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Water Quality Trading Programs: An International Overview

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Summary

Water quality trading is gaining traction in a number of watersheds around the world. It is a market-based approach that works alongside water quality regulation to improve water quality, providing flexibility in how regulations are met and potentially lowering regulatory compliance and abatement costs. Our research identified 57 water quality trading programs worldwide. Of these, 26 are active, 21 are under consideration or development, and 10 are inactive or are completed pilots with no plans for future trades. The majority of programs were located in the United States, with only six programs existing outside the United States—four in Australia, one in New Zealand, and one in Canada.

From our assessment of these water quality trading programs, we identified five key factors that stakeholders believed were important for the successful implementation of their trading programs:

- Strong regulatory and/or non-regulatory drivers, which helped create a demand for water quality credits;
- Minimal potential liability risks to the regulated community from meeting regulations through trades;
- Robust, consistent, and standardized estimation methodologies for nonpoint source actions;
- Standardized tools, transparent processes, and online registries to minimize transaction costs; and
- Buy-in from local and state stakeholders.

Before going to the expense of developing a water quality trading program, we recommend that the relevant bodies—either governmental or nongovernmental—ensure these factors are in place.

Setting the Scene

Water quality is one of the most pressing environmental concerns facing many parts of the world today. In the United States, for example, 48 percent of assessed rivers and streams, 60 percent of assessed lakes, reservoirs, and ponds, and 61 percent of assessed estuaries were threatened or impaired for their designated uses in 2006. A significant number were impaired by nutrients.[1]

Globally, approximately 532 coastal areas around the world have been identified as experiencing some form of eutrophication, or nutrient overenrichment. Of these, at least 405 coastal areas experience hypoxia (oxygen depletion).[2] Eutrophication affects the ability of lakes, rivers, streams, and estuaries to support aquatic life and provide suitable drinking water. It can also lead to the formation of hypoxic areas or "dead zones" in lakes and coastal areas such as the Black Sea (Eastern Europe), Pearl River Delta (China), the Gulf of Mexico (U.S.), and the Chesapeake Bay (U.S.).

Sources of water quality impairment are generally divided into two categories: point sources and nonpoint sources. Point sources are those sources that discharge pollutants into a waterbody via a discrete conveyance such as a pipe. Examples of point sources include sewage treatment plants and industrial facilities. By contrast, pollution from nonpoint sources is typically diffuse in nature, such as agricultural or urban runoff. Because the precise origin of pollution from nonpoint sources is difficult to identify, these sources are frequently not regulated for pollutant discharges.[3]

To address the increasing occurrence of eutrophication in local waterbodies, some government agencies are beginning to implement nutrient caps or limits for sources that discharge nutrients in waterways. In some cases, water quality trading is being proposed to reduce the costs associated with meeting nutrient caps, as well as to offset additional nutrient discharges that may result from urban or agricultural productivity growth.

While some jurisdictions are experimenting with water quality trading as a means of reducing the costs associated with restoring and protecting water quality, the potential efficiencies from trading programs can only be realized if programs are appropriately structured and implemented. The purpose of this brief is to provide an overview of water quality trading programs, outline the various approaches to program design, and explore the program design elements that are important for implementing effective water quality trading programs. We use stakeholder satisfaction, trading activity, and ability to meet the environmental goal as our measures for an effective trading program. However, we do recognize that in many instances programs have not been operating long enough to adequately assess progress toward environmental goals or the ability of programs to continue meeting these goals in the long term.

What is Water Quality Trading?

Water quality trading is a market-based instrument that is gaining popularity as a mechanism to cost-effectively meet water quality goals. It is premised on the fact that the costs to reduce pollution differ among individual entities depending on their size, location, scale, management, and overall efficiency. Trading allows sources with high abatement costs to purchase pollution discharge reductions from sources that have lower abatement costs. Entities with lower abatement costs are able to economically lower their pollution discharges beyond regulated or permitted levels, enabling them to sell their excess reductions to entities with higher costs. Water quality trading is most commonly applied to nutrients (such as nitrogen and phosphorus), but has also been applied to temperature, selenium, and sediment.[4]

Water quality trading has many formulations. Trades between regulated point sources—that is, two sewage treatment plants trading to meet permitted discharge levels—are the most straightforward. The Long Island Sound Nitrogen Credit Exchange Program (Connecticut, U.S.) is an example of such a point-to-point-source trading program. Water quality trading programs can also allow trading between regulated point sources and unregulated nonpoint sources, such as agriculture. Trading between point and nonpoint sources enables point sources with high compliance costs to purchase pollution reduction credits (also referred to as "offsets") from nonpoint sources with lower pollution reduction costs. In most instances, point-source facilities are controlled by regulatory discharge permits—for example, the U.S. Environmental Protection Agency's National Pollutant Discharge Elimination System (NPDES) permits—while nonpoint sources are generally not controlled by regulatory discharge limits. In these types of programs, nonpoint sources are typically sellers of pollution reduction credits and not buyers, since they are under no regulatory obligation to reduce their discharge.

In some instances, trading programs are focused entirely on nonpoint sources. In these instances, one or both of the nonpoint sources involved in the trades have been regulated. For example, the Lake Taupo Nitrogen Trading Program in New Zealand (under development) is allocating nitrogen discharge allowances to all agricultural sources within the Lake Taupo watershed. It will allow them to trade among each other to maintain compliance or to expand production.

Globally, the majority of nutrient pollution originates from nonpoint sources, principally agricultural sources. In the United States, approximately 82 percent of the nitrogen and 84 percent of the phosphorus in U.S. lakes, rivers, and estuaries come from nonpoint sources.[5] Water quality trading programs that allow point-to-nonpoint trades may therefore be viewed as mechanisms for leveraging point-source regulatory requirements to generate reductions from unregulated nonpoint sources. The point-to-nonpoint trades also provide point sources with flexibility in achieving their regulatory limits in a cost-effective manner, while providing incentives (in the form of additional revenue streams from credit sales) to nonpoint sources to reduce their pollution loads. Over 70 percent of active water quality trading programs allow trades between point and nonpoint sources.

Survey of Water Quality Trading Programs

In 2008, WRI undertook an assessment of water quality trading programs worldwide. We identified 57 programs; of these, 26 are active,[6] 21 are under consideration or development, and 10 are inactive. Of the programs identified, all but six are located in the United States. (See Box 1 for a discussion of the reasons why water quality trading has taken off in the United States.) The six trading programs that are not in

BOX 1 Water Quality Trading in the United States

The majority of the water quality trading programs identified by WRI were located in the United States. Three factors have helped spur the proliferation of water quality trading programs in the United States:

- *Increased regulatory interest in controlling nutrients as a result of increasing occurrences of eutrophication and hypoxia in U.S. waterbodies.* In the late 1990s, the enforcement of the Clean Water Act's (CWA) total maximum daily load (TMDL) requirement began in earnest. As a result of the enforcement of this provision, there was a proliferation of nutrient-based TMDLs. Point sources within nutrient-impaired TMDL watersheds are assigned permits, which limit their nutrient discharges to the waterbody.
- *The U.S. Environmental Protection Agency's (EPA) endorsement of water quality trading.* In 2003, EPA released its Water Quality Trading Policy, which encouraged the use of water quality trading to achieve watershed goals. More specifically, the policy was intended to encourage voluntary trading programs to facilitate the implementation of TMDLs, reduce the costs of complying with CWA regulations, establish incentives for voluntary reductions, and promote watershed-based initiatives. (See EPA's *"Final Water Quality Trading Policy"* available online at: http: //www.epa.gov/owow/watershed/trading/finalpolicy2003.html.)
- *Availability of government funding to finance market-based water quality initiatives.* EPA, together with the United States Department of Agriculture (USDA), encouraged the implementation of water quality trading programs through grant funding. Three of the primary funding sources for developing water quality trading programs include EPA's Targeted Watershed Grant and Section 319 grants, and the Conservation Innovation Grants Program authorized under the 2002 Farm Bill and funded through the USDA's Natural Resource Conservation Service (USDA-NRCS). These grants provide the resources to cover program start-up costs and fund any initial scoping or communication activities.

the United States include the Lake Taupo Nitrogen Trading Program (New Zealand; under development), Hunter River Salinity Trading Scheme (Australia; active), South Nation River Watershed Trading Program (Canada; active), South Creek Bubble Licensing Scheme (Australia; active), Murray-Darling Basin Salinity Credits Scheme (Australia; active), and the Moreton Bay Nutrient Trading Scheme (Australia; under development). Table 1 provides a list and brief profile of the trading programs evaluated.

