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A QUALITATIVE MODEL FOR DESIGNING AND IMPLEMENTING EFFLUENT TRADING PROGRAMS

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A QUALITATIVE MODEL FOR DESIGNING AND IMPLEMENTING EFFLUENT TRADING PROGRAMS

A Dissertation APPROVED FOR THE
SCHOOL OF CIVIL ENGINEERING AND ENVIRONMENTAL SCIENCE

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LIST OF ACRONYMS

ACSP	Agricultural Cost Share Program (North Carolina)
AGPN	Geneva Association for the Protection of Nature
AO	Administrative Order
ASL	Association for Safeguarding the Leman
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
BOD_5	5-day Biochemical Oxygen Demand
$CBOD_5$	5-day Carbonaceous Biochemical Oxygen Demand
C-BT	Colorado-Big Thompson
CCBWQA	Cherry Creek Basin Water Quality Authority (Colorado)
CIPEL	International Commission for the Protection of the Leman Waters
CLE	Lemanic Council for the Environment
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
COTRAO	Work Community for the Western Alps
CRFG	Franco-Geneva Regional Committee
CWA	Clean Water Act
CZARA	Coastal Zone Act Reauthorization Amendments
DDAF	Departmental Directorate for Agriculture and Forests (France)
DDASS	Departmental Directorate for Public Health and Social Action (France)
DDE	Departmental Directorate for Equipment (France)
DEHNR	Department of Environment, Health, and Natural Resources (North Carolina)
DEM	Division of Environmental Management (North Carolina)
DIREN	Regional Directorate for the Environment (France)
DO	Dissolved Oxygen
DRIRE	Regional Directorate for Industry, Research, and the Environment (France)

DSWC	Division of Soil and Water Conservation (North Carolina)
EMC	Environmental Management Commission (North Carolina)
ERC	Emission Reduction Credit
ETP	Effluent Trading Program
FF	French Franc
FRAPNA	Rhone-Alps Federation for the Protection of Nature
GAO	U.S. General Accounting Office
GIS	Geographic Information System
gpd	gallons per day
gpm	gallons per minute
GWLF	Generalized Watershed Loading Function
IEPA	Illinois Environmental Protection Agency
IU	Industrial User
kg/yr	kilograms per year
km^2	square kilometers
m	meter
$\mu g/l$	micrograms per liter
mg/l	milligrams per liter
mgd	million gallons per day
mmBTU	million British Thermal Units
MAHL	Maximum Allowable Headworks Loading
MAIL	Maximum Allowable Industrial Loading
MDE	Maryland Department of the Environment
MPCA	Minnesota Pollution Control Agency
N	Nitrogen
NCPDI	National Coastal Pollutant Discharge Inventory
NCWCD	Northern Colorado Water Conservancy District
NGO	Non-Governmental Organization
NO_3^-	Nitrate
NOV	Notice of Violation

NO_x	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
NRI	National Resources Inventory
NSW	Nutrient Sensitive Waters
NSWEPA	New South Wales Environment Protection Agency (Australia)
NWCCOG	Northwest Colorado Council of Governments
O&G	Oil and Grease
ODEQ	Oklahoma Department of Environmental Quality
P	Phosphorus
PO_4	Phosphate
PDC	Pineland Development Credit (New Jersey)
POTW	Publicly Owned Treatment Works
PRC	Pollutant Reduction Credit
PUC	Public Utility Commission
PVSC	Passaic Valley Sewage Commission
QA/QC	Quality Assurance/Quality Control
RECLAIM	Regional Clean Air Incentives Market
RMC	Rahr Malting Company
ROG	Reactive Organic Gas
SCAQMD	South Coast Air Quality Management District (California)
sec	second
SF	Swiss Franc
SIG	Geneva Industrial Services
SIU	Significant Industrial User
SIVOM	Inter-municipality Syndicate with Multiple Goals
SS	Settleable Solids
SO_2	Sulfur Dioxide
SO_x	Sulfur Oxide
SPE	Society for the Protection of the Environment (Switzerland)

SWQC	Summit Water Quality Committee (Colorado)
TDR	Transferable Development Right
TMDL	Total Maximum Daily Load
TPBA	Tar-Pamlico Basin Association
TSS	Total Suspended Solids
UNCTAD	United Nations Conference on Trade and Development
USEPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Compound
WBS	Water Body System
WDNR	Wisconsin Department of Natural Resources
WQCC	Water Quality Control Commission (Colorado)
WQCD	Water Quality Control Division (Colorado)
WWF	World Wildlife Fund
WWTP	Wastewater Treatment Plant
yr	year

A QUALITATIVE MODEL FOR DESIGNING AND IMPLEMENTING EFFLUENT TRADING PROGRAMS

ABSTRACT

Effluent trading programs (ETPs) have been proposed as cost-effective alternatives to traditional command-and-control regulations for surface water quality management. In addition to reducing environmental compliance costs, ETPs may encourage pollution prevention, promote the development and installation of more efficient abatement technologies, and even reduce pollutant loadings from previously unregulated nonpoint sources, thus improving overall water quality within watersheds. However, despite these theoretical advantages, relatively few (< 15) extant ETPs have been identified, and trading activity to date has been minimal. Such trading and the success of ETPs may be limited by technical, economic, institutional, and administrative factors that increase the uncertainty and expense associated with trading program participation. Therefore, the major focus of this research was to develop a qualitative model for designing and implementing successful ETPs. The fundamental model was based on minimizing or eliminating the negative effects of factors that may influence ETPs; the model contains 10 components and 37 associated criteria questions. The 10 components include: (1) watershed suitability; (2) pollutant type; (3) trading market size and characteristics; (4) legal authority; (5) administrative acceptability and capability; (6) specific policies, procedures, and trading rules; (7) pre- and post-trade monitoring; (8) effective enforcement; (9) program evaluation; and (10) public involvement. The developed qualitative model is applicable to point-point, point-nonpoint, and/or nonpoint-nonpoint source ETPs. It can be used to evaluate the effectiveness of existing ETPs, to identify the feasibility of effluent trading in a given watershed, and/or to develop a detailed plan for ETP design, implementation, and evaluation.

Additional emphases of this research included the development of derived models specific to intraplant and pretreatment ETPs and the identification of methods that can be used to mitigate or overcome various barriers to trading programs. The derived model for intraplant trading consists of two components (ETP Feasibility and ETP Design Considerations) and 23 criteria questions, while the pretreatment trading derived model also has two similarly titled components and 29 related criteria questions. Methods for mitigating or overcoming barriers which can be used include by agencies administering ETPs include gathering and communicating pertinent information; incorporating stakeholder involvement in all phases of ETP planning and implementation; and ensuring that the rules and regulations governing the ETP are comprehensive, clear, and standardized.

Recommendations for future research or other actions include: (1) refining the qualitative and derived models through additional evaluations of existing ETPs and their application to feasibility studies; (2) aggregation of information regarding marginal abatement costs for point and nonpoint sources, nonpoint source pollutant loadings, and the effectiveness of best management practices in differing environmental settings; (3) design of water quality monitoring networks and development of modeling techniques to accurately assess the environmental effects of proposed trades; (4) amending federal, state, and local laws and regulations to explicitly authorize effluent trading as an acceptable water quality management compliance alternative; and (5) developing strategies and methods to appropriately integrate ETPs into existing watershed planning and management activities.

CHAPTER 1

INTRODUCTION

Effluent trading programs (ETPs) allow dischargers with low marginal abatement costs to generate pollutant reduction credits (PRCs) by reducing their discharges below permitted levels. These PRCs may be retained for their own future use or sold to other point and nonpoint source operators in the watershed. Dischargers with high marginal abatement costs may reduce their environmental compliance costs by purchasing PRCs in lieu of upgrading pollution control equipment to exceed minimum effluent quality requirements or implementing best management practices (BMPs) at their own facilities. Therefore, ETPs represent a cost-effective alternative to traditional command-and-control approaches for water quality management. In addition, trading programs provide continuing economic incentives to reduce pollutant discharges, thus encouraging technological innovation and pollution prevention activities. Finally, some programs, like point-nonpoint and nonpoint-nonpoint source ETPs, may even be used to reduce pollutant loadings from previously unregulated sources, thus improving overall water quality within the trading area.

However, despite the theoretical advantages of effluent trading, very few extant ETPs have been identified, and effluent trading activity remains extremely limited. Experience with conceptually similar environmental management programs, primarily for air quality in the United States, has indicated that the implementation and success of ETPs may be influenced by scientific, economic, and institutional factors; for example, difficulties in quantifying pollutant loading reductions, excessive transaction costs, limited market size and composition, and insufficient administrative authority and resources. Therefore, for the full potential of effluent trading to be realized, these limiting factors must be identified, and trading programs must be designed to minimize or eliminate their negative influence. Therefore, the purpose of this research is to develop a conceptual model, based on these identifiable factors, for designing and implementing successful ETPs.

RESEARCH HYPOTHESIS AND SCOPE OF WORK

The hypothesis of this research is that a conceptual qualitative model can be developed for use in evaluating existing ETPs relative to their effectiveness; and for identifying the feasibility of an ETP in a given watershed and then developing a detailed program design, implementation, and evaluation plan. Further, the model should be applicable, either directly or in modified form, to the five types of trades which could be incorporated in trading programs -- point-point source, point-nonpoint source, nonpoint-nonpoint source, intraplant, and pretreatment. To develop the qualitative model and test this hypothesis, the following major objectives were identified and are discussed in more detail in the following sub-sections:

(1) to review pertinent literature in order to identify technical (scientific), economic, institutional and (administrative) barriers that may negatively influence ETP design, implementation, and/or effectiveness;

(2) to develop a qualitative model for designing and implementing successful ETPs;

(3) to test the qualitative model via its application at a screening level to 12 extant ETPs, and via its use in three detailed case studies;

(4) to evaluate the use of the qualitative model to design and implement an intraplant and a pretreatment ETP; and

(5) to identify methods that can be used to mitigate or overcome scientific, economic, and institutional barriers to ETPs.

Literature Review

The first step in the development of the qualitative model was to identify factors that may positively or negatively influence ETP planning and performance. Eighteen such factors were identified through a comprehensive literature review divided into three parts:

(1) the conceptual basis for marketable permit programs, their theoretical advantages and disadvantages, and their use in land development and water allocation programs;

(2) the use of marketable permit programs for air quality management, including emissions trading, lead trading, and allowance trading programs in the United States, proposed programs that cross state or federal borders, and a proposed international program to control global emissions of carbon dioxide; and

(3) the use of marketable permit programs for water quality management.

Existing and proposed ETPs to be included in the comparative analysis (objective 3) were also identified during the literature review. Parts 1, 2, and 3 of the literature review are summarized in Chapters 2, 3, and 4, respectively.

Model Development

The qualitative model for designing and implementing ETPs was based on 18 factors, identified during the literature review, that may positively or negatively influence ETPs. The focus of this model is on point-point source, point-nonpoint source, and nonpoint-nonpoint source trading since these types of trades are the most common and complex of the five types of trades. The developed model contains 37 criteria questions grouped into 10 components: (1) watershed suitability; (2) pollutant type; (3) trading market size and characteristics; (4) legal authority; (5) administrative acceptability and capability; (6) specific policies, procedures, and trading rules; (7) pre- and post-trade monitoring; (8) enforcement mechanisms; (9) program evaluation; and (10) public involvement. The model can be used to evaluate an existing or proposed ETP and to compare the features of two or more ETPs. Alternatively, criteria questions associated with the first five components can be used to assess the feasibility of effluent trading in a particular watershed, while the remaining components can be used to aid in site-specific ETP design. The development of the qualitative model is summarized in Chapter 5.

Model Testing

Model testing in relation to point-point source, point-nonpoint source, and nonpoint-nonpoint source trading was divided into two phases: (1) a "screening-level" analysis based on 11 existing and one proposed ETP; and (2) detailed case studies of the Lake Dillon ETP in Colorado, the Tar-Pamlico River Basin ETP in North Carolina, and a potential ETP for Lake Geneva, which borders Switzerland and France. Information for model testing was obtained through watershed- and program-specific literature review and personal contacts with ETP managers and other relevant stakeholders.

The "screening-level" analysis was intended to evaluate the qualitative model through its application and relative comparisons developed in association with 12 point-point, point-nonpoint, and/or nonpoint-nonpoint source ETPs. As part of the analysis, the model's 10 components were used as criteria to review the characteristics of each ETP. Other factors that may need to be included in the model, along with scientific, economic, and institutional barriers to ETP planning and implementation, were also identified. In addition, the comparative analysis provided "state-of-practice" information, including ETP location, effective date, tradeable pollutants, types of trades, and trading ratios, for national and international trading programs. The results of the comparative review are summarized in Chapter 6.

Chapters 7 and 8 illustrate the application of the qualitative model to the Lake Dillon ETP and the Tar-Pamlico River Basin ETP, respectively. Both case studies were designed to test the applicability of the model for existing ETPs and to identify any necessary model revisions. Accordingly, each chapter begins with brief descriptions of the relevant watershed and the development and current status of its ETP. The application of the model to the ETP is then described. Each chapter is concluded with a discussion of effluent trading as a management tool for the specific watershed, the use of ETPs in similar situations, and the use of the qualitative model for evaluating extant ETPs, including any required modifications to the model.

Chapter 9 describes the application of the qualitative model to the Lake Geneva watershed in Western Europe. Conceptually similar to the case studies described above, this study was designed to test the applicability of the qualitative model and to identify any necessary revisions. However, since the Lake Geneva area does not currently have an ETP, the model was used to assess ETP feasibility and to identify elements that should be included in a site-specific ETP. In addition, this study was specifically designed to examine transboundary issues that may affect ETP design and implementation. This chapter begins by summarizing the physical and hydrological characteristics of the watershed, lake water quality, and institutional aspects of lake water quality management. The chapter then addresses the detailed application of the qualitative model to the Lake Geneva watershed and concludes by highlighting the use of a point-nonpoint source ETP to reduce phosphorus levels in Lake Geneva, the use of ETPs in similar situations, and the use of the qualitative model to assess ETP feasibility and aid in ETP design. Also described are modifications to the model that may be needed if the trading area encompasses two or more political jurisdictions.

Use of Model for Intraplant and Pretreatment ETPs

As noted above, model development and testing were primarily based on the characteristics of point-point, point-nonpoint, and nonpoint-nonpoint source ETPs. As a result, the qualitative model may not be directly applicable to intraplant ETPs, which involve trades among multiple outfalls or processing lines at a single facility, or pretreatment ETPs, which involve two or more industrial facilities that discharge their effluent to the same publicly owned treatment works (POTW). Therefore, the fourth objective of this research was to evaluate the use of the qualitative model for designing and implementing intraplant and pretreatment ETPs.

Chapter 10, which summarizes the application of the model to intraplant ETPs, was based on literature review and water quantity and quality data previously collected at the Stilwell Canning Company in Stilwell, Oklahoma (see Note 1). This chapter briefly describes the vegetable processing industry, specific characteristics of the Stilwell Canning Company, the theoretical advantages of intraplant ETPs, and the use of intraplant ETPs in other industries. Chapter 10 then summarizes the use of the model for designing and implementing intraplant ETPs, the feasibility of an intraplant ETP for the Stilwell Canning Company, and site-specific ETP design considerations. The chapter concludes with a discussion of a derived sub-model, which contains two components and 23 criteria questions, that is specific to designing and implementing intraplant ETPs.

Chapter 11, which summarizes the application of the qualitative model to pretreatment ETPs, was based on literature review and the local pretreatment program currently administered by the POTW operator in Stillwater, Oklahoma. This chapter briefly highlights federal and state requirements for pretreatment, specific characteristics of the Stillwater pretreatment program, the theoretical advantages of pretreatment ETPs, and the use of pretreatment ETPs to date. Chapter 11 then addresses the use of the qualitative model for designing and implementing ETPs, the feasibility of a pretreatment ETP for the Stillwater POTW, and site-specific ETP design considerations. The chapter concludes with a discussion of a derived sub-model, which contains two components and 29 criteria questions, that is specific to designing and implementing pretreatment ETPs.

Overcoming or Mitigating Barriers to ETPs

The fifth objective associated with the research hypothesis was to summarize scientific, economic, and institutional barriers to ETPs and measures that could be used to overcome or mitigate them. Factors which may adversely affect technological innovation and pollution prevention, as well as corresponding mitigation measures, were identified through literature review. These barriers were included in this study since innovation and pollution prevention efforts, like effluent trading, represent alternatives to traditional command-and-control regulatory programs for water quality management. Barriers to innovation and pollution prevention were then compared to ETP barriers, which had been previously identified during the literature review described for the first research objective. Based on this comparison, seven barriers that are unique to ETPs and nine barriers that are common to innovation, pollution prevention, and effluent trading were identified. These barriers and associated mitigation measures are described in Chapter 12.

CONTENTS OF DISSERTATION

Chapter 1 provides a general introduction to ETPs and the hypothesis and major objectives of this research. The literature review related to the first research objective is summarized in Chapters 2, 3, and 4. Chapter 5 describes the development of the qualitative model for designing and implementing ETPs, with this effort corresponding to the second research objective. Chapters 6 through 9 summarize the two phases of model testing, thus corresponding to the third research objective. Chapters 10 and 11, which describe the application of the model to intraplant and pretreatment ETPs, respectively, correspond to the fourth research objective. Chapter 12 summarizes barriers to ETPs and potential mitigation measures, thus fulfilling the fifth research objective. Finally, Chapter 13 contains a brief summary of the research findings, general conclusions, and suggestions for further research efforts. Cited references are listed, in alphabetical order, at the end of each chapter. (See Notes 2 and 3).

Note 1: The industrial plant case study used in Chapter 10 to examine intraplant trading is hypothetical (but based on the actual results of a 1971 survey of pollutant loadings from different process lines at a vegetable cannery). The results of this 1971 survey were assumed to be transposed in time to 1999, and thus still applicable. The 1971 survey was conducted by Dr. L.W. Canter for the Oklahoma Economic Development Foundation, Inc.

Note 2: In addition to this dissertation, Chapters 5, 9, and 12 were provided to the International Academy of the Environment in Geneva, Switzerland, as Working Papers W64, W74, and W84, respectively. Modified versions of Chapters 5 and 6 were also presented at the 19th Annual Meeting of the International Association for Impact Assessment in Glasgow, Scotland (June 15-19, 1999) and will be published in the conference proceedings.

Note 3: It should be noted that some redundancies occur in Chapters 6 through 11. These chapters contain the case studies involving various tests of the qualitative model. These case studies were written as "stand alone" chapters in anticipation of several publication submittals. Further, Chapter 12 also has some redundancies with earlier chapters; again, this was done in anticipation of the submittal of Chapter 12 (or a portion thereof) as a journal publication.

CHAPTER 2

FUNDAMENTALS OF MARKETABLE PERMIT PROGRAMS

This chapter briefly describes the three types of instruments (suasive, regulatory, and economic) that have been used in pollution control and environmental policy and their relative advantages and disadvantages. This chapter then addresses, in more detail, the concept of marketable permits as an economic instrument, the different types of permit programs, and their conceptual and theoretical advantages and disadvantages. Similar types of programs that have been used to regulate land development and the distribution of water rights are also reviewed. This chapter concludes by identifying criteria that should be considered when designing and implementing a marketable permit program. Additional criteria will be identified in subsequent chapters by reviewing applications of marketable permit programs in air and water quality management.

SUASIVE INSTRUMENTS

Suasive instruments, which encourage individuals and firms to avoid polluting the environment by appealing to their sense of civic duty or moral obligation, may be the only effective policy instrument when violators are scattered throughout the population (Field, 1994). In addition, suasion promotes additional environmentally responsible behavior. For example, a person who responds to a campaign to save landfill space by recycling his waste paper may also begin to compost his yard waste or to take his household hazardous waste to an approved recycling center. An environmentally conscious society may also be conducive to the introduction, administration, and enforcement of new regulatory or economic policies designed to protect the environment.

However, since suasive programs are voluntary, their success depends upon the initial and continuing responses of individuals or firms. In some cases, the desired environmental result may not be achieved without supplemental regulations or economic incentives. Even individuals, industries, or municipalities who participate readily at the beginning of a program may be discouraged by its lack of success and abandon their efforts. Suasive instruments also depend upon the quantity and quality of information available to the public, and on the levels of public education and environmental commitments.

<u>REGULATORY INSTRUMENTS</u>

Regulatory instruments, which dominate pollution control policy in most countries, are defined as institutional measures that directly influence the environmental performance of "polluters" by regulating processes or products used, by prohibiting or limiting the discharge of certain pollutants, and/or by restricting potentially polluting activities (Hahn and Stavins, 1991; Opschoor and Vos, 1989). In general, the "command-and-control" regulatory approach involves the following steps (Mercuro, López, and Preston, 1994):

(1) The government, usually the legislature, grants an agency the right to regulate pollution sources related to environmental quality.

(2) The agency develops regulations for pollution sources that are necessary to achieve stated environmental quality goals, standards, or objectives.

(3) The agency establishes civil and criminal penalties for polluters (pollution sources) that do not comply with the agency's regulations.

(4) The agency monitors pollution sources to determine whether or not they are in compliance with applicable regulations. Pollution sources may report their own monitoring data to the agency, or the agency may conduct periodic inspections and audits.

(5) Depending upon the severity of non-compliance, the agency may use courts to impose civil and criminal penalties on violators of their regulations regarding discharges (emissions) and environmental quality standards.

Screening, another type of command-and-control regulation, uses general criteria, such as "unreasonable risk," on a case-by-case basis to determine whether particular products or facilities are environmentally acceptable (Stewart, 1988).

A standard is a mandated level of performance that is legally enforceable (Field, 1994). Ambient standards, usually expressed in terms of concentration over time, refer to pollutant levels in the air, water, or soil that cannot be exceeded. Technology standards dictate technologies, techniques, or practices that potential polluters must use to minimize discharges of air, water, or soil pollutants. Performance standards specify an environmental discharge objective but allow industries, firms, and governmental entities to choose control technologies or techniques to meet that objective (Hahn and Stavins, 1991). In reality, however, most pollution sources choose to install the technology, technique, or practice that was used to establish the performance standard in order to avoid accusations of non-compliance or lack of environmental responsibility.

Emission standards, a type of performance standard, restrict the quantity of emissions that polluters can discharge into the air, water, or soil (Field, 1994). Emission (or discharge) standards are usually expressed in terms of quantity of material over time, such as pounds of pollutant per day. Even if all pollution sources in a given area comply with their emission standards, ambient standards in the area could still be violated. In some cases, meteorological and hydrological processes that influence pollutant fate and transport are responsible for this failure. In others, the magnitude of human activities are responsible. For example, even if each individual wastewater treatment plant on a heavily populated river segment meets its discharge standards, the aggregate discharges may cause a violation of ambient water quality standards. Ambient standards may also be violated when unregulated sources (for example, nonpoint sources in urban areas) contribute significant amounts of pollutants into the same receiving environment.

Standards can be established by using several different approaches. First, regulators can consider the environmental impact of each incremental unit of pollution or its marginal damages (Field, 1994). To obtain a no-risk level, emission (discharge) standards should be set below the level where environmental damage first occurs, represented by e_t in Figure 2.1. However, carcinogenic pollutants typically do not exhibit a threshold, thus implying that any emissions of that pollutant should be prohibited. While completely banning emissions may be appropriate for highly toxic chemicals, it is impossible to do so for all pollutants. Alternatively, regulators could choose to establish the discharge standard at the point where marginal damages begin to rise sharply, represented by e_0 in Figure 2.1. Standards could also be set as closely as possible to the point where the cost of marginal damages equals the cost of marginal abatement, represented by e^* in Figure 2.1. To the right of this point, costs associated with environmental damage exceed abatement costs; to the left of this point, abatement costs exceed environmental damage costs. The concepts depicted in Figure 2.1 are also applicable when the x-axis displays media quality; e.g., water quality for a particular pollutant expressed in mg/l.

Advantages of Regulatory Instruments

Regulatory instruments such as discharge or media quality standards are more effective when all affected sources have similar characteristics and when regulators have thorough information

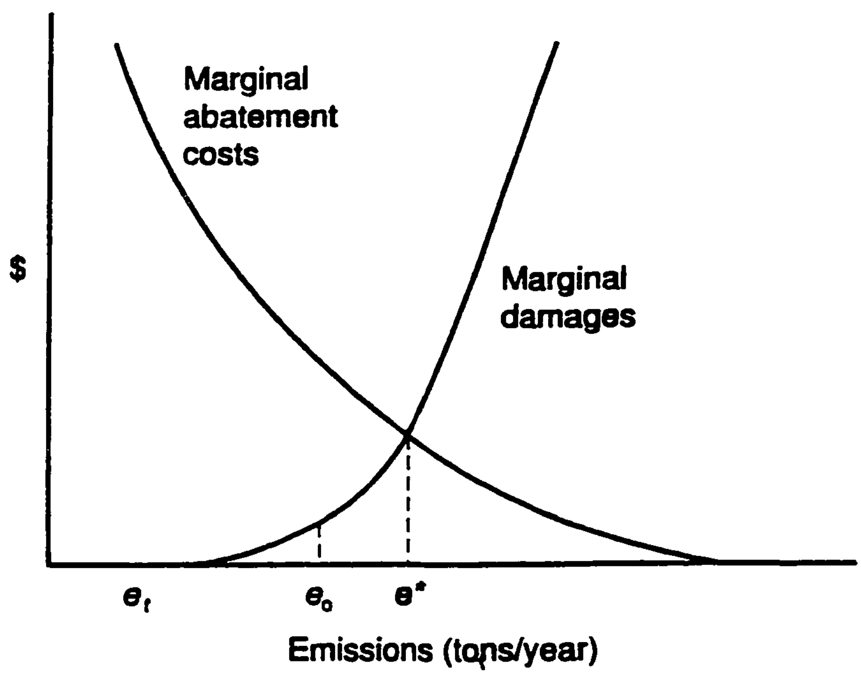

Figure 2.1: Setting Emission (Discharge) Standards (Field, 1994)

regarding available abatement options (Carlin, 1992). Since regulations do not depend only on emission rates, they are more broadly applicable than economic instruments (Rees, 1988). For example, regulations may include storage and transportation requirements for hazardous chemicals or dictate procedures that must be followed whenever hazardous substances are released into the environment. Regulators, industries, municipalities, and environmental groups may all prefer regulations because they set clearly defined environmental targets (Opschoor and Vos, 1989). Regulations also reinforce the common perception that pollution should be illegal and conform to existing legal systems (Field, 1994).

