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Water Quality Trading Assessment Handbook:

EPA Region 10's Guide to Analyzing Your Watershed

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Preface

Water quality trading can be a business-like, cost-effective, local solution to problems caused by pollutant discharges to surface waters. Generally, water quality trading (WQT) involves a party facing relatively high pollutant reduction costs who compensates another party to achieve a less costly, pollutant reduction with the same or greater water quality benefit. The concept of using "market-based" innovations is not entirely new, but there have been relatively few successful trades in the U.S. While trading is not a panacea, it can be a useful tool for water quality enhancement in the right circumstances and some dischargers will welcome the flexibility it can provide.

All markets evolve to help fulfill the demands of consumers. Consumers provide producers an opportunity to earn a profit for altering their behavior and attending to the market's constantly changing demands for goods and services. Until a consumer decides she "needs" a soda, and is willing to pay someone to produce it, there is no market for sodas.

Total Maximum Daily Loads (TMDLs) are the leading market drivers for WQT markets today because they potentially create the "need" to alter behavior by reducing pollutant loadings discharged to waterways. TMDLs and similar frameworks are sometimes described as "budgets" for the introduction of pollutants into watersheds. Scientific studies estimate the volume of discharge a specific watershed, or segment of the watershed, can assimilate without exceeding the water quality standards enacted to protect the watershed's designated beneficial use(s). This "pollutant budget" is then allocated across point sources and non-point sources located in the watershed. The allocation of discharge limits forces sources in the watershed to analyze current practices to see if they need to alter their discharging behavior and the associated costs to do so.

The United State Environmental Protection Agency's (EPA's) Region 10 office has taken an active role in exploring the mechanics of water quality trading and developing water quality trading markets in hopes of lowering the cost of improving water quality. For example, working with the Idaho Department of Environmental Quality and a wide variety of stakeholders, Region 10 has been helping dischargers to the Lower Boise River create the detailed knowledge, regulatory framework, and techniques for cooperation needed to achieve phosphorus reductions through trades. Region 10 has also supported trading in the Middle Snake River by preparing model NPDES permits that would facilitate trading by the City of Twin Falls and a local business. In Washington and Oregon, Region 10 is supporting assessments to identify opportunities for individual trades or broader trading markets.

Careful analysis is required to identify watersheds with the combination of characteristics to support cost-effective trading. Region 10 encourages stakeholders to be active in identifying potential new trading markets. To that end, this Handbook is designed to provide you, the watershed participant, with an efficient means to assess your watershed's water quality trading potential and the attractiveness of trading for particular dischargers.

Such an assessment involves several types of analysis. Water quality specialists may need to call on specialists in engineering, finance, and/or regulatory interpretation. This Handbook is intended to help you identify what you need to know, with whom you need to consult, and where you may find the information you need.

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Introduction

In January 2003, the United States Environmental Protection Agency issued a *Water Quality Trading Policy* enabling and supporting the adoption of market-based programs for improving water quality. The policy acknowledges that the progress made towards restoring and maintaining the chemical, physical, and biological integrity of the nation's waters under the 1972 Clean Water Act (CWA) and its National Pollutant Discharge Elimination System (NPDES) permits has been incomplete.[1] When the policy was issued, 40 percent of rivers, 45 percent of streams, and 50percent of lakes that had been assessed in the United States failed to support their designated uses.[2] Faced with CWA statutory obligations to achieve their watershed's designated uses, stakeholders have been looking for innovative, supplementary ways to achieve federal, state, tribal, and local water quality goals. The policy specifically enables and endorses the use of "water quality trading" to accelerate compliance.

Water quality trading can be a cost-effective solution to local problems caused by pollutant discharges to surface waters. A party facing relatively high pollutant reduction costs might elect to compensate another party who can achieve an equivalent, though less costly, pollutant reduction with similar water quality benefits. The flexibility offered by water quality trading is one of its strongest selling points

This Handbook is designed to provide you, the watershed participant, with an efficient means for assessing your watershed's potential to capitalize on this innovative "trading" policy. The viability of trading, as discussed in this Handbook, depends on conditions discussed in EPA's Water Quality Trading Policy, including: a market structured around the current CWA regulatory framework; voluntary participation; a suitable pollutant; and public participation.

Today, several trading markets are already helping to reduce the cost of improving water quality. Experience with these markets offers insights into the opportunities and challenges trading may present in your watershed. Experience teaches that success in water quality trading markets will be influenced by several factors, including:

- the pollutant in question;
- the physical characteristics of the watershed;
- the cost of pollution control for individual dischargers;
- the mechanisms used to facilitate trading; and
- the ability and willingness of stakeholders to embrace and participate in trading.

This Handbook will help you assess the environmental, economic, and technical factors that will influence your ability to create and sustain a water quality trading market. During the assessment, you will focus on each of the individual factors that make trading viable. As these factors are examined, you will organize disparate types of information into a comprehensive view of relevant local conditions. You will need to obtain some information from other stakeholders in your watershed. Your efforts will be much simpler if most stakeholders speak a common language. This Handbook will help provide that common language, giving you a methodology for organizing critical information into a logical, easy-to-follow format.

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[1] *Water Quality Trading Policy* (EPA, January 2003)
[2] Ibid.

The first chapter of the Handbook—Pollutant Suitability—addresses whether a "common" or “tradable” commodity exists that is important to the water quality goals for the watershed. Certain pollutants and watershed conditions are more suitable for trading than others. Pilot projects in Region 10 and elsewhere have demonstrated that nutrients can be successfully traded. Less information is available about trading other pollutants. After reading the Pollutant Suitability chapter and examining your own pollutant characteristics and watershed conditions, you will be better able to decide whether to pursue trading.

The second chapter—Financial Attractiveness—addresses how to evaluate the economics of a pollution trading market through consideration of the financial viability of potential individual and aggregate trades. The financial attractiveness of trading depends on whether the incremental costs of trading are less than the incremental costs of control options otherwise available to an individual. Incremental cost (essentially a hybrid of marginal and average cost) is the average cost of control for the increment of reduction required to meet compliance obligations. Incremental cost represents a good approximation of the upper-bound of a source’s willingness to pay others within their watershed to alter their discharging behavior. For trading to be financially attractive, the difference in incremental costs between dischargers must, at a minimum, be sufficient to cover trade transaction costs and offset any sense of increased (non-compliance) risk. Assessing the incremental cost spreads associated with specific transactions provides information on whether trading - in practice - will be financially attractive to potential market participants. After reading the Financial Attractiveness chapter, exploring the example provided, and employing the tools/methodologies discussed, you will be able to make a more informed decision about whether to pursue trading.

The Market Infrastructure chapter will help you determine whether the market infrastructure needed to facilitate trading can be built. The analysis will not provide a specific blueprint for creating a market, but will highlight likely challenges and identify ways in which your watershed can benefit from lessons learned in other markets. After reading the Market Infrastructure chapter, exploring the examples provided, and reflecting on the lessons from the first two chapters of the Handbook, you will better understand the watershed’s unique market infrastructure needs, possible mechanisms suited for the watershed, and the commitment level likely needed to create a market.

Finally, the Stakeholder Readiness chapter addresses the level of stakeholder interest and support needed to pursue water quality trading. If you decide to pursue trading opportunities, you will need to work with other potential participants and stakeholders in the watershed. They may need to be convinced that the time they spend exploring opportunities will lead to worthwhile, currently unavailable options. Parties with the greatest potential to produce and/or consume reductions are necessary participants. In addition, there must be a reasonable level of support from non-discharging stakeholders, including citizen’s groups and regulatory authorities concerned with water quality issues in the watershed. After reading this chapter, you should have a better understanding of how to engage other stakeholders.

The Handbook offers common themes that are important to your assessment and market creation efforts. Among these is the recognition that water quality trading involves a variety of risks and market development costs. Potential trade participants will face the possibility that, despite their hard work, the market they desire will not emerge. Friction around regulatory issues may emerge as the federal, state, and local regulatory framework, as well as necessary stakeholder involvement, add costs or complicate market design. After the market emerges and trading begins, transaction costs will be associated with information gathering, trade execution, and compliance efforts. The attractiveness of pollution trading markets will be affected by these cost and uncertainty factors. Higher development and transaction costs, market uncertainty, and regulatory impediments can suppress market activity to the point where trading will not occur. Lessons learned from other markets and discussed in this Handbook will help you assess whether costs and friction can be managed in your watershed to support a viable market.

Pollutant Suitability

Purpose

This chapter is intended to help you assess your watershed and associated pollutants for water quality trading potential. The first step is to review the pollutant characteristics and the watershed conditions. Certain pollutants and watershed conditions are more suitable for trading than others.

This chapter considers:

- What factors determine a pollutant's suitability for water quality trading in a particular watershed?
- Do the watershed conditions and pollutant characteristics warrant consideration of water quality trading in the watershed?

Pilot projects have demonstrated that nutrients, such as phosphorus and nitrogen, can be successfully traded. Less information is available about trading other pollutants, although pilot projects have explored sediment, ammonia, and selenium trading. The EPA Water Quality Trading Policy specifically supports nutrient (e.g., total phosphorus and total nitrogen) and sediment trading. However, the policy indicates that other pollutants, such as metals and pesticides, will require more scrutiny to ensure that trading can lead to meeting water quality standards. EPA will support trading of these pollutants only under limited conditions as part of a pilot project. For temperature, total dissolved gas, BOD/Ammonia, and bacteria, this Handbook cannot provide a clear "yes" or "no" answer, but this chapter should suggest whether to continue consideration of water quality trading using the following chapters.

Approach

This chapter discusses conditions needed for a pollutant to serve as a commodity that can be bought and sold in a trading system. Common commodities, like wheat, can be traded easily because buyers and sellers understand and can clearly compare the characteristics of the product. For example, with wheat, all market participants have a common understanding of the meaning of a bushel of hard, red winter wheat. For water quality trading opportunities to exist, dischargers in a watershed must establish a common understanding of the commodity that is being bought and sold, including the effects of trading on water quality.

The chapter then suggests a process for analyzing the suitability of trading a particular pollutant in a particular watershed. To enrich your understanding of the conditions that enable trading, the Handbook employs a hypothetical watershed to illustrate key points and highlight potential trading opportunities.

What is needed for a pollutant to serve as a "tradable commodity" that dischargers can buy and sell in a given watershed?

A condition for water quality trading is identification of a pollutant commodity that can be sufficiently controlled, measured, and traded by sources (possibly including both point and nonpoint sources) in the watershed or targeted market area. The four key *trading suitability factors* – Type/Form, Impact, Time, and Quantity – are related to inherent pollutant characteristics, watershed conditions, and the compliance regime.

- ***Type/Form:*** Potential trading partners must not trade "apples and oranges." Generally, they must identify a single pollutant, in a common form. For example, dischargers could trade Total Phosphorus, but might not be able to trade soluble for non-soluble forms of phosphorus. In some cases, different pollutant types (e.g., Total Phosphorus and Dissolved Oxygen) can be traded using a defined translation ratio based on the quantities of each that have an "equal" overall effect on water quality.
- ***Impact:*** There must be environmental equivalence between the discharge points of purchase and sale to ensure that the water quality impact will be at least equivalent to, if not in excess of, established water quality-based requirements. For example, participants must predict the water quality effects of a one pound phosphorus reduction as required by a TMDL at one point in a watershed compared to a reduction of one pound (or more or less) at another point downstream.
- ***Time*:** Participants must consider and work to align two time dimensions to support a trade. First, purchased reductions must be produced during the same time period that a buyer was required to produce them (e.g., during the permit compliance reporting period or during the same season when the permit limit was applicable). Second, TMDL compliance deadlines must reasonably align as sources consider their options for meeting future reduction obligations.
- ***Quantity:*** Overall supply and demand must be reasonably aligned. The total amount and increments of reductions available must reasonably align with the needs of potential purchasers.

For water quality trades to occur, potential trading partners must be able to align all four suitability factors.

The Six Step Suitability Analysis

This section will help you examine the four trading suitability factors. For each factor – Type, Impact, Time, and Quantity – this section provides additional background information and examples in the form of six steps. Each step involves a series of questions to evaluate whether potential trading partners will be able to establish a tradable commodity. To help answer the questions, the inherent characteristics of a number of common pollutants are provided. Appendices A, B, and C contain this information. Stakeholders should also consider TMDLs, implementation plans, NPDES permit language, and other local assessments and requirements to evaluate specific sources or conditions in your watershed.

STEP ONE: CREATE A WATERSHED DISCHARGE PROFILE

The purpose of this step is to characterize the pollutant(s) of concern that are discharged in the watershed or defined trading area. You will use this information in later steps to evaluate suitability and, in the next chapter, the financial attractiveness of trading. During this step, it will be important to understand the type/form, location, and quantity of pollutants being discharged from point and non-point sources.

One way to display this information is to use a simple chart, as in Figure 1.1. You will complete only certain columns during this step; in subsequent steps you will gather more information to fill in additional columns. In the example that follows, this same format is used to create a profile for the sources in a hypothetical watershed.

Figure 1.1: Template for Creating a Watershed Discharge Profile

Name of Discharge Source, Diversion, Agricultural Drain, or Tributary	Discharge Location	Form of Pollutant		Timing		Quantity			
	River Mile	As Addressed by TMDL	As Discharged	Discharge (e.g., seasonal, cyclical, etc.)	Obligation (Regulatory)	Baseline Load* (lbs./day)	Current Load* (lbs./day)	Target Load* (lbs./day)	Total Reduction Needed* (lbs./day)
Source #1 Source #2 Diversion #1 Return #1 Source #3									

* The **Baseline Load** is the amount of discharge used to develop a TMDL. During TMDL development, a specific year or flow rate is typically chosen to characterize the discharge behavior of point and non-point sources. This information can be found in the TMDL. The **Current Load** is the amount of pollutant discharged as you analyze the watershed for trading viability. The **Target Load** is the amount of pollutant discharge allocated to each source in the TMDL. The **Total Reduction Needed** is the difference between the Current Load and the Target Load.

You can typically find information to complete the chart in the text of a TMDL, in the TMDL implementation plan, or from other sources in the local watershed. For example, information about quantities discharged by point sources is contained in TMDL analyses and in the relevant NPDES permits (permit numbers are often listed in the TMDL). The TMDL will typically describe quantities discharged during a selected baseline period (e.g., 1995), current discharges (or "loads"), and the TMDL's specified waste load allocation for each point source based on a calculation of what is required to meet desired instream concentrations and achieve water quality standards. Additional guidance is provided in the following chapter (Financial Attractiveness) about calculating quantities associated with projected future growth. For nonpoint sources, TMDLs generally do not provide data about each individual source, but estimate quantities from selected reaches, inflows, or tributaries. Additional information about cropping patterns and agricultural practices in each area will be needed to estimate current loads from individual sources.

This profile offers a coarse initial screen for water quality trading viability. For example, if there are no major point sources in the watershed that are required to reduce pollutant loads, or if only a small number of widely dispersed sources discharge small quantities of the pollutant of concern, trading may not be viable. On the other hand, a watershed that includes a point source with large reduction obligations and many other closely clustered sources of the same pollutant may present opportunities for water quality improvements and other environmental benefits at lower cost through trading.

The questions below will help create a profile of pollutants being discharged into the watershed. It is important to gather as much of this information as possible because you will need it in later steps to evaluate suitability more specifically with regard to pollutant type/form, impact, time, and quantity.

For each source of the selected pollutant in the watershed:

- What is the geographic location of the discharge (by river mile)?
- What form of the pollutant is discharged (and/or controlled) by the source?
- What quantity of the pollutant does the source discharge? If possible, this should include current loads and allocated loads from the TMDL, along with any seasonal or other cyclic load variability considerations.

Overview of Happy River Basin

To demonstrate how you will use the information gathered to assess trading opportunities, a hypothetical watershed, the Happy River Basin, is presented below.

A number of segments along the Happy River currently experience nuisance aquatic growth conditions. A TMDL for phosphorus has recently been completed for the main stem of the river, providing Waste Load Allocations for the permitted point sources and Load Allocations for the nonpoint sources and tributaries. The TMDL indicates that, to achieve water quality standards, the concentration of phosphorus in the water column must be at or below .07 milligrams per liter along the entire river with monitoring stations established for compliance purposes. Eight sources of phosphorus discharge in the basin.

- Herb's Farm, a family-owned farm growing a range of crops, is located on an irrigation district controlled return flow which enters the Happy River at RM (river mile) 570.
- Pleasantville POTW (publicly owned treatment works), a municipal wastewater treatment plant owned and operated by the City of Pleasantville, is located at RM 567.
- Acme Inc., a food processing facility, is located four miles up Nirvana Creek, a tributary to the Happy River. The creek currently meets water quality standards and is not subject to a TMDL; therefore, Acme has not received a Waste Load Allocation. However, the Happy River TMDL provides a Load Allocation requiring a reduction in the phosphorus loads entering Happy River from Nirvana Creek. The creek's confluence with the Happy River is at RM 547.
- Hopeville POTW, a municipal wastewater treatment plant, owned and operated by the City of Hopeville, is located at RM 546.
- AAA Corp., a sugar mill owned and operated by a multinational corporation, is located three miles up Lucky Creek, a tributary to Happy River. AAA Corp. is required to meet a Waste Load Allocation provided in the Lucky Creek TMDL, which was finalized two years ago. Lucky Creek enters the Happy River at RM 544 and has been given an allocation at its confluence with the main stem.

- Ortho Company is a chemical manufacturing plant and a major discharger of phosphorus located downstream of Hopeville at RM 541.
- Easyville Dam, owned by Peaceful Power Company, is located downstream, at the end of Lake Content, a fifty-mile long reservoir, which is the pool behind Easyville Dam. The dam does not produce phosphorus. However, the power company has been given a load allocation under the TMDL to improve depressed levels of dissolved oxygen (DO) in the reservoir. The Dam sits at RM 490.
- Laughing Larry's Trout Farm, a privately owned aquaculture facility, is located at River Mile 489, below the Easyville Dam.

Figure 1.2: Schematic Map of Happy River Basin

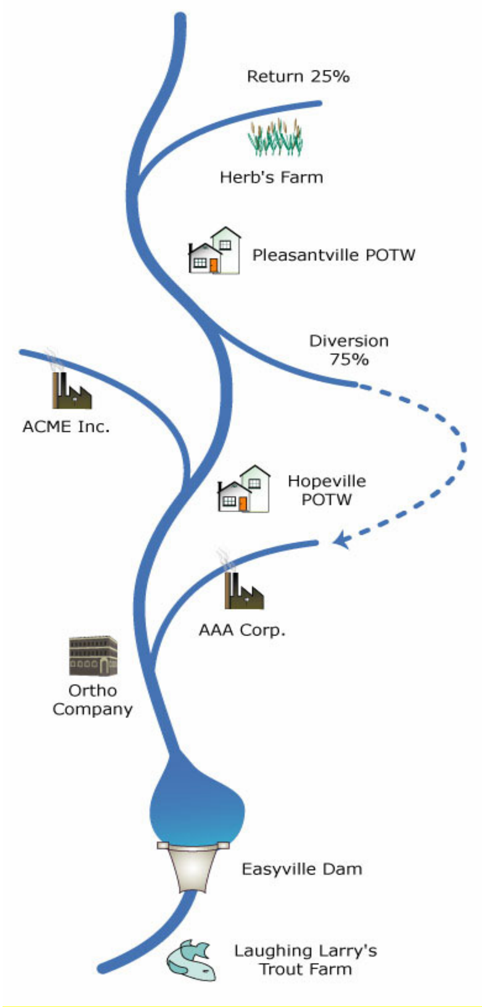

Figure 1.3: Chart of Sources with Location, Pollutant Form, and Quantity Information

Name of Discharge Source, Diversion, Agricultural Drain, or Tributary	Discharge Location	Form of Pollutant	Quantity			
	River Mile	As Addressed by TMDL	Baseline Load* (lbs./day)	Current Load* (lbs./day)	Target Load* (lbs./day)	Total Reduction Needed (lbs./day)
Drain A--Herb's Farm	570	Total Phosphorus	632	753	527	226
Pleasantville	567	Total Phosphorus	760	791	633	158
Acme Inc. (Nirvana Creek Confluence)	547	Total Phosphorus	492	547	410	137
Hopeville	546	Total Phosphorus	60	62	50	12
AAA Corp. (Lucky Creek Confluence)	544	Total Phosphorus	199	195	166	29
Ortho Company	541	Total Phosphorus	786	1645	655	990
Laughing Larry's Trout Farm	489	Total Phosphorus	185	250	154	96

*Note: Nirvana Creek and Lucky Creek have received allocations at their confluene with Happy River. The Baseline, Current, and Target Loads displayed are for the actual point of discharge to the tributary and are derived from the discharges' environmental impact at the confluence with Happy River.

STEP TWO: IDENTIFY TYPE/FORM OF POLLUTANT DISCHARGED BY SOURCES

The purpose of Step Two is to help evaluate whether sources are discharging the same *type and/or form* of pollutant. Type/Form is the first of the four factors that must be aligned among dischargers for trading to be viable. Sources must first determine that there is a common *type* of pollutant to be traded (e.g., phosphorus, sediments, or temperature). *Types* of pollutants may or may not be sufficiently correlated to allow trading. Even if sources are discharging the same type of pollutant, the form of pollutant as discharged may differ from source to source. Current practice requires that pollutant trading systems use an identified controllable pollutant common to all potential market participants. This establishes a "common currency" with which market participants can evaluate offers of behavior change from others.

A. Determine if sources are discharging the same form of pollutant as regulated by the TMDL.

Using the information developed in Step One, identify the form of pollutant addressed in the TMDL, and the form discharged by each identified source. In some cases, the form-suitability determination may be simple. If the TMDL has provided the majority of dischargers an allocation expressed as the same form of the pollutant (e.g., Total Phosphorus), then potential trading participants will have a solid match. For example, phosphorus loading is often regulated in TMDLs because excessive phosphorus concentrations encourage nuisance aquatic growth, reduce dissolved oxygen levels, and result in violations of water quality standards. In many cases, TMDLs provide load allocations for Total Phosphorus, rather than soluble or non-soluble forms because Total Phosphorus can be easily measured in monitoring samples.

Although Total Phosphorus is the pollutant form being measured, most sources discharge a combination of phosphorus forms (e.g., soluble or non-soluble). However, certain pollutants, including phosphorus, may pose difficulties even if the TMDL assigns allocation of a single pollutant form to all dischargers. (See Appendix A for more information.) For example, if individual dischargers have load characteristics that vary widely (e.g., one primarily discharges soluble phosphorus while another primarily discharges non-soluble sediment attached phosphorus) then a trade between the two may not be environmentally equivalent. As trading opportunities are considered in a watershed, it will be important to understand the actual forms of the pollutant being discharged by each source to assure that trades represent an equivalent impact on water quality.

The following questions are intended to help assess whether the pollutant can be treated as a "tradable commodity" based on commonality of the form of the pollutant being discharged.

- What is the form of pollutant addressed in the TMDL? For each pollutant, does the TMDL provide load allocations for more than one form?
- Do sources discharge the same form of the pollutant? If not, what form is discharged?
- What are the impacts of concern for this pollutant and do they vary by the different forms (if any) discharged?

In answering these questions, if you find that, 1) the TMDL provides load allocations for a single pollutant form; and 2) sources in a watershed discharge and measure that same form—you are in a strong position to continue the trading analysis. If this is the case, proceed to Step Three, to evaluate the potential for establishing environmental equivalence. If this is not the case, use the next set of questions in Step Two (B) to consider whether you can establish translation ratios between different pollutant types or forms.

B. Determine if there are opportunities to trade between different forms of the same pollutant, or between different types of pollutants.

This section considers circumstances in which different forms or types of a pollutant might be involved in a water quality trade. For example, if the TMDL provides load allocations for different forms (e.g., chemical compounds) of the same pollutant, you would need to assess the potential for establishing a *translation* between them. In some instances, such a translation can make it possible to trade more than one form of pollutant by defining the ratio at which the two forms may be exchanged with an "equal" effect on water quality. Without a reliable, scientifically defensible translation basis, it may be impossible to trade different forms of a pollutant.

In some cases, trading can even occur between two different types of pollutants if there is sufficient information to establish translation ratios that describe how they interrelate. For example, reductions in upstream nutrient levels can improve downstream dissolved oxygen levels or biochemical oxygen demand. The EPA Water Quality Trading Policy supports cross-pollutant trading for oxygen-related pollutants when translation ratios can be established.

The following questions should be answered if you are considering trading more than one form of the same pollutant, or if you are considering trading two different types of pollutants. (This will also help you identify situations where a TMDL provides load allocations for a single form, but sources actually discharge very different forms that have different impacts on water quality.) Establishing translation ratios requires adequate data and analysis about how pollutants behave under specific watershed conditions. If it appears that the data or analysis cannot be developed, water quality trading opportunities will be limited.

- If different forms are being discharged, is there sufficient information to establish a translation basis between those different forms of the pollutant?
- Is the pollutant measured/regulated directly or by using an indicator of its indirect effects on water quality? Has a basis for translating direct regulatory limits to indirect effects been established?
- Is there a typical causal relationship between this pollutant and others? Has a specific translation relationship been established between two pollutants within this watershed?

Type/Form: Exploring Potential Trading Opportunities Between Dischargers

The hypothetical TMDL provides Total Phosphorus load allocations for all dischargers located on the main stem of the Happy River. Lucky Creek, where AAA Corp. discharges, has a phosphorus TMDL in place and AAA is subject to a WLA. Because these dischargers have allocations for the same form of phosphorus, and their loads have reasonably similar form characteristics, they will be sufficiently matched to proceed with further consideration of trading.

The following examples of potential trades illustrate how pollutant form and type play a role in assessing the viability of trading in a watershed.

Pleasantville POTW and Hopeville POTW. The discharges from the two POTWs located at Pleasantville and Hopeville contain a similar combination of both soluble and non-soluble attached forms of phosphorus. Because the discharges will be measured using the same form of phosphorus (Total Phosphorus) and the actual forms discharged are also very similar, trading opportunities between these two sources can exist.

Herb's Farm and Pleasantville POTW. Herb's Farm is the only farm located on the irrigation district drain flowing into the Happy River at RM 570. Although the phosphorus entering the river through this agricultural drain is likely to be primarily the non-soluble sediment attached form, Total Phosphorus will be the form measured to monitor compliance with the TMDL load allocations. The discharge from the Pleasantville POTW, which contains a different combination of actual phosphorus forms than the Herb Farm drain, will also be measured and reported in units of Total Phosphorus. Although both dischargers will be measuring and reporting the same form of phosphorus, this trade might raise concerns because these sources are discharging different combinations of phosphorus forms. However, in practice, the trade is not likely to create localized impacts, and trading opportunities between these two sources can exist.

