Nutrient Credit Trading – a Market-based Approach for Improving Water Quality

By

Harbans Lal, Environmental Engineer
WNTSC / NRCS / USDA
Portland, Oregon

1. Abstract

Imagine the day when you could gain financial rewards for implementing conservation practices on your farm. It is now possible because these practices can assist industrial users in the watershed meet regulatory requirements, thus reducing the overall pollutant discharge to a water body and improving its water quality. This is not a scenario of the future. Rather, it is currently being practiced and developed in many states around the United States, and it is called Water Quality Trading. Producers are getting paid for their stewardship in natural resource conservation activities. They are accumulating and selling credits earned through nutrient or sediment reduction by implementing conservation measures. Wastewater treatment plants are buying these credits to meet their regulatory requirements within the National Pollutant Discharge Elimination System (NPDES) permits. These permits restrict the amount of pollutants the plants can discharge from their facilities to the local water bodies. It provides an economic incentive for the agricultural sector as well as contributes to cleaner rivers and streams.

Water quality trading leads to a mutually beneficial situation for all involved in the process. Treatment plants utilize a full suite of measures to meet their regulatory requirement. Purchasing water quality credits allows industries more flexibility in investment in new technologies; the producers get rewarded for their efforts, and the environment benefits in multiple facets including water quality, wildlife habitat, and carbon sequestration. This chapter reviews the approaches to water quality trading, its current status of implementation around the nation, and different tools (including the Nitrogen Trading Tool (NTT) being developed by the USDA/ NRCS) to facilitate in this process.

2. Introduction:

Water quality trading is a market-based approach that pairs buyers of water quality credits with the people generating these credits through conservation and stewardship to achieve the best results for the least cost. For example, a downstream wastewater treatment plant needs to reduce the amount of pollutants it discharges to meet its NPDES permit requirements. Instead of spending huge amounts of money to upgrade or install new equipment on-site, it could fund less expensive agricultural conservation practice(s) upstream and achieve better quality of pollution control. These agricultural practices, also known as Best Management Practices (BMPs), would not only combat the pollutant

reduction sought by the plant, but would also provide additional ecological benefits as listed in Table 1 and Table 2.

The basic idea of this approach is to make use of market mechanisms in promoting environmental-friendly activities for cleaner water, preserving wetlands and habitats in order to protect endangered species, and reducing greenhouse gas emissions. It is being designed to supplement, but not replace federal efforts to encourage conservation and environmental protection that the government currently uses through subsidies and cost sharing. The USDA considers environmental credits from agriculture the property of the farmer, the landowner, the one who applied for conservation practices on the land, regardless of the federal cost-share dollars that were invested (USDA, 2007).

Water quality trading is a voluntary effort, in which farmers have full freedom to participate or not. Wastewater treatment facilities and landowners are encouraged to get involved; however, no laws or regulations require them to participate in this program. It is supported by federal agencies such as the US Department of Agriculture (USDA), the US Environmental Protection Agency (EPA), and several other state and local agencies. States such as Connecticut, Pennsylvania, North Carolina, Colorado, Idaho, and Oregon are either practicing the trading or are in the process of developing guidelines for its implementation.

Water quality trading provides an additional source of funding for farmers and rangers for implementing and maintaining conservation practices for agronomic, economic, and environmental and health benefits. The payment received will depend upon effectiveness for the conservation practice and the structure of the trading program. Farmers or ranchers could receive a one-time payment to cost-share or reimburse the cost of implementing the practice. Alternatively, they could receive on-going monthly, seasonal, or annual payments for the conservation practice they have implemented. Regardless of the mode of payment, water quality trading will permit farmers and ranchers to implement conservation practices with private investments that will improve and protect water quality. However, it requires developing measurable units of trades to bring buyers and sellers together on a common platform. Significant efforts are underway around the nation to develop these units both for individual pollutants, such as nitrogen, phosphorus, and sediments, and for the entire ecosystem. Once these units are developed, it is envisaged that water quality credits will be traded as freely as corn or soybeans are traded today. Water quality trading is a location-specific process. Thus, state and local authorities, such as watershed councils, are developing trading rules most applicable to their specific conditions.

3. Types of Trade

Water quality trading has been classified into two broad categories: 1) cap and trade and 2) field and trade. The cap and trade system is based on the regulations imposed by regulatory agencies. On the other hand, the field and trade system is designed to improve the quality of the entire ecosystem without any pre-defined limits. However, both systems are designed to help municipal waste and wastewater treatment plants, generally

known as point sources, to meet their regulatory requirements. They can either buy credits from another point source or from agricultural producers referred to as non-point sources. The trade could involve a single pollutant such as nitrogen, phosphorus, or sediment; or the entire suite of services of a conservation activity such as a riparian buffer or a wetland. Such a trade is referred as ecosystem trading. Producers may be able to generate and sell credits to multiple markets from a single conservation activity. For example, the Great Miami River Watershed Water Quality Credit Program encourages farmers to implement conservation measures, such as no-till farming, to generate phosphorus credits to sell through water quality trading programs and carbon credits for sale through the Chicago Climate Exchange.

3.1. Cap and Trade

This system of water quality trading is based on fixed limits of pollutant discharge to water bodies. The discharge is regulated by the Clean Water Act, which requires state regulatory agencies to develop Total Maximum Daily Loads (TMDLs) for impaired waters that serve as road maps for meeting the water quality standards. TMDLs contain a maximum pollutant budget or load that impaired water can assimilate without hampering the designated water uses of the waterbody. TMDLs allocate portions of the total load to permitted facilities and other sources contributing to the load. If the permitted facilities do not achieve their pollutant reductions, they are in violation of state and federal laws. However, if permitted by state laws, these facilities can meet their regulatory requirements by purchasing credits from other facilities that have already met their requirements and have generated extra credits from the farming operations that reduce pollutant runoff through conservation practices within the trading program. As permitted facilities face increased costs to control pollutants, especially pollutants like phosphorus, nitrogen, and sediment, the market demand for pollutant reductions generated by agricultural conservation practices is likely to increase. The state and federal regulatory agencies, such as the EPA, are supporting water quality trading and provide guidance to interested parties. However, it is important to note that the trading process must meet the over arching TMDL requirements and lead to nutrient reduction and improving the water quality.