In practice, regulatory authorities may also prefer standards because they are familiar with this approach, which is commonly used in many fields of governmental policy. In contrast, applying economic instruments to regulate environmental quality remains largely theoretical and less utilized (Opschoor and Vos, 1989). Regulated industries and municipalities typically prefer regulatory instruments because they may be able to influence the content of regulations or delay their implementation by negotiating with regulators, participating in agency proceedings, or requesting judicial review (Stewart, 1988). In addition, there is concern that economic instruments could add to their existing compliance costs. Environmental groups, which are also able to participate in agency hearings or request judicial review, may prefer standards to economic incentives. Further, environmental groups may also be able to petition the court to implement and enforce standards.

Disadvantages of Regulatory Instruments

One of the major disadvantages of regulations is that they may not vary with circumstances even though factors such as geographical region, meteorological conditions, and seasons of the year can affect both damage and abatement costs (Field, 1994). For example, damage costs rise more steeply in heavily populated areas, since more people are affected, so a uniform emission standard may not provide enough protection in urban areas and provide over-protection in rural ones. Marginal abatement costs may vary depending upon factors such as the selected control technologies, the types of raw materials, and the ages of pollution sources and/or treatment facilities. Theoretically, a regulatory agency could adopt individual standards for each pollution source, but the administrative costs of data collection and enforcement would be prohibitively expensive. Uniform standards avoid the complexity and expense of individual standards but, because they do not consider variable marginal abatement costs, they typically result in higher compliance costs than necessary to achieve identified environmental objectives.

Regulatory standards also fail to provide incentives to discover and implement improved methods of pollution control once compliance has been achieved (Field, 1994). Technology standards provide no rewards for finding less expensive or more effective control techniques since pollution sources are required to install the exact technology dictated by regulations. Furthermore, the emphasis on controlling pollutant discharges discourages "pollution prevention" modifications in raw materials or plant operations that may actually be more effective in reducing mass rates of discharge. Finally, technology standards are usually stricter for new sources, which may delay the construction of newer industrial plants with less polluting technology while older, more polluting plants operate longer (Stewart, 1992).

The only incentive for technological innovation associated with emission (discharge) standards is to meet the standards as inexpensively as possible. Industries or municipalities that develop new technology to reduce emissions below the standard may even be penalized if regulators respond by tightening the standard (Field, 1994). Strict, "technology-forcing" standards could encourage pollution sources to divert money from research and development to lobbying to delay the onset of new standards. The low rate of investment in pollution control research and development compared to total pollution control expenditures is evidence of the lack of incentive for technological innovation associated with technology- and performance-based standards (Carlin, 1992).

Although standards may be viewed as defining clear environmental objectives, the objectives may never be reached without effective monitoring and enforcement programs, and environmental agencies may not have the necessary budgetary and personnel resources. In general, compliance rates are affected by the costs of compliance and by the size of potential penalties for non-compliance; stricter standards, which are more expensive to implement, require greater levels of monitoring and enforcement (Field, 1994). When environmental agency budgets for audits and inspections are limited, more lenient standards with high compliance rates may actually improve environmental quality more than stricter standards with lower compliance rates. Likewise, establishing technology standards does not guarantee improvements in environmental quality. Although the pollution source may install the appropriate abatement equipment, continued compliance depends upon proper operation and maintenance of the equipment. Without recurring compliance inspections, the source operator may have limited incentives to continue meeting the standard.

<u>ECONOMIC INSTRUMENTS</u>

Instead of dictating the emission or media standards that must be met or the control technologies that must be installed, economic instruments incorporate the societal and environmental costs of pollution into goods and services by imposing economic costs on polluting activities or by offering financial rewards to those who mitigate the negative environmental impacts of their activities. Individual pollution source operators can then compare the costs of the economic instrument to their abatement costs and select the most appropriate alternatives, or combinations thereof, for their specific situations. A fundamental presumption is that no pertinent discharge or media standards will be violated. The following categories of economic instruments are defined in Table 2.1: charges, subsidies, deposit-refund systems, market creation, and financial enforcement incentives. A survey conducted by the Organization for Economic Cooperation and Development in the mid-1980s identified 153 different economic instruments in 14 countries; over half of the identified instruments involved charges (Opschoor and Vos, 1989).

Advantages of Economic Instruments

Economic instruments are typically less expensive to the regulated community than command-and-control approaches. Instead of complying with uniform technology- or performance-based standards, industrial plant and/or municipal executives and engineers are allowed to choose the most appropriate, effective, and least-cost pollution control technologies for their particular circumstances (Stewart, 1988). This freedom to make decisions at the plant level may have the added benefit of reducing litigation and facilitating compliance. Economic instruments also provide continuing incentives to develop and implement new technologies to further reduce pollution and environmental compliance costs. Some economic incentives, like charges and marketable permits distributed by auction, even raise revenue that can be used to fund environmental programs or to supplement the general budget.

Table 2.1: Types of Economic Instruments (after Opschoor and Vos, 1989)

Charges	
Effluent Charges	Charges based on the quantity and/or quality of pollutants discharged to the environment
User Charges	Charges for the costs of collective or public treatment of effluents
Product Charges	Charges added to the price of polluting products
Administrative Charges	Charges for agency services (e.g., permit processing fees)
Tax Differentiation	Taxes are lowered for less polluting products and raised for more polluting products
Subsidies	
Grants	Non-repayable forms of financial assistance to encourage industries or municipalities to reduce pollution levels
Soft Loans	Loans with interest rates below the market rate to encourage industries or municipalities to reduce pollution levels
Tax Allowances	Forms of tax or charge exemptions or rebates, such as accelerated depreciation, to encourage industries or municipalities to reduce pollution levels
Deposit-Refund Systems	Surcharge is added to the price of potentially polluting products and refunded when products are returned for proper collection and disposal
Market Creation	
Marketable Permits	Industries or municipalities which reduce pollution below assigned limits can sell or trade excess reductions to other industries or municipalities or store them for future use
Market Intervention	Price intervention or guarantees to create or stabilize a market
Liability Insurance	Insurance for industries or municipalities to claim in the event of accidental pollutant releases or historical pollution from improper disposal practices. Industries or municipalities with better environmental programs and fewer accidents have lower insurance premiums
Financial Enforcement Incentives	
Non-compliance Fees	Charges based on the profits made through non-compliance with regulations
Performance Bonds	Payments to regulatory authorities in expectation of compliance with imposed regulations that are refunded after compliance is achieved

Disadvantages of Economic Instruments

Theoretical analyses of economic instruments are usually based on conceptual models that do not adequately reflect the real difficulties of implementing such a system, either alone or in conjunction with command-and-control regulations. These analyses typically ignore distributional, administrative, and legal constraints and assume that technical, perceptual, organizational, and capital availability restraints do not exist (Rees, 1988). In addition, economic instruments may not be applicable to all types of pollutants. For example, direct regulations are probably more appropriate when pollutants have localized effects or when there is not a quantifiable index of "pollution risk" that can serve as a basis for charges, refunds, or permit units (Stewart, 1988). Economic instruments can increase compliance costs of pollution sources, particularly when used in conjunction with regulations, and imply a "license to pollute," which may be unpopular with citizen groups and environmental organizations. In practice, the use of economic instruments is often limited by bureaucratic inertia, problems of transition from regulatory to economic instruments, and a lack of experience in designing and implementing incentive systems. Economic instruments may also require more complicated systems of monitoring than do regulatory instruments.

One of the most commonly cited advantages of economic instruments is that they permit individual pollution source managers to choose control strategies and technologies that are best suited to their particular facilities, thus reducing compliance costs. However, some comparative studies which have been conducted on effluent charges indicate that up to 30 percent of dischargers do not understand that compliance costs would vary significantly if they altered effluent strength, volume, or composition (Rees, 1988). Dischargers that did understand the variable pricing system lacked information on alternative treatment methods and costs, recycling opportunities, or the potential for product, process, or input changes. Without this information, one of the major theoretical advantages of economic instruments may not be realized in practice. If dischargers also lack information on new technologies to reduce pollution, which seems likely, economic instruments will also fail to stimulate pollution prevention activities and technological innovation.

MARKETABLE PERMITS

Under a system of marketable permits, environmental authorities allow each source of a specific pollutant to discharge a specific amount of that pollutant. Industries and/or municipalities with low abatement costs can then reduce pollutant discharges below assigned levels and sell or lease surplus reductions to other industries and/or municipalities. Surplus reductions can also be used to offset other emissions within the industry and/or municipality or stored for future use during expansions or to comply with more stringent standards. Industries and/or municipalities with high abatement costs could avoid installing expensive control technologies by purchasing or leasing excess reductions from other industries and/or municipalities with surplus reductions. With these approaches, the total amount of a pollutant entering the environment in a designated area remains constant while overall compliance costs are reduced for the affected pollution sources.

Figure 2.2 illustrates the concept of marketable permits for a uniformly mixed assimilative pollutant (Tietenberg, 1985). It is assumed that the initial emission rate for both sources is 15 units, for a total of 30 units, and that emissions must be reduced by 15 units. Suppose that the regulatory agency allows Source No. 1 to emit 7 units and Source No. 2 to emit 8 units, so Source No. 1 and Source No. 2 must control 8 and 7 units, respectively. At that

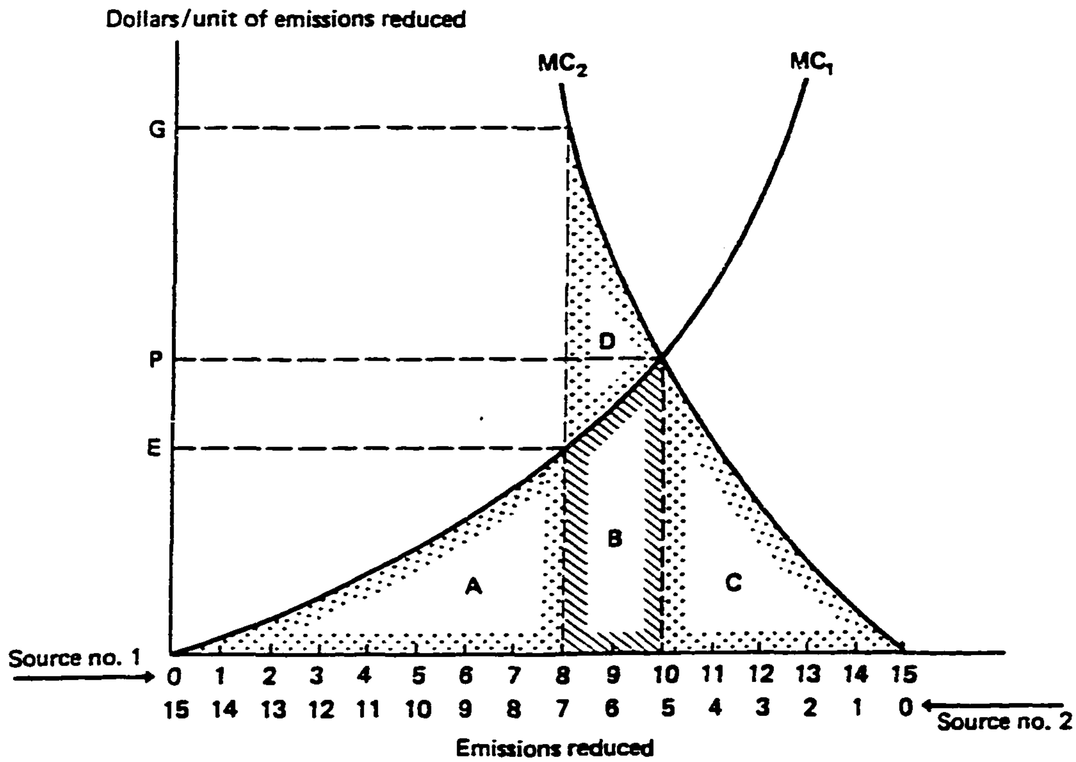

Figure 2.2: Marketable Permits (Tietenberg, 1985)

point, the marginal control costs for Source No. 2, represented by MC_2, are higher than the marginal control costs for Source No. 1, represented by MC_1, which means that the two sources have an incentive to trade. Source No. 2 can reduce control costs by purchasing emission reductions from Source No. 1 at a price lower than G. Source No. 1 profits by selling its reductions to Source No. 2 at a price higher than E. Emission reductions are transferred until Source No. 1 controls 10 units and Source No. 2 controls 5 units. At this point, the sources' marginal control costs are equal, and neither source has any further incentive to trade. The total control cost after trading is represented by the area A + B + C, where A + B is the cost of control for Source No. 1 and C is the cost of control for Source No. 2; any other allocation of control responsibility would result in higher control costs. Area D represents the cost savings associated with the trade.

Marketable permit systems based on similar concepts to those in Figure 2.2 can also be devised for nonuniformly mixed assimilative pollutants and for uniformly mixed accumulative pollutants; accumulative pollutants can remain in the environment over time. These systems are discussed in more detail below.

Types of Marketable Permit Systems

There are five different types of marketable permit systems: ambient permit systems, emission permit systems, zonal permit systems, single-market ambient permit systems, and trading rules (Tietenberg, 1985). This section defines each type and summarizes their major advantages and disadvantages.

Ambient permit systems, designed for nonuniformly mixed assimilative pollutants in air or water, limit the permissible ambient concentration of pollutants measured at specific receptor locations. Permits are defined in terms of units of concentration at the receptor location, and separate markets are associated with each receptor. A single source of pollutants, therefore, will require different permitted emissions for each receptor. Transfer coefficients, which incorporate the distance between source and receptor as well as the assimilative capacity of the environment, are used to relate emission (discharge) levels and ambient air or water concentrations. For example, a source located three miles upstream from a receptor will have a lower transfer coefficient, thus requiring fewer permitted emissions, than a source adjacent to the receptor that is discharging equivalent amounts of pollution.

Although ambient permit systems conceivably would result in the lowest control costs because the assimilative capacity of the environment is incorporated in the system, they may be too complex to implement. Since regulators must use air or water dispersion and transport and fate models to derive transfer coefficients for all combinations of pollutant sources and receptors, ambient permit systems require more information than any other type of system. Market prices at each receptor would vary with the difficulty in meeting the ambient standard at that particular location, and problems associated with obtaining emission reductions in one market could jeopardize the entire transaction. In addition, higher permit prices in heavily populated or polluted areas could encourage industries to locate in pristine areas. Ambient permit systems may also lead to violations of anti-degradation provisions in federal and state laws.

In contrast, emission permit systems do not focus on the impact of a source's discharge on ambient quality, rather, they limit emissions directly. Cumulative emission permit systems can be used to restrict the total amount of uniformly mixed assimilative or accumulative pollutants entering the environment. Once all permits (emissions) for an assimilative or accumulative pollutant have been used, no more emissions are allowed. A key issue in this type of system is the establishment of the "emissions cap" or "discharge cap" for the designated geographical area.

Emission permit systems are much simpler to design and implement than ambient permit systems. However, since these systems do not consider source location or the assimilative capacity of the environment, emission controls for some sources may be stricter than necessary to attain the desired level of ambient environmental quality. Trading may increase the risk of forming "toxic hot spots," i.e., local areas where environmental quality standards are violated. To minimize this risk, emission permit systems generally incorporate a margin of safety, which may further increase the control requirements of certain sources.

In a zonal permit system, regulators divide the designated control region into zones and require each zone to reduce pollutants by a given amount. Emission reductions can be traded within each zone on a one-to-one basis, but trading among the zones is prohibited. Zonal permit systems create separate markets for near and distant sources, thus reducing the possibility of imposing excessively stringent control requirements on some sources. Zonal systems also reduce the likelihood of developing toxic hot spots, and sources subjected to the systems are allowed to function in only one permit market. However, cost savings may be limited since trading opportunities are restricted to the same geographical zone, particularly if the individual zones are small. Regulators are required to define zones and allocate reductions among zones, which makes zonal systems more administratively complex than emission permit systems.

Like ambient permit systems, the single-market ambient permit system uses transfer coefficients to determine the impact of a source's emissions on ambient environmental quality. Instead of a separate permit market for each receptor, however, regulators evaluate all trades based on their effect on a single worst-case receptor. If the ambient standard is met at this critical receptor, it should also be met at all other receptors in the designated control region. Having only one permit market simplifies implementation and participation in the permit system, and regionwide trades can eliminate the cost penalties associated with trading restrictions. Single-market ambient permit systems also protect against hot spots as long as the chosen receptor remains the worst-case receptor. However, as sources locate as far away from the critical receptor as possible in order to facilitate cheaper emission reductions, the ambient quality standard at closer receptors may be exceeded. Separate markets for each receptor could then be established; eventually, the single-market system would become a full-fledged ambient permit system as described above with all of its inherent advantages and disadvantages.

Trading rules, which combine aspects of the four permit systems discussed above, may be the most practical way to design and implement a marketable permits program. Typically, trading rules permit areawide trades and use transfer coefficients selectively to avoid hot spots. Rules may be developed to allow trades among sources if: (1) ambient standards are not exceeded; (2) if ambient standards are not exceeded and total emissions do not increase; or (3) if neither ambient quality nor the ambient standard, whichever is more stringent, is exceeded at any receptor in the designated control area (or region).

Advantages of Marketable Permits

Like other economic instruments, marketable permits are perceived to reduce the costs of complying with given environmental standards and encourage pollution reductions below the standards. Marketable permits are preferred over charges (another economic instrument) for several reasons. First, since permits delineate the amount of pollution that can be discharged into the environment, the resulting environmental quality can be predicted with certainty within the bounds of the utilized predictive model (Stavins and Whitehead, 1992). If ambient standards are not met, regulators can decrease the number of available permits. Charges only specify the cost associated with discharging a given amount of pollution and do not regulate the total amount of pollution entering the environment. If charge levels are too low, ambient quality standards may be exceeded. Regulators could raise the charge level through a trial-and-error process, but the resulting uncertainty would make it almost impossible for industries and/or municipalities to make long-term control decisions that would reduce their compliance costs (Tietenberg, 1991). In practice, it may be extremely difficult to raise rates except in rare occasions, and, unless charge rates are adjusted for inflation, their effectiveness will decrease with time. At least in the United States, permits are more politically acceptable than charges because they more closely resemble the existing regulatory structure.

Marketable permits can also stimulate the invention and adoption of more cost-effective pollution control technologies. The incentive to install new technology is illustrated in Figure 2.3 (Tietenberg, 1985). Initially, it is assumed that the source is controlling Q^o emissions in response to an emission standard $\bar{Q}$ or a permit price P. The source's marginal control costs with existing technology are represented by MC^o; installing new technology would reduce the marginal control costs to MC'. If the new technology is installed, the source would save area A in compliance costs, even if regulated by an emission standard. However, since marketable permit systems allow sources to sell excess emission reductions, the source will save an additional amount equal to area B. Therefore,

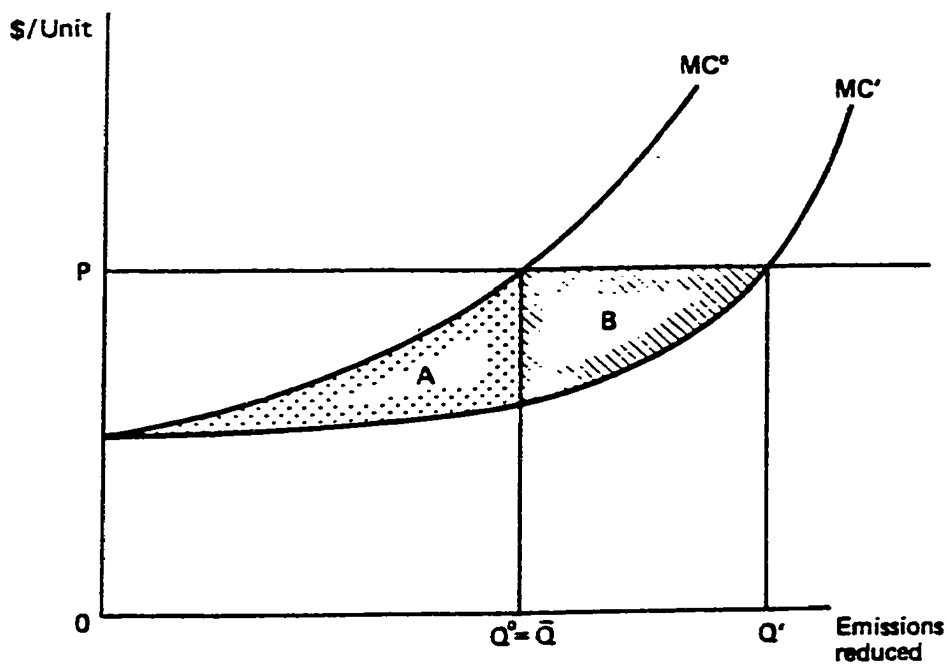

Figure 2.3: Technological Innovation and Cost Savings with Marketable Permits (Tietenberg, 1985)

marketable permits may often provide greater incentives for technological innovation than command-and-control regulations.

Marketable permit systems also offer some unique advantages. First, permit markets protect environmental quality without restricting economic growth. In fact, such markets can be viewed as a tool for sustainable development. As more sources are built, permit demand and prices rise, but the amount of allowed pollution remains constant if the system has a pre-established cap. In contrast, even if each source in a geographical area meets its individual emission standards, more sources will result in deteriorating environmental quality unless stricter standards are adopted (Tietenberg, 1985). Second, marketable permit programs can be designed to include previously unregulated sources of pollutants that wish to reduce emissions and sell the resulting credits. These sources may be a particularly important source of emission reductions when regulated sources have already installed extensive pollution control equipment. Finally, industries and/or municipalities with periodic emission increases, or industries that are about to close, may be allowed to lease permits instead of installing expensive control equipment (Tietenberg, 1991).

Disadvantages of Marketable Permits

Despite the purported advantages of marketable permit programs, the cost savings for actual programs have been found to be well below theoretical predictions, due in part to regulatory and legal requirements that restrict trading opportunities (Carlin, 1992). Trading opportunities may also be limited in areas where sources are already required to implement stringent controls and by unique local circumstances (Tietenberg, 1985). Predicted cost savings may be inflated because studies comparing regulations and economic instruments typically assume the absence of environmental controls. In reality, permit markets usually complement an existing regulatory scheme, and sources have already purchased and installed durable capital equipment. Cost studies may also ignore transaction costs.

One of the major concerns when developing a marketable permit program is the initial distribution of "pollution rights" (emission or discharge rights). These rights should be predicated on a pollution cap (emission or discharge cap). Regulators can distribute pollution rights equally among existing sources, but this approach may provide too many rights to smaller sources and too few to larger ones. Pollution rights can also be issued based on existing emissions; however, this approach penalizes industries and/or municipalities that have already reduced their emissions and may encourage them to increase their emissions in order to receive more rights. Pollution rights can also be auctioned. Although an auction could raise funds for use in administering the trading program, it would raise environmental compliance costs and may be politically unacceptable. Using existing regulations to define control responsibilities is typically the most acceptable method of pollution rights distribution. With this approach, sources in areas that meet applicable ambient standards would be at least as well off with a trading program as they would be with direct regulations. Fortunately, the initial distribution does not affect cost-effectiveness as long as the permit market is functioning properly (Tietenberg, 1991).

Sources may be reluctant to participate in trading programs when the rules governing a trading program are uncertain or subject to change and court challenge (Hahn and Hester, 1989). Industries and/or municipalities may be particularly unwilling to rely on trading programs when making long-term control decisions (McCann, 1996). For example, financial entities such as banks and investing groups often require companies to secure environmental permits for 15 to 20 years. In these situations, traditional emission controls are preferred because the future characteristics of marketable permit programs are more uncertain. Permit programs may also be biased against new sources since participation is frequently optional for existing sources but mandatory for new ones (Hahn, 1989).

Competition among sources may also influence the success of a marketable permit program. Theoretically, trading areas should be as large as possible in order to maximize the number of participants. In reality, however, ecological conditions and/or administrative boundaries often limit the sizes of trading areas. Permit systems with only a few participants are more susceptible to manipulative strategic behavior (Stavins and Whitehead, 1992). For example, one source may try to reduce its control expenditures by attempting to influence permit (emission or discharge) prices (Tietenberg, 1985). Sources may also withhold permitted emissions or discharges in an effort to force competitors to cut production or to exclude new competitors from the market.

Finally, technologies to accurately monitor emissions or discharges may not be very reliable or even available. Assumptions about manufacturing processes, operating hours, and pollution abatement equipment, which regulators have traditionally used to estimate emission or discharge rates, may not be sufficient to prevent hot spots and environmental deterioration, particularly if a source's actual emissions or discharges are more than its calculated emissions (Hahn and Hester, 1989).