Easyville Dam and Hopeville POTW. Easyville Dam has a load allocation for dissolved oxygen (DO), not for Total Phosphorus (TP). Phosphorus loading in the Happy River above the dam contributes to nuisance aquatic growth in the reservoir, which is the major cause of violations of water quality standards related to DO. Hopeville POTW has a waste load allocation for Total Phosphorus. The operators of the dam have expressed interest in substituting upriver TP reductions for more direct DO enhancement efforts in the reservoir (e.g., direct oxygenation) to meet its allocation. A clear causal relationship does exist between phosphorus loading and DO levels, and the TMDL modeling provides a basis for developing a translation ratio to support TP to

DO trading. If a reliable translation ratio can be established between the two types and the two sources, trading opportunities between these two sources can exist. In the absence of such a translation ratio, however, Easyville Dam would lack the basis for trading in the Happy Basin market.

Figure 1.4, Chart of Sources with Type of Pollutant in TMDL, and Type of Pollutant actually discharged.

Name of Discharge Source, Diversion, Agricultural Drain, or Tributary	Location	Form of Pollutant	
	River Mile	As Addressed by TMDL	As Discharged (% Soluble/ % Non-Soluble)
Herb's Farm	570	Total Phosphorus	30/70
Pleasantville	567	Total Phosphorus	90/10
Acme Inc. (Nirvana Creek Confluence)	547	Total Phosphorus	100/0
Hopeville	546	Total Phosphorus	90/10
AAA Corp. (Lucky Creek Confluence)	544	Total Phosphorus	100/0
Ortho Company	541	Total Phosphorus	100/0
Laughing Larry's Trout Farm	489	Total Phosphorus	50/50

STEP THREE: DETERMINE THE POTENTIAL ENVIRONMENTAL EQUIVALENCE OF DIFFERENT DISCHARGE POINTS

The purpose of Step Three is to evaluate the location of potentially tradable discharges and relevant receiving water conditions to determine whether the environmental impact is equivalent. Environmental impact is the second of the four factors that must be aligned for trading to be viable. Your Step One watershed discharge information will give you the location of the pollutant discharges. Participants must be able to establish that the trade would result in the same (or better) environmental improvement in the receiving water if pollutant loadings are reduced in the seller's discharge rather than in the buyer's.

Two related factors influence environmental equivalence. First, the fate and transport characteristics of a pollutant (e.g., how it behaves in a river system) must be considered. Second, the unique conditions of the watershed must be evaluated. The pollutant's concentration or presence and its effects on water quality may vary greatly as it moves from upstream to downstream. For example, a pound of phosphorus discharged into a river can "disappear" as it travels down a river through uptake by aquatic plants, settling out, and/or water diversion for agricultural or other uses. This can diminish the environmental value of a purchased pollutant reduction as it travels downstream. Purchasers therefore may be required to buy more total loading reduction from other sources than would have been required at their discharge point . Some trading systems use pollutant "equivalence ratios", or similar mechanisms, to establish the necessary environmental equivalence relationships. In these systems, each source or trade transaction is assigned a ratio to account for the effects of inputs, withdrawals, and diversions between the seller's and buyer's discharge points and all relevant compliance points. These ratios depend on pollutant parameter stability as well as the distance, river hydrology, and other relevant environmental conditions.

In general, the greater the geographic distance between discharge points, the greater the chance of high volume pollutant uptake and settlement, and/or complex hydrology in the receiving waters between those points. Therefore, sources in close geographic proximity are more likely to be able to establish a straightforward environmental equivalence relationship. In some cases, the influence of diversions and tributaries may be too great to establish reliable impact relationships.

How Ratios Are Used to Establish Environmental Equivalence

Most trading systems use equivalence ratios, or similar mechanisms, to adjust for the complex fate and transport characteristics of pollutants and variable watershed conditions. In these systems, each source or trade transaction is assigned a ratio to account for the effects of inputs, withdrawals, and other effects on the pollutant between the seller and buyer's discharge points, and any other monitoring points, to assure the equivalent environmental impact from pollutants present in the water column. Ratios allow trading partners to adjust the amount of reductions to assure trades create environmentally equivalent outcomes at the point(s) of environmental concern. Ratios are often based on each source's location along the river, tributary, or agricultural drain in relation to other market participants and/or designated instream compliance points. They can also be based on other site location factors that reflect the potential for further diversion and reuse of water below the point of discharge. Other site location factors for nonpoint sources include soil type and permeability, slope, vegetation, amount of rainfall, etc. Some demonstration programs use separate ratios to account for river location and other site location factors. Others use a composite ratio that accounts for all factors.

The example of phosphorus helps illustrate why equivalence ratios are needed. A pound of phosphorus discharged upstream may not arrive as a pound of phosphorus at a given point downstream. Some may be lost as the stream is diverted for agricultural use or for other water supply needs. Phosphorus can also drop out of the water column and be deposited as sediment, transmitted to groundwater through infiltration, or taken up by plants along the way.

The ratio reflects the best estimate of the effect of a reduction that will be realized at the buyer's discharge point, or other compliance points. For example, a 3:1 ratio indicates that for every three pounds of phosphorus released by a discharger, one pound will reach and have an environmental effect on water quality at the critical monitoring point. River location ratios are often calculated using modeling. Often, modeling (such as mass balance calculation) has already been used for TMDL development.

Appendices A, B, and C of this Handbook provide information about the inherent characteristics of selected pollutants that is relevant to how they may behave in receiving waters. You will also need to collect information about relevant conditions in your specific watershed, such as the locations and volumes of major inflows and outflows. If necessary data or reliable models are lacking, or pollutant fate and transport characteristics are very complex, uncertain, or unknown, conditions for trading may not be favorable.

Localized Impacts

Some potential trades that could result in a general water quality improvement in a broad area may also result in acute, localized impacts. Trades that create "hot spots" -- localized areas with high levels of pollution within a watershed – should be avoided. The following factors should be considered.

- *Characteristics of the Pollutant--*
  - *Each pollutant poses different risks to local water quality.*
- *Watershed conditions--*
  - *Areas that have no additional assimilative capacity for the relevant pollutant may show localized impacts if loads are increased.*
  - *Areas with low flows and/or a high capacity for retentiveness will be more likely to show localized impacts.*
  - *The presence of other pollutants will affect the potential for localized impacts.*
- *Type of trade--*
  - *Downstream trades (i.e., a source compensates a source downstream to overcontrol its discharge) have greater risks of localized impacts because if the buyer's discharge exceeds its TMDL allocation, loads in the stream segment between the sources may be too high.*
  - *Upstream trades (i.e., a source compensates a source upstream to overcontrol its discharge) present lower risks because overcontrol by the upstream discharger will result in improvements to water quality beyond those specified in the TMDL in the segment between the sources.*
- *Use of monitoring--*
  - *Monitoring programs designed to support trading should identify potential localized impacts and provide for control regime modifications to mitigate impacts.*

Answering the following questions will help you assess the potential environmental equivalence between discharges. Information to help answer these questions can be found in the Watershed Discharge Profile developed in Step One, in Appendices A, B, and C, and in relevant TMDLs.

- Where are the discharges of the relevant pollutant?
- Where are the major hydrologic inflows and outflows?
- What are the general fate and transport characteristics of the pollutant?
- How do river conditions, such as flow rate and temperature, affect the behavior and impact of the pollutants?
- Is there a potential for localized impacts? Under what conditions?
- What options need to be considered for establishing environmental impact equivalencies for different areas of the river?

Water quality trading is one of several tools available to implement TMDLs. Trading requires understanding the effect of pollution reductions by sources at different points in the watershed. Trades that result in localized impacts and fail to meet water quality standards are not acceptable. It is possible to use predictive models to estimate the environmental equivalence of different discharges, but water quality monitoring will be an essential element in any trading program to ensure that water quality goals are achieved.

Environmental Equivalence: Exploring Potential Trading Opportunities Between Dischargers

Information on the general fate and transport characteristics of phosphorus is provided in Appendix A. With that information in mind, you are ready to take a closer look at the specific conditions in the Happy River Basin watershed to assess the potential environmental equivalence and trading opportunities among dischargers.

The following examples of potential trades illustrate how environmental equivalence can play a role in assessing the viability of trading.

Herb's Farm and Pleasantville POTW
Herb's Farm is the only identifiable source located on an agricultural drain that empties into the Happy River at RM 570. The Pleasantville POTW discharges nearby, only three miles downstream. Because of swift flowing water, no other intervening diversions or returns, and little plant life between the two sources, the equivalence ratio between the two dischargers is close to 1:1. (Trades involving other sources will require calculation of separate ratios.) Because of the low equivalence ratio between Herb's Farm and Pleasantville POTW, opportunities for water quality trading between these two dischargers can exist.

Pleasantville POTW and Hopeville POTW
The Hopeville POTW is located over 21 miles from the Pleasantville POTW. Between Hopeville and Pleasantville is one major agricultural diversion, which diverts 75 percent of the flow of the river. Because of the diversion and resulting slower river flow, as well as plant uptake and other factors, trades between Hopeville and Pleasantville will have a 5:1 ratio.

There are two potential options for trading between the POTWs. One option is an "upstream trade," in which Pleasantville overcontrols phosphorus reductions beyond its waste load allocation to create reduction credits. In this case, Hopeville would purchase reduction credits from Pleasantville. However, because of the 5:1 ratio, Hopeville would need to purchase five pounds of reductions at Pleasantville to achieve an equivalent reduction of one pound of phosphorus at its plant. (This may or may not be cost effective for Hopeville.) Pleasantville would then reduce its phosphorus discharges beyond its waste load allocation and water quality in the 21 mile segment would be improved beyond that specified by the TMDL. This trade should also result in improved water quality in the river segment below Hopeville.

Another option is a "downstream trade," in which Hopeville reduces its phosphorus discharge beyond its TMDL allocations and Pleasantville purchases reduction credits from Hopeville. In this example, Pleasantville would not meet its TMDL waste load allocation and this will result in no phosphorus reduction in the 21 mile segment between the two dischargers. However, water quality downstream of Hopeville would improve as a result of its overcontrol. A downstream trade such as this would satisfy the TMDL only if the water quality impairment occurs in the river segment below Hopeville and not between Pleasantville and Hopeville. It is possible that, Pleasantville's TMDL waste load allocation was established to reduce its contributions to impairments below Hopeville. However, except in such unique circumstances, the elevated concentrations of phosphorous in the 21 mile segment between the sources is likely to cause unacceptable localized adverse impacts.

Laughing Larry's Trout Farm and Hopeville POTW
Laughing Larry's Trout Farm is located downstream of Lake Content, the reservoir behind Easyville Dam. A reliable location ratio has not been established for the trout farm that would allow it to trade with any dischargers located upstream. The complexity of the river ecosystem increases significantly in this area of the Basin as water flows through the reservoir. The slower moving water promotes aquatic plant growth and higher retentiveness of phosphorus in this area. The fate and transport characteristics of phosphorus and the complexity of the watershed conditions make it difficult to predict how phosphorus reductions above the dam will affect water quality at locations below the dam. This high level of uncertainty will likely prevent development of a ratio allowing Laughing Larry's to trade in the Happy River market area.

STEP FOUR: DETERMINE THE POTENTIAL FOR ALIGNING THE TIMING OF LOAD REDUCTIONS AND REGULATORY TIMEFRAMES AMONG DISCHARGERS

Timing is the third factor that must be in alignment for trading to be viable. In Step Two, you considered the variability among discharges in terms of the *forms* of a pollutant or *types* of pollutants. In Step Three, you considered the variability of geographic *locations* in the watershed. In this step, you will consider how discharges from different sources vary across *time* and the implications of this variability for the viability of trading. Three timing dimensions must be considered. Alignment of all three is needed to match trading partners.

Load variability: A discharger's load is likely to vary from time to time. You will need to identify only major load variations that occur over the course of the year, not minor fluctuations in discharges. For example, some POTWs reduce discharges to zero by substituting land application during summer months. Some agricultural nonpoint sources have significant reductions of nutrient loadings during the winter months. One important consideration is whether the load allocations in the TMDL are seasonal or annual. Potential trading partners must meet TMDL timing requirements and also link up with other sources with similar discharge timing. Because of the effects of temperature and sunlight, for example, winter nutrient loadings have very different environmental impacts from summer loadings.

Compliance determination variability: Because of the different considerations in establishing appropriate NPDES permit limits, as well as other factors such as the cost of monitoring, the temporal specifications for discharge monitoring and compliance determinations vary among dischargers (e.g., some have monthly limits, others have daily limits, and some have both). To be viable, a trade must be consistent with the time periods that are used to determine compliance with permit limitations or other regulatory requirements. For example, a point source with a permit that requires compliance with monthly average limitations will be able to trade only with a discharger who can demonstrate monthly reductions.

Compliance deadline variability: For a viable trade, dischargers' compliance deadlines must be reasonably aligned. For example, a potential purchaser may need to meet pollutant reduction requirements in 24 months. It may take twelve months to fund, install, and fully implement the pollution control technology needed to meet those requirements. Such a potential purchaser cannot wait 18 months while a potential reduction provider verifies its own obligations, selects its mitigation option, and calculates any surplus reductions available for purchase. In some cases, potential market participants may have different compliance deadlines because they are located in nearby tributaries with different TMDL implementation schedules.

Much of the information required to assess time dimension variability in Step Four will be found in the TMDL and NPDES permit language specific to each watershed and source. Appendices A, B, and C also include a discussion of the typical range of regulation for each pollutant.

Answering the following questions will help determine the potential alignment of schedules in terms of seasonal requirements, metrics for pollutant limits, and deadlines for compliance. If participants are unable to align all three dimensions of time, trading may not be viable. It is not necessary for all sources in the watershed to align their compliance schedules; however, a sufficient number must be aligned to support one or more beneficial trades.

- Permit and TMDL Compliance Periods-
  - Does the TMDL establish seasonal allocations or year-round reductions?
  - What units of time are used to define and monitor compliance with relevant permit limits?
  - What time period is used by non-permitted dischargers (e.g., nonpoint sources) to measure and, where applicable, report discharges? (Hourly, daily, weekly, annually?)
  - Do any sources have significant seasonal or other cyclical load variability?
- TMDL Compliance Deadlines-
  - Has a TMDL implementation schedule been established? If so, do compliance schedules among major dischargers reasonably match up?
  - Are there other compliance deadlines (e.g., permit requirements based on national effluent guidelines) that must be considered?

Timing: Exploring Trading Opportunities Between Dischargers

Three types of timing issues present challenges to potential trading partners in the Happy River Basin. The following examples illustrate issues relating to (1) seasonal load variability, (2) compliance determination variability, and (3) compliance deadline variability.

Herb's Farm and Pleasantville POTW (load variability)
Pleasantville POTW operates year-round, with some minor variation in the amount of phosphorus in its discharge. Herb's Farm contributes to phosphorus loading in the river only during the growing season. In the winter, when farmland is frozen over, the farm contributes very little phosphorus.

If the TMDL required year-round load reductions to meet Pleasantville's waste load allocations, Herb's Farm would not be able to produce reductions for the entirety of the relevant time period. However, the Happy River phosphorus TMDL is typical of other phosphorus TMDLs and establishes only seasonal load allocations which are applicable between April and September. Therefore, opportunities for trading between these two dischargers can exist.

Hopeville POTW and Pleasantville POTW (compliance determination variability)
In this hypothetical, both POTWs are regulated by NPDES permits with limits expressed in similar temporal terms (e.g., monthly averages). These closely matched limits help support water quality trading opportunities between the POTWs.

AAA Corp. (compliance deadline variability)
AAA is located on Lucky Creek, a tributary to the Happy River. Lucky Creek has its own separate TMDL and implementation plan. AAA was given a waste load allocation under the Lucky Creek TMDL. The Lucky Creek and Happy River TMDL plans have different compliance deadlines, so there is a potential timing misalignment. If the TMDL for Lucky Creek had not yet been completed, AAA might not be able to participate in the trading market with Happy River dischargers. However, because the Lucky Creek TMDL has been completed, AAA currently has sufficient knowledge about its requirements. With this knowledge, they may be able to align the timing of their compliance efforts in order to participate.

STEP FIVE: DETERMINE IF THE SUPPLY OF AND DEMAND FOR POLLUTION REDUCTION CREDITS IS REASONABLY ALIGNED WITHIN THE WATERSHED

The watershed discharge information developed in Step One should include quantities of the relevant pollutant discharged by the sources in the watershed. In this Step, that information will be analyzed to determine whether supply and demand are reasonably aligned. For trading to be viable, the quantity of reductions that can be supplied must meet or exceed the quantity of reductions needed to ensure compliance.

Demand for reductions is driven by current and future loads (what dischargers are currently discharging or expect to discharge in the future), as compared to target loads (what the TMDL allows sources to discharge). For individual nonpoint sources, estimates of these quantities are not normally specified in the TMDL, and so will need to be calculated, using aggregated nonpoint discharge data from the TMDL along with other information, such as data developed by soil conservation districts. The TMDL will provide information about current and target loads from inflows and tributaries. Methodologies for calculating historical, current, and target loads for individual non-point sources along each inflow and tributary may differ from watershed to watershed and from state to state. These calculations may have a high degree of uncertainty, but can produce a valuable rough understanding of the supply and demand dynamics in the watershed.

Supply is dictated by a discharger's ability to "overcontrol," or reduce its discharges below the target load specified by the TMDL. The volume of reductions achieved beyond TMDL obligations represents the stock of potential surplus reductions available for exchange with other parties. The increments, or range, of reductions demanded and supplied will determine whether a match is possible. The quantity of reductions that may be supplied is determined by the efficacy of control techniques and management methods available to sources. These techniques and methods include altering industrial product production levels or land management practices, substituting inputs such as raw materials and agricultural chemicals, or investing in new technology.

In the next chapter, the financial feasibility of various control options are examined as a factor in projecting supply and demand. At this stage, answering the following questions will help develop an initial understanding of the supply and demand dynamics in the watershed. If it appears that the supply of reductions can reasonably meet the demand, then trading may be a viable tool to address water quality problems.

- For each relevant discharger, what are the quantities of current/future loads compared to target loads?
- For each discharger, what is the capacity to provide reductions beyond applicable required TMDL load allocations (i.e., do they have the technical capacity to generate overcontrol)?

Supply and Demand: Exploring Trading Opportunities Among Dischargers

It is often difficult to project the balance of supply and demand for reductions. In the Happy Basin hypothetical, you have a general idea of the total amount of reductions needed by all sources to meet TMDL load allocations. In the next chapter on Financial Attractiveness, the Handbook will examine how differing costs of control options may make some sources likely buyers and others likely sellers. But even at this stage, some early supply and demand patterns begin to emerge.

The following examples illustrate how supply and demand plays a role in assessing the viability of trading.

Acme Inc. and Hopeville POTW (Supply and Demand in Balance)
Hopeville has projected that it will need to reduce phosphorus discharges by 12 pounds per day to meet TMDL target allocations. (See Figure 1.5, Chart of Sources with total reductions needed by Happy River dischargers.) Hopeville may consider purchasing reduction credits from Acme Inc. rather than investing in control technology that is projected to produce considerably greater pollutant loadings reductions than it needs. To meet its load allocation, Acme also expects to install control technology with potential to overcontrol, thus generating potentially saleable reduction credits. Other dischargers in the Basin also have potential to generate a sufficient supply of reduction credits to meet Hopeville's demand.

Ortho Company (Demand outstrips Potential Supply)
Ortho Industries, located at River Mile 541, is a major discharger of phosphorus. To meet its TMDL waste load allocations, Ortho will need to reduce its discharges by about 990 lbs./day. Ortho is considering an on-site control option that will meet its allocation. It is also considering purchasing reductions from other dischargers in the Basin. For cost reasons, Ortho has decided to focus on a "one size fits all" control technology package. There is no available alternative that would allow for a blended strategy that includes the use of both a less effective, less costly technological treatment control option and purchased reductions from other dischargers. Ortho must choose trading or on-site control. As Ortho considers purchasing reductions from other dischargers, it will need to project whether the potential supply of reductions will meet its demand (i.e., enable it to comply fully with its waste load allocation). The calculated ratios needed to ensure environmental equivalence are likely to at least double the reduction needed, increasing Ortho's demand to approximately 2000 lbs./day. Using Figure 1.5, Chart of Sources, you can calculate that it will be almost impossible for the remaining dischargers in the Basin to create a sufficient supply of reduction credits to meet Ortho's demand. Even if all other sources reduced their phosphorus discharges to zero, the supply of reduction credits generated by such overcontrol would total only about 1900 lbs./day. Ortho can see that trading will not be an option for its compliance plan because the supply of reductions cannot meet its demand.

STEP SIX: REVIEW THE RESULTS OF STEPS ONE THROUGH FIVE TO COMPLETE THE POLLUTANT SUITABILITY DETERMINATION

Before moving on to the next chapter, review the outcome of the suitability analysis in the five steps above. Pollutant suitability requires a high potential that all four suitability factors will be in alignment for at least two market participants. If any one of the five Pollutant Identification steps (i.e., watershed discharge profile, type/form, location, timing, and supply/demand) show low potential for alignment, the pollutant is probably not suitable for water quality trading in this watershed. Unless the pollutant has a medium to high potential for all four factors, further analysis to assess water quality trading of this pollutant in your watershed is probably not warranted. However, the user may wish to consider whether other pollutants discharged by sources in the watershed may have potential trading.

Figure 1.5, Complete Discharge Profile with all pertinent information

Name of Discharge Source, Diversion, Agricultural Drain, or Tributary	Location	Form of Pollutant		Timing		Quantity			
	River Mile	As Addressed by TMDL	As Discharged (Soluble/Non-Soluble)	Discharge (e.g., seasonal, cyclical, etc.)	Obligation (Regulatory)	Baseline Load* (lbs./day)	Current Load* (lbs./day)	Target Load* (lbs./day)	Total Reduction Needed* (lbs./day)
Herb's Farm	570	Total Phosphorus	30/70	Seasonal	June-Sept.	632	753	527	226
Pleasantville	567	Total Phosphorus	90/10	Year-round	June-Sept.	760	791	633	158
Acme Inc. (Nirvana Creek Confluence)	547	Total Phosphorus	100/0	Year-round	June-Sept.	492	547	410	137
Hopeville	546	Total Phosphorus	90/10	Year-round	June-Sept.	60	62	50	12
AAA Corp. (Lucky Creek Confluence)	544	Total Phosphorus	100	Year-round	June-Sept.	199	195	166	29
Ortho Company	541	Total Phosphorus	100	Year-round	June-Sept.	786	1645	655	990
Laughing Larry's Trout Farm	489	Total Phosphorus	50/50	Seasonal	June-Sept.	185	250	154	96

Outcome of Six Step Suitability Analysis

Of the seven Happy Basin sources identified at the beginning of the Six Step Suitability analysis, five appear to reasonably meet the four suitability factors; while two appear to be unlikely trading participants because they cannot match a key trading suitability factor with other sources.

- Laughing Larry's is located downstream of the Easyville Dam. Its location involves complex factors that prevent definition of a reliable relationship with other dischargers to ensure environmentally equivalent water quality improvements. (Trading Suitability Factor: Environmental Equivalence)
- Ortho Company will require more pollution reductions than could possibly be generated from all the sources in the basin when likely trading ratios are factored in. Its demand far outstrips potential supply. (Trading Suitability Factor: Supply/Demand)

In the next chapter, the remaining five sources will be further examined to assess if trading will be financially attractive for dischargers in the Happy River Basin.

Financial Attractiveness

Purpose

Financial attractiveness is the second major consideration in assessing water quality trading potential in your watershed. This chapter reviews the financial relationships affecting the viability of trading. The potential economic gains associated with trading are influenced by factors specific to the watershed as well as factors external to the watershed. Because the relevant financial relationships are often nuanced and dynamic, this section can offer only the foundation needed to begin examining current financial relationships in the watershed and their sensitivity to different assumptions. This chapter will help answer the following questions:

- What makes water quality trading financially attractive?
- How can I measure financial attractiveness?
- Where can I find the data?
- What could the analysis mean for my watershed?
- What should I do next?

After reading this chapter, considering the examples provided, and employing the tools or methodologies discussed, the watershed participant will be able to screen out unlikely trading scenarios and make an informed decision as to whether further pursuit of pollutant trading is warranted. Although this chapter discusses detailed calculations, a rigorous analysis will not typically lead to a definitive answer. However, the reader will be able to locate an individual trade's position along a relative continuum of financial attractiveness, from "high" to "low". This chapter will also help improve the reader's ability to discuss water quality trading with other watershed participants by creating a common "language" to describe their needs and issues. In watersheds across the country, people are talking with one another and developing new, non-traditional ways to "trade" and solve their problems. Understanding the financial challenges potential trading partners face can help you identify such opportunities in your watershed.

Approach

This chapter reviews the primary drivers of financial attractiveness and describes the steps for conducting an analysis to assess those drivers in a specific situation. First, the Handbook suggests investigating a discharge source for which the necessary data are relatively accessible. The investigation includes building a basic model assessing the source's current and future costs for controlling the relevant pollutant(s). With this basic understanding of the financial considerations for one source, the reader is encouraged to compile data for other sources in the watershed. Data collection strategies and data formatting are considered. Finally, this chapter details the factors that influence the strength of financial attractiveness and how to incorporate them into an analysis.

Possible barriers to a viable trading market are discussed. Certain types of trades will present themselves as relatively straightforward, easy to execute, and financially beneficial to all parties. Other potential trades will be more difficult and may not result in cost savings. For example, two point sources of phosphorus, located a quarter-mile apart, and facing large differences in their control costs likely will uncover a compelling case for trading. On the other hand, two sources at opposite ends of a complex watershed, attempting to control temperature, and sharing only moderately different control costs are unlikely to obtain any advantages from trading. The ability to differentiate scenarios systematically will help watershed participants use trading wisely as a tool to improve water quality at lower cost. Throughout this chapter, the Happy River Basin hypothetical will be used to illustrate the analytical process and some of the common barriers.

The economic models, financial models, and analysis techniques provided in this chapter are, by design, very basic. They will help you screen your watershed for financial attractiveness at a very general level and provide you with the basic ability to gauge whether you have low, medium, or high financial opportunities. Pilot projects have indicated that conducting more precise and in-depth analysis will typically involve a substantially increased level of effort and will quickly move outside the realm of readily available data. The tools provided in this chapter have been well tested, do not require sophisticated economic modeling skills to implement, and are fully sufficient for basic screening purposes. More precise analysis will typically require in-depth interaction with individual discharge sources and may quite quickly encounter barriers related to proprietary business information. As a result, this more in-depth work will often be best conducted by individual sources in the context of specific trade negotiation activities.

What Makes Water Quality Trading Financially Attractive?

The financial attractiveness of pollution trading is created by differences in the pollution control costs faced by individual dischargers. These differences may make it possible to improve water quality at lower cost overall by allowing pollution dischargers facing high control costs to pay dischargers with lower cost control options to “overcontrol” their discharges. “Overcontrol” as used herein means reducing a pollutant discharge below the target load specified by the watershed’s market driver (typically a TMDL). The volume of reduced discharge below obligations represents the stock of potential surplus reductions available for exchange with other parties. Pollution overcontrol creates a “product” with buyers and sellers in a potentially competitive market that can encourage innovation and efficiency untapped by a conventional regulatory regime.

