviated the need for

trading. The success of the Charles River and Great Miami River programs have yet to be determined since the programs began in October of 2004.

Table 7: Number and Frequency of Trades for Programs Experiencing Trading

Program Name	Number of Trades	Trade Details	Years In Which Trades Occur
Grassland Area Farmers Tradable Loads Program, CA	39	9 agreements: 8 in 1998, 1 in 1999, 0 after	2 (1998-2000)
Bear Creek, CO	1		1
Chatfield Reservoir, CO	1		1
Cherry Creek, CO	3	-	-
Clear Creek, CO	1		1
Lake Dillon, CO	3		2 (1995; 1997)
Long Island Sound, CT	63	38 in 2002; 25 in 2003	2 (2002-2004)
Lower Boise River, ID	0	-	-
Charles River, MA	0	-	-
Kalamazoo River, MI	0	-	-
Truckee River Quality Settlement Agreement, NV	33	17 before 2001; 16 after 2001	8 (1996-2004)
Passaic Valley Sewerage Commission Pretreatment Trading, NJ	2		2 (1997; ?)
New York City Watershed Offsets Pilot Program, NY	1		1 (1998)
Neuse River Basin, NC	0	-	-
Tar-Pamlico Basin, NC	0	-	-
Great Miami River Watershed Trading Pilot Program, OH	0	-	-
Fox-Wolf Basin, WI	0	-	-
Red Cedar River, WI	22 ea yr	1 PS w/ 22 NPS each year	3 (2001-2004)
Rock River, WI	0	-	-

For programs in which trades occurred, Table 8 reports the price per pound (when available) and the total amount of the pollutant traded. Some of these trading programs have a fixed price already established per unit of pollutant before any trading occurs. For instance, the price of nitrogen in the Long Island Sound program is set by the State of Connecticut. Other programs allow the price to be negotiated by

the buyer and seller (or a third party broker) and therefore the price per unit of pollutant may differ across trades. For instance, for the Grassland Area Farmers Tradable Loads Program, the price established for selenium was approximately $40 per pound for monthly loads and $100 per pound for annual loads. However, in many cases irrigation districts traded in-kind services rather than paying a fee. In the Clear Creek offset program, the one trade that occurred for the clean up of an abandoned mine was in return for an in-kind reward of better relations with the public and EPA.

The total amount traded of a particular pollutant varies widely across programs. For the more active programs, such as Long Island Sound, trading has resulted in a substantial amount of the pollutant being traded each year (2.7 million lbs. of nitrogen). In other cases, a very small amount of pollutant has been traded (for instance, only 2 lbs. of phosphorus were traded in the Chatfield Reservoir program).

Table 8: Price and Amount Traded for Programs That Have Had Trades

Program Name	**Price**	**Total Amount Traded**
Grassland Area Farmers Tradable Loads Program, CA	$40/lb monthly; $100/lb annual	605 lbs (monthly); 128 pounds (annual)
Bear Creek, CO	Undisclosed – est. $5,000/yr	40-80 lbs (annual)
Chatfield Reservoir, CO		2 lbs
Clear Creek, CO	In-kind	750 cubic yards
Lake Dillon, CO		116.5 lbs
Long Island Sound, CT	$1.65/credit (2002); $2.14/credit (2003)	2.7 million lbs (in 2003)
Truckee River Quality Settlement Agreement, NV		4,197 acre feet
Passaic Valley Sewerage Commission Pretreatment Trading, NJ		
New York City Watershed Offsets Pilot Program, NY		36,000 gpd (offset)
Red Cedar River, WI	$14,526 annual[a]	5,000 lbs annual

[a] This is the total amount paid to 22 landowners for phosphorus reduction which resulted in 5000 lbs of phosphorus credits.

Table 9 lists the reasons why more trades have not occurred once these programs were in place. Programs for which trades have occurred are colored white. Programs for which no trades occurred are colored grey. The one program that did not list any reasons for a lack of trades is the Long Island Sound program in Connecticut, which has had more trades than any other program - a total of 63 trades over a two-year time period. The most common reason given for a lack of trades, even for programs that had trades, is that point sources have been able to meet their limits without trading either because the limits were not strict enough or other initiatives made trading unnecessary. The high costs of trades, regulatory obstacles, difficulty in identifying sellers, and uncertainty over trading rules are also listed as reasons why trades have not occurred. In the Cherry Creek and Kalamazoo River programs, credits were actually generated but not used by point sources. In the Lower Boise program, trading has been delayed because no TMDL was in place.

Table 9: Reasons Why Trades Did Not Occur in Offset/Trading Programs

Program Name	**Reasons for lack of trades**
Grassland Area Farmers Tradable Loads Program, CA	Weather uncertainty; After 2000, other initiatives made it easy to meet limits without trading
Bear Creek, CO	Expect more trades in future; small no. of PSs so few trades likely to occur
Chatfield Reservoir, CO	Limits are not strict enough to require trading; NPS involvement not cost-effective under current limits
	Credits accumulated but no PS purchase: difficult application process; initial allocations were generous
Clear Creek, CO	Obstacles to orphan site trading; lack of Good Samaritan Clause in CWA
Lake Dillon, CO	Methods available to inexpensively reduce phosphorus without trading; limits not stringent enough
** Long Island Sound, CT	Large number of trades have occurred

Program Name	Reasons for lack of trades
	Trading delayed by EPA approval of TMDL setting limits
Charles River, MA	Program began in Oct 2004
	NPS credits generated but none purchased; difficulty identifying PS participants; slow pgm implementation
Truckee River Quality Settlement Agreement, NV	Water rights is highly contentious issue; has led to many delays in purchases; difficult to find sellers
Passaic Valley Sewerage Commission Pretreatment Trading, NJ	Uncertainty regarding trading rules; high transaction costs; alternate compliance investments made trading unnecessary for many
New York City Watershed Offsets Pilot Program, NY	Legal and regulatory obstacles; those who benefit from improved water quality not the same as those facing limits on water quality
	Limit easily met with capital and operational offsets without trading
	Able to discharge below the cap without trading
	Program began in Oct 2004
	Lack of regulatory drivers and economic incentives: limits met by PSs without trading
Red Cedar River, WI	Only one PS deemed trading feasible; administrative costs too high
	Trading determined not to be economically feasible

Table 10 describes the various reasons cited by the projects and proposals as the biggest challenges to implementing these programs. Two of the most common challenges are identifying participants for trading, and uncertainties related to calculating the number of credits generated by non-point source activities. Other challenges include negotiating trade rules, market and price uncertainties, and lack of regulatory drivers.