3.2. Field and Trade

In this trading model, farmers are paid to preserve the wildlife habitat, especially for an endangered species. The credits are earned for land preservation of the habitat. These credits can then be sold to land use industries or others who are required to mitigate the loss of habitat by the Endangered Species Act and other laws that restrict or prohibit development. The USDA would like to harness the market forces to change farmers' outlooks on endangered species protection from the three S's (Shoot, Shovel and Shut-up) to the three P's (Plan, Preserve and receive Payment) where they are paid for their stewardship in conserving and preserving wildlife and their habitat (AgriPulse, 2007). The USDA/NRCS, the Fish and Wildlife Service and the Association of Fish and Wildlife Agencies have signed a partnership agreement to evaluate endangered species

habitat credit trading. The partnership is mandated to develop standards and then test them through a couple of pilot projects.

4. Concept of Baseline and Saleable Credits

The question about the amount of credits a conservation practice can generate and how much of it is really saleable are common questions among water quality trading communities. These are complex but important issues, and primary driving forces for producers to participate in this process. The issue of how much a producer can trade depends on multiple factors including eligibility requirement for trading, the amount of pollutant reduced through conservation practice implementation, and discount factors (trade ratios) established by the trading program. These ratios account for challenges and characteristics unique to the trade, such as effectiveness and certainty of the conservation practice.

The baseline and saleable credits in water quality trading depends upon the commodities or services a producer can trade. These commodities and services are measured in units, such as ponds, acres, or credits. The commodities, such as nitrogen, phosphorus, and sediments, are expressed in pounds that are reduced to flow into the environment, such as a water body. In general, the producer will implement a conservation practice and then sell the pounds of a specific pollutant removed or reduced.

Factors such as uncertainty of the conservation practices, distance between the location of the conservation practice to the waste treatment plant buying the credits, pollutant fate and transport, and other site-specific characteristics and regulations are taken into account while calculating credits eligible for trade. To account for these features and challenges, one or more conversion factors, also known as trade ratios, are used. These ratios estimate the impact of a conservation practice at a farmer's land to pollutant reduction in the water body.

Unlike cap and trade system where nutrients are traded in pounds of pollutant reduced due to a conservation activity, the field and trade programs deal in acreage of conservation activity implemented and maintained to achieve the defined objectives. For example, a wastewater treatment plant could pay for implementing a conservation practice at the farmer's land in exchange for a commitment by the producer to regularly maintain the practice. In this case, the producer is selling a service instead of a commodity—the service of implementing and/or maintaining a conservation practice to help a permitted facility meet its permit requirements.

Different trading programs are adopting different approaches for fixing baselines. These include: 1) a specific pollutant reduction (in pounds), 2) a percentage of a pollutant reduction, and 3) a minimum required level of conservation practice implementation.

The specific pollutant reduction approach assigns the producer a baseline reduction from a conservation practice before it would be eligible for generating tradable credits. The percentage reduction approach requires that a certain defined percentage of reduction

must be achieved before a conservation practice generates pollutant reduction credits. A producer generating reductions greater than the predefined percentage of current discharge can participate in trading. In the case of the minimum level of conservation practice implementation approach, the producer has to implement certain practices before he/she can even participate in the trading program. For example, the Pennsylvania Department of Environmental Protection requires that the producer must implement one of the following three conservation practices before it can participate in the state sponsored trading program (PADEP, 2006):

1. A **100-foot mechanical setback** is achieved when manure is not mechanically applied within 100 feet of a stream, there are no surface waters within 100 feet of operation, or the operation uses no manures and applies commercial fertilizers at or below the recommended agronomic rates of Pennsylvania State University.

2. A **35-foot buffer** is achieved when a minimum of 35 feet permanent vegetation is established and maintained between the field and the stream. The area can be grassed or cropped; however, the permanent vegetation must be maintained at all times.

3. A **Reduction in nutrients beyond baseline** is achieved when the operation reduces nutrients beyond baseline compliance. Pennsylvania is currently discussing the feasibility of a 20% beyond-baseline reduction option.

The process of estimating pollutant reduction credits from a conservation practice involves: 1) determining the current pollutant contribution from the farm, 2) identifying and implementing one or more conservation practice(s) and estimating effectiveness, 3) determining and meeting the baseline requirements for trading, 4) quantifying conservation practice pollutant reduction, 5) adjusting pollutant reduction trading credit based upon the location (trading ratio) factor, and 6) identifying buyers and meeting their purchasing requirements.

To demonstrate these steps, here is a simple hypothetical scenario presented by the Conservation Technology Information Center (CTIC, 2006). A producer owns a farm on the Rushing River, which empties into Placid Lake. The lake is polluted with excess phosphorus. The farm is one mile upstream from the lake. The state has developed a TMDL that requires that all sources of phosphorus discharge must reduce their discharge by 78%. The farm owner wants to generate credits to sell by reducing the phosphorus loading from his 300 acre flood irrigated field on his farm. He wants to install a sprinkler system capable of eliminating all sediment loss from the field. The sprinkler system he has selected is capable of reducing the sediment loss by 100%, thus completely eliminating sediment discharge from the field. However, the state trading program requires that a 10% uncertainty discount be applied to credit reductions associated with this practice to account for the variations in installation and maintenance of the system. In addition, the following assumptions are made for the farm based upon the trading program policies and available literature for the region.