To assess trading viability, a common measure is needed to assess the costs each discharger will face to comply with its requirements. Chapter One explained the need to identify a tradable commodity. Moving on to calculate the cost of producing the commodity in the form of surplus pollution reductions will show whether the relative cost efficiency of some dischargers’ control options can lead to economically efficient trades. Some pilot projects have used “incremental cost of control” as the common measure. Incremental cost of control is calculated as the average cost of control *for the increment of reduction required for an individual source to achieve compliance*. For example, if a discharger needs a 5 lbs./day reduction to comply but the only reasonably available technology costs $10 million and produces a 20 lbs./day reduction, then the incremental cost associated with the 5 lbs./day reduction is substantial relative to the average cost of reductions. Traditional average cost would divide costs by 20 lbs./day; incremental analysis divides the costs by 5 lbs./day and would be four times higher than average cost. As discussed earlier, incremental cost represents a good approximation of the upper-bound of a source’s willingness to pay others within their watershed to alter their discharging behavior.

STAGE 1: CALCULATING INCREMENTAL COST OF CONTROL FOR A SINGLE SOURCE

The first step to assess financial attractiveness is to calculate the incremental cost of control for each pollution source. You may have ready access to needed data for at least one source. (Gathering information from other sources is discussed later.) The following data are needed to calculate incremental cost of control:

- The source's current load;
- The source's TMDL (or equivalent) target load;
- The source's projected load on its required compliance date if no controls are implemented;
- The source's projected long-term future load (considering anticipated growth and other relevant factors);
- Annualized cost of the control option(s) including capital investment and annual operating and maintenance (O&M) costs; and
- Expected reductions achieved by the control option.

Calculating the incremental cost then involves the following tasks.

Task 1: Calculate Required Reductions

A facility's future discharge will be influenced by any changes in demand for the facility's primary services or products (e.g., municipal sewage treatment, industrial production, or agricultural production). For a publicly owned wastewater treatment plant, discharge will likely vary as local population increases and/or the number and activity level of industrial users changes. Industrial sources may discharge more as production rises. An increase (or decrease) in discharge (and resulting reductions needed to maintain compliance) will affect needed reductions, incremental cost of control and, potentially, the financial attractiveness of trading in the watershed.

The reductions needed to comply equal the discharger's target pollutant waste load minus its current loads and any expected future loading increases. Both the projected load at the compliance date and the projected long-term future load should be calculated. Compliance dates and capital budgeting interact with changing demand to influence discharge control choices; therefore, multiple timeframes may require examination. The motivation for cost savings will materialize when a looming compliance date presents the possibility of enforcement and penalties if discharges are not reduced. Currently, NPDES permits implement TMDLs for point sources and typically give sources three to five years to control their discharge. This normally gives dischargers a window of opportunity to evaluate their options, select the best alternative, and implement it. In the Happy River Basin hypothetical, the NPDES permit holders have five years to comply.

Water pollution control technology often represents a significant, fixed, long-term capital investment. If a discharge increases beyond the existing control technology's ability to maintain compliance during its useful life, new investments may be required in the future. Sources therefore need to examine the implications of their available options over an extended period.

In the hypothetical, the sources project discharge volumes in five years for compliance requirements and in ten years for capital budgeting needs. Future discharge levels can be difficult to estimate. For the purposes of analysis, it may be best to create several scenarios with different levels of anticipated growth. Past pilot projects have used a system of "High," "Moderate," and "Low" growth trends. Current pollutant loadings may be estimated to increase at a constant rate over a specified period to estimate future loads and future required reductions.

Hopeville's Incremental Cost of Control

Projecting Hopeville's Needed Reductions

The Hopeville POTW currently discharges, on average, 4.1 million gallons of wastewater per day. Routine sampling results show that the Total Phosphorus (TP) concentration in the effluent is 2.99 milligrams/liter. Converting gallons into liters and milligrams into pounds, the POTW's current TP load is 62 lbs./day[3]. POTW managers believe their system could face demand increases between 1 percent and 8 percent, on average, over 10 years. Hopeville believes that a reasonable assumption is that moderate population and industrial growth will increase its TP load 3 percent annually over the next five years to 72 lbs./day. The TMDL assigns Hopeville a waste load allocation, or Target Load, of 50 lbs./day and this is an enforceable compliance requirement in its permit. The following table summarizes needed reductions at today's current discharge, five years from now at the time permit compliance is required, and ten years in the future assuming 1 percent, 3 percent, and 8 percent annual growth.

As shown in the table, Hopeville needs to consider a wide range of potential reductions to meet its permit under the TMDL. At current discharge levels, the POTW needs to reduce TP discharge by 12 lbs./day. Five years from now, when failing to comply has real economic consequences, Hopeville will need to have reduced its TP discharge by between 16 and 42 lbs./day, depending on demand for its services. Looking further into the future, Hopeville will need to generate between 19 and 84 lbs./day of TP reductions to remain in compliance. For the purposes of examining financial attractiveness, you will focus on reductions needed in five years for compliance and assume that Hopeville will experience moderate growth. Therefore, the assumption is that Hopeville will be generating 72 lbs./day of TP and will have to reduce that discharge by 22 lbs./day in five years.

[3] 1lb = 453592.37 milligrams and 1 gallon =3.785411784 liters

Figure 2.1, Hopeville's POTW Load Projections

Hopeville POTW Load Projections (lbs./day)				
Current Discharge	Annual Growth	TP Load	Target Load	Reduction Needed
Current Baseline				
62	0%	62	50	12
5 years (Compliance Date)				
62	1.0%	66	50	16
62	3.0%	72	50	22
62	8.0%	92	50	42
10 years (Capital Budgeting)				
62	1.0%	69	50	19
62	3.0%	83	50	33
62	8.0%	134	50	84

Task 2: Examine Control Technology Options

The next task is to examine available technologies' ability to control the pollutant discharge and the associated costs. Multiple technologies and mitigation approaches may be available to each source to help address water quality impairments. The cost and efficacy of control options varies. Usually, more control equals greater cost. Moreover, current control technology often achieves reductions by removing pollutants in large increments. Some control technologies will, therefore, produce the needed reduction increment and a (significant) additional increment for little or no additional cost. As control needs increase past the technology's ability to control pollution, the facility may need to invest in more control and/or take the next "technology step."

Hopeville's Technology Options
Hopeville's wastewater treatment engineers have identified three technologies that could reduce phosphorus discharge from their POTW and offer a range of control. Advanced Primary Treatment (APT) is capable of removing 16 lbs./day. After an investment in APT, the next "step" is Biological Nutrient Removal which would remove an additional 24 lbs./day. Finally, additional aeration basins and secondary clarifiers would eliminate 55 lbs./day of additional total phosphorus.

Task 3: Calculating Incremental Reductions Needed for Compliance

When a technology step (or combination of steps) fails to generate, at a minimum, the total reduction needed, a source may be forced to consider investment in an additional technology step, even though this would produce more reductions than are needed. To evaluate its options, Hopeville generated the following table for its 5-year projection.

Figure 2.2, Hopeville's POTW 5-Year Projection

Hopeville POTW 5-Year Projection (lbs./day)

	Low Growth						
	Annual Growth	TP Load	Target Load	Total Reduction Needed	Reduction Achieved	Cumulative Reduction Achieved	Incremental Reductions Needed for Compliance
	1.0%	66	50	16			
Step 1					16	16	0
Step 2					22	38	N/A
Step 3					30	68	N/A

	Moderate Growth						
	Annual Growth	TP Load	Target Load	Total Reduction Needed	Reduction Achieved	Cumulative Reduction Achieved	Incremental Reductions Needed for Compliance
	3.0%	72	50	22			
Step 1					16	16	6
Step 2					22	38	N/A
Step 3					30	68	N/A

	High Growth						
	Annual Growth	TP Load	Target Load	Total Reduction Needed	Reduction Achieved	Cumulative Reduction Achieved	Incremental Reductions Needed for Compliance
	8.0%	92	50	42			
Step 1					16	16	26
Step 2					22	38	4
Step 3					30	68	N/A

Hopeville's Incremental Reductions Needed for Compliance

Under low growth assumptions, Hopeville faces a reduction need of 16 lbs./day. As the table demonstrates, APT generates 16 lbs./day of reductions, the exact volume of reductions required by the TMDL. If the POTW implemented this control technology, compliance would be reached and there would be no incremental reductions needed. However, under moderate growth estimates, the TMDL would require Hopeville to reduce its discharge by 22 lbs./day. The difference between the reductions achieved with APT (16 lbs./day) and the total reductions needed (22 lbs./day) would equal 6 lbs./day. These represent the incremental reductions needed for compliance. Similarly, under high growth assumptions, implementing APT and Biological Nutrient Removal would generate 38 lbs./day of reductions, while Hopeville would be required to reduce its TP discharge by 42 lbs./day. Under these assumptions, the POTW would fall short of compliance and need 4 lbs./day of incremental reductions.

Task 4: Calculating Annualized Control Costs

To estimate the anticipated annualized cost of each control option, you will need to total the annualized capital cost and the annual O&M cost.

- Annualized capital cost is the total cost (including associated finance charges) incurred for installing a control option divided by the control option's useful life.
- Annual O&M cost should include but not be limited to monitoring, inspection, permitting fees, waste disposal charges, repair, replacement parts, and administration.

The following worksheet describes the calculations[4]:

Calculation of Annualized Control Costs

Cost of Installing Control Option	________________	(1)
Time Period of Financing (Expressed as years)	________________	(n)
Interest Rate for Financing (Expressed as a decimal)	________________	(i)
Annualization Factor*	________________	(2)
Annualized Capital Cost [Calculate (1)x(2)]	________________	(3)
Annual Cost of Operation & Maintenance**	________________	(4)
Total Annual Cost of Control [(3)+(4)]	________________	

* Appendix D contains the Annualization Factor for a range of interest rates and time periods

** For recurring costs that occur less frequently than once a year, pro rate the cost over the relevant numbers of years (e.g., for pumps replaced once every three years, include one-third of the cost in each year).

The appropriate interest rate will depend on the facility's ability to access financing. Public treatment works may have access to grants and revolving funds designated for water quality infrastructure improvements. Currently, the EPA and state funded Clean Water State Revolving Fund issues loans at rates between 0 percent and market rates, with approximately 2.5 percent being average. In some circumstances, certain private entities are also eligible for loans from these below market funds. Borrowers from the capital markets currently face interest rates of approximately 6 percent.

[4] As previously mentioned, the models and tools in this chapter provide you with general screening capabilities. In certain cases, an investment made in control technologies may be phased in over several years. This potentially affects your annualized cost calculation. When analyzing a phased investment, the precision of your analysis will increase by appropriately modeling each phase of the project and summing the individual results in a logical manner.

Hopeville's Annualized Control Costs
Hopeville is analyzing its control costs based on installing APT. The equipment costs $332,468 to install (1) and will be financed through a municipal bond backed by Hopeville's water and sewer fees over a 10-year period (n). Currently, similar bonds issued by comparable municipalities pay 4.5 percent (i). The Annualization Factor for a 10 year financing period at 4.5 percent is .1264 (2); therefore the annualized Capital Cost equals ($332,468) multiplied by (0.1264) or $42,024 per year (3). The O&M costs for this option are estimated to total $14,008 (4) annually. Therefore it will "cost" the POTW $56,032 each year to control their discharge and maintain compliance by investing in APT.

Task 5: Calculating Incremental Control Cost

The final task is to divide annualized costs by the incremental reductions needed for compliance. This should be done for each relevant time period (e.g., 5 years and 10 years) under each growth scenario. Hopeville analyzed its three options for the POTW and produced the following table for its five-year projection.

Figure 2.3, Hopeville's POTW 5-Year Projection Including Costs

Hopeville POTW 5 Year Projection (lbs./day)

Control Option	Low Growth									
	Annual Growth	TP Load	Target Load	Total Reduction Needed	Reduction Achieved	Cumulative Reduction Achieved	Incremental Reduction Needed for Compliance	Control Increment Capital/O&M Incurred Annualized	Incremental Control Cost	Average Control Cost
	1.0%	66	50	16			16			
Step 1					16	16	0	$56,032	$9.59	$9.59
Step 2					22	38	N/A	$219,022	N/A	$27.28
Step 3					30	68	N/A	$339,450	N/A	$31.00

Control Option	Medium Growth									
	Annual Growth	TP Load	Target Load	Total Reduction Needed	Reduction Achieved	Cumulative Reduction Achieved	Incremental Reduction Needed for Compliance	Control Increment Capital/O&M Incurred Annualized	Incremental Control Cost	Average Control Cost
	3.0%	72	50	22			22			
Step 1					16	16	6	$56,032	N/A	$9.59
Step 2					22	38	N/A	$219,022	$100.01	$27.28
Step 3					30	68	N/A	$339,450	N/A	$31.00

Control Option	High Growth									
	Annual Growth	TP Load	Target Load	Total Reduction Needed	Reduction Achieved	Cumulative Reduction Achieved	Incremental Reduction Needed for Compliance	Control Increment Capital/O&M Incurred Annualized	Incremental Control Cost	Average Control Cost
	8.0%	92	50	42			42			
Step 1					16	16	26	$56,032	N/A	$9.59
Step 2					22	38	4	$219,022	N/A	$27.28
Step 3					30	68	N/A	$339,450	$232.50	$31.00

Hopeville's Incremental Control Cost
As noted earlier, Hopeville's "Step 1" control option generates the exact number of reductions needed for compliance under low growth assumptions. Therefore, the incremental control cost for Step 1 is equal to $56,032 (the annualized cost) divided by 16 lbs./day (the incremental reduction needed for compliance with no additional control) or $9.59/lb./day.[5] If the city experiences medium growth over the next five years, Step 1 will fall 6 lbs./day short and force Hopeville to implement both Step 1 and Step 2. The incremental control cost for Step 2 is equal to $219,022 (the annualized cost of Steps 1 and 2) divided by 6 lbs./day (the incremental reduction needed for compliance using Step 1 control) or $100.01/lb./day. However, Step 1 and Step 2 together would not produce compliance under a high growth scenario. Consequently, the incremental control cost would be $339,450 (the annualized cost of Steps 1, 2, and 3) divided by 4 lbs./day (the incremental reduction needed for compliance using Steps 1 and 2) or $232.50/lb./day.

STAGE 2: *EXAMINING THE WATERSHED*

As already discussed, the goal of water quality trading is to take advantage of differences in incremental control costs among sources in a watershed by allowing facilities facing higher costs to compensate those who can produce reductions at lower cost, thereby producing the same (or more) environmental benefit with less overall cost to society. Analyzing incremental costs for all dischargers in a watershed may be seen as a premature segmentation of the market into high cost reduction producers (likely buyers) and low cost pollutant reducers (likely sellers). However, at this time, the main focus of analysis should be to characterize the size of the incremental control cost differences present in your watershed. The differences in incremental control costs may be consumed by other financial and market factors that are discussed in Stage 3. At this time, you are concerned only with identifying the range of differences present based on different growth assumptions.

Compiling Information from Other Sources

The potential advantages of trading may motivate a variety of actors, both public and private, to investigate trading opportunities in the watershed. Analyzing trading potential therefore may involve compiling information from many sources, including family farms, POTWs, and publicly traded corporations. These potential market participants, while under pressure from the same market driver (e.g., the need to meet a TMDL allocation), may have different motivations for discussing water quality trading. In addition, incentives to share information with outsiders, like regulators or environmental groups, may vary. Engendering trust and being creative may help in acquiring needed data. (For example, Appendix E is a sample data sheet distributed to pollutant sources participating in a pilot project. This information was then compiled into spreadsheets used for a market assessment.)

[5] Most pilot projects have chosen to denominate their costs in dollars/pound/day. Accordingly, the table divides the annualized control cost by 16 lbs. and 365 days. $56,032/16 lbs./365=$9.59.

Public Point Sources

Ability to gather the needed control cost information for POTWs or other public point source dischargers is likely enhanced by public disclosure and information laws. Citizens are often entitled to obtain a wealth of information including planning documents and discharge data from individual industrial dischargers to the public system. Often, public facilities have required planning cycles for projecting future demands for service and preparing to cost-effectively manage community infrastructure needs. In addition, working directly with the POTW to obtain the pertinent information may help develop relationships beneficial to future trading efforts.

Private Point and Non-point Sources

Soliciting information from private sources is more challenging. Creating a water quality trading market is an unconventional approach to improving water quality which explicitly depends on the potential benefits of trading in a given watershed. In conventional markets, cooperation evolves during the exchange of goods and services when buyers indicate their willingness to pay and sellers exhibit their willingness to accept. Consequently, in a traditional market, information sharing is usually limited to negotiating a specific transaction. Analyzing the financial attractiveness of water quality trading requires sharing information prior to negotiating trades. The desired information includes potential reduction costs, which could give competitors clues about a facility's future strategic plans. Wide dissemination of this information could reduce competitive advantages currently enjoyed by the local facility. In addition, detailed information on cost, market supply, and market demand for pollutant reductions may allow other market participants to capture larger shares of trade benefits. Therefore, both the information required to develop the watershed trading financial analysis and the results of that analysis may be perceived as potentially leading to financial losses.

Private entities may be understandably reluctant to provide information considered business sensitive. It is even possible that some entities may attempt to secure bargaining power by providing inaccurate cost information. This could allow them to buy reductions at a price lower than their willingness to pay or selling reductions at prices higher than their actual willingness to accept. Although these incentives may muddy the financial analysis, private sources are unlikely to game themselves out of participating in a water quality trading market.

Sources for Non-Point Source Cost/Pollutant Reduction Information

In many cases, non-point sources have access to information resources pertinent to their likely costs. If they are unwilling or unable to share the information, non-point cost and pollutant reduction information will likely have to be pieced together from a variety of sources. Some trading pilot projects, like Tar-Pamlico in North Carolina, have completed studies and published them on the Internet. Other information sources include the U.S. Department of Agriculture's Natural Resource Conservation Service, Agricultural Research Service, and agricultural extension programs at colleges and universities.

Putting the Information Together

As more dischargers are included in an analysis, complexity increases. The key to organizing the information is to ensure an "apples to apples" comparison. As discussed in the previous chapter, annual and seasonal TMDL allocations are often implemented through NPDES permit limits with daily, weekly, or monthly compliance metrics. In the hypothetical, as in many pilot phosphorus trading projects, the pollutant is measured in pounds per day. Although translating between any two metrics is possible, you should verify that the analysis employs a common numerator and denominator for all sources. The format used below to analyze incremental cost of control in the hypothetical has been used in pilot trading programs. It is always wise, however, to tailor the format for the analysis according to the needs and skills of watershed participants.

A Financial Snapshot of the Happy River Watershed

Combining the Needed Data
Hopeville and its fellow sources exchanged the needed information and produced the following spreadsheet, cataloging each source's incremental control cost in five years under a moderate growth scenario. Sources are listed from upriver to downriver and all possible technology steps for each source are listed.

Figure 2.4, Happy River Watershed Combined Analysis

Medium Growth 5 Year Projection (lbs./day)											
Facility	Annual Growth	TP Load	Target Load	Total Reduction Needed	Reduction Achieved	Total Reduction Achieved	Incremental Reduction Needed for Compliance	Control Increment Capital/O&M Incurred Annualized	Incremental Control Cost	Average Control Cost	Potential Surplus Reductions Available to Market
Pleasantville	3.0%	917	633	284							
Step 1					662	662	N/A	$ 2,074,237	$20.01	$8.58	378
Step 2					107	769	N/A	$ 5,222,364	N/A	$133.72	485
Herb's Farm	3.0%	873	527	346							
Step 1					91	91	255	$ 49,823	N/A	$1.50	None
Step 2					623	714	N/A	$ 464,444	$4.99	$2.04	368
Acme Inc.	5.0%	698	410	288	506	506	N/A	$ 6,308,251	$60.01	$34.16	218
Hopeville	3.0%	72	50	22							
Step 1					16	16	6	$ 56,032	N/A	$9.59	None
Step 2					24	40	N/A	$ 219,022	$100.01	$27.28	18
Step 3					55	95	N/A	$ 339,450	N/A	$31.00	73
AAA Corp.	7.0%	274	166	108	163	163	N/A	$ 590,906	$14.99	$9.93	55

STAGE 3: ANALYZING THE RESULTS

Task 1: Identifying Potentially Viable Trades

The format used to compile incremental control cost information for the hypothetical watershed allows watershed participants to analyze a one-to-one pollution reduction purchasing relationship. The next step is to identify potentially viable trades. As demonstrated in the 5-Year Medium Growth Projection, the incremental control costs ($/lb), in descending order, are:

- Hopeville $100.01;
- Acme $60.01;
- Pleasantville $20.01;
- AAA Corp. $14.99; and
- Herb's Farm $4.99.

Because trading allows facilities facing higher reduction costs to compensate those with lower reduction costs, sources theoretically would consider trading with any source below them on the list. Using this simple assumption, the following nine possible transactions appear to be financially attractive:

- Hopeville compensates Acme Inc. to overcontrol;
- Hopeville compensates Pleasantville to overcontrol;
- Hopeville compensates AAA Corp. to overcontrol;
- Hopeville compensates Herb's Farm to overcontrol;
- Acme compensates Pleasantville to overcontrol;
- Acme compensates AAA Corp. to overcontrol;
- Acme compensates Herb's Farm to overcontrol;
- Pleasantville compensates AAA Corp. to overcontrol;
- Pleasantville compensates Herb's Farm to overcontrol; and
- AAA Corp. compensates Herb's Farm to overcontrol.

Task 2: Detailed Analysis

Although the Preliminary Analysis may identify potential trades, assessing financial attractiveness on this basis alone requires making several assumptions. (The previous chapter discussed how unlikely some of these assumptions may be.) For example, one would have to assume that:

- The effectiveness of the control technology selected is not variable;
- Reductions in all locations in the watershed are environmentally equivalent;
- Transaction costs are zero;
- Reductions are certain to occur; and
- The timing of all reductions will coincide with compliance mandates.

The financial attractiveness of a trade is subject to deterioration as these and other complicating factors are included in the analysis. Pilot project experience indicates that an organized analysis is needed to add the relevant additional considerations as an overlay to the preliminary analysis. These additional considerations (discounts, ratios, transaction costs, and risk) are best investigated in ascending order of complexity. As each consideration is added to the analysis, the stakeholder can decide whether further effort to create a trading market is warranted. If the incremental cost differences become very small, thereby substantially reducing financial attractiveness, watershed participants may decide that trading is not viable. If a reasonable level of financial attractiveness remains, additional factors can be considered.

Uncertainty Discount Adjusted Incremental Control Cost

Two types of pollutant reductions have been identified in pilot projects and the literature—measured reductions and calculated reductions. Certain control technologies result in easily measured water quality improvements; ongoing monitoring effectively quantifies the actual reductions achieved. In some cases, however, measuring a control option's impact on pollutant loading is either infeasible or very costly. Reductions for these control options are often estimated based on scientific modeling for the watershed. Loading reductions from Best Management Practices (BMPs) used by non-point sources are most likely to be calculated.

BMPs perform differently based on a variety of site specific factors that may not be included in the model, introducing the chance for variable and unpredictable results. In pilot projects, the relatively variable and unpredictable performance of BMPs has been handled by discounting the associated estimated reductions available for trade. The uncertainty discount ensures that estimate errors in the BMP reduction equation (derived from the model) will not jeopardize the environmental equivalence between different types of pollutant reduction methods. The size of the discount will likely be driven by local conditions with input from stakeholders. To measure the uncertainty discount's effect on the financial attractiveness of individual trades, you will need to recalculate the source's incremental cost of control using the discounted reductions.

Analyzing the Happy River Watershed

Pleasantville and Herb's Farm

Herb's Farm can use its Step 1 and 2 control options -- sediment ponds and constructed wetlands – to control discharges from its fields and trade the overcontrol to Pleasantville. Research shows that, on average, these options could reduce phosphorus loadings from the farm by 623 lbs./day. At an annualized cost (based on the length of the growing season when the farm can generate reductions) of $464,444 the incremental control cost for Step 1 is $4.99/lb./day[6]. However, reductions by Herb's Farm are likely to vary based on its unique (and sometimes unknown) characteristics. It would be too costly to measure the actual phosphorus reduction achieved on a daily basis. Potentially, stakeholders could ask that an uncertainty discount factor be applied to the projected reductions achieved. A 50 percent discount would mean, in effect, that the farm must produce 2 lbs. of projected reductions for every 1 lb. it wishes to trade. Consequently, from Pleasantville's perspective, the total cost of achieving its needed increment of control through trading will increase because it will need to purchase more credits to achieve an environmentally equivalent reduction. The price per pound of reduction increases from $4.99 to $9.98, modestly eroding the financial attractiveness of a trade between Herb's Farm and Pleasantville.

[6] The cost per pound per day is based on the same incremental costs analysis performed for Hopeville. As per Figure 2.4, Herb's Farm Step 1 reduces discharge by 91 lbs. The farm would need an additional increment of 255 lbs. to comply with the TMDL. As such, to calculate the incremental control cost, the annualized cost for Steps 1 and 2 ($464,444) must be divided into 255 lbs.

Environmental Equivalence Ratios

The water quality impact of a pollutant discharge varies depending on its location in the watershed. As discussed in the previous chapter on Pollutant Suitability, a discharge's impact depends on the pollutant's fate and transport as well as hydrologic conditions in the watershed. Environmental equivalence ratios must sometimes be established to ensure that the overall pollutant load does not impair beneficial uses of the river at specific monitoring points. But ratios can be distributed within a market to find the least cost pathway to achieving the load goal.

Pilot projects have used different environmental equivalence ratio methodologies ranging from the simple to highly complex. Some have used a simple fixed ratio (i.e., 2-1) for all trades. Others have created an index system based on a mass balance model that accounts for inputs, withdrawals, and groundwater infiltration. In these systems, a compliance point downstream is used to index the fate and transport of the pollutant from upstream sources. Dividing Source A's index by Source B's index determines the ratio of reductions Source A would have to buy from Source B.

Because these ratios can compare environmental equivalence only between two sources, it is difficult to present a comprehensive analysis of their effects on the financial attractiveness of trading for the whole watershed in a single spreadsheet. Watersheds with a large number of sources can be extremely complex. Ten potential trading sources would involve 54 trade permutations, many of which are not likely to prove viable. The goal of your analysis should be to identify "Alpha Trades," those with potentially significant financial gains, and, therefore, strong financial attractiveness even after environmental equivalence ratios are introduced. As suggested by the previous chapter, Alpha Trades are not likely to involve sources separated by significant distances or sources with significant water diversions in the stream segment separating them.

Alpha Trades that may merit analysis in the Happy River Watershed are:

- Hopeville compensates Pleasantville to overcontrol;
- Hopeville compensates Herb's Farm to overcontrol;
- Pleasantville compensates Herb's Farm to overcontrol; and
- Acme Inc. compensates Pleasantville to overcontrol.