Table 10: Biggest Implementation Challenges for Trading Programs

Program Name	Biggest Implementation Challenge
Grassland Area Farmers Tradable Loads Program, CA	Establishing a reasonable price for trades
Bear Creek, CO	Reporting standards not met; compliance issues for small firms
Chatfield Reservoir, CO	Measuring water quality changes from NPS reductions; NPS involvement
Cherry Creek, CO	Lack of pressure on PSs
Clear Creek, CO	No guidance on orphan site trading; financial resources
Lake Dillon, CO	Limited demand for credits; NPS monitoring; standard for accumulation and distribution of stored credits
Long Island Sound, CT	Continued funding
Lower Boise River, ID	TMDL passage; NPS participation
Charles River, MA	Changing thinking about water flows and water quality
Kalamazoo River, MI	Negotiation of trading rules; staff shortage for permit approvals; identification of PS and NPS participants
Truckee River Quality Settlement Agreement, NV	Water rights highly contentious; finding sellers; flawed TMDL
Passaic Valley Sewerage Commission Pretreatment Trading, NJ	Uncertainties in price negotiations; transaction costs; small market; lack of information
New York City Watershed Offsets Pilot Program, NY	Participation; regulatory changes; identifying surplus reductions and appropriate offset mechanisms
Neuse River Basin, NC	-
Tar-Pamlico Basin, NC	Difficulty predicting cost share funds; staffing
Great Miami River Watershed Trading Pilot Program, OH	Uncertainty regarding calculation of NPS reductions; limited market
Fox-Wolf Basin, WI	Lack of regulatory driver; no state guidance on trading; high transaction costs and uncertainty
Red Cedar River, WI	Determining credits available from BMPs; administrative costs; encouraging NPS participation
Rock River, WI	Establishing trading ratios; 5 yr limit on BMPs reduced cost effectiveness; NPS outreach

3. One-Time Offset Agreements

There are eight programs we classify as one-time offset agreements in the U.S. (see Table 11). Four of these offset agreements occurred in Massachusetts. Two were negotiated in Minnesota. The remaining offset agreements occurred in Colorado

and Illinois. Only one of the four states in which offset agreements were negotiated has a state trading policy in place (i.e. Colorado). The others have no standard framework under which trading or offset agreements take place.

Each of these offset agreements is a project undertaken or agreed to by a point source to reduce non-point source pollution in the watershed. For instance, the Edgartown and Falmouth Waste Water Treatment Plant (WWTP) offset agreements involve offsetting nitrogen discharge that resulted from facility upgrades to increase flow capacity. Nitrogen discharges were offset through non-point source projects that included connecting individual properties to sewer systems. The offset agreement for the Piasa Watershed allowed direct discharge by a point source in exchange for sediment reductions through non-point controls by individual landowners.

In general, point sources are held responsible for obtaining and verifying the non-point source credits generated. In some cases point sources obtain credits through a facilitator that works with the non-point sources to generate credits. For example, in the Piasa Creek Watershed agreement in Illinois, the Great Rivers Land Trust worked with non-point sources to implement sediment control practices that generate credits. These credits were paid for and used by the Illinois American Water Company to avoid the costs of putting in a lagoon, as well as a dewatering and landfill management system. Both the Rahr Malting Company and the Southern Minnesota Beet Sugar Cooperative offset agreements in Minnesota used trust funds to oversee and implement non-point source controls.

A total maximum daily load (TMDL) for a particular watershed is one possible impetus for an offset agreement. A TMDL indicates the maximum amount

of a pollutant that a watershed can receive and still meet Federal water quality standards, and it allocates this load among point and non-point sources. Trading is one possible way to ensure that a TMDL is met. However, the Minnesota River is the only watershed of those listed for one-time offset agreements that has a draft TMDL, although two others (one in Colorado and one in Massachussetts) have plans to develop a TMDL in the near future.

In most cases, one-time offset agreements have been generated as a condition of the renewal of a NPDES or WWTP permit that requires a plant to improve water quality through offsets or upgrades. For instance, the Specialty Minerals agreement in Massachusetts was negotiated to allow for greater water discharge by an existing WWTP. The two offset agreements in Minnesota were negotiated to allow for new WWTPs on the Minnesota River. Legal liability and penalties are determined under the NPDES or WWTP permit limits. Thus, there is no need to establish liability independently.

Most offsets have been negotiated to reduce discharges in one pollutant and allow increases elsewhere in the same pollutant (see Table 11). The exception is the Rahr Malting Co. agreement, which pertains to offsets across three possible pollutants. The pollutant most commonly traded is related to nutrient runoff: six of the eight one-time offsets are for nitrogen and/or phosphorus. One offset agreement pertains to water temperature (Specialty Minerals, Inc.), although it cannot be characterized as a formal trade since the firm is not legally obligated to contribute to the offset project.

Table 11: One-Time Offset Agreements by Pollutant, Year, and Size

Program Name	Pollutant	Year of Trade	Geographic Size[18]
Boulder Creek, CO	Nitrogen	1991	286,600 acres
Piasa Creek Watershed, IL	Sediment	1995	78,000 acres
Edgartown WWTP, MA	Nitrogen		5,150 acres
Falmouth WWTP, MA	Nitrogen		
Specialty Minerals, MA	Temperature		2.2 miles of channels
Wayland Business Center, MA	Phosphorus	1998	28.8 mile long river
Rahr Malting Co., MN	Phosphorus, nitrogen, BOD	1997	10.7 million acres
Southern Minnesota Beet Sugar Cooperative, MN	Phosphorus	1999	10.7 million acres

Table 12 lists the market structure used for each one-time offset agreement, when it is possible to classify. In some cases, this is a difficult task. For instance, the Specialty Minerals offset agreement approves an increase in NPDES permit limits for the facility because of restoration projects funded and implemented by the Army Corps of Engineers. Specialty Minerals has no role in determining the projects undertaken and any monetary contribution to these projects is voluntary.