1. *Average Surface Irrigation Soil Loss (SISL) factor for predominant soils = 7.3 tons/acres*
2. *Phosphorus lost per ton of soil loss that washes away with sediments = 2 pounds*
3. *Trading ratio based upon distance of the farm from the lake = 95%*
4. *Tradable months and their flow loss factors = June (35%), July (45%), and August (20%)*

Based upon these assumptions, the following steps demonstrate the process of calculating pollutant reduction credits from the farm:

Step 1. The current phosphorus discharge from the field
- 300 (acres)* 7.3 (soil loss/year) * 2 (phosphorus in sediments) = 4,380 lbs P/year

Step 2. Conservation practice phosphorus removal capability
- 4,389 (Current Phosphorus Discharge) * (1(Conservation Practice Effectiveness)-0.1(Uncertainty Discount)) = 3,942 lbs/year

Step 3. Determine baseline for trading
- 4,380 (Current Phosphorus Contribution)*0.78(Required Reduction) = 3,416.4 lbs P/Year

Step 4. Tradable (Excess) Phosphorus after meeting the baseline reduction
- 3,942 (Phosphorus reduction due conservation practice)-3,416.4(Baseline Requirement) = 525.6 lbs P/year

Step 5. Phosphorus reduction credits adjusted for farm location
- 525.6(Phosphorus reduction for eligible for trading)* 0.95 (Trading ratio) = 499.32 lbs P/year

Step 6. Monthly Phosphorus tradable credits

Annual Net Phosphorus Tradable Credit*Monthly Flow Loss factor
June Tradable Credits = 499.32*0.35 = 174.8 lbs P
July Tradable Credits = 499.32*0.45 = 224.7 lbs P
August Tradable Credits = 499.32*0.20 = 99.9 lbs P

The above calculations show that the producer can generate about 500 lbs of P credits per year by adopting a sprinkler system compared to the current flood irrigation system on the 300 acre field. He can sell these credits to the purchaser over the three month period of June, July, and August.

However, it is important to understand the difference between the maximum tradable load reduction and the number of credits available for trade. A number of factors, referred to as trading ratios, affect the quantification of tradable credits based upon load reduction. These include the distance of the point source from the credit generation source, and the geomorphic characteristics of the region. Because of the vast variation in the trading ratios, determining the maximum tradable nonpoint source load reduction is key to estimating the number of tradable credits based upon watershed characteristics.

5. Players involved

The process of trading water quality credits involves a number of players. They include: 1) the seller (farm operators or the waste treatment plants with excess credits), 2) the buyer (municipal waste or other wastewater treatment facilities needing the credits), 3) the regulatory agency (federal, state, or local agency responsible for establishing policies and guidelines for the trading), and 4) trading facilitators (aggregators, consolidators, central exchanges serving as intermediaries between buyers and sellers to facilitate trading transactions, etc.).

Agricultural (farm) producers most often play the role of sellers in water quality trading. They implement conservation practices that generate pollutant reduction credits, which are bought by municipal waste or wastewater treatment plants. They need these credits to meet the requirements established by the regulatory agencies of the trading program. In addition, these agencies may also establish trading guidelines and procedures for completing these transactions smoothly. For example, the EPA's Trading Policy document establishes broad guidance regarding trading, and individual state governments establish specific policies appropriate for their specific situations. Some of the states pioneering in this effort are Pennsylvania, Connecticut, Idaho, and Oregon. They are defining the policies and procedures under which pollutant trading may take place, establishing record keeping and reporting guidelines, and deciding on conservation practices eligible for generating credits under different situations.

Trading facilitators are entities or individuals that bring buyers and sellers together under the rules and regulations set by regulatory agencies. They facilitate the exchange of credits. There are several variations of trading facilitators, which include brokers, aggregators, and central exchanges (Figure 1). The role of trading facilitator can be fulfilled by state agencies, local conservation districts, non-governmental organizations, private industries, or individual entrepreneurs.

Brokers work independently or as a part of a trading program. They do the necessary work to match buyers and sellers based upon their needs. The buyer may establish direct contact with the seller and negotiate the terms of the trade. The broker would then help in drafting a trade agreement between the trading partners. The broker may charge a fee for the services, either from the buyer, seller, or both.

Unlike brokers, aggregators collect pollutant reduction credits from several producers to sell in bulk to permitted industrial and municipal facilities. As a result, trade agreements exist between the producer and the aggregators and between the permitted facility (the buyer) and the aggregator. There are no direct agreements between the producers and the waste treatment facilities. The presence of an aggregator helps both the buyer and seller. It eliminates the need of the buyer (the treatment facility) to contact several producers to accumulate enough pollutant reduction credits necessary to meet the regulatory requirements. The producers can also participate in the trading process without having to establish a relationship with permitted industrial or municipal facilities.

Aggregators also charge fees for their services, but it may be much less than the cost of trading through an individual broker.

Similar to aggregators, central exchanges purchase pollutant reduction credits from one or more producers and then distribute the credits among different buyers. The sellers and buyers who trade through central exchange do not meet or negotiate trades directly with one another. In general, central exchange performs the same function as an aggregator. The primary difference between a central exchange and an aggregator is that typically there will be only one exchange in a trading program, and the trading program will be structured around the central exchange. In contrast, multiple aggregators may operate within a trading program. The aggregators operate as independent agents, and no one aggregator is central to the functionality of the trading program.

6. Case studies

Several states all over the United States are developing and implementing water quality trading programs within the overall guidelines provided by the US Environmental Protection Agency. The state and local environmental regulatory agencies are adopting these guidelines to come up with their own trading policies and procedures for their specific conditions. These include deciding the primary pollutant for trading, baseline and saleable credits, and the mode and process of trading. A few cases are discussed below. These examples were selected to demonstrate the diversity in types of pollutants and the modes of trading being practiced around the nation.

6.1. Long Island Sound (LIS) of Connecticut and New York

The water quality trading in the Long Island Sound (LIS) basin is driven to correct the declining population of fish and shellfish; the most pressing water quality problem in the Sound. Oxygen levels during the July through September period are inadequate to support a healthy population. The Total Maximum Daily Load (TMDL) has identified nitrogen as the pollutant most responsible for this hypoxic condition. Excess loads of nitrogen from sewage treatment plants (STP), storm water runoff, and atmospheric deposition over-enrich the Sound with microscopic plant life. These plants eventually die and sink to the bottom and decay. During decay, oxygen is consumed that drives dissolved oxygen to unhealthy levels well below the state water quality standards.