Environmental equivalence ratios can have a profound effect on financial attractiveness. As the ratio between buyer and seller increases, the volume of purchased reductions to maintain compliance increases, driving the cost per unit of purchased reduction higher. Conversely, as the ratio between buyer and seller gets smaller, cost per unit of purchased reduction falls. The following hypotheticals illustrate various key nuances of this relationship.

Hopeville, Pleasantville, and Herb's Farm
Hopeville faces incremental control costs of $100/lb. Pleasantville is able to control for $20/lb. creating an incremental control cost difference of $80/lb. Financial attractiveness appears high assuming the reductions have an equivalent effect on water quality. However, as a mass balance model indicates, the long distance between the two sources and an intervening river diversion between create an environmental equivalence ratio of 5.0. Therefore, Hopeville must purchase 5

lbs. of reductions from Pleasantville for every 1 lb. of its own required reduction. The cost to Hopeville of a one pound reduction purchased from Pleasantville increases from $20 to $100, completely eroding any potential gains from the trade.

In contrast, Herb's Farm is able to overcontrol for $5/lb., creating an incremental control cost difference between Hopeville and the farm of $95/lb. The river diversion creates an environmental equivalence ratio of 3.0 between the POTW and the farm. Therefore, Hopeville must purchase 3 lbs. of reductions from Herb's Farm for every 1 lb. of its own required reduction. In this case, the unit cost to Hopeville of a one pound reduction purchased from the farm increases from $5 to $15. The difference between Hopeville's cost of controlling one pound of phosphorus or purchasing the environmental equivalent from the farm is ($100 minus $15) $85. This appears to be a highly attractive potential trade.

Pleasantville's close downstream proximity to Herb's Farm means that almost every pound of phosphorus the farm can remove from the river achieves more environmental benefits than if Pleasantville made the pollutant reductions itself. Mass balance modeling shows that Pleasantville needs to purchase only six-tenths (0.6) of a pound of overcontrol for every pound of reduction it needs. The cost to Pleasantville per pound of equivalent reduction purchased from the farm would be $3 rather than $5.

Acme and Pleasantville

Environmental equivalence ratios in downstream trades can reverse the relationship between higher and lower incremental control cost sources. Acme's index to the compliance point at the confluence of its tributary and the mainstem is (0.9). The large diversion downstream of Pleasantville means only a portion of the discharge from its facilities remain in the mainstem of the river at the compliance point. Pleasantville has received an index of (0.25). In this case, Pleasantville would need to buy a little over a quarter of a pound (0.25/.9=.2777) of reductions from Acme for every one pound of required reductions at its facility to lower the watershed's Total Phosphorus at the compliance point. This means the unit cost to Pleasantville of a one pound reduction purchased from Acme is approximately $16.66/lb. $3.34 less than the $20/lb. Step 1 would achieve at Pleasantville's own facility. Therefore, in this case, the lower cost producer of reductions may find it beneficial to purchase reductions from a higher cost source.

Transaction Costs

Transaction costs influence the financial attractiveness of a trade. Transaction costs represent all the resources needed to affect the trade, including information gathering, negotiation, execution, and monitoring. For a trade to be developed, at least one party must expend resources (usually time and effort) assessing the potential viability of the trade and communicating findings to the other party. To achieve the necessary "meeting of the minds," discussions with the other party and additional key stakeholders (i.e., regulatory agencies and local interest groups) must be undertaken. These negotiations may involve staff time, travel expenses, and legal fees. Costs are later incurred in monitoring compliance with trade agreements and maintaining communications with stakeholders.

It may be helpful to consider transaction costs in your financial attractiveness analysis. Transaction costs are highly variable, depending on such factors as the volume of trading, the infrastructure needed to facilitate trading, and the number and types of participants involved. Regulatory agencies may have significant influence on the relevant variables, and are therefore key controllers of transaction costs. Trading system designers must be attentive to the transaction costs they design into each trading arrangement. Failure to adequately take account of financial realities by controlling transaction costs can diminish or even eliminate the potential benefits of trading.

Several common tools can be used to estimate transaction costs. For example, Full Time Equivalents (FTEs) can be used to represent the salary and personnel overhead expenses of employees typically performing functions related to the trading market. In addition to assessing and negotiating a trade, employees will need to meet monitoring and reporting obligations related to the trade. New equipment needed for effluent and instream monitoring and data management may be needed and/or fees for laboratory analysis may be incurred. All these transaction costs of trading, along with the annualized capital and O&M cost for each control technology step, increase incremental control cost. To the extent that you are able to include these in your annualized costs, the precision of your in incremental control costs estimates will increase.

Risk

Risk is the final factor to consider in assessing the financial attractiveness of a trade. The first consideration is that efforts to create a trading system may or may not result in an approved trade. As already discussed, designing a water quality trade can be difficult and highly complex. The costs involved can be substantial. During initial design and negotiation, watershed participants are likely to reassess the chances of success continuously and will discount the value of a potential trade accordingly. For a trade to be viable, potential participants must believe that the financial benefits of the trade will be large enough to justify bearing the market risk. The timeliness and predictability of the decision processes prior to the first trade are therefore key leverage points to mitigate market risk and facilitate trading.

The other dimension of risk is trade risk. In a water quality trading market, one party must rely on other party(s) to fulfill its obligations. Agreed upon terms of a trade may or may not be performed by the parties. If agreed upon reductions are not achieved and NPDES permit requirements are thereby violated, the purchaser of those reductions may face legal enforcement and monetary penalties. In the context of water quality trading, trade risk represents the expected cost of non-compliance and the perceived probability that such non-compliance will occur. Currently no entity provides third-party insurance policies for water quality trading. Because they must self-insure, watershed participants will value trade risk subjectively and mitigate for it by discounting the price paid for available reductions.

The subjective valuation of trade risk limits your ability to estimate the trade risk markdowns watershed participants are likely to demand when negotiating a trade. At this point in your analysis, it may prove beneficial to discuss trade risk and the associated discounts with other watershed participants. Risk markdowns may be considerable in light of the large noncompliance penalties authorized by the Clean Water Act and the uncertainties surrounding trade risk.

As you begin to examine risk and transaction costs, you may wish to review the likely incremental cost differences between parties after uncertainty discounts and location ratios are considered. If a substantial difference remains, it is likely that risk and transaction costs will erode only a portion of the remaining financial attractiveness of a trade. If uncertainty discounts and location ratios have already significantly eroded the difference in incremental control costs, the remaining financial attractiveness may well be entirely consumed by transaction costs, market risk, and the buyer’s trade risk markdown.

Implications of Transaction Costs, Risk, and Market Design

Transaction costs and risk can be mitigated to some extent through thoughtful market design. Chapter 4 more fully describes the building blocks and key functions of a market and offers specific advice on how to tailor a market to its watershed's unique characteristics. Many stakeholders may be involved, each with different needs. A highly constructive stakeholder will focus on designing a market that meets, at a minimum, two goals: 1) reduced risk and 2) lower transaction costs. Transaction costs are largely associated with collecting and communicating information and obtaining agreements and regulatory approvals. To the extent that trading arrangements are transparent and frictionless, costs and risks associated with communication and understanding can be reduced. Similarly, transparency and the free flow of information create stable expectations and outcomes for market participants. With fewer lurking "unknowns", participants will feel less vulnerable in the marketplace and their required risk discount may shrink.

Other Important Factors

As you can see, the financial attractiveness of water quality trading may be highly nuanced by the considerations already addressed. Other factors may arise in your watershed based on its unique characteristics. The following are just two examples of watershed-specific considerations.

Market Size

Because pollution control technologies often produce reductions in large blocks, the water quality trading marketplace may be "lumpy". Depending on how much reduction a potential buyer needs relative to what technology can deliver, this can limit or enhance financial attractiveness. If a discharger needs one pound per day of reductions to comply, but the only available control technology is very expensive and will produce reductions well in excess of one pound per day, then that discharger's willingness to pay another party for that one pound of reduction could be very strong. On the other hand, if the same discharger needs 200 lbs./day, they will only be willing to purchase reductions if the entire 200 lb. reduction is reliably available. If that 200 lb. reduction is available only from diffuse sources with small individual surplus reductions, the associated transaction costs and risks may be so significant that trading is not viable.

Missing the Market

The ratio of fixed to variable costs associated with control options, combined with the timing of reduction demand and supply, will affect the financial attractiveness of a trade. If the discharger's control option involves relatively high fixed costs, the incremental costs of control will differ dramatically before and after investment in that control option. Before investment, a potential reduction purchaser will calculate the incremental cost of control as the combination of the amortized fixed and the annual variable costs of control. Once the discharger invests in high fixed-cost controls, those fixed costs are "sunk" and he will calculate the incremental cost of control based only on his annual variable costs. As a result, any trades that were financially attractive before the investment, will have a greatly diminished incremental cost differential after the investment and may actually represent a negative financial return.

It is especially important to consider the fixed/variable cost profile in cases where supply will lag behind demand. In such situations, the potential reduction purchaser will need to comply (i.e., meet demand) by creating its own reductions, at least initially. If this discharger needs a high fixed cost control strategy to create these reductions, the financial attractiveness of any potential future trade will be altered, probably diminished. In effect, the parties will have missed the market unless potential reduction suppliers have low incremental control costs that can compete with the discharger's lowered incremental control costs after its large fixed cost investment. In some cases, a discharger can use a high variable cost control strategy to create the reductions needed initially without incurring large fixed costs. In such cases, the discharger may still find it financially attractive to purchase reductions from another party in order to avoid continued implementation of its short-term, variable-cost control strategy (or in order to create additional margins for growth).

Alternative Scenarios

In light of the various factors influencing financial attractiveness and market participation, a watershed participant would be wise to assess market resiliency under alternative assumptions. This is especially important relative to the two factors that are likely to exhibit variability due to quantification difficulties and/or subjectivity—transaction costs and perceived risk. Spreadsheet programs allow for easy scenario playing, including: removing individual participants from the market; changing environmental equivalence ratios; or projecting alternative TMDL reduction requirements. Examining alternative scenarios may reveal, for example, that a large source unable to garner all reductions it needs from other watershed participants may decide to invest in controls and thereby eliminate almost all of the demand in the watershed, rendering trading unlikely or impossible due to insignificant remaining demand. You may discover other factors that could erode control cost differences beyond the level at which trading remains financially attractive. Identifying the most sensitive factors in your watershed will help you build a more robust understanding of trading viability in your watershed as well as highlight specific relationships to keep in mind as you move forward and design your market.

Market Infrastructure

Purpose

The first two chapters of this Handbook addressed the viability of trading based on pollutant suitability, watershed and discharger characteristics, and the financial attractiveness of likely trades. This chapter considers the infrastructure required to enable trading. This chapter will help answer the following questions:

- What functions must a water quality trading market perform?
- Why is each function important to the success of water quality trading?
- What mechanisms have been used to perform these functions in demonstration trading projects?
- What are the considerations in selecting appropriate mechanisms and integrating them into a market?

After reading this chapter, considering the examples provided, and reflecting on what you have learned in the previous chapters, you will better understand the watershed's unique market infrastructure needs, market mechanisms best suited for the watershed, and the commitment that may be needed to create a market. This Handbook does not provide a specific blueprint for creating a market, but does highlight challenges you will face and identify ways to benefit from lessons learned in other watersheds. With this information you will be better able to decide whether trading is viable and tailor a market to your watershed's unique needs.

Approach

All viable markets, whether trading water pollutant reductions or widgets, must efficiently create benefits for its participants. "Markets" are social constructs facilitating interactions among parties interested in exchanging goods or services. Research indicates that successful markets evolve to reduce costs associated with:

- identifying others willing to purchase or supply goods or services;
- comparing the goods or services offered by other parties;
- negotiating the terms of an exchange of goods and services; and
- enforcing the terms of the exchange.

A market is more likely to be successful if it has rules, procedures, and norms allowing parties to participate at a cost acceptable to everyone involved. Viable water quality trading (WQT) markets are no different from conventional markets in this regard. However, WQT markets are unconventional in the sense that they exchange goods (pollutant loading reductions) that are created primarily by (i.e., have value because of) regulations and administrative procedures. As such, WQT markets may require different and/or additional infrastructure to ensure environmental equivalence and practical enforceability, while providing the opportunity for cost savings.

This chapter of the Handbook will introduce you to the primary functions of a viable WQT market. These functions are to ensure that, along with satisfying the efficiency criteria for conventional markets, WQT markets provide for environmental equivalence and practical enforceability.

Market development and transaction costs, as well as risks associated with various uncertainties, play an ongoing role in encouraging or suppressing market activity. These considerations, which collectively represent the degree of "friction" individual transactions face in the marketplace, should remain central to all infrastructure design decisions. Failure to manage market friction effectively will substantially constrain and may entirely stifle otherwise environmentally equivalent and financially attractive trades.

As discussed in the previous chapter, potential WQT market participants may be challenged by a variety of ***market development costs***, including those associated with analyzing the viability of trading in the watershed, developing and selecting options for market infrastructure, convening interested parties to discuss trading perspectives and options, and creating the infrastructure. ***Market development uncertainty*** – the risk that a market may not emerge – compounds these challenges.

In addition to market development costs, ***transaction costs*** include information gathering, trade execution, and compliance monitoring efforts undertaken while trading is underway. These transaction costs will be driven largely by the procedures, trade execution methods, and tracking infrastructure established by the market for the watershed. ***Transaction uncertainty*** due, for example, to an unclear basis or time-frame for regulatory approvals will compound these costs. A market that needs trade-by-trade regulatory approval, for example, will be relatively costly and uncertain. There will be a constant risk that any particular trade will not materialize or will not receive regulatory approval in time to satisfy a source's capital budgeting and/or compliance deadline constraints.

High market development costs/uncertainty combined with high transaction costs/uncertainty produce substantial overall market friction. High market friction will limit activity to only very, very financially attractive trades. The market's infrastructure will contribute to or reduce this friction. Therefore, the infrastructure designer's goal is to create the smoothest transaction path consistent with regulatory requirements and water quality improvement goals.

WQT markets are intended to provide for improved water quality at a lower societal cost. In most situations, market drivers are primarily concerned with attaining environmental goals and allow trading only as one option to further that effort. Federal, state, and local laws and the need for stakeholder involvement may require complex infrastructure mechanisms (monitoring regimens, auditing practices, public participation opportunities, etc.) that increase costs and may restrict and/or complicate market infrastructure design. For purposes of this analysis, you may think of these considerations as "regulatory friction". When designing a WQT market you need to look for ways to minimize both market friction and regulatory friction.

This chapter of the Handbook suggests ways to manage market and regulatory imperatives to encourage efficiency and increase the likelihood that trading will occur. To this end, three WQT models will be discussed based on how each model performs particular functions. Building on the information and analysis you were asked to develop in the previous chapters, this additional information will help you design an appropriate market infrastructure to perform the essential functions in your watershed. No particular approach is prescribed, but this chapter offers options and criteria to evaluate them.

Considerations: Market Sizing

This section is intended to help you find ways to substantially reduce market and regulatory friction by appropriately sizing your market infrastructure to your watershed's unique trading characteristics. The first two chapters of this Handbook, Pollutant Suitability and Financial Attractiveness, help you develop a solid understanding of where your watershed might be positioned along the water quality trading spectrum. At one end of the spectrum is a watershed with a single viable trade between two point sources who will experience modest financial benefits and are expected to sustain the trading relationship for the foreseeable future. At the other end of the spectrum is a watershed with an unknown number of viable trades among both point and non-point sources. These trades would be for limited durations and require frequent negotiations and approval, while potentially saving millions of dollars. For the watershed with only one viable trade, a market infrastructure consisting of a web-based trading platform linked to state agency databases would be unnecessary and so expensive that, if it were required, it would likely make the trade unattractive. On the other hand, if participants in the large, dynamic market were required to continually revise their NPDES permits to reflect every new trading arrangement, the costs and uncertainty in the market would diminish or eliminate the value of trading to many if not all of them. The following information and examples illustrate ways to tailor your "overhead" costs to the potential size of the market in your watershed.

What Is Driving the Market?

All markets evolve to help fulfill the demands of consumers. Consumers provide producers an opportunity to earn a profit for altering their behavior and attending to the market's constantly changing demands for goods and services. Until a consumer decides they "need" a soda, and is willing to pay someone to produce it, there is no market for sodas.

Total Maximum Daily Loads (TMDLs) are the leading market drivers for WQT markets today because they typically create the "need" to alter behavior by reducing pollutant loadings discharged to waterways. TMDLs and similar frameworks are sometimes described as "budgets" for the introduction of pollutants into watersheds. Scientific studies estimate the volume of discharge a specific watershed, or segment of the watershed, can assimilate without exceeding the water quality standards enacted to protect the watershed's designated beneficial use(s). This "pollutant budget" is then allocated across point sources and non-point sources located in the watershed, as well as a federal mandated "margin of safety." The allocation of discharge limits forces sources in the watershed to analyze current practices to see if they need to alter their discharging behavior and the associated options and costs to do so.

Although the EPA Water Quality Trading Policy indicates, "[A]ll water quality trading should occur within a watershed or a defined area for which a TMDL has been approved," the EPA's 1996 Draft Framework for Watershed-Based Trading also acknowledges trading may be possible in equivalent analytical and management frameworks like the Lakewide Area Management Plans (LaMPs) and Remedial Action Plans (RAPs) found in the Great Lakes. The Water Quality Trading Policy also supports "pre-TMDL trading in impaired waters to achieve progress towards or the attainment of water quality standards," as well as "pre-TMDL trading that achieves a direct environmental benefit relevant to the conditions or causes of impairment to achieve progress towards restoring designated uses where reducing pollutant loads alone is not sufficient or as cost-effective." This chapter assumes that your watershed has a TMDL, or similar framework, driving your interest in creating a WQT market.

What Are the Essential Functions of a Water Quality Trading Market?

Based on a review of the academic literature and the water quality trading projects conducted to date, a WQT market has at least eight essential functions. Various mechanisms can perform these functions. Market mechanisms are limited only by participants' creativity, the regulatory environment, and the characteristics of the watershed. In some cases, specific mechanisms may perform more than one function, potentially increasing market efficiency.

The eight essential functions are:

1. Defining marketable reductions;
2. Communicating among buyers and sellers;
3. Ensuring environmental equivalence of trades;
4. Defining and executing the trading process;
5. Tracking trades;
6. Assuring compliance with relevant federal Clean Water Act and state and local requirements;
7. Managing risk among parties to trades; and
8. Providing information to the public and other stakeholders.

The following discussions review briefly why these functions may be necessary for conventional markets and why they are essential for WQT. How well a mechanism may perform its function is discussed in light of market and regulatory friction.

1. DEFINING MARKETABLE REDUCTIONS

Conventional Market Function—In conventional markets, a "marketable" product or service is anything that one individual is willing to compensate another individual to produce. The marketability of a product or service may be influenced by personal need, taste, and economic conditions. For example, a person may need shelter, may prefer to live in a townhouse, and may find it financially advantageous to pay someone to build the house rather than foregoing salaried employment to build it alone. A product may be marketable to one person but not another. For example, some people need shelter, prefer to live in treehouses, and have the skills and time to build it themselves. Such a person might not be open to purchasing a townhouse.

Marketable Products in WQT Markets—TMDLs are intended to set a budget for local pollutant discharges that ensures water quality standards, including designated uses, are attained in a watershed. Discharge "overcontrol" is the marketable product and is produced when the reduction of pollutant loadings goes beyond a discharger's regulatory obligation. A WQT market must do two things to create a marketable product. First, the market must identify the relevant pollutant control obligations. Overcontrol cannot exist until a regulatory framework sets the baseline obligations. Second, the market must transform overcontrol into a marketable product by allowing that behavior to acquire value. Value is acquired when a regulatory framework allows one source to offset its discharge reduction obligations with overcontrol by other sources. As described in the Financial Attractiveness chapter of this Handbook, the value of overcontrol is highly dependent upon differences in incremental control costs. Minor differences will create little, if any, value even if the regulatory framework allows offsets.

2. COMMUNICATING AMONG BUYERS AND SELLERS

Conventional Market Function—All conventional markets are first and foremost communication systems. They provide participants with information on product availability, variety, quality, quantity, and price. This information is used to:

- Identify parties willing to produce or consume goods;
- Compare the merits of similar offers; and
- Negotiate mutually beneficial terms of exchange.

Without a means to acquire the needed information, potential market participants would be unable to benefit from each other's ability and willingness to produce goods and services.

Communication's Unique Role in WQT Markets—A WQT market gives dischargers who face pollutant control costs a forum for communicating with other sources to identify environmentally equivalent discharge reductions potentially executable at a lower cost. Because pollutant suitability and financial attractiveness are specific to the pollutant's chemical properties, the watershed's physical characteristics, and the relevant economic conditions, WQT markets must facilitate sharing information regarding a relatively complex product—a certain type/form of pollution reduction, at a specific time and place, for a predetermined duration, in a particular quantity, for a certain cost.

A good WQT market allows parties to learn what quantity of discharge reductions are being offered and demanded, when they can/will be delivered, their duration, their likely impact on water quality at the point of purchase/sale and all relevant compliance points, and how much they will potentially cost to acquire. A WQT market is more likely to succeed if it allows participants to efficiently survey the details of all potential offers to buy or sell overcontrol and identify those most beneficial to their unique needs. It is less likely to succeed if it fails to disseminate the pertinent information and/or requires participants to expend an inordinate amount of time, energy, and money to do so.

3. ENSURING ENVIRONMENTAL EQUIVALENCE

Conventional Market Function – Some market mechanisms allow consumers to compare the characteristics and quality of products targeting similar needs. For example, over the counter drug packaging must inform consumers of the drug's chemical contents—including the relative volume of active ingredients. This allows consumers to compare the likely effectiveness of various painkillers and cold remedies so they can select the product that best meets their needs.

Equivalence in WQT Markets—As mentioned earlier, trading requires that the impact of the purchased pollutant reduction is (at least) environmentally equivalent to the required reduction. Market participants and other stakeholders must be able to evaluate the environmental equivalence of reducing pollutants at the points of purchase and sale. For example, hydrologic conditions in the stream between the two trading points must be evaluated because they can have a profound impact on environmental equivalence.

Demonstration WQT projects have used various mechanisms to perform the essential market function of facilitating environmental equivalence assessments. One important consideration is the higher cost of developing an accurate model versus setting ratios based on a rule of thumb (i.e., 3 to 1). Although establishing ratios based on accurate modeling and a wealth of ambient data may be the most scientifically precise approach, your WQT program may not be viable unless less costly approaches can be found. The potential participants may be willing to make a tradeoff in such a case. For example, a rule of thumb ratio that is less expensive to develop can be set artificially high to ensure equivalence with a margin of safety, even though this might drive up the cost per unit of needed reductions. A good equivalence mechanism will keep the total cost of a specific trade (i.e., costs to develop the ratio and the cost of needed equivalent reductions) to a minimum. A poor mechanism will fail to control total costs.

4. DEFINING AND EXECUTING THE TRADING PROCESS

Conventional Market Function— Each conventional market has its own unique trading process. The types of trading processes depend on the types of products and participants involved. For example, in a simple retail exchange at the local convenience store, a customer chooses a loaf of bread based on personal taste and posted prices, pays the proprietor at the cash register, and leaves the store free to eat the bread or feed it to the pigeons. A more complex trading process occurs when a party seeks to purchase goods and services for construction of a new skyscraper. This process may involve a request for proposals, bidding by several interested firms, financing the project, selecting a general contractor, purchasing materials, subcontracting special elements of the work, overseeing and inspecting physical construction, and agreeing on the level of completion. Friction in conventional markets can be minimized if participants have a solid understanding of the steps involved in a transaction, the order in which they need to be completed, and each step's likely cost.

The Trade Process in WQT Markets—EPA's Water Quality Trading Policy supports trading under different conditions (i.e., both within the context of a TMDL and prior to its approval.) The policy does not prescribe specific processes that each market must employ to complete a trade. Each WQT market may develop its own trading process.

The "Trading Process" includes the steps all parties must take to complete a proposed trading transaction that ensures full CWA practical enforceability and fully supports TMDL requirements. These steps could include, but are not limited to:

- Negotiating a transaction;
- Accounting for environmental equivalence;
- Completing and conveying appropriate paperwork;
- Reviewing and approving trades;
- Installing control technologies or adopting pollutant management methods;
- Monitoring and verifying reductions;
- Reporting to appropriate regulatory agencies and other stakeholders;

- Auditing reported information against regulatory obligations; and
- Taking enforcement actions, if necessary.

A good trading process covers these steps in the appropriate order while minimizing uncertainty and costs associated with the trading transaction. A poor mechanism is incomplete and adds to uncertainty and costs associated with the transaction so that trading is potentially suppressed. This can happen if the steps don't generate enough momentum towards trade completion. For example, if the process requires control technology installation and monitoring to confirm reductions prior to allowing sale of such reductions, dischargers may be reluctant to commit scarce resources to overcontrol. In addition, redundancies in the process (i.e., steps that are revisited without adding sufficient value) add to transaction costs and will erode the value of trading.

Some states considering trading and those with demonstration projects underway, have developed "State Trading Documents" to describe the process the state will use to formally recognize water quality trades. These documents usually do not prescribe exacting protocols for individual trades, but provide general guidelines while maintaining the state's ability to control water quality administration. Great care should be taken to review your state's document (if it has one) and design the market within its guidelines.

5. TRACKING TRADES

Conventional Market Function—Most conventional markets track transactions. How much information is gathered, who stores it, and its future use depend on the types of transactions and the purposes for tracking. For example, when an individual purchases a loaf of bread at the local convenience store, the store may track the amount paid, when the transaction was completed, and what was purchased. This information may be saved by the register or transmitted to a large database for all transactions completed in the region. The information may be used to justify keeping that store open until 2 a.m., to document sales tax collection, or to manage inventory. The customer receives a receipt that can help reconcile their budget, obtain reimbursement from housemates, or enable a return of damaged goods.

Why Trades Need to be Tracked in WQT Markets—Tracking trades in a WQT market is necessary to ensure that trades are not double counted (i.e., one source does not sell the same reductions to more than one buyer) and to provide an easy audit trail for compliance assurance purposes. The two crucial pieces of information a water quality trade tracking mechanism must include are volume of reduction and chain of custody. In this context, chain of custody refers to the possession of the right to use the pollutant reduction for regulatory compliance purposes. Keeping track of this information helps ensure that the goal of the TMDL, improved water quality, is being advanced and that practical enforceability is maintained. In addition, this information makes the creation and ownership of individual reductions clear and traceable in the context of determining if sources are complying with NPDES or other relevant permits.

