AARES meeting—Canberra, Australia
February 2008

Conference: AARES 52nd Annual Conference

Year: 2008

Paper Title:
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A Comparison between the Northern and Southern Hemispheres

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Abstract
Water quality trading is being widely explored and increasingly implemented to improve water quality in many parts of the world. Water quality trading programs are being used to cost effectively meet water quality goals such as point and non-point source nutrient discharge limits. A comparison between evolving trading programs in Australia, New Zealand and North America illustrates both differences and similarities in successes and hurdles. These can be used to design more effective programs.

Key words: water quality trading, nutrients, market-based, non-point source, point source

Setting the Scene

Water quality is rapidly becoming one of the most pressing environmental concerns facing many parts of the world. This paper focuses on excess nutrients or eutrophication as the water quality impairment of interest. Nutrient over-enrichment—one of the leading causes of water quality impairment—has led to the eutrophication of many lakes, rivers and streams, and to the formation of hypoxic zones in coastal areas such as the Black Sea (Eastern Europe), the Pearl River Delta (China), the Gulf of Mexico (U.S.), and the Chesapeake Bay (U.S.).

Approximately 415 coastal areas around the world have been identified as experiencing some form of eutrophication or nutrient over-enrichment. Of these, 169 are hypoxic (or oxygen-depleted) and only 13 systems are classified as "systems in recovery" (Selman et al., in press). Recent coastal surveys found that 78 percent of the assessed coastal areas in the continental United States experienced moderate to high[3] eutrophic conditions (Bricker et al., 2007). Similarly, approximately 65 percent of Europe's Atlantic coast exhibit symptoms of eutrophication (OSPAR, 2003).

Similarly, a survey of freshwater lakes between 1988 and 1993 showed that 54 percent of lakes in Asia are eutrophic; 53 percent in Europe; 48 percent in North America; 41 percent in South America; and 28 percent in Africa (ILEC/Lake Biwa Research Institute, n.d.). Looking more closely at the United States, 39 percent of assessed rivers and streams, 45 percent of assessed lakes, reservoirs and ponds, and 51 percent of assessed estuaries were threatened or impaired for their designated uses in 2000 (USEPA, 2002). In New Zealand, water quality degradation is threatening iconic water bodies such as Lake Taupo and the Rotorua lakes in the North Island.

This paper explores the differences and similarities between various water quality trading programs—a market-based solution for improving water quality—that have emerged around the world. The prevalence of water quality trading is expanding rapidly in the United States, and there are an increasing number of programs being considered or coming on-line in Canada, Australia and New Zealand. While water quality trading has been considered in Europe, programs are yet to materialize.

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[3] Overall eutrophic condition was based on an assessment of five symptoms: chlorophyll *a*, macroalgae, dissolved oxygen, submerged aquatic vegetation, and nuisance/toxic blooms. Eutrophic condition was determined by evaluating the occurrence, spatial coverage and frequency of these symptoms. Moderate eutrophic condition is where symptoms occur less regularly and/or over a medium area. High eutrophic condition is where symptoms occur periodically or persistently and/or over an extensive area (i.e. 50% or more of the system).

Where do the Nutrients come from?
A majority of the nutrients causing eutrophication come from non-point sources, principally agriculture. Approximately 82 percent of the nitrogen and 84 percent of the phosphorous in U.S. lakes, rivers and estuaries come from non-point sources (Carpenter et al., 1998). Similarly, in the Lake Taupo catchment in New Zealand, approximately 90 percent of the nitrogen impairing the lake is non-point source (Environment Waikato, 2007). Non-point source pollution is frequently not regulated because its precise origin cannot be identified. Point source pollution, from facilities such as sewage treatment plants, can be pinpointed to a specific point of origin, e.g., discharge from a pipe into a waterbody, and are therefore more commonly regulated.

What is Water Quality Trading?
Water quality trading is a market-based instrument that is gaining popularity as a mechanism to meet water quality goals cost effectively. Water quality trading is premised on the fact that costs to reduce discharges differ between individual entities depending on their size, location, scale, management, and overall efficiency. When discharges are regulated, trading gives regulated entities the flexibility to comply with their regulatory obligations by purchasing equivalent reductions in the relevant pollutant elsewhere. The ability to trade discharge allowances or reduction credits creates an incentive for those who can reduce their discharges most cost effectively to do so and sell excess reductions to those for whom the cost of reducing discharges is higher. Participation in trading programs is always voluntary for both buyers and sellers. Water quality trading is most often associated with nutrients (phosphorus and nitrogen), though a handful of water quality trading programs have developed around other pollutants such as salinity and temperature.

Many trading programs focus on point sources as their discharges are relatively straightforward to measure, document, and regulate. The Long Island Sound Nitrogen Credit Exchange Program in the United States is such a program. The monitoring of non-point source discharges and the attribution of those discharges to particular sources is significantly more challenging. It is only now that we are seeing programs emerge that focus on non-point sources. The proposed Lake Taupo Nitrogen Trading Program in New Zealand is currently in the process of establishing discharge limits for agricultural sources.