Summary of Marketable Permit Programs

According to the theoretical literature, marketable permit programs have two major advantages when compared to command-and-control regulatory instruments. First, marketable permits reduce compliance costs by allowing individual industries and municipalities to select the most appropriate alternatives for their specific situations. Second, marketable permits provide financial incentives to reduce emissions below applicable standards and to invent and implement more cost-effective abatement technologies. However, marketable permit programs must be carefully balanced so that they are not too complex or expensive to implement while still achieving desired environmental objectives.

OTHER APPLICATIONS OF MARKETABLE PERMITS

The use of marketable permits is not exclusive to pollution control. Conceptually similar programs have been used to regulate property development and to control the transfer of water supplies from one user to another. Overall, these applications have been successful; however, several issues can be identified from these applications that could also affect the success of marketable permit programs designed for air or water quality management.

Transferable Development Rights

Transferable development right (TDR) programs authorize the transfer, usually by sale, of development rights from preservation areas, where little or no development is allowed, to designated growth areas. Preservation areas include environmentally sensitive or historically significant sites, while growth areas are defined as suitable for high-density residential or commercial development (Tripp and Dudek, 1989). Local land use officials distribute TDRs to property owners in designated preservation areas in exchange for permanently restricting the development of their land. Within the designated growth areas, local land use officials must designate a base zoning density and a higher level of zoning density that applies only when developers obtain TDRs. TDR programs can be used to direct development away from sensitive areas, to control the total amount of development, and to provide financial benefits for owners in newly designated preservation zones.

For a TDR program to be successful, local land use officials must ensure that variances to base zoning densities in growth areas can only be obtained by purchasing TDRs (Kayden, 1992). Otherwise, the demand, and consequently the price, for TDRs may be too low. High transaction costs may also inhibit the development of an active TDR program. These costs may result from time-consuming negotiations between buyers and sellers, disagreements over property values, and administrative costs. The local government may also incur monitoring costs when tracking transferred rights and ensuring controlled development.

Four examples of TDR programs will be briefly described. First, Montgomery County, Maryland, near Washington, D.C., implemented a TDR program designed to preserve agricultural and rural areas in 1980 (Carlin, 1992). County officials rezoned approximately 90,000 acres in agricultural areas from 1 dwelling per 5 acres to 1 dwelling per 25 acres. Approximately 18,000 TDRs were distributed to affected landowners at a rate of 1 TDR per 5 acres minus 1 TDR per existing dwelling. County officials also designated receiving areas where TDRs could be used to increase the base zoning density to a specified maximum. TDRs have been sold by agricultural landowners to developers; prices typically varied from $4,500 to $5,000 per TDR. To date, Montgomery County's TDR program has achieved its objective of preventing further conversion of farms to subdivisions.

Talbot County, Maryland, has two TDR programs. The first program was created in 1989 to protect both the shoreline of the Chesapeake Bay and certain interior lands. TDRs were distributed for inland preservation areas at a rate of 1 per 20 acres and they can be used, if erosion is controlled, to increase the base density within 1,000 feet of Chesapeake Bay from one dwelling per 20 acres to one dwelling per 5 acres. As of 1992, 3 TDRs had been sold for $40,000 to $50,000 each, a price which reflects the value of a shoreline lot.

The second TDR program was designed to control the total amount of development in a designated Rural Agricultural Conservation Zone. TDRs were distributed at a rate of 1 TDR per 10 acres, which was the base zoning density in the Conservation Zone. Although the maximum zoning density was then raised to one dwelling per 5 acres, TDRs are required to build any dwelling, thus limiting the overall development to 1 dwelling per 10 acres.

The New Jersey Pinelands Commission administers the largest TDR program in the United States (Tripp and Dudek, 1989). The Pinelands program was designed to channel development to designated growth areas and to preserve the Pinelands, a significant ecosystem of forest, wetlands, and endangered species habitats which covers approximately one million acres in southeastern New Jersey (Carlin, 1992). In 1981, authorities distributed TDRs, known as Pineland Development Credits (PDCs), to landowners in preservation and agricultural production areas in return for their agreement to limit development. PDC distribution was based on land type; for example, 2 PDCs were distributed per 39 acres of farmland in agricultural production and preservation areas while only 0.2 PDCs were distributed per 39 acres of wetlands in the preservation area. In growth areas, one PDC authorizes development up to 4 units above the base zoning density. By 1992, developers had purchased approximately 100 PDCs.

Even though developers have not purchased large numbers of TDRs via the four described programs, these programs have successfully protected environmentally sensitive areas from disruptive development. In all four examples, TDRs were clearly defined by local officials, and this probably contributed to the programs' success. However, trading activity in some programs may have been limited by the high transaction costs.

Water Markets

Water markets have been used in the western United States to reallocate water supplies, previously allocated on the basis of prior appropriation, among agricultural, municipal, and industrial users. In most cases, water rights have been transferred from irrigated agriculture to municipal or industrial uses. For example, the Sierra Pacific Power Company, a local area water utility, began purchasing irrigation rights in the Truckee River Basin, Nevada, in the mid-1940s, and cities and developers entered the market in the early 1980s as human populations in Sparks and Reno began to grow (Saliba, 1987). Water sales and rentals, primarily involving irrigators, have also occurred for decades in the Lower Sevier River Basin, Utah. Water markets may become even more important as the demand for limited water supplies increases in response to the demands of growing human communities and municipalities and of preserving instream uses; however, the development of active water markets has been hindered by the lack of well-defined and quantified water rights, institutional restrictions, and excessive transaction costs (Michelsen, 1994).

Typically, only the amount of water that has historically been used may be transferred while the remaining water that has been diverted must be returned to the basin to prevent damage to other users or third parties. However, this amount is usually only vaguely specified and varies with annual conditions. More definitive quantification requires significant investments in both technical and policy studies; for example, it was estimated in 1983 that merely obtaining the data necessary for an adjudication of ground water rights in California's San Joaquin Basin could cost more than $100 million (McCormick, 1994). Requirements to maintain instream flows to support recreation and wildlife, social and economic considerations, and reserved federal rights, which often predate other established rights but are not quantified, could also increase uncertainty when determining the quantity of water available for transfer. Transaction costs result from searching for trading partners, identifying legal and hydrologic characteristics of water rights, negotiating price and other financial arrangements of the transfer, and satisfying state laws and transfer approval procedures (Saliba, 1987). The many uncertainties and high transaction costs associated with water markets have tended to make many water users reluctant to participate.

The Colorado-Big Thompson (C-BT) project in northeastern Colorado, which was constructed to provide additional water to the South Platte River Basin, is one of the most active and well-established water markets in the western United States. The project became fully operational in 1957, and active trading between agricultural, municipal, and industrial users began in the early 1960s (Michelsen, 1994). Each year, Northern Colorado Water Conservancy District (NCWCD) authorities determine the maximum quantity of water available for the current year. Water rights are then divided into 310,000 equal allotments; each allotment represents a 1/310,000 share of the available supply. Between 1970 and 1993, 2,698 transfers were approved, representing approximately one third of the C-BT allotments over the period. Approximately 83 percent of the allotments transferred were sold by agricultural operations and purchased by municipalities, farmers, other landowners, and industry.

The C-BT Project has several unique features which have contributed to its success. First, each allotment represents an equal amount of the available supply, which means that potential buyers and sellers are certain of the amount of water that can be transferred. In addition, since all of the water provided by the C-BT Project is supplemental to the Basin, determination of consumptive use or the amount of return flow needed to protect other users and third parties is unnecessary. Second, instead of requiring unused flows to be returned to the basin, the C-BT Project allows unused water to be stored for use or sale in the next year. This provides incentives to conserve water and increases the flexibility and value of C-BT water rights. Finally, transaction costs are reduced by simplifying the administrative procedures for water transfers. Approving permanent transfers of C-BT water rights usually takes four to six weeks. By contrast, the State of Colorado water right adjudication process takes an average of 20 months. Seasonal water transfers simply require mailing a postcard to the NCWCD that identifies the allotment owner and the temporary user.

In summary, water markets appear to be significantly affected by uncertain definitions of water rights, complex administrative requirements, and high transaction costs. When these problems are reduced or eliminated, as they have been for the C-BT Project in Colorado, water markets successfully distribute previously allocated water supplies to more valued uses.

CONCLUSIONS

This chapter has summarized the theoretical advantages and disadvantages of marketable permit programs for air and water management programs and has included examples of their conceptual application in land use development and water supply allocation. Based on this review, the following five issues were identified that appear to be crucial in determining the success or failure of a marketable permit program: (1) availability of information regarding alternatives that can be used to minimize compliance costs, (2) initial permit (emission or discharge rights) distribution, (3) market size and composition, (4) clearly defined trading rules, and (5) transaction costs. Each issue, including its potential impact on effluent (discharge) trading programs, is discussed below.

First, in order to realize the cost savings promised by marketable permit programs, dischargers must have enough information about abatement alternatives to select the alternative, or combinations thereof, that will minimize their compliance costs. This information may be collected only for sources within the industry or municipality to evaluate the potential for internal trading. Evaluating possible external trades requires additional information since dischargers must also identify potential trading partners that discharge the pollutant of interest, that either have created or could create sufficient reduction credits, and that would be willing to sell (or lease) their reductions to another source. This information may be fairly easy to obtain for point sources of water pollution, including publicly owned treatment works. However, acquiring sufficient information to evaluate trades with nonpoint sources, such as agricultural and urban runoff, may be extremely difficult since nonpoint sources are typically small, numerous, and unregulated. In addition, the effectiveness of alternatives to control nonpoint source pollution, termed best management practices, varies greatly depending upon local conditions. However, in some geographical areas, information may be available from local agencies, such as soil and water conservation districts, that are responsible for implementing voluntary programs to control nonpoint pollution.

Second, marketable permit programs are affected by the initial permit distribution, which determines the amount that a source can discharge, thus influencing all its subsequent compliance decisions. If active trading markets are not expected to develop, the initial permit distribution is particularly important since inequitable allocations cannot be corrected through trading. Limited activity may be a problem for effluent trading programs, whose participants, by definition, are limited to compatible trading partners within a single watershed. Like permits for marketable programs in other media, effluent trading permits can be distributed based on existing laws and regulations and/or through several types of auctions. In general, distribution based on existing requirements is preferred since it does not increase industries' compliance costs, thus reducing political opposition.

The third issue affecting the success of marketable permit programs is market size and composition. If the number of potential trading partners is too small, cost savings will be reduced and strategic behavior, such as hoarding credits to prohibit the expansion of existing competitors or the entrance of new sources into the market, may occur. Alternatively, if the number of potential trading partners is too large, the costs of identifying a suitable partner may eliminate the economic advantages of trading. In general, the number of participants in an effluent trading program is expected to be fairly small. Fortunately, however, the program's success within a particular watershed may depend more heavily upon market composition. For example, a single point source facing restrictive nitrogen or phosphorus effluent limitations could reduce its compliance costs through nutrient trading with several small nonpoint sources. The costs of individual negotiations with managers of numerous nonpoint sources may be prohibitive; however, these costs can be reduced by identifying a local spokesperson or government agency to act as an intermediary.

Fourth, clearly defined trading rules reduce the uncertainties associated with marketable permit programs. Such rules can also encourage dischargers to trade, simplify program administration, and standardize and streamline applications for regulatory approval of trades. At a minimum, an effluent trading program should include rules governing geographical and temporal boundaries of the watershed, eligible market participants, initial permit distribution, administrative and technical procedures for approving proposed trades, monitoring, reporting and recordkeeping requirements, and enforcement procedures. Such rules would be particularly important when evaluating trades involving highly variable pollutant reductions from nonpoint sources.

Finally, excessive transaction costs, which include identifying potential trading partners, negotiating trades, and applying for regulatory approval, may reduce or eliminate the economic advantage of discharge trading, thus eliminating any incentive to participate in a trading program. All trading programs for water quality management should be designed to minimize these costs. For example, specific requirements for applications requesting regulatory approval of trades can reduce the costs of compiling such applications, while brokers or regulatory agencies can decrease transaction costs by matching potential trading partners and supervising negotiations.

The practical significance of these issues will be identified in Chapters 3 and 4 by reviewing specific applications of marketable permit programs in air and water quality management, respectively.

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CHAPTER 3

MARKETABLE PERMIT PROGRAMS AND AIR QUALITY MANAGEMENT

Marketable permits have been used in air quality management programs, primarily in the United States, in an effort to decrease emission sources' environmental compliance costs and to promote technological innovation. In general, the theoretical promise of these programs has not been realized in practice due to political, economic, and technological factors that have influenced program design and implementation (Hahn and Hester, 1989a). The impact of these factors must be clearly understood since they will likely affect liquid effluent trading programs in similar ways. This chapter briefly describes (1) emissions trading in the United States, (2) emissions trading in Germany, (3) lead trading in the United States, (4) allowance trading in the United States, (5) proposed transboundary emissions trading programs, and (6) a proposed program for international carbon dioxide trading. This chapter also summarizes the environmental and economic impacts of each trading program as well as factors that have positively or negatively affected program performance. The chapter concludes by highlighting factors that should be considered when designing and implementing effluent trading programs.

EMISSIONS TRADING IN THE UNITED STATES

The U.S. Environmental Protection Agency's (USEPA) Emissions Trading Policy Statement, effective December 4, 1986, defines emissions trading as consisting of:

> ...bubbles, netting, emission offsets, and emission reduction banking. These steps involve creation of surplus emission reductions at certain stacks, vents or similar sources of emissions and use of these emissions reductions to meet or redefine pollution control requirements applicable to other emission sources. Such emissions trades can provide more flexibility to meet environmental requirements, and may therefore be used to reduce control costs and encourage faster compliance (U.S. Environmental Protection Agency, 1986).

Bubbles, netting, emission offsets, and emission reduction banking are discussed below and briefly summarized in Table 3.1. Internal transactions involve sources within the same industrial company; external transactions involve different industries. Surplus emission reductions, termed emission reduction credits (ERCs), are usually expressed in terms of quantity of pollutant reduced per unit time. ERCs are created by reducing pollutant emissions below permitted levels, by retiring equipment, or by closing facilities. In order to be certified as an ERC, the achieved reductions must be surplus, enforceable, permanent, and quantifiable.

Bubbles

Under USEPA's "bubble program," which was promulgated in 1979, industrial plants do not have to meet emission standards for every individual source at a facility. Instead, facilities can increase emissions from sources with potentially high compliance costs and decrease emissions from sources with lower compliance costs as long as the total emissions do not exceed permitted levels. In some cases, reductions below permitted levels may be required in order to improve ambient air quality. Bubbles can involve internal or external trades at one or more facilities, but all of the participating sources must be within the same airshed. As of 1989, all but two of the 129 bubbles approved by USEPA or state regulatory agencies involved internal trading (Hahn and Hester, 1989b). States have approved more than twice as many bubbles as USEPA, primarily

Table 3.1: Summary of Emissions Trading Activity (Hahn and Hester, 1989b)

Activity	Estimated Number of Internal Transactions	Estimated Number of External Transactions	Estimated Cost Savings (Millions)	Environmental Quality Impact
Netting	5,000 to 12,000	None	\$25 to \$300 in permitting costs; \$500 to \$12,000 in emission control costs	Insignificant in individual cases; probably insignificant in aggregate
Offsets	1,800	200	Probably large but not easily measured	Probably insignificant
Bubbles				
Federally Approved	40	2	\$300	Insignificant
State Approved	89	0	\$135	Insignificant
Banking	<100	<20	Small	Insignificant

because their application processes are simpler, quicker, and less expensive.

Bubbling can substantially reduce environmental compliance costs. For example, a study of 548 emission sources at 52 industrial plants operated by DuPont Chemical estimated that the annual cost to reduce pollution by 85 percent under command-and-control regulations was $105.7 million; bubbles could achieve equivalent pollution reductions at an annual cost of $42.6 million (Griffin, 1992). Alternatively, bubbles could be used to reduce pollution by 99 percent for an annual cost of $92.4 million. In 1985, USEPA estimated that potential cost savings from all bubbles in the United States, including state-approved bubbles and those under review or development, exceeded $800 million (Hahn and Hester, 1989b). Since bubbles do not allow emission increases above permitted levels, their impact on environmental quality is neutral. In cases where reductions below standards are required, air quality may actually improve.

Frequent policy changes in bubble programs have made industries reluctant to participate and regulators uncertain of applicable requirements. In addition, since every bubble is unique, uniformity in monitoring, recordkeeping, and enforcement is extremely difficult. Although used only minimally, cost savings for external bubbles are limited by the amount of information available to potential trading partners, by restrictive trading rules, and by anti-degradation requirements (Atkinson and Tietenberg, 1991).

Netting

Netting, which was implemented in 1974, has been the most frequently used as well as the most controversial component of USEPA's emissions trading policy (Hahn and Hester, 1989b; Dudek and Palmisano, 1988). Netting allows firms to increase emissions from modified sources if they decrease emissions from other internal sources so that the net increase does not meet or exceed significance levels defined by regulation (Hahn and Hester, 1989b). Critics of netting argue that this policy allows industries to install new sources of emissions without proper abatement equipment and to increase their total emissions.

Industries using netting can reduce costs in three ways. First, they avoid the stricter emissions standards associated with major sources and the resulting higher compliance costs. Firms also avoid complicated air quality permitting procedures as well as construction delays due to completion of the permitting process. Reasonable average compliance cost savings were estimated to be $100,000 to $1 million per source, while average air quality permitting cost savings ranged from $5,000 to $25,000 per source (Hahn and Hester, 1989b). However, netting has not had a significant impact on environmental quality. Since netting, by definition, involves only internal trades, it does not promote active ERC markets and may even encourage industries to save ERCs for their own use.

<u>Emission Offsets</u>

USEPA's offset program was initiated in 1976 to facilitate economic growth that would have been prohibited in geographical areas that did not meet ambient air quality standards (Carlin, 1992). Under this program, industries may construct major new stationary emission sources in nonattainment areas if they offset their new emissions with greater decreases in the same type of emissions from other sources in the same airshed (Hahn and Hester, 1989b). Trading ratios specify the number of ERCs that must be acquired for a new source to increase its emissions by one unit. For example, a new refinery expected to generate 10,000 tons per year of volatile organic compounds (VOCs) would have to obtain more than 10,000 tons per year of VOC reductions within the same nonattainment area before regulators could issue its construction permit. Approximately 2,000 offset transactions, mostly internal, occurred between 1977 and 1986 (Hahn and Hester, 1989b).

The major economic advantage of emission offsets, i.e., allowing new sources to locate in nonattainment areas, cannot be easily quantified. In general, emission offsets should slightly improve environmental quality, particularly in areas where trading ratios exceed 1:1. In some cases, however, ERCs for emission offsets have been calculated using allowable instead of actual emissions. If actual emissions are already less than allowable emissions, these "paper" offsets may not lead to an improvement in air quality.

<u>Emissions Reduction Banking</u>

Emissions reduction banking, established in 1979, allows industries to store ERCs for subsequent use in offset or netting programs or for sale to other industries (Hahn and Hester, 1989b). Banking programs must be established by state regulators with USEPA approval and must delineate the rules for creating, certifying, storing, and using banked ERCs (Dudek and Palmisano, 1988). However, banking programs are fairly limited in number; for example, by 1986, USEPA had only approved emission reduction banks for five state and local agencies (Hahn and Hester, 1989b). Since only a few ERCs have been deposited into banks, banking has had only minimal effects on ambient air quality.

The most active banking program in the United States is located in Louisville, Kentucky. Over 26,000 tons per year of ERCs have been deposited by 18 different industries, and the bank has provided credits for two USEPA-approved bubbles and 28 emission offsets. Reasons for the bank's success include few restrictions on the use of banked ERCs, clear and detailed trading rules, and maintenance of a public ledger that can be used to identify potential trading partners. Banking programs in other locations are often hindered by limitations on the use of banked ERCs and uncertainty regarding their future value.

In theory, certifying and banking ERCs should reduce uncertainties about an industry's ability to use ERCs in emissions trades. Banking programs, similar to the one in Louisville, that maintain public records can even help potential trading partners identify each other. In practice, however, some banking programs include provisions to discount or confiscate banked ERCs or to limit the amount of time that banked credits can be used. Industries tend to have minimal incentives to bank ERCs when they may expire before they can be used or sold, particularly if the costs of certifying ERCs are high.

Informal banks, where regulators allow industries to store emission reductions that are not included in the source's operating permit, also exist. Informally banked credits cannot be used in external transactions unless they are converted, through the certification process, to formal ERCs. Like emission reduction banking programs, informal banks can reduce compliance and air quality permitting costs by allowing participating industries to store emission reductions for future use. Industries may be more likely to use informal banks since the included emission reductions are not usually subject to discounting or confiscation. However, because these credits cannot be traded externally, informal banking may impede the development of an active trading market.

Emissions Trading in Los Angeles

The Los Angeles basin, an extreme nonattainment area for ozone, has had the most active emissions offset market under USEPA's emissions trading program (Foster and Hahn, 1995). Tables 3.2 and 3.3 provide an overview of offset activity in the Los Angeles basin, by number and volume of transactions, respectively, from 1985 to 1992. Two special funds, which were used much more frequently than

Table 3.2: Offset Activity in the Los Angeles Basin by Number of Transactions (Foster and Hahn, 1995)

Year	Trades	Community Bank	Priority Reserve	Total
1985	7	...	...	7
1986	27	...	...	27
1987	24	...	...	24
1988	55	...	...	55
1989	30	...	...	30
1990	27	26	...	53
1991	31	2,113	64	2,208
1992	14	3,557	107	3,678
Total	215	5,696	171	6,082

Table 3.3: Offset Activity in the Los Angeles Basin by Volume of Transactions Expressed in Tons Per Year (Foster and Hahn, 1995)

Year	Trades	Community Bank	Priority Reserve	Total
1985	839	...	...	839
1986	946	...	...	946
1987	2,621	...	...	2,621
1988	2,769	...	...	2,769
1989	1,292	...	...	1,292
1990	701	16	...	717
1991	1,218	1,171	43	2,432
1992	441	1,886	55	2,832
Total	10,827	3,073	98	13,998

the offsets program, were established in 1991. The Community Bank supplies ERCs to sources that produce less than two tons of pollutant per year, and the Priority Reserve provides ERCs for essential public services. These special funds may decrease overall trading activity by exempting some sources from participation in the market.

The most frequently traded pollutants were nitrogen oxides (NO_x) and reactive organic gases (ROGs). This was expected since these pollutants are precursors of ozone formation in the troposphere. Over 200 offsets, involving more than 100 industries and 10,000 tons of pollutant per year, occurred from 1985 to 1992 (Foster and Hahn, 1995). In addition, there were 62 trades of banked ERCs, involving approximately 4,100 tons of pollutant per year, during the same time period. ERC prices ranged from less than $100 to over $700 per ton per year for ROGs, with a similar range for NO_x. Minimum prices remained relatively constant, probably reflecting basic transaction costs that did not vary with the size or type of trade. The South Coast Air Quality Management District (SCAQMD), the regulatory agency responsible for managing the offset program, estimated that total ERC expenditures for the period from 1985 to 1992 were approximately $2 billion.

Several factors have particularly encouraged the use of emissions offsets in the Los Angeles area. First, the general area's rapid economic growth has resulted in a significant demand for emissions offsets. Second, the level at which new sources are classified as major is much lower in the Los Angeles basin than in the rest of the United States, so more sources are required to obtain offsets before air quality permits can be approved. Finally, standards for existing sources are also more stringent, so more industries must use offsets instead of netting.

Despite the statistics as shown in Tables 3.2 and 3.3, offset trading activities in the Los Angeles basin are still relatively limited due to regulatory uncertainties and high transaction costs. First, uncertainty regarding regulatory approval of proposed trades and/or excessive transaction costs may make industries reluctant to enter the trading market. For example, approximately 50 percent of all proposed trades in the Los Angeles basin did not survive the negotiation process; only about 20 percent of the remaining proposals were approved, without changes, by the SCAQMD. The remaining proposals were either completely rejected, or the quantity of ERCs to be traded was reduced due to difficulties in certifying ERCs and in determining how pollutant reductions should be measured. This uncertainty is not conducive for industries to expend the time and effort needed to locate trading partners and negotiate trades, particularly when transaction costs are high. In this regard, the overall transaction costs for both trading partners may be as high as $25,000. When high transaction costs are added to the cost of purchasing ERCs, the economic advantages of emissions trading over command-and-control regulation may simply disappear.

Second, changes to the regulatory program have also affected banking and the offset trading program in Los Angeles. For example, banking increased after the contemporaneous requirement, which stated that shutdown ERCs could only be sold to firms who filed an application to trade within 90 days of shutdown and devalued banked shutdown ERCs by 80 percent, was abolished in 1990. Also in 1990, the emissions trading area was divided into 38 different zones, with rules governing the trading of ERCs between zones. After this change, ERC price ranges increased dramatically, probably because the equilibrium price in each of the 38 zones was slightly different and because one market was divided into many smaller ones. However, frequent regulatory changes may also make industries reluctant to rely on emissions offset programs since they cannot predict future requirements.

In 1994, the SCAQMD implemented the Regional Clean Air Incentives Market (RECLAIM), a trading program to reduce NO_x and sulfur oxides (SO_x) emissions from the approximately 400 stationary sources in the Los Angeles basin that emit more than four tons per year of NO_x or SO_x (Guerrero, 1997). RECLAIM was designed to reduce NO_x emissions by 75 percent and SO_x emissions by 60 percent by 2003 (Lents and Leyden, 1996). SCAQMD officials estimated that RECLAIM would save regulated sources $57.9 million annually over command-and-control regulations; the petroleum processing and utility industries should realize almost 90 percent of the cost savings (Guerrero, 1997; Hall and Walton, 1996). Although SCAQMD officials wanted to include VOCs in RECLAIM, it was not possible because reliable emissions inventories were lacking, appropriate monitoring techniques were unavailable, and stakeholders disagreed on the baseline level of VOC emissions (Guerrero, 1997).