In addition, we identified 13 statewide water quality trading guidance, policies, or rules that exist or are in development in the United States. These include:

- Colorado Pollutant Trading Policy (*inactive*),
- Connecticut Water Quality Trading Legislation,
- Delaware State Trading Initiatives *(under development)*,
- Florida Water Quality Trading Rules *(under development)*,
- Idaho Pollutant Trading Guidance,
- Maryland State Water Quality Trading Policy *(under development)*,
- Michigan Water Quality Trading Rules,
- Minnesota Water Quality Trading Policy *(under development)*,
- Ohio Water Quality Trading Rules,
- Oregon Final Internal Management Directive of Water Quality Trading,
- Pennsylvania State Water Quality Trading Policy,
- Virginia State Water Quality Trading Rules,
- West Virginia Water Quality Trading Guidance *(under development)*, and
- Georgia Water Quality Trading Initiatives *(under development)*.

Comparing Water Quality Trading Programs

We compared water quality trading programs along seven dimensions—policy drivers, allocation of caps, establishment of nonpoint-source baselines, nonpoint-source nutrient reduction calculations, use of trading ratios, market structure, and trading activity. Our comparison is based on literature research and phone interviews with water quality trading program representatives. In addition, we conducted in-person interviews with a variety of stakeholders involved with the eight trading programs listed below.

- Cherry Creek Reservoir Watershed Phosphorus Trading Program, Colorado
- Chatfield Reservoir Trading Program, Colorado
- Long Island Sound Nitrogen Credit Exchange Program, Connecticut
- Great Miami River Watershed Trading Pilot, Ohio
- Pennsylvania Water Quality Trading Program, Pennsylvania
- Red Cedar River Nutrient Trading Pilot Program, Wisconsin
- South Nation River Watershed Trading Program, Ontario, Canada
- Lake Taupo Nitrogen Trading Program, New Zealand

TABLE 1 Water Quality Trading Programs, 2008

PROGRAM NAME	STATE/COUNTRY	TYPES OF TRADES	MARKET TYPE§
Active Programs/Pilots			
Hunter River Salinity Trading Scheme*	New South Wales, Australia	PS-PS	Exchange market
South Nation River Watershed Trading Program *	Ontario, Canada	PS-NPS	Clearinghouse
South Creek Bubble Licensing Scheme	New South Wales, Australia	PS-PS	Clearinghouse (aggregate permit)
Murray-Darling Basin Salinity Credits Scheme†	Southeastern Australia		Bilateral
Grassland Area Farmers Tradable Loads Program*	California, U.S.	NPS-NPS	Bilateral
Bear Creek*	Colorado, U.S.	PS-PS/NPS	Bilateral
Chatfield Reservoir Trading Program*	Colorado, U.S.	PS-PS/NPS	Sole-source offsets
Cherry Creek Reservoir Watershed Phosphorus Trading Program*	Colorado, U.S.	PS-PS/NPS	Sole-source offsets
Lake Dillon (Dillon Reservoir) Trading Program*	Colorado, U.S.	PS-NPS	Bilateral
Long Island Sound Nitrogen Credit Exchange Program*	Connecticut, U.S.	PS-PS	Clearinghouse
Delaware Inland Bays*	Delaware, U.S.	PS-NPS	Sole-source offsets
Lower Boise River Effluent Trading Demonstration Project	Idaho, U.S.	PS-NPS	Bilateral
Middle Snake River Demonstration Project	Idaho, U.S.	PS-PS	Bilateral
Minnesota River Basin Trading Program*	Minnesota, U.S.	PS-PS	Bilateral
Rahr Malting*	Minnesota, U.S.	PS-NPS	Bilateral
Southern Minnesota Beet Sugar Cooperative Program*	Minnesota, U.S.	PS-NPS	Clearinghouse
Las Vegas Wash	Nevada, U.S.	PS-PS	Clearinghouse (aggregate permit)
Taos Ski Valley	New Mexico, U.S.	PS-NPS	Sole-source offsets
Neuse River Basin Total Nitrogen Trading Program*	North Carolina, U.S.	PS-PS/NPS	Clearinghouse (bubble permit)
Tar-Pamlico Nutrient Trading Program*	North Carolina, U.S.	PS-PS/NPS	Clearinghouse
Great Miami River Watershed Trading Pilot	Ohio, U.S.	PS-PS/NPS	Clearinghouse
Alpine Cheese Company/Sugar Creek*	Ohio, U.S.	PS-NPS	Bilateral
Clean Water Services/Tualatin River*	Oregon, U.S.	PS-PS/NPS	Bilateral, Sole-source offsets
Pennsylvania Water Quality Trading Program*	Pennsylvania, U.S.	PS-PS/NPS	Exchange market
Virginia Water Quality Trading Program	Virginia, U.S.	PS-PS/NPS	Clearinghouse/ Bilateral
Red Cedar River Nutrient Trading Pilot Program*	Wisconsin, U.S.	PS-NPS	Bilateral
Programs/Initiatives In Development or Under Consideration			
Moreton Bay Nutrient Trading Scheme	Queensland, Australia	TBD	TBD
Lake Taupo Nitrogen Trading Program	New Zealand	NPS-NPS	TBD
Lower Colorado River Basin	Colorado, U.S.	TBD	TBD
Florida Ranchlands Environmental Services Project	Florida, U.S.	NPS-NPS	TBD
Lake Allatoona	Georgia, U.S.	PS-PS or PS-PS/ NPS	TBD
Maryland Water Quality Trading Program	Maryland, U.S.	PS-NPS	Exchange Market
Massachusetts Estuaries Project	Massachusetts, U.S.	PS-NPS	TBD

TABLE 1 *continued*

PROGRAM NAME	STATE/COUNTRY	TYPES OF TRADES	MARKET TYPE§
Charles River Flow Trading Program	Massachusetts, U.S.	PS-PS	Bilateral
Kalamazoo: Gun Lake Tribe Trading Initiative	Michigan, U.S.	PS-NPS	Exchange market
Upper Mississippi River Basin	Minnesota, U.S.	PS-NPS	Clearinghouse
Vermillion River	Minnesota, U.S.	TBD	TBD
Cape Fear	North Carolina, U.S.	PS-NPS	TBD
Passaic River	New Jersey, U.S.	PS-PS/NPS	TBD
Lake Tahoe	Nevada, U.S.	NPS-NPS	TBD
Truckee River Water Quality Settlement Agreement	Nevada, U.S.	PS-NPS	TBD
Shepherd Creek	Ohio, U.S.	PS-NPS	Clearinghouse
Upper Little Miami River Basin	Ohio, U.S.	PS-NPS	TBD
Portland Tradable Stormwater Credit Initiative	Oregon, U.S.	PS-PS	TBD
Willamette Partnership	Oregon, U.S.	TBD	TBD
Bear River	Idaho/Utah/Wyoming, U.S.	TBD	TBD
West Virginia Potomac Water Quality Bank and Trade Pilot	West Virginia, U.S.	PS-PS/NPS	Exchange market
Inactive Trading Programs/Completed Pilot or Demonstration Programs			
Clear Creek*	Colorado, U.S.	PS-PS[1]	Sole-source offsets
Boulder Creek Trading Program*	Colorado, U.S.	PS-NPS	Sole-source offsets
Upper Maquoketa and South Fork Maquoketa Watersheds Nutrient Trading Directory*	Iowa, U.S.	NPS-NPS	Bilateral
Sudbury River (Wayland Center)*	Massachusetts, U.S.	PS-PS	Bilateral
Kalamazoo River	Michigan, U.S.	PS-NPS	Clearinghouse
Passaic Valley Sewerage Commission Pretreatment Trading*	New Jersey, U.S.	PS-PS	Bilateral
New York City Watershed Phosphorus Offset Pilot Programs*	New York, U.S.	PS-PS	Sole-source offsets
Lake Champlain*	New York/ Vermont, U.S.	PS-PS	Sole-source offsets
Fox-Wolf Basin	Wisconsin, U.S.	PS-NPS	Bilateral
Rock River	Wisconsin, U.S.	PS-NPS	Bilateral

Notes

NPS = nonpoint source; PS = point source; TBD = to be determined

§ Market types are described in the market structure section later.

