OBSTACLES & OPPORTUNITIES FOR WATER QUALITY TRADING IN THE LONG ISLAND SOUND WATERSHED

NOVEMBER 2021

NEIWPCC is a regional commission that helps the states of the Northeast preserve and advance water quality. We engage and convene water quality professionals and other interested parties from New England and New York to collaborate on water, wastewater, and environmental science challenges across shared regions, ecosystems, and areas of expertise.

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PROJECT TEAM:

NEIWPCC
Emma Gildesgame | Environmental Analyst, Project Manager
Richard Friesner | Director of Water Quality Programs
Jane Stahl | Connecticut Commissioner

Footprints in the Water LLC
Paul Stacey | Owner, Principal Scientist

Rbouvier Consulting
Rachel Bouvier | President, Principal Economic Investigator
Joie Grandbois | Research Associate
Averi Varney | Research Assistant
Claire James | Research Assistant

The project team also appreciates the input and guidance of Bessie Wright, EPA Project Officer.

This report was written and reviewed by NEIWPCC staff; references to and inclusion of reports by the rest of the project team do not imply their approval of this final document or its findings.

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EXECUTIVE SUMMARY

In 2020, NEIWPCC began work on an exploratory study into the opportunities and obstacles to expanding water quality trading to further improve water quality and ecosystem health in the Long Island Sound watershed.This project supports the Long Island Sound Study (LISS) in implementing their Comprehensive Conservation and Management Plan (CCMP). LISS is committed to reducing nutrient pollution in the Sound as part of their work towards clean waters and healthy watersheds.

NEIWPCC convened an interdisciplinary team to identify opportunities, obstacles, and potential innovative approaches to build on the success of existing point source nutrient trading programs in the region, notably Connecticut's successful Nitrogen Credit Exchange. This team of ecologists, economists, and policy experts explored the issue from many perspectives to analyze how an expanded trading program could support LISS goals.

The study findings are clear: **expanded water quality trading is unlikely to be an effective tool to meet water quality goals under current ecological, economic, and regulatory conditions in the Long Island Sound watershed.**

Lack of Regulatory Drivers: Nutrient trading relies on a clear driver, usually regulatory, to create demand for trading credits. The existing Nitrogen Credit Exchange successfully helped wastewater treatment facilities meet and exceed the reductions required in their waste load allocations under the 2002 LIS nitrogen TMDL. Likewise, most point sources across the LIS watershed discharge nitrogen well within their applicable regulatory limits, providing no clear driver for expanded participation in nutrient trading.

Market is Unsupported: Without a clear regulatory driver, there is insufficient demand for nutrient reduction credits to support a trading program. Without adequate demand, there is no financial incentive for dischargers to reduce "extra" pollution to generate credits.

Limited Water Quality Capacity: Many streams across Connecticut and the Long Island Sound watershed are already stressed by nutrient loading and other factors linked to development. These stressed streams do not currently have the capacity to generate trading credits without sacrificing ecological integrity or creating pollution hotspots.

Organizational Capacity: Successful water quality trading relies on a strong network of potential partners to build support for and manage the trading program. The Long Island Sound Study, NEIWPCC, state agencies, and existing networks across the region have a long history of the types of successful collaboration and leadership which could support an expanded trading program under different regulatory and water quality conditions.

Though this comprehensive analysis found extremely limited potential for expanded water quality trading to meet current LISS goals, changes to the regulatory or ecological conditions in the watershed may create favorable trading conditions in the future. Such changes could include reevaluated standards and water quality goals focused on ecosystem function and capacity and/or expanded regulatory, financial, or political incentives to participate in trading.

However, trading is just one tool of many available and must be considered within the context of other available tools to support water quality improvements in Long Island Sound. Even under conditions more favorable to trading, this evaluation suggests that reducing pollutants from the source may be a more efficient and cost-effective strategy to meeting LISS goals.

CONTENTS

CAN NUTRIENT TRADING HELP MEET LISS GOALS?