The TMDL requires Connecticut and New York to attain a 58% collective reduction of nitrogen loading from the established baseline from different sources to LIS by 2014. A 64% reduction goal was set for Connecticut STPs which are the major source of nitrogen loading to the Sound. The Connecticut Department of Environmental Protection (Con-DEP) evaluated different options and identified nitrogen “trading” as the most cost-effective mechanism for attaining these goals. Thus, Con-DEP established a Nitrogen Credit Exchange (NCE) overseen by a Nitrogen Credit Advisory Board, and authorized issuance of a Nitrogen General Permit. This permit establishes annual limits for each

facility based on the expectation that the cumulative amount of nitrogen discharged from all of Connecticut's public owned STPs will decrease annually as nitrogen treatment projects are completed. The NCE program provides incentive to facilities that complete nitrogen treatment projects, while allowing other facilities to remain in compliance with the general permit (GP) by purchasing nitrogen credits from other facilities that have surpassed their basic requirement. For each participating facility, the GL also establishes an "equalization factor" that accounts for each facility's geographic location in relation to the most impacted site of the Sound.

There are 79 STP facilities covered under the GP. By March 2003, 39 facilities installed nitrogen treatment plants to meet their permit requirements and generated extra credits. Thirty-eight facilities were required to purchase credits in order to remain in compliance with the GP and two facilities discharged an amount exactly equal to their permit limit and were not required to sell or purchase credits. These transactions generated a total cash flow of over $2.7 millions. The selling facilities received payments from the facilities that purchased the credits and from the State of Connecticut. Due to the exceptional performance of Connecticut facilities in 2002, the state disbursed $1,440,100 to purchase Nitrogen Credits in excess of the credits purchased by municipal STPs. The introduction and adoption of the Nitrogen Credit approach by the State of Connecticut has helped in reducing nitrogen discharge to the Sound at a much faster rate than expected, thus proving the validity of this new approach.

6.2. Pennsylvania

As part of the 2000 Chesapeake Bay Agreement, the states of Maryland, Virginia, and Pennsylvania are required to achieve significant reduction of nutrient and sediment flow from the Susquehanna and the Potomac watersheds. The increased load of nutrients such as nitrogen, phosphorus, and sediments has impaired the water quality of the bay. The Pennsylvania Department of Environmental Protection (Penn-DEP) has recognized that the projected high and expensive levels of treatment for point sources alone will not be enough to reduce nutrients to the bay and prevent its water quality impairments. Thus, the Penn-DEP is instituting a nutrient trading program and encouraging non-point sources to participate in these efforts. The program allows the pollutant source to meet its goals by acquiring nutrient reduction credits from another source within the same watershed. Credits are generated when a source reduces nutrient loading to an extent greater than what is required by law.

Unlike the LIS watershed in Connecticut, trading in Pennsylvania can take place between any combination of eligible entities- point sources, non-point sources, and third party sources. However, each entity must meet applicable criteria established by the Penn-DEP before being eligible to participate in the program. For example, a point source should be able to demonstrate that it is implementing treatment beyond the required limits. On the other hand, non-point sources should first ensure that they are meeting minimum "threshold requirements" before they become eligible for generating the tradable credits.

The Penn-DEP has a procedure of credit certification for entities interested in participating in the program. The department has a listing of credit generating BMPs, which can be submitted to the Penn-DEP for review. The department analyzes these applications against the procedures outlined in the trading of nutrient and sediment reduction credits and policies and guidelines (PADEP, 2006) to determine their eligibility. The applicant can also use NutrientNet, a nutrient trading tool created by the World Resources Institute to calculate and post credits for sale on their website.

The landmark sale under this program involved the sale of nitrogen credits by a private aggregator to a Susquehanna County development. The developer is using the purchased credits toward permitting a package sewage treatment plant for a residential development. The aggregator bought credits from its agricultural clients — mainly commercial poultry operations. These credits are generated by exporting chicken manure outside of the Chesapeake Bay watershed to be applied to nutrient-deficient land. This manure was previously used within the watershed, either on the operator's cropland or on the adjacent field through a manure broker. Using this approach, the aggregator has become a leader in the generation of nutrient credits in Pennsylvania and holds the majority of available DEP certified credits. This is the first complete trade of water quality credits certified by the DEP for trading.

6.3. Miami Conservancy District (Ohio's Great Miami River Watershed)

The Miami Conservancy District (MCD) of the Great Miami River Watershed covers a total area of 4,000 square miles. It is an agricultural dominant watershed with 1.5 million inhabitants. The Water Conservation Sub-District (WCS) of the MCD is implementing the Great Miami River Watershed Water Quality Trading Program so that the Great Miami River Watershed and downstream receiving waters can benefit from this innovative strategy. Water quality trading credits are generated from pounds of phosphorus (TP) and pounds of nitrogen (TN) that are prevented from discharging into the rivers and streams of the Great Miami Watershed. Water quality credits only originate from an activity undertaken voluntarily (i.e. not otherwise required by local, state, or federal law). Water quality credits may be purchased by permitted dischargers who become eligible buyers for the purpose of complying with regulations related to the particular nutrient for which the credit is generated.

The management practices that generate credit are proposed by the county. The conservation district staff works with agricultural producers to identify practices that accomplish the desired nutrient reduction. The reduction is verified through inspection and by conducting water quality monitoring at the project site. The continuous monitoring over the project life span since 2005 has shown much lower nutrient discharge from agricultural activities than previously predicted by Ohio Department of Natural Resources (Ohio DNR) and USEPA.

The program utilizes a Load Reduction Spreadsheet (v1.2) to calculate nutrient discharge reductions for specified agricultural practices. This spreadsheet is available online through the Ohio Department of Natural Resources (Ohio DNR) website. However, they

acknowledge that the existing models are inadequate to estimate the load reduction for many proposed practices. A user-friendly model that is capable of estimating benefits of implementing a variety of practices is needed.

6.4. Willamette Ecosystem Marketplace

The Total Maximum Daily Load (TMDL) of the Willamette Basin in Oregon has identified three main pollutants: temperature, bacteria, and mercury. These pollutants need to be reduced for meeting the Willamette river water quality requirements. The Oregon Department of Environmental Quality (OR-DEQ) is encouraging point sources needing upgrades to comply with the NPSES permits to consider water quality trading. In this system, a point source could pursue buying credits in lieu of installing expensive refrigeration equipment to reduce its temperature impacts. These credits could be generated by agricultural producers by installing BMPs that augment the water flow or accelerate restoration of riparian vegetation. These practices are direct and less expensive ways to cool the flowing water than refrigeration. In addition, they do not require significant amounts of electricity and provide several additional environmental benefits as illustrated in Table 1.