More commonly, non-point sources remain unregulated and are included in trading programs as potential sources of nutrient reduction credits for regulated point sources. Non-point nutrient reduction costs are often lower than the compliance costs for a point source, providing an incentive for the point sources to purchase non-point source nutrient reduction credits. In such cases the establishment of appropriate baselines is important if true reductions in total discharge are to be ensured. Two programs that allow point source and non-point source trading are the South Nation River Watershed Trading Program in Ontario, Canada, which targets phosphorus, and Pennsylvania Water Quality Trading Program in the United States, which targets nitrogen and phosphorus.

Water Quality Trading Initiatives
An assessment of 55 water quality trading programs[4] was undertaken. Of these, 24 were active[5] (Table 1), 20 were under consideration or development (Table 2), and 11 are now inactive (Table 3). Six trading programs were assessed from outside the United States: one from New Zealand—Lake Taupo Nitrogen Trading Program (under development), one from Canada—South Nation River Watershed Trading Program (active), and four from Australia—Hunter River Salinity Trading Scheme (active), South Creek

[4] This assessment is partly based on the World Resources Institute review of trading programs undertaken in 2007 (WRI, 2007). However, some programs were deleted from the list, additional information was sort, and the review was supplemented with additional Australian programs.
[5] Programs that have finalized their trading program design and trades can occur. It does not mean that actual trades have occurred.

Nutrient Trading Scheme (active), Murray-Darling Basin Salinity Credits Scheme (active), and the Moreton Bay Nutrient Trading Scheme (under development). In addition, 13 states in the United States also have or are developing state-wide water quality trading guidance, policy or rules that we assessed (Table 4).

Table 1: Active water quality trading programs (see text for further explanations of categories and terms)

Program Name	State/Country	Participants	Type of Market	Date of Inception
Hunter River Salinity Trading Scheme*	New South Wales, Australia	PS-PS	Exchange market	1995[d] 2002[b]
South Nation River Watershed Trading Program *	Ontario, Canada	PS-NPS	Clearinghouse	1998[b]
South Creek Bubble Licensing Scheme	New South Wales, Australia	PS-PS (trialing NPS)	Clearinghouse (bubble[6] permit)	1996[b]
Murray-Darling Basin Salinity Credits Scheme	South-Eastern Australia	States[7]	Bilateral	1998[b]
Grassland Area Farmers Tradable Loads Program*	California, U.S.	NPS-NPS	Bilateral	1998[a]
Bear Creek Trading Program*	Colorado, U.S.	PS-PS/NPS	Bilateral	2006[a]
Chatfield Reservoir Trading Program*	Colorado, U.S.	PS-PS/NPS	Clearinghouse, Bilateral	1996[b]
Cherry Creek Basin Water Quality Authority Trading Program*	Colorado, U.S.	PS-PS/NPS	Clearinghouse	1997[a] 2003[c]
Dillon Reservoir Pollutant Trading Program*	Colorado, U.S.	PS-NPS	Bilateral	1984[b]
Long Island Sound Nitrogen Credit Exchange Program*	Connecticut, U.S.	PS-PS	Clearinghouse	Jan, 2002[a]
Delaware Inland Bays*	Delaware, U.S.	PS-NPS	Sole-source offsets	2007[b]
Lower Boise River Effluent Trading Demonstration Project	Idaho, U.S.	PS-NPS	Bilateral	1998[d]
Middle Snake River	Idaho, U.S.	PS-PS	Bilateral	2002[b]
Minnesota River Basin Trading Program*	Minnesota, U.S.	PS-PS	Bilateral	2005[b]
Rahr Malting Company Permit*	Minnesota, U.S.	PS-NPS	Bilateral	1997[b]
Southern Minnesota Beet Sugar Cooperative Permit*	Minnesota, U.S.	PS-NPS	Clearinghouse	1999[b]
Neuse River Basin Nutrient Sensitive Waters Management Strategy*	North Carolina, U.S.	PS-PS/NPS	Clearinghouse	1998[b]
Tar-Pamlico Nutrient Reduction Trading Program*	North Carolina, U.S.	PS-PS/NPS	Clearinghouse (bubble permit)	1989[b]
Great Miami River Watershed Water Quality Credit Trading Program	Ohio, U.S.	PS-PS/NPS	Third party broker	2005[a]
Sugar Creek (Alpine Cheese Trading Program)*	Ohio, U.S.	PS-NPS	Third party broker	2006[b]
Clean Water Services Permit, Tualatin River*	Oregon, U.S.	PS-PS/NPS	Third party broker, Sole-source offsets	2004[b]
Pennsylvania Water Quality Trading Program*	Pennsylvania, U.S.	PS-PS/NPS	Exchange market	2006[a]
Virginia Water Quality Trading Program	Virginia, U.S.	PS-PS/NPS	Clearinghouse, Bilateral	2006[b]
Red Cedar River Nutrient Trading Pilot Program*	Wisconsin, U.S.	PS-NPS	Third party broker	1997[b] 1999[d]

Notes: The table was adapted from WRI (2007)
NPS = non-point source; PS = point source; * Program has transacted at least one trade or offset
a: refers to when the trading program was finalized and trading could commence; b: refers to when trading was allowed, under a general permit, individual permit or legislation; c: refers to when revised trading guidelines were finalized; d: refers to when a demonstration or pilot program commenced.