In 2020, NEIWPCC began work on an exploratory study into the potential for expanded nutrient trading to further improve water quality and ecosystem health in the Long Island Sound watershed. Of particular interest were the obstacles and opportunities to expand trading to include non-point source discharges or interstate trading.

In their 2015 Comprehensive Conservation and Management Plan (CCMP), the Long Island Sound Study (LISS) committed to “reduce contaminant and nutrient loads from point and nonpoint sources” in support of clean waters and healthy watersheds (Long Island Sound Study 2015). LISS developed an extensive series of implementation actions to guide work towards the targets and goals of the CCMP.

This project supports implementation action (IA), WW-3, to explore the expansion of point source and nonpoint source nutrient trading programs for the Long Island Sound watershed. (Long Island Sound Study 2014). This implementation action seeks to build on the success of existing point source nutrient trading programs in the region, notably Connecticut’s Nitrogen General Permit and Nitrogen Credit Exchange Program. Since 2002, the Connecticut Nitrogen Credit Exchange (NCE) has provided an efficient and cost-effective trading program for

Connecticut sewage treatment plants to reduce their nitrogen loads to the Long Island Sound (CT DEEP 2021) .

The goal of this project is to identify opportunities, obstacles, and potential innovative approaches to expanded water quality trading. A team of ecologists, economists, and policy experts conducted a comprehensive review of existing trading programs, environmental data, and economic research to analyze how an expanded trading program could work in the context of the LIS watershed's economic and ecosystem conditions.

This interdisciplinary team explored the issue from many perspectives and came to a common conclusion: **expanded water quality trading is unlikely to be an effective tool to meet water quality goals under current ecological, economic, and regulatory conditions in the Long Island Sound watershed.**

The reports for this project synthesize research, case studies of water quality trading programs, and local data to identify key elements of successful water quality trading program and evaluate the feasibility of expanded trading for the Long Island Sound watershed.

A. **Lessons from Water Quality Trading Case Studies** is a literature review focused on research and case studies of water quality trading programs from across the United States and around the world. (Mascia and Gildesgame 2021)
B. **Water Quality Trading in The Long Island Sound Study Area: A Preliminary Look at Some Economic Issues** is a literature review focused on the economic decisions and conditions that lead to successful trading programs. (Bouvier 2020)
C. **Summary of Interviews with Selected Trading Programs and Individuals** provides insights from trading program managers, economists, and policymakers involved with active trading programs. (Bouvier 2021)
D. **Feasibility Of Point-Nonpoint Nutrient Trading In The Long Island Sound Watershed** applies the lessons summarized in the economic issues and interview reports and applies them to evaluate the potential for water quality trading within the LIS watershed. (Bouvier et al. 2021)
E. **An Alternative, Ecosystem-Based Analytical Platform to Test and Facilitate Water Quality Trading** evaluates an innovative approach to water quality trading which focuses on biointegrity and ecosystem-based management to improve water quality. (Stacey 2021)

In addition to the reports listed above, the findings described here are informed by extensive discussions by the project team over the course of the 18-month project period. The project team includes Emma Gildesgame (NEIWPCC), Richard Friesner (NEIWPCC), Jane Stahl (NEIWPCC Commissioner), Raphaella Mascia (NEIWPCC), Rachel Bouvier (rbouvier consulting), Joie Grandbois (rbouvier consulting), Averi Varney (rbouvier consulting), Claire James (rbouvier consulting), Paul Stacey (Footprints in the Water), and Bessie Wright (EPA Project Officer).

Throughout this report, key terms are identified with a double underline. Refer to the glossary at the end of this document for definitions and more information on these important terms and concepts.

WHAT DOES SUCCESSFUL TRADING LOOK LIKE?

Water quality trading is a market-based system in which pollution reduction credits are bought and sold as a cost-effective tool to reach environmental goals. Trading takes advantage of the varied costs associated with pollution reductions from different sources. For example, it may be less expensive for a farmer to implement practices that reduce nutrient pollution than it is for a wastewater treatment plant to upgrade infrastructure to achieve equivalent reductions. In this case, the treatment plant can purchase reduction credits from the farmer to meet their permit requirements.