A good trade tracking mechanism minimizes market and regulatory friction by keeping transaction costs for chain of custody low, while providing regulators with easy and prompt access to appropriate levels of transaction detail. Transaction costs can be kept low by setting clear and consistent expectations for what information is required and limiting the administrative burden on trading partners. Sizing the tracking system to the market will help limit transaction costs. When regulators can access trade information efficiently, they are less likely to intervene on particular trades or in the market system. A poor trade tracking mechanism will drive up the cost of administering individual trades to the point where it erodes the value of trading. It may require trading partners or regulatory agencies to perform non- value-added administrative tasks (i.e., completing unnecessary paperwork, reconstructing market activity from inconsistent transaction statements).

6. Assuring Compliance with Clean Water Act and state/ local requirements

Conventional Market Function—In some conventional markets, buyers and sellers have regulatory obligations to entities outside the transaction. These obligations derive from a variety of public policy goals including protecting the parties directly involved in the trade and/or those with an indirect interest in the transaction's outcome. For example, the Securities and Exchange Commission requires publicly traded companies to conduct third-party audits of financial statements and report specific information annually to the public. This reduces the opportunity to commit fraud and lowers investors' market risk.

Regulatory Obligations in WQT Markets—WQT processes must involve various watershed participants, including important non-discharging stakeholders like regulatory agencies. According to the EPA Water Quality Trading Policy, trading programs must be developed in the context of regulatory and enforcement mechanisms, which predominantly rely on discharge permits. Thus, the market, federal, state and local regulations, and the agencies responsible for their enforcement are closely connected. EPA's Water Quality Trading Policy, says that "mechanisms for determining and ensuring compliance are essential for all trades and trading programs . . . States and tribes should establish clear, enforceable mechanisms consistent with NPDES regulations that ensure legal accountability for the generation of (reductions) that are traded." EPA's 1996 Draft Framework for Watershed-Based Trading suggests a market must meet conditions, standards, and procedures for ensuring that agencies maintain their ability to enforce the intent of a specific regulation. The appropriate regulatory agency(s) therefore will need a process to authorize, evaluate, permit, verify, and audit trading programs or even individual trades. Demonstration projects have performed this function in a variety of ways.

A good regulatory compliance assurance mechanism minimizes the regulatory friction, transaction costs, and transaction uncertainty associated with any potential trade by achieving consistent approval decisions—in both outcome and timing—based on the data needed to ensure environmental equivalence, prevent degradation, and preclude localized impacts. A poor mechanism increases regulatory friction, transaction costs, and transaction uncertainty by sending incorrect signals to the market regarding what is expected of participants and then inconsistently processing the provided information.

7. Managing transaction risk among parties to a trade

Conventional Market Function—During the exchange of goods or services, a chance always exists that the specific terms or the intent of a negotiated deal will not be fulfilled. Conventional markets allow parties to identify this transaction risk, assign the burden of the risk to the appropriate party, and provide the opportunity for recourse if it is needed. Escrow deposits and performance bonds are examples of such risk mitigation mechanisms.

Managing Transaction Risk in WQT Markets—WQT markets involve three facets of transaction risk:

- The risk that regulators will find that the discharge reductions negotiated under the agreement do not conform to market rules;
- The risk that the specific discharge reductions negotiated under the agreement (for a certain type/form, at a specific time, for a predetermined duration, in a particular quantity) will not be produced; and
- The risk that reductions will fail to have the required impact on water quality.

The chapter on Financial Attractiveness explained the detrimental effects transaction risk can have on trading. Insufficiently managed risk will induce participants to steeply discount the price they are willing to pay for discharge overcontrol. This erodes the financial benefits associated with trading and can potentially suppress market activity. Risk management transaction costs (identifying and assigning risk) increase when remedies for nonperformance of discharge reduction obligations are less certain and the number of parties involved in enforcement issues (regulators, lawyers) increase and/or they become adversarial.

A good transaction risk management mechanism identifies and assigns the three risks associated with WQT to specific parties, and sets reasonable expectations about how failure to fulfill terms of the agreement will be handled, including the size of the remedy. As always, good mechanisms minimize transaction costs. A poor mechanism will create high transaction costs and fail to account for all three transaction risks, assign the risk to an inappropriate party, and/or create ambiguity over how a transaction “gone bad” will be handled.

8. PROVIDING INFORMATION TO THE PUBLIC AND OTHER STAKEHOLDERS

Conventional Market Function—Some conventional markets recognize that commercial activity can directly or indirectly affect parties other than the traders. For example, the Securities and Exchange Commission requires corporate managers to notify the public when they decide to purchase or sell stock in the companies they manage. Public dissemination of this information provides investors and securities regulators with information relevant to investment decisions and public policy.

Public Information in WQT Markets—The CWA and other federal, state, and local water quality regulations require provision of opportunities for public participation, including public notice and opportunity for comment. WQT markets, given this regulatory framework, must therefore perform this essential function. WQT viability often depends on the public participation process to generate understanding and trust among watershed participants. Failure to do so could influence stakeholders to challenge the market system or specific trades, potentially introducing uncertainty and eroding the value of trading.

Although EPA’s Water Quality Trading Policy supports, “public participation at the earliest stages and throughout the development of water quality trading programs to strengthen program effectiveness and credibility,” informing the public about on-going operations and trades may be even more important. Easy and timely public access to transaction information may increase market efficiency. Improving water quality takes sustained effort. An uninformed public may lose interest in a trading program, threatening its long-term viability. Informed watershed participants are more likely to discover and/or support new forms of trading. Some trading markets have produced trading opportunities that do not conform to the market design's original vision of trading, but do provide real water quality and economic benefits. Such opportunities evolve as watershed participants learn more about each other's needs, and the needs of the watershed's ecosystem.

A good public information mechanism is transparent, easy to engage, and available to all interested parties while controlling transaction costs. The EPA Water Quality Trading Policy encourages electronic publication of information on:

- Boundaries of the watershed and trading areas;
- Discharge sources involved;
- Volume(s) of reductions generated and sold; and
- Price(s) paid for reductions.

Additional information may be important to participants in your watershed. The value of satisfying all interests should be weighed against the cost of collecting, managing, and distributing data. A poor public information mechanism will be resource intensive for both the information distributors and its consumers. This leads to higher transaction costs and can have serious regulatory friction consequences. As watershed participants work harder to get information, their level of trust may diminish, thereby threatening the market's stability.

Current Market Models

The remaining market infrastructure discussion focuses on three market models that are in various stages of implementation in the United States. Each of these market models responds to the unique needs of its watershed and market participants while handling the essential WQT market functions discussed above. Each market model is discussed in terms of the basic premise underlying the market, important mechanisms used to support the system, and how the model performs certain WQT market functions. These models illustrate significantly different approaches. After reviewing them, you will have a better understanding of approaches potentially suitable for your watershed.

A Private, Non-profit Co-operative Facilitating Pre-Approved, Dynamic Trading

In 1998, the Lower Boise River Water Quality Trading Pilot Project undertook design of a WQT system for approximately 64 miles of river from Lucky Peak Dam to the mouth of the Boise River. Market participants agreed they could make trading more robust, flexible, and cost-effective by focusing on minimizing regulatory friction. Participants identified seven design principles they felt were crucial to a viable market in their watershed, including the following:

- Avoid trade-by-trade changes to the TMDL;
- Avoid trade-by-trade changes to NPDES permits; and
- Minimize trade-by-trade agency review and approval.

To support these three design principles, watershed participants and regulatory stakeholders worked together to design clear guidelines and requirements for trades that would preclude the need for trade-by-trade review of most transactions. Public notice, review, comment, and agency approval of these trading guidelines and requirements were pivotal to this approach and created a model for dynamic trading. The key element of the Lower Boise market that allows market participants to trade in this fashion is the pre-approval of trade transactions through the issuance of a single new or modified NPDES permit enabling trading.[7]

The Idaho Clean Water Cooperative, a private, nonprofit association of various watershed participants, is charged with the day-to-day management of trading in the Lower Boise River. The Co-op will rely on language in the TMDL, language in NPDES permits, and a State Trading Document establishing the ground rules for creating and verifying trade transactions to facilitate trading. The Co-op will be responsible for helping connect buyers and sellers, developing and maintaining a trade tracking database, and preparing monthly watershed-wide trade summaries. The Cooperative will provide an important link among trading parties, the environmental agencies ensuring Clean Water Act compliance, and the public. By maintaining the trade tracking database and regularly disseminating transaction details, the association will also ensure that timely information about trades is available to the public and the environmental agencies. As a non-governmental organization, the Cooperative will be dedicated to supporting the trading system as requested and agreed to by its members.

Water Quality Market Functions in the Lower Boise River

Defining marketable reductions—The Lower Boise market uses a common definition of overcontrol (control below a source's TMDL defined allocation) to classify the reductions that sources may sell. To enable non-point source market participation, market stakeholders (including state and federal regulators as well as agricultural and technical assistance agencies) created a list of Best Management Practices and construction management, monitoring, and verification protocols that pre-qualify resulting reductions for sale. The BMP List provides the basis for the straight-forward verification of the non-point source generated reductions. This was done to eliminate the need for an intermediary in any transaction and create the opportunity for direct participation of non-point sources in dynamic trading. Non-point sources that can demonstrate they follow the appropriate protocols have reductions automatically recognized as valid and fungible.

Communicating among buyers and sellers—Although the Co-op is charged with connecting buyers and sellers, the mechanisms used to fulfill that role are currently undefined. As the market manager, to which all sources must report certain information if they choose to trade, the Co-op is uniquely situated to act as a "broker". This may entail providing an electronic or physical bulletin board of bids and offers for reductions or may evolve into a more formal matchmaking role where the Co-op introduces sources with reduction needs to dischargers capable of addressing them. Both methods can help

[7] As of the publication of this document, trading in the Lower Boise market has not been initiated. Several steps and mechanisms have been created to enable trading, including the creation of the Idaho Clean Water Co-operative, reporting forms, model NPDES permit language, model TMDL language, and the State Trading Document.

participants identify trades that may meet their needs. The costs of communication in the Lower Boise will be borne by both the Co-op and market participants.

Ensuring environmental equivalence—One significant barrier to dynamic, pre-approved trading is the potential for adverse environment impact resulting from individual trades. To lower the total cost of developing a ratio and the needed equivalent reductions, the Lower Boise market will rely on the water quality model developed for formulating the TMDL. This model provided each major discharger with an individual index, allowing a source to relate their discharge's effect on water quality to discharges by other sources. Use of an existing model keeps development costs to a minimum. In addition, this model ensures that trading ratios used are consistent with the TMDL. Relative to ratios based on a rule of thumb set artificially high to ensure equivalence, this minimizes the number of reductions a source must purchase.

Assuring compliance with the Clean Water Act—The Lower Boise market supports consistent approval decisions—in both timing (immediate) and outcome (if protocols are followed). This limits friction in the market through use of specific mechanisms to marry the pre-approval process to compliance assurance.

In this market, the pertinent TMDLs will contain base phosphorus waste load allocations (WLAs) for point sources and a provision for trade-dependent WLA variability. Sources will then receive a new or modified permit incorporating their WLA as a limit and, if desired, a provision enabling a trade-dependent variable limit. As explained below, the enabling provision will allow monthly changes to either the sources' discharge limits (the amount of discharge both sources are allowed to put into the river) or the recognized discharge volume (the amount of discharge counted against the limit) based on trading arrangements.

In all point-source to point-source trades, the enabling provision automatically adjusts the buyer's NPDES discharge limit up and the seller's NPDES discharge limit down, based on the volume of reductions traded and their environmental equivalence ratio. If a source exceeds its adjusted discharge limit during a reporting period, it is in violation of the CWA and potentially subject to regulatory enforcement.

In non-point source to point source trades, the enabling provision gives the point source a "credit" that can be applied against the point source's NPDES permit limit during that reporting period. The credit is based on the volume of environmentally equivalent reductions that have been traded from the non-point source(s) to the point source. A point source violates the CWA if its actual discharge, adjusted for all reduction credits acquired through trading during that period, exceeds its discharge limit. In this market, EPA or the Idaho Department of Environmental Quality (DEQ) may invalidate credits established by the non-point source reductions if they fail to meet BMP protocols and retain full authority to enforce the corresponding point source's effluent limit without crediting its discharge volume.

Point sources involved in a trade will use modified *Discharge Monitoring Reports (DMRs)* to report to the EPA. Along with the modified DMR, each source will submit an individual *Monthly Trade Report* created by the Co-op. DMRs and Trade Reports include actual discharge, point source trades lowering or increasing their discharge limit, and non-point source credits reducing their recognized discharge volume. The EPA uses this information to assure CWA compliance.

Defining and executing the trading process—The Lower Boise stakeholders developed a trading framework clearly defining the roles and responsibilities of all parties involved in a transaction (the buyer, the seller, the Co-op, and the regulatory agencies) and the steps needed to "complete" a transaction. Two steps common to water quality trades are handled automatically by certain mechanisms: 1) accounting for environmental equivalence; and 2) reviewing and approving trades.

The framework allows market participants to negotiate trades on their own and provides clear guidelines for paperwork submission, control technology or process installation, and reporting protocols. Reduction monitoring and/or verification is generally assigned to point sources, while the Co-op, Idaho DEQ, and EPA work together to audit trades and assure regulatory compliance. EPA is responsible for regulatory enforcement actions.

Without trade-by-trade regulatory review, transactions could fail to maintain or improve water quality. To prevent the need for trade-by-trade review without increasing transaction costs or transaction uncertainty, the Lower Boise market uses three market mechanisms to eliminate the potential adverse environmental effects of individual trades. The use of known, published ratios lowers transaction costs because this eliminates the need for potentially time and resource intensive discussion with regulators over individual trades. The pre-qualified BMP list provides participants a clear understanding of what reductions will be recognized, minimizing transaction uncertainty. To preclude localized impacts, modified NPDES permits will include caps limiting the downstream trading capacity of individual sources. This will ensure that individual trades do not produce discharges in excess of the local assimilative capacity of the river segment between trading sources.

How the Idaho Clean Water Co-operative tracks trades—In the Lower Boise, the tracking system was designed to establish chain of custody, maintain accountability, and provide the public with a means of readily tracking all reductions bought and sold. Key elements of the trade tracking system are 1) a record keeping and reporting protocol, and 2) a trade tracking database. The system strives to minimize transaction costs by setting clear and reasonable expectations for reporting. Regulatory friction is managed by providing reasonably direct communication channels between participants, the Co-op, and the regulatory agencies.

Trading parties are required to gather documentation and retain specific information pertaining to trades and then report selected information to the Co-op using standardized forms. For each point-source to point-source trade, a *Trade Notification Form* is required to officially register the trade, transfer reductions from seller to buyer, and trigger the enabling NPDES permit provision(s) to adjust allowable discharge limits. For trades involving non-point sources, both a *Trade Notification Form* and a *Reduction Credit Certificate* must be submitted by the point source to certify the non-point source reduction and generate a credit against the point source's discharge volume. The Co-op will maintain a trade tracking database as well as individual trade and account information and produce a *Monthly Trade Report* for each source.

Managing risk among Lower Boise market participants—The Lower Boise market manages the three risks associated with WQT through its trading framework and private contracts. The market mitigates the risk that specific transactions will not be recognized by regulatory authorities by including in the market driver (applicable TMDLs and implementation plans), as well as the regulatory mechanism (NPDES permits), and the state trading document, the explicit requirements for defining marketable reductions and their proper conveyance to other sources. This information is publicly available, so buyers and sellers of reductions jointly assume the risk that the paperwork documenting their transaction is proper and filed with the required entities.

A defining feature of the Lower Boise market is how it manages the risk that an agreed upon reduction will not be achieved. Water quality regulatory agencies in the Lower Boise have limited or no authority over non-point sources' discharge behavior. Although non-point sources are issued "load allocations" by the TMDL, they are not issued NPDES (or state equivalent) permits that create CWA regulatory liability. Non-point sources involved in creating the market wanted to maintain their independence from CWA regulatory liability and still be allowed to participate in the market. Faced with supporting point source trading while maintaining regulatory independence for non-point sources, market designers decided that CWA liability would reside with NPDES permit holders, while the liability for failing to produce purchased credits would be handled, particularly in the case of non-point source trades, through private contracts.

In the Lower Boise WQT market, trading parties agree on the specific terms of a trade by entering into a private contract that identifies the trading parties, reduction measures to be undertaken, reduction amounts to be achieved, effective date, responsibilities of each party, price and payment provisions, and remedies for failure to deliver reductions. Although private contracts cannot shift regulatory liability from one source to another, they can assign the financial liability of regulatory non-compliance to the seller of pollution reductions. Subject to applicable contract law, the parties to the trade can decide between them who will pay for damages in the event reductions are not delivered and the purchasing source is consequently found to be violating its NPDES permit.

As in all markets, the water quality science is still imperfect and there is some risk that the TMDL analysis was mistaken. The TMDL's waste load allocations, along with associated trading may not be strict enough to achieve water quality standards, including protection of the watershed's desired beneficial use. The TMDL allocations may ultimately be ratcheted down by regulators if water quality improvement is insufficient. Sources committing to discharge reduction strategies—whether through trading, control, or a combination of the two—could find themselves looking for additional reductions after making capital expenditures and/or purchasing/selling reductions. Private contracts help manage this risk in two ways. First, the duration of individual trades is up to the parties. This allows participants to manage uncertainty about future load allocations by choosing the length of time they are willing to commit to a certain strategy. Private contracts can also provide for a party to cancel its contractual obligations in the event that the trade does not ensure compliance with future, more stringent TMDL allocations.

Private contracts in the Lower Boise allow parties to the trade to decide how great they believe the risks are and who will bear them. Writing the contract may require legal assistance, which may be relatively expensive for some non-point sources. It is important to remember that the contract terms used to manage risk will be based on the buyer's and seller's ***perceived*** risk. High perceived risk may result in large price discounts and erode the financial attractiveness of trading.

Providing information to the public and facilitating their participation—The public participation mechanism in the Lower Boise relies on transparency in the Co-op's activities and in the issuance of relevant NPDES permits. This is extremely important because pre-approved, dynamic trading in the Lower Boise requires market designers to generate and maintain trust from non-discharging stakeholders and also satisfy CWA public notice and comment procedures.

A point source wanting to trade remains subject to the standard NPDES permitting process. The usual CWA public notice and comment procedures will give stakeholders the opportunity to learn about and participate in the consideration of issues surrounding market participation by a specific source. Where appropriate, the new or revised NPDES permits will then include language supporting trading. As already noted, trade enabling permit provisions will include: the authorization to trade; the adjustment of the discharge limit or discharge volume; trading caps to prevent localized impacts; and trading procedural requirements. Once a trade enabling permit has been issued, the source's discharge limits and/or discharge volume may be adjusted without further administrative process for each qualifying trade, thereby minimizing transaction costs and uncertainty. The permit will be renewed according to the standard permit cycle schedule (e.g., once every five years).

The Co-op will be responsible for making transaction information accessible to the public. The marginal cost of providing the information—whether on demand or published at regular intervals—will be minimal, as the trade tracking database already manages the information likely to be requested. In the Lower Boise, non-discharging stakeholders have an open forum to question and influence the permitted discharge limits and then easy access to information keeping them informed of actual discharge behavior.

A Public Authority Banking and Managing Phosphorus Credits

In 1985 Cherry Creek Basin Water Quality Master Plan was created to manage development's environmental impact on the Cherry Creek Reservoir in Colorado. In the basin, point source and non-point source nutrient discharges cause eutrophication problems that preclude attainment of the reservoir's designated uses. Rapid economic development in the area was forecasted to strain the ability of local Publicly Owned Treatment Works' (POTWs) to serve the burgeoning population without further degrading water quality in Cherry Creek Reservoir. As dischargers of predominantly soluble phosphorus, which is readily available biologically and promotes rapid algal growth, seven utility districts operating POTWs were challenged to limit their phosphorus contribution to the Cherry Creek reservoir. A Total Maximum Annual Load (TMAL) for phosphorus discharged into the reservoir was set at 14,270 pounds. The wastewater facilities received a total allocation of 2,310 pounds per year.

Two counties, four cities, and the seven utility districts reached an intergovernmental agreement chartering a state empowered government entity, the Cherry Creek Basin Water Quality Authority (the Authority), to develop and administer a water quality trading program facilitating continued economic growth while minimizing adverse impact on water quality in the basin. Although a pilot trading program has been in place for several years, few trades have been completed. Recently, an effort has been made to elicit more market activity. The Authority has been charged with designing a market in which POTWs and other point source dischargers would be able to purchase "credits" included in the POTWs' 2,310 pound phosphorus allocation while funding new phosphorus reduction projects. These credits may increase an individual point source's TMAL allocation and allow it to expand its services to new developments, which would otherwise cause the POTW to exceed its Waste Load Allocation. The trading market requires POTWs to fund phosphorus removal projects in exchange for an allocation of additional phosphorus discharge.

In the Cherry Creek market, the Authority functions as a "Water Quality Bank" by owning and allocating purchasable phosphorus credits associated with four non-point source phosphorus control projects built by the Authority in the 1990's with taxes levied by the Authority on watershed residents. These projects have reduced the net amount of phosphorus discharged, creating additional loading capacity in the reservoir. The credits from these projects have been placed in the "Phosphorus Bank" from which POTWs may draw credits to meet their regulatory obligations. A total of 216 annual pounds of phosphorus credits were allocated to the Phosphorus Bank by the TMAL.

The control technologies used in the non-point source projects include retention/detention ponds, constructed wetlands, and shoreline stabilization above and beyond required BMPs, leading to phosphorus discharge overcontrol. The Authority has total control over these “Sale Credits” and decides who may purchase them. Funds raised from the sale of Sale Credits will be used by the Authority to fund additional projects that will further improve water quality.

The Authority also manages an additional 216 pounds of *phosphorus credit allowances* that give POTWs the right to purchase reductions from non-Authority phosphorus reduction projects and receive an increased WLA. The TMAL allocated the allowances to a “Reserve Pool.” POTWs wanting to increase their phosphorus allocation may construct projects and/or compensate third-party landowners, local governments, or other POTWs to do so for them.[8] “Transfer Credits” tied to these reductions enable the Authority to transfer a portion of the Reserve Pool phosphorus allocation to POTWs. A phosphorus reduction project will be evaluated by the Authority before a specific agreement is reached to use Transfer Credits. An approved project’s reductions are registered with the Authority and create “Transfer Credits.” A POTW may seek additional phosphorus discharge capacity by compensating the owner of the Transfer Credits for their use. The total number of credit allowances third-party projects may generate for redistribution to the POTWs is currently capped at 216 pounds annually.

Important Market Functions in the Cherry Creek Basin

Defining marketable reductions—Marketable reductions in the Cherry Creek market are defined as reductions accruing from the implementation of control technologies in excess of those expected from the Mandatory Best Management Practices identified in the Cherry Creek Reservoir Control Regulations. Mandatory BMPs include temporary measures implemented to mitigate construction runoff (i.e., filter fences, re-vegetation, and hay bales) and/or permanent water quality improvements required by drainage criteria and land use regulations for all new development (i.e., detention ponds, swales, and constructed wetlands).[9]

The Reserve Pool marketable reductions, as defined in the draft guidelines, evolve from one of six different types of projects.

- **Additions to Existing Development**—Phosphorus removals from BMPs not completed during land development prior to January 1, 2000 are eligible for trading.
- **Expanded or Retrofitted BMP Removals**—Phosphorus removals from BMPs that are added to land development undertaken prior to January 1, 2000 that result in additional reductions are eligible for trading.
- **Projects Beyond Required BMPs**—Phosphorus removals from BMPs that result in reductions in excess of the removals from required BMPs are eligible for trading.
- **Cooperative Authority Projects**—Phosphorus removals from Authority and third party co-development projects are eligible for trading. Credits placed in the Reserve Pool will be limited to the proportion constructed or funded by the third party.

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[8] A more detailed description of these projects is provided below.
[9] *Phosphorus Credit Trading in the Cherry Creek Basin: An Innovative Approach to Achieving Water Quality Benefits.* Water Environment Research Foundation. Project 97-IRM-5A. 2000.

- **Engineered Authority Projects**—Phosphorus removals from any non-point source project for which the Authority completes preliminary engineering and design and which the Authority agrees to third party construction of that project are eligible for trading.
- **Water Supply Operations**—Phosphorus removals beyond the incidental reductions from regular, normal operations are eligible for trading.

Not every pound of phosphorus overcontrol from a project may be associated with credit allowances in the Reserve Pool. A project specific "Trade Ratio" is applied to calculate the volume of phosphorus reduction that results in credit allowances recognized by the Authority and the regulatory agencies.

Defining and executing the trading process— Similar to other trading programs, the Cherry Creek Authority and various stakeholders have developed a trading framework clearly defining the roles and responsibilities of all parties (the buyer, the seller, and the Authority) in reviewing reduction projects and trades and administering the allocations of credits. Program evaluations have identified four steps that support these efforts in the Cherry Creek basin.[10] The fifth step described below provides for regulatory review and transforms the trade into a regulatory obligation.

- **Project Evaluation and Approval**—Authority constructed phosphorus reduction projects have already been evaluated and their credits placed in the Phosphorus Bank. Interested parties may nominate other projects for consideration by the Authority. The technical specifications of the project, the estimated reductions, reliability of the project operations, comments from Colorado's Water Quality Control Division (WQCD), consistency with the Master Plan, trading guidelines, and control regulations, and the effect on water quality are all considered by the Authority. Other stakeholders may contribute input at a public meeting. The Authority's Board of Directors votes to recognize the validity of the reductions.
- **Credit Calculation**—After voting to include reductions in the Reserve Pool, the Authority's Board of Directors determines the volume of credit allowances that will be associated with the project based on projected reductions and a project specific trading ratio.
- **Credit Allocation**—Point sources looking to exceed their permitted discharge limits may apply to acquire phosphorus credits from the Phosphorus Bank or credit allowances from the Reserve Pool. Trades are reviewed based on the buyer's history of regulatory compliance and operating abilities, as well as the trade's conformance to the Master Plan and control regulations. Potential Sale Credit applicants are also reviewed based on their "need" as defined by the Authority. A Technical Advisory Team (TAC) reviews all trades and makes recommendations to the Authority Board of Directors. The Board then approves or disapproves each specific trade.
- **Trade Review**—After a transaction is completed, the Authority retains the right and obligation to review reduction performance and periodically adjust the number of credits or credit allowances awarded to point sources based on actual reduction performance.
- **NPDES Permitting**—Prior to discharging phosphorus in excess of its existing NPDES permit, the credit or credit allowance purchaser must be issued a new or modified permit.

[10] Ibid.

The trading guidelines used in the Cherry Creek market provide all participants with a clear understanding of what's expected of market participants. Transaction costs are likely to be relatively known prior to initiating a trade, as the information needed and the process used to evaluate a trade are well defined. Market participants are also likely to understand the transaction costs associated with the permitting process.

Ensuring environmental equivalence—The focus of water quality trading in this market is to maintain the designated uses of the Cherry Creek Reservoir, not to improve water quality within specific stretches of rivers or tributaries. Environmental equivalence is therefore confined to the effect each sources' individual discharge has on the concentration of phosphorus in the reservoir.