In most other cases, it is possible to determine the market structure that the offset agreement most closely resembles. Two agreements are characterized as sole-source offsets. According to Woodward and Kaiser (2002), a sole-source offset is one in which no actual trading occurs. Instead, the source takes action offsite to offset its own increase in discharges. An example of this is the Falmouth WWTP offset agreement. In this case, the WWTP is owned and operated by the city, which also manages and implements any offsetting restoration projects.

[18] When possible, the size listed in the database has been converted to a consistent measure. For instance, when size is described in terms of square miles, it has been converted to acres.

Both Minnesota offset agreements most closely resemble a clearinghouse market structure (see Woodward and Kaiser 2002) because of their use of a trust fund, whose board includes a number of third-party members. In the case of Rahr Malting Co., it contributes funding for non-point source projects up-front. The board then determines which non-point source projects to fund to generate offsets. Rahr can then purchase these offsets from the fund at a pre-determined and fixed price. Unlike a traditional clearinghouse in which the buyer and seller have no contact, however, Rahr Malting has a representative that serves on the board and is still responsible for contracting with selected non-point sources and submitting reports related to planned and completed non-point source projects. The Southern Minnesota Beet Sugar Cooperative offset agreement is structured similarly. In the case of the Piasa Creek Watershed offset agreement, the point source has contracted with a third party to arrange non-point source reductions that offset its discharges. In the two remaining cases, it appears that the point source is responsible for arranging offsets directly with a large number of non-point sources, also referred to as bilateral negotiation.

Trading ratios are often used as a mechanism to manage uncertainty associated with the effects of cross-pollutant trading or the effectiveness of non-point source controls in reducing discharges. In Table 12, we see that trading ratios for the offset of emissions between point and non-point sources vary from 1 to 1 for temperature (Specialty Minerals, Inc) and nitrogen offsets (Falmouth WWTP) to 3 to 1 for phosphorous offsets (Wayland Business Center). In the case of cross-pollutant offsets, the Rahr Malting Co. agreement specifies a 2 to 1 trading ratio for all offsets between the point source and non-point sources. In addition, it specifies an 8 to 1

trading ratio for biochemical oxygen demand (BOD) and phosphorus offsets, and a 4 to 1 trading ratio for BOD and nitrogen offsets. Additional discounts apply to non-point sources according to location in relation to the river.

Table 12: One-Time Offset Agreements by Market Structure and Trading Ratio

Program Name	Market Structure	Trading Ratio
Boulder Creek, CO	Sole source offset	1:1
Piasa Creek Watershed, IL	Third party	2:1
Edgartown WWTP, MA	Bilateral	1:1
Falmouth WWTP, MA	Sole source offset	1:1
Specialty Minerals, MA	NA	1:1
Wayland Business Center, MA	Bilateral	3:1
Rahr Malting Co., MN	Clearinghouse (with aspects of bilateral)	2:1 in general; 8:1 BOD-phosphorus; 4:1 BOD-nitrogen
Southern Minnesota Beet Sugar Cooperative, MN	Clearinghouse (with aspects of bilateral)	2.6:1

In some cases, the database provides information on the transaction costs associated with one-time offset agreements (see Table 13). Low transaction costs for the Boulder Creek program resulted from the City of Boulder's involvement in coordinating and implementing stream restoration projects to offset nitrogen loads. In contrast, transaction costs for the Rahr Malting offset agreement were high since Minnesota had no previous experience designing water quality trading programs. Transaction costs were lower for the Beet Sugar Cooperative agreement because of the experience gained with the Rahr Malting agreement.

The database also contains information on government or third-party administrative costs for six of the eight offset agreements. Two offset agreements are characterized as having low administrative costs. In the case of the Wayland Business Center offset agreement, this is mainly because additional monitoring and oversight of

non-point sources is not required. Administrative costs are higher for the Minnesota programs because of the staff time required to modify permits and implement offsets. In the case of the Southern Minnesota Sugar Beet Cooperative they are particularly high due to the requirement that all trades be individually approved. While the Boulder Creek program has low transaction costs, this is in large part due to increased involvement by the City, which results in higher administrative costs.

Table 13: Administrative and Transaction Costs for One-Time Offsets

Program Name	**Adminstrative Costs**	**Transaction Costs**
Boulder Creek, CO	High	Low
Piasa Creek Watershed, IL	15% of individual project costs	
Edgartown WWTP, MA		
Falmouth WWTP, MA		
Specialty Minerals, MA	Low	
Wayland Business Center, MA	Low	
Rahr Malting Co., MN	Medium	High
Southern Minnesota Beet Sugar Cooperative, MN	High	Medium

Offsets are often a potentially cheaper alternative to plant upgrades that would otherwise be required to meet existing permit limits. For example in the Boulder Creek offset agreement, the City of Boulder used a combination of WWTP upgrades and stream restoration projects to meet water quality standards. The stream restoration project was implemented in four phases over a four-year period at an estimated cost of $1.3 to $1.4 million. Even with the significant WWTP upgrades, the city saved an estimated $3 to $7 million. In the Piasa Creek program, the high costs

of installing an expensive lagoon and landfill management system were avoided through funding of non-point sediment control measures.

In addition to avoiding costs associated with expensive plant upgrades, benefits associated with these offset agreements include increased operational flexibility, lower operational costs and improved water quality. However, offset agreements also faced challenges. These included the initial reticence of landowners to participate, the establishment of appropriate trading ratios, funding, and limits that are not stringent enough to encourage offset agreements.