Nutrient trading can be an effective tool for meeting water quality goals under a specific set of conditions:

- **Program Drivers:** Clear regulatory, economic, or social drivers which create demand for trading credits and establish clear program goals. Of these drivers, regulatory requirements like permits, TMDLs, or trading caps are often the most effective.
- **Market capacity:** A watershed-based market with sufficient demand for and supply of nutrient credits. This is often facilitated when different dischargers face varying costs of compliance with water quality requirements, setting up potential cost savings through trading.
- **Water quality capacity:** Tributaries and subwatersheds in the region have sufficient water quality to participate in trading without creating localized pollution hotspots.
- **Organizational capacity:** There is a strong network of potential partners and existing, related work (i.e. water quality monitoring and stakeholder engagement) to support and oversee the trading program; barring that, there is a potential leader with the capacity to build that network.

Once it has been established that a trading program has the potential to be an effective tool for a watershed through an evaluation of the above basic elements, program managers must carefully craft a watershed-specific trading program that is tailored to the regulatory, economic, environmental, and social conditions of the region.

There are several common factors that tend to support successful water quality trading programs: simplicity, low barriers to entry, flexibility for participants, accountability, transparency, and effective risk management. Additionally, trading programs are more successful when they recognize co-benefits, allowing participants to generate credits across numerous markets (i.e. allowing a riparian buffer reforestation project to earn credits in both water quality and carbon reduction markets) (Mascia and Gildesgame 2021).

Developing a successful trading program requires a careful balancing act between program features which ensure environmental benefits and those which maximize economic benefits and lead to an active trading program. Decisions around baselines, trade ratios, the approach to risk management, and the size and scope of the market all have profound effects on the ability of a trading program to successfully meet its goals.

For example, dischargers must reduce pollutant loads below an established baseline before they're able to generate credits to trade and must purchase credits when their discharge levels are above the baseline. Less stringent baselines allow for more trading activity and make it easier for participants to generate salable credits, while more stringent baselines provide more assurance that water quality will improve and can increase demand for credits.

The literature reviews and interview summary associated with this project (resources A, B, and C above) each provide additional information on features and factors that lead to successful trading programs. However, it is important to note that "success" is a hard term to define in water quality trading – though each program defines success differently, there are very few examples of programs which have successfully encouraged robust trading, incentivized conservation funding, or been directly linked to water quality improvements, especially in the context of trading between point and nonpoint sources (Bouvier 2021).

Potential for Expanded Trading is Currently Limited

The team's extensive research drew a clear conclusion: **expanded trading is unlikely to be the best tool to meet water quality goals for Long Island Sound under current conditions.** Companion reports by rbouvier consulting and Footprints in the Water provide supporting information related to the potential to expand the current CT NCE market beyond Connecticut, expand to non-point sources, and expand the trading program to an ecosystem-based approach.

Lack of Regulatory Drivers

The existing Nitrogen Credit Exchange successfully helped wastewater treatment facilities meet and exceed the reductions required in their waste load allocations under the 2002 LIS nitrogen Total Maximum Daily Load (TMDL). Likewise, most point sources across the LIS watershed discharge nitrogen well within their applicable regulatory limits, providing no clear driver to participate in trading.

Market is Unsupported: Lack of Demand, Uncertain Credit Supply

Without a clear regulatory driver, there is insufficient demand for credits to support a trading program which would improve water quality. Without adequate demand, potential credit generators have limited financial incentives to participate in a trading program.

Though supply of potential credits appears to exceed the (limited) demand, there are several issues which may affect the stable supply of nutrient credits in the LIS watershed. Most examples of successful point-nonpoint trading rely on nutrient reductions from agricultural land, which is declining throughout the LIS watershed, reducing potential supply of credits. While there is potential for this decline to be balanced by the growth of seaweed and shellfish aquaculture within the Sound, credit prices must be high enough to attract aquaculture operators to the market.