* Program has had at least one trade or offset.

† This program differs from others as the salinity credits are held by the Australian states that are part of the program, not individual sources.

1. In the Clear Creek program, a mining company financed clean-up efforts at an abandoned mine. Mines are "orphan" sources. They are not permitted, not owned by an individual, and are difficult to monitor, but are similar to point sources because they are one central source of pollutant discharge.

These programs were selected because they represented a diverse cross-section of different market structures, different scales, different participants, different commodities, differing lengths of time since establishment, and differing levels of trading activity. See Box 2 for brief descriptions of the water quality trading programs that WRI selected for interviews.

1. Policy Drivers

The primary policy driver for all water quality trading programs has been the implementation or forthcoming implementation of nutrient caps that limit pollutant discharges. In the United States, the Clean Water Act (CWA) provides the foundation for point-source nutrient caps. The law requires states to adopt water quality standards for various pollutants. Violation of these standards may result in a total maximum daily load (TMDL)

BOX 2 Selected Water Quality Trading Programs

Cherry Creek and Chatfield Reservoir Trading Programs, Colorado, U.S.

The Cherry Creek and Chatfield reservoirs are both subject to a state-imposed Total Maximum Annual Load (TMAL) that limits the amount of phosphorus that can be discharged into the reservoir by both point and nonpoint sources. There are five point sources that discharge to the Cherry Creek reservoir and 12 point sources that discharge to the Chatfield reservoir. To meet short-term credit demand (for example, upset conditions at a treatment facility that cause the facility to exceed its permit), regulated point sources are allowed to purchase credits from other regulated point sources or from the Watershed Authorities' Reserve Fund which has established long-term credit-generating projects. For credits needed to offset new or expanding facilities, facilities must generate credits through the implementation of urban nonpoint source projects that reduce phosphorus loads to the reservoir. While most regulated facilities have been discharging below their allowable loads, a few trades have occurred: four trades in Cherry Creek and seven trades in Chatfield.

Long Island Sound Nitrogen Credit Exchange Program, Connecticut, U.S.

In 2001 a TMDL for dissolved oxygen was implemented for the Long Island Sound. As a result, point sources were given caps for total nitrogen discharges; in total there are 79 point sources that trade in the Long Island Sound program. The nitrogen cap allocations were distributed to each facility depending on discharge volume, with allocations decreasing every year or every other year. Any new facilities must purchase credits to offset 100 percent of their discharge (though there have been no new facilities since inception of the program). In 2002 the Connecticut legislature created a Nitrogen Credit Exchange (NCE) that is overseen by the Nitrogen Credit Advisory Board. One of the principal roles of the Nitrogen Credit Advisory Board is to determine the price of a nitrogen credit. Credit trading occurs once yearly after the close of the permit year. To date nearly 12 million credits have been bought and sold on the NCE for a total value of nearly $30 million.

Great Miami Water Quality Credit Trading Program, Ohio, U.S.

A TMDL is in place for one of three subwatersheds in the Great Miami, and TMDLs are under development for the remaining two. The TMDLs are expected to result in strict phosphorus discharge limits for regulated facilities. The Great Miami pilot began in 2006 and seeks to encourage facilities under threat of regulation to be early actors by purchasing phosphorus credits before permit limits are enacted. The Water Conservation Subdistrict of the Miami Conservancy District has led the pilot and acted as a credit bank or clearinghouse. The credit bank was capitalized with money from grants as well as money from point sources wishing to purchase credits. To obtain credits, the Miami Conservancy District issued a request for proposals to generate agricultural credits. Soil and Water Conservation Districts in the area worked with farmers to submit applications for credit generation. Once applications were received, the Miami Conservancy District held a reverse auction to select and fund those applications that provided the greatest phosphorus reductions at the least cost. Credits were then allocated to investors based on their initial investment amount. To date, the Miami Conservancy District has held four rounds of reverse auctions to purchase phosphorus credits. A total of 50 projects have been funded, with payments totaling $923,069. The projects have produced 324 tons in phosphorus reductions. (Hall, D. and S. Hippensteel. 2008. "Benefits and Obstacles to Trading." CTIC Workshop, Troy, Ohio.)

Pennsylvania Water Quality Trading Program, Pennsylvania, U.S.

Under the Chesapeake Bay Agreement, Pennsylvania must reduce nitrogen and phosphorus loads to the Chesapeake Bay by 2010, or a TMDL will be developed for the watershed. Beginning in 2010, Pennsylvania plans to issue nitrogen and phosphorus discharge limits for permitted facilities. These permit limits will affect 183 permitted dischargers in Pennsylvania's Potomac and Susquehanna watersheds. In addition, new and expanding facilities of any size will be required to offset 100 percent of nitrogen and phosphorus discharges.

being developed for the waterbody. A TMDL defines the maximum amount of a pollutant that can be discharged into a waterbody, yet still maintain water quality standards. During the TMDL development process, pollutant loads are allocated among the various sources in a watershed (point and nonpoint), so that water quality standards can be met. The pollutant limit allocated to point sources under a TMDL, or "wasteload allocation," forms the basis of a water quality-based effluent limit that is placed in a regulated facility's NPDES permit. These permit limits—or threat of permit limits—have driven the development of a large number of water quality trading programs in the United States.

Local and regional pollution caps have been the driver for trading in other countries as well as for some of the trading programs in the United States. Under the Resource Management Act, which grants regional governments in New Zealand the authority to make resource management decisions, the Waikato Regional Council has imposed nitrogen discharge caps on all sources in the Lake Taupo catchment. The Provincial Ministry of Environment (MOE) guidelines are the driver for the South Nation River Watershed Trading Program in Ontario, Canada. MOE is responsible for water quality and sewage treatment plant licensing in Ontario. It stipulates that if water quality

BOX 2 *continued*

In anticipation of these permit limits, Pennsylvania issued water quality trading guidance in 2006. Pennsylvania's guidance allows for point-to-point and point-to-nonpoint trades. To date, five point-to-nonpoint trades have been completed and approved though the actual exchange of credits will not take place until 2010 when permit limits are in place. Most of the nitrogen and phosphorus credits generated thus far have been generated through manure export projects where the landowner agrees to export manure generated on his or her agricultural operation to nutrient-poor abandoned mine lands. Pennsylvania is structured as an exchange market where credit prices are determined by the market. While Pennsylvania has implemented an online marketplace to facilitate trades, all trades to date have been transacted through private bilateral negotiations.

Red Cedar River Trading Program, Wisconsin, U.S.

The City of Cumberland wastewater treatment facility faced a total phosphorus limit of 1 mg/l and elected to meet this cap through trading with agricultural nonpoint sources. The City of Cumberland was required to obtain 4,400 pounds of phosphorus credits per year in order to meet its discharge permit. The City of Cumberland worked with the Barron County Land Conservation District to identify and enroll farmers that were willing to generate phosphorus reductions through the implementation of no-till or conservation tillage practices on their operations for a period of three years. The credit payments that participating farmers receive from the City of Cumberland are equal to the incentive payments they would have received from the federal cost-share programs. The number of credits generated through these practices has been pre-determined using average soil loss values and soil phosphorus concentrations. The first trades took place in 2001, and to date there have been eight rounds of credit purchases.