Within the RECLAIM program, each facility's emission limit was based on the highest year of reported emissions between 1989 and 1991 and reduced as required by rules adopted through 1993 (Lents and Leyden, 1996). Therefore, total allowable emissions exceeded actual emissions when the RECLAIM program began. Annual reductions were based on the characteristics of each facility's equipment; average reduction rate requirements were 8.3 percent and 6.8 percent for NO_x and SO_x, respectively. Installation costs for monitoring equipment for the affected facilities were estimated to be $13 million.

When designing the RECLAIM program, SCAQMD officials directly addressed several of the issues that may influence the performance of emissions trading programs. First, a computer bulletin board was used to identify potential trading partners, thus possibly reducing transaction costs. Second, there is no incentive to hoard ERCs since credits expire after one year. RECLAIM trading rules also attempted to balance environmental protection and administrative complexity when considering the potential for toxic hot spots. For example, changes in the pollutants' environmental distribution resulting from trades are mapped, compared to the original distribution of SO_x and NO_x allocations, and assessed annually using a regional photochemical air quality model. If potential hot spots develop, trading will become restricted in those areas. Additionally, RECLAIM rules specifically allow SCAQMD officials to discontinue RECLAIM and confiscate ERCs if the basin cannot demonstrate required progress to attainment.

Although in-depth analyses of RECLAIM's performance are not yet available, trading activity appears to be increasing rapidly, and approximately $33 million in ERCs had been traded as of April, 1997 (Guerrero, 1997). District officials believe that the recent increase in trading indicates that surplus ERCs due to the initial allocation of credits are beginning to disappear.

Potential Concerns in Emissions Trading Programs

Industrial plant owners and operators typically want reduced compliance costs and increased certainty in environmental regulation. Environmentalists and environmental advocacy groups favor protecting or improving ambient environmental quality, even if some of the economic advantages of emissions trading must be foregone. Many of the administrative requirements governing USEPA's 1986 emissions trading policy can be traced to regulators' attempts to minimize conflict between industries and environmental groups; the resulting policy is "a careful compromise which honors the required environmental integrity of each emission trade" (Dudek and Palmisano, 1988).

This section now summarizes some of the issues that may have influenced the use of the emissions trading programs discussed above. In general, requirements that restrict potential trading activity or increase transaction costs will negatively affect emissions trading programs.

Probably due to political pressure from industry, USEPA's emissions trading policy favors existing sources over new ones. For example, under the Clean Air Act, new sources have more stringent emissions limitations than existing sources but cannot use emissions trading to meet the stricter requirements (Hahn and Hester, 1989a). Modified sources can use netting to avoid the more stringent emission limits that would apply to a new major source, but modified sources cannot use external trades which have a greater potential to reduce environmental compliance costs. Trading ratios in offset programs also discriminate against new sources because they are always greater than 1:1; under netting, modified sources can increase their overall emissions, so trading ratios are typically less than 1:1.

Most recorded trades have been between two sources within the same industrial facility, even though external trades are theorized to yield greater cost savings. Researchers have attributed industry's reluctance to participate in external trades to the high transaction costs associated with identifying trading partners, quantifying the amount of ERCs available for trade, ensuring that promised reductions are actually made, and submitting potential trades for regulatory approval (Hahn and Hester, 1989b). Pre-trade environmental modeling and monitoring requirements may also increase transaction costs. In contrast, the use of emission reduction banks, which contain certified ERCs, could reduce some of the uncertainty and costs associated with external trades, particularly if clear rules were available regarding the certification and use of banked ERCs. High transaction costs have been identified as the single most important determinant of overall trading program performance (Hahn and Hester, 1989a).

In theory, the ERCs that an industry can trade are calculated by comparing the industry's actual emissions to the applicable baseline quantity of emissions (Hahn and Hester, 1989b). In practice, however, the baseline may not be clearly and simply defined, and even if it is, emissions data may be unavailable. Under these circumstances, it is difficult, if not impossible, for industries, as well as regulators, to quantify ERCs. The selection of a baseline may also be controversial. For example, if regulators choose allowable emissions as the baseline and an industry's allowable emissions significantly exceed its actual emissions, the industry would receive ERCs without actually reducing its emissions. In effect, the industry would receive "paper credits" (Dudek and Palmisano, 1988).

Another controversial component of emissions trading is the use of ERCs that are created when industries shut down specific sources or facilities. Environmentalists argue that "shutdown" credits should be permanently retired, resulting in improved ambient environmental quality. Industrial managers, however, argue that such credits represent legitimate reductions in emissions below permitted levels and are therefore equivalent to ERCs created by installing more effective pollution control equipment. Restrictive requirements on the use of shutdown credits, such as the contemporaneous requirement in Los Angeles' offset trading program, may discourage trading and banking activities.

Key Elements of an Emissions Trading Program

In 1993, existing and proposed emissions trading programs in the United States were surveyed to determine the effectiveness of USEPA's final emissions trading policy as well as the current status of emissions trading programs (Shah, 1993). Twenty agencies with emissions trading or banking programs were identified by contacting USEPA's regional offices; seventeen agencies responded to a comprehensive evaluation questionnaire. Based on the results of the questionnaire and the literature review, the following elements have been identified as key to a successful emissions trading program (Canter, 1998):

(1) clear delineation of the geographical boundaries of the trading area;

(2) a systematic determination of the total annual quantity of pollutant emissions allowed within the geographical boundary;

(3) an equitable distribution of the total annual quantity of emissions to all sources of that pollutant within the geographical boundary;

(4) monitoring and reporting requirements for pollutant sources;

(5) recordkeeping requirements for pollutant sources; and

(6) specific rules regarding tradeable pollutants, determining the baseline against which pollutant reductions are measured, procedures for quantifying and certifying ERCs, types of trades, trading ratios, use of ambient air quality modeling to demonstrate ambient equivalence, use of shutdown ERCs, and adjustment of banked ERCs in response to changes in regulatory requirements or ambient air quality.

Clear rules and policies regarding these requirements, which summarize the basic elements needed to design and implement emissions trading programs, can simplify program administration and encourage trading activity by reducing the uncertainty for participating firms.

EMISSIONS TRADING IN GERMANY

Although excess emission reductions cannot be traded or banked in Germany, the country's Plant Renewal Clause and compensation settlements resemble the USEPA's offset policy (Opschoor and Vos, 1989). Under the Plant Renewal Clause, licenses for new sources in nonattainment areas are issued only when new sources replace old sources of the same type and emissions are significantly reduced. Reductions in emissions may be obtained from sources owned by the same industry or from sources in the same area that are owned by different industries. Renovation of old industrial plants may also result in emissions reductions that can be used to offset emissions from new sources. Although the Plant Renewal Clause was designed to improve environmental quality while allowing economic growth, it has not been widely used because there are only a few nonattainment areas in Germany. Like other economic instruments, the policy encourages technological innovation since industrial plants can increase production if their total atmospheric emissions are reduced by more efficient emission control equipment.

Compensation settlements allow authorities to vary licensing procedures for industrial plant renewals when emission reductions within the subject plant or reductions in other plants in the same area exceed those required by the licensing procedures. Reductions can be credited for the same pollutant or for pollutants which have similar environmental effects. Compensation settlements are only approved if they do not interfere with environmental protection. Such settlements have been limited because the sources must be close together and different partners are required for each different pollutant.

LEAD TRADING IN THE UNITED STATES

The USEPA introduced lead trading in 1982 as part of a 6-year regulatory program to reduce the amount of lead added to gasoline (Hahn and Hester, 1989a). The program, which was developed primarily to help small refineries meet more stringent lead emission standards, allowed refiners to trade "rights" to add specified quantities of lead to gasoline. Rights were distributed to firms based on the amount of leaded gasoline produced and the current lead standard. If a refiner added less lead than was allowed to a gallon of gasoline, then that refiner could sell excess rights to other refiners, who could then add more lead to a gallon of gasoline than they were allowed. Transactions were reported to USEPA at the end of each calendar quarter. Before 1985, lead rights had to be used or sold during the same quarter in which they were created. Throughout 1985, however, refiners could bank such rights for future use or sale. The lead trading program actually expired in December, 1986, although the usage of banked rights was continued through 1987.

In general, small refiners tended to purchase "lead rights" from large refiners, and large refiners tended to sell or bank their lead rights. Some small refineries were also able to reduce lead levels in their gasoline and sell or bank the resultant rights. In the first and second quarters of 1985, both small and large refiners banked lead rights in anticipation of a stricter lead standard that was implemented during the third quarter of 1985. Small refineries were able to meet the new limit by withdrawing banked rights and by purchasing rights from large refiners. Beginning in 1986, when lead limits were lowered even further, both large and small refiners withdrew banked rights to delay compliance with the new standard. Throughout the life of the lead trading and banking program, the market in lead rights was extremely active; USEPA estimated that the lead banking program could have saved refiners as much as $226 million.

Several factors contributed to the success of the lead trading and banking program. First, there were only three restrictions on program activities. One restriction applied only to refiners in California, and another expired in 1983 when all refiners became subject to the same lead standard. Most significantly, unused rights expired at the end of each calendar quarter until the lead banking program was established in 1985. Although trading levels were high both before and after banking was introduced, indicating that this restriction did not negatively affect the trading program, lead rights did become more valuable once banking was possible. Unlike ERCs described earlier which could be discounted or confiscated, banked lead rights were equivalent to rights that were created and used in the same quarter.

Since the administrative requirements for lead trading and banking were minimal, and only one industrial category was involved, transactions costs were also low. Reporting was also minimal since refiners were already required to submit a quarterly report to USEPA on their total gasoline production and lead usage. Refiners that participated in the trading program simply included the identity of their trading partners and the volumes of rights traded in their quarterly reports. Refiners that used banking also included opening and closing "lead right" balances and transactions in banked rights.

The clarity of the regulations governing lead trading and banking contributed to the program's success. Well-established markets in feedstocks and products, which meant that personnel at different refineries were already accustomed to working together, facilitated the identification of trading partners. Additionally, the program was not controversial. All refiners were at least as well off with the trading and banking program as they would have been under traditional regulations, and environmentalists and environmental groups accepted the program because its environmental effects were neutral, the total amount of lead allowed in gasoline was significantly reduced, and the life of the program was limited.

ALLOWANCE TRADING IN THE UNITED STATES

Title IV of the Clean Air Act Amendments of 1990 was primarily designed to reduce annual emissions of sulfur dioxide (SO_2), the major precursor of acid rain in the United States, by 10 million tons below 1980 levels (U.S. Environmental Protection Agency, 1992). To achieve this reduction, the law tightened restrictions placed on emissions from fossil fuel-fired power plants. Phase I of Title IV, which began in 1995 and affected 110 of the nation's largest coal-burning electric utility plants, required a 50 percent reduction in SO_2

emissions from 1980 levels (Mostaghel, 1995). Phase II, which begins in 2000 and will affect all existing utility units with an output capacity greater than 25 megawatts and all new utility units, sets an annual nationwide emissions cap of 8.9 million tons of SO_2. The geographic distribution of the affected utilities included in Phases I and II is shown in Figure 3.1 (U.S. General Accounting Office, 1994).

Under the Title IV program, USEPA annually distributes allowances (the right to discharge one ton of SO_2 during or after a specified year) to utilities based on their historic fuel consumption multiplied by an emission rate of 2.5 pounds SO_2/mmBTU during Phase I and 1.2 pounds SO_2/mmBTU during Phase II. Affected utilities may meet their reduction requirements by installing scrubbers, by switching from high-sulfur to low-sulfur fuels, by reducing consumer demand for electricity, by purchasing allowances from other utilities, or by combinations of these options. USEPA also distributes allowances through special reserve funds, direct sales, and an annual auction conducted by the Chicago Board of Trade. At the end of the year, the quantity of allowances a utility holds must equal or exceed its SO_2 emissions for that year or the utility must pay a penalty of $2,000, indexed to inflation, per excess ton of emissions and offset the excess emissions with allowances in the following year.

Utilities' flexibility to select the best control alternative, or combinations thereof, for their particular circumstances should reduce the costs of complying with Title IV. Guerrero (1997) reported that cost savings have been large for individual utilities; for example, Illinois Power, Duke Power, and Wisconsin Electric Power Company estimated saving $91 million, $300 million, and $90 million, respectively, by purchasing allowances instead of installing scrubbers. As shown in Figure 3.2, trading activity between utilities

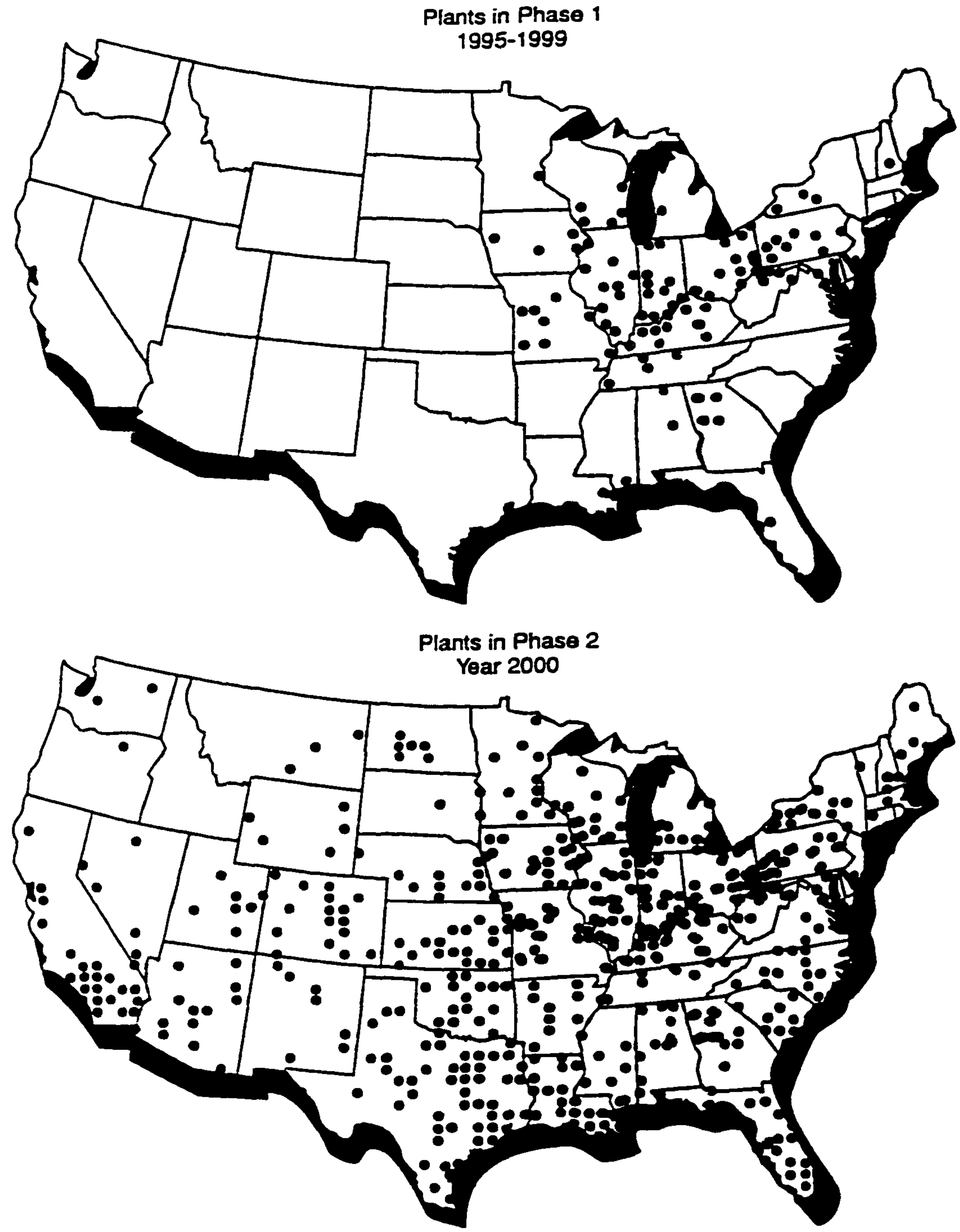

Figure 3.1: Geographic Distribution of Phase I and Phase II Affected Utilities (U.S. General Accounting Office, 1994)

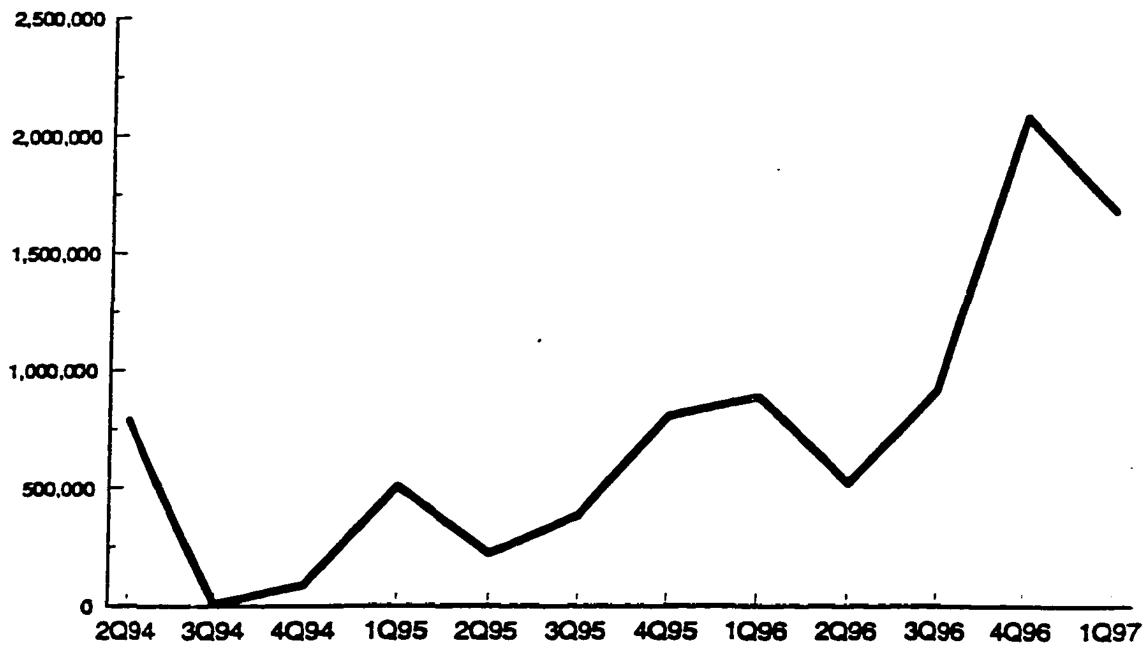

Figure 3.2: Number of Allowances (Tons of SO_2) Traded Quarterly (Guerrero, 1997)

or between utilities and brokers has increased approximately 400 percent from 1994 to 1997. Allowance prices at USEPA's annual auction have decreased from an average winning bid of $159 in 1994 to $68 in 1996. Prices for allowances that can be used six or seven years after the auction and prices for allowances sold through private trades are also decreasing.

Analysts attribute the low allowance prices to problems with the design of USEPA's auction and to reduced demand for allowances due to decreasing prices for compliance alternatives. Prices for low-sulfur coal have dropped dramatically due to productivity increases, increased competition for rail transport, and competition among mines (Burtraw, 1996). Scrubber prices have fallen almost 50 percent since 1990, and vendors have introduced innovations, like larger absorbers, new anticorrosive materials, and the use of chemical additives, that reduce operating and maintenance costs (U.S. General Accounting Office (GAO), 1994). The expense of an extra absorber module can also be eliminated since allowances can be used to cover SO_2 emitted during scrubber maintenance or unplanned outages (Burtraw, 1996). Allowance trading, especially between utilities, is expected to become more frequent during Phase II when SO_2 reductions from other inexpensive compliance options have been exhausted, and when the number of affected utility sources jumps from 110 to over 2200.

However, despite the low cost of allowances, only 3 percent of Phase I utilities initially chose to purchase allowances as their primary means of compliance (GAO, 1994). This reluctance to enter the allowance trading market was probably due to one or a combination of the following factors: (1) the division of the allowance program into two different phases, (2) the general regulatory structure governing utilities, (3) the design of USEPA's auction, (4) states' attempts to add restrictions to allowance trading to protect local environmental quality, and (5) miscellaneous factors, such as the way allowances are taxed by the Internal Revenue Service and the potential for negative publicity.

First, the small number of utilities in Phase I (110) limited trading opportunities; only about 14 percent of the affected power plants in the United States are included in Phase I, while Phase II involves over 2,000 additional units (GAO, 1994). In addition, most Phase I utilities, which can reduce SO_2 emissions relatively cheaply due to economies in scale and/or energy conservation programs, will become allowance sellers, not buyers. Trading opportunities are also limited because most Phase I utilities have decided to bank allowances for use during Phase II, when they can be used to meet reduced allowances, delay the installation of scrubbers, or sold for higher prices.

Second, many public utility commissions (PUCs) have not issued regulations governing allowance trading and the distribution of any resulting profits or losses between shareholders and ratepayers. This situation has exacerbated the uncertainties surrounding allowance trading. The Federal Energy Regulatory Commission, which regulates interstate transactions related to electricity, has also failed to issue comprehensive guidelines for allowance trading. Since utilities are unsure if they can recover the costs of purchasing allowances, they tend to favor other self-controlled compliance options, such as scrubbers or low-sulfur fuels, that have traditionally been approved by PUCs. In states where PUCs have issued guidelines on allowance trading, ratepayers usually receive the profits from trading while shareholders must pay for any losses. In addition, allowance costs are not recoverable until the year in which the allowance is used (Burtraw, 1996). Summarizing, regulatory uncertainty as well as utilities' reluctance to penalize shareholders have restricted allowance trading activity to date.

Analysts have also identified several problems with the structure of USEPA's annual allowance auctions. Auction participants must submit sealed bids containing the number of allowances they wish to purchase along with the price they are willing to pay for them (Fradette, et al., 1995). Allowances are then distributed by matching the lowest-priced offers to the highest-priced bids, which generates a range of winning prices (GAO, 1994). This matching process encourage sellers to lower their offers in order to receive higher bids, and buyers to bid lower since they know most allowances will be very inexpensive, particularly since the allowances offered by USEPA have no minimum price. At the first two auctions, held in 1993 and 1994, allowance prices were up to 33 percent below allowance prices reported for private trades. Therefore, buyers are reluctant to participate in private trades, and sellers are reluctant to participate in USEPA's auction because they do not receive adequate compensation for their allowances (Fradette, et al., 1995). In addition, the auction generates a range of winning prices instead of a single market price, making it difficult for utilities to consistently compare the price of allowances with the price of other control options and to select the most cost-effective alternatives (GAO, 1994).

Some states that are particularly concerned about the local effects of acid rain have attempted to pass laws restricting allowance trading (Mostaghel, 1995). For example, New York legislators introduced a bill that prohibited allowance sales to upwind utilities and required utilities to submit potential trades for state approval. Wisconsin legislators may require that proposed allowance sales or purchases be publicly announced, approved by the Wisconsin Public Service Commission, and reviewed for environmental impacts by the Wisconsin Department of Natural Resources. Additional local or state regulatory requirements may impede active allowance trading in three ways. First, if administrative requirements become too burdensome, the affected utilities may simply eliminate allowance trading as a compliance option. Second, utilities currently have an incentive to reduce SO_2 emissions below mandated levels since excess allowances can be sold or stored for future use. However, if trading is heavily restricted, these allowances will lose much of their value, and the utility will lose its incentive to over-control its SO_2 emissions. Third, state laws would probably make trading between in-state and out-of-state utilities much more difficult.

Two other factors may have affected the slow rate of development of the allowance trading market. First, the Internal Revenue Service's guidelines favor internal uses of allowances since allowances are not subject to taxation until they are sold by the utility that created them (GAO, 1994). At that point, almost one third of the allowance's value is taxed as capital gains. Finally, negative publicity accusing traders of "selling pollution" is making utilities extremely reluctant to enter the allowance trading market (Burtraw, 1996).

PROPOSED TRANSBOUNDARY EMISSIONS TRADING PROGRAMS

Marketable permit programs have also been proposed for use in regional or international air quality management (Naughton, 1994; Wilson, 1995; Menz, 1995). Benefits of expanding trading programs across regional or national borders include increasing the number of trading partners, decreasing environmental compliance costs, and decreasing the probability of self-serving strategic behavior. Less developed countries who participate in transboundary trading programs may also benefit from technology transfer. However, these programs are still vulnerable to problems, such as the development of toxic hot spots, that may affect local emissions trading programs. In addition, the rules governing transboundary trading programs must be consistent across jurisdictions.

Without consistent rules, each jurisdiction could conceivably create ERCs using different baselines, calculation methods, or monitoring techniques (Winslow, 1987). Therefore, ERCs created in one jurisdiction would not necessarily be equivalent to ERCs created in another and could not be traded until they were certified under the rules applicable to the purchaser. Requiring double certification would increase transaction costs and the time required for administrative review. In addition, different certification methods may create a bias toward jurisdictions with liberal policies. Likewise, similar sources from each jurisdiction should be included to maximize the number of potential trading partners, and approval procedures should be standardized to decrease transaction costs and encourage active trading (Naughton, 1994). Banking systems would also need to be coordinated to minimize the costs of transferring ERCs between jurisdictions.