Each Reserve Pool transaction receives a trade ratio, which translates phosphorus reductions into credit allowances, set between a minimum of 2-to-1 and a maximum of 3-to-1. The trade ratio varies based on the relative load of soluble and non-soluble phosphorus between the two parties and/or the attenuation of discharged phosphorus as it moves through the watershed. For example, the ratio may be increased when the credit allowance buyer is closer to the reservoir than the credit producer. This adjustment is based on site-specific monitoring data, empirical modeling, and/or best available scientific evidence to account for environmental equivalence. Institutional and scientific uncertainty factors help ensure the ratios reflect actual benefits to the reservoir.

Communicating between buyers and sellers—Use of this market model influences the transaction costs associated with trading partner identification, product comparison, and deal negotiation and their effect on market efficiency. All available credits or credit allowances are held or managed by the Authority. Buyers do not have to contact several potential trading partners to find a mutually beneficial deal. This market model can inherently limit interactions between certain buyers and sellers. The Authority explicitly identifies and then selects trading partners allowed into part of the market by placing reductions from specific projects into the Phosphorus Bank and allowing certain buyers, based on Authority defined "need," to apply for the right to buy the Sale Credits. For the Reserve Pool, the Authority only approves or disapproves the transfer of credit allowances for individual transactions. The Authority has limited justifications for stopping a transaction. As such, market participation in this segment of the market is not limited.

The Authority manages product comparison for Phosphorus Bank reductions by quantifying their volume, applying a project specific trade ratio, and establishing the price of credits. For these reductions, the authority sets the terms of the trade based on authority funded costs of building, operating, and monitoring current and future phosphorus reduction projects, as well as the costs of establishing and administering the trading market. The Authority also manages product comparison for Reserve Pool trades by quantifying available credit allowances based on the trade ratio. However, the Authority does not price these allowances; price is negotiated by the parties to the trade.

Tracking Trades—The Authority is in a unique position to track trading activity because it plays an active role in all transactions. In addition, trades are considered to last in perpetuity, limiting the number of actual transactions that will take place during any given period. The trading activity to date has imposed minimal tracking burdens on the Authority. It is anticipated that the Authority will develop a trade tracking system as trading activity increases. Most likely, a spreadsheet managed by the Authority will be used to ensure that reductions and their associated credits or credit allowances are traded to other sources only once. Trades approved by the Authority are documented in Appendix A of the Cherry Creek Water Quality Authority Trading Program Guidelines.

Compliance assurance with regulations in the Cherry Creek Basin—Although the Authority administers the transfer of credits and credit allowances in the Cherry Creek water quality market, transactions do not *automatically* alter a source's obligations to federal, state, or local water quality regulations. In this watershed, Colorado's Water Quality Control Division (WQCD) is responsible for administering NPDES permits. The WQCD does not acknowledge Sale or Transferred Credits as immediately off-setting the sampled, actual phosphorus discharge counting against the source's NPDES permit limit.

As stated in the Trading Guidelines, "It shall be the sole responsibility of the (credit buyer) to obtain any approvals or modifications to their discharge permits necessary to allow increased or modified phosphorus discharges." Therefore, a source wishing to use 10 pounds of Sale or Transfer Credits must go through the normal permit modification process to increase their discharge by 10 pounds. Sources purchasing credits must work with the WQCD to amend their NPDES permit limits, prior to discharging excess phosphorus. Monitoring and reporting protocols for the POTWs are set out in their individual NPDES permits and follow the standard reporting mechanisms used for NPDES permitting.

Managing risk among parties trading in the Cherry Creek Market—As is common with most water quality banks, Phosphorus Bank credits are made up of credits from various projects co-mingled together. A quantity of credits sold out of the Phosphorus Bank likely includes reductions from several projects that have different risks associated with them. The Cherry Creek market model both actively and passively manages the risk that reductions do not conform to market rules, the risk that specific reductions fail to materialize, and the risk that reductions fail to have the required impact on the designated uses of the watershed for these transactions. The risk management mechanisms are largely a result of the banking model and the trading guidelines developed by stakeholders specifically for Cherry Creek.

In this market, the Authority is delegated the responsibility of evaluating and allocating credits and credit allowances by the regulatory and administrative agencies responsible for watershed oversight. The Cherry Creek Authority, a water quality bank operated as a quasi-government entity, plays an active role in defining marketable reductions. For both Phosphorus Bank and Reserve Pool transactions, the Authority, per its charter, is only allowed to allocate credits or credit allowances if reductions conform to market rules. Therefore, the Cherry Creek Authority manages the buyer's risk of purchasing non-marketable reductions by acting as a credit and credit allowance certifier.

The Authority's certification role also helps manage the risk that the credits or credit allowances purchased by the buyer are not connected to actual overcontrol. The rigorous reduction certification during project approval coupled with the trade ratio creates leeway between the desired environmental benefit and the reductions outlined in the transaction agreement. In addition, if phosphorus reduction projects begin to perform poorly, the Authority may revoke or adjust the number of credit or credit allowances downward. For Phosphorus Bank credits, if re-evaluation results in lowering the reductions achieved (and therefore the credits), the Authority relies on surplus credits in the trading pool that have not been allocated and sold to other sources to make up the difference. If there are insufficient surplus credits in the Phosphorus Bank, the Authority notifies all Phosphorus Bank credit holders that their credits have been reduced on a pro-rata basis for three years. If additional credits become available from the Phosphorus Bank during those three years, credits will be restored. After three years, the credit reductions are permanent.

Transaction risk management for Reserve Pool transactions, where the credit allowances are merely "warehoused" by the Authority until a private deal is struck, is not as actively managed by the Authority. The Authority also certifies these credit allowances. However, Reserve Pool credit allowance purchasers, who have negotiated with a specific reductions producer for specific reductions, cannot be awarded surplus Reserve Pool credit allowances if reductions fail to materialize. They must negotiate another trade and pay for additional allowances.

Finally, the market manages the risk that new development and use of reductions fail to protect the designated uses of the waterbody. The TMAL driving the Cherry Creek market has a periodic review schedule, during which the TMAL allocations may be modified, up or down. Allocations may be adjusted to reflect the volume of phosphorus being discharged into the reservoir or existing water quality. Therefore, the TMAL allocation process manages the risk that reductions will fail to maintain designated uses by ratcheting up and down the volume of phosphorus permitted into Cherry Creek Reservoir by changing the allocation among POTWs and by adjusting the volume of credits and credit allowances available for use.

Providing information to the public and other stakeholders—The on-going public participation mechanism in Cherry Creek relies on standard public notice and comment procedures commonly used for NPDES permits. In the Cherry Creek market, non-discharging stakeholders have several opportunities to play an active role in trading activity, including open forums to question and influence project evaluation, credit and credit allowance allocation, and permit modification. For project evaluation and allocation, the Authority is required to issue a public notice of its intent to review specific proposals and listen to stakeholders attending that hearing. A similar procedure is used during permit modification. These steps are necessary to create transparency and engender trust in the trading system.

The Authority is responsible for making transaction information accessible to the public. The marginal cost of providing the information—whether on demand or published at regular intervals—will likely be minimal as the Authority already possesses or generates all the pertinent information. Trades approved by the Authority are documented in Appendix A of the Cherry Creek Water Quality Authority Trading Program Guidelines.

A NITROGEN CREDIT EXCHANGE

In 1990, Connecticut, the State of New York, and the federal EPA adopted a Comprehensive Conservation and Management Plan (CCMP) for the Long Island Sound National Estuary Program, known as the Long Island Sound Study (LISS). The CCMP calls for the reduction of nitrogen to increase dissolved oxygen in Long Island Sound and mitigate hypoxia damaging the Sound's ecosystem. The CCMP was designed to reduce the total enriched nitrogen load coming from point and non-point sources by 58.5 percent between 2000 and 2015. A TMDL, approved in April 2001, includes Waste Load Allocations for point sources and Load Allocations for non-point sources in the watershed. Connecticut chose to develop a trading program for the sources within its borders to lower the cost of implementing the CCMP and the TMDL.

The main mechanism facilitating trading in Connecticut is a "General Watershed Permit." Connecticut's program uses both its general state authority and its EPA delegated NPDES permitting authority to issue a single General Permit for the nitrogen dischargers it regulates in the watershed. The General Permit covers the nitrogen discharges of all point sources willing to trade on a voluntary basis through a single permit. POTWs can have opt out of the General Permit and receive a traditional permit and implementation schedule. However, all POTWs have chosen to take advantage of trading under the General Permit. The General Permit sets a ceiling for annual, permitted, nitrogen discharges at 2000 levels, and reduces the total nitrogen discharges allowed in each year between 2000 and 2015 on a percentage basis. Individual point sources under the permit (called sub-dischargers) are required to lower their proportional share of the annual percentage reduction based on their normalized discharge in 2000.

Market designers faced two challenges. The Connecticut market area is predominantly urban, with very few opportunities for low-cost nonpoint source controls. To achieve the 58.5 percent nitrogen reduction from all identifiable sources, Connecticut's 79 POTWs located within the watershed were tasked with lowering their nitrogen discharge by 64percent from 2000 baseline levels. The second challenge involved several factors, including the proximity of certain dischargers in western Connecticut compared to their eastern counterparts, Connecticut's previous efforts to fund nutrient removal projects near Long Island Sound, and the economic disparity between communities in western and eastern Connecticut. The communities in western Connecticut are generally more affluent and able to absorb the cost of implementing new control technology. They also had been the focus of pre-trading nitrogen removal grants. Eastern Connecticut communities are relatively less affluent. Market designers felt that the water quality trading market models used in other pilot projects might lead to inequities across the regulated communities, as affluent western communities would likely be able to generate environmentally equivalent reductions by relying on previous control technology investments and their larger tax bases. Under some market models, the generally poorer eastern communities would then have to pay for available western reductions.

The trading program that evolved from this effort is best described as a "Nitrogen Credit Exchange." Sources discharging less than their annual limit receive "credits" for overcontrol. CTDEP is obligated by state law to purchase all nitrogen credits from these sources. Facilities that exceed their limit are considered out of compliance. These sources are allowed to purchase nitrogen credits from DEP to meet compliance obligations. DEP is obligated by state law to sell the credits it purchases from overcontollers to facilities that fail to comply.

Important Market Functions of the Connecticut Nitrogen Credit Exchange

Defining marketable reductions—Marketable reductions in Connecticut's Nitrogen Credit Exchange are defined as reductions in excess of a point source's Waste Load Allocation. As described in the February 2003 *General Permit for Nitrogen Discharges and Nitrogen Credit Exchange Program* publication, by March 31 of each year, the Nitrogen Credit Exchange Program (NCEP) and the Connecticut Department of Environmental Protection (CTDEP) compile the calendar year monitoring data for each individual source. The average nitrogen discharge for each month is calculated and the end-of-pipe surplus or deficit is reported as a yearly average. Marketable reductions emerge if the actual, sampled yearly average is less than the WLA for that year. A "Nitrogen Equivalency Factor," based on a source's contribution of nitrogen to Long Island Sound, is then applied to calculate the number of credits that the Nitrogen Credit Exchange (NCE) buys from that source. Appendix 1 of the General Permit provides a schedule of each sub-discharger's individual Annual Discharge Limit for Total Nitrogen as well as a Nitrogen Equivalency Factor.

Defining and executing the trading process—Unlike the other two models discussed in this section, Connecticut's trading process is stipulated in state law. Public Act No. 01-

180 describes the processes used to transfer marketable reductions from POTWs achieving overcontrol to POTWs out of compliance with their NPDES permit.

Trading in this market is executed through a multi-step process completed on an annual basis. The first step is the setting of the annual discharge limits in the General Permit. These limits, set by the Nitrogen Credit Exchange Board, are based on a 2000 baseline for each POTW, reduction goals ensuring compliance with the TMDL by 2015, and the projected nitrogen reductions to be achieved by control projects likely to be operating during the year. The annual limits require each POTW to attain an equal percentage reduction from its 2000 baseline.

POTWs unable to meet their new limits may elect to build nitrogen control projects. Funding for projects is available on a competitive basis through the Connecticut Clean Water Fund. Funding consists of a 30 percent grant with the balance loaned at 2 percent interest. Alternatively, POTWs may choose to find alternative revenue sources. Regardless of their approach to meet their annual regulatory obligations, POTWs monitor and report their discharge throughout the ensuing year pursuant to language in the General Permit.

At the end of the year, the Nitrogen Credit Exchange Board (NCEB), in conjunction with the CTDEP, analyzes the discharge for individual dischargers for compliance with the annual WLA. This analysis includes the calculation of credits produced by dischargers able to overcontrol and the number of credits needed by POTWs failing to meet their WLA. Credits are generated if the actual, sampled yearly average nitrogen discharge of a particular POTW is less than its WLA for that year. The Equivalency Factor translates the overcontrol into credits automatically purchased by the NCEP. Conversely, if the actual, sampled yearly average is more than the WLA for that year, the POTW needs to purchase credits. The Equivalency Factor translates the difference between actual, sampled discharge and the WLA into the number of credits that the POTW must buy from the NCE.

The NCEB then calculates the price of credits for both buyers and sellers. The dollar value of credits is determined annually, based on the average capital and operating costs of all nitrogen removal projects operating during that year and the total reductions achieved by those projects during that year. This is the uniform price (per pound) buyers are charged to reach permit compliance or sellers credited for their overcontrol. Those POTWs exceeding compliance with their annual WLA receive a check for their credits. Those POTWs out of compliance receive a bill for the total cost of all credits that would bring them into compliance with the General Permit.

Ensuring environmental equivalence—The focus of water quality trading in this market is to attain the designated uses of the Long Island Sound, not to improve water quality within specific watersheds or basins that drain into the Sound. Environmental equivalence is therefore confined to the effect each sources' individual discharge has on the concentration of nitrogen in the Sound itself.

As part of the LISS, a peer-reviewed water quality model was developed to delineate the impact nitrogen discharges in the large area covered by the TMDL has on oxygen concentrations in Long Island Sound. This broke the area affected by the TMDL into six different zones closely aligned with the major watersheds or basins and relates their nitrogen to oxygen impacts. Some zones were further broken down into tiers. Further modeling was done to relate nitrogen discharges within each of the identified zones or tiers. The final step used to calculate environmental equivalence involved multiplying the two factors together to create an Equivalency Factor that relates the impact of all individual discharges across the market to one another.

Communicating between buyers and sellers—The Connecticut water quality trading model does not promote contact between individual dischargers. The NCEP manages the transaction costs that would otherwise be associated with trading partner identification, product comparison, and deal negotiation because redistribution of the cost of nitrogen control is handled exclusively by the NCEP as it carries out its statutory responsibilities. As previously discussed, the NCEP gathers information from regulated dischargers, rewards POTWs for overcontrolling, and charges others for failing to comply with their permit. This results in redistributing the cost of overcontrolling nitrogen between the two groups.

NCEP administrators of the program need three sets of information to facilitate trading in this market—discharge volumes, nitrogen reductions achieved by control projects, and the cost of those control projects. Actual, sampled discharge volumes are collected by CTDEP as part of its General Permit administration responsibilities.

The NCEP relies on funds from the purchase and sales of nitrogen credits for administration of the NCEP. Currently, the NCEP is staffed by 2.5 FTEs assigned to several programs throughout the CTDEP.

Tracking Trades—In the Connecticut market, trade tracking consists of analyzing discharge, overcontrol, and cost redistribution. In this program, trading is an annual process. By March 31 of each year, the NCEP notifies each individual facility regarding their credit balance. After the credit checks and bills are paid or redeemed, the books are "closed" for that year and the process begins again. The additional burden of trade tracking (on top of the year-end analysis) borne by the NCEP entails collecting payments from dischargers buying credits to reach compliance.

Assuring compliance with regulations in the Connecticut Market—Trading in the Connecticut market takes place within the framework of the General Permit, which regulates the annual discharge of nitrogen into Long Island Sound. The aggregated General Permit discharge is set each year to ensure steady progress towards full implementation of the TMDL in 2015, as well as providing a buffer in case total reductions achieved fall below those anticipated in the annual allocation. Each individual discharger is issued a WLA incorporating the annual reduction of the aggregated General Permit and their baseline discharge in 2000.

Trading in this market is performed based on actual, sampled discharge performance. Monitoring and reporting protocols for point source discharge are set out in the General Permit and follow the standard reporting mechanisms used for NPDES permitting. Sampling frequency and procedures are based on the volume treated by the POTW on a daily basis. The collected chemical analysis samples are entered into a Nitrogen Analysis Report (NAR) and Monthly Operating Report (MOR) and submitted to the CTDEP. In addition, each POTW calculates a monthly mass loading of total nitrogen and submits it to the CTDEP in a Discharge Monitoring Report (DMR). Each POTW is also responsible for retaining a copy of all reports submitted to CTDEP as well as the data used to generate those reports for at least five years.

POTWs failing to reach compliance must purchase credits from the NCEP by July 31st of each year for their previous year's discharge. Failure to purchase credits by this date results in non-compliance and opens the POTW to enforcement actions by the CTDEP.

Managing risk among parties participating in the Nitrogen Credit Exchange Program—In the Connecticut market, credits are based on the level of nitrogen discharged during the year and the WLA. Implicitly, they can only be generated by the sources subject to the General Permit, which are all POTWs. The authorizing legislation (Public Act No. 01-180), the General Permit, and CTDEP publications, clearly describe the process used to create the annual permitted limit, calculate discharge, and the analysis used to compute the surplus or deficit of credits for compliance purposes. Nitrogen credits are only available from the NCEP, making the program the de-facto certifier of the credits and eliminating the risk of purchasing non-marketable reductions.

The Connecticut Nitrogen Exchange Program executes trading at the end of the year, when actual discharge volumes and overcontrol are known. The NCEP is obligated by state law to sell all the credits needed by all sources to meet their regulatory obligation under the General Permit. This statutory requirement eliminates the risk to individual dischargers that specific credits will fail to materialize, regardless of the actual supply that year.

There are two risks created by this market model because of its reliance on cash management and load allocations lower than TMDL implementation requirements to maintain active participation from the POTWs . First is the risk that during the year the POTWs, in aggregate, will create more credits than are needed to offset the POTWs that fail to meet their regulatory obligations. As the NCEP is obligated by law to purchase all credits and unable to sell them to other sources, the NCEP annually runs the risk of subsidizing the surplus overcontrol. For example in 2002, the NCEP purchased $2,757,323 worth of credits from 39 dischargers. The program sold $1,317,233 worth of credits. The $1,440,110 deficit was paid for by NCEP funds.

The second risk is that during the year the POTWs, in aggregate, may fail to create enough credits for other POTWs to maintain compliance. In years when the demand for credits is larger than the supply, the NCEP receives a net infusion of cash because all sources must purchase credits to meet compliance and the NCEP must sell them, regardless of their actual availability. This infusion of cash is designed to pay off any deficits from previous years when there is a credit surplus. Purchasing credits from the NCEP relieves the POTW from regulatory consequences under the General Permit. The annual allocations are low enough to maintain compliance with the TMDL implementation. In addition, allocations may be adjusted in light of the previous year's deficit or surplus and the projected control to be completed during the year. This helps manage the annual deficits and surpluses, both control and dollars, while encouraging additional nitrogen projects.

Finally, the market manages the risk that reductions generated and traded in the market do not achieve the designated uses of the waterbody by providing for periodic review of both TMDL allocations and the General Permit allocations. These are adjusted to reflect actual progress towards the designated use. The TMDL driving the Connecticut market includes a periodic review schedule, during which the TMDL allocations may be modified, up or down. A change in the TMDL allocation could force a modification of the annual allocations of the General Permit. Therefore, the TMDL and General Permit allocation process manages the risk that reductions will fail to achieve designated uses by ratcheting up and down the volume of nitrogen allowed to enter Long Island Sound.

Providing information to the public and other stakeholders—The on-going public participation mechanism in Connecticut relies on traditional public notice and comment procedures commonly used for NPDES permits. The NCEP is operated within the framework of the General Permit, providing the opportunity for public comment for the permit when it was issued and when it is renewed. Public comment is only allowed on the aggregated General Permit and not allowed for the WLAs for individual sub-dischargers regulated.

In addition, the NCEP annually produces a publication listing the price of nitrogen credits as calculated by the NCEB. Included with the report is a *LIS Total Nitrogen Credit Exchange Final Balance* detailing the dollar value of the credits bought by the NCEP from POTWs discharging less than their WLA as well as the dollar value of credits to be purchased by facilities exceeding their WLA.

Stakeholder Readiness

Purpose

The first three chapters of this Handbook suggested how to assess your watershed's potential to create a viable water quality trading market based on pollutant suitability, watershed and discharger characteristics, the financial attractiveness of likely trades, and an understanding of the infrastructure required to enable trading. As you pursue further consideration of trading opportunities, you will need to reach out to other potential participants and stakeholders to begin exploring water quality trading opportunities in the watershed. This chapter will help answer the following questions:

- Which other participants will be needed to create a viable water quality trading market in your watershed?
- Do key participants have a reasonable level of interest in considering water quality trading as a potential mitigation option?

After completing this section and reflecting on the lessons in the first three chapters of this Handbook, you should have a better understanding of how to engage other stakeholders in the watershed to discuss water quality trading opportunities. The previous chapter on market infrastructure, may have helped you begin to identify parties to include in discussions about water quality trading in your watershed. Because each situation will present unique challenges, this chapter does not prescribe a specific path for you to follow, but does offer tools to assist you in identifying and engaging the necessary players.

Approach

This chapter recognizes that water quality trading requires the participation of certain parties. In addition to dischargers, there are many other critical players that must be engaged in development of a viable water quality trading system. Each watershed will have a unique set of potential participants. This chapter suggests a two step approach for engaging stakeholders. The first step involves identifying essential participants by using tools such as a checklist of potential participants, a description of their roles, and a series of questions that can help evaluate how the conditions in your watershed will influence your priority list of participants. The second step is designed to improve your understanding of the interests of priority participants so that you will be better prepared to recruit them. It includes a review of key benefits of trading that can help you begin discussions. It also suggests several likely stakeholder needs and interests and offers tips for responding to them. Finally, this section gives with three examples of how trading programs have provided for stakeholder participation.

Identifying and Prioritizing Potential Participants

A wide range of parties may have an interest in participating in discussions about water quality trading in your watershed. To begin the process of identifying key parties, you should focus on the water quality problem that is being addressed. Looking at potential solutions to the problem will help you identify those parties whose behavior needs to change. The first Chapters have prepared you for this phase by increasing your understanding of the suitability of the pollutant, the conditions in the watershed, the control cost differentials among dischargers, and the market infrastructure needs. In identifying parties that need to work together to consider the viability of trading, each category of participants can be important for different reasons.

Dischargers in the watershed. Dischargers include municipal and industrial point sources, and nonpoint sources located in relevant urban and rural areas. You should focus especially on any dischargers that need to achieve substantial reductions and may be capable of overcontrolling their discharges. Dischargers make up the pool of potential trading partners. As discussed in Chapter 2, it will be important to engage dischargers to gather information to evaluate financial attractiveness. It will also be important to build an understanding of the water quality challenges individual dischargers face to help identify those that will be essential parties to viable water quality trades. For example, at an early decision point in the Lower Boise River discussions, the group recognized that a viable program could not be developed without the involvement of nonpoint sources from the agricultural community. Other watersheds may need the participation of a major point source facing imminent and more stringent permit limitations.

Federal, tribal, state, and local government. The participation of federal, tribal, state, and local regulatory agencies in the watershed will be essential to assess whether and how trading might fit within current regulatory requirements. EPA has federal oversight responsibilities under the Clean Water Act (CWA) and also implements the NPDES program in some states (e.g., Idaho and Alaska). Most states and some tribes have delegated CWA authorities. Participation of NPDES permitting and TMDL development authorities will be needed to interpret CWA requirements, formulate new rules where possible and necessary, and, perhaps, to provide technical and scientific expertise. Depending on the market's design, it is also likely that these agencies will need to approve elements of the trading program. Other governmental agencies may need to be involved because of their responsibilities for protecting fish and wildlife, regulating water supply, managing irrigation projects, land management, or other activities affecting the watershed. These agencies may also be able to provide valuable technical assistance. Tribal governments may be interested for a variety of reasons, including potential impacts on businesses they operate and their treaty rights to harvest fish and shellfish in the watershed.

In addition to local government agencies that operate treatment plants which are NPDES permitted point source dischargers, other agencies may operate water or power utilities that impact water quality in the watershed. Other government agencies may need to be involved because their activities contribute to nonpoint source runoff or storm water discharges related to transportation, construction, or urban drainage systems.

Local businesses. Some local businesses will have a direct interest in water quality trading because they are dischargers. Certain businesses may utilize public water treatment facilities. As indirect dischargers, these businesses may face rate increases resulting from investment in control technologies and will have an interest in trading. Affected businesses may include significant industrial water users, land owners, canal companies, developers, recreation and tourism interests in the watershed, commercial fishermen, and others.

Interest groups. Groups or associations representing affected businesses and local governments will have an interest in discussions about trading in the watershed. Examples of these groups include Farm Bureau chapters, water users associations, and associations of local county officials or wastewater treatment authorities. Of critical importance are active citizen environmental groups in the watershed. Many environmental groups are watching trading efforts carefully to ensure that all CWA-related substantive and procedural requirements are met and that TMDL water quality objectives are fully supported by proposed water quality trades. Many environmental group members are very knowledgeable about watershed conditions and challenges. In addition, some watersheds have councils or watershed management organizations with various planning and implementation responsibilities. It is important to include these groups in market design.

College and university resources. Local colleges and universities may be good sources of information and technical assistance to support trading development efforts.

As you consider which participants should be included, the first step is to identify the range of potential participants. The checklist provided below will assist you in this effort.

Checklist of Potential Participants

- *Dischargers in the watershed*
  - *Individual Point Sources (including wastewater and storm water dischargers)*
    - *Municipal*
    - *Industrial (Direct and Indirect)*
  - *Individual Nonpoint Sources*
    - *Urban entities*
    - *Farmland owners/operators*
    - *Canal companies*
    - *Irrigation districts*
    - *Forest land managers*
    - *Range land managers*
- *Federal agencies*
  - *The Regional U.S. EPA Office*
  - *U.S. Department of Agriculture*
    - *Natural Resource Conservation Service (NRCS)*
    - *Resource Conservation and Development Councils*
    - *Soil and Water Conservation Districts*
  - *U.S. Bureau of Reclamation (USBR) (related to irrigation activity)*
  - *U.S. Fish and Wildlife Service*
  - *National Marine Fisheries Service*
- *State/Tribal Government*
  - *Department of Environmental Conservation (DEC, DEQ, etc.)*
  - *Department of Fish and Game*
  - *Department of Water Resources*
  - *Court-appointed water master*
  - *Tribal Councils*
- *Local Government*
  - *Municipal utilities*
    - *Water supply*
    - *Power*
  - *Cities*
  - *Counties*
- *Local Businesses*
  - *Significant industrial users (dischargers to POTW treatment systems)*
  - *Developers*
  - *Power companies*
- *Interest Groups*
  - *Associations*
    - *Water users*
    - *Local business (e.g., Farm Bureau)*
    - *Local government*
  - *Environmental Groups*
  - *Watershed groups*
- *Colleges and Universities (and other water quality research facilities in the area)*

BENEFITS OF WATER QUALITY TRADING

In discussing water quality trading opportunities with potential participants, it may be helpful to keep in mind the following benefits.