South Nation Total Phosphorus Management Program, Ontario, Canada

The South Nation Conservation Association (SNCA) runs a phosphorous management program that allows 15 municipal and two industrial dairy wastewater treatment plants to comply with federal load limits for the South Nation River. Under the "Policy 2" requirement established by the Canadian Ministry of the Environment, no new construction that could increase total phosphorous discharge may occur because the South Nation River exceeds water quality guidelines.

SNCA has established a Clean Water Committee comprised of agriculture and point source representatives to manage the Clean Water Fund (Fund). The Fund allocates money to farmers to pay for BMPs that generate credits. Point sources may purchase credits from the Fund to offset their increased phosphorous discharge, and sale revenue is used to replenish the fund.

Lake Taupo Trading Program, Waikato, New Zealand

Lake Taupo in New Zealand is located in a primarily agricultural watershed. Under the Resource Management Act, Environment Waikato (the regional council with regulatory authority) has capped the amount of nitrogen entering the lake. Each land use and hectare of land in the Lake Taupo watershed will have a nitrogen discharge limit. The benchmark (or initial allowance allocation) for agricultural sources is based on the average nitrogen losses between 2000 and 2005. There is a goal to reduce nitrogen losses to Lake Taupo by 20 percent. However, the trading program, which focuses on agricultural sources, is aimed at maintaining water quality at 2001 levels. Any landowners wishing to increase their nitrogen discharge will need to purchase allowances from other landowners in the watershed. A separate fund, The Lake Taupo Protection Trust, has the mandate to achieve the permanent 20 percent reduction in nitrogen entering the lake. They are likely to achieve this through a mix of land retirement, land conversion, and purchasing allowances that result in permanent reductions of nitrogen. The Lake Taupo program has been under development for the past 7 years and will allow trading once agricultural sources have been benchmarked.

guidelines are exceeded, then no new pollutant discharge is allowed in a watershed.[7]

In Australia, the Hunter River Salinity Trading Scheme in New South Wales is driven by salinity concerns for the Hunter River. To address these concerns, the New South Wales Environmental Protection Agency (NSW EPA) set a numeric salinity goal for the river, with the major point sources holding an Environmental Protection License to discharge.[8] Similarly, NSW EPA created a total pollutant load limit for nutrients in South Creek and allowed the affected sewage treatment plants to trade in order to stay within that limit.[9]

2. Allocation of Water Quality Caps

Once a watershed water quality cap has been established, the cap has to be allocated among all regulated entities. Pollutant caps for point sources are generally allocated based on regulatory numeric effluent concentration limits for a given pollutant. To facilitate trading, effluent pollutant concentration limits are often translated into an annual discharge limit expressed as a unit of mass over time (for example, pounds per year). The annual discharge limit is based on the numeric effluent concentration limit and an annual facility flow volume. In many instances, the flow volume used to determine the annual discharge limit is equal to the facility's annual average design flow. A sewage treatment plant, for example, that has an annual discharge limit based on a nitrogen concentration of 6 mg/l and a design flow of 20 million gallons per day (mgd) would be allowed to discharge a total of 365,292 pounds of nitrogen per year.[10]

Because most discharge limits are allocated based on design rather than actual flows, many point sources have not been in danger of exceeding their permitted limit in the short term, as they operate below their maximum capacity. In our example, if a treatment plant has a current flow of 14 mgd and a current nitrogen concentration of 8 mg/l, it would discharge approximately 340,939 pounds of nitrogen per year—which is under its annual discharge limit of 365,292 pounds of nitrogen per year (a limit that was based on design flow of 20 mgd and a nitrogen concentration limit of 6 mg/l). In many water quality trading programs (for example, Cherry Creek and Chatfield Reservoir trading programs in Colorado, U.S.), increases in urban growth—which translate to greater flow rates—is the main factor threatening the ability of sewage treatment plants to meet their discharge limits.

In some cases, such as the South Creek Bubble Licensing Scheme and Tar-Pamlico Nutrient Trading Program, the point sources involved must meet the cap in aggregate, and there is no allocation to the individual sources. This type of voluntary grouping of point sources for the purpose of meeting a cap is generally referred to as a "trading association." These associations often consist of multiple facilities grouped together under a single aggregate permit and are generally free to choose whatever means they prefer to achieve the cap.

However, many water quality trading programs have not yet allocated water quality caps for the pollutants of concern to the regulated sources. For example, the Middle Snake River Demonstration Project in Idaho was developed in anticipation of a TMDL for phosphorus, but the TMDL has yet to be finalized. As a result, point source regulatory caps for phosphorus have not been enacted or allocated. Other active programs where there has been no allocation of individual caps to sources include the Lower Boise River Effluent Trading Demonstration Project and the Great Miami River Watershed Trading Pilot. In addition, many of the programs under development are also awaiting finalization of a TMDL or relevant legislation and/or allocation of water quality caps. Until these caps are allocated, trading is unlikely to occur.

3. Establishment of Nonpoint Source Baselines

As nonpoint sources are typically not regulated, their baseline nutrient discharges have to be established before they are able to generate and trade any nutrient reduction credits. Establishing baselines is critical to ensure that credits generated by nonpoint sources are "additional" water quality improvements that would not otherwise have taken place. For agricultural nonpoint sources, baselines are frequently either a cut-off date for eligible activities that reduce pollutant loadings—for example, a program might stipulate that no practices installed before 2007 are eligible to generate credits—or a performance standard, where a program might stipulate that a farm must implement a certain suite of practices or achieve a certain level of environmental performance before they are eligible to generate credits. Virginia, for example, established a performance-based baseline for agriculture requiring farmers to implement riparian buffers, streambank fencing, cover crops, and no-till agriculture before subsequent activities that reduce pollution are eligible to generate credits that can be used in Virginia's trading program. Similarly, the Maryland program (under development) is considering a performance-based baseline for agriculture that is expressed as a numeric per acre nutrient load that a farm must achieve before being able to generate credits. In the Lake Taupo Nitrogen Trading Program, nitrogen discharge permits will be allocated to each farm based on their highest annual discharge between July 2001 and June 2005. Choosing the highest year during this period allows for the variation in nitrogen discharges related to weather conditions to be taken into account.

4. Nonpoint-Source Nutrient Loss and Reductions Calculations

Because current nutrient losses and thus reductions in nutrient losses from nonpoint sources are difficult to measure, program designers have to identify the measurement or estimation approach they will use to determine the nutrient losses and reductions from these sources. Three common approaches are:

- ***Direct measurement through monitoring***. This approach uses direct measurements based on in-field samples to determine the nutrient reductions that result from the implementation of a control measure. While this approach is potentially the most accurate, it is also costly and is not readily applicable to all sources of nutrients or actions that reduce nutrient losses. The diffuse nature of agricultural nutrient pollution means that most agricultural best management practices (BMPs) are not readily monitored. The Chatfield Reservoir Trading Program in Colorado requires regulated point sources to monitor the performance of the practices implemented to offset their nutrient discharge. The initial estimated number of credits that the project receives is then adjusted up or down once monitoring data is available. The Lower Boise River

Effluent Trading Demonstration Project (Idaho, U.S.) does not require monitoring, but provides incentives to directly measure nutrient reductions from BMPs on irrigated lands by lowering the uncertainty ratio (see the trading ratio section) and thus the discount rate applied to reductions from monitored projects.