4. State and Regional Trading Policies

Six state and regions that have established trading policies are included in the water quality database. These are the Chesapeake Bay, Maryland, Michigan, Pennsylvania, Virginia, West Virginia, and Wisconsin. In addition to these states and regions, Colorado, Oregon, and Idaho are in the process of implementing their own pollutant trading policies.[19] While not in the current version of the database, we have added them to this section's discussion. In addition, there exists a US Water Quality Trading Policy, developed by the US EPA. While not explicitly discussed in this section, it has been cited by several state policies as an important building block.

The impetus for the state and regional policies in development or in place are largely regulatory. Trading often has been explored in the context of possible TMDL

[19] The draft Colorado Pollutant Trading Policy, released in October 2004 is available at: www.bearcreekwatershed.org/Program%20Elements/Colorado%20Pollutant%20Trading%20Policy%208-24-04.doc. The Oregon DEQ Internal Management Directive, issued in January 2005, is available at: http://www.deq.state.or.us/wq/wqTrading/wqTrading.htm. The draft Idaho Pollutant Trading Guidance, dated November 2003, is available at: http://www.deq.state.id.us/water/prog_issues/waste_water/pollutant_trading/guidance .

implementation, more stringent discharge limits, or watershed-wide caps. For instance, the Chesapeake Bay is slated for a TMDL if water quality standards remain unmet by 2010. This possibility has motivated the Chesapeake Bay Trading Guidance, as well as exploration of a multi-media trading registry in Pennsylvania and state-wide policies in Virginia and Maryland that will be used to adhere to the interstate Chesapeake Bay Agreement.

The state or region-wide trading policies are in various stages of completion (see Table 14). Some, such as Maryland, have drafted concept papers to examine nutrient trading. Others, such as Maryland, Wisconsin, and Michigan, have authorized pilot projects. Of those that have begun to develop a trading policy, Michigan, Colorado, Virginia, Idaho, and the Chesapeake Bay are furthest along. They have developed trading rules, frameworks, or guidance. The Chesapeake Bay has a well-developed guidance that considers trading as an alternative for meeting nutrient reduction goals in member states, but the policy has not been officially adopted by any of the states. Virginia has draft guidelines based on those of the Chesapeake Bay, Idaho also has a draft guidance document, and Colorado has a draft trading policy.

Only Michigan has actually adopted official trading rules (in 2002).[20] Other states have run into a variety of difficulties in their development of trading policies or guidance. In Maryland, for instance, a recent provision that dedicates funding to wastewater treatment plant upgrades has diminished incentives to explore trading.

[20] Michigan has set up trading rules that include: trading occurs by rule and not by individual permit modification, that reductions are "real, surplus, and quantifiable." "Real, surplus, and quantifiable" implies actual improvements in water quality that are above those required by regulation and that these changes in water quality are measurable. In addition all trading parties must be within the same watershed. Point sources must be in compliance with all monitoring and record-keeping requirements.

Wisconsin and West Virginia also have experienced difficulties in developing a state policy. Based on its pilot projects, Wisconsin has found that the existing discharge limit does not create enough incentive to encourage trading. A TMDL or performance standard would be needed to create that incentive. In West Virginia, the committee tasked with exploring the appropriateness of a statewide trading framework did not reach consensus for reasons that include possible insufficient funding and enforcement actions needed for water quality trading.

Table 14: Status of State and Regional Policies

Policy Name	Status
Chesapeake Bay Trading Guidance	Guidance for member states developed in 2001; no official adoption through the passage of regulation
Colorado Pollutant Trading Policy	A draft trading policy was released in 2004.
Idaho Pollutant Trading Guidance	A draft guidance document was issued in November 2003
Maryland Nutrient Trading Policy	Concept paper and forum on trading have occurred; Two pilot projects are in the proposal stage.
Michigan Water Quality Trading Rules	Formal rulemaking to adopt trading rules adopted in 2002; one pilot project
Oregon DEQ Water Quality Trading Policy	An internal management directive was released in 2005 to provide guidance on trading in Oregon.
Pennsylvania Multi-Media Trading Registry	A trading registry is being developed but there have been no official trading rules developed to-date; one pilot project
Virginia Nutrient Trading Program	Draft guidelines based on Chesapeake Bay guidelines are available; nutrient trading among point-sources allowed when final guidelines are in place
West Virginia Trading Framework	Committee formed in 2002 to evaluate suitability of trading; no consensus reached on whether a statewide policy should be pursued in 2004 report; two pilot projects proposed.
Wisconsin Nutrient Trading Rules	Three pilot projects were authorized in 2002 but discontinued due to lack of funding

State and regional policies often specify what types of pollutants may be traded (see Table 15). In all cases, the policies address trading among point-sources

and trading between point and non-point sources. Three state policies also consider trading solely between non-point sources: Maryland, Michigan, and Wisconsin.

The policies in Wisconsin, Maryland, Virginia, Michigan, and the Chesapeake Bay focus on nutrient trading. Idaho limits trading to pollutants for which a TMDL has been established. Other policies have a much broader scope. For instance, while Oregon anticipates that the majority of its trades will pertain to temperature, it also considers trading of nutrients, across pollutants, and, on a case-by-case basis, of bio-accumulative toxic substances. Colorado's policy is aimed at trading of non-toxic substances such as nutrients, sediments, and salinity, but allows for the consideration of trading of toxic substances on a case-by-case basis. West Virginia considers trading for BOD, nutrients, metals, and across pollutants. In a few instances, state policies enumerate substances for which trading is not allowed: bacteria (Oregon), bio-accumulative toxics (Colorado), and across pollutants (Michigan).