[6] A bubble permit is where an aggregate discharge limit is set for all entities under the 'bubble'. No one entity is therefore responsible for meeting a specified discharge limit, but collectively they must not violate the aggregate limit.
[7] Program differs from others as salinity credits are held by participating Australian States, not individual sources.

Table 2: Water quality trading programs/initiatives in development or under consideration.

Program Name	State/Country	Participants	Type of Market
Moreton Bay Nutrient Trading Scheme	Queensland, Australia	PS-PS/NPS	TBD
Lake Taupo Nitrogen Trading Program	New Zealand	NPS-NPS	TBD
San Francisco Bay	California, U.S.	TBD	TBD
Lower Colorado River	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-PS/NPS	TBD
Massachusetts Estuaries Project	Massachusetts, U.S.	PS-NPS	N/A
Charles River Flow Trading Program	Massachusetts, U.S.	PS-PS	Bilateral
Kalamazoo: GLT trading initiative	Michigan, U.S.	PS-NPS	Exchange market
Vermillion River	Minnesota, U.S.	TBD	TBD
Cape Fear	North Carolina, U.S.	PS-NPS	Third party broker
Passaic River	New Jersey, U.S.	PS-PS/NPS	TBD
Lake Tahoe	Nevada, U.S.	NPS-NPS	Third party broker
Shepherd Creek	Ohio, U.S.	PS-NPS	Third party broker
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	Utah/Wyoming/ Idaho, U.S.	TBD	TBD
West Virginia-Upper Potomac	West Virginia, U.S.	PS-PS/NPS	Exchange market

Notes: The table was adapted from WRI (2007)
NPS = non-point source; PS = point source; TBD = to be determined

Table 3: Inactive water quality trading programs

Program Name	State/Country	Participants	Type of Market
Clear Creek*	Colorado, U.S.	PS-PS[8]	Sole-source offsets
Boulder Creek Trading Program*	Colorado, U.S.	PS-NPS	Sole-source offsets
Upper Moquoketa and South Fork Moquoketa Watersheds Nutrient Trading Directory*	Iowa, U.S.	NPS-NPS	Bilateral
Sudbury River (Wayland)*	Massachusetts, U.S.	PS-PS	Bilateral
Kalamazoo River	Michigan, U.S.	PS-NPS	Third party broker
Passaic Valley Sewerage Commission Pretreatment Trading*	New Jersey, U.S.	PS-PS	Bilateral
Truckee River Water Quality Settlement Agreement	Nevada, U.S.	PS-NPS	N/A
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: The table was adapted from WRI (2007)
NPS = non-point source; PS = point source

[8] 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 loading.

Table 4: U.S. States with Water Quality Trading Guidance, Policy, or Rules

Active Guidance, Policy or Rules

- Connecticut State Trading Legislation
- Idaho Pollutant Trading Guidance (Draft guidance November 2003)
- Michigan Water Quality Trading Rules (Legislation effective 2002)
- Ohio State Trading Rules (Rules adopted January 2007)
- Oregon Trading Guidance (Internal Management Directive, Jan 2005)
- Pennsylvania State Nutrient and Sediment Trading Policy (Final policy and guidelines, Dec 2006)
- Virginia State Trading Rules (2006)

Guidance, Policy or Rules in Development

- Delaware State Trading Initiatives
- Florida State Trading Rules
- Maryland State Trading Policy
- Minnesota State Trading Policy
- Georgia Water Quality Trading Initiatives

Inactive Guidance, Policy or Rules

- Colorado State Trading Policy
- West Virginia Trading Guidance

Comparing Water Quality Trading Programs

We compared water quality trading programs using six different factors—drivers, participants, allocation methodologies, non-point source nutrient reduction calculations, use of trading ratios, and type of market.

a) Drivers

The driver for all trading programs has been the implementation or forthcoming implementation of nutrient caps, either as water quality goals or nutrient water quality criteria.

In the United States, the Clean Water Act of 1972 regulated point sources requiring them to meet certain water quality-based effluent limits. These limits are frequently based on state nutrient water quality criteria, which in turn can be translated into Total Maximum Daily Loads (TMDL) for waterbodies[9]. Regulated facilities are assigned permits via the National Pollutant Discharge Elimination System (NPDES) that limit their nutrient discharge. These, together with the clear endorsement by the U.S. Environmental Protection Agency (USEPA) on the use of water quality trading in 2003 to meet TMDLs and improve water quality, have resulted in a proliferation of trading programs (USEPA, 2003). Fourteen[10] of the U.S. active trading programs have been driven by TMDLs and three by the threat of a TMDL. Similarly, 13 of the 18 U.S. programs in development are driven by TMDLs or the threat of one.