- ***Site-specific calculations***. This approach uses established calculation methodologies to estimate nutrient losses and reductions from nonpoint sources, taking into account site-specific variables such as soil type, slope, and fertilizer application rate. The Pennsylvania Water Quality Trading Program, Maryland Water Quality Trading Program, Great Miami River Watershed Trading Pilot, Gun Lake Tribe Trading Initiative, and Lake Taupo Nitrogen Trading Program use this approach for estimating reductions. Some examples of tools that have been developed to estimate on-farm losses and reductions include the OVERSEER®[11] program in New Zealand, the Nitrogen Trading Tool, the Region 5 model, and WRI's NutrientNet in the United States (see Box 3). Site-specific calculations are typically more accurate than pre-determined levels of nutrient discharges (described below).
- ***Pre-determined nutrient reductions for practices regardless of location or other site-specific characteristics***. This approach assigns a pre-determined reduction credit for each practice based on an estimated average nutrient reduction. These credit values are generally derived from scientific literature or watershed-level modeling and do not change across the watershed or region. The Red Cedar River Nutrient Trading Pilot Program, for example, uses average erosion rates and phosphorus soil concentrations to assign a phosphorus reduction of 12 pounds per acre per year for converting from conventional tillage to no-till and 8 pounds per acre per year for converting to conservation tillage. The South Nation River Watershed Trading Program and Virginia Water Quality Trading Program also use this approach. This is an appealing approach because it is simple to administer, and nonpoint source generators know in advance the reductions they can achieve for implementing a practice. However, it reduces the ability to capitalize on the biophysical heterogeneity within a watershed, which limits the ability of a trading program to identify the most cost-effective activities for generating nutrient reductions.

Box 3 Tools of the Trade: Estimating the reduction in nutrient losses from U.S. farms

In the United States, several tools have been developed to estimate nutrient losses from farms for use in water quality trading programs.

Nitrogen Trading Tool

The USDA has begun development of the Nitrogen Trading Tool (NTT). The NTT is an online tool that allows users to calculate changes in nitrogen loss potential based on changes in crop management practices. Users can assess how various BMPs may affect the nutrient losses from their farm, and calculate the total nitrogen reductions they can generate through changes in management practices. Although NTT is currently being developed only for nitrogen, the USDA hopes to adapt it to other pollutants such as phosphorus and sediment. The NTT is currently under development and is not yet used in any trading programs. The demonstration site can be accessed at http://199.133.175.80/nttwebax/.

Region 5 Load Estimation Spreadsheet Model

The U.S. EPA Region 5 spreadsheet model estimates pollutant reductions for (a) sediment; (b) sediment-borne phosphorus and nitrogen; (c) feedlot runoff; and (d) commercial fertilizer, pesticides, and manure utilization. Unlike the NTT, which is based on a dynamic field-level model, the Region 5 model is based on farm-level data inputs coupled with static equations that characterize relationships between field-level practices and nutrient losses. While Region 5 has acknowledged the limitations of its tool, it does provide a uniform system of estimating relative pollutant loads. The Region 5 model is the standard used in the Michigan trading rules for estimating nonpoint source reductions and is also used in the Great Miami Watershed Trading Pilot. The spreadsheet model can be found at http://it.tetratech-ffx.com/stepl/.

NutrientNet

NutrientNet is an online application developed by the World Resources Institute that can be used to estimate nonpoint source reductions from agriculture. Like the Region 5 Load Estimation Spreadsheet Model, NutrientNet estimates nitrogen, phosphorus, and sediment losses from farms using farm-level data inputs. Unlike the NTT model and the Region 5 model, NutrientNet applies program-appropriate delivery factors and trading ratios to the edge-of-field losses and reductions in order to calculate the actual number of credits generated through the implementation of best management practices. NutrientNet calculation tools have been developed for the Pennsylvania, Maryland, West Virginia, and Kalamazoo trading programs. NutrientNet can be found at www.nutrientnet.org.

5. Trading Ratios

Trading ratios are frequently used to account for a number factors in water quality trading programs such as uncertainty in reduction estimates (particularly for nonpoint-source reductions), creating equivalency among multiple pollutants, ensuring overall water quality benefits, accounting for the effects of nutrient transport, and mitigating buyer risks. Trading ratios are applied to the estimated nutrient reductions to determine the saleable reduction credit. For instance, a 2:1 trading ratio means that an entity needs to purchase two pounds of pollutant reductions to offset every pound they discharge above their regulatory limit. Below are the types of ratios that are used in water quality trading programs:

- ***Delivery ratio***. Delivery ratios (also called "attenuation factors") are ratios applied to point and nonpoint-source pollutant reductions to account for pollutant losses/attenuation during transport in a watershed. Unlike carbon markets, where the location of pollutant discharges are not generally important, location is important in water quality markets. Physical, chemical, and biological processes can diminish the effect of some pollutants—such as nutrients—as they move downstream. A pound of nitrogen or phosphorus reduced further upstream from the point of concern often has a smaller water quality benefit than a pound of nitrogen or phosphorus reduced closer to the point of concern. Similarly, a pound of reduction close to a point of concern—such as a dead zone—can have a greater water quality benefit than an upstream reduction occurring several miles from the point of concern. In water quality trading programs, delivery ratios are used to estimate the percentage of nutrients and sediment ultimately delivered to a waterbody from a particular location within the watershed—such as a farm or sewage treatment plant discharge pipe—and the percentage that is "lost" or "attenuated" during transportation.

  Applying a delivery ratio helps ensure equivalency between the water quality effect of a purchased credit and the purchaser's nutrient discharge at the point of concern. This maintains the environmental integrity of the water quality trading program and provides fungibility between credits. Despite the importance of equivalency, many of the programs surveyed by WRI did not use delivery ratios. One reason for this omission was the difficulty in determining an appropriate ratio. Most delivery ratios are determined using a watershed fate and transport model.[12] This is often beyond the capability of many programs due to the funding and knowledge needed to create such watershed models. The Chesapeake Bay Watershed Model, developed and maintained by the U.S. Environmental Protection Agency, models nutrient losses and transport from over 300 subwatersheds to the mouth of the Chesapeake Bay. All of the Chesapeake Bay state water quality trading programs—Pennsylvania, Virginia, Maryland and West Virginia—use these model-derived delivery factors, applying them to point source and nonpoint source nutrient discharges. The Minnesota River Basin Trading Program also uses model-derived delivery factors to convert reductions into "Jordan Trading Units," which account for the attenuation of phosphorus from various points within the watershed to a monitoring point in Jordan, Minnesota.

- ***Uncertainty ratio***. Uncertainty ratios are used by water quality trading programs to compensate for two factors: (1) random variability in weather and other environmental factors that affect the efficacy of pollution reduction measures (especially for nonpoint sources), and (2) uncertainty regarding efficiency values used to estimate nonpoint-source reductions in nutrient losses. Uncertainty ratios mean that credit buyers are required to purchase more reductions than they need to meet their regulatory obligation. Uncertainty ratios are often set at 2:1, though this varies among programs. We found no instances where uncertainty ratios were derived based on scientific or statistical information; rather these ratios were generally set at a value deemed suitably conservative, while remaining politically acceptable to stakeholders.

- ***Equivalency ratio***. An equivalency ratio is used when two or more pollutants are traded in a market to achieve the same environmental result. Some pollutants contribute to the same environmental problem; however one pollutant may be more potent than another at producing the effect. An equivalency ratio is needed to make the two pollutants equivalent to one another. The Rahr Malting trade in Minnesota used an equivalency ratio. Rahr Malting's discharge permit allows it to choose between reducing five-day carbonaceous oxygen demand (CBOD5), phosphorus, nitrogen, or sediment loads to the receiving water. The Minnesota Pollution Control Agency established equivalency ratios between these four pollutants. The ratios are based on a scientific assessment of the relative impacts of these pollutants on chlorophyll levels in the river. For example, one pound of phosphorus has the same impact as eight pounds of CBOD5 and one pound of nitrogen the same as four pounds of phosphorus. Rahr Malting chose to meet its CBOD5 requirements by purchasing phosphorus offsets.