Additionally, technologies to reduce discharges from wastewater treatment plants continue to improve and become more affordable. In many cases, upgrades are more cost-effective than installing and maintaining best management practices which reduce NPS pollution. This makes trading less attractive, as it is often easier and less expensive for point sources to upgrade their facilities than participate in a trading program (Bouvier et al. 2021). Generally, source reductions are becoming more economically efficient, providing alternative options to reduce costs of compliance with Clean Water Act requirements.

Limited Water Quality Capacity

While expanding the geographic scope of a water quality trading program could increase demand for credits, trades across larger geographic areas must be "carefully vetted to ensure that they do not adversely affect water quality in one geographic area" (Bouvier et al. 2021).

Many streams across Connecticut and the Long Island Sound watershed are already stressed by nutrient loading and other factors linked to development. These stressed streams do not currently have the capacity to generate trading credits without sacrificing ecological integrity or creating pollution hotspots. An ecosystem management scenario which improves water quality enough to make trading feasible may "exceed a plausible Best Attainable Condition." (Stacey 2021).

Barriers to Interstate Trading

There are many ecological, legal, and logistical challenges inherent in establishing an interstate water quality trading program. State agencies within an interstate trading program must come to consensus on definitions of credits, use of consistent and shared water quality data and models, and formal, legal agreement on trading structure and frameworks. The process of overcoming these challenges requires extensive administrative oversight and associated costs (Bouvier et al. 2021). As noted in Lessons from Water Quality Trading Case Studies, high administrative and transaction costs can make trading programs less feasible (Mascia and Gildesgame 2021).

As noted above, trades across large geographic boundaries come with risks of pollution hotspots and unequal or ineffective pollution reductions. However, a trading program which sets agreed upon, binding targets for subwatersheds that cross state lines may facilitate interstate trading within small watersheds.

Strong Organizational Capacity

There are strong existing networks throughout the region which could support an expanded trading program under different regulatory and water quality conditions. The Long Island Sound Study, NEIWPCC, state agencies, nongovernmental organizations, academic institutions, and other partners across the region have a long history of the types of successful collaboration and leadership essential for successful trading.

Under Different Conditions, Trading Could Be Reevaluated

Though this study found that the current watershed conditions are not conducive to successful trading, the team identified several opportunities under which trading may become a feasible tool to meet LISS goals.

Successful trading programs rely on the type of strong partnership structures already in practice though the Long Island Sound Study management structure. As conditions change in the watershed, the CCMP and adaptive management processes already in place will play an important role in reevaluating whether and how expanded trading could be successfully employed.

Many of the changes needed to support expanded trading for LIS require regulatory changes, political support, financial investment, and/or management of significant logistical challenges. Though trading may be feasible under these conditions, additional analysis would be needed to establish the appropriate trading structures and systems to meet LISS goals. The component reports of this study could provide important context and background information to aid in that process.

A Strong Scientific Foundation

Any approach to water quality trading must be developed with explicit goals related to environmental integrity and water quality. LISS' vision of a restored and protected Long Island

Sound goes beyond nutrient load reductions. The themes of the CCMP call on LISS to use sound science and inclusive management to work towards clean waters and healthy watersheds, thriving habitats and abundant wildlife, and sustainable and resilient communities.

Though current nitrogen limits are largely being met, hypoxia and other nutrient-based water quality concerns persist in LIS. Revised ecosystem targets developed to support the LISS CCMP should be based on holistic ecosystem health approaches and rooted in the latest scientific understandings and tools.

Ecosystem Health as a Watershed Target

The Decision Support Framework (DSF) described in Footprints in the Water's component report for this project (Stacey 2021) is a promising tool with the potential to easily conduct watershed evaluations, set science-based trading caps and watershed targets, test management scenarios, and identify water quality trading potential based on biological integrity outcomes. This tool also allows trading program managers to set watershed targets for individual segments and larger portions of the watershed.