PROPOSED PROGRAM FOR INTERNATIONAL CARBON DIOXIDE TRADING

Unless emissions of carbon dioxide (CO_2) and other greenhouse gases are controlled, the world could face significant climate changes, including increasing temperatures and shifting weather patterns (LeBlanc and Dudek, 1993). Under the terms of the Framework Convention on Climate Change, signed at the United Nations' Conference on Environment and Development in 1992, developed countries agreed to reduce emissions of CO_2 and other greenhouse gases not controlled by the 1987 Montreal Protocol to 1990 levels. The Intergovernmental Panel on Climate Change's Response Strategies Working Group has recommended using a marketable permits program to control greenhouse gas emissions since such a program "offers the advantages of flexibility, efficiency in pollution abatement, direct control of total emission levels, a mechanism for trading reductions in different gases, and incentives for research into pollution abatement technology" (United Nations Conference on Trade and Development (UNCTAD), 1995).

In the beginning of the program, UNCTAD (1995) recommends limiting the trading to CO_2 since the effects of CO_2 emissions on global warming are better understood and CO_2 emissions can be more accurately monitored and documented. Permits could be based on fossil fuel production, fossil fuel consumption, CO_2 emissions, or combinations thereof. Later, when the potential warming effects of other greenhouse gases are better understood and more accurate inventory and monitoring techniques are available, they can be incorporated into the trading system. Trading of different greenhouse gases could also be allowed if the relative contribution of the gas to global warming, compared to CO_2, along with any uncertainties were reflected in included trading ratios.

The first steps in designing and implementing an international trading system for greenhouse gases are to define total allowable emission levels and to distribute permits, which sum to the defined levels, among participating nations (Tietenberg, 1992). Permit allocation could be based on each nation's historical emissions, economic indicators, population, or some combination thereof (LeBlanc and Dudek, 1993). Individual nations must then reduce their CO_2 emissions or obtain permits (allowances) so that their actual CO_2 emissions do not exceed the number of allowances they possess. Emissions of CO_2 can be reduced by switching to fuels that contain less carbon, by developing alternative sources of fuel, or by increasing the efficiency of industrial processes, electricity generation, appliances, and automobiles. Permits (allowances) could be purchased from other nations who have reduced their CO_2 emissions below mandated levels. Allowances can also be obtained through the certified destruction of greenhouse gases or, since trees remove CO_2

from the atmosphere, through forestry management (Tietenberg, 1992; LeBlanc and Dudek, 1993).

One of the major advantages of a global CO_2 trading program is that it would allow developed countries to fund CO_2 reduction projects, including forest preservation or restoration, in developing nations. Developed nations would benefit through reduced compliance costs, while developing nations would benefit through improved environmental quality and technology transfer.

An international organization must be chosen to oversee the trading system and to act as a monitoring and enforcement authority. Emissions of CO_2 can be accurately estimated by the quantities of carbon-based fuels that are burnt, and most nations already have existing systems for monitoring the flow of fossil fuels (UNCTAD, 1995). Under the proposed system, individual nations will have to monitor their own greenhouse gas emissions and report them to the international agency. The international agency will verify each nation's report and issue an annual report containing compliance information for each nation, a summary of progress toward obtaining the overall goals of the trading program, and recommendations for future actions. These reports, which will be publicly available, are one way that the requirements of the trading program will be publicly scrutinized and enforced (Tietenberg, 1992). In addition, the international organization governing the trading program could prohibit trades involving any nation suspected of non-compliance (UNCTAD, 1995).

A global greenhouse gas trading program holds promise of significant environmental benefits and reduced compliance costs. However, establishing total emissions levels and allocating permits among different nations at different stages of development will be extremely controversial. In addition, an international agency may lack sufficient authority to enforce the program, particularly if the consequences of compliance are severe and the sovereignty of nations is challenged.

CONCLUSIONS

This chapter has summarized the use of marketable permit programs in air quality management. With the exception of the lead trading program, trading activity in existing programs has been fairly limited and/or the cost savings predicted by economic theory have failed to materialize. Based on this review, the following issues seem to be crucial in planning and implementing a successful marketable permit program: (1) minimizing transaction costs, (2) rules regarding the discounting or confiscation of banked ERCs and the use of shutdown credits, (3) a precise definition of the initial baseline from which emission reductions will be calculated, (4) maximizing the number of participants in the market, (5) consideration of unique regulatory requirements that may affect the trading program, and, (6) if permits (allowable emissions) are to be distributed at auction, auction design. Each factor and its relationship to effluent (discharge) trading programs in water are discussed in more detail below.

Once again, transaction costs are identified as a crucial factor in determining the success or failure of marketable permit programs. High transaction costs incurred while identifying potential trading partners, negotiating trades, and seeking regulatory approval of proposed trades can reduce or eliminate cost savings from trading. Trading programs in air quality management have reduced transaction costs by simplifying the administrative requirements for trade approval and by establishing ledgers or computer bulletin boards that can be used to identify potential trading partners. Similar cost-minimizing strategies could be included when designing and implementing effluent trading programs.

In order to encourage dischargers to bank ERCs for future use, rules prohibiting the discounting or confiscation of banked credits should be established. Without such rules, dischargers may have less flexibility in their use or sale of ERCs and, consequently, less incentive to create them. However, in order to protect local water quality, effluent trading banks may need to establish supplementary rules regarding the use of banked ERCs. For example, the use of banked ERCs when river flows are low and temperatures are high could be prohibited or pertinent dischargers may be required to obtain additional approvals. Clear rules regarding the use of shutdown credits that maximize the flexibility of dischargers while protecting water quality should also be established.

Third, the initial baseline that regulators will use to calculate allowable discharges and emissions reductions should be precisely defined so that sources can accurately determine the number of ERCs they have available to sell. This definition should also prevent the sole use of paper credits. In general, all point sources of water pollution in the United States must meet specific technology-based effluent limitations. In addition, point sources may trade with point sources or nonpoint sources to meet more stringent water-quality based effluent limitations in areas where ambient water quality standards are violated. Therefore, a source's water-quality based effluent limitation would serve as its baseline to determine excess reductions.

Theoretically, the number of potential trading partners should be as large as possible in order to maximize cost savings for individual partners; however, identifying suitable trading partners in extremely large markets may be cost-prohibitive. In reality, the size of the market in effluent trading programs is determined by the size of the watershed (or a portion thereof) and the number of sources in the watershed (or selected portion) that discharge the pollutant of interest. In some cases, the market can be expanded by including nonpoint sources that discharge the same pollutant.

Fifth, unique regulatory requirements may affect trading. The theory supporting marketable permit programs assumes that all dischargers will act to minimize their compliance costs. However, some industries, like electric utilities, that are regulated by government agencies may choose not to participate in trading programs, particularly when agency regulations do not allow marketable permit programs or the distribution of profits and losses from trading. Publicly owned treatment works may be subject to similar regulatory constraints and, unless USEPA or state regulatory agencies furnish guidance on effluent trading, may elect to install additional control equipment instead of purchasing reduction credits. The acceptable uses of profits generated by selling excess emission reductions may be equally unclear. Although programs to control nonpoint pollution are typically voluntary, governmental agencies that provide grants or subsidies to nonpoint polluters may reduce their incentive to participate in effluent trading programs.

Finally, as demonstrated by the allowance trading program, the type of auction selected to distribute allowable emissions may influence marketable permit programs. In general, auctions tend to be politically unacceptable because they are perceived to increase dischargers' compliance costs. Distributing emissions through auctions will probably be unnecessary for effluent trading programs, which encompass single watersheds and thus are much more limited in scope than the national allowance trading program. Effluent trading permits will most likely be distributed by USEPA or the state environmental agency and adjusted as necessary.

These issues, along with issues identified in other sections of the literature review (for example, in Chapters 2 and 4), will be used to develop a conceptual model for designing and implementing effluent trading programs (Chapter 5).

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CHAPTER 4

MARKETABLE PERMIT PROGRAMS AND WATER QUALITY MANAGEMENT

INTRODUCTION

Marketable permit programs for water quality management have been proposed as an alternative to traditional command-and-control regulations. Such programs, economists argue, should decrease environmental compliance costs and encourage the development and installation of more cost-effective pollution control technologies. After introducing relevant terms and concepts, this chapter summarizes the U.S. Environmental Protection Agency's (USEPA) current policy guidance for effluent trading programs (ETPs). Next, summaries are included on the concepts and issues, including case studies, for each of five types of ETPs. Factors that may affect the performance of each type of ETP are also identified and discussed. Finally, factors that should be considered when designing and implementing any ETP are highlighted. These factors, along with those identified from the theory of marketable permit programs (Chapter 2) and the use of marketable permit programs for air quality management (Chapter 3), will be used to develop a conceptual model for designing and implementing ETPs (described in Chapter 5).

FUNDAMENTALS OF WATER QUALITY MANAGEMENT

This section includes terminology that will be used in this chapter, as well as subsequent chapters, when addressing marketable permit programs for water pollution control. Also highlighted are the major laws and regulations governing water pollution control in the United States as well as pertinent effluent trading guidance issued by the USEPA.

Categories of Water Pollutants

Categorization of water pollutants is important in relation to policy decisions regarding intrapollutant and interpollutant trading. However, there is no single categorization of water pollutants. For example, three general categories of water pollutants have been defined by Hines (1988). First, conventional pollutants, such as sewage, oil, grease, and suspended sediment, are produced by residential, municipal, and industrial facilities. Since many of these pollutants are biodegradable if sufficient oxygen is available in the receiving waters, their water quality impact can be determined by measuring the amount of oxygen their degradation consumes -- their biochemical oxygen demand (BOD). Second, nonconventional pollutants include ammonia, sulfides, nitrogen, phosphorus, and some pesticides and herbicides. Many nonconventional pollutants remain in the water environment for long periods of time, thus endangering ambient water quality and possibly contributing to violations of water quality standards. Toxic pollutants are the third category; examples of such pollutants include acids, heavy metals, radioactive materials, polychlorinated biphenyls, and some pesticides and herbicides. Toxic pollutants can be of concern due to their persistence, accumulation characteristics, and toxic properties within the water environment.

Water pollutants may also be classified as conservative or nonconservative (Davis, 1983). Conservative pollutants do not degrade in the receiving environment and thus may accumulate in various "compartments" within a stream, river, lake, or estuary. Fairly simple water quality models involving water balances and dilution effects can be used for approximating concentrations of conservative pollutants. Since nonconservative pollutants do degrade in the environment, their environmental impact at a particular location, such as a monitoring station, depends upon the distance between the monitoring station and the point of discharge, and natural and man-altered hydrodynamic and aquatic ecological processes. More sophisticated water quality models may be required to predict the impacts of effluent trades involving nonconservative pollutants, particularly when, like ammonia, these pollutants may also exhibit toxic effects.

Water Pollution Control Laws and Regulations

The Clean Water Act (CWA), which is administered by the USEPA in conjunction with state environmental (water) agencies, is the major law governing water pollution control in the United States. The CWA requires the USEPA to issue technology-based effluent limitations for dischargers in major industrial categories. In addition, each state must adopt water quality standards, consisting of a designated use and numeric and/or narrative criteria designed to protect that use, for every body of water within its borders. Each state must also adopt an anti-degradation policy specifying that all existing uses of a water body must be maintained, even if they are not designated uses, unless justified by socioeconomic considerations. The CWA also regulates point sources that discharge their effluent directly into receiving waters, commercial and industrial sources that discharge their effluent to publicly owned treatment works (POTWs), and, to a much lesser extent, nonpoint sources of water pollutants.

The CWA defines a point source as "any discernable, confined, and discrete conveyance ... from which pollutants are or may be discharged" (Gallagher, 1997). Point sources include POTWs, industrial dischargers, active and inactive mining operations, aquaculture operations, and large stormwater outfalls (USEPA, 1996). Under the National Pollutant Discharge Elimination System (NPDES) permit program, all point source dischargers require a permit from USEPA or the authorized state agency (Gallagher, 1997). The NPDES permit specifies the technology-based effluent limitations that each point source must meet. The permit may also contain more stringent water quality-based effluent limitations if receiving waters violate state water quality standards. NPDES permits also require point source dischargers to periodically monitor their effluent and provide results to the permitting authority using standard discharge monitoring reports. Reissuing a permit with less stringent technology-based effluent limitations is generally prohibited by the USEPA's anti-backsliding policy. This policy also prevents reissuing permits with less stringent water quality-based effluent limitations unless the new limitations will ensure compliance with water quality standards or meet the requirements of the anti-degradation policy (USEPA, 1996).

Water quality-based effluent limitations for an individual point source may be calculated by considering dilution factors or mixing zones -- the portion of the receiving water where initial dilution of the effluent occurs (Gallagher, 1997). In addition, if state water quality standards are violated even after all dischargers to the watershed have met their technology-based effluent limitations, Section 303(d) of the CWA requires the appropriate state environmental agency to perform a total maximum daily load (TMDL) analysis for that water body (USEPA, 1996).

TMDLs are used to determine the maximum pollutant load that a water body can assimilate without violating water quality standards and to allocate that load among point sources, nonpoint sources, background sources, and safety margins (USEPA, 1991). Although specific methods vary by state, TMDLs are generally calculated by determining the pollutant loading that will meet applicable water quality standards during all flow conditions. Accordingly, the TMDL should be determined for both low flow conditions, when point source contributions may be more significant, and high flow conditions, when nonpoint source contributions are most significant; the more stringent limit should be chosen to consistently protect water quality. TMDL margins of safety are included to minimize the effects of uncertainties associated with pollutant loadings, ambient water quality conditions, and/or model analysis.

Industrial sources that discharge their effluent to POTWs are regulated by the CWA's pretreatment program. The program establishes effluent limitations for major industrial categories and prohibits the discharge of pollutants that could interfere with the POTW's operations. If necessary to comply with its NPDES permit, a POTW may establish local effluent limitations that are more stringent than federal standards or may regulate pollutants that are not included in federal standards; these local limits supersede federal standards. Each POTW develops local limits for its dischargers by calculating the maximum allowable industrial loading, which is the total daily mass of a pollutant that a POTW can accept from all permitted industrial sources, and adopting procedures to allocate that loading among its dischargers (USEPA, 1996). Conceptually, such procedures are analogous to allocations related to TMDLs.

Nonpoint sources transport pollutants to surface waters through erosion, runoff, and snowmelt; examples of such sources include agricultural and silvicultural operations, urban development, construction, large industrial areas, and land disposal of wastes (USEPA, 1996). The CWA does not directly regulate nonpoint sources of water pollution (Gallagher, 1997). Instead, Section 319 of the CWA requires states to identify watersheds that may violate applicable water quality standards unless nonpoint source loadings are decreased. States must also develop management programs describing measures to reduce pollutant loadings from nonpoint sources, and implement these measures in accordance with a specified schedule. The Coastal Zone Act Reauthorization Amendments require coastal states to develop similar plans to protect coastal areas

(USEPA, 1996). In addition, state and local ordinances may specify best management practices (BMPs) to control nonpoint pollution.

USEPA's EFFLUENT TRADING POLICY

In January, 1996, the USEPA issued a policy statement promising to "actively support and promote effluent trading within watersheds to achieve water quality objectives, including water quality standards, to the extent authorized by the Clean Water Act and implementing regulations" (USEPA, 1996). The policy identified economic, environmental, and social benefits of effluent trading, listed in Table 4.1, and proposed definitions for the following types of ETPs:

(1) Intra-plant trading which allows a single facility with more than one outfall to allocate pollutant discharges among outfalls in a cost-effective manner.

(2) Point-point source trading which allows one point source to purchase or lease effluent reduction credits from other point source(s) who have reduced their pollutant discharges below permitted levels.

(3) Pretreatment trading which allows facilities that discharge wastewater to POTWs to alter their pollutant load allocations to meet local effluent limitations more cost-effectively.

(4) Point-nonpoint source trading programs which allow point sources to reduce environmental compliance costs and meet water quality standards by funding reductions in nonpoint source loadings within the same watershed, with these reductions typically being less expensive than additional point source reductions.

(5) Nonpoint-nonpoint source trading programs which allow nonpoint sources to reduce pollutant loads at other nonpoint source sites.

PRINCIPLES FOR WATERSHED-BASED TRADING

The USEPA has identified eight principles that ETPs must strive for in order to remain in compliance with the CWA and other applicable laws and regulations. These principles and their implications for ETPs are summarized in Table 4.2 (USEPA, 1996). In addition, issues have been identified that could affect program performance for each of the ETP categories identified in its policy

Table 4.1: Potential Economic, Environmental, and Social Benefits of Effluent Trading (after USEPA, 1996)

Economic Benefits	
	Reduces treatment-related costs for individual sources contributing to water quality problems
	Allows dischargers to take advantage of economies of scale and treatment efficiencies that vary from source to source
	Reduces overall cost of addressing water quality problems in the watershed
Environmental Benefits	
	Achieves equal or greater reduction of pollutant discharges for the same or less cost
	Creates an economic incentive for dischargers to go beyond minimum pollution reduction and also encourages pollution prevention and the use of innovative technologies
	Reduces cumulative pollutant loading, improves water quality, accommodates human population growth and development, and prevents future environmental degradation
	Facilitates the achievement of broader environmental goals within a trading area, e.g., ecosystem protection, ecological restoration, improved wildlife habitat, endangered species protection, etc.
Social Benefits	
	Encourages dialogue among stakeholders and fosters concerted and holistic solutions for watersheds with multiple sources of water quality impairment

Table 4.2: Effluent Trading Principles (after USEPA, 1996)

Effluent Trading Principle	Implications for Effluent Trading Programs (ETPs)
(1) Trading participants must meet applicable CWA technology-based requirements.	Preserves minimum levels of water quality protection mandated by the CWA Promotes fairness by allowing only those sources which meet fundamental requirements to benefit from trading
(2) Trades are consistent with water quality standards throughout a watershed, as well as the anti-backsliding policy and other requirements of the CWA, other federal laws, state laws, and local ordinances.	Ensures a certain level of water quality prior to implementation of a trading program Promotes fairness by allowing only those sources which meet baseline requirements to benefit from trading
(3) Trades are developed within a TMDL process or other equivalent analytical and management framework.	Allocates pollution control responsibilities among covered dischargers using a process that can be easily utilized to document trades Data and analyses typically enable water quality managers to better understand and predict general effects of proposed trades
(4) Trades occur in the context of current regulatory and enforcement mechanisms.	Trading partners must work with federal, state, tribal, and/or local regulatory authorities on a case-by-case basis to ensure an appropriate level of accountability and enforceability
(5) Trading boundaries generally coincide with watershed or water body segment boundaries, and trading areas are of a manageable size.	Ensures that trading partners are affecting the same water body or stream/river segment, thus protecting against adverse local effects Boundaries may vary for different pollutants Boundaries may also be affected by the governing body or management structure of the trading program
(6) Trading will generally add to existing ambient monitoring.	Assessing the water quality impacts of trades may involve water quality analysis and modeling. The data needed depend on the sophistication of the analysis, the pollutant(s) involved, and the hydrodynamic and quality characteristics of the receiving water. In general, data on current water quality conditions, predicted effectiveness of pollution reduction options, and assessment of trading results are required.
(7) Careful consideration is given to the types of pollutants traded.	Analysis of trades, including the potential impacts of spatial or temporal variations in loadings, is necessary to avoid local violations in water quality standards USEPA does not currently envision a situation in which cross-pollutant (interpollutant) trading could work under current regulatory conditions and technical limitations
(8) Stakeholder involvement and public participation are key components of trading.	Educates stakeholder groups and the general public about the cost savings and environmental benefits of effluent trading Educates ETP managers about the concerns of the general public Builds new alliances among stakeholders and between stakeholders and the general public, thus fostering better management approaches and more effective environmental protection

statement. Accordingly, intra-plant, point-point source, pretreatment, point-nonpoint source, and nonpoint-nonpoint source ETPs are discussed in greater detail in the following sections.

INTRA-PLANT EFFLUENT TRADING

Iron and Steel Facilities

Iron and steel facilities are the only industrial category to date which has been allowed to use formal intra-plant ETPs to meet technology-based effluent limitations (Industrial Economics, Inc., 1994). Under the "steel bubble policy," a facility at a given location that reduces pollutant discharges below technology-based standards at one or more outfalls may increase discharges of the same pollutant above technology-based effluent standards at other local outfalls as long as the total discharge is less than that allowed by relevant standards. The following restrictions apply to any proposed trade (Kashmanian et al., 1995):

(1) Post-trading discharges cannot cause violations of any applicable water quality standard.

(2) Each outfall must be assigned specific, fixed effluent limitations for the traded pollutant(s).

(3) Pollutant(s) in process wastewaters from cokemaking and cold-forming cannot be traded.

(4) The net discharge of traded pollutant(s) must be less than the discharge allowed without the trade. In general, trades must reduce discharges of total suspended solids (TSS) and oil and grease (O&G) by 15 percent and all other pollutants by 10 percent.

(5) Applications for intra-plant trading can be accepted during permit issuance, during permit reissuance, or during the permit period if there was no opportunity to use intra-plant trading when the permit was issued.

(6) Trading must involve the same pollutant(s).

(7) Only existing facilities are allowed to trade to meet technology-based effluent limitations; new iron and steel facilities must install best demonstrated technology.

In a study designed to estimate the use and impact of intra-plant trading, it was determined that 235 iron and steel facilities in the United States were candidates for intra-plant effluent trading; however, by 1994 only 10 facilities either were using or had used such trading (Industrial Economics, Inc., 1994). Information provided by the 10 facilities and related federal and state regulatory personnel was used to evaluate the environmental consequences, economic benefits, and administrative requirements of iron and steel intra-plant trading. In addition, 8 facilities that did not choose to use intra-plant trading were contacted to identify factors that were disincentives to its use.

Table 4.3 lists the facilities engaged in intra-plant trading, the number of outfalls involved, the pollutant(s) traded, and the total reduced expenditures through 1993. Only four pollutants (TSS, O&G, lead, and zinc) have been traded, with net daily reductions at an individual facility ranging from less than one pound for lead and zinc to several thousand pounds for TSS and O&G. The 10 facilities participated in intra-plant trading because existing treatment or other circumstances had already reduced their discharges below required effluent quality levels, thus meaning that pollutant reductions were already available. Accordingly, trading did not encourage the installation of additional control technology. In fact, since dischargers were allowed to reallocate existing reductions to outfalls that would have otherwise required control, trading may actually have allowed pollutant discharges to increase.

Based on data from 7 of the 10 facilities, reduced capital and operation and maintenance expenditures through 1993 exceeded $122.6 million for the facilities which had used or were continuing intra-plant trading (Industrial Economics, Inc., 1994). The magnitude of the reported cost savings was influenced by the number of outfalls and the quantity of wastewater involved, the pollutant(s) traded, the duration of the trade, and the net reduction of traded pollutant(s) (Kashmanian et al., 1995).

Table 4.3: Summary of Intra-Plant Trading for the Iron and Steel Industry (after Industrial Economics, Inc., 1994)

Facility Name	Number of Outfalls Involved in Trade	Pollutant(s) Traded	Total Reduced Expenditures Through 1993 ($ x 10^6)
Armco Steel Middletown, OH	5	TSS[1], O&G[2], lead, zinc	6.3
Babcock and Wilcox[3] Beaver Falls, PA	2	TSS, O&G, lead, zinc	NA[4]
Bethlehem Steel Sparrows Point, MD	2	Zinc	4.8
Inland Steel East Chicago, IN	3	Lead, zinc	3.2
LTV Steel Indiana Harbor, IN	4	O&G, lead, zinc	NA
Republic Steel[3] Massillon, OH	2	TSS, O&G	14.2
Rouge Steel Dearborn, MI	2	TSS, lead, zinc	8.6
U.S. Steel[3] Clairton, PA	2	TSS	15.7
U.S. Steel Gary, IN	3	TSS, O&G	69.8
U.S. Steel[3] Homestead, PA	3	TSS, O&G	NA

[1] Total suspended solids

[2] Oil and grease

[3] Trade no longer in effect

[4] Information not available

The administrative effects of intra-plant trading were minimal. According to involved USEPA and state personnel, intra-plant trading lengthened the amount of time required to develop a permit by only one day, while administering and enforcing a permit incorporating trading did not differ from administering or enforcing standard permits since each outfall still had specific effluent quality limitations.

The 8 surveyed facilities which did not use intra-plant trading identified the following as deterrents to such trading: (1) state water quality requirements that were more stringent than federal effluent limitations; (2) facilities had only a single discharge or monitoring point; and/or (3) pollutant discharges at different outfalls were incompatible (Industrial Economics, Inc., 1994). In general, excluding new facilities and effluent from cold-forming and cokemaking may have also limited trading opportunities. Finally, water quality-based permitting, which also provides flexibility to many other pollutant dischargers, may make iron and steel intra-plant ETPs comparatively less important.

Informal Intra-Plant Effluent Trading

Informal intra-plant effluent trading may occur when NPDES permits include discharge limits for each pollutant that are based on the sum of applicable effluent limitations for all point sources at a facility that discharge that particular pollutant (Veil, 1997). This "building block" approach allows dischargers to minimize compliance costs by reallocating pollutant discharges among processes. Hundreds of NPDES permits, including permits for facilities in the iron and steel and aluminum smelting industries, may incorporate this informal trading approach.

Industries may actually prefer informal intra-plant ETPs since potential trades do not require regulatory approval, thus reducing transaction costs. In addition, industrial sources with centralized wastewater treatment plants, which are ineligible for formal intra-plant trading programs, and additional categories of dischargers may choose to participate in such programs.

Energy-Industry Opportunities for Intra-Plant Effluent Trading

Opportunities for intra-plant trading in the exploration/production and the distribution/marketing segments of the oil and gas industry are extremely limited (Veil, 1997). However, based on the number of petroleum refineries with multiple outfalls and the probability that the outfalls discharge similar pollutants, the USEPA has judged the feasibility of intra-plant trading for the refining segment of the oil and gas industry to be "small to medium." Existing effluent quality guidelines that specify single plant-wide limits for pollutants may promote informal intra-plant trading; such plant-wide limits allow refineries to allocate their total loading among outfalls in the most cost-effective manner.