- ***Retirement ratio***. When retirement ratios are used, a proportion of the credits are retired with each trade, resulting in net water quality benefits. Retirement ratios, or "environmental benefit ratios," are used to ensure that the program achieves a net water quality benefit beyond what can be achieved through regulation alone. For example, the Michigan Water Quality Trading Rules stipulate a 1:1.1 environmental benefit ratio for point-to-point trades. This means that 10 percent of all credits generated and sold by point sources are retired and cannot be used to offset new loads. Similarly, Maryland's program (under development) will employ a five percent retirement ratio for all point and nonpoint-source credits generated.

- ***Insurance/Reserve ratio***. An insurance or reserve ratio is used to set aside a portion of all generated credits into a reserve pool or insurance fund. A reserve ratio is used in the Pennsylvania Water Quality Trading Program and is being considered in the West Virginia Potomac Water Quality Bank and Trade Pilot as well. Pennsylvania applies a 10 percent reserve ratio to all generated credits. These credits are held in a centrally administered credit reserve fund and serve as insurance for regulated sources should any purchased credits default. In addition, Pennsylvania has pledged to also use the credit reserve to create liquidity in the market when credit supplies are low.

All or some of these trading ratios are used by most trading programs in the United States and Canada. Of the 26 active trading programs in the United States, 20 programs use some form of trading ratio; another is considering using trading ratios in the future. In many cases the trading ratio is not clearly defined and actually represents a stacked ratio. The South Nation River Watershed Trading Program, for example, applies a 4:1 trading ratio to all phosphorus reductions to compensate for delivery as well as uncertainty factors.

6. Market Structure

Market structure defines how trading will occur and the infrastructure used to support the water quality trading program. The water quality trading programs reviewed by WRI have engaged in the following types of trading:[13]

- ***Bilateral trades***. Bilateral trades are characterized by one-on-one negotiations where a price is typically arrived at through a process of bargaining and not simply by observing a market price. This market structure generally has high transaction costs. Of the 26 active trading programs evaluated, 10 operate through bilateral negotiations. The Virginia Water Quality Trading Program has a hybrid bilateral/clearinghouse market structure; the Tualatin River program uses bilateral and sole-source offsets.
- ***Sole-source offsets***. Sole-source offsets occur when sources are allowed to increase nutrient discharge at one point if they reduce their nutrient discharge elsewhere (either on-site or off-site). In both cases the nutrient reductions are undertaken by the regulated entity. Five active programs have this market structure, including the Cherry Creek Reservoir Watershed Phosphorus Trading Program, the Chatfield Reservoir Trading Program, Delaware Inland Bays, Taos Ski Valley, and the Tualatin River Program. In the Chatfield Reservoir Trading Program, many of the trades involved offset projects that decommissioned septic systems and connected homes to a sewage treatment plant. The sewage treatment plant receives credits equivalent to the total amount of nutrients retired through decommissioning the septic systems. Programs using sole-source offsets often involve a single offset project that can generate sufficient credits for the duration of one or more permit cycles.[14]
- ***Clearinghouse***. A clearinghouse market is one where a single intermediary links buyers and sellers of credits. The clearinghouse converts a commodity that may have a variable price—such as a nutrient credit—into a uniform commodity. The clearinghouse market structure is used by nine of the active water quality trading programs, including the Virginia Water Quality Trading Program. Regulated facilities that need to purchase credits pay into a clearinghouse fund. The fund then purchases nutrient credits generated from reductions achieved either within the regulated community or from nonpoint sources outside the regulated community. This type of market structure can also be thought of as a "fee-in-lieu" system. A clearinghouse creates a simplified market that regulated facilities may prefer since they avoid having to locate and purchase credits on their own, thereby lowering their transaction costs and mitigating their risk. This type of market structure works more efficiently where there are a number of regulated entities and economies of scale can be achieved.
- ***Exchange market***. An exchange market is where buyers and sellers meet in a public forum (for example, online) with all commodities being equivalent and all prices transparent. An exchange is characterized by its open information structure and fluid transactions between buyers and sellers. The two active programs with exchange markets are the Hunter River Salinity Trading Scheme and the Pennsylvania Water Quality Trading Program. Online marketplaces to facilitate exchange markets are also being developed or considered for the Gun Lake Tribe Trad-

ing Initiative, Maryland's trading program, and the West Virginia Potomac Water Quality Bank and Trade Pilot.

Third parties—such as brokers, aggregators, or credit banks (for example, an agricultural association)—are sometimes considered to constitute a distinct market structure. However, brokers, aggregators, and banks are in reality simply operators within the market. Regulated entities who wish to purchase nutrient credits can contract with a third party broker, aggregator, or bank to identify and purchase credits on their behalf. In practice, brokers, aggregators, and banks have typically worked within the agricultural sector as an entity that collects nutrient reduction credits and re-sells them to the regulated point source community. Some programs where third-party aggregators or banks have come to the fore include the Red Cedar River Nutrient Trading Pilot Program, Great Miami River Watershed Trading Pilot, Pennsylvania Water Quality Trading Program, Tualatin River program, and Alpine Cheese Company/Sugar Creek trade.

Some trading programs combine elements of several of these market structures. For example, the Virginia Water Quality Trading Program will use a combination of a clearinghouse and bilateral trades. Existing point sources that need to trade to meet their cap will trade within the Virginia Nutrient Credit Exchange Association, which is a clearinghouse run by the association of point sources. The Exchange will facilitate the identification of available point-source credits and set credit prices. However, new or expanding facilities under the Virginia Water Quality Trading Program must obtain offsets from nonpoint sources.[15] These credits must be located and purchased by the facility through a bilateral trade. If the facility is unable to locate credits, they are given the option of paying into the state Water Quality Improvement Fund (WQIF). The WQIF will be administered by the Virginia Department of Environmental Quality, and will be tasked with banking nonpoint-source credits and will sell credits to point sources that are unable to locate their own offsets for a set fee.

As water quality trading becomes more widespread, we can expect to see a variety of new, innovative market structures emerge.

7. Trading Activity

Most active programs reviewed have experienced at least one trade. According to the U.S. EPA, in 2006 there were a total of 236 point source facilities in the United States covered by permits that allowed trades. Of these, 121 facilities had traded at least once over the life of the permit.[16] Unfortunately, there is no accurate record of the total number of trades completed each year. Most U.S. facilities that were shown to have traded at least once over the life of their permit had completed only one trade; however, some have conducted many trades. For example, in the Tualatin River program, Clean Water Services acquired temperature credits from 25 different farmers who generated the credits by implementing riparian buffers on their property. The riparian buffers are expected to generate credits for 30 years, meaning that Clean Water Services will not have to acquire additional temperature credits until 2035 or until the regulatory conditions of their permit change. The Southern Minnesota Beet Sugar Cooperative trades were similar; they acquired credits from 256 of their cooperative farmers as a condition of their permit. In fact, it is expected that in most cases (especially those involving point-to-nonpoint trades) trading activity is unlikely to be continuous and ongoing, but rather involve single transactions that create credit streams of up to 10 years or more. This is preferable, as regulated entities are likely to want the certainty of securing credits upfront for future compliance periods, and sellers want continuous funding streams for the life of their water quality improvement practice.

Of the active trading programs, only the Long Island Sound Nitrogen Credit Exchange Program in Connecticut and Hunter River Salinity Trading Scheme in Australia have experienced continuous trading activity since inception. The Hunter River Salinity Trading Scheme has conducted approximately 170 trades since 2002, and the Long Island Sound Nitrogen Credit Exchange Program trades nearly one million credits per year. The Hunter River and Long Island Sound programs are the water quality trading programs that come closest to commoditizing water quality credits. In large part, this is possible because both of these programs are limited to trades between regulated point sources where there is considerable certainty in the value of the reductions and the certainty of delivery of those reductions. Second, these programs have a large number of regulated entities eligible to participate in the market, creating depth and fluidity in the market.