More localized resource caps have been the main drivers in other countries. Under the Resource Management Act (RMA), which grants regional authorities in New Zealand the authority to make crucial resource management decisions, Waikato Regional Council has imposed nitrogen discharge caps on all sources in the Lake Taupo catchment. The South Nation River Watershed Trading Program in Ontario,

[9] Under section 303(d) of the Clean Water Act (CWA), states must assess their waters every 2 years and create a list of impaired waters, i.e. those waters that do not meet water quality standards. States are then required to create TMDLs for waterbodies on the 303(d) list of impaired waters. A TMDL defines the maximum amount of a pollutant that can be discharged into a waterbody and still maintain water quality standards. During the TMDL development process, pollutant loads are allocated among the various sources in a watershed (point and non-point) so that that water quality standards can be met.

[10] Including two programs in Colarado that are driven by Regional Total Maximum Annual Loads.

Canada, is driven by the Provincial Ministry of Environment (MOE) guidelines. MOE is responsible for water quality and for licensing the operation of sewage treatment plants in Ontario, and stipulates that if water quality guidelines are exceeded then no new pollutant discharge is allowed in a watershed (O'Grady, n.d.).

In Australia, the Hunter River Salinity Trading Scheme in New South Wales is driven by specific salinity concerns for the Hunter River and the subsequent setting of a numeric environmental goal for the river by NSW Environmental Protection Agency (NSW EPA), with the major point sources holding an Environmental Protection License to discharge[11] (NSW EPA, 2008a). Similarly, the NSW EPA for the South Creek Bubble Licensing Scheme also mandated a total pollutant load limit for South Creek, and allowed the affected sewage treatment plants to trade to stay within that limit (NSW EPA, 2008b).

b) Participants
Nutrient trading program participants are divided into two categories—point source and non-point source. Point source participants are those whose nutrient discharge can be directly measured, for example, sewage treatment plants or industrial facilities that discharge nutrients via a pipe to waterways. Non-point source participants are those whose discharge is diffuse, for example, pastoral and arable agriculture, urban run-off, and forestry. Non-point source discharge loads are frequently estimated.

The variation in eligible participants for the assessed trading programs is outlined in Tables 1, 2 and 3. The exception is the Lake Taupo Nitrogen Trading Program, which caps pastoral agriculture and ensures all trading will be non-point source trades. Most other trading programs cap the point source sector, and trading is either point source only or point source to point source with non-point sources as an uncapped sector allowed to trade with point sources.

c) Allocation of Caps and Baselines
As each trading program is based on some form of nutrient cap, this cap has to be allocated between the relevant regulated sources. All trading programs face the same challenges when determining the allocation methodology as there will 'winners' and 'losers' no matter how the cap is allocated among sources.

The allocation of discharge limits to point sources has most commonly been a free allocation based on design flow, estimated future flows or existing flows. This means that, in the short term, point sources like sewage treatment plants have rarely been in danger of violating their allocated discharge limit. However, the increase in urban growth is now threatening sewage treatment plants' ability to meet their discharge limits in a number of programs (e.g., Cherry Creek and Chatfield trading programs). Similarly, the Lake Taupo Nitrogen Trading Program, a non-point source trading program, is giving a free allocation of discharge limits based on recent nitrogen discharge levels[12], and landholders will only begin to encounter difficulties if they increase production or convert to more nitrogen intensive land uses. In some cases, such as the South Creek Bubble Licensing Scheme and the Tar-Pamlico Nutrient Reduction Trading Program, the point sources involved must, in aggregate, meet the cap, and there is no allocation to individual sources.

As non-point sources are typically not regulated, their baseline nutrient discharges have to be established before they are able to trade any nutrient reduction credits. This baseline is often based on the management practices in place before the nutrient reducing practice or technology was implemented.

[11] Environment protection licenses are a central means to control the localised, cumulative and acute impacts of pollution in NSW. They set limits on the pollutant loads emitted by holders of environment protection licenses, and links license fees to pollutant emissions.
[12] As of July 2007, farmers were regulated for their nitrogen discharges, and their discharge limit is based on their average annual nitrogen discharge between July 2001 and June 2005.

Alternatively, a baseline year might be established, beyond which any additional best management practices are eligible to generate credits. In some instances, trading programs have established more rigorous non-point source baselines that attempt to address issues of fairness and distinguish between "good actors" (i.e. those farmers that have consistently employed good management practices) and "bad actors" (i.e. those farmers that have not consistently employed good management practices). In this way, the baseline ensures that bad actors are not generating credits for management practices they should have already been implementing. For example, Virginia's (U.S.) recently released non-point source trading guidelines require that farmers must have already implemented a suite of best management practices, including cover crops, conservation tillage, and streambank fencing, before they are eligible to generate credits within the trading program.

d) Nonpoint source nutrient reduction calculations
As nutrient losses from non-point sources are difficult to measure, programs have to identify the approach that will be used to determine the nutrient losses from these sources.