The coal industry effluent quality limitations provide similar opportunities for informal trading by allowing waste streams from mining activities, preparation plants, and post-mining areas to be combined. Final effluent limitations are based on the most stringent set of limits applicable to the individual waste streams in the combined discharge. Each coal facility can then select the most cost-effective alternatives to meet its combined limit; for example, a source may be able to reduce its total compliance costs by installing highly effective abatement equipment to reduce pollutants from mining activities and preparation plants, thus eliminating the need to install controls in post-mining areas.

Conclusions

Intra-plant trading is a simple type of ETP since all dischargers are already subject to the provisions of NPDES permits. In addition, each outfall is still subject to limits on the quantity of pollutant(s) that can be discharged, so intra-plant ETPs do not complicate compliance monitoring and enforcement. Cost savings, as illustrated by the example of iron and steel intra-plant trading, may be substantial. However, the application of these programs is restricted by regulations prohibiting the use of effluent trading as a substitute for compliance with technology-based effluent quality limitations.

POINT-POINT SOURCE EFFLUENT TRADING

USEPA's Study on Point-Point Source Effluent Trading

In 1993, Industrial Economics, Incorporated reported on the use of point-point source ETPs to meet water quality-based effluent limitations. Potential economic benefits of these trading programs were identified by reviewing 12 case studies on point-point source ETPs or other least-cost approaches. The selected case studies, identified through literature review, were hypothetical and considered only potential *cost* savings while *ignoring* the complexities and potential costs associated with designing and implementing an actual ETP. Barriers to the implementation of such programs were also identified.

The included case studies, along with their projected annualized cost savings, are summarized in Table 4.4 (Industrial Economics, Inc., 1993). Although all studies resulted in possible cost savings, the magnitude of such savings varied depending upon the baseline allocation to which trading was compared and the number and characteristics of participating dischargers. In addition, transaction and administrative costs, including monitoring and reporting, were not deducted from the reported cost savings. Further, cost savings generally were projected to increase under the following conditions:

(1) when the cost-effectiveness of pollution abatement varied significantly among the types of dischargers in the defined trading region;

Table 4.4: Summary of Point-Point Effluent Trading Case Studies (Industrial Economics, Inc., 1993)

Waterbody and State(s)	Number of Dischargers	Length of Receiving Waterbody (miles)	Pollutants Traded	Annualized Cost Savings ($\$ \times 10^6$)
Fox River, WI	7	22	BOD[1]	6.8
Delaware River, PA, NJ, and DE	10-12	13-18	BOD	0.046 to 9.2
Lake Michigan, WI	53	NR[2]	Phosphorus	0.62
Holston River, TN	4	20	BOD	3.7 to 27.2
Houston Ship Channel, TX	51	NR[3]	BOD, TSS[4]	4.56
Neches River, TX	3	13	Lead	0.18 to 0.26
Lake Lena Run, FL	3	6	BOD	1.34 to 1.66
Rocky Fork, OH	3	20	Oil and grease	0.023 to 2.4
Monongahela River, PA	8	NR[2]	TSS	0.49
Mohawk River, NY	8	NR[2]	BOD	0.56 to 0.97
Willamette River, OR	5-11	184	BOD, phosphorus, nitrogen	0.34 to 1.4
Upper Hudson River, NY	NR[2]	NR[2]	BOD	0.040 to 0.45

[1] Biochemical oxygen demand

[2] Not reported

[3] Not reported in study, but is about 24 miles in length

[4] Total suspended solids

(2) when large quantities of effluent could be shifted from high-cost to low-cost treatment technologies;

(3) when some dischargers could avoid installing additional pollution abatement equipment due to trading opportunities; and

(4) as the baseline allocation of control responsibility to which trading was compared became less representative of the cost-effective distribution.

To estimate the potential for application of point-point source ETPs throughout the United States, a screening technique, based on the USEPA's Water Body System (WBS) database, was used to identify water bodies that may be candidates for such programs (Industrial Economics, Inc., 1993). The WBS contains state-reported water quality data, including information on the number of permittees and the sources and causes of nonattainment, for 41,760 defined water bodies. The first and second screening criteria were used to identify water bodies subject to water quality-based effluent limitations and that receive discharges from two or more point sources, respectively. The third criterion identified water bodies where point sources were major contributors to the violation of water quality standards.

Based upon these three criteria, a total of 418 water bodies were identified as potential candidates for the development and implementation of point-point source ETPs. However, this may be an underestimate of the potential for this type of trading due to incomplete reporting, the exclusion of several states from the WBS, and the existence of many unassessed water bodies. Alternatively, sole dependence on the WBS may lead to overestimates of point-point source trading opportunities since the database does not include information on the water quality compatibility of discharges, relative locations of dischargers (potential trading partners), variations in abatement costs among dischargers, and water body conditions that may restrict or prohibit trading opportunities.

Potential barriers to the implementation of point-point source ETPs were identified by soliciting written comments on a draft of the study report, by sending questionnaires to pertinent water agencies in Colorado, Michigan, North Carolina, New York, Pennsylvania, Texas, Virginia, Washington, and Wisconsin, and by interviewing regulatory personnel at USEPA headquarters, USEPA regional offices, and state agencies in North Carolina, Pennsylvania, and Wisconsin (Industrial Economics, Inc., 1993). States were selected based on the composite consideration of whether they had implemented trading programs or were interested in doing so, they considered economic factors when allocating wasteloads among dischargers, and/or they had several water bodies that were candidates for point-point trading. Four key barriers were identified as a result of these efforts: human and financial resource availability, water quality, legal or policy limitations, and administrative issues.

In general, states that have established trading programs report that trading increases agency workloads and administrative costs. For this reason, state environmental agencies with limited personnel and financial resources may find it difficult to implement any ETP. For example, TMDLs are necessary for establishing initial wasteload allocations and determining the water quality impacts of proposed trades. However, limited budgets may preclude the scientific development of TMDLs and the collection of water quality data needed for TMDL modeling. Personnel limitations may also delay the implementation of permitting and recordkeeping efforts that are necessary for effluent trading. Further, ETPs may be unpopular with regulators unless they are carefully designed to minimize increases in permitting workloads.

The effects of trading on water quality may also limit point-point source ETPs. Respondents to the "barriers study" were particularly concerned about the creation of "toxic hot spots" if toxic pollutants were included in trading programs. Methods to predict the water quality and aquatic ecosystem impacts of proposed trades, particularly of nonconservative pollutants like BOD, need to be improved. Further, trades that may affect the loadings of conservative pollutants must be carefully modeled and analyzed, both spatially and temporally (Industrial Economics, Inc., 1993).

Concern was also expressed that the CWA's anti-degradation and anti-backsliding provisions may prohibit or severely restrict effluent trading opportunities. However, these provisions should not inhibit point-point source effluent trading as long as ETPs are confined to water quality-limited water bodies. Other legal concerns included potential liability for trade violations and/or unexpected water quality impacts, the potential for increased litigation, and the effects of the CWA's "zero-discharge" goal, which may limit the long-term incentives for dischargers to participate in trading programs by continually decreasing the quantity of credits available for purchase or lease (Industrial Economics, Inc., 1993).

Administrative issues that could become barriers to ETPs include the selection (or creation) of a permitting authority, trading frequency, and the duration of trading agreements. Most respondents felt that an ETP should be administered by a single agency and preferred local over federal authority. Regulators argued that trading at five-year intervals, similar to current permitting practices, would simplify monitoring and enforcement while the regulated community preferred more flexibility depending on specific issues associated with individual trades.

Case Study to Control Selenium Discharges to the San Francisco Bay

Tietz (1994) proposed the use of a point-point source ETP for six oil refineries that discharge selenium into the San Francisco Bay estuary, where its accumulation is threatening aquatic and avian wildlife populations. Although the estuary also receives selenium loadings from POTWs and inflows from the Sacramento and San Joaquin Rivers, refineries contribute 66 and 74 percent of the total selenium loading during periods of average and low flow, respectively. Thus, any program to reduce selenium in San Francisco Bay should address the refineries' discharges. Separately, Young and Congdon (1994) proposed a nonpoint-nonpoint source ETP to control selenium discharges to the San Joaquin River; this ETP will be addressed in a subsequent section on nonpoint-nonpoint source effluent trading.

The San Francisco Bay estuary has been identified as a promising candidate for a point-point source ETP for several reasons (Tietz, 1994). First, since the environmental effects of selenium in the estuary are a function of total loading, not concentration per se, selenium trading should not result in any negative aquatic ecosystem impacts as long as total selenium loading to the Bay does not increase. In addition, since water concentrations of selenium are very low, the development of toxic hot spots is unlikely. Second, the six refineries discharge different quantities of selenium and have different marginal abatement costs, thus suggesting that point-point source trades could result in substantial cost savings. Finally, the expected costs of selenium control under traditional command-and-control regulations are very high; therefore, a more cost-effective program like effluent trading may be both economically and politically appealing.

However, three major barriers to point-point source selenium trading in the Bay estuary were also identified (Tietz, 1994). First, if regulators mandate large reductions in selenium discharges, the creation of additional selenium reductions for trading may be technologically impossible or economically infeasible. This lack of tradeable reductions, as well as the small number of market participants (six refineries), may substantially decrease potential cost savings. Second, trading opportunities may be limited by regulatory requirements that restrict flexibility and impose high transaction costs. Finally, selenium trading appears to lack the stakeholder support necessary for successful program implementation. For example, refineries are reluctant to support point-point trading because potential cost savings may be reduced by limited trading opportunities, while regulators are hesitant to adopt ETPs that may increase administrative burdens.

Energy-Industry Opportunities for Point-Point Source Effluent Trading

Point-point source effluent trading opportunities may exist in the energy industry, particularly for the petroleum refining segment of the oil and gas industry (Veil, 1997). Petroleum refineries, which frequently have water quality-based effluent limitations for nontoxic pollutants in their NPDES permits, may be able to negotiate trades with other nearby refineries that discharge effluent to the same watershed, with POTWs, and/or with other industrial sources with compatible effluents. In addition, since most refineries are located near fresh or estuarine waters, loadings can be readily calculated using TMDLs. The promulgation of more stringent water quality standards in such receiving waters may further encourage refineries to participate in point-point source ETPs.

Other trading opportunities exist for the electric power and coal industries (Veil, 1997). For example, coal production and/or processing facilities could be potential trading partners unless a facility is unwilling to trade with its competitors. Secondly, cooling water flows from the electric power industry that contain copper and/or other toxic metals could also be trading candidates if toxic pollutant trading is permitted by the USEPA.

Conclusions

In general, point-point source ETPs are relatively easy to implement since all trading partners are subject to NPDES permit limitations, monitoring requirements, and enforcement procedures. However, regulators must carefully evaluate proposed trades to ensure that trades will not cause or contribute to any negative aquatic ecosystem impact or local violation of water quality standards. However, the application of point-point source trading programs may be limited unless the subject watersheds (or trading zones within water bodies) have two or more point source dischargers with compatible effluents and water quality-based effluent limitations.

PRETREATMENT EFFLUENT TRADING

USEPA's Study on Pretreatment Effluent Trading

In addition to its above-described study on point-point source ETPs, the USEPA commissioned a study on the use of effluent trading by industrial sources that discharge their effluent to POTWs (Industrial Economics, Inc. and Science Applications International Corporation, 1994). The latter study was based on the assumption that pretreatment effluent trading would only be applicable when local effluent quality limitations were more stringent than federal standards or if the pollutant of interest was not regulated by federal standards.

Like other marketable permit programs, pretreatment ETPs may reduce compliance costs and encourage the development and installation of more effective pollution control technologies. Pretreatment ETPs could also provide several unique advantages (Industrial Economics, Inc. and Science Applications International Corporation, 1994). First, since all pollutants in the "ETP area" would be discharged to a single treatment works (POTW), regulators do not have to evaluate local water quality impacts of the discharges from proposed trades. Second, the CWA's anti-backsliding provision, which may restrict effluent trading in some situations, does not apply to pretreatment trading as long as applicable water quality standards are not violated. Finally, the POTW, which would be anticipated to provide some treatment for other pollutants that may be affected by the trade, serves as a buffer between the industrial sources and the receiving water.

Based on this study, the following fundamental requirements crucial to the success of pretreatment ETPs were identified (Industrial Economics, Inc. and Science Applications International Corporation, 1994): (1) the POTW must have two or more industrial sources that discharge the same or similar pollutant(s); (2) current or anticipated control costs must vary among industrial sources; and (3) the management of the POTW and the managements of its industrial sources, as well as elected officials, environmental agencies, environmental organizations (nongovernmental organizations or NGOs), and the general public, must support the program. In addition, pollutant allocations should be based on mass loadings, not effluent concentrations or best management practices, to simplify program administration.

Four issues critical to the design and implementation of a pretreatment ETP were noted (Industrial Economics, Inc. and Science Applications International Corporation, 1994): (1) the identification of participants and establishment of the program framework; (2) the selection of tradeable pollutants and the process for evaluation of proposed trades; (3) the assignment of initial effluent limitations (allocation of pollutant loadings) to industrial sources; and (4) the establishment of rules regarding trade frequency, timing, and duration. Each of these issues is addressed in more detail below.

Although the major participants in a pretreatment ETP will always be the POTW and its industrial sources, elected officials, environmental organizations (NGOs), and federal, state, and local agency staff, as well as the general public, should be requested to provide input in the design and approval of the ETP. In general, pretreatment trading should be an acceptable alternative to traditional regulatory approaches as long as such programs provide economic benefits and do not impair receiving water quality. Trading frameworks may be either informal or formal. If the trading program is informal, the administering agency would simply encourage trading among industrial sources and review any proposed trades on an ad hoc basis. Alternatively, a formal pretreatment ETP would delineate specific procedures that potential trading partners must follow when requesting approval of proposed trades from the administering agency.

Second, the administering agency must identify tradeable pollutants, the industrial sources that discharge the pollutant(s) of interest and which are thus eligible to participate in the trading program, and the quantity of pollutant reduction necessary to protect receiving water quality or the POTW's operations. The administering agency must also select the unit(s) of measurement and the time period(s) to be used when calculating pollutant reductions. For example, two sources could trade 25 pounds of BOD per day or 100 kilograms of phosphorus per month. Since most industrial effluents contain more than one pollutant, the administering agency must carefully evaluate proposed trades to identify potential impacts of trading on other effluent components. For example, if Source A discharges copper and Source B discharges copper and cyanide, "trading" a portion of Source B's control responsibility to Source A may inadvertently increase cyanide loadings to the POTW. Alternatively, additional pretreatment of the tradeable pollutant could reduce loadings of other pollutants in the effluent; for example, sedimentation to remove metals also reduces concentrations of organic compounds (Industrial Economics, Inc. and Science Applications International Corporation, 1994).

Third, the administering agency must assign initial pretreatment effluent quality and/or quantity limitations to each contributing industrial source. Such assignments may be based on uniform concentration limits, concentration- or mass-based limits that vary with the quantity of effluent discharged, case-by-case analyses, and/or auctions (Industrial Economics, Inc. and Science Applications International Corporation, 1994). Pretreatment ETPs may be significantly affected by the distribution of the initial limitations, which determine the quantity of pollutant reductions each industrial source may be eligible to sell, lease, or purchase. In addition, program implementation may be delayed if one or more industrial sources protest their effluent limitations. If trading opportunities are extremely limited, the initial effluent limitations will essentially establish the control technologies that must be installed and the resulting environmental compliance costs.

Finally, the administering agency must establish clear rules governing trade frequency, timing, and duration. In general, trading programs should be carefully balanced to maximize flexibility and economic benefits without substantially increasing administrative workloads. For example, short-term trades may be difficult for the administering agency to monitor and enforce, while long-term trades may prevent a source from responding to changes in the marketplace, thus decreasing the economic incentives to trade. Alternatively, industrial sources may reject short-term trades due to high transaction costs and the uncertainties associated with frequent renegotiations. Allowing trading only during the local permit renewal process would simplify regulatory administration of the pretreatment ETP but may also restrict trading opportunities.

Illinois Environmental Protection Agency's Conceptual Framework

The Illinois Environmental Protection Agency (IEPA) has explored the applicability of pretreatment ETPs in Illinois through discussions with representatives from industry, POTWs, and the Environmental Defense Fund (IEPA, undated). Unlike the USEPA's study, which assumed that federal effluent standards would be met before trading was allowed, the IEPA's proposal would allow pretreatment effluent trading to meet federal standards.

The IEPA's team identified some of the same critical design issues as the USEPA study and provided the following additional information (IEPA, undated):

(1) Several characteristics, such as whether or not the pollutant violates the POTW's influent loading goal, the number of pollution control alternatives, and the availability of monitoring data, could be used to select pollutants that are eligible for the pretreatment ETP. Pollutants for which concentration- or mass-based limits cannot be developed, like temperature and pH, should be excluded from the trading program. Pollutants that may cause fires, explosions, or the release of toxic gases or vapors in the municipal sewer system should also be excluded from the trading program.

(2) The administering agency must also identify the pollutant sources that are eligible to participate in the trading program. Participants may include a single category of industrial sources (such as iron and steel facilities), multiple categories of industrial sources, and/or sources that discharge the pollutant of interest but are not subject to federal effluent standards. In general, increasing the potential number of trading partners increases the potential economic benefits and the likely use of ETPs.

(3) The administering agency must also determine the time interval to be used when calculating pollutant reductions. The time interval should be based on the effluent characteristics of the trading partners. For example, annual limits may be sufficient for industries with consistent effluent discharges, while industries with variable discharges may require daily or weekly limits. POTWs that receive "slug" or "batch" discharges may even require hourly limits.

The IEPA's study also identified several issues that were not addressed in the USEPA study. Additional trading restrictions may be necessary to prevent problems in the sewer system or for combined sewer outflow systems. Current pretreatment programs may need to be modified, particularly in the area of enforcement, to accommodate effluent trading, and industrial sources that participate in trades may need to provide additional data to ensure that applicable standards are not violated. In addition, POTWs that raise revenue through pretreatment effluent charges based on pollutant concentrations may be affected by pretreatment trading programs (IEPA, undated).

Pretreatment Effluent Trading for the Rhode Island Jewelry Industry

The effluent from electroplating operations associated with Rhode Island's jewelry industry frequently contains harmful quantities of cyanide, copper, nickel, and zinc. In response, the USEPA proposed restrictions on the concentrations of cyanide and seven metals that could be discharged to POTWs. The costs of complying with the restrictions, which required at-source, conventional treatment for all electroplating operations in Rhode Island, regardless of size, could have forced as many as 60 percent of the smaller operations out of business. As an alternative to the USEPA's command-and-control approach, Opaluch and Kashmanian (1985) evaluated the use of a pretreatment "bubble" to regulate pollutants from the jewelry industry.

A linear programming model was used to determine the least-cost combination of at-source treatment, centralized treatment, and no treatment when constrained by aggregate effluent limitations on the pollutants of interest (Opaluch and Kashmanian, 1985). The effect of changing production processes to reduce water use by 50 percent was also evaluated. According to the model, the bubble approach reduced total treatment costs by $2.2 million and $5.8 million at full and one-half flow, respectively, without increasing pollutant discharges.

Based on these economic considerations, all electroplating operations in the Rhode Island jewelry industry should prefer the bubble approach to the USEPA's proposal. However, if all sources are required to purchase discharge permits, the distribution of the cost savings may make marketable permit programs politically unacceptable. For example, Table 4.5 illustrates the costs of complying with the bubble approach and the USEPA's proposal assuming a permit charge of

Table 4.5: Costs of Compliance With Electroplating Bubble and USEPA Proposal By Size of Electroplating Operation in the Jewelry Industry in Rhode Island (Opaluch and Kashmanian, 1985)

Size of Firm	Permit Expenditure[1] ($)	Treatment Costs ($)	Total Costs ($)	USEPA Proposal ($)	Savings ($)
Small[2]	100	23,100	23,200	33,500	10,300
Medium[3]	36,600	33,800	70,400	89,400	18,800
Large[4]	37,600	180,400	218,000	180,400	-37,600

[1] Discharge fee of $70 per pound of copper

[2] Group treatment

[3] At-source treatment, cyanide only

[4] At-source treatment, metals and cyanide

$70 per pound of copper emitted. Use of the bubble approach reduces compliance costs for both small- and medium-sized operations. However, the bubble approach actually increases compliance costs for large operations since, in addition to installing the most cost-effective control technologies (which are the same technologies required by the USEPA's proposal), large sources must also procure permits and pay discharge fees for any remaining copper in their effluent. Therefore, large sources, as well as lobbyists and industrial organizations disproportionately funded by large sources, would be expected to oppose ETPs. Political opposition may be reduced by distributing some or all of the revenue from discharge fees to affected industrial sources, an action that would further reduce control costs for small- and medium-sized firms without increasing control costs for large firms.

Energy-Industry Opportunities for Pretreatment Effluent Trading

Since most facilities in the electric power industry, the coal industry, and the exploration/production and distribution/marketing segments of the oil and gas industry discharge their effluent directly into receiving waters, opportunities for pretreatment ETPs are minimal (Veil, 1997). However, petroleum refineries that discharge their effluent to POTWs may be potential trading candidates, particularly if other industrial sources with compatible effluents are included in the pretreatment ETP.

Conclusions

In general, pretreatment ETPs should be carefully designed to maximize flexibility, and the resulting economic benefits, while minimizing administrative complexity. Since pretreatment trades do not impact receiving water quality directly because POTWs handle the pretreatment plant effluents, their environmental impact may be relatively simple to determine. However, such trades must still be carefully evaluated to ensure that they will not cause the receiving POTW to violate its NPDES permit, interfere with the operation of the POTW, cause or contribute to problems in the sewer system, or increase the loadings of other POTW effluent components. Like other ETPs, prohibiting the use of pretreatment trading to meet federal effluent standards will severely restrict its applicability.

POINT-NONPOINT SOURCE EFFLUENT TRADING

Point-nonpoint source ETPs may yield the greatest economic and environmental benefits of any type of ETP due to two reasons. First, since most point source loadings have already been effectively controlled through the CWA's NPDES permitting program, rural and urban nonpoint pollutant sources are often the major cause of remaining water quality impairment (Apogee Research, Inc., 1992). For example, the USEPA has identified over 18,000 water bodies that will not meet water quality standards due to nonpoint source pollution. Second, since nonpoint sources are largely unregulated, substantial and cost-effective reductions in pollutant loadings should be readily achievable.

The major difficulties associated with designing and implementing point-nonpoint source trading programs are associated with quantifying initial and continuing reductions in pollutant loadings from nonpoint sources and establishing an appropriate trading ratio. Although these issues are not unique to point-nonpoint source ETPs, the characteristics of nonpoint source pollutants make them particularly complicated to manage.

In contrast to point source loadings, which are relatively constant and thus fairly predictable, nonpoint source loadings are scattered and dependent upon local meteorological and topographic conditions. Therefore, point source discharges may have the greatest impact during low flow conditions, while nonpoint sources have the greatest impact during periods of high flow when runoff is maximum

(Senjem, 1997). However, pollutant-laden sediments from nonpoint sources that are deposited on river or lake bottoms during high flow periods may serve as a continuing source of the slow release of pollutants. Pollutants from point and nonpoint sources may also be discharged in different chemical forms, thus altering their environmental impacts. The effectiveness of nonpoint source controls also varies with site-specific conditions, thus further complicating the quantification of nonpoint source loading reductions.

The trading ratio, the rate at which nonpoint reductions are traded for point source reductions, should be partially based on the difficulties associated with quantifying nonpoint source reductions (Apogee Research, Inc., 1992). Other important considerations include the need to offset impacts from new growth, monitoring costs, and enforcement costs (Bartfield, 1993). In general, trading ratios for point-nonpoint source trading programs have been greater than 1:1. However, trading ratios that are too large may severely reduce the economic advantages of trading, thus eliminating the incentive for point sources to participate in the trading program.

USEPA's Study on Point-Nonpoint Source Effluent Trading

In 1992, Apogee Research, Incorporated, issued a report on the potential for point-nonpoint source ETPs for nutrients. Nutrients were chosen for evaluation because they are common to both point and nonpoint sources and because they have been the focus of most of the trading experiences to date. Rural sources of nutrients include runoff from fertilizers, crops, and livestock residuals as well as land-disturbing activities that release soil nutrients and free sediment. Urban nutrient sources include lawn fertilizers, septic tank systems, and stormwater runoff.

The USEPA identified nine conditions that contribute to the success of point-nonpoint trading programs; each condition is identified and discussed briefly as follows (Apogee Research, Inc., 1992):

(1) The water body must be identifiable as a watershed or segment thereof. This condition establishes the boundaries of the ETP and delineates the area that will be subject to post-trade monitoring.

(2) Both point sources and controllable nonpoint sources of the pollutant(s) of interest must be located within the trading area (boundary), and both types of sources must contribute significantly to total pollutant loads. If controllable nonpoint source loadings are limited, it may not be possible to reduce nonpoint loadings sufficiently to avoid installing additional abatement equipment for point sources. Alternatively, if point source loadings are limited, trading may not significantly reduce nonpoint source loadings. In general, a trading ratio of 2:1 should be effective if point and nonpoint sources account for 20 and 80 percent of the load, respectively.

(3) The watershed must have water quality goals or objectives to serve as the basis for allocating pollutant loadings among dischargers, to measure pollutant reductions, and to evaluate the effectiveness of the trading program.