While many programs have experienced at least one trade, there are many that have yet to experience any trades. In many cases, the program was developed in anticipation of a regulatory driver that is not yet in place (for example, a permit discharge limit for regulated sources), or the established regulatory limits did not necessitate trading (for example, the regulated facility is already operating below its regulatory limit and does not currently need to trade). The Great Miami River Watershed Trading Pilot, the Middle Snake River Demonstration Project, and Lower Boise River Effluent Trading Demonstration Project are all programs that were developed in anticipation of a TMDL driver that has yet to be finalized. In the Gun Lake Tribe Trading Initiative, the TMDL is in place, but it is not sufficient to create a demand for trading by the regulated point sources in the watershed. Absent or weak nutrient regulations—which in turn lead to little or no demand for credits by regulated sources—are often cited by experts as the foremost reason for little or no trading activity in water quality trading programs.[17]

Lessons Learned: Elements of effective water quality trading programs

Much can be learned from existing and inactive trading programs, especially the elements and conditions that lead to programs with trading activity and/or stakeholder perceptions that the program is a viable means of meeting their regulatory obligations. These lessons should be considered and solutions incorporated into new or emerging water quality trading programs. The following elements emerged from our analysis as being important for the development of effective water quality trading programs.[18]

Adequate drivers exist for pollutant reductions. We found that many water quality trading programs were developed in anticipation of regulatory caps that never materialized, or the regulatory requirements ultimately proved too weak (that is, nutrient caps were set at a level that did not create sufficient demand for trading). As a result, these programs experienced little or no trading. The Lower Boise River Effluent Trading Demonstration Project is an example of a water quality trading program that was developed in anticipation of a TMDL that has yet to be finalized. The water quality trading program was finalized in 2002 but has sat idle for the past six years. In contrast, water quality trading programs in the Chesapeake Bay states (Virginia, Maryland, Pennsylvania, and West Virginia) are being developed in conjunction with newly adopted water quality standards. These standards have been translated into nutrient limits in point-source discharge permits. These meaningful nutrient limits have meant that trades have already occurred in the watershed, despite these programs being relatively young. Our recommendation is that before spending the time and money to develop a water quality trading program, ascertain whether regulatory requirements or voluntary motives are likely to generate the demand for credits.

Potential risks to the regulated community are adequately addressed. Because of the potential for costly CWA enforcement actions for permit violations, regulated point sources in the United States are generally risk-averse. Frequently, when faced with regulatory limits, point source entities express a preference for costly upgrades that they can control, rather than being exposed to risks associated with purchasing credits from other parties, either point or nonpoint source, in a trading market. Under the CWA, a regulated point source purchasing credits from another regulated point source can transfer regulatory compliance liability to the seller. However, a regulated point source purchasing credits from an unregulated nonpoint source cannot transfer legal liability. This creates the risk that a regulated point source buyer would be held in violation of his permit should the contract with the unregulated entity default. While the contract between the buyer and seller could protect the buyer financially in this event, it does not preclude enforcement action from the regulatory agency, nor the public disapprobation that goes with it. This legal reality makes the purchase of nonpoint-source credits too risky for some regulated sources.

Purchasing credits from nonpoint sources also holds other risks for regulated point sources. In most instances, regulated facilities are looking for long-term supplies of credits in order to sustain new or expanded operational capacity. However, the supply of nonpoint-source credits, especially those from agriculture, is variable and can depend on annual management decisions made by farmers. In addition, farmers are often unable to guarantee a supply of credits over a long period of time due to the nature and duration of typical on-farm nutrient management practices.

WRI identified a number of ways of addressing this risk, including:

- ***Allowing and encouraging aggregators to operate within the market***. Aggregators are entities that purchase credits (generally large quantities of nonpoint source credits) to re-sell them to interested buyers. By introducing an aggregator, the direct liability link between the regulated entity and the unregulated nonpoint-source entity is severed. Because an aggregator deals with large portfolios of credits, it can more easily mitigate risks associated with delivery and performance of nonpoint-source credits. For example, an aggregator might sell only a portion of its credit portfolio and keep the remainder in reserve should one or more of the credit-generating projects fail or are not implemented as promised.
- ***Creating credit reserves***. Pennsylvania's water quality trading program has created a centrally administered credit reserve to mitigate risks for regulated buyers. This

credit reserve effectively guarantees that a buyer who acts in good faith to secure credits will be able to draw from the reserve should his purchased credits default at the end of the compliance year. Similarly, Virginia's trading statute stipulates that credits will be available from the state if there are shortfalls in the market or credits default. If a buyer is not able to locate credits at reasonable cost within its watershed, it can buy them from the Virginia Water Quality Improvement Fund.

- ***Creating reconciliation periods***. Because sewage treatment plants are subject to periodic "upset conditions" (for example, unexpected disruptions of the treatment process from variations in temperature, flow, and nutrient concentration levels), regulated sources cannot predict with absolute certainty the number of credits they will need to buy—or conversely, how many they might be able to sell—in a given compliance period. Some programs have created reconciliation periods at the end of the annual compliance period to allow regulated facilities sufficient time to either purchase credits to make up for any shortfalls or place excess credits on the market. These reconciliation periods work hand-in-hand with the credit reserves.

Standardized estimations of nonpoint-source emissions and reductions are developed. Determining pollutant reductions from nonpoint sources represents a considerable challenge for water quality trading markets. Generally, pollutant loads and reductions from the implementation of nonpoint-source pollution abatement measures are not practical to measure directly and are, therefore, estimated. It is important that estimation methodologies used to calculate the reductions from nonpoint sources are defensible from a scientific and regulatory perspective.

Methodologies to estimate the reduction in nutrient losses from agricultural practices can be time-consuming to develop, but much can be learned from the experiences of existing and emerging programs. In the United States, some trading programs use spreadsheet-based tools that incorporate nationally available algorithms (for example, the Revised Universal Soil Loss Equation, which estimates sediment losses from farms). These are relatively straightforward to adapt to different watersheds. The Chesapeake Bay Program has incorporated a set of long-term average agricultural loading rates and BMP nutrient removal efficiencies into its watershed model. New Zealand's Crown Research Institute, AgResearch, has developed Overseer®, a nutrient budgeting model to facilitate the estimation of nitrogen and phosphorus losses from pastoral lands. This model is national in scope, enabling it to be used by any watershed in the country that may propose a trading program. Because of national similarities in data availability and farming practices, estimation algorithms may be more difficult to transfer between countries, but they are most likely transferable within a country.

Transaction costs within the trading program are minimized. There are many ways to streamline the trading process and reduce transaction costs within a trading program. For instance, developing standardized language in regulatory compliance documents, drafting model contracts for sale transactions, and streamlining processes to eliminate unnecessary delays are all important for improving the efficiency of a trading program.

Identifying and locating buyers and sellers within the market is one transaction cost common to many trading programs. In particular, point sources often find it difficult to locate willing nonpoint-source credit sellers due to both thin markets—that is, few qualified sellers—and the unfamiliarity of the nonpoint source sector with trading markets. Aggregators can, in part, reduce these transaction costs. Aggregators are typically established entities within the nonpoint-source community—for example, agricultural consultants or conservation district staff—and are well-placed to identify and purchase credits from nonpoint source sellers and resell these to point sources. By purchasing from an aggregator, a point-source entity eliminates the need to manage and police multiple contracts from a variety of sellers, thus reducing transaction costs for the buyer.

Tools such as online marketplaces and registry databases to track credits and trades can also help reduce transaction costs and may be easily transferable between trading programs. There should be little need to dramatically change the marketplaces and registries between watersheds and countries. The use of existing tools that provide a ready-made structure for markets and transaction processes can decrease the time and cost of developing, implementing, and administering the various aspects of a trading program. In collaboration with WRI, the Pennsylvania Water Quality Trading Program, West Virginia Potomac Water Quality Bank and Trade Pilot, Maryland Water Quality Trading Program, and the Gun Lake Tribe Trading Initiative have all developed (or are developing) an online trading tool called NutrientNet that will facilitate market transactions and the administration of the water quality trading program (see Box 4).