Three approaches are commonly used that provide increasing levels of accuracy:

- General Models (low accuracy) – Pre-determined, standardized nutrient discharge rates for practices regardless of location or other site-specific characteristics. The nutrient discharge rate for each practice is based on average expected discharge calculated through scientific literature or modeling and does not change across the catchment. Red Cedar River Nutrient Trading Pilot Program (U.S.), South Nation River Watershed Trading Program (Canada) and Virginia Water Quality Trading Program (U.S.) use this approach. This approach is appealing as it is simple and farmers know in advance the reductions they can achieve for implementing a practice. However, it reduces the ability to capitalize on the bio-physical heterogeneity within a catchment, potentially reducing the trading opportunities.
- Site-specific Models (moderate accuracy) – Based on accepted nutrient calculation methods, this approach takes into account site-specific variables, such as soil type, slope and fertilizer application rate. Pennsylvania Water Quality Trading Program (U.S.), Great Miami River Watershed Water Quality Credit Trading Program (U.S.), Michigan Water Quality Trading Rules (U.S.), and the Lake Taupo Nitrogen Trading Program (New Zealand) use this approach. Employing standard calculation methods is more cost-effective than monitoring and has the potential to more accurately assess nutrient loads at the farm level as compared to average values derived from watershed-level models such as the Chesapeake Bay Watershed Model in the United States.
- Direct Monitoring (high accuracy) – This approach is the most costly and is not readily applicable to all sources of nutrients or practices that reduce nutrient losses. Many of the Colorado trading programs in the United States (e.g., Chatfield Reservoir Program) require the regulated point sources to monitor the performance of the practices that were implemented to offset their nutrient discharge.

e) Trading Ratios
Trading ratios are used to account for various factors in a water quality trading program. For instance, a 2:1 trading ratio means an entity needs to purchase a 2-kilogram reduction in nutrient load to offset every kilogram it discharges above the regulatory obligation. There are generally four different types:

- Delivery ratio (or attenuation factors) – applied to nutrient discharging sources to account for nutrient transport and deposition within a catchment. For example, Pennsylvania Water Quality Trading Program (U.S.), Virginia Water Quality Trading Program (U.S.), and Minnesota River Basin Trading Program (U.S.) use model-derived delivery ratios; and South Nation River Watershed Trading Program (Canada) uses simplified delivery ratios.
- Uncertainty ratio – hedges against uncertainty regarding whether or not a non-point source nutrient reducing practice will yield its estimated amount of reductions. The purpose of this ratio

is to mitigate risk should a management practice underperform. Lower Boise River Effluent Trading Demonstration Project (U.S.) and the Minnesota River Basin trading program (U.S.) clearly define uncertainty ratios, while most other programs do not explicitly state an uncertainty ratio. However, in many instances the stated trading ratio for point source to non-point source trades does include an uncertainty ratio.

- Equivalency ratio – used when one or more pollutants are traded in a market to achieve the same environmental result. While some pollutants have the same environmental effect, on occasion one pollutant may be more potent than another. An equivalency ratio is needed to make the two pollutants equivalent to one another. The Rahr Malting Company (U.S.), for instance, is regulated for chlorophyll biological oxygen demand (CBOD) and applies an equivalency ratio of 8 pounds of CBOD for every pound of phosphorus. This reflects the relative impacts on chlorophyll from phosphorus runoff and from CBOD discharge.
- Retirement ratio (or environmental benefit ratio) – a certain portion of the credits from each trade are retired and are used to ensure the trading program achieves a net water quality benefit. The Michigan Water Quality Trading Rules (U.S.) specifies a water quality contribution where 10 percent of an entities reduction in nutrient discharge is given to the state environmental agency to address uncertainty and provide a net water quality benefit. These ratios can be applied in both point source only trading programs and programs with non-point source participation.

Most trading programs lack scientifically based uncertainty, and sometimes delivery ratios; instead, values for these ratios are often chosen arbitrarily or based on political feasibility. All or some of the four types of trading ratios are used by most trading programs in the United States and Canada. Of the 24 active trading programs in the United States, 20 programs use some form of trading ratio, with another considering using trading ratios in the future. Delivery ratios appear to be considered in the Australian programs but the Lake Taupo Nitrogen Trading Program in New Zealand does not specify the use of any form of trading ratio.

f) Type of Market

The type of market defines both how trading will occur and the infrastructure that may be needed to support the trading program. There are five categories of markets[13]:

- Sole-source offsets – Sources are allowed to increase nutrient discharge at one point if they reduce their nutrient discharge elsewhere (either on or off site). In both cases the nutrient reduction efforts are undertaken by the regulated entity. Only one of the active programs has this type of market and another is a third party broker with sole-source offsets.
- Bilateral negotiations – Trades are characterized by one-on-one negotiations where a price is typically arrived at through a process of bargaining and not simply observing a market price. This type of market generally has high transaction costs. Of the 24 active trading programs, eight operate through bilateral negotiations and another two are clearinghouses that allow bilateral negotiations.
- Clearinghouse – An intermediary in a trading program that aggregates credits from different sources with different prices and converts them to fixed price commodity that is resold. For example, a clearinghouse may aggregate point source reductions for re-sale at a fixed price (e.g., Long Island Sound Nitrogen Credit Exchange Program) or be the central body to which point sources pay non-compliance fines and they in turn pay farmers to install nutrient reducing management practices (e.g., Tar-Pamilico Nutrient Reduction Trading Program). Commonly, the