Table 15: State and Regional Policies by Type of Trading and Pollutants Traded

Policy Name	Type of Trading	Pollutants Traded
Chesapeake Bay	PS-PS, PS-NPS	Nitrogen, phosphorus, cross-pollutant
Colorado	PS-PS, PS-NPS, NPS-NPS	Non-toxics (nutrients, sediment, salinity), toxics (case-by-case)
Idaho	PS-PS, PS-NPS	Pollutants subject to a TMDL
Maryland	PS-PS, PS-NPS, NPS-NPS	Nitrogen, phosphorus
Michigan	PS-PS, PS-NPS, NPS-NPS	Nutrients, sediments
Oregon	PS-PS, PS-NPS, NPS-NPS	Temperature, nutrients, sediments; bio-accumulative (case-by-case); cross-pollutant
Pennsylvania	Not specified	Multi-media, not specified
Virginia	PS-PS, PS-NPS	Nutrients
West Virginia	PS-PS, PS-NPS	Cross-pollutant, BOD, metals, nutrients
Wisconsin	PS-PS, PS-NPS, NPS-NPS	Phosphorus

While the policies developed for Colorado, Oregon, Wisconsin and West Virginia do not specify or recommend a particular market structure, others do (see Table 16). The Chesapeake Bay guidance prefers the clearinghouse structure, in particular an online-based registry system called NutrientNet. It also allows for the option of bilateral negotiation. Idaho appears to have established an equivalent system that allows for bilateral negotiation but requires that all trades be recorded in a trading database that is administered by a neutral third party, who reviews the trades for consistency with the basic trading requirements. Connecticut and Maryland prefer the clearinghouse structure; Virginia and Michigan rely on bilateral negotiations. However, the Michigan Department of Environmental Quality also maintains a registry to record and monitor trades.

Table 16: Market Structure, Certification, and Banking

Policy	Market Structure	Certification of Trades	Banking?
Chesapeake Bay	Determined by state: bilateral, clearinghouse	Varies by state; recommends that state certifies trades	Allow if goals not met by 2010
Colorado	Not specified	Yes for credit generation and use	Not determined
Idaho	Bilateral, clearinghouse (trading registry)	Yes for credit generation and use (to third party)	No
Maryland	Clearinghouse is possible (NutrientNet)	Not determined	Not determined
Michigan	Bilateral; state maintain trading registry	Yes for credit generation and use; PS must modify permit	Yes, 5 years
Oregon	Not specified	Case-by-case approval process	Not allowed
Pennsylvania	Clearinghouse	Not determined	Not determined but considered
Virginia	Bilateral	Not determined	Yes, 1 year for own use
West Virginia	Not determined	Yes for credit generation and use; PS must modify permit	Allows for possibility
Wisconsin	Not determined.; broker or facilitator to assume administrative role	Not determined	Not determined

Establishing the trading baseline for sources and determining how many credits are generated by a particular activity varies by state and regional policy.[21] Most states have yet to address credit allocation issues. In both Michigan and Colorado, point-source baselines are established by actual loading levels over a three-year period. In Idaho, point sources have NPDES effluent limits, written to reflect TMDL waste load allocations. Point sources generate credits when they reduce pollution below these allocations. When traded, the point source is then subject to the lower limit. Non-point source baselines in Michigan are determined by a TMDL or some other action or management plan in a closed trading system and by a certified nutrient management plan, or from loading estimates for particular management practices in an open trading system. Colorado uses a similar system noting that the method used to determine the baseline should be the most protective. In Idaho, non-point sources must demonstrate that the generation of credits through BMPs results in a net environmental benefit. In other words, credits are only generated from reductions beyond the water quality goals established by the TMDL (which are based on estimate loadings for non-point sources). In particular, the Idaho Department of Environmental Quality subtracts out of the total credits generated by a non-point source's BMP the amount needed to achieve the load allocation in the TMDL; the amount that remains is considered surplus and available for trade.

The Chesapeake Bay Trading Guidance establishes a mechanism for certifying and registering credits and for tracking trades. While not yet operational,

[21] Guidance on establishing a baseline may be found in the EPA's Water Quality Trading Policy (WQT) Section IIID.

Pennsylvania shares this aim in its efforts to create a multi-media trading registry. Colorado requires registration and certification of credits with "an appropriate entity" prior to generation, trade, or use. Idaho, Michigan and West Virginia have similar requirements. Oregon notes criteria for identifying acceptable trades and requires that information demonstrating the trade resulted in maintained or improved environmental quality be submitted for approval on a case-by-case basis.

Only two state policies explicitly allow banking or the saving of credits for future use: Michigan allows banking for up to five years (with individual approval) while Virginia allows banking for one year for a point source's own use. The Chesapeake Bay policy allows for the possibility of banking in the future, if reduction goals are not met by 2010. The Colorado policy acknowledges the flexibility that may be introduced by banking and will determine the degree to which banking is allowed on a case-by-case basis. While no trading framework is in place in West Virginia, the report released to consider trading also allows for the possibility of banking. The Oregon and Idaho policies do not allow banking of credits.

Because trading rules have not been established in most states and regions (the exception is Michigan), few have set specific trading ratios. Michigan specifies a 1.1 to 1 trading ratio for point source trades. Virginia suggests a 1 to1 ratio for point sources. Only Michigan has specified a trading ratio when non-point sources are involved in the trade. It has specified a 2 to 1 trading ratio in these cases, but also mentions that further site-specific discount factors may apply. Where trading ratios have been discussed, other states have suggested trading ratios ranging from 2:1 to 10:1 for trades involving non-point sources. In Colorado, Idaho, and Oregon, trading

ratios are determined on a case-by-case basis (determined by pollutant and watershed). Factors that should be taken into account when determining a trading ratio in Colorado include technical and logistical uncertainty, whether the credits are estimated or measured, the fate and transport of the pollutant, the distance between the pollutant source and the regulatory source, temporal variability, and any time lag between implementation and full performance.

What type of monitoring and reporting should take place is not specified in many of the state and regional policies. In the cases of Idaho, Michigan, West Virginia, Colorado, and the Chesapeake Bay, detailed monitoring and reporting requirements are outlined. For instance, most of these policies require an initial (and often annual) inspection of the installation of BMPs by non-point sources. Additional monitoring or reporting requirements for non-point sources may be required as well. Monitoring of point sources varies from monthly reporting (Chesapeake Bay and Idaho) to quarterly sampling and analysis (West Virginia) to regular monitoring reports coupled with comprehensive program evaluation every five years (Michigan). Colorado determines the level of monitoring needed on a case-by-case basis.