In addition, the Willamette Partnership, a local coalition of leaders and non-profit organizations, is developing the Willamette Ecosystem Marketplace to further improve ecosystem functions in the basin. In this approach, the regulated industries, developers, and other investors can pay land managers to implement conservation practices that can protect and enhance ecosystem services, such as clean abundant water, healthy population of fish and wildlife, and a stable climate. This effort is funded through the "Target Watershed Grant" from the US EPA. Under the terms of the grant, the marketplace must first target transactions to achieve temperature reductions for the Willamette River, which are consistent with the Willamette Basin TMDL objectives. In the marketplace, cities and industries that discharge hot water into rivers and streams will be able to purchase conservation credits offered by landowners who restore streamside shade, reconnect floodplains, or take other actions that cool water naturally. The experience gained in temperature trading will help develop approaches for other nutrients within the marketplace. This approach of thermal trading based upon riparian restoration could save Oregon taxpayers and utility rate payers millions of dollars in construction and operating costs for conventional water cooling facilities.

7. Tools

7.1. NutrientNet

The NutirentNet (Figure 2) is a water quality tool developed by the World Resources Institute (WRI) to facilitate water quality trading. The WRI, headquartered in Washington, D.C., is an environmental policy institute that researches and creates practical ways to protect earth and improve people's lives. The NutrientNet is a web-based system that offers the following capabilities:

- *A simple way for buyers and sellers to locate each other*
- *Standardized and consistent nutrient loading estimation methods for all users*
- *A readily accessible record of trades*

The tool consists of user-friendly screens to: 1) estimate their existing load, 2) explore pollutant reduction options, and 3) buy or sell the credits. Using a series of maps on the computer screen, users can quickly and easily locate their farm or facility within a given watershed. Based upon the location information along with a series of questions about the farm or facility, the system provides an estimate of the user's existing nutrient loadings. Having the knowledge about their existing loadings, the user can then investigate various reduction options and their likely costs to determine the most economical reduction strategy for their situation. After selecting a management strategy, the user is given an estimate of the number of nutrient reduction credits available for trading. These credits can then be posted on the website as available for sale. On the other hand, the prospective buyers can either respond to the offer to buy the credits available or they can post their nutrient credit needs on the NutrientNet marketplace. The tool supports trading programs in the Kalamazoo River Watershed of Michigan and the Chesapeake Bay Watershed. These include projects in the Susquehanna and Conestoga watersheds of Pennsylvania and the Potomac watershed of Pennsylvania, Virginia, West Virginia, Washington D.C., and Maryland.

7.2. WRI Spreadsheets

In addition to NutrientNet, the WRI, in consultation with the Agricultural Workgroup, has developed standardized credit estimation spreadsheet programs (Figure 3) in Excel. These programs estimate nutrient reduction credits from different agricultural BMPs based on the Pennsylvania Department of Environmental Protection (Penn DEP) nutrient trading policies. These spreadsheets will be available on the NutrientNet website as well as the Penn-DEP website. Users will be able to submit spreadsheets to the Penn-DEP for review along with other items needed in the proposal to generate credits.

For the next phase of the development, WRI intends to incorporate the Excel spreadsheets into NutrientNet. The GIS mapping interface of the NutrientNet will provide underlying spatial information needed to estimate nutrient loadings, such as Chesapeake Bay Model delivery factors and soil type. The WRI also plans to integrate a previously developed credit estimation tool for point sources into NutrientNet. This integrated tool will thus allow both point sources and non-point sources to estimate the credits they could have available for sale or the credits needed to purchase in order to meet their regulatory requirements. In addition, the non-point sources could use this tool to estimate the credit that could be generated by adopting one or more BMPs within the Pennsylvania Trading Policy.

7.3. Nitrogen Trading Tool (NTT)

The Nitrogen Trading Tool (Figure 4) is being developed by the West National Technology Support Center of the NRCS/USDA to support water quality trading.

Although it is only currently being implemented for nitrogen, its generic structure would lend itself easily for other pollutants such as phosphorus or sediments. The Nitrogen Trading Tool estimates pollutant reduction under combination of field and farm level conservation practices also referred to as BMPs. The pollutant reduction can then be used to estimate tradable credits based upon the local conditions and regulations. Field level practices deal with fertilizer management (quantity, type, timing, method of application), irrigation management, and tillage management for cropping systems of the region. On the other hand, the farm level practices are structural activities such as riparian buffers, wetlands, etc. that control pollutants flow to waterbodies.

The NTT is a web-based system with an easy to use interface. The user starts by selecting the state, county, and a weather station nearest and representative to the farm location. Based upon these selections, a list of cropping systems along with their tillage management, irrigation management, and nitrogen input management are identified and presented to the user to choose the baseline and alternative options that he/she wants to evaluate. The management choices along with the sitespecific soil and weather information are inputted into the Nitrogen Leaching and Environment Assessment Program (NLEAP) (Delgado and Shaffer, 1998) that simulates the flux of the nitrogen in the system to predict nitrogen losses through different pathways both for the baseline and alternative scenarios.