Under a trading program focused on ecological integrity, credits can only be generated once an individual watershed has met a biointegrity target. Under current conditions, most watersheds in the region are unlikely to be able to meet these targets without significant recovery of natural systems.

Consistent Regional Data

If modified regulatory conditions (as described below) make expanded trading a feasible tool to achieve LISS goals, watershed entities who will be involved with trading must come to consensus on a single watershed model with agreed-upon delivery factors[1] and trade ratios, source definitions, and BMP tracking systems to consistently define credits.

The DSF (Stacey 2021) could provide an analytic platform to streamline these efforts. The tool makes it simple to develop enrichment factors[2] and develop nutrient trading focused on biointegrity goals.

Current work underway to develop a nitrogen reduction tracking and accounting tool for LISS could also play a critical role in this regionally consistent approach.

Stronger Regulatory Drivers

Currently, a lack of clear regulatory driver is the primary barrier to expanding water quality trading for LIS. Existing programs have achieved significant progress in reducing nitrogen pollution and improving water quality in the Sound. Point sources in the watershed comply with the requirements of the 2002 TMDL, and there is no other direct driver for point sources or nonpoint sources to enter a trading market.

Revisit Regulatory Requirements

Over the last few decades, we've seen significant improvements in water quality and ecosystem health in the Long Island Sound, but there is still much progress needed to achieve the CCMP's

[1] Delivery factors are a measure of how much a discharged pollutant is attenuated by filtration, absorption, or other process between its discharge point in the watershed and the receiving water of interest. They are frequently used to calculate trade ratios.

[2] Enrichment factors are the amount of total nitrogen relative to a natural state in the ecosystem. It is calculated as the current TN yield divided by an estimated natural TN yield (Stacey 2021).

vision and goals for clean waters and healthy watersheds. This is especially true considering the increasing and threat-multiplying effects of climate change and increasing development on our ecosystems. An approach that evaluates watershed goals in the context of ecosystem function could help set appropriate watershed targets in support of LISS goals. One such approach is the DSF described in Component Report E of this project. Adaptive management towards more stringent regulatory limits, including a revised TMDL targeted towards sustainable ecosystem health and biointegrity goals, could create enough demand to support an expanded water quality trading market.

Additionally, there may be potential for a phosphorus trading program between point sources in the upper states of the Long Island Sound Watershed. However, this would require the introduction of some regulatory driver to induce trading (Bouvier et al. 2021).

Expand the Regulated Community

In addition to regulatory drivers set by TMDLs, other federal and state programs working towards clean water could set regulatory drivers which encourage trading and improved water quality. Increasing the number of regulated entities could create more demand for water quality credits and provide additional sources of credit supply, increasing the likelihood of a successful trading market.

This could include binding targets or reduction incentives through Clean Water Act programs including TMDLs, NPDES and MS4 permitting, and the 319 grant program, agricultural programs, or other programs focused on nonpoint source pollution reduction.

This expansion is consistent with EPA's 2020 white paper "Water Quality Trading on a Watershed Scale", which encourages programs to work towards complementary policies across jurisdictions and alignment across regulatory programs. Notably, EPA recommends that "trading program managers consider regulatory or policy modifications where necessary" in watersheds that cross political boundaries, including the establishment of watershed-based permits that as a "more efficient approach to facilitate cross-boundary trading than coordinating trading policies or regulations across jurisdictions" (EPA 2020).

Expanding the current Connecticut Nitrogen Credit Exchange or developing a new trading program which includes these partners would require extensive communication and collaboration between federal, state, and local agencies working towards clean water. Any efforts to expand the regulated community must be carefully managed to ensure additionality: that credits generated reflect additional reductions above and beyond those included in existing discharge reduction programs like those managed by the Natural Resources Conservation Service.

In some cases, these changes would require policy changes or changes to the Clean Water Act, which is a major obstacle in our current political reality.