In most cases where liability has been specified, point sources are liable for permit compliance and ensuring that adequate credits are delivered. The Chesapeake Bay and Colorado policies allow for some supplier liability through contractual obligation. Depending on the contract, the supplier may share the burden through agreed-upon penalties such as payment of penalties, loss of trade certification or return of funding. Michigan holds both credit buyers and sellers liable for the trade.

5. Other Projects and Recent Proposals

There are 31 other projects and recent proposals related to water quality trading in the database; we have added to these four others for which we have information to Table 17 (see the footnotes for each project). Of these 35 projects and recent proposals, 12 are case studies, pilot studies, or feasibility studies aimed at illuminating the usefulness of trading for improving water quality in a particular area. In 10 cases, trading was considered as an option when determining how to reduce discharges of a particular pollutant. In eight cases, trading frameworks have been put into place, trading has been proposed, or it is planned for the near future.

Table 17 also describes the pollutants for which these projects and proposals are being considered. Nearly half of these projects and proposals pertain to lowering nutrients discharges such as nitrogen and phosphorus. The remaining projects consider trading for a wide range of pollutants. For instance, a couple of proposals consider trading for mercury. One proposal pertains to storm-water runoff, one to selenium discharges, and another to water temperature. Where specified, most proposals consider point source trading with non-point sources. In a few instances, point-source to point-source trading is considered in conjunction with point-source to non-point source trading.

The database also contains information on potential regulatory drivers for 16 of the projects and recent trading proposals. When this information is available, we have included it in Table 17. Seven of the projects and recent proposals are for watersheds that have a TMDL in place. An additional two projects or proposals are for watersheds that have some other type of regulatory limit in place. Seven projects

or proposals are for watersheds that are currently developing a TMDL or are considering a TMDL for the near future.

Table 17: Recent Projects/Proposals by Type, Pollutant, and Regulatory Driver

Name	Project Type	Pollutant	Regulatory Driver?
Montgomery Water Works & Sanitary Sewer Board, AL	Pilot study	Multi-pollutant	
Sacramento Regional County Sanitation District Mercury Offset, CA	Feasibility study	Mercury, gold mines	
San Francisco Bay Mercury Offset Program, CA	Trading considered	Mercury	TMDL
Lower Colorado River, CO	Trading program	PS-NPS, selenium	Possible TMDL
Lake Allatoona, GA	Trading framework	Phosphorus	
Illinois Pretreatment Trading Program, IL	Trading considered	Multi-pollutant; indirect discharges	
Lake Erie Land Company/ Little Calumet River, IN	Trading considered		
Monocacy, River, MD	Trading proposal	PS-PS, NPS-NPS, PS-NPS	
St Martins River Watershed, MD	Trading considered		
Wicomico River, MD	Trading simulation	PS-NPS, phosphorus	
Acton WWTP, MA	Trading considered	PS-NPS, phosphorus	Possible TMDL
Massachusetts Estuaries Project, MA	Pilot studies	PS-NPS, nitrogen	Possible TMDL
Nashua River, MA	Trading proposal	PS-NPS, phosphorus	Possible TMDL
Gun Lake Tribe, Kalamazoo River, MI	Trading proposal	PS-NPS, nutrient loading	TMDL
Minnesota River, MN	Trading plan	PS-PS, phosphorus	TMDL
East River, NY	Trading framework	PS-PS, nitrogen	TMDL
New York City Watershed, NY[22]	Pilot study; offsets	PS-NPS, phosphorus	TMDL

[22] The proposed pilot program for the New York City watershed is not included in the Water Quality Trading Database. The Memorandum of Agreement that put the offset program in place is available at: http://www.nysefc.org/tas/MOA/moa_6.htm Information on this program also can be found at: http://www7.nationalacademies.org/wstb/new_york_city_watershed_management.html.

Name	Project Type	Pollutant	Regulatory Driver?
Cape Fear, Jordan Lake, NC[23]	Pilot study	PS-PS, PS-NPS, stormwater runoff	TMDL planned
Clermont County, OH	Trading considered	PS-NPS, nutrients, solids	TMDL planned
Ohio River Basin, OH	Trading proposal	Nitrogen	Nutrient criteria
Honey Creek Watershed, OH	Case study	PS-NPS, phosphorus	
Lower North Canadian River, OK	Case study	PS-PS, PS-NPS	
Tualatin River, OR	Trading authorized	PS-PS, PS-NPS, ammonia, BOD, temperature	TMDL
Conestoga River, PA	Pilot study	PS-NPS, nitrogen, phosphorus	Possible TMDL
Boone Reservoir, TN	Feasibility study	PS-NPS, nitrogen, BOD, phosphorus	
Blue Plains WWTP, VA	Trading considered	PS-PS, nitrogen	Reduction goal
Colonial Soil and Water Preservation Project, VA	Trading proposal	Nitrogen, sediment, phosphorus	
Henry County Public Service Authority/City of Martinsville, VA	Trading considered	PS-PS, total dissolved solids	TDS limit
Chehalis River, WA	Trading considered	PS-NPS, NPS-NPS	TMDL
Puyallup River, WA	Pilot study	PS-PS, BOD, ammonia	
Yakima River, WA	Feasibility study	PS-NPS, water quality	TMDL
Cacapon/Lost River, WV	Pilot proposal	Nutrients	
Cheat River, WV	Pilot study; framework	PS-NPS, pH, iron, manganese, zinc, aluminum	TMDL
Bear River, ID, UT, WY[24]	Trading proposal	PS-NPS, phosphorus	TMDL
Lake Tahoe, CA and NV[25]	Trading proposal	PS-NPS, NPS-NPS, nutrients, sediments	TMDL planned

[23] The proposed trading pilot study for Cape Fear is not included in the Water Quality Trading Database. Summary information on the proposed study funded by EPA can be found at: www.epa.gov/twg/2004/04selectsumm.html. The complete proposal also is available at: http://www.epa.gov/owow/watershed/initiative/2004/2004proposals/04capefear.pdf.

[24] The Bear River watershed project is not included in the Water Quality Trading Database. More detailed information on the proposed project and the role that trading may play can be found at: www.epa.gov/twg/2004/04selectsumm.html. The complete proposal also is available at: http://www.epa.gov/owow/watershed/initiative/2004/2004proposals/04bearriver.pdf.