The NLEAP simulations are run on a daily basis for 24 continuous years. The first 12 years of the simulations are used to stabilize the system, and the last twelve years are used for analyzing the effects of different management scenarios. The nitrogen losses through different pathways, such as volatilization, leaching, runoff, and emission, are presented both for the base and alternative scenarios. The positive difference between the base and alternative scenarios represents the reduction in N losses by adopting the alternative management over the base scenario. This reduction can be translated into the nitrogen credits, which can be traded in the water quality market. However, the actual units of tradable credits from this reduction will depend upon the local rules and regulations and trading ratios adopted by the trading program. In addition to the biological active nitrogen (sum of nitrogen leached, volatilized, and lost to runoff), the NTT also presents the savings in the nitrogen emitted in the form of nitrous oxide (N_2O) that can be traded in the air quality market. Unlike other nitrogen oxides, N_2O is a major greenhouse gas. While its radiative warning effect is substantially less than CO_2, nitrous oxide's persistence in the atmosphere when considered over 100 years period, per unit of weight, has up to 310 times more impact that per mass unit of CO_2 (Jevtovic-Todorovic, et. al, 2003 and USEPA, 2002)

8. Concluding Remarks

Water quality trading is an innovative, market-driven approach for improving water quality in a watershed framework. With this approach, the public and private partners work together constructively to achieve important ecological objectives. It is a mechanism for public and private investors to strategically focus resources to produce the greatest public benefits at the lowest cost; thus, resulting in the greatest ecological returns

for the investments in resource conservation. It provides incentive for those who have access to low cost pollution reduction options to reduce their nutrient loads beyond what is required of them. They can then sell their excess credits to others who are unable to make reductions because of higher costs. It greatly reduces the cost of improving water quality. To achieve these goals, we need functional and robust tools and approaches with high degree of transferability across the nation. As we move towards a new generation of environmental and economic challenges, it is important to work collaboratively to build tools that link farmers, foresters, municipalities, businesses and industries, and urban residents toward common and mutually supportive goals of ecological stewardship. These tools can evaluate and quantify benefits of conservation practices on the overall environment quality including water resources. The market-based approach to natural resource conservation is a step in this direction. It will help us meet our goals in a way that maximizes benefits for the entire ecosystem. The benefits can be translated into monetary values that can be traded in the market. Tools such as NTT by the NRCS and Nutrient.Net by the World Resources Institute are specific examples of such efforts.

Table 1: Added (environmental) benefits of agricultural practices in water quality credit trading

Environmental Benefits	WWTP Upgrade	Agricultural Practices
Pollutant of Concern	Yes	Yes
Other Pollutant	?	Yes
Habitat	No	Yes
Canopy / Thermal	No	Yes
Stream bank protection	No	Yes
Velocity	No	Yes
Wetland	No	Yes
Floodplain	No	Yes
Assimilative Capacity	No	Yes

WWTP – Waste Water Treatment Plan

Table 2: Nutrient Reduction Costs for Chesapeake Bay (USEPA, 2007)

Conservation Activity	Phosphorus ($/lb)	Nitrogen ($/lb)
Municipal waste treatment	$4.78-$105.67	$5.73-$10.78
Conservation Tillage	$7.39	$1.59
Agricultural Grass Buffer	$20.69	$1.03
Animal Waste Management/Runoff Control	$30.55	$3.93

References:

AgriPulse. 2007. USDA advances habitat credit trading, providing more incentives. AgriPulse Communication Inc. Vol. 3, No. 16. April 18, 07

CTIC. 2006. Getting Paid for Stewardship: An Agricultural Community Water Quality Trading Guide" of the Conservation Technology Information Center (CTIC), 1220 Potter Drive, West Lafayette, IN, July 2006 based upon a study funded by the U.S. Environmental Protection Agency

Delgado, J.A., M. Shaffer, and M. K. Brodahl. 1998. New NLEAP for Shallow and Deep Rooted Rotations—Integrated agriculture in the San Luis Valley of South Central Colorado. J. Soil and Water Conservation. 53(4) 328-340.

Jevtovic-Todorovic V, Beals J, Benshoff N, Olney J (2003). "Prolonged exposure to inhalational anesthetic nitrous oxide kills neurons in adult rat brain". *Neuroscience* **122** (3): 609-16

ODEQ. 2006. Willamette Basin TMDL. Oregon Department of Environmental Quality, Portland, Oregon

PADEP (Pennsylvania Department of Environmental Protection). 2006. Ag Workgroup Status Report. June 19, 2007.

USDA. 2007. Transcript of remarks by Agricultural Secretary Mike Johanns to the American Water Resources Association. Release No. 0011.07. Arlington, VA, January 23, 2007.

USEPA. 2002. Greenhouse gases and global warming potential values – Excepts from the inventory of the US Greenhouse Emissions and Sinks: 1990-2000. US Greenhouse Gas Inventory Program, the Office Of the Atmospheric Programs. April 2002.

USEPA. 2007. Water Quality Trading Toolkit for Permit Writers. Office of Water Management, Water Permit Division. EPA 833-R-07-004, August 2007.