Address Atmospheric Nitrogen Deposition

Atmospheric nitrogen deposition contributes approximately 31% of the nitrogen load to Long Island Sound (Bouvier et al. 2021). Most atmospheric nitrogen is produced by combustion of fossil fuels for power generation, transportation, and industry. While no known water quality trading programs currently work across media to include atmospheric deposition, there may be potential to explore air-water trading programs which address nitrogen pollution.

As these emissions are also of concern for climate trading markets, an innovative trading program could be developed to allow credit stacking or direct trading between air quality and water quality markets. However, any efforts to do so must be done with extreme care to set appropriate trade ratios and ensure additionality.

Trading as One Tool to Meet Water Quality Goals

Water quality trading can be an effective tool to achieve water quality goals under the right conditions, and establishment of a water quality program should not be considered a standalone goal.

Though this extensive analysis found extremely limited potential for expanded water quality trading to meet current LISS goals, changes to the regulatory or ecological conditions in the watershed may create favorable conditions for expanded trading. This could include reevaluated standards and water quality goals focused on ecosystem function and capacity and/or expanded regulatory, financial, or political incentives to participate in trading. LISS' existing organizational and scientific capacity could play a critical role in overcoming existing obstacles and set strong, science-based foundations for a trading program.

However, trading is just one tool of many available and must be considered within the context of other available tools to support water quality improvements in Long Island Sound. Even under conditions more favorable to trading, this evaluation suggests that "the effort and cost necessary to expand trading in the LIS watershed would be more appropriately channeled into reducing pollutants at the source…" (Bouvier et al. 2021).

To learn more about the analyses conducted in support of this project, refer to each component report and NEIWPCC's project webpage.

A. Lessons from Water Quality Trading Case Studies (Mascia and Gildesgame 2021)
B. Water Quality Trading in The Long Island Sound Study Area: A Preliminary Look at Some Economic Issues (Bouvier 2020)
C. Summary of Interviews with Selected Trading Programs and Individuals (Bouvier 2021)
D. Feasibility Of Point-Nonpoint Nutrient Trading in The Long Island Sound Watershed (Bouvier et al. 2021)
E. An Alternative, Ecosystem-Based Analytical Platform to Test and Facilitate Water Quality Trading (Stacey 2021)

KEY TERMS

ADAPTIVE MANAGEMENT

Adaptive management is an iterative learning process structured to improve management outcomes. It can promote "flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood." (Williams, Szaro, and Shapiro 2009, v) As trading programs must be customized to each individual watershed and inherently include significant uncertainty, adaptive management is an important tool to support successful trading programs.

Source: Williams, B. K., Szaro, R. C., & Shapiro, C. D. (2009). *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Adaptive Management Working Group, U.S. Department of the Interior. https://www.doi.gov/sites/doi.gov/files/migrated/ppa/upload/TechGuide.pdf

ADDITIONALITY

Duke et al. (2014) define additionality as the idea that an introduced management practice provides an ecosystem service (i.e., nutrient load reduction or carbon sequestration) that currently is not provided or would not have been provided in the absence of the management action. Further, they define Nonadditionality as "an ecosystem service provided prior to the policy, but that is claimed to be an environmental-improvement outcome of the policy." Environmental quality can decrease if policymakers allow these nonadditional "reductions" to be traded as offsets and then emitted by another source.

Source: Duke, J. M., McGrath, J., Fiorellino, N. M., Monteith, T., & Rosso, E. (2014). *Additionality in Water Quality Trading: Evidence from Maryland's Nutrient Offset Program* (APEC RR14-06). Applied Economics and Statistics, Department of Delaware.

CO-BENEFITS

Within the context of a water quality trading program, co-benefits refer to the non-water quality benefits generated from measures taken to reduce pollutant discharges (Gasper, Selman, and Ruth 2012, 758).

Source: Gasper, R. R., Selman, M., & Ruth, M. (2012). Climate co-benefits of water quality trading in the Chesapeake Bay watershed. *Water Policy*, *14*(5), 758–765. https://doi.org/10.2166/wp.2012.166

Credit Stacking

Credit stacking occurs when trading programs allow co-benefits to be traded across multiple markets. For example, certain nonpoint pollution reduction BMPs also sequester carbon, and may therefore generate credits within carbon or climate-emissions trading markets in addition to water quality trading markets.