(4) There must be accurate and sufficient data to establish water quality goals, to determine allowable loadings for the watershed and for individual pollutant sources, to measure loading reductions, and to evaluate control alternatives for point and nonpoint sources. Modelling will probably be needed to establish the relationship between loadings and water quality and to aid in allocating loadings among sources and in selecting trading ratios.

(5) Point sources must comply with technology-based effluent limitations established by the USEPA. Point-nonpoint source trading may only be used to meet more stringent water quality-based effluent limitations.

(6) The marginal costs of nonpoint loading reductions, including the trading ratio, must be less than the marginal costs of additional point source controls. In addition, point sources must be able to obtain a sufficient quantity of nonpoint source reductions.

(7) Point sources may be reluctant to participate in the trading program unless regulatory requirements force them to decrease pollutant loadings and the costs of additional pollution abatement equipment are significant.

(8) A specific organization must design, administer, and monitor the ETP. This organization should have the authority to revise individual permits and/or the ETP itself if water quality standards are not met. Since trades alter the NPDES permits of point sources, the agency responsible for such permits should be involved in the trading program. Local jurisdictions and landowners in the area where nonpoint source controls will be implemented should also be included.

(9) The ETP must be designed to ensure that the economic advantages of trading are not reduced or eliminated by confusing or restrictive program requirements. In addition, enforcement mechanisms must be carefully chosen since point sources, although dependent upon pollutant reductions from nonpoint sources, may not have direct control over the actions of those nonpoint sources.

Using the USEPA's WBS database mentioned earlier, the number of water bodies that could potentially benefit from point-nonpoint source nutrient ETPs was estimated (Apogee Research, Inc., 1992). Selection criteria included: (1) the quality of the water body did not support its designated uses; (2) industrial or municipal point sources were present within the watershed; (3) nonpoint sources including agriculture, urban runoff, and land disturbing activities were present within the watershed; and (4) nutrients were a causal factor of the water body's failure to support its designated uses. A total of 943 water bodies, listed by state or territory in Table 4.6, met all four of the selection criteria and were thus potentially eligible for nutrient-focused point-nonpoint source ETPs. The study also identified 17 additional water bodies that were not currently water quality-limited but that could benefit from nutrient trading.

The above estimate, however, is only a rough approximation of the potential for nutrient point-nonpoint source ETPs in the United States. Since the WBS database does not include all states and the data from participating states may be incomplete, the number of eligible water bodies may be underestimated. However, the WBS may also overestimate the potential for nutrient ETPs because (1) the water body may not be water quality-limited due to nutrients; (2) point and nonpoint sources may not both be significant contributors to nutrient loadings in the water body; and (3) states may report segments or reaches of the same creek, river, lake, or estuary as different "water bodies." Additional state or local data would be needed in order to determine if a point-nonpoint ETP for nutrients would be suitable for a specific watershed.

Table 4.6: Water Bodies Eligible for Nutrient Point-Nonpoint Source ETPs, by State or Territory (Apogee Research, Inc., 1992)

State	Number of Water Bodies
Illinois	221
Florida	129
West Virginia	78
Iowa	56
Mississippi	50
Virginia	49
Tennessee	47
Pennsylvania	45
Maryland	29
Massachusetts	27
Vermont	27
New Jersey	22
North Carolina	22
Connecticut	19
Washington	19
Minnesota	17
Wisconsin	16
Arizona	14
Kentucky	12
Puerto Rico	10
Montana	9
Rhode Island	7
North Dakota	5
Texas	4
Delaware	2
Ohio	2
U.S. Virgin Islands	2
Maine	1
South Dakota	1
Washington, D.C.	1
Total	943

Minnesota Pollution Control Agency's Guidelines

In 1997, the Minnesota Pollution Control Agency (MPCA) published a study evaluating the potential for use of point-nonpoint source ETPs (Senjem, 1997). Researchers determined that successful trading programs should meet the criteria of equivalence, additionality, efficiency, and accountability. Equivalence refers to the fungibility of point and nonpoint source loadings, which may vary with chemical form, time of discharge, and/or place of discharge. Under the additionality criterion, only nonpoint source reductions that would not have occurred without the trading program may be credited to a point source. In order for a trading program to be successful, all stakeholders must agree on the rules that will be used to equate point and nonpoint source loadings and to determine how "additional" nonpoint source reductions will be defined.

Efficiency refers to the cost savings that point sources must be able to realize by reducing nonpoint source pollutant loadings. However, the general assumption that nonpoint source reductions are less expensive than point source reductions is not always accurate. For example, two case studies in Minnesota found that if a POTW discharged more than one million gallons of wastewater per day and its phosphorus effluent limitation was relatively high, its phosphorus removal costs were likely to be lower than nonpoint source phosphorus removal costs, which varied with local geography. Reductions in nonpoint phosphorus loadings were particularly expensive for land that sloped gently, that had some vegetative cover during spring and summer, and that was located at least a quarter mile from surface water channels (Senjem, 1997). Negotiating and enforcing contracts with different landowners, as well as designing educational programs to overcome resistance to BMP implementation, further increased the cost of nonpoint phosphorus reductions.

However, it was determined that point-nonpoint source phosphorus ETPs could be beneficial for small POTWs, for POTWs with low influent concentrations of phosphorus, and for POTWs that must reduce phosphorus discharges below Minnesota's current effluent limitation in order to meet water quality standards (Senjem, 1997). Nonpoint source phosphorus reduction costs were minimized whenever there was a high potential for nonpoint source pollution, with this potential indicated by land that was steeply sloped, that lacked vegetative cover, and that was adjacent to surface water channels. Figure 4.1 illustrates the combinations of POTW size and nonpoint source pollution potential that are likely to promote or discourage point-nonpoint source ETPs for phosphorus (Senjem, 1997).

Accountability refers to the need to ensure that trades are equivalent and additional as well as the need to ensure that both point and nonpoint source partners comply with the terms of the trading agreement. Point sources can be held responsible for pollutant reductions through monitoring and enforcement provisions in their NPDES permits. However, since nonpoint sources are not regulated by such permits, the administering agency must ensure that BMPs are properly selected, sited, installed, and maintained. The administering agency must also ensure that nonpoint sources can be penalized for failure to abide by the trading agreement (Senjem, undated). In order to simplify the administration of nonpoint source controls, Taff and Senjem (1996) recommended the publication of an approved list of BMPs with minimum siting and design criteria; thus installing an approved BMP at any location within the trading area would automatically represent a pre-quantified reduction in the pollutant of interest. Approving only BMPs that can be easily confirmed by visual inspection should reduce monitoring and enforcement costs, thus making the program more acceptable to both regulators and pollutant sources.

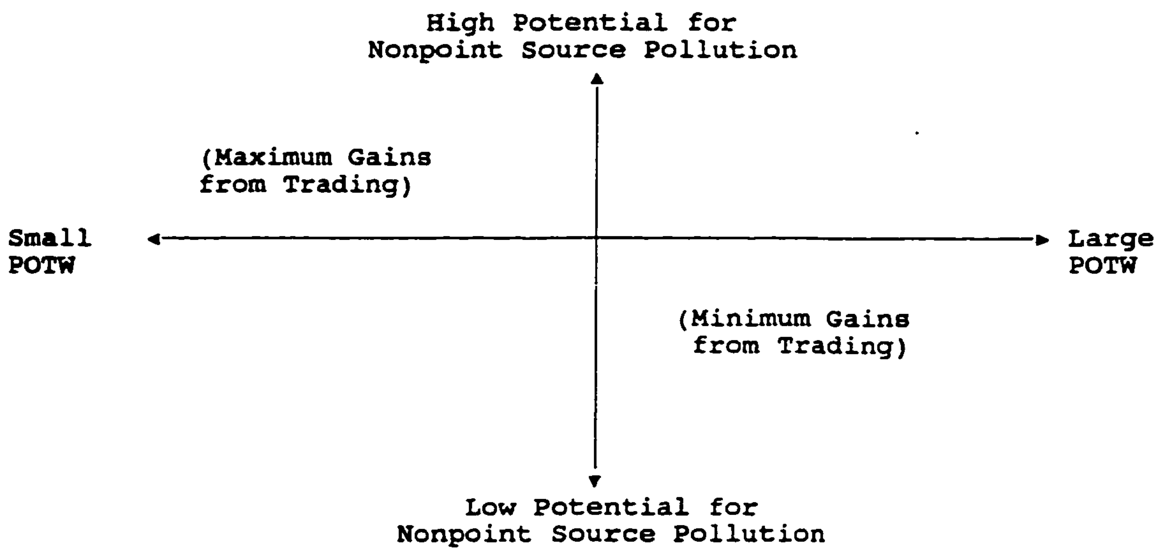

Figure 4.1: Potential Gains of Point-Nonpoint Source Effluent Trading Programs for Phosphorus (Senjem, 1997)

The MPCA also developed policy guidelines for point-nonpoint source ETPs. Six prerequisite guidelines, listed in Table 4.7, can be used to determine whether a point-nonpoint source ETP is suitable for both the watershed and pollutant(s) of interest. Once a watershed has been determined to be suitable, 13 implementation steps are listed in Table 4.8. Seven methods to reduce transaction costs associated with point-nonpoint source ETPs, thus enhancing their feasibility, have also been proposed (Senjem, 1997):

(1) The administering agency should facilitate the identification of potential trading partners. The administering agency should also serve as a technical consultant to point or nonpoint sources who are considering participating in an ETP.

(2) The administering agency should ensure that information about the ETP is readily available, thus allowing sources to estimate the costs and benefits of program participation.

(3) Instead of requiring that a single point source negotiate individual contracts with several different landowners, local government agencies could coordinate nonpoint source reduction efforts.

(4) Alternatively, point sources could contribute to a fund to finance nonpoint source pollutant reductions in the watershed.

(5) Point sources should be given the flexibility to negotiate individual contracts with landowners or local governments or to make payments to the fund.

(6) In order to minimize the costs associated with quantifying nonpoint source reductions, the administering agency should evaluate proposed trades based on ambient water quality modeling. Trading guidelines for specific BMPs should also be developed.

(7) The administering agency should develop specific, transparent trading rules to reduce the uncertainties associated with trading to meet environmental requirements.

Point-Nonpoint Source Effluent Trading to Protect Coastal Waters

The Coastal Zone Act Reauthorization Amendments (CZARA) of 1990 required all coastal states to develop nonpoint source pollution control programs to protect coastal water quality. In an effort to determine the benefits of including point-nonpoint source ETPs as a

Table 4.7: Prerequisites for Point-Nonpoint Source Pollutant Trading Programs (Senjem, 1997)

1.	Point source discharges of the tradeable pollutant(s) must have a significant negative impact on water quality.
2.	Point source discharges must contribute, either individually or collectively, to a chronic violation of water quality standards, goals, or objectives.
3.	Both point and nonpoint sources must contribute significantly to the total pollutant loading.
4.	The administering agency must determine that the pollutant(s) of interest is suitable for trading.
5.	All point sources must meet technology-based effluent limitations for the pollutant(s) of interest.
6.	Federal, state, and local laws and regulations authorizing the trading program must be identified. If any aspects of the trading program lack legal support, the trading program should be modified or the required laws and/or regulations developed. Laws or regulations that may discourage trading should also be identified and, if possible, amended.

Table 4.8: Implementation Steps for Point-Nonpoint Source Pollutant Trading Programs (after Senjem, 1997)

1. The administering agency must define a trading ratio for point and nonpoint sources of the pollutant(s) of interest.

2. The trading ratio should include a safety factor to compensate for the uncertainties associated with quantifying, monitoring, and enforcing reductions in nonpoint source pollutants.

3. The administering agency must establish pollutant reduction targets and collect sufficient data to accurately assess progress toward the selected targets.

4. The water quality goal must force point sources and/or nonpoint sources to take action to reduce their pollutant loadings.

5. The administering agency must designate a schedule for achieving required loading reductions.

6. Individual point sources must determine whether it is less expensive to meet their reduction requirements by sponsoring nonpoint source controls, by installing additional abatement equipment, or by implementing pollution prevention measures at their own facilities.

7. In order to make the decision described in Step 6, the point source must obtain information on the effectiveness of nonpoint source BMPs. Program participation may be encouraged if this information is provided by the administering agency.

8. Trading agreements should be based on the predicted quantities of pollutant reduction resulting from the installation of approved BMPs.

9. All nonpoint source reductions must be equivalent, additional, and accountable.

10. An institutional structure to facilitate trading and monitor the results of the ETP must be established.

11. The roles of all participants (stakeholders) in the ETP, including point sources, nonpoint sources, and the administering agency, must be clearly defined.

12. The administering agency must ensure that BMPs are properly implemented and maintained. The administering agency should also instigate a water quality monitoring program to determine the long-term impacts of the ETP.

13. Demonstration projects may be useful to introduce the concept of ETPs to regulators, pollutant sources, and the general public.

component of such programs, researchers used pre-existing databases to identify coastal watersheds where point-nonpoint source trading involving agriculture might improve water quality (Crutchfield et al., 1994). Data for 350 U.S. Geological Survey cataloging units, which represented all or part of a surface drainage basin or a distinct hydrologic feature, were obtained from the National Coastal Pollutant Discharge Inventory (NCPDI) and the National Resources Inventory (NRI). Although similar to the study of point-nonpoint source effluent trading for nutrients described earlier, the coastal study focused only on watersheds affected by the CZARA and agricultural nonpoint sources, and the data set included all relevant watersheds.

Researchers identified three screening criteria that coastal watersheds must meet to be considered suitable for potential ETPs (Crutchfield et al., 1994):

(1) Both point sources and agricultural nonpoint sources must contribute significantly to total pollutant loadings of nitrogen, phosphorus, and/or sediment. Although coastal watersheds were considered minimally eligible for trading if both point and agricultural nonpoint sources contributed at least 20 percent of total pollutant loadings, researchers selected the 35 watersheds where point and nonpoint sources each accounted for at least 30 percent of total loadings for further analysis.

(2) In order to decrease the administrative burdens and transaction costs associated with ETPs, the coastal watershed should contain only a few point sources of significant size. Data from the NCPDI were used to estimate each point source's contribution to total loadings of nitrogen, phosphorus, and sediment; watersheds were deemed eligible for trading if the total loadings of the five largest point sources accounted for at least 75 percent of point source loadings of at least one pollutant. Fourteen of the earlier selected 35 watersheds met the criteria for all three pollutants, 20 watersheds met the criteria for at least two pollutants, and 22 watersheds met the criteria for at least one pollutant.

(3) The third screening criteria used NRI data to estimate the percentage of land in each watershed where BMPs could be applied to reduce agricultural nonpoint loadings. Overall, researchers concluded that BMPs to improve water quality could be implemented for approximately 30 percent of the agricultural land in the selected watersheds.

Although not considered in this study, other conditions that encourage point-nonpoint source effluent trading include the presence of an agency to administer the trading program, large variations between the costs of point and nonpoint source reductions, and the need for point sources to reduce their loadings in order to meet or remain in compliance with ambient water quality standards.

Using the results of the second and third screening criteria, researchers then developed a decision matrix, shown in Table 4.9, to rank each watershed's potential for point-nonpoint source trading as none (16 watersheds), low (10 watersheds), medium (8 watersheds), or high (1 watershed). Although slightly relaxing the screening criteria did increase the number of watersheds potentially suitable for trading, it did not alter the overall finding that the applicability of point-nonpoint source ETPs involving agriculture in coastal nonpoint source pollution programs is limited.

Energy-Industry Opportunities for Point-Nonpoint Source Effluent Trading

Petroleum refineries that are unable to locate point source trading partners may be able to negotiate trades with nonpoint sources (Veil, 1997). For example, a refinery could fund measures to control stormwater runoff outside its boundaries or remediate contaminated sediments that serve as a continual source of pollution to the water body. Electric utilities may be able to engage in similar trades. The greatest potential for point-nonpoint source ETPs within the energy industry exists for coal mining operations since many streams do not meet water quality standards due to the effects of drainage from abandoned mines. Members of the coal industry could "remine" these abandoned sites, thus simultaneously recovering additional coal reserves and reducing or eliminating the amount of uncontrolled mine drainage. However, participation in such projects may be discouraged by restrictive legal requirements that

Table 4.9: Decision Matrix Used to Determine Trading Potential for Coastal Watersheds (Crutchfield et al., 1994)

If the number of pollutants for which Level 2 criteria met (small number of large point sources) is	And the value of the Level 3 criteria (percent of land with identified conservation needs) is	Then the Potential for Point-Nonpoint Source Trading Programs Is
None	Any Value	None
1, 2, or 3	0-10%	None
1, 2, or 3	11-25%	Low
1	26-50%	Low
2 or 3	26-50%	Medium
1	51-100%	Medium
2 or 3	51-100%	High

prohibit the violation of water quality standards and punish the violation of NPDES permits, even under unforeseen circumstances.

Conclusions

Point-nonpoint source ETPs expand the number of potential trading partners and, since nonpoint sources have traditionally been unregulated, could increase the likelihood of cost-effective reductions in pollutant loadings. The economic efficiency of such programs may be particularly high when point sources must severely restrict their loadings and when nonpoint source pollution has increased due to population growth and community development. In addition, programs that include both types of sources may promote the development of watershed-wide management strategies.

Before designing a point-nonpoint source ETP for a given watershed, regulators should determine if the watershed is a suitable candidate for trading. Necessary characteristics may include the existence of water quality standards or goals that force point sources to reduce their pollutant loadings, the availability of sufficient data to allocate pollutant loadings among sources and to evaluate the environmental effects of proposed trades, the presence of both point and nonpoint sources that contribute significantly to total pollutant loadings within the watershed, and the availability of sufficient cost-effective nonpoint source reductions to allow point sources to meet water quality goals. Rules governing the ETP should be clearly defined and provide adequate enforcement, particularly for nonpoint sources that are not subject to provisions in NPDES permits. Programs should also be designed to minimize transaction costs, thus increasing the economic incentive to participate in point-nonpoint source trading programs.

NONPOINT-NONPOINT SOURCE EFFLUENT TRADING

Many of the same problems associated with point-nonpoint source ETPs, such as quantifying pollutant reductions from nonpoint sources, may also affect the performance of nonpoint-nonpoint trading programs. In addition, since neither trading partner is subject to NPDES permit limitations, such trades may be particularly difficult to monitor and enforce. This section briefly describes a feasibility study for a nonpoint-nonpoint source ETP in the San Joaquin River Valley. In addition, two nonpoint-nonpoint source ETPs (Lake Dillon, Colorado, and the Williamsburg Stormwater Management Plan, Virginia) that were designed to control phosphorus loadings in runoff resulting from residential, commercial, and recreational development will be discussed in Chapter 6.

The San Joaquin study examined the use of several different economic incentives to reduce selenium discharges from subsurface farm drainage in the Grasslands area of California (Young and Congdon, 1994). Ultimately, researchers concluded that combining an ETP for existing water and drainage districts with input pricing for individual farmers was the best alternative; their decision was based on the following criteria: ability to meet the environmental goal, cost-effectiveness, compatibility with affected sources (who valued flexibility and decentralized decision-making), equity, verifiability, and ease of administration. Recommendations for reducing the administrative burden of the proposed ETP included using existing institutions and programs, allowing each district to develop its own selenium reduction plan, and restricting trading activity to the district level.

CONCLUSIONS

Like their counterparts in air quality management, ETPs may significantly reduce environmental compliance costs, stimulate technological innovation, and encourage the use of pollution prevention techniques. ETPs may also allow economic growth in watersheds that do not meet water quality standards and offset the environmental effects of increased growth and development. Cost savings for such programs, demonstrated by case studies of intra-plant and point-point source programs, may be substantial. However, in order for ETPs to be successful water quality management tools, factors that influence their design and implementation must be considered. Ten such factors, identified through this review, are discussed below. In general, characteristics which decrease the costs of participating in or administering the ETP or increase the number of compliance alternatives for pollutant sources should promote effluent trading.

First, market size and composition may influence ETP design and performance. Since compatible trading partners are required for any trading program, this criterion can be used to determine whether a watershed is suitable for trading. In general, compatibility means that sources discharge the tradeable pollutant(s) to the same watershed, that variations in their abatement costs provide sufficient economic incentive to trade, and that sources are not direct competitors and thus willing to trade. Pollutants, like pH and temperature, which cannot be expressed in terms of concentration or mass loading should not be included in ETPs. Trading potential typically increases as the number of participants in the ETP increases. However, if one source must negotiate with many different sources to obtain pollutant reductions, the economic advantages of trading may be severely reduced or even eliminated.

Second, regulators must establish a "baseline" pollutant loading using an analytical framework, such as a TMDL analysis. Once established, the baseline can be used to allocate initial pollutant loadings to all sources within the watershed and to evaluate the environmental effects of the ETP. The use of an analytical framework also simplifies the evaluation of proposed trades, since much of the needed data will already have been collected. In order to avoid legal challenges and implementation delays, all stakeholders in the watershed should agree on the baseline loading.

The third factor that may influence ETP performance is the initial allocation of discharge rights. This allocation, which determines the quantity of reduction credits each source may need to sell, purchase, or lease, establishes each participant's relative position in the trading market. If the trading market is extremely inactive, the initial allocation also determines the pollution control technology that the source must use and its resulting compliance costs. This distribution may also affect the political acceptability of the ETP since sources who feel that their initial limits are unfair may refuse to participate in the ETP or challenge it in court. ETPs may be particularly unpopular if sources are required to purchase discharge rights, thus increasing their compliance costs.

Fourth, water quality goals, objectives, and/or standards that force point and/or nonpoint sources to reduce pollutant loadings promote the development of ETPs, particularly if the installation of additional abatement equipment would be extremely expensive. Sources faced with escalating compliance costs may be more willing to consider ETPs as a compliance alternative, while regulators may be more willing to assume the administrative burdens of an ETP under such circumstances.

Fifth, federal, state, and local laws and/or regulations may restrict or prohibit ETP development. For example, since the CWA does not explicitly authorize the use of ETPs to meet water quality standards, pollutant sources may be unwilling to rely on trading to meet their compliance obligations. Anti-backsliding and anti-degradation provisions in the CWA may further restrict effluent trading opportunities. As another example, the applicability of ETPs is restricted because most ETPs can only be used to meet water quality-based limitations, not technology-based effluent limitations which apply to many more sources and watersheds across the United States. Regulators should carefully evaluate the relative advantages and disadvantages of relaxing these legal requirements in order to promote ETPs.

Sixth, the environmental impacts of proposed trades as well as the overall trading program must be determined. Relying on generic ambient water quality models to predict the environmental impacts of proposed trades may reduce the costs of participating in trading programs, but such models may ignore local conditions and be unable to predict the development of local "hot spots." As an alternative, more expensive, watershed-specific models could be developed. Regulators should also carefully evaluate the impact that proposed trades may have on other effluent components and institute a long-term, comprehensive water quality monitoring program to evaluate the impacts of the ETP.

Seventh, in order to reduce transaction costs and ETP complexities, a single, preferably local, agency should administer the trading program. The agency should have sufficient authority to modify individual NPDES permits or the ETP itself if the program is not functioning properly. The selected agency should also have the authority to inspect BMPs installed to control nonpoint source loadings and to penalize nonpoint sources that do not comply with the terms of their trading agreements.

Eighth, comprehensive rules governing the trading program should be established by the administering agency. Clearly defined trading rules can reduce the uncertainties associated with participating in trading programs, thus encouraging more active markets. For example, publishing the criteria that will be used to evaluate proposed trades allows potential trading partners to determine, in advance, if their trade is likely to be approved. Establishing procedures for submitting proposed trades for regulatory approval will also standardize trading applications and reduce administrative workloads.

Ninth, trading ratios should be determined based on the relative environmental impacts of tradeable pollutants as well as monitoring and enforcement costs. If the quantities of pollutant reductions are uncertain or variable, trading ratios can be increased to provide safety margins. Larger trading ratios may be particularly important for point-nonpoint source ETPs, since nonpoint source reductions depend on local geographic and meteorological conditions and are usually based on water quality modelling rather than direct measurement. However, trading ratios that are too large may severely reduce potential cost savings, thus eliminating the incentive to participate in the ETP.

Tenth, regulators must ensure that all trades can be properly enforced. Enforcing point source reductions is relatively simple since point sources who participate in ETPs remain subject to specific effluent limitations, as well as monitoring and reporting requirements, in their NPDES permits. However, enforcing nonpoint source reductions is much more difficult since both nonpoint pollutant loadings and the effectiveness of nonpoint source controls vary with local conditions. Trading program rules must clearly specify how nonpoint source reductions will be quantified and enforced; such difficulties may be partially ameliorated if regulators only approve trades involving nonpoint controls that can be readily confirmed through visual inspection.

These factors, along with factors identified by reviewing the theory of marketable permit programs and their use in air quality management, will be used in Chapter 5 to determine the essential components of an ideal ETP.

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CHAPTER 5

A QUALITATIVE MODEL FOR DESIGNING AND IMPLEMENTING EFFLUENT TRADING PROGRAMS

INTRODUCTION

Effluent trading programs (ETPs), which allow dischargers the flexibility to select the most efficient control alternatives for their specific situations, have been described as cost-effective means for achieving water quality goals, standards, and objectives. In addition, since pollutant reductions below mandated levels can be stored for future use or sold to other dischargers within the watershed, ETPs continuously encourage pollution prevention and the development and installation of more efficient and cost-effective abatement technologies. Some programs, like point-nonpoint and nonpoint-nonpoint ETPs, may even reduce pollutant loadings from previously unregulated sources, thus improving overall water quality management within the watershed (Canter, et al., 1998). However, experience with conceptually similar programs, primarily for air quality management in the United States, has indicated that the success of ETPs may be influenced by technical, institutional, and administrative factors such as difficulties in quantifying and certifying pollutant loading reductions, market size and composition, and transaction costs, respectively. In order for ETPs to realize their full potential, all such factors must be identified, and trading programs must be designed to minimize or eliminate their negative effects.