[13] Sole-source offsets, bilateral negotiations, clearinghouse and exchanges were identified by Woodward (2004) in an analysis of water quality trading markets; third party broker was added to refine the various types of markets further as there is a growing prevalence of intermediaries, acting more as pass-through organizations than clearinghouses that are bundling and re-selling credits at a fixed price.

clearinghouse has been established as part of the trading program. Seven of the active trading programs have clearinghouses with another two allowing bilateral negotiations as well.

- Third Party Broker – An intermediary in a trading program that aggregates credits from different sources with different prices to either re-sell directly to a buyer or bundles the credits together creating large credit lots for sale. In practice, the broker frequently sources the nutrient reduction credits from the agricultural sector, and operates independently of the program itself. The four active programs where third party brokers are used are Red Cedar River Nutrient Trading Pilot Program, Great Miami River Water Quality Credit Trading Pilot Program, Clean Water Services Permit and Sugar Creek-Alpine Cheese Trading Program—all in the United States.
- Exchange market – Where buyers and sellers meet in a public forum (e.g., online) with all commodities being equivalent and all prices observed. 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 Program (Australia) and the Pennsylvania Water Quality Trading Program (U.S.).

g) Trading Activity

Most active programs have experienced at least one trade. 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 (Ginny Kibler, USEPA, personal communication). Unfortunately, there is no accurate record of the total number of trades completed each year, though there is most certainly a wide discrepancy in the trading activity of individual facilities. While most facilities have traded once, some facilities have completed many trades. For example, the Southern Minnesota Beet Sugar Cooperative Permit has completed at least 256 trades and Clean Water Services, which trades within the Tualatin River, has completed at least 24 trades.

The Hunter River Salinity Trading Scheme in Australia has experienced approximately 170 trades since 2002 and the South Nation River Watershed Trading Program in Canada has had at least 6 facilities purchase credits.

How do the programs stack up?

Of course the most obvious difference between the northern and southern hemispheres is the sheer number of programs in the United States compared with the number found in Canada, Australia and New Zealand. Why? A number of reasons come to mind—the successful U.S. SO_2 trading market clearly demonstrates the benefits of trading, the earlier occurrence and recognition that nutrients are a key source of water quality impairment, and greater federal or national government support and guidance for water quality trading.

Because of the volume of trading programs coming on line in the United States there has also been a move by states to develop state-wide trading rules (see Table 4) to facilitate the development of the individual catchment-based trading programs. The USEPA has also provided a number of tools to help with various aspects of the development of trading programs, e.g., the 'Water Quality Trading Assessment Handbook' (USEPA, 2004), and the 'Water Quality Trading Toolkit for Permit Writers' (USEPA, 2007). As more programs evolve in Canada, Australia and New Zealand, the supporting tools for programs in these countries may also increase.

However, perhaps the most striking difference is the willingness in New Zealand to regulate the agricultural sector in the proposed Lake Taupo Nitrogen Trading Market. Pastoral agriculture contributes approximately 44 percent of the manageable nitrogen load[14] in the Lake Taupo catchment (Environment

[14] Undeveloped land contributes approximately 32 percent of the manageable nitrogen load, while point sources are 10 percent and forestry is 13 percent of the manageable load.

Waikato, 2007). The high portion of the nutrient loads coming from agricultural sources is not unique to New Zealand, but to date New Zealand is the only country that has taken the plunge to regulate that sector. Anecdotally, in the United States there is a reticence to regulate the agricultural sector in any significant manner because of its political power and because of some of the difficulties associated with a large number of small dischargers whose individual contribution is not straightforward to assess.

The use of trading ratios also varies between countries. The Lake Taupo Nitrogen Trading Program in New Zealand is not considering using any type of trading ratio, while there are few programs in the United States that do not use some form of trading ratio. In Australia, delivery ratios appear to be the most common form of trading ratio used. Despite trading ratios being relatively common components of a trading program, they have also been cited as a disincentive for trading. King and Kuch (2003) observed that high trading ratios of 3:1 or 4:1 meant point sources often opted to undertake their own internal reduction efforts because the inflated credit costs from high trading ratios made it less attractive to purchase non-point source credits or other point source credits from other parts of the catchment.

In most instances, non-point source loads are the largest contributor to nutrient pollution around the world. While this is recognized in most programs, non-point sources are only involved as voluntary suppliers of nutrient credits. With the exception of the Lake Taupo Nitrogen Trading Program (and possibly the Murray Darling Basin Salinity Credits Scheme), all programs are focused on point source dischargers, mostly sewage treatment plants.