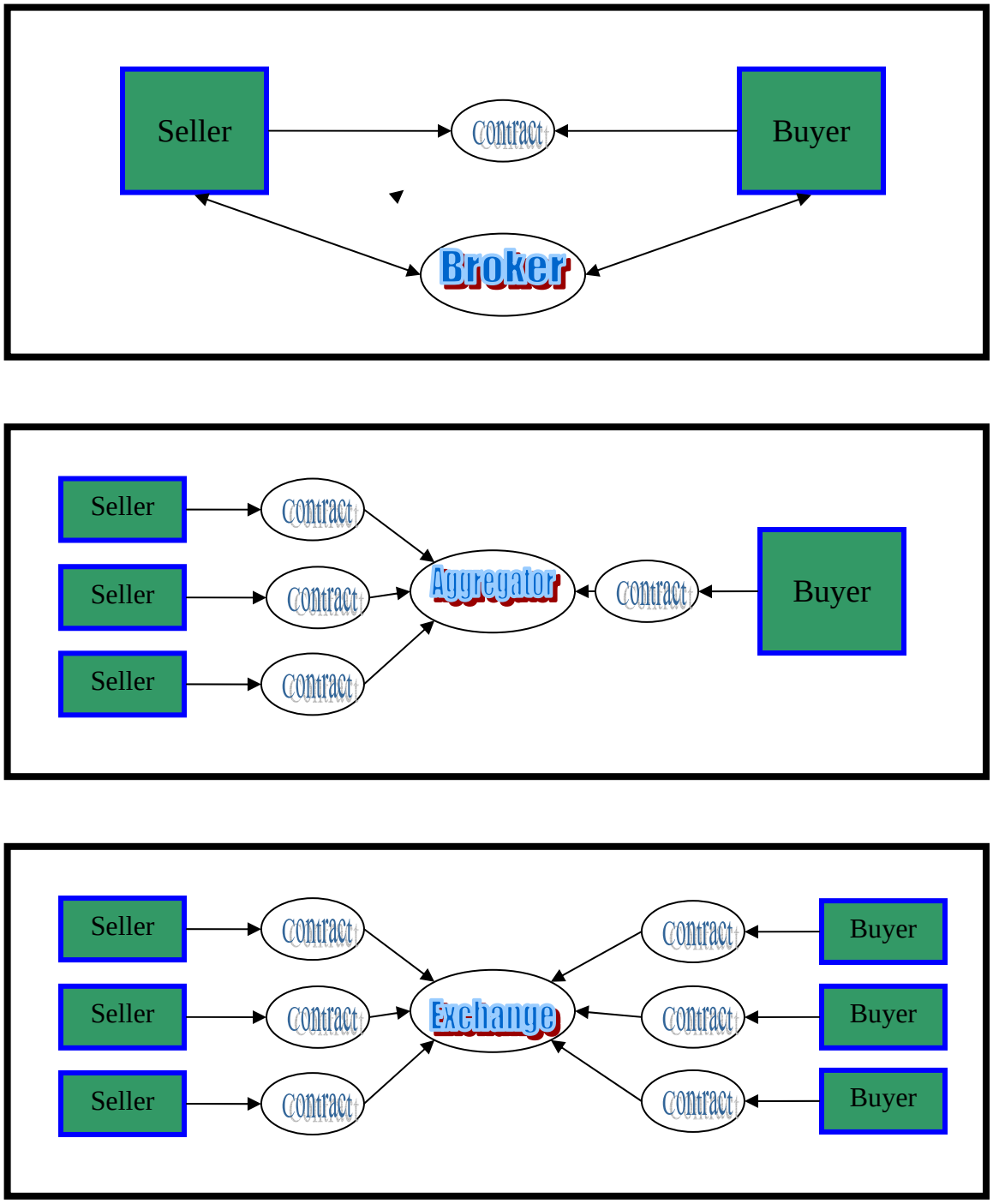


Figure 1. Key Players in Water Quality Trading.

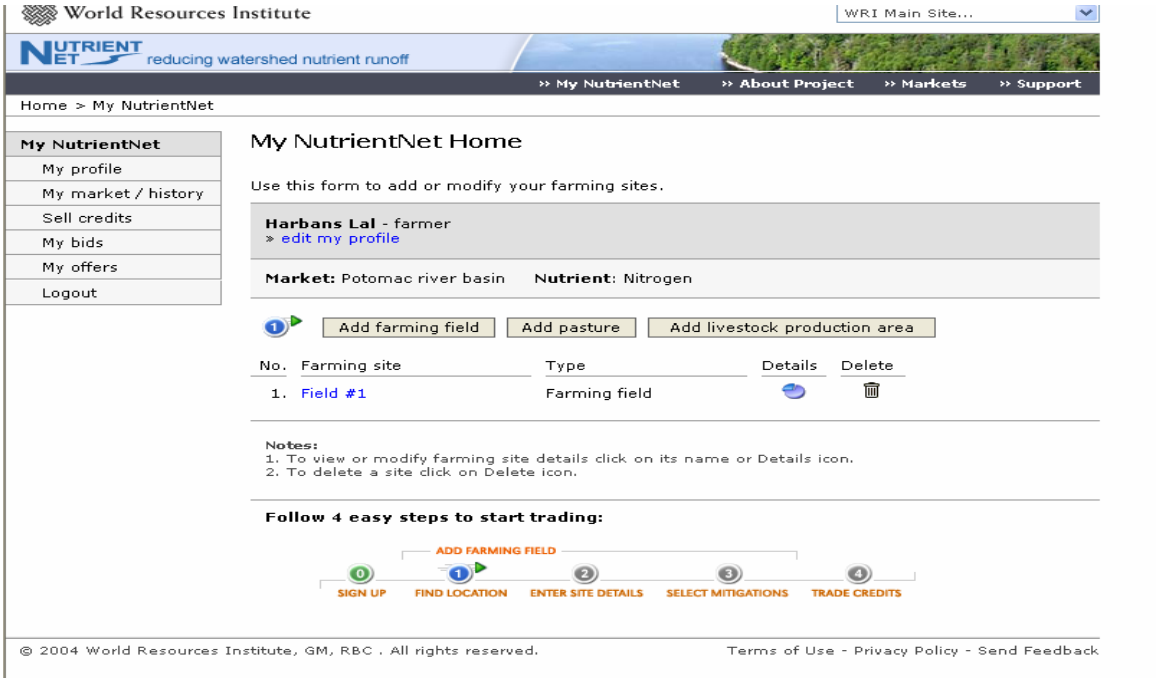
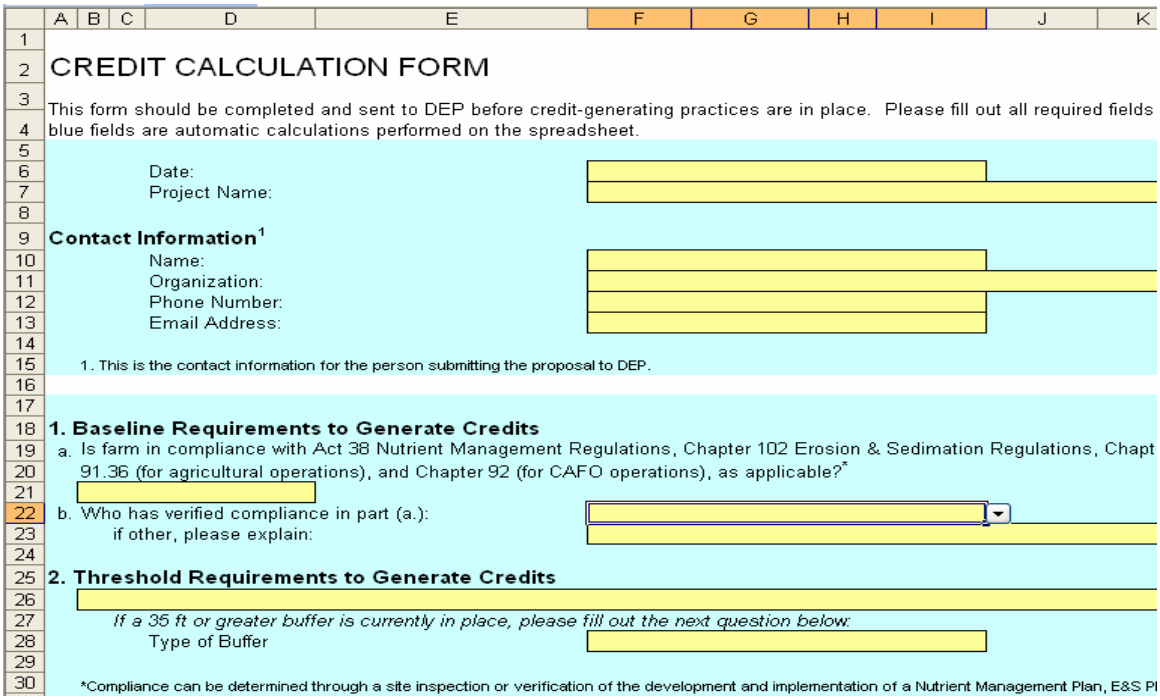