[25] Lake Tahoe watershed project is not included in the Water Quality Trading Database. More detailed information on the proposed project and the role that trading may play can be found at:

In seven cases, the database contains some details on a trading program in development (or considered at one point in time). To the extent that these details are available, we have provided them in Table 18. Four of these projects or proposals have proposed a trading ratio ranging from 1:1 to 3:1. For instance, the Henry Country, Virginia proposal suggests a 1 to 1 trading ratio for trading of total dissolved solids among point sources, while the East River, New York proposal suggests a 2 to 1 trading ratio for trading of nitrogen among point sources. Both the Acton WWTP and the New York City Watershed proposals suggest a higher trading ratio of 3 to 1 for the trading of nutrients between point sources and non-point sources.

Three projects and proposals also provide us with information on key concerns with regard to the use of trading to improve water quality. For instance, the New York City Watershed has expressed concern over how to monitor storm-water best management practices. Both the Lower Colorado River and Massachusetts Estuaries Project have expressed concern related to non-point sources, either how to encourage non-point source participation, or whether trading can occur when there are only a few non-point sources in the watershed.

Table 18: Trading Ratios and Key Concerns of Recent Projects/Proposals

Name	Trading Ratio	Concerns
Lower Colorado River, CO		How to get NPSs to participate
Acton WWTP, MA	3:1 proposed	
Massachusetts Estuaries Project, MA		Small number of NPSs and geographic size
Minnesota River, MN	1.1:1 proposed	

www.epa.gov/twg/2004/04selectsumm.html. The complete proposal also is available at: http://www.epa.gov/owow/watershed/initiative/2004/2004proposals/04laketahoe.pdf.

Name	Trading Ratio	Concerns
East River, NY	2:1	
New York City Watershed, NY	3:1 proposed	Monitoring of stormwater BMPs
Henry County Public Service Authority/City of Martinsville, VA	1:1 proposed	

Ten projects initially considered trading as an option for discharge reductions but decided not to implement a trading program. Table 19 lists the reasons cited for not implementing a trading program. They vary from regulatory constraints or changes (e.g. in Illinois, Washington, New York, and Virginia) to a lack of non-point sources with which to trade (e.g. in Oklahoma and Massachusetts) to changes in point-source finances (e.g. in Virginia and Washington). In two cases, studies showed that trading would likely lead to cost savings and improved water quality but for unspecified reasons, trading was never pursued (e.g. in Maryland and Tennessee).

Table 19: Reasons Why a Trading Program Was Not Implemented

Name	Why a trading program has not developed
Illinois Pretreatment Trading Program, IL	EPA does not allow categorized pretreatment loading allowances to be traded, which is the type of trading that is feasible
Wicomico River, MD	While the simulation showed potential cost savings and water quality improvements from trading, no program was developed
Acton WWTP, MA	Chose to discharge into groundwater infiltration basin due to degraded water quality and difficulty identifying sufficient NPSs
East River, NY	While the TMDL allows for trading, between management zones, with East River plants split between 2 zones, and establishes a procedure for trading and a trading ratio between zones, New York has not promulgated regulation requiring nitrogen trading.
Lower North Canadian River, OK	Watershed is unsuited to PS-NPS trading because PSs contribute over 90% of the nutrient load; leaves open the possibility of PS-PS trading, which was not explored in the study

Name	Why a trading program has not developed
Boone Reservoir, TN	While a combination of PS and NPS controls was found most cost-effective, no trading program was ever developed
Blue Plains WWTP, VA	At a late stage, the trade agreement was not finalized; more stringent reduction goals provided incentives to the facility to perform upgrades rather than trade. Also, the State no longer made funding available.
Henry County Public Service Authority/City of Martinsville, VA	The textile plant that contributed 95% of total waste to the river went out of business making trading no longer necessary
Chehalis River, WA	TMDL did not layout a framework for trading; all PSs are located in the sections of the river with the lowest assimilative capacity
Puyallup River, WA	Plans to modify the permits of two PSs to allow for trading of BOD, but no trading occurred due to the changing economic needs of the PSs.

6. Conclusions

In this paper, we examine key features of water quality trading initiatives in the U.S. based on information from a recently compiled database. We divide these initiatives into four categories: one-time offset agreements, on-going offset/trading programs, regional and state trading policies, and other trading projects or recent proposals. Trading is often considered as an option for reducing discharges into a watershed when a source – often a point source – is faced with some sort of discharge limit but wants to expand production (and therefore discharges). To avoid the cost of upgrades needed to reduce the discharges associated with this expansion, the source seeks to offset the increases by finding another source of the pollutant – either a point source or a non-point source - in the watershed that is willing to reduce its loadings.

We find that the trading has often been explored in the context of more stringent discharge limits, or watershed-wide caps (e.g. TMDL). Most trading programs and policies focus on trading between point sources and non-point sources,

and the trading of nutrients such as nitrogen and phosphorus. In many cases, trading programs are in place for fairly large watersheds with many possible non-point trading partners. Point sources are often held liable for the trades with non-point sources. Uncertainty associated with non-point source controls is frequently mitigated through trading ratios by requiring non-point sources to more than offset the increase in a point source loading. Trading ratios are also used to account for differences in the location of sources in a watershed and for ensuring a net water quality improvement from a trade. Both trading ratios and market structures are found to vary widely across trading programs.

Actual trades or offsets occurred in 19 cases: eight one-time offset agreements, and 11 ongoing trading/offset programs. Of the ongoing trading programs, only four experienced a large number of trades. The most common reason trading programs reported so few, if any, trades is a non-stringent discharge limit, making it easy for sources to meet standards without trading. Transaction and administrative costs, if too high, may also be a deterrent to trading; they vary considerably among the programs. Programs that had mechanisms in place to facilitate trading had lower transaction costs compared to programs with more complicated and lengthy trade negotiation processes. Similarly, programs with lower levels of oversight of non-point source controls and review of trades had lower administrative costs than programs with more review and oversight.