Water quality trading can result in significant cost savings. Water quality trading is a business-like way to solve water quality problems by focusing on cost-effective, local solutions. Typically, a party facing relatively high pollutant reduction costs compensates another party to achieve an equivalent, though less costly, pollutant reduction. Cost savings for a municipality could result in lower sewage treatment bills to citizens. For an industry, trading may translate into lower operating costs and/or more capital available for productive investment enabling a stronger competitive position and more economic opportunity in the community. For some sources, trading may be a source of revenue. In the right circumstances, trading markets can help participants achieve needed water quality improvements at the lowest possible cost to society.

Water quality trading provides flexibility to dischargers in meeting pollutant load reductions. Trading opens up new options for meeting TMDL load allocations. Although water quality trading cannot compensate for common technology based standards, trading can be used to access the water quality improvements that are created by other discharger's adoption of different technologies, expanding options for meeting TMDL obligations. In addition to possible cost reduction benefits, trading provides opportunities for creating new value to businesses and consumers through the use of creative ideas for improving water quality in the watershed.

Water quality trading is voluntary. Successful trades will occur only if both parties perceive they will gain benefits from the trade. Some dischargers, especially nonpoint dischargers, are more likely to come to the table to discuss reductions in a voluntary context. Voluntary approaches may lead to more effective and immediate water quality improvements. Because most trading systems are designed to fit within existing regulatory frameworks, trading typically will not create new regulatory control obligations.

Water quality trading provides incentives for overcontrol beyond current limits. For point sources, trading provides financial incentives for installing pollution control technology beyond TMDL waste load allocations because increments of pollution reduction beyond TMDL allocations can be sold to other dischargers. Nonpoint sources can be compensated for installation of best management practices that result in pollution reductions beyond meeting their load allocations. Trading provides additional incentives to create reductions where the incentives and disincentives (such as enforceable requirements for nonpoint source management) are relatively weak or nonexistent. These additional incentives can accelerate the rate of water quality improvements in many areas.

Water quality trading places a greater emphasis on measuring water quality outcomes and will provide additional data about the watershed. Trading will provide additional information, through monitoring and specific nonpoint source screening criteria, regarding water quality in and the dynamics of the watershed. This information will provide a better understanding of watershed conditions and increase awareness of the progress of water quality improvements.

Water quality trading can result in other ancillary environmental benefits. Trading provides incentives to use control options such as wetland restoration, floodplain protection, or other management practices that both improve water quality and provide additional fish and wildlife habitat.

Likely Participant Needs and Interests Relating to Water Quality Trading

Even if participants understand the benefits of trading, they will have legitimate needs and concerns that must be addressed. The following list of likely needs and interests also includes some suggestions for responding to them.

Lack of a Market Driver. Dischargers are likely to be interested in exploring alternative pollution reduction options only if they are facing an imminent change to their regulatory requirements.

> ***Response:*** *In the watersheds being evaluated for trading viability, the market driver is the TMDL (or similar framework). The TMDL provides waste load allocations for point sources and load allocations for nonpoint sources dischargers that generally require new pollutant discharge reductions. The allocations will result in new permit limits for point source dischargers and goals for nonpoint sources. Watersheds with new TMDL's generally have a sufficient incentive to explore trading as a possible cost–effective pollution control option.*

Monitoring of nonpoint discharges will be costly, technically challenging, and will lead to increased regulation. Some nonpoint dischargers may be concerned that trading will require on-site monitoring to measure pollution reductions. Monitoring may be perceived as intrusive, costly, unreliable, and a precursor to additional regulatory requirements.

> ***Response:*** *Effective monitoring of nonpoint source discharges for trading purposes is designed to determine the value of the pollution reduction credits being generated. These credits, when established through monitoring, become a valuable commodity that can be sold to willing buyers. Those who participate in the discussions about trading in the watershed can help shape a monitoring program that meets their needs. Depending on the market infrastructure developed, the cost burden associated with monitoring can be assigned to an appropriate party.*

It is better to wait for regulators to enforce TMDL requirements than to proactively expend resources designing a new, untested compliance strategy. Participation in discussions about trading in the watershed could represent a significant investment in time and resources. Unless participants see the potential benefits, they will be reluctant to commit the resources and prefer to see greater emphasis on meeting TMDL load allocations employing traditional approaches.

> ***Response:*** *Trading discussions among dischargers and regulators provides new opportunities for meeting the TMDL requirements for improved water quality that incorporates the concerns of local participants. Potential participants should also be made aware of the key benefits of trading suggested above, especially the opportunity trading provides for more effective and immediate water quality improvements.*

If trading results in more efficient pollution reduction, it could provide incentives for additional development in the watershed. Participants often bring different perspectives about the broad goals of water quality trading. Some groups may only support trading if they believe it will achieve early reductions and improve water quality beyond the requirements of the TMDL. They may not support the flexibility of trading if they believe it will lead to growth and development in the watershed.

> ***Response:*** *It will be important to come to an early understanding about the goals of water quality trading in the watershed. For example, is the goal for trading to produce more cost-effective TMDL implementation or do stakeholders expect trading to produce environmental improvements beyond those required by the TMDL? In general, the focus has been on cost-effectiveness, while*

producing some ancillary benefits. There is no CWA requirement or EPA guidance that requires trading programs to achieve environmental outcomes in excess of TMDL requirements. However, there are water quality benefits from more active engagement by nonpoint sources that leads to more immediate improvements, additional habitat improvements, and increased instream flows, rather than simply end-of-the-pipe traditional controls.

Trading reduces the degree of certainty in meeting water pollution reduction targets. Some groups are concerned that trading does not include enough safeguards to ensure that it will produce real reductions in the amount of pollutants entering the watershed. They perceive that trading could sacrifice almost guaranteed, enforceable reductions from point sources in return for uncertain, unenforceable nonpoint source reductions elsewhere.

Response: *Trading systems can be designed to use monitoring, specific nonpoint source screening criteria, and other mechanisms to assure that only verified reductions can be traded. They also use discounting factors to account for the uncertainty of nonpoint management practices. Conservative river ratios are also used to predict the amount of pollution that will reach downstream compliance points.*

Trading can create "hotspots," or localized areas with high levels of pollution within a watershed. Concerns are often raised that a trading program may improve the watershed's overall water quality, but may leave certain areas with highly degraded water quality.

Response: *Trading programs can be designed to avoid unacceptable localized impacts by considering the characteristics of the pollutant, the watershed conditions, the location of potential trading partners, the type of trades, the scope of the trading area, and the use of effective monitoring programs in the design of trading programs. Programs should consider specific mechanisms related to the direction of trades (e.g., upstream versus downstream) and the use of caps and ratios to avoid localized impacts. EPA's Water Quality Trading Policy supports trades only in the same watershed or the boundary established by a TMDL. This policy helps ensure that water quality standards are maintained or achieved throughout the trading area and contiguous waters.*

Trading provides less opportunity for public participation in pollution reduction activities. There is rising public interest in watershed related activities. Citizen groups are interested in becoming involved in decisions that affect local watersheds. These groups will be concerned about whether trading will change conventional public participation opportunities such as public notice and comment for NPDES permit modifications. Representatives of these groups will want to be engaged in discussions about the design and implementation of trading programs. Groups will be particularly sensitive to issues relating to monitoring and enforcement.

Response: *Participating in the early stages of a trading program development provides a more meaningful opportunity for public involvement than responding to an already developed proposal. Concerns about enforcement and monitoring can be raised during program design. All public participation requirements applicable during implementation must also be satisfied by the market according to EPA guidance. However, it may be harder to influence the specifics of a market approach once the details have been established. Early participation will* *help all parties understand the information and assumptions used in the market's development*

STAKEHOLDER PARTICIPATION IN MARKET INFRASTRUCTURE

Each of the three trading programs described in the Market Infrastructure chapter provided for stakeholder involvement during the development stage. This section briefly describes the range of stakeholder participants, the function and authority of the stakeholder group and any other key opportunities for stakeholder involvement that were provided during program development in two of those markets.

Lower Boise River Effluent Trading Demonstration Project

As described in the market characterization, participants in the Lower Boise River project worked together to develop a trading program framework. The project was launched with a state workshop to educate all attendees about the trading concept and to direct participation in the Lower Boise. Participants included wide representation from federal, state, and local agencies with water quality responsibilities, agriculture, municipalities, industry, and the environmental community. Participants included: the Idaho Water Users Association; the Idaho Farm Bureau; Pioneer Irrigation District; the Payette River Water Master; the Canyon Soil Conservation District; the Idaho Soil Conservation Commission; the Natural Resources Conservation Service; Idaho Rivers United; the Ada County Highway District; the Association of Idaho Cities; the Cities of Boise, Meridian, Nampa, and Middleton; the U.S. Bureau of Reclamation; the Southwest Idaho Resource Conservation and Development Council; Micron; Simplot; American Wetlands; Idaho Power Company; Idaho Division of Environmental Quality; US EPA; and the Boise State University Environmental Finance Center.

Participants were supported by a contractor providing neutral facilitation, process support, and various forms of analysis. Process support from neutral parties was important for recruiting participation and managing the program development process to allow EPA and Idaho DEQ to be involved as project participants.

As the participants worked together to pursue the development of a trading system, they recognized that state and federal regulatory agencies would maintain their existing authorities, but the group would develop and provide recommendations for their consideration that would likely carry significant weight. The participants were divided into three main teams: 1) the Framework Team, charged with developing the mechanisms, rules, and procedures for dynamic trading in the watershed; 2) the Point Source-Point Source Model Trade Team, responsible for developing a model trade between two point sources; and 3) the Point Source-Nonpoint Source Model Trade Team, tasked with developing a model trade between a point source and a nonpoint source. Smaller workgroups were also formed to work through specific parts of the trading system. These workgroups also provided an opportunity for stakeholder groups to identify and resolve issues specifically related to their interests and needs. These included the Agriculture Workgroup, the Ratios Workgroup, the Trading Framework Workgroup, the Indirect Dischargers Workgroup, and the Association Workgroup. Stakeholder participation was supported by a state-run small grants program, facilitating production of materials for the workgroups. Idaho DEQ is also preparing for public comment a state water quality trading guidance, model permit language for point source to point source trading, and the BMP list for the Lower Boise project.

Connecticut's Nitrogen Credit Exchange Program

As described in the Market Infrastructure section, a nitrogen trading program was established in Connecticut as a means for attaining the nitrogen reduction requirements outlined in the TMDL waste load allocations. Connecticut's program does not include nonpoint sources of nitrogen discharge and is limited to the 79 municipal wastewater treatment plants in the region. Because of this limitation to point sources, the range of interested stakeholders was generally more restricted than other trading projects that included rural and urban nonpoint sources.

Public involvement in the program has been provided through a traditional administrative process of public workshops and hearings, through the legislative process required during the passage of implementing legislation, and through ongoing monthly meetings of the Nitrogen Credit Advisory Board. In addition, a number of individual meetings were held with affected sources, cities and towns, and other interested parties.

Administrative Process

Prior to the development of the trading program, a series of six informational public workshops were held in the region on the Waste Load Allocations proposed in the nitrogen TMDL for Long Island Sound. Nitrogen trading was one of the options discussed at the workshops for meeting the TMDL load allocations. These workshops were attended by affected point sources, local communities, and local and national environmental groups.

Another series of public workshops were held by the Connecticut Department of Environmental Protection to increase public understanding of the General Permit for Nitrogen Discharges and the Nitrogen Credit Exchange Program. Invitations and public notices were issued for these workshops and they were attended by point sources and other interested parties.

Following the informational meetings, a two day formal public hearing was held to receive comments on the General Permit for Nitrogen. The agency formally responded to these comments and made several changes to the General Permit.

Legislative Process

Several components of the program required enabling state legislation for implementation. Legislation was introduced in the Connecticut General Assembly to implement the Nitrogen Credit Exchange Program. Opportunity for stakeholder groups and the general public to comment on the program were provided through the normal legislative process, which included hearings in relevant legislative committees. As a result of the legislative process, a number of changes were made to the proposed program.

Nitrogen Credit Advisory Board

The legislation established a Nitrogen Credit Advisory Board to assist and advise the Commissioner of Environmental Protection in administering the program. In addition to three representatives of state agencies, the board includes nine public members. The legislation requires that public members reflect a range of interests and experience and is well balanced with regard to buyers and sellers of credits, large and small municipalities, and representatives from different geographic regions of the state. In addition, members with experience in wastewater treatment, environmental law, or finance will be included. The Board has been conducting monthly meetings that are open to the public.

Glossary

Best Management Practice (BMP): A method that has been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources.

Designated Uses: Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act. Uses can include cold water fisheries, public water supply, irrigation, and others.

Discharge Monitoring Report (DMR): The EPA uniform national form, including any subsequent additions, revisions, or modifications for the reporting of self-monitoring results by permitees. DMRs must be used by approved stated as well as by EPA.

Discharge: Flow of surface water in a stream or canal or the outflow of groundwater from a flowing artesian well, ditch, or spring. Can also apply to discharge of liquid from a facility or to chemical emissions into the air through designated venting mechanisms.

Downstream Trade: A water quality trade in which one source compensates another source downstream of its position within the watershed for producing an environmentally equivalent pollutant reduction impact at all pertinent compliance points within the watershed.

Effluent: Wastewater, treated or untreated, that flows out of a treatment plant, sewer, or industrial outfall.

Incremental cost: The average cost of control for the increment of reduction required for an individual source to meet compliance. For example, if a discharger needs a 5 lbs./day reduction to comply with requirements but that drives a $10 million technology investment that actually reduces 20 lbs./day, then the incremental cost associated with the 5 lbs./day is substantial relative to the average cost of reductions. Traditional average cost would divide costs by 20 lbs./day; incremental analysis divides the costs by 5 lbs./day and would be four times higher than average cost.

Indirect Discharge: A non-domestic discharge introducing pollutants to a publicly owned treatment works.

Load Allocation: The portion of a receiving water's loading capability that is attributed to either one of its existing or future non-point sources of pollution or to natural background sources. Load allocations are best estimates of the loading which can range from reasonable accurate to gross allotments, depending on the availability of data and appropriate techniques for predicting loading.

National Pollutant Discharge Elimination System (NPDES): The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits and imposing and enforcing pretreatment requirements under Sections 307, 402, 318, and 405 of the Clean Water Act.

Non-point source: Diffuse pollution sources (i.e., without a single point of origin or not introduced into a receiving stream from a specific outlet). The pollutants are generally carried off the land by stormwater. Common nonpoint sources are agriculture, forestry, urban mining, construction, dams, channels, land disposal, saltwater intrusion, and city streets.

Overcontrol: Taking steps to reduce pollutant discharge below the waste load allocation for individual point sources or the load allocation for nonpoint sources.

Point source: Any discernible confined and discrete conveyance, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged.

Total Maximum Daily Load (TMDL): The sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background. TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure that relates to a state's water quality standard.

Upstream Trade: A water quality trade in which one source compensates another source upstream of its position within the watershed for producing an environmentally equivalent pollutant reduction impact at all pertinent compliance points within the watershed.

Appendix A

Water Quality Trading Suitability Profile for *Phosphorus*

Trading Suitability Overview

The EPA Water Quality Trading Policy supports nutrient (e.g., total phosphorus and total nitrogen) trading. Sources of phosphorus include background sources such as natural springs, point sources such as municipal sewage treatment plants and food processors, and non-point sources such as irrigated agriculture. Water quality trading pilot projects across the country have demonstrated that phosphorus from these and other sources can be successfully traded. These projects have found that phosphorus discharges and in-stream concentrations can be readily measured at key points within a watershed, and that the pollutant is relatively stable as it travels through river systems. As a result, phosphorus dischargers will have a reasonable ability to establish environmental equivalence relationships between themselves or between a discharger and a compliance point.

TMDLs address phosphorus and nitrogen to control a number of water quality problems including aquatic plant growth, low dissolved oxygen, and high pH. To establish equivalence appropriately, trading parties will need to understand how their load connects to the specific problem. Phosphorus and nitrogen are nutrients which are often associated with eutrophication in fresh waters. Excessive phosphorus contributes to exceeding the narrative water quality criteria established by many states relating to nuisance aquatic plant growth, deleterious materials, floating, suspended, or submerged matter, oxygen-demanding materials, or other similar standards. Excessive phosphorus concentrations have both direct and indirect effects on water quality. Direct effects include nuisance algae and periphyton growth. Indirect effects include low dissolved oxygen, increased methylmercury production, elevated pH, cyanotoxins from blue-green algae production, trihalomethane production in drinking water systems, and maintenance issues associated with domestic water supplies.

Most TMDLs recognize the correlation between phosphorus concentrations and these water quality concerns. Excess nutrient loading causes excess algal growth within the water column, which in turn affects levels of dissolved oxygen and pH in aquatic systems. This correlation between phosphorus concentrations and other water quality concerns can be seen in the Draft Snake River- Hell's Canyon TMDL recently developed by the states of Idaho and Oregon. In this TMDL, concentration levels are established for both Chlorophyll a and Total Phosphorus to ensure that nutrient concentrations do not result in excessive algae or other aquatic growth, which may impede the attainment of water quality standards for dissolved oxygen and pH.

Key Trading Points

A. Phosphorus Pollutant Form(s)

Total Phosphorus TMDLs —Most TMDLs establish load allocations for Total Phosphorus, although levels of both Total Phosphorus and Ortho-phosphorus are often monitored. Total Phosphorus is, however, comprised of two forms:

- Soluble—also known as Dissolved Ortho-phosphate or Ortho-phosphorus—includes highly soluble, oxidized phosphorus. Because of its solubility, ortho-phosphorus is commonly more available for biological uptake and leads more rapidly to algal growth than non-soluble phosphorus.
- Non-Soluble—also known as Sediment-Bound or Particulate-Bound phosphorus—is mineral phosphorus incorporated in sediment and is not as likely to promote rapid algal growth, but has the potential to become available to plants over time.

The concentration of total phosphorus is calculated based on the sum of the soluble and non-soluble phosphorus. Due to phosphorus cycling in a waterbody (conversion between forms) TMDLs usually consider Total Phosphorus concentrations. Total Phosphorus then represents the phosphorus that is currently available for growth as well as that which has the potential to become available over time.

Sources covered by a Total Phosphorus TMDL will be measuring discharges and reductions using a common metric. Use of this common metric for measuring phosphorus reductions in a TMDL should provide a high potential for matching phosphorus discharges from various sources in the watershed. It will be important, however, to understand the actual forms of phosphorus being discharged because some trades may not represent an equivalent impact on water quality. For example, if individual dischargers have substantially divergent load characteristics (e.g., one primarily discharges soluble phosphorus while another primarily discharges non-soluble phosphorus) then a trade between the two may not be environmentally equivalent. If a high percentage of the total phosphorus is present as soluble ortho-phosphate, it is more likely that rapid algal growth will occur than if the majority of the total phosphorus is mineral phosphorus incorporated in sediment. Adjustments, using a trade ratio or other means of establishing and equivalence relationship, may be needed to account for such differences.

Other Phosphorus-Related TMDLs—To the extent that a TMDL establishes load allocations in terms of individual phosphorus forms, challenges to trading may exist. If a TMDL provides load allocations for different forms, participants in the watershed will be limited to trading within two, smaller, more constrained markets for each form. Alternatively, a reliable translation ratio may be generated to create broader trading opportunities.

There may be circumstances where some dischargers receive phosphorus allocations while others receive dissolved oxygen allocations. There is a known and well-characterized link between phosphorus concentrations and dissolved oxygen problems. This relationship provides an opportunity to establish a specific translation ratio between Total Phosphorus and Dissolved Oxygen, potentially enabling additional trading opportunities. For example, under the Draft Snake River-Hells Canyon TMDL, Idaho Power Company was given a load allocation for DO, while municipal, industrial, and agricultural sources have received Total Phosphorus allocations. Idaho DEQ is exploring the development of a total phosphorus/dissolved oxygen (TP/DO) translation ratio, which would enable Idaho Power to become a potential purchaser of TP surplus reductions from other sources.

B. Impact

Adjusting for Fate, Transport, and Watershed Considerations—In general, phosphorus fate and transport are sufficiently well understood, and the models used to develop phosphorus TMDLs are reasonably well suited, to support the development of environmental equivalence relationships among potential phosphorus trading parties. The phosphorus "retentiveness" of a water body describes the rates that nutrients are used relative to their rate of downstream transport. As ratios are set for trading opportunities, the factors that contribute to retentiveness should be considered. Areas of high retentiveness are usually associated with low flows, impoundments, dense aquatic plant beds, and heavy sedimentation. Trades that involve phosphorus loading through these areas will likely require high ratios (e.g., 3:1) to achieve environmental equivalence between dischargers. In areas with swift flowing water and low biological activity, phosphorus is transported downstream faster than it is used by the biota, resulting in low levels of retentiveness and minimal aquatic growth. In areas of low retentiveness, where phosphorus is transported rapidly through the system, low ratios (e.g., 1.1/1) will likely emerge.

Other factors, including substrate stability and light contribute to plant growth and factor into a segment's "retentiveness." Sedimentation is another condition that can affect how phosphorus will move through and be utilized in a system. Phosphorus is often found in sediments and will persist longer in them. As a result, the presence of these factors should be an explicit consideration in setting environmental equivalence ratios.

<u>Examining Local Considerations</u>—In a downstream trade, the upstream source will not meet its allocation under the TMDL because it is purchasing reductions from another source downstream. Discharges from the upstream source will not be reduced, and water quality will not be improved in the segment between the two sources. Overcontrol by the downstream source will result in improved water quality further downstream. These types of trades will only avoid unacceptable localized impacts if the segment between the two sources has not reached its assimilative capacity.

Additionally, a trade, irrespective of its direction (up or downstream), involving sources discharging substantially different phosphorus forms may be vulnerable to creating localized impacts. In particular, a trade that involves offsetting a primarily soluble phosphorus discharge with a sediment-attached discharge will leave a greater quantity of readily available phosphorus in the water body than otherwise would have been the case. This readily available phosphorus has the potential, as discussed earlier, to contribute to short-term, local nuisance aquatic growth problems.

C. Timing

The key time element to consider when examining phosphorus trading is the seasonal load variability among dischargers. Agricultural non-point sources usually discharge during the growing season only, i.e., between April and October. Point sources generally discharge all year round. The relative importance of this difference plays out in the context of how TMDL phosphorus allocations are set. Many TMDLs provide seasonal phosphorus load allocations that apply only during those months of the growing season. The potential for excessive algal growth occurs predominately in the summer when sufficient light and temperature conditions support plant growth. Under these circumstances, both point and non-point sources will likely receive a seasonal allocation, and their ability to match reduction needs with the timing of phosphorus reduction credits will overlap and readily support trading. However, allocations to lakes or other large water bodies may be annual because of the relationship in these water bodies between annual phosphorus loadings and eutrophication. In such cases, sources receiving year-round allocations may be restricted from trading with sources that produce seasonal loads.

D. Quantity

Typically, phosphorus TMDLs establish WLAs and LAs in terms of concentration or mass based reductions. For the most part, these allocations provide a straight forward means to establish over control for purposes of identifying marketable reductions. For example, a POTW with a permit limit established at 700 lbs./day that currently discharges 600 lbs./day, will have 100 lbs./day of marketable reductions. However, for some non-point sources, estimates may need to be utilized to establish the level of phosphorus reductions. This will likely be needed when sampling a discharge is complex, infeasible, and/or not cost effective. Pilot projects have used estimation methods based on the type and degree of BMP implementation to establish phosphorus reductions. Such estimates should be based on the type and extent of BMP implementation and local conditions. While less precise, if conservative assumptions are utilized, the degree of control which can be achieved with various BMPs can be estimated and utilized for trading purposes. Thus, in either case, reasonably well established methods exist for understanding the degree of over control achieved by phosphorus sources and enabling trading parties to clearly verify the existence of marketable reductions.

Appendix B

Water Quality Trading Suitability Profile for *Temperature*

TRADING SUITABILITY OVERVIEW

Unlike nutrient trading, which has been piloted in a number of areas around the country, there is very little experience trading water temperature. The EPA Water Quality Trading Policy does recognize that trading of pollutants other than nutrients and sediments has the potential to improve water quality and achieve ancillary environmental benefits if trades and trading programs are properly designed. Issues related to determining the tradable commodity and establishing environmental equivalence are currently being considered in a few watersheds in EPA Region 10. These efforts, as well as discussions within Region 10, indicate that temperature impacts, fate, and transport are sufficiently well understood to support at least some level of trading among sources of elevated temperature sources. The current expectation is that environmental equivalence can be established through direct sampling and through the models used in TMDL development.

Temperature standards have been established to protect beneficial uses such as cold water biota, salmonid spawning and rearing, and anadromous fish passage. TMDLs in Region 10 address water temperature primarily to protect cold water fish (salmonids) as the most sensitive beneficial uses. As of 1996, water temperature was addressed in 240 TMDLs in Region 10 (38 by Idaho, 141 by Oregon, and 61 by Washington). Water temperature is also an important consideration in Region 10 because a number of salmonid species listed as threatened or endangered under the Endangered Species Act (ESA) inhabit these waters and require improved water quality to support survival and recovery.

In Region 10, water temperature has direct and indirect impacts on native salmonids, bull trout, and other species listed under the ESA. Water temperature affects all life stages of these fish. It directly affects spawning, rearing, feeding, growth, and overall survivability. The incidence and intensity of some diseases are directly related to increased water temperatures. Indirect effects include changing food availability, increasing competition for feeding and rearing habitat, and enhancing the habitat for predatory fishes. Increased water temperature also indirectly affects water quality by increasing the toxicity of many chemicals, such as un-ionized ammonia. High water temperatures reduce DO concentrations by increasing plant respiration rates and decreasing the solubility of oxygen in water.

Sources of elevated temperature increases usually include both natural loading (from high air temperatures and solar radiation) and anthropogenic loading (from point source discharges and nonpoint sources such as devegetation of riparian areas, agricultural and stormwater drains, and tributary inflows). Non-point sources contribute to solar radiation heat loading by removing near stream vegetation and decreasing stream surface shade. In urban areas, impervious surfaces reduce the cooling effect of natural infiltration of surface runoff and increase the temperature of stormwater inflows. The Pacific Northwest State and Tribal Water Quality Temperature Standards[11] identified the four largest sources of increased temperature in the Pacific Northwest to be 1) removal of

[11] *Pacific Northwest State and Tribal Water Quality Temperature Standards* (US EPA, April 2003, 901-B-03-002)

streamside vegetation, 2) channel straightening or diking, 3) water withdrawals, and 4) dams and impoundments.