Benefits of stacking include the additional financial incentives for nonpoint sources to participate in nutrient trading markets.

Sources:

Bouvier, R. (2020). *Water Quality Trading in the Long Island Sound Study Area: A Preliminary Look at some Economic Issues* (p. 32). rbouvier Consulting; NEIWPCC; LISS.

Gasper, R. R., Selman, M., & Ruth, M. (2012). Climate co-benefits of water quality trading in the Chesapeake Bay watershed. *Water Policy*, *14*(5), 758–765. https://doi.org/10.2166/wp.2012.166

Hotspots

Hotspots are areas where discharges from a credit buyer inadvertently cause a localized pollution problem (EPA 2008, 35/ 3-9). Hotspots are often linked to concerns over environmental justice, as point sources are often sited in minority and/or low-income communities. If these point sources offset on-site discharges with off-site credits, nearby communities would face disproportionate impacts of pollution. (Bouvier 2020, 23; Steinzor et al. 2012)

Sources:

EPA. (2008). *EPA Water Quality Trading Evaluation: Final Report*. 90. https://www.epa.gov/sites/default/files/2016-04/documents/wqt.pdf

Bouvier, R. (2020). *Water Quality Trading in the Long Island Sound Study Area: A Preliminary Look at some Economic Issues* (p. 32). rbouvier Consulting; NEIWPCC; LISS.

Steinzor, R. I., Verchick, R. R. M., Vidargas, N. W., & Huang, Y. (2012). Fairness in the Bay: Environmental Justice and Nutrient Trading. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2139116

Trading Caps

A trading cap is a limit on the total amount of a pollutant (i.e., nitrogen) which can be discharged over a specific time period, often a year. These caps can be set by a TMDL, a discharge permit, or other regulatory action and are widely considered to be a main regulatory and economic driver of a successful water quality trading program (Puzyreva, Roy, and Stanley 2019).

In some cases, like the CT Nitrogen Credit Exchange, the cap declines each year to gradually achieve a pollution reduction goal. (Powers 2006)

In a review of six water quality trading programs, Puzyreva et al found that load-based caps are key for successful programs, as “in the case of concentration caps, the wastewater treatment facilities or lagoons may discharge their effluent at times of peak flow (e.g., in the spring) so that

it dilutes to meet the regulated concentration limits on nutrients. This practice may not reduce overall nutrient loading or resulting eutrophication."

Sources:

Puzyreva, M., Roy, D., & Stanley, M. (2019). *Case Study Research on Offsets for Water Quality Management* (Case Study Research on Offsets for Water Quality Management). International Institute for Sustainable Development (IISD); JSTOR. https://doi.org/10.2307/resrep21977.2

Powers, A. (2005). *Connecticut Nitrogen Credit Exchange Program*. 8.

Variable Costs of Compliance

Once a regulation is in place to control discharges of a specific pollutant, dischargers often face widely disparate costs to meet their regulatory requirements. This cost variability provides the main incentive for dischargers to participate in a trading program as it establishes favorable trading opportunities (Jarvie and Solomon 1998). Without variable costs of compliance, there is no feasible market for trading.

Sources:

Jarvie, M., & Solomon, B. (1998). Point-nonpoint effluent trading in watersheds: A review and critique. *Environmental Impact Assessment Review*, *18*(2), 135–157.

Baselines

Baselines serve as the starting point for trading within a water quality market and determine when credits may be generated for trading. Often, this is set based on a TMDL waste load allocation or permitted discharge limit. EPA guidance suggests that "baselines for generating pollution reduction credits should be derived from and consistent with water quality standards." (US-GAO 2017)

Sources:

Ribaudo, M., & Savage, J. (2014). Controlling non-additional credits from nutrient management in water quality trading programs through eligibility baseline stringency. *Ecological Economics*, *105*, 233–239. https://doi.org/10.1016/j.ecolecon.2014.06.017

US-GAO. (2017). *Some States Have Trading Programs to Help Address Nutrient Pollution, but Use Has Been Limited*. US Government Accountability Office.