Turning to the different types of markets, we see there is quite a large variation in form ranging from very hands-on bilateral trading to the more anonymous open exchange type of market. We also see a shift over time from bilateral trading, with more recent programs opting for exchanges and third party brokers/banks. This, we believe, has been in response to the high transaction costs experienced by the participants in earlier trading programs and the desire to simplify and streamline the trading process for participants.

Governments are also playing a large role in the establishment of trading programs, pilots and demonstrations. As there is still an aspect of the unknown with water quality trading programs, governments are providing significant levels of funding for interested regional, state and local governments, and other organizations to undertake the design and engage the stakeholder processes that typically accompany the development of a water quality trading program. In the United States, funding can be obtained through the USEPA Watershed Grants Program and the U.S. Department of Agriculture's Conservation Incentive Grants. Australian funding is also at the national level via the National Market Based Instruments Pilot Program. In New Zealand, the central government has made a 'one-time' contribution[15] to efforts to meet the Lake Taupo water quality goals, but it is the Waikato Regional Council that bears the lion's share of the cost for developing the regulation and trading program.

Perhaps the most common (and regrettable) factor in all programs is the difficulty experienced in allocating a cap between regulated entities. To date, there has been no allocation method developed from which every individual gains. The first point of contention is where to set a cap—should it be where water quality is maintained or truly restored? Setting a very weak cap will not have environmental integrity; a very stringent cap may be too costly for society. The next point of contention is between the affected stakeholders in the catchment in question. No matter how the allocation is made there will always be someone that 'loses'—whether it be from the lost opportunity costs, from future decisions or from being

[15] The Central Government, Waikato Regional Council and Taupo District Council have contributed an equal share to establish the Lake Taupo Trust (NZD 81 million) aimed at meeting the water quality goals established for Lake Taupo.

penalized for activities that until the point of regulation had been allowed. This has meant that during the design of most trading programs the issue of allocation has typically been the most contentious.

What can be learned from existing and emerging trading programs?
Because there are trading programs in a number of countries around the world, much can be learned from their experiences that can then be used to develop markets that successfully reduce the cost of maintaining or improving the quality of our waterways.

Of first importance is that we must continue to learn from the past. We often fall into the mindset that the conditions with which we are dealing are unique to our watershed and therefore we cannot learn from others. While this may be true for some aspects, there are many areas where experiences and knowledge from other catchments can be capitalized on. For instance, methodologies to estimate the reduction in nutrient losses from agricultural practices can be difficult and time-consuming to develop. In the United States this has often been done using Microsoft Excel™ or web-based tools that incorporate nationally available algorithms (e.g., Revised Universal Soil Loss Equation). These are relatively straightforward to adapt to different watersheds. In New Zealand, the Crown Research Institute, AgResearch, has developed Overseer®, a nutrient-budgeting model to facilitate the estimation of nitrogen and phosphorous losses from pastoral lands. CLUES[16], which models nitrogen and phosphorus loads in streams, and IRAP[17], an integrated groundwater model, are also national in scope and could easily be used by different New Zealand catchments embarking on water quality trading. Estimation algorithms may be more difficult to transfer between countries but they are most likely highly transferable within a country.

Trading infrastructure is another area that may have easily transferable material and tools. There should be little need to change the trading marketplace between catchments and countries dramatically. Using existing marketplaces can decrease the time and cost of implementing that part of a trading program, allowing program developers to concentrate on more controversial and difficult areas.

One such area is stakeholder processes. These processes are crucial to the adoption of any trading program and most programs highlight their importance. Material developed for communicating trading concepts to stakeholders can be 'borrowed' from other programs. However, the success of the stakeholder process will frequently depend on the process employed and the personalities of the stakeholders. The identification of a 'trading champion' can be useful in this context. A high-level elected official (e.g., a Governor, head of environmental agency, council chairman, etc.) 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.

Identifying alternative drivers for trading will also promote development of and improve participation in trading. Most trading programs currently rely on regulatory caps for a limited set of point source discharges, e.g., sewage treatment plants. Broadening the scope of trading programs should increase participation. For instance, regulating the agricultural sector will not only increase the number of potential participants but also bring into the fold the largest overall contributor to many water quality problems. Potential restrictions on urban development (e.g., no nutrient run-off from new development) and concerns over the future supply of drinking water may also drive the development of innovative water quality trading programs.

Once the implementation phase of the program is functioning, streamlining the actual trading process is important to reduce the transaction costs. For instance, the development of standardized language in

[16] http://www.niwa.co.nz/ncwr/wru/ma/2007-22/impacts
[17] http://www.irap.org.nz/

regulatory compliance documents, 'model' contracts for sales, and mechanisms to facilitate an actual trade and the speed at which it can be finalized are all important for promoting trading activity.