KEY TRADING POINTS

A. Temperature Pollutant Form(s)

Temperature TMDL allocations are designed to limit human-caused water temperature increases and to meet the applicable water quality standards. The standards are usually expressed as specific limitations on surface water temperatures, as expressed in degrees. For example, temperature load capacity in the Snake River-Hell's Canyon TMDL is defined (through Oregon state standards) as no measurable increase over natural background levels. The quantitative value used by Oregon Department of Environmental Quality as "no measurable increase" is 0.25°F (0.14° C).

Most TMDLs provide temperature waste load allocations to point sources in degrees Centigrade, (°C), degrees Fahrenheit (°F), or as heat per unit time, such as BTU's or Kilocalories per day. In effect, allocations establish what volume of discharge at a given temperature may enter a water body over a given period of time.

For non-point sources, temperature load allocations are often expressed as "no anthropogenic increase" or no loading by human sources. For ease of implementation these are also expressed in terms of percent of stream area shade required, providing site-specific targets for land managers. In temperature impaired reaches, non-point sources often meet this target by allowing stream banks to revegetate naturally until it attains "system potential," or the near stream vegetation condition that would naturally grow and reproduce on a site, given elevation, soil properties, plant biology, and hydrologic processes.

Although point and non-point sources tend to receive different forms of temperature allocations, models have been developed to convert the effect of increased stream shade into degrees cooling. Oregon DEQ uses several different models during TMDL development. The "Heat Source" model uses multiple data sources related to temperature, vegetation, and hydrology to accurately predict stream temperature at 100-foot distances. Other models are used to simulate stream temperatures for various hypothetical riparian restoration strategies. These models provide a basis for converting between point and non-point source temperature reductions for purposes of trading allocations.

B. Impact

<u>Adjusting for Fate, Transport, and Watershed Conditions</u>—In general, temperature fate and transport are sufficiently well understood, and the models to develop temperature TMDLs are reasonably well suited, to support the development of environmental equivalence relationships among potential temperature trading parties. Moreover, EPA Region 10 temperature guidance currently supports the establishment of a mixing zone for temperature discharges. If a similar provision is included in the state's water quality standards and utilized in the development of the WLAs in the TMDL, this provides for some mixing between the discharge water and receiving stream. If the receiving water is sufficiently cool as a result of upstream overcontrol, additional mixing may be allowed provided that the temperature standard is met at the edge of the mixing zone.

However, water temperature fluctuates in response to natural conditions, such as ambient air temperature, solar heating, and flows. Thus, the temperature effects of control options can dissipate quickly as water bodies rapidly reach a new water temperature equilibrium with the atmospheric and hydrologic conditions. As a result, although models and sampling can be used to predict and track the impacts of water temperature reductions at locations in a watershed, major water temperature effects are not likely to be seen at distant locations. For trading purposes, this suggests that potential trading parties will likely need to reside in relatively close proximity to each other for an environmentally equivalent trade to emerge.

A second aspect of assessing the environmental equivalence of temperature reductions relates to the potential importance of cold water refugia in streams which provide salmonid habitat. Although temperature load allocations are designed to meet the numeric criteria of applicable water quality standards, narrative standards also often address the need to protect ecologically sensitive cold-water refugia. Thus, it will be important to identify how sources of temperature impacts are connected to these refugia. If these connections can be modeled to determine how overcontrol options can benefit refugia, then trading opportunities that provide targeted temperature improvements to refugia can be explored. In this context, and as discussed under the Quantity section below, certain locations of temperature reductions will be of higher quality (more valuable to protection of the desired beneficial use) and therefore more desirable. To the extent a trading system can recognize this value and help to steer reductions to these areas it can substantially support the TMDL goals.

<u>Examining Local Considerations</u>—Certain forms of temperature trades hold the potential to create localized impacts. In some areas, high water temperatures can have harmful or even lethal impacts on fish populations. In other areas, fish may be able to avoid the hotspots with little effect on the species. The creation of a mixing zone under NPDES permits will provide some flexibility in this context, although the expectation is that even if standards are met at the zone's edge, there will be elevated temperature impacts at and in close proximity to the discharge point. Any established threshold temperature level will be site and conditions specific, and watershed participants should expect that the presence of cold water refugia will almost certainly require limitations on the degree to which a source could exceed their temperature allocation and mitigate through trading. In general, caps on purchasing activity placed in NPDES permits will be a primary means to control for local temperature impacts.

C. Timing

Exceedances of temperature-related water quality standards are more likely to occur in the summer months. As a result, temperature TMDLs have focused allocations seasonally, with required temperature reductions applying at the typically hottest times of the year. In response, many waste load allocations provide (or are expected to provide) different allocations for various times of the year, with more stringent limits during summer months and salmonid spawning or other life cycle periods that are critical to fish survival. In general, this seasonal approach supports opportunities for point sources and non-point sources to consider temperature trading options. Irrespective of the temperature allocation cycle, non-point source temperature reduction efforts in the form of shade are seasonally dependent, as greater cooling effects are provided from the shade during this period. Most nonpoint source temperature allocations are not seasonal—thus encouraging the vegetation to be in place year-round and indirectly support channel stability and other key channel characteristics. Under a seasonal temperature TMDL, point sources' need for reductions or willingness to overcontrol will coincide with the non-point sources ability to influence stream temperature, thus establishing a strong match for trading from a timing standpoint.

D. Quantity

Based on the nature of temperature allocations and related control options, both point and non-point sources of temperature impacts have the ability to over control their "discharge" and create temperature credits. For point sources, overcontrol would take the form of lowering discharge temperature below that required in a TMDL. In instances where the point source is a significant contributor to elevated in-stream temperatures (e.g., the discharger's flow is greater than the in-stream flow with a temperature 50 percent higher), the impact of over control will likely be discernable for some distance. This situation would readily support upstream trading with other point or non-point sources. In EPA Region 10, however, most point sources of heat are relatively small and have limited thermal loads. As a result, it is anticipated that their over control would quickly be offset by more dominant in-stream and riparian conditions. Trading opportunities, as a consequence, would be constrained to other sources in very close proximity to the source of over control.

In order to attain most non-point source allocations in temperature TMDLs, land along streams would need to achieve site potential shade. Natural re-vegetation varies with species, climate, and local conditions, requiring between 20 and 80 years to achieve site potential shade. If there are no state or local measures in place requiring landowners to actively plant and restore riparian areas, non-point sources can over control by influencing stream area shade in three ways: 1) earlier shade creation through tree planting; 2) more effective shade creation through selection of planted vegetation with a denser canopy; and 3) increasing the total shaded area of the stream.

In Region 10, tree planting programs that substantially advance the creation of shade as compared to natural re-vegetation have emerged as strong candidates for creating over control. Current thinking indicates that generating temperature benefits sooner than would be present under either natural or required stream bank re-vegetation can be used, at least temporarily, as reduction credits available for trading. The value of these credits may be quite high, as they are potentially available for at least five and possibly up to fifteen years, allowing other sources to delay what might otherwise be very substantial capital expenditures to reduce discharge temperatures.

Other means of non-point source over control are more theoretical at this time. Although it remains an untested concept, certain trees that create a denser and/or higher canopy than natural vegetation may produce greater shading and thus reduce the warming effects of sun light. Under such an approach, tree planting would not only produce temperature benefits earlier than natural re-vegetation, it would create a more consistent and/or greater area of shade than described in the TMDL. If utilized, tree selection should take into consideration a diversity of species and the ability of the re-vegetated community to sustain other functions of the riparian area.

Additionally, in instances where TMDLs do not require site potential shade throughout a watershed, expanding the area of stream bank vegetation beyond TMDL allocations could represent over control. However, Region 10 temperature TMDL experience to date indicates that a typical TMDL approach will be to require natural re-vegetation throughout the TMDL area, substantially reducing the opportunity for this option.

Both point and non-point sources may have two additional options for creating temperature reduction credits for either their own use or for sale to others. First, modifications to channel complexity that return streams to more natural width-to-depth ratios may result in temperature reductions. Moreover, reestablishing tree-covered islands in mid stream is another channel modification that can create additional shading effects to reduce water temperature.

Second, water volume and flow are critical factors affecting water temperature. Creative solutions to water temperature problems often involve changes in flow regimes. Water temperature improvement measures relating to flow include changes in location of discharges, increases in irrigation efficiencies, and water right purchases or leases. It is likely that any such changes in flow regimes that result in improved temperature conditions can be easily accounted for with models used in the development of the TMDL.

Irrespective of the means by which non-point sources achieve over control, these actions hold the potential to be more attractive than point source temperature reductions from an overall watershed health standpoint. Non-point source over control options that accelerate the return of vegetation in riparian areas provides important benefits to water quality and fish and wildlife habitat. Increased vegetation along stream banks helps to maintain temperature improvements from other sources. Increased vegetation in riparian areas support other water quality objectives by reducing erosion, sediments, and providing natural filtration of water entering the stream. Vegetated stream banks improve the health of riparian areas, which provide important habitat for many types of wildlife and aquatic species. As a result, a trade in which a point source opts to pay for non-point source over control may prove highly desirable from an overall watershed health perspective.

Appendix C

Water Quality Trading Suitability Profile for *Sediments*

TRADING SUITABILITY OVERVIEW

The EPA Water Quality Trading Policy specifically supports sediment trading. Sources of sediments include both natural and anthropogenic sources. Soil erosion from surface water flow is the largest natural source of sediments. Erosion from high flow events, such as flash floods or snow melt can result in greater sediment deposition in a single large event than occurs all year from average flows. Nonpoint sources of sediment include agricultural sources such as plowing and flood and furrow irrigation, forestry sources, such as logging and stream bank disturbance, and urban/suburban sources including construction, stormwater runoff, and irrigation. Point sources generally contain sediment discharge limits in their NPDES permits but are usually not major contributors to sediment concentrations.

Region 10 has had limited experience considering sediment trading opportunities. However, other areas of the country have had more experience with sediment trading, with pilot projects involving sediments conducted in the Delaware River, PA, the Truckee River, NV, and the Lower Smith River, VA.

Water quality standards are developed to protect the most sensitive beneficial use and have generally been established for sediments to protect designated uses associated with aquatic life. They are often based on both a numeric standard related to turbidity (e.g., 50 NTU's above background), and a narrative standard that protects beneficial uses. Narrative standards are translated into a wide range of numeric criteria depending on the conditions in the watershed, the fish species present, and the interpretation of the agencies and stakeholders in the area.

TMDLs address sediments to meet water quality standards and control a number of water quality problems. To establish appropriate environmental equivalence, trading parties will need to understand how their sediment loads connect to the specific problem. High concentrations of sediment can have both direct and indirect effects on water quality. Excessive amounts of sediment can directly impact aquatic life and fisheries. Excessive sediment deposition can choke spawning gravels, impair fish food sources, and reduce habitat complexity in stream channels. Excessive suspended sediments can make it more difficult for fish to find prey and at high levels can cause direct physical harm, such as scale erosion, sight impairment, and gill clogging. Stream scour can lead to destruction of habitat structure. Sediments can cause taste and odor problems for drinking water, block water supply intakes, foul treatment systems, and fill reservoirs. High levels of sediment can impair swimming and boating by altering channel form, creating hazards due to reductions in water clarity, and adversely affecting aesthetics.

Indirect effects associated with sediment include low dissolved oxygen levels due to the decomposition of organic sediment materials, and water column enrichment by attached pollutant loads, such as nutrients, or legacy application of DDT or mercury-based seed treatments. Elevated stream bank erosion rates also lead to wider channels which can contribute to increased temperatures. Sediment targets and monitored trends often function as indicators of reductions in transport and delivery of these attached pollutants.

Sedimentation is also an important consideration in Region 10 because a number of species listed as threatened or endangered under the Endangered Species Act (ESA) inhabit impaired waters in the region and require cold, clear, well oxygenated water to support spawning, survival, and recovery.

KEY TRADING POINTS

A. Sediment Pollutant Form(s)

Sediment TMDLs—Sediment is discharged by sources in a wide range of particle sizes and weights. TMDLs generally provide separate load allocations for sediments based on two different particles sizes.

- Suspended or "water column" sediments are particles that are small and light enough to remain suspended in the water column, generally less than 1 mm. Sources also discharge two different types of these suspended sediments. Nonpoint sources discharge geological particles, which are derived from rock and soil. Point sources, such as wastewater treatment plants, usually discharge biological particles as part of the treated wastewater. These different forms of suspended sediments may have different impacts on water quality. As discussed below, TMDLs often establish different load allocation forms for point and nonpoint sources to control water column sediments.
- Bedload sediments are larger particles that are too heavy to be suspended in the water column. They are generally discharged by nonpoint sources and are transported by sliding, rolling, or bouncing along the bed of the stream. Bedload sediments consist of particles greater than 1 mm in diameter and can range in size from sand and gravel to small pebbles or large boulders. TMDLs often establish mass-based load allocations for bedload sediments such as pounds per day or tons/square mile/year of sediment loading, or use a percentage of fines deposited in stream bottoms.

TMDLs often establish different load allocation forms for point and nonpoint sources. Waste load allocations for point sources often use concentration-based limits, such as an average weekly limit of 45 mg/L of Total Suspended Solids (TSS). Load allocations for nonpoint sources are often expressed in mass-based allocations, such as tons/square miles/year of sediment loading. Point source dischargers with similar sediment discharge forms and waste load allocation metrics may have trading opportunities. For example, two POTWs from neighboring jurisdictions in Virginia have entered into a cooperative agreement whereby one POTW has agreed to a reduction in its permit limit for discharging total dissolved solids so the other can have an increased limit. The allocations are both expressed in terms of kg/day of total dissolved solids. The two plants discharge into the same stream segment and the Virginia DEQ has determined that the agreement would not result in a decrease in water quality. However, point sources will also need to be aware of the form of sediment being discharged. A point source discharging a biological form of sediment can have different water quality impacts than a source discharging a geological form.

B. Impact

Adjusting for Fate and Transport Characteristics and Watershed Considerations—As dischargers consider trading opportunities, it will be important to understand the specific water quality impacts of each potential trading partner. Sediment load reductions by sources may be measured directly by sampling, with the models used to develop sediment TMDLs, or using surrogate measures, such as percentage of fines in stream bottoms. Other site specific watershed conditions, such as velocity, slope, channel conditions, and type of sediment, are important considerations for understanding water quality impacts and matching potential trading partners.

For suspended sediments, models are available to determine the impacts of reductions. However, depending on the watershed conditions, and the water quality problem that is being addressed, geological and biological forms of suspended sediments may have different impacts. It is likely that trading between similar forms (e.g., geological to geological, and biological to biological) will support water quality improvements. But trading between different forms of suspended sediments will be dependent on the water quality impacts that each reduction is intended to address. For example, if a source's reduction in geological suspended sediments is intended primarily to reduce levels of attached phosphorus, then a trade with a source discharging a biological form of suspended sediments will not meet the water quality improvement needs of the watershed. However, if suspended sediment reductions are intended primarily to reduce turbidity, then a trade between two different forms may be supported.

While bedload sediment reductions may also be easily modeled, the impacts of bedload sediments are generally experienced relatively close to the source of discharge as the heavier particles are transported very slowly along the river bottom. Thus, opportunities for trading bedload are likely to be limited to geographically smaller market areas. Because suspended sediments and bedload sediments will have different impacts on water quality, it is unlikely that there will be direct opportunities for trading between these two different forms of sediment.

Watershed flow patterns are also likely to define market areas for trading. Sediment movement in a stream varies as a function of flow. Suspended sediments discharged into high flow areas will travel longer distances and may define a large market area. The boundaries of markets may be defined by lower flows areas. The areas usually occur in the lower sections of watersheds where flows decrease and the lighter, smaller suspended sediments fall out. Upper sections of watersheds with higher flows often transport more bedload sediment. Impoundments create significant barriers that restrict sediment transport and create areas of sediment deposition. These distinct areas, based on flow patterns, are likely to delineate defined trading market areas, with trading limited to within each defined area.

<u>Examining Local Considerations</u>—Because watershed conditions relating to velocity, slope, and channel conditions will directly affect the impact of sediment reductions, each trade will have to be assessed to determine the potential for localized impacts. As with other pollutants, downstream trades will only avoid unacceptable localized impacts if the segment between the two sources has not reached its assimilative capacity. Additionally, a trade, irrespective of its direction (up or downstream), involving sources discharging substantially different sediment forms may be vulnerable to creating localized impacts. For example, a trade that involves offsetting a biological form of suspended sediment discharge with a geological form of suspended sediment discharge will leave a greater quantity of biological sediments in the water column. This form of sediment may have a greater impact on dissolved oxygen levels and may lead to unacceptable dissolved oxygen-related water quality problems.

C. Timing

Although sediment delivery to streams from nonpoint sources is an inherently seasonal phenomenon, sediment allocations are generally applied year round. Allocations are expressed as an average amount of sediment per year. To account for variability between years (i.e., years with high snow melt or other extreme weather events will have higher sediment delivery) some TMDL load allocations are expressed as ten year rolling averages. Because sediment load allocations are generally applied on an average basis year round, participants will be likely to align reductions between potential buyers and sellers.

D. Quantity

There are a number of ways that sources can apply control options to reduce sediment loads. These controls can be sampled and/or modeled to determine the amount of sediment reduction beyond TMDL allocations.

Point sources can apply technological control options that result in a measurable change in sediment concentration and associated loads. Permit limits for point sources are usually based on a technology-based limit which may be lower than required to meet the TMDL target. Under the Clean Water Act, point sources are required to comply with their technology-based limits, irrespective of watershed conditions or their opportunities to trade. Under such circumstances, there is no incentive for such sources to become purchasers of sediment reductions. However, in circumstances where the technology-based limit is higher than the water quality standards, incentives for trading may exist.

In many watersheds experiencing sediment related water quality problems, point sources are often only minor contributors to excessive sediment loads. Therefore, they may have a limited capacity to overcontrol in a meaningful way to improve water quality. As discussed above, point sources also discharge a different form of suspended sediment. Point sources may be limited to trading with other sources discharging similar forms. Nonpoint sources have the ability to overcontrol using more aggressive controls than required to meet load allocations, using controls that cover broader areas, or using controls that target more valuable areas for sediment reduction.

Nonpoint sources can overcontrol using Best Management Practices (BMPs). Aggressive BMPs, such as conversion to drip irrigation on agricultural lands have the ability to reduce sediment loads below TMDL allocations. BMPs can also be applied to cover broader areas than specified in a TMDL.

Another potential overcontrol option is for sources to select higher value areas to apply nonpoint BMPs, thus achieving higher reductions in the waterbody of concern. Marketable reductions may be generated by applying control options that focus on areas with highly erodible soils, or areas that have a direct impact on the beneficial use, such as salmonid spawning areas, and may create a greater improvement in water quality than specified under the TMDL allocation.

BMPs can be modeled to project the reduction in sediment loading. However, models used in TMDL development usually provide only very coarse estimates of sediment loading. Because of the limitations of models in projecting sediment reductions, TMDLs often use surrogate measures that provide a more direct connection to the beneficial use that is being protected. Measures such as the depth of sediment fines in riffle pools are used in addition to the numeric targets to assess sediment reductions. These methods should allow nonpoint sources to calculate the amount of reductions beyond TMDL load allocations.

Appendix D

Capital Cost Annualization Factors

	Interest Rate							
Year	0.50%	1.00%	1.50%	2.00%	2.50%	3.00%	3.50%	4.00%
1	1.005	1.01	1.015	1.02	1.025	1.03	1.035	1.04
2	0.5038	0.5075	0.5113	0.515	0.5188	0.5226	0.5264	0.5302
3	0.3367	0.34	0.3434	0.3468	0.3501	0.3535	0.3569	0.3603
4	0.2531	0.2563	0.2594	0.2626	0.2658	0.269	0.2723	0.2755
5	0.203	0.206	0.2091	0.2122	0.2152	0.2184	0.2215	0.2246
6	0.1696	0.1725	0.1755	0.1785	0.1815	0.1846	0.1877	0.1908
7	0.1457	0.1486	0.1516	0.1545	0.1575	0.1605	0.1635	0.1666
8	0.1278	0.1307	0.1336	0.1365	0.1395	0.1425	0.1455	0.1485
9	0.1139	0.1167	0.1196	0.1225	0.1255	0.1284	0.1314	0.1345
10	0.1028	0.1056	0.1084	0.1113	0.1143	0.1172	0.1202	0.1233
11	0.0937	0.0965	0.0993	0.1022	0.1051	0.1081	0.1111	0.1141
12	0.0861	0.0888	0.0917	0.0946	0.0975	0.1005	0.1035	0.1066
13	0.0796	0.0824	0.0852	0.0881	0.091	0.094	0.0971	0.1001
14	0.0741	0.0769	0.0797	0.0826	0.0855	0.0885	0.0916	0.0947
15	0.0694	0.0721	0.0749	0.0778	0.0808	0.0838	0.0868	0.0899
16	0.0652	0.0679	0.0708	0.0737	0.0766	0.0796	0.0827	0.0858
17	0.0615	0.0643	0.0671	0.07	0.0729	0.076	0.079	0.0822
18	0.0582	0.061	0.0638	0.0667	0.0697	0.0727	0.0758	0.079
19	0.0553	0.0581	0.0609	0.0638	0.0668	0.0698	0.0729	0.0761
20	0.0527	0.0554	0.0582	0.0612	0.0641	0.0672	0.0704	0.0736

	Interest Rate							
Year	4.50%	5.00%	5.50%	6.00%	6.50%	7.00%	7.50%	8.00%
1	1.045	1.05	1.055	1.06	1.065	1.07	1.075	1.08
2	0.534	0.5378	0.5416	0.5454	0.5493	0.5531	0.5569	0.5608
3	0.3638	0.3672	0.3707	0.3741	0.3776	0.3811	0.3845	0.388
4	0.2787	0.282	0.2853	0.2886	0.2919	0.2952	0.2986	0.3019
5	0.2278	0.231	0.2342	0.2374	0.2406	0.2439	0.2472	0.2505
6	0.1939	0.197	0.2002	0.2034	0.2066	0.2098	0.213	0.2163
7	0.1697	0.1728	0.176	0.1791	0.1823	0.1856	0.1888	0.1921
8	0.1516	0.1547	0.1579	0.161	0.1642	0.1675	0.1707	0.174
9	0.1376	0.1407	0.1438	0.147	0.1502	0.1535	0.1568	0.1601
10	0.1264	0.1295	0.1327	0.1359	0.1391	0.1424	0.1457	0.149
11	0.1172	0.1204	0.1236	0.1268	0.1301	0.1334	0.1367	0.1401
12	0.1097	0.1128	0.116	0.1193	0.1226	0.1259	0.1293	0.1327
13	0.1033	0.1065	0.1097	0.113	0.1163	0.1197	0.1231	0.1265
14	0.0978	0.101	0.1043	0.1076	0.1109	0.1143	0.1178	0.1213
15	0.0931	0.0963	0.0996	0.103	0.1064	0.1098	0.1133	0.1168
16	0.089	0.0923	0.0956	0.099	0.1024	0.1059	0.1094	0.113
17	0.0854	0.0887	0.092	0.0954	0.0989	0.1024	0.106	0.1096
18	0.0822	0.0855	0.0889	0.0924	0.0959	0.0994	0.103	0.1067
19	0.0794	0.0827	0.0862	0.0896	0.0932	0.0968	0.1004	0.1041
20	0.0769	0.0802	0.0837	0.0872	0.0908	0.0944	0.0981	0.1019

	Interest Rate							
Year	8.50%	9.00%	9.50%	10.00%	10.50%	11.00%	11.50%	12.00%
1	1.085	1.09	1.095	1.1	1.105	1.11	1.115	1.12
2	0.5646	0.5685	0.5723	0.5762	0.5801	0.5839	0.5878	0.5917
3	0.3915	0.3951	0.3986	0.4021	0.4057	0.4092	0.4128	0.4163
4	0.3053	0.3087	0.3121	0.3155	0.3189	0.3223	0.3258	0.3292
5	0.2538	0.2571	0.2604	0.2638	0.2672	0.2706	0.274	0.2774
6	0.2196	0.2229	0.2263	0.2296	0.233	0.2364	0.2398	0.2432
7	0.1954	0.1987	0.202	0.2054	0.2088	0.2122	0.2157	0.2191
8	0.1773	0.1807	0.184	0.1874	0.1909	0.1943	0.1978	0.2013
9	0.1634	0.1668	0.1702	0.1736	0.1771	0.1806	0.1841	0.1877
10	0.1524	0.1558	0.1593	0.1627	0.1663	0.1698	0.1734	0.177
11	0.1435	0.1469	0.1504	0.154	0.1575	0.1611	0.1648	0.1684
12	0.1362	0.1397	0.1432	0.1468	0.1504	0.154	0.1577	0.1614
13	0.13	0.1336	0.1372	0.1408	0.1444	0.1482	0.1519	0.1557
14	0.1248	0.1284	0.1321	0.1357	0.1395	0.1432	0.147	0.1509
15	0.1204	0.1241	0.1277	0.1315	0.1352	0.1391	0.1429	0.1468
16	0.1166	0.1203	0.124	0.1278	0.1316	0.1355	0.1394	0.1434
17	0.1133	0.117	0.1208	0.1247	0.1285	0.1325	0.1364	0.1405
18	0.1104	0.1142	0.118	0.1219	0.1259	0.1298	0.1339	0.1379
19	0.1079	0.1117	0.1156	0.1195	0.1235	0.1276	0.1316	0.1358
20	0.1057	0.1095	0.1135	0.1175	0.1215	0.1256	0.1297	0.1339

Appendix E

Participant Pollutant Management Options Characterization

1. Background Information
   a. Model Trade Participant Organization Name:
   b. Organization Representative Contact Information:
      i. Name:
      ii. Address:
      iii. Phone Number:
      iv. E-mail:
2. Phosphorus Load Source(s) for Consideration:
   a. Source A: (provide name of load source e.g., Trout Growers, Inc at Bhule)
   b. Source B:
   c. Source C:
3. Individual Source Characterization (Source A)
   a. Source Description:
   b. Source Location (river mile):
   c. Source Discharge Location (river mile):
   d. Source Phosphorus Type(s):
   e. Source Baseline Discharge Quantity (from TMDL):
   f. Source TMDL Target Load (from TMDL):
   g. Source Current Load (by type if possible):
   h. Source Expected Future Load (annual growth/decline rate and time horizon):
   i. Seasonal or Other Cyclic Load Considerations:
4. Source Phosphorus Control Option(s):
   a. Option A:
   b. Option B:
   c. Option C:
5. Source Phosphorus Control Option Description (Option A):
   a. Description: (include technology/management practice, ability to scale/size to specific control levels, seasonal variability of control, and design, construction, shakedown periods along with overall lifespan)
   b. Currently in Place: (yes or no, and provide date of completion and expected lifespan)
   c. Capital Cost:
   d. Annual O&M Cost:
   e. Phosphorus Control Achieved/Expected (in lbs. Phosphorus/day):