Figure 2. NutientNet, A web-based system by World Resources Institute



CREDIT CALCULATION FORM

This form should be completed and sent to DEP before credit-generating practices are in place. Please fill out all required fields blue fields are automatic calculations performed on the spreadsheet.

Date:
Project Name:

Contact Information[1]
Name:
Organization:
Phone Number:
Email Address:

1. This is the contact information for the person submitting the proposal to DEP.

1. Baseline Requirements to Generate Credits

a. Is farm in compliance with Act 38 Nutrient Management Regulations, Chapter 102 Erosion & Sedimation Regulations, Chapt 91.36 (for agricultural operations), and Chapter 92 (for CAFO operations), as applicable?*

b. Who has verified compliance in part (a.):
if other, please explain:

2. Threshold Requirements to Generate Credits

If a 35 ft or greater buffer is currently in place, please fill out the next question below:
Type of Buffer

*Compliance can be determined through a site inspection or verification of the development and implementation of a Nutrient Management Plan, E&S Pl

Figure 3. N-Credit Calculator by World Resources Institute, Washington D.C.

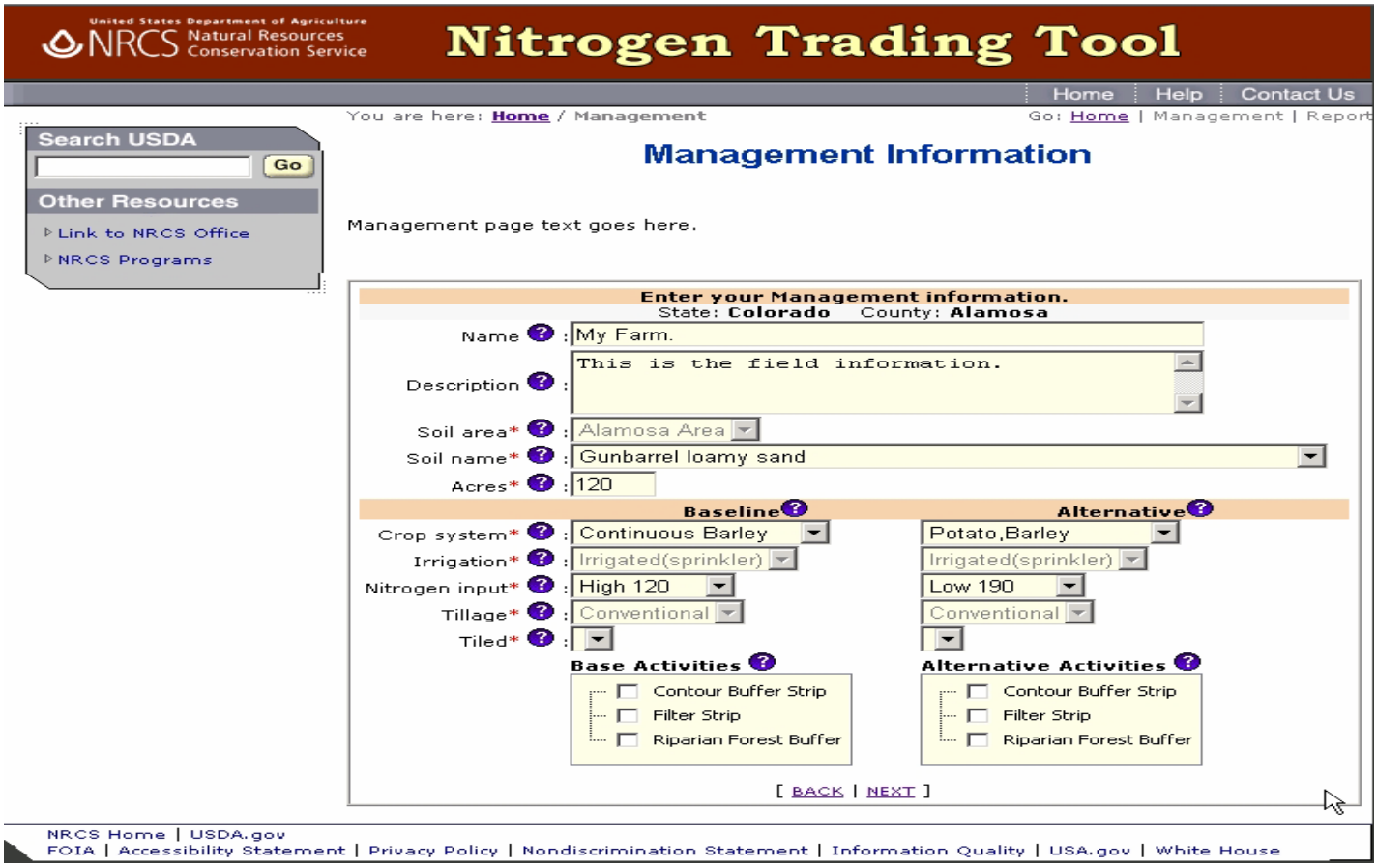


Figure 4. The Nitrogen Trading Tool (NTT) being developed by the USDA-NRCS