Tied to implementation are systems that may help kick start a trading program. Uncertainty about how trading works, fear of regulatory non-compliance, and the inherent distrust of many people for something new may mean trading is slow to start. Systems that can be used to develop trust and test the functionality of a new trading mechanism can be useful in this context. Reverse auctions and the establishment of trading banks are being explored to do this. If an initial pot of money is available or can be borrowed, then a trading bank can be established. The bank, through a reverse auction, can purchase the most cost-effective credits from various sources in a catchment (Greenhalgh et al., 2007). These credits can then be re-sold to provide further liquidity for the bank or to repay the initial loan.

Lastly, trading programs are only as successful as the water quality improvement they achieve. However, programs often overlook or underfund the extent of monitoring needed to gauge progress and manage the trading program adaptively. Progress towards catchment water quality goals needs to be monitored over the long term, as does trading activity so that, over time, the trading program improves its operation and management.

Where Next?

Water quality issues are on the rise—over the last 12 years there has been a four-fold global increase in identified hypoxic zones (Selman et al., in press)—and governments will increasingly be looking for ways to deal with these problems. Consequently, the number of water quality trading programs has continued to grow and will most likely continue to do so. Trading complements regulation, providing flexibility for entities to meet their regulatory obligations at lower costs, making trading an attractive option for governments tasked with improving water quality.

To ensure the lessons learned by trading programs are shared more widely, programs need to make concerted efforts to document these lessons and provide the opportunity for others to access this information, for instance: web-sites dedicated to sharing information between trading programs; workshops for program developers and/or stakeholders that specifically target certain elements of a trading program (e.g., trading ratios and their use, non-point source credit calculations, running effective stakeholder processes); the provision of simple, easy-to-understand explanatory material on what water quality trading is and how it affects stakeholders; and the development of material that explains the important elements of a trading program, where crucial decisions have to be made, and the steps necessary in designing such a program. In addition, the transparent reporting of progress towards water quality goals and program activity will further illustrate how trading programs have or have not helped catchments meet their water quality goals.

Over time, the design of trading programs and the necessary infrastructure (e.g., marketplaces and trading registries) that supports them will become more consistent, and trading processes more streamlined as programs and their participants learn better ways to design and implement trading programs.

References

Bricker, S. B. Longstaff, W. Dennison, A. Jones, K. Boicourt, C. Wicks, and J. Woerner (2007) *Effects of Nutrient Enrichment in the Nation's Estuaries: A Decade of Change*. NOAA Coastal Ocean Program Decision Analysis Series No. 26. Silver Spring, MD: National Centers for Coastal Ocean Science. Online at: http://ccma.nos.noaa.gov/publications/eutroupdate/

Environment Waikato (2007) Proposed Waikato Regional Plan Variation 5—Lake Taupo catchment (Hearings Committee recommendations version). Evaluation of alternatives, benefits and costs under

section 32 of the RMA—Explanation of the approach taken in the Variation. *Environment Waikato policy series 2007/09*. EW document #1093829.

Greenhalgh, S., J. Guiling, M. Selman and J. St John (2007) Paying for Environmental Performance: Using Reverse Auctions to Allocate Funding for Conservation. *World Resources Institute Policy Note*, Environmental Markets No. 3, Washington D.C.

ILEC/Lake Biwa Research Institute [n.d.]. 1988–1993 Survey of the State of the World's Lakes. Volumes I-IV. International Lake Environment Committee, Otsu and United Nations Environment Programme, Nairobi.

King, D and P. Kuch (2003) *Will Nutrient Credit Trading Ever Work? An Assessment of Supply and Demand Problems and Institutional Obstacles*. Environmental Law Institute, Washington, DC. (33-ELR-10352).

NSW EPA (2008a) Hunter River Salinity Trading Scheme. http://www.epa.nsw.gov.au/licensing/hrsts/index.htm (visited Jan 10, 2008)

NSW EPA (2008b) South Creek Bubble Licensing Scheme. http://www.environment.nsw.gov.au/licensing/bubble.htm (visited Jan 10, 2008)

O'Grady, D. [n.d.] 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 Jan 10, 2008)

OSPAR Commission (2003) *OSPAR integrated report 2003 on the eutrophication status*. London, U.K.: OSPAR.

Selman, M., S. Greenhalgh, R. Diaz and Z. Sugg (in press) Eutrophication and Hypoxia in Coastal Areas: A Global Assessment of the State of Knowledge. World Resource Institute Policy Note (forthcoming 2008, draft manuscript).

USEPA (2002). *National Water Quality Inventory: 2000 Report* (EPA 841-R-02-001). Washington, DC: Office of Water, USEPA.

USEPA, Office of Water (2003) *Final Water Quality Trading Policy*. United States: Environmental Protection Agency. Online at: http: //www.epa.gov/owow/watershed/trading/finalpolicy2003.html

USEPA (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

Woodward, R.T., R.A. Kaiser, A., and M.B. Wicks (2004). "The Structure and Practice of Water Quality Trading Markets." *Journal of the American Water Resources Association* 38(4): 967–980.

WRI (2007) *An Overview of Water Quality Trading Programs*. World Resources Institute, June 2007, unpublished manuscript.