A total of eight states and regions are in various stages of developing water pollution trading policies. Michigan, Colorado, Virginia and the Chesapeake Bay have developed trading rules, frameworks, or guidance while states such as Maryland

and West Virginia are exploring the viability of trading through pilot projects. In many cases the state and regional policies provide guidance on the type of pollutant that may be traded, the sources that may trade, and the market structure that should be used. Trading rules, monitoring and reporting requirements, allocation of credits among sources, and mechanisms for tracking trades are less developed in most state and regional policies.

The database also contains a brief description of 35 other projects and recent proposals that range from pilot studies or case studies to trading frameworks. For the programs that considered trading, reasons for not implementing include changes in regulation and lack of sufficient trading partners. While most of these projects or proposals also target nutrient reductions, several consider trading for mercury, selenium and storm-water runoff.

The success of any water-quality trading program does not appear to be driven by any one factor. The water-quality database collects information on programs and presents that information in a systematic way. A read-through of this information makes it clear that differences across trading programs lead to different results and different success rates. One question that may be addressed with future research is, are the myriad of different trading approaches warranted? Or is there a more limited set of approaches that could be used to design a successful water-quality trading program? How to consistently and accurately measure the costs associated with a trading program is another fruitful topic for future research. These estimates then may be used to compare costs across the different trading programs to determine if one design is more effective than another.

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New York City Watershed Pilot Program (1997). Memorandum of Agreement. http://www.nysefc.org/tas/MOA/moa_6.htm

Oregon Deparment of Environmental Quality (2005). Water Quality Trading Internal Management Directive. January. http://www.deq.state.or.us/wq/wqTrading/wqTrading.htm.

U.S. EPA (2003). US Water Quality Trading Policy. January. http://www.epa.gov/owow/watershed/trading/finalpolicy2003. html.

Woodward, Richard, and Ronald Kaiser (2002). "Market Structure for U.S. Water Quality Trading." *Review of Agricultural Econo*mics 24(2): 366-383.

Appendix[26]

Table A-1: One-Time Offset Agreements

Program Name	In Database?
Boulder Creek WWTP, CO	p.31
Piasa Creek Watershed, IL	p.110
Edgartown WWTP, MA	p. 131
Falmouth WWTP, MA	p. 137
Specialty Minerals, MA	p. 147
Wayland Business Center, MA	p. 154
Rahr Malting Co., MN	p. 176
Southern Minnesota Beet Sugar Cooperative, MN	p. 183

Table A-2: Ongoing Offset/Trading Programs

Program Name	In Database?
Grassland Area Farmers Tradable Loads Program, CA	p. 10
Bear Creek, CO	p. 24
Chatfield Reservoir, CO	p. 37
Cherry Creek, CO	p. 44
Clear Creek, CO	p. 56
Lake Dillon, CO	p. 64
Long Island Sound, CT	p. 80
Lower Boise River, ID	p. 97
Charles River, MA	p. 125
Kalamazoo River, MI	p. 162
Truckee River Quality Settlement Agreement, NV	p. 190
Passaic Valley Sewerage Commission Pretreatment Trading, NJ	p. 199
New York City Watershed Offsets Pilot Program, NY	p. 207
Neuse River Basin, NC	p. 219
Tar-Pamlico Basin, NC	p. 226
Great Miami River Watershed Trading Pilot Program, OH	p. 238
Fox-Wolf Basin, WI	p. 269
Red Cedar River, WI	p. 275
Rock River, WI	p. 282

* This is a pilot that does not rely on real sources engaging in actual trade but rather in simulated trades to generate information used to assess whether a trading program should be implemented.

[26] Page numbers are based on the August 4, 2004 version of the database.

Table A-3: State and Regional Trading Policies

Policy Name	In Database?
Chesapeake Bay Trading Guidance	p. 289
Colorado Pollutant Trading Policy	No
Idaho Pollutant Trading Guidance	No
Maryland Nutrient Trading Policy	p. 297
Michigan Water Quality Trading Rules	p. 300
Oregon DEQ Water Quality Trading Policy	No
Pennsylvania Multi-Media Trading Registry	p. 305
Virginia Nutrient Trading Program	p. 308
West Virginia Trading Framework	p. 312
Wisconsin Nutrient Trading Rules	p. 316

Table A-4: Other Projects and Recent Proposals

Name	In Database?
Montgomery Water Works & Sanitary Sewer Board, AL	p. 320
City of Santa Rosa, CA	p. 320
Sacramento Regional County Sanitation District's Mercury Offsets, CA	p. 322
San Francisco Bay Mercury Offset Program, CA	p. 19
Lower Colorado River, CO	p. 74
Lake Allatoona, GA	p. 322
Illinois Pretreatment Trading Program, IL	p. 106
Lake Erie Land Company/ Little Calumet River, IN	p. 324
Monocacy, River, MD	p. 324
St Martins River Watershed, MD	p. 324
Wicomico River, MD	p. 324
Acton WWTP, MA	p. 120
Massachusetts Estuaries Project, MA	p. 143
Nashua River, MA	p. 325
Gun Lake Tribe, Kalamazoo River, MI	p. 325
Minnesota River, MN	p. 170
New York City Watershed, NY	No
East River, NY	p. 326
Cape Fear, NC	p. 327
Clermont County, OH	p. 233
Ohio River Basin, OH	p. 328
Honey Creek Watershed, OH	p. 329
Lower North Canadian River, OK	p. 329
Tualatin River, OR	p. 330
Conestoga River, PA	p. 246
City of Providence, RI	p. 330
Boone Reservoir, TN	p. 331
Blue Plains WWTP, VA	p. 260
Colonial Soil and Water Preservation Project, VA	p. 331
Henry Count, VA	p. 265

Name	In Database?
Chehalis River, WA	p. 332
Puyallup River, WA	p. 333
Yakima River, WA	p. 333
Cacapon/Lost River, WV	p. 334
Cheat River, WV	p. 334
Bear River, ID, UT, WY	p. 323
Lake Tahoe, CA and NV	p. 321