Woodward, R. T. (2000). Market-Based Solutions to Environmental Problems: Discussion. *Journal of Agricultural and Applied Economics*, *32*(2), 259–266. https://doi.org/10.1017/S1074070800020344

EPA. (2019). *Water Quality Trading Under the National Pollutant Discharge Elimination System Program (FR Notice)* [Federal Register].

Transaction Costs

Transaction costs are those costs associated with administering and managing a trading program. They can include costs of entry into a program (i.e., application fees and requirements), costs of establishing individual trades, program administration and oversight costs, and monitoring and inspection costs to ensure that trading is having the intended environmental results.

Higher transaction costs tend to discourage trading.

Sources:

Bouvier, R. (2020). *Water Quality Trading in the Long Island Sound Study Area: A Preliminary Look at some Economic Issues* (p. 32). rbouvier Consulting; NEIWPCC; LISS.

Jarvie, M., & Solomon, B. (1998). Point-nonpoint effluent trading in watersheds: A review and critique. *Environmental Impact Assessment Review*, *18*(2), 135–157.

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Motallebi, M., Hoag, D. L., Tasdighi, A., Arabi, M., & Osmond, D. L. (2017). An economic inquisition of water quality trading programs, with a case study of Jordan Lake, NC. *Journal of Environmental Management*, *193*, 483–490. https://doi.org/10.1016/j.jenvman.2017.02.039

Puzyreva, M., Roy, D., & Stanley, M. (2019). *Case Study Research on Offsets for Water Quality Management* (Case Study Research on Offsets for Water Quality Management). International Institute for Sustainable Development (IISD); JSTOR. https://doi.org/10.2307/resrep21977.2

Woodward, R. T. (2000). Market-Based Solutions to Environmental Problems: Discussion. *Journal of Agricultural and Applied Economics*, *32*(2), 259–266. https://doi.org/10.1017/S1074070800020344

Trade Ratios

Not all sources of pollution are created equal within a watershed. A discharged pound of nitrogen may impact the receiving water differently based on a multitude of factors, including distance from the water body, geologic and hydrologic conditions in the watershed, discharge types, and others. This attenuation is often measured as a delivery factor, here higher delivery factors refer to lower rates of attenuation. To account for these differences, most trading programs establish trading ratios where not all units of pollution reduction are credited equally.

While reduction in pollution from point sources is easily measurable, reductions for non-point sources can be harder to measure. Consequently, trade ratios for programs which include both nonpoint and point sources must "adjust" the market so point and nonpoint discharges can trade "apples for apples" (Woodward 2000, 262).

Appropriate trade ratios are a critical factor in establishing a successful program and can help address sources of risk within a program. The **bolded** sources below have in-depth discussions on potential factors for consideration in setting trade ratios.

Sources:

Bouvier, R. (2020). *Water Quality Trading in the Long Island Sound Study Area: A Preliminary Look at some Economic Issues* (p. 32). rbouvier Consulting; NEIWPCC; LISS. Section 2: Trading Ratios.

EPA. (2008). *EPA Water Quality Trading Evaluation: Final Report* (p. 90). https://www.epa.gov/sites/default/files/2016-04/documents/wqt.pdf

Water Environment Federation (Ed.). (2015). *Advances in water quality trading as a flexible compliance tool: A special publication*. Water Environment Federation. https://www.e-wef.org/Default.aspx?TabID=251&productId=45390843/. Section 2.3.4: Trading Ratios.

Willamette Partnership, World Resources Institute, & National Network on Water Quality Trading. (2015). Building a Water Quality Trading Program: Options and Considerations. National Network on Water Quality Trading. http://willamettepartnership.org/wp-content/uploads/2015/06/BuildingaWQTProgram-NNWQT.pdf. Section 5.1: Trading Ratios

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