Increasing standardization of water quality trading programs through the use of standard tools, marketplaces, registries, and credit calculations may provide additional benefits beyond reducing transaction costs. Increasing standardization will likely facilitate the future broadening of water quality markets where it makes sense. For example, states within the Chesapeake Bay (Virginia, Pennsylvania, Maryland, and West Virginia) share many commonalities in their established and developing trading programs, making it possible that in the future, interstate trading within major basins may be possible.

Program has buy-in from local government, the regulated community, and other stakeholders within the watershed. A stakeholder process that complements the development of a water quality trading program is important for successful implementation. Often the lack of understanding about what water quality trading is—and is not—creates misconceptions and tensions during the development and implementation phase of a program. Early education and ongoing dialogue with relevant stakeholders on trading concepts and the goals of the trading program are necessary to ensure that the development process runs smoothly and to create stakeholder buy-in and support. However, it is not necessary to "reinvent the wheel" when it comes to communicating trading concepts and creating elements of a trading program—to a large extent educational materials have already been developed or can be borrowed from existing programs.[19]

The success of the stakeholder process will frequently depend on the process employed and the stakeholder personalities involved. Identifying a "trading champion" can be useful in this context. A high-level elected official—for example, a governor, head of an environmental agency, or a council chairperson—can help motivate other high-level officials during the early stages of developing a trading program, while a local trading champion can generate enthusiasm for trading at the grassroots level and help push a trading program forward. Many of the programs in the United States that have languished have not had the support of important stakeholders. For example, with the encouragement of the director of the Michigan Office of the Great Lakes and support from key staff members within Michigan's Department of Environmental Quality (DEQ), Michigan implemented state trading regulations in 2002, but support for trading diminished once the director and key DEQ staff left. Subsequently, the Gun Lake Tribe Trading Initiative has suffered several set-backs as a result of agency resistance to trading. For this reason, bottom-up approaches are perhaps more successful and easier to maintain over time. The Great Miami River Watershed Trading Pilot is one that has enjoyed considerable buy-in at the local level, which has led to significant support for the program at the state level.

BOX 4 NutrientNet—Water Quality Trading Online

The World Resources Institute has created an online trading tool—NutrientNet—that can act as a registry, marketplace, and estimation tool. NutrientNet has been developed for the Gun Lake Tribe Trading Initiative and the Pennsylvania Water Quality Trading Program. It will also be used to underpin the programs in Maryland and West Virginia. NutrientNet is designed to serve the following functions:

- Provide farmers, sewage treatment plants, and industrial plants with tools for estimating nutrient losses to surface waters from their operations;
- Provide a marketplace where market participants can identify each other, and buy and sell credits;
- Provide a registry that can track the volume and type of trades within a watershed; and
- Provide potential market participants and other stakeholders with background information on nutrient trading.

See http://www.nutrientnet.org for more information.

Where Next?

Water quality issues are on the rise—there has been a fourfold increase in identified hypoxic zones globally in the past 12 years—and governments will increasingly look for new ways to deal with these problems. The prevalence of water quality trading programs has steadily grown and will likely continue to grow. While trading does not supplant regulation, it does provide a mechanism to help regulated sources meet their regulatory obligations at lower costs than traditional command and control approaches, and allows new or expanding regulated entities to operate within watersheds with nutrient caps. Over time, there is likely to be more standardization between trading programs and the infrastructure that supports them. In addition, trading processes will become more streamlined and efficient. All of these developments are good news for those who believe that water quality trading can indeed be a cost-efficient mechanism to help meet water quality goals.

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Notes

1. USEPA. 2006. *Water Quality Assessment and TMDL Information.* http://iaspub.epa.gov/waters10/attains_nation_cy.control (Accessed 8/29/2008).
2. Statistics compiled from Selman, M., S. Greenhalgh, R. Diaz and Z. Sugg. 2008. *Eutrophication and Hypoxia in Coastal Areas: A Global Assessment of the State of Knowledge*. Washington, DC: World Resource Institute; and Diaz, R. and R. Rosenberg. 2008. "Spreading Dead Zones and Consequences for Marine Ecosystems." *Science* 321(5891): 926–929.
3. Not all nonpoint-source runoff is unregulated. In the United States, urban stormwater runoff is often regulated through stormwater permits. In New Zealand, some regions have begun to regulate nonpoint-source agricultural runoff as well.
4. Because water quality trading depends on the environment being relatively indifferent to the source of the pollutant, trading programs are generally deemed unsuitable for toxic and bioaccumulative pollutants.
5. Carpenter, S.R., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, and V.H. Smith. 1998. "Nonpoint Pollution of Surface Waters with Phosphorous and Nitrogen." *Ecological Applications* 8(3):559–568.
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7. O'Grady, D. (unknown) "Phosphorus Trading in the South Nation River Watershed, Ontario, Canada." http://www.wvnet.org/downloads/posted%20nov282004%20PSIG/OGrady_2003%20South%20Nation%20River%20P%20Trading.pdf (accessed 110/2008)
8. Environmental protection licenses are a central means to control the localized, cumulative, and acute impacts of pollution in NSW. They set limits on the pollutant loads emitted by holders of environmental protection licenses, and link license fees to pollutant emissions. See NSW EPA (2008) Hunter River Salinity Trading Scheme. http://www.epa.nsw.gov.au/licensing/hrsts/index.htm (accessed 1/10/2008)
9. NSW EPA. 2008. "South Creek Bubble Licensing Scheme." http://www.environment.nsw.gov.au/licensing/bubble.htm (accessed 1/10/2008)
10. To calculate the annual discharge mass load limit from the concentration limit and flow, the following formula is used: 365 (days) * flow (million gallons/day) * concentration (mg/l) * 8.34 lbs/gal.
11. See http://www.agresearch.co.nz/overseerweb/ for more details.
12. An example of a watershed fate and transport model is the "soil and water assessment tool" (SWAT), which can be modified for various watersheds. SWAT is able to model the flow of water and sediment throughout the basin based on existing or projected hydrology and land use patterns.
13. Adapted from Woodward, R.T., R.A. Kaiser, and M.B. Wicks. 2002. "The Structure and Practice of Water Quality Trading Markets." *Journal of the American Water Resources Association* 38(4): 967–980.
14. The U.S. NPDES permit cycle is 5 years.
15. Virginia's water quality trading regulation stipulates that new or expanding sources must obtain offsets from nonpoint sources, and cannot purchase allowances from existing point sources. http://www.deq.virginia.gov/vpdes/nutrienttrade.html for more information.
16. Personal communication with Virgina Kibler at U.S. EPA.
17. For a larger discussion on these issues, see King, D and P. Kuch. 2003. *Will Nutrient Credit Trading Ever Work? An Assessment of Supply and Demand Problems and Institutional Obstacles*. Washngton, DC: Environmental Law Institute (33-ELR-10352); and King, Dennis. 2005. "Crunch Time for Water Quality Trading." *Choices* 20(1): 71–75.
18. WRI convened an advisory group of water quality trading experts to help identify the major successes and failures of water quality trading schemes to date. The advisory group consisted of Paul Faeth of Global Water Challenge, Virginia Kibler of U.S. EPA, Mark Kieser of Kieser and Associates, Dennis King of University of Maryland, Clay Landry of WestWater Research LLC, and Rhonda Sandquist of Jackson Kelly, PLLC.
19. Examples of water quality trading educational resources include:
    - US EPA. 2004. *Water Quality Trading Assessment Handbook (EPA 841-B-04-001). Washington, DC: Office of Water, USEPA.* http://www.epa.gov/owow/watershed/trading/handbook/
    - USEPA. 2007. Water Quality Trading Toolkit for Permit Writers (EPA 833-R-07-004). Washington, DC: Office of Water, USEPA. http://www.epa.gov/owow/watershed/trading/WQTToolkit.html
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About WRI

The World Resources Institute is an environmental think tank that goes beyond research to find practical ways to protect the Earth and improve people's lives. Our mission is to move human society to live in ways that protect the Earth's environment and its capacity to provide for the needs and aspirations of current and future generations.

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