This chapter defines a qualitative model for designing and implementing successful ETPs. The first section briefly addresses the development of the model, including 18 factors that may affect

ETP performance, the components of the qualitative model, and a rating scheme that will be used to evaluate each model component. The second section discusses the criteria questions associated with each model component in greater detail, the third section describes planned applications of the qualitative model, and the final section contains some general conclusions.

MODEL DEVELOPMENT

The first step in the development of the qualitative model for designing and implementing ETPs was to identify factors that might positively or negatively influence ETP planning and performance. Eighteen such factors were identified through a comprehensive literature review, which was divided into three parts: (1) the conceptual basis for marketable permit programs, their theoretical advantages and disadvantages, and their use in land development and water allocation programs; (2) the use of marketable permit programs for air quality management, including emissions trading, lead trading, and allowance trading in the United States, proposed programs that cross state or federal borders, and a proposed international program to control global emissions of carbon dioxide; and (3) the use of marketable permit programs for water quality management.

The 18 identified factors are listed, in alphabetical order, in Table 5.1, which also depicts the parts of the literature review in which each factor was identified. For example, the acceptability of the trading program to industries, municipalities, regulators, and the public was identified as an issue of concern for both air and water quality management (Parts 2 and 3), while transaction costs were identified as an issue of concern from all three parts of the literature review. The identified factors were then grouped into 10 categories (model components): (1) watershed suitability; (2) pollutant type; (3) trading market size and characteristics; (4)

Table 5.1: Factors Affecting the Performance of ETPs

Factors Affecting ETP Performance	Theoretical Literature Review	Use in Air Quality Management	Use in Water Quality Management	Component Number*
Acceptability of program to industries, municipalities, regulators, and public		X	X	5,9,10
Action-forcing mechanism			X	1
Administering agency			X	4,5
Clearly defined trading rules	X	X	X	2,6,7,9
Data availability	X	X	X	5,9
Enforcement procedures		X	X	8
Environmental impact of proposed trades	X		X	2,6
Establishment of baseline conditions for trading program	X	X	X	4,6
Geographic boundaries of trading program			X	1
Initial allocation of discharge rights	X	X	X	6
Legal authority for the trading program			X	4
Legal requirements that restrict trading	X	X	X	4
Market size and composition	X	X	X	3
Resource availability			X	5
Temporal boundaries of trading program			X	1
Tradeable pollutants	X		X	2,6
Trading ratio		X	X	6
Transaction costs	X	X	X	6,7,10

*Components are numbered as follows: (1) Watershed Suitability; (2) Pollutant Type; (3) Trading Market Size and Characteristics; (4) Legal Authority; (5) Administrative Acceptability and Capability; (6) Specific Policies, Procedures, and Trading Rules; (7) Pre- and Post-Trade Monitoring; (8) Enforcement Mechanisms; (9) Program Evaluation; and (10) Public Involvement.

legal authority; (5) administrative acceptability and capability; (6) specific policies, procedures, and trading rules; (7) pre- and post-trade monitoring; (8) enforcement mechanisms; (9) program evaluation; and (10) public involvement. The components associated with each factor are shown in the last column of Table 5.1.

Model components may be organized by category or by the time period during which most activities associated with the component occur. Table 5.2 depicts the ten components organized by six topical categories: problem context, legal, policy, technical, administrative, and enforcement issues. Since almost all components belong to more than one category, it is impossible to isolate a single category. For example, an ETP planning team assigned to address technical issues concerning pre- and post-trade monitoring must also address policy and enforcement issues. Likewise, any legal authority granted to an ETP must specify the powers that the administering agency will have to evaluate, monitor, and enforce trading activities. For this reason, the ETP should be designed and implemented as a comprehensive unit by stakeholders representative of all six topical categories.

Model components may also be organized by the time period of related activity, as shown in Table 5.3. In this table, the first five components (watershed suitability, pollutant type, trading market size and characteristics, legal authority, and administrative acceptability and capability) are most important when stakeholders are determining whether an ETP should (or even could) be implemented in a particular watershed. The sixth component (specific policies, procedures, and trading rules) is most important during the design and initial implementation of an ETP, while the next three components (pre- and post-trade monitoring, enforcement mechanisms, and program evaluation) are most relevant during ETP operation. The last

Table 5.2: Components of Qualitative Model for Designing and Implementing Effective ETPs, Organized by Category of Component

Component of Qualitative Model	Categories of Component					
	Problem Context	Legal	Policy	Technical	Administrative	Enforcement
Watershed Suitability	O			X		
Pollutant Type	X		O	X		
Trading Market Size and Characteristics	O			X		
Legal Authority		O			X	X
Administrative Acceptability and Capability				X	O	
Specific Policies, Procedures, and Trading Rules				O	X	X
Pre- and Post-Trade Monitoring			X	O		X
Enforcement Mechanisms		X	X			O
Program Evaluation					O	
Public Involvement			O			X

Note: "O" denotes that the listed component is primarily associated with the topical category; "X" denotes that the listed component secondarily includes aspects of the topical category.

Table 5.3: Components of Qualitative Model for Designing and Implementing Effective ETPs, Organized by Time Period of Activity

Component of Qualitative Model	Time Period of Activity		
	Before Design of ETP	During Design and Initial Implementation of ETP	During Operation of ETP
Watershed Suitability	O		
Pollutant Type	O		
Trading Market Size and Characteristics	O	X	
Legal Authority	O		
Administrative Acceptability and Capability	O	X	
Specific Policies, Procedures, and Trading Rules		O	X
Pre- and Post-Trade Monitoring		X	O
Enforcement Mechanisms			O
Program Evaluation			O
Public Involvement	X	O	X

Note: "O" denotes that the listed component should be primarily addressed during the listed time period; "X" denotes that the listed component is secondarily relevant during the listed time period.

component, public involvement, is important in the design and continued success of the ETP.

The qualitative model can be used to evaluate existing ETPs and/or to design new ETPs. Regarding the evaluation of an existing ETP, program-specific information should be used to answer the criteria questions associated with all ten components. Each component should then be scored using the self-explanatory rating scheme depicted in Table 5.4. Although the resulting values cannot be averaged to yield an overall score, they can be used to compare the relative features of different components and to identify components that may need to be modified. For example, if periodic evaluation of the ETP is not currently required (component 9), it might be possible to amend the regulations governing the trading program to require such evaluations. The qualitative model could also be used to systematically compare the features of two or more ETPs. Alternatively, by answering questions and rating components as described above, stakeholders could use the first five components of the model to establish the feasibility of effluent trading in a particular watershed. If stakeholders decided that an ETP is the best alternative to manage site-specific water quality issues, the criteria questions associated with the remaining components can be used to aid ETP design and implementation.

CRITERIA QUESTIONS FOR EACH MODEL COMPONENT

Criteria questions have been developed for each component of the qualitative model for designing and implementing effective ETPs. The questions, which are based on fundamental information needed to evaluate or plan any ETP, and on the factors identified in Table 5.1, should facilitate the collection and organization of information concerning each model component. Answering each question as completely as possible should also simplify component rating assignments. Further, insufficient information for answering

Table 5.4: Rating Scheme for Each Component of Qualitative Model

Degree of Compliance With Criteria Questions for Each Component	Rating
Compliant from all perspectives	4
Compliant from majority of perspectives	3
Compliant from only a few perspectives	2
Compliant from no perspectives	1
Degree of compliance with perspectives depends upon specific ETP design	0

questions can aid in identifying data and information deficiencies. Each of the 10 components and their related criteria questions are listed in Table 5.5 and discussed in more detail below.

Watershed Suitability

The first component, watershed suitability, contains four criteria questions and is primarily based on concerns related to the geographic and temporal boundaries of the trading area; these factors were identified in part 3 of the literature review. Circumstances within the watershed that might encourage or discourage the use of ETPs, also identified in part 3, are included in this component.

1. Does the watershed (or watershed segment or estuarine zone) have a clearly defined geographic boundary? What is the basis for defining the watershed, segment, or zone?

The geographic boundary of the watershed, watershed segment, or estuarine zone can be used to define the ETP area, thus providing the spatial framework needed to determine the maximum acceptable pollutant loading and to identify the area subject to post-trade ambient water quality monitoring. Such boundaries can also be used to identify the point and nonpoint pollutant sources that will be eligible to participate in the trading program. Since clearly defined boundaries will facilitate the identification of potential trading partners for eligible sources, such boundaries may even encourage ETP participation by reducing uncertainty. ETP planners should ensure that hydrologically-based boundaries are chosen and should carefully document their rationale. In most cases in the United States, geographic boundaries have already been designated by federal or state regulatory agencies. Alternatively, geographic boundaries can be based on land elevation and delineated using topographic maps (U.S. Environmental Protection Agency (USEPA), 1997).

Table 5.5: Criteria Questions for Each Component of the Qualitative Model for Designing and Implementing Effective ETPs

<u>Watershed Suitability</u> 1. Does the watershed (or watershed segment or estuarine zone) have a clearly defined geographic boundary? What is the basis for defining the watershed, segment, or zone? 2. Are temporal variations in flow well understood? 3. Do existing water quality conditions or other circumstances within the watershed encourage the use of an ETP? 4. Are there circumstances within the watershed that would discourage the use of an ETP?
<u>Pollutant Type</u> 1. Are the pollutant(s) of interest classified as conservative, non-conservative, or toxic? 2. Will inter-pollutant trading be allowed? What is the basis for the decision to permit or prohibit inter-pollutant trading? 3. Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality? 4. Do the environmental effects of the pollutant(s) of interest result more from total loading over time than local, short-term toxic effects? 5. Can mass- or concentration-based limits be established for the pollutant(s) of interest?
<u>Trading Market Size and Characteristics</u> 1. Have all sources of the pollutant(s) of interest been identified? 2. Are the relative contributions of all source categories (point, nonpoint, and background) known? 3. Are temporal variations in loadings of the pollutant(s) of interest well understood? 4. Are there significant differences in marginal abatement costs among sources in the same category and/or sources in different categories? 5. Could sources and/or governmental entities within the watershed be potentially unwilling to trade? 6. Are there unique circumstances that may influence the behavior of market participants?
<u>Legal Authority</u> 1. Are there water quality standards, goals, and/or objectives that can be used as a basis for the ETP? 2. Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so? 3. Is there an existing agency with sufficient authority to implement and enforce an ETP, can such authority be conferred on an existing agency, or can such an agency be created? 4. Does the implementing agency have sufficient authority to require all contributing sources to meet their discharge allocations?
<u>Administrative Acceptability and Capability</u> 1. Does the administering agency have sufficient knowledge and information to designate the maximum allowable pollutant loading (loading cap) for the watershed, to allocate portions of that loading to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades as well as the overall trading program? 2. Is the administering agency willing to use effluent trading as a management strategy to supplement traditional regulation? 3. Does the administering agency have sufficient resources to design and implement an ETP?

Table 5.5 (continued):

Specific Policies, Procedures, and Trading Rules 1. If nonpoint sources are to be included in the ETP, do policies or procedures account for their inherent variability? 2. Have procedures been clearly defined for the following aspects of the ETP? (a) determination of the maximum allowable pollutant loading (loading cap) for the watershed (b) allocating portions of the loading cap to all sources within the watershed that discharge the pollutant(s) of interest (c) types of trades that will be allowed (d) trading ratio(s) 3. Have rules or procedures been clearly defined for the following operational aspects of the ETP? (a) quantifying and certifying PRCs (b) quantifying the environmental impacts of trades (c) application procedures for proposed trades (d) administrative procedures for the evaluation of proposed trades (e) time periods that trades remain in effect (f) treatment of banked or shutdown credits (g) reporting and recordkeeping requirements 4. Will non-dischargers, such as environmental groups, be allowed to purchase and retire PRCs?
Pre- and Post-Trade Monitoring 1. Are responsibilities for pre- and post-trade source and ambient water quality monitoring clearly defined? 2. Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for both source and ambient water quality monitoring? 3. Will source monitoring requirements discourage trading activity?
Enforcement Mechanisms 1. Can trading agreements be effectively enforced for each source category? 2. Should uncontrollable circumstances for both point and nonpoint sources be considered in the enforcement process?
Program Evaluation 1. Are responsibilities for evaluating ETP performance clearly defined? 2. How often will the ETP be reviewed? 3. Have the criteria that will be used to evaluate ETP performance been specified?
Public Involvement 1. Was the public, including industries and municipalities, actively involved in ETP design and operation? 2. In general, did industries, municipalities, government agencies, and the public support the development of the ETP? 3. Does the ETP include any educational and/or outreach efforts designed to increase public support?

2. Are temporal variations in flow well understood?

Since the assimilative capacity of a water body varies with flow, temporal variations must be known in order to determine the maximum allowable pollutant loading. Longer-term variations in flow may be important when designing an ETP; for example, if water withdrawals from the watershed are increasing annually, the assimilative capacity of the waterbody may decrease, thus requiring a corresponding decrease in pollutant loading caps and allocations. Information regarding point and nonpoint source flows may also be needed to convert concentration-based limits to pollutant loadings.

3. Do existing water quality conditions or other circumstances within the watershed encourage the use of an ETP?

In general, the use of ETPs for water quality management is initiated by the existence of an action-forcing mechanism. Such mechanisms may include more stringent water quality standards; new water quality goals or objectives; or other circumstances within the watershed, such as rapid commercial and residential development, that may dramatically increase pollutant loadings. Managers of point sources who have already installed pollution abatement equipment to meet effluent standards, only to be faced with extremely high marginal abatement costs as a result of the action-forcing mechanism, may be more willing to risk participation in an ETP, particularly if their additional compliance costs could be significantly reduced. Regulators may also be more willing to assume the administrative burden associated with ETPs in such circumstances. For example, the Tar-Pamlico River Basin ETP was proposed by publicly owned treatment works (POTWs) and state (North Carolina) and regional environmental groups as an alternative to new effluent standards for phosphorus and nitrogen (Apogee Research, Inc., 1992).

4. Are there circumstances within the watershed that would discourage the use of an ETP?

In addition to the general constraints to effluent trading, such as the lack of suitable analogs and high transaction costs, watershed-specific conditions may also discourage the use of ETPs. For example, the presence of many stakeholders, all with different opinions, may discourage the use of ETPs for large water bodies with multiple uses; while different laws and regulations and the absence of a coordinating agency may discourage their use for transboundary water bodies. As another example, the watershed may contain plant and/or animal species that would be extremely sensitive to local increases in pollutant loadings. Many of the following criteria questions are based on the need to identify these potential constraints and to mitigate their effects on ETPs.

Pollutant Type

The second component of the qualitative model, pollutant type, contains five criteria questions, which are based on the following factors: (1) the need to clearly define trading rules, which was identified in all three parts of the literature review; (2) the need to determine the environmental impacts of proposed trades, identified in parts 1 and 3 of the literature review; and (3) the need to select which pollutants are included in the ETP, also identified in parts 1 and 3.

1. Are the pollutant(s) of interest classified as conservative, non-conservative, or toxic?

The classification of the pollutant(s) of interest must be determined in order to predict their environmental effects and to select appropriate water quality models. Conservative pollutants, which do not degrade in the receiving environment, typically accumulate in various compartments within a stream, river, lake, or estuary, and simple water quality models, based on mass balance and dilution effects, can be used to approximate their relative concentrations. The environmental impact of non-conservative pollutants, which do degrade in the receiving environment at a particular location, depends upon the distance from the point of discharge and watershed-specific fate and transport processes; therefore, more sophisticated water quality models will probably be necessary to predict the impacts of trading such pollutants. Since trading toxic pollutants may result in local "hot spots," even when overall water quality standards for the watershed are met, models capable of detecting such localized impacts should be used when evaluating any proposed trade involving toxic pollutants.

2. Will inter-pollutant trading be allowed? What is the basis for the decision to permit or prohibit inter-pollutant trading?

Inter-pollutant trading allows sources to purchase or exchange pollutant reduction credits (PRCs) for different pollutants. For example, one source may be able to maintain (not lower) its discharge of biochemical oxygen demand (BOD) by purchasing phosphorus PRCs from urban and agricultural nonpoint sources located upstream. Inter-pollutant trading may encourage ETP participation by increasing the size of the trading market, and, therefore, the potential cost savings. However, the complexities associated with participation in and administration of an inter-pollutant ETP increase since two or more pollutants are involved, and the resulting transaction costs may eliminate the potential economic advantages. Further, trading ratios must be established. In addition, it may be more difficult to predict the environmental impacts of proposed inter-pollutant trades.

The decision to allow inter-pollutant trading is a policy choice; ETP planners can completely prohibit such trading, require extensive modeling to document equivalency before approving such trades, or require the use of trading ratios which incorporate any uncertainties associated with inter-pollutant trading as well as a margin of safety. Such a policy choice should be based, at least in part, on compiled information related to: (1) the number of point and nonpoint sources in the ETP area discharging the pollutants of interest; (2) the quantities of each pollutant discharged by each source; (3) each source's marginal abatement costs; (4) the environmental benefits of reducing the discharge of each pollutant; (5) the relevant contributions of the pollutants to current and/or future water quality concerns; (6) the strength of scientific evidence linking the pollutants to the goals of the ETP; and (7) the increased administrative burdens associated with an inter-pollutant ETP.

3. Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality?

The environmental impacts of a given pollutant also depend upon the physical/chemical form in which it is released into the environment and its subsequent transport and fate. For example, although both POTWs and nonpoint sources may contribute significant amounts of phosphorus to a water body, only the soluble inorganic forms, like phosphate, are readily available to algae. Therefore, even though particulate phosphorus loadings from nonpoint sources may be an order of magnitude greater in quantity, phosphorus loadings from POTWs, which are primarily in the phosphate form, may have the greater environmental impact (Reckhow, et al., 1980). Under certain circumstances, however, such general assumptions may not be true. For example, if the hypolimnion in a lake is anoxic, phosphorus bound to bottom sediments may be released as phosphate, thus becoming biologically available during lake overturn. The discussion for the previous question on inter-pollutant trading also applies to trading two or more forms of the same pollutant with different environmental impacts.

4. Do the environmental effects of the pollutant(s) of interest result more from total loading over time than local, short-term toxic effects?

Although trading programs are designed to improve overall water quality, pollutant discharges at certain locations may increase as a result of trading. If the pollutant's impacts are due to total loading, localized increases will probably be insignificant. Modeling and monitoring requirements can probably be reduced for such pollutants, thus simplifying ETP administration, reducing transaction costs, and encouraging program participation. However, if the pollutant's impacts are due to acute effects, effluent trading could result in the formation of toxic "hot spots." Therefore, whenever "acute-effects" pollutants are to be traded, the potential for severe localized effects must be carefully evaluated through modeling; follow-up source and ambient water quality monitoring will probably also be required.

5. Can mass- or concentration-based limits be established for the pollutant(s) of interest?

In order for a source to determine the quantity of PRCs that it is eligible to sell or lease, or that it needs to purchase or lease, it must be able to quantify its pollutant discharges. Such discharges are typically quantified using mass-based limits, such as kilograms per day, and/or concentration-based limits, such as milligrams per liter, which can be converted to mass-based limits by multiplying by flow and unit conversion factors. If mass- or concentration limits cannot be established for a pollutant (for example, like temperature or pH), the pollutant should not be included in the ETP.

Trading Market Size and Characteristics

The third model component, trading market size and characteristics, includes six criteria questions. These questions were formulated from the issue of market size and composition, which was identified as a factor of concern in all three parts of the literature review.

1. Have all sources of the pollutant(s) of interest been identified?

Point, nonpoint, and/or naturally-occurring background sources may discharge the pollutant(s) of interest to the water body being considered for an ETP. Atmospheric deposition, both directly to the water body's surface and to sediments that are later transported to the water body via overland flow, may also be a significant source of some pollutants, such as nitrogen (Thomas, et al., 1996). All sources of the pollutant(s) of interest should be identified and quantified in order to accurately determine the maximum allowable pollutant loading (loading cap) and to allocate portions of the allowable loading among dischargers. Identifying all sources also maximizes the size of the trading market and the number of potential trading partners, thus increasing the economic incentive to participate in ETPs.

2. Are the relative contributions of all source categories (point, nonpoint, and background) known?

ETP planners must have information regarding the relative contributions of point, nonpoint, and background sources, in order to determine whether effluent trading is a feasible water quality management option in a defined geographical area. The relative contributions will vary as a function of specific watershed characteristics. Since background pollutant loadings are largely uncontrollable, other management alternatives (for example, air pollution control) should be chosen whenever background sources contribute significantly to total pollutant loading. Alternatively, if point sources and/or nonpoint sources are major contributors to total loading, ETPs may be used to successfully achieve water quality objectives. If ETP rules allow trading between point and nonpoint sources, both source categories must contribute significantly to the total pollutant loading. For example, if point sources must be able to purchase enough PRCs from nonpoint sources to avoid the installation of additional abatement equipment, nonpoint source contributions must be significant (on a percentage or a mass basis). Point source contributions must also be significant so that purchasing PRCs from nonpoint sources will result in measurable improvements in water quality.

3. Are temporal variations in loadings of the pollutant(s) of interest well understood?

ETP planners need information concerning temporal variations in pollutant loadings in order to determine the maximum allowable pollutant loading. Under dry conditions, most of the pollutant loading in a drainage basin (watershed or portion thereof) is attributable to base flow, point sources, and irrigated agriculture. Under wet conditions, however, a greater percentage of the loading may be associated with nonpoint sources, such as urban, agricultural, and silvicultural runoff; further, combined sewer overflows may also contribute significantly to flow in wet conditions. Ideally, a watershed-specific pollutant loading cap should be determined by calculating the maximum allowable loading under wet, dry, and average conditions, and selecting the smallest loading, along with a margin of safety, thus protecting water quality under all flow conditions. Longer-term trends, such as residential, commercial, and industrial development, may also affect future pollutant loadings and should be considered when establishing the maximum allowable loading.

In order to maximize their effectiveness, source and ambient water quality monitoring programs should also be designed to address the temporal variability of pollutant loadings. For example, point sources with consistent discharges might be required to monitor monthly or annually, while nonpoint sources could be required to monitor after major storm events when their loadings are highest.

4. Are there significant differences in marginal abatement costs among sources in the same category and/or sources in different categories?

Allowing dischargers with high marginal costs to reduce their environmental compliance costs by purchasing or leasing PRCs from sources with lower marginal costs is the basis of any ETP. Without such differences, there would be no economic incentive to participate in ETPs. Differences in marginal abatement costs may exist among sources in the same category as well as among sources in different categories. For example, marginal abatement costs for point sources may vary with facility size, type, and age as well as the type, age, and size of pollution control equipment, while costs for nonpoint sources may vary with local land use, topography, type of soil, and meteorological conditions. Under current conditions in the United States, the greatest differences in marginal abatement costs, and therefore the greatest economic incentives for effluent trading, exist between point sources and nonpoint sources. Since most point sources have already installed abatement equipment to meet technology-based effluent limitations, installing additional equipment to meet water quality-based limitations is expected to be very expensive because of high marginal abatement costs. Nonpoint sources, however, are largely unregulated, so implementing basic best management practices (BMPs) to control nonpoint pollutant loadings should be relatively inexpensive (low marginal abatement costs). Point-nonpoint trades may be particularly cost-effective when BMPs are implemented on land near surface water channels with steep slopes and little or no vegetative cover (Senjem, 1997).

5. **Could sources and/or governmental entities within the watershed be potentially unwilling to trade?**

Sources with excess PRCs may prefer to save them in order to meet future water quality standards or to allow future expansion, particularly if trading program activity is minimal. Sources may also be unwilling to sell or lease their PRCs, because they might provide economic benefits in the form of reduced compliance costs to direct competitors in the geographical trading area. By hoarding excess PRCs, sources may even attempt to prevent new competitors from locating in the watershed and existing competitors from expanding their operations. Similarly, municipalities, states, and even countries may prefer to retain any PRCs they create for their own future expansion, particularly if the governmental or private sector entity purchasing or leasing the PRCs would receive significant economic benefits. ETP planners may be able to alleviate this problem by including as many sources as possible in the effluent trading market.

6. **Are there unique circumstances that may influence the behavior of market participants?**

The economic theory underlying ETPs assumes that all dischargers will seek to minimize their environmental compliance costs. While this assumption is probably true for industrial point sources, it may not apply to municipal point sources and nonpoint sources. For example, POTW operators may feel that ETP participation is too risky, particularly if agency regulations do not address ETPs or the distribution of profits and losses from trading. Therefore, POTW operators may choose more traditional methods of meeting their environmental compliance obligations. Nonpoint sources may be less inclined to participate in ETPs if other sources of BMP funding, such as governmental agency grants and subsidies, are available. ETP planners should carefully evaluate how such circumstances could affect trading market size and composition.

Legal Authority

The fourth component of the qualitative model for designing and implementing ETPs, legal authority, contains four questions that are based on the following factors identified earlier: (1) the administering agency, identified in part 3 of the literature review; (2) the establishment of a "baseline" for the trading program, identified in all three parts; (3) legal authority for the trading program, identified in part 3 of the literature review; and (4) legal requirements that may restrict trading, identified in all three parts of the literature review.

1. Are there water quality standards, goals, and/or objectives that can be used as a basis for the ETP?

Ambient water quality standards are essential in the development, implementation, and evaluation of ETPs. As a cost-effective alternative to command-and-control regulation, ETPs are most often used in watersheds that are not meeting relevant water quality standards for one or more constituents. In addition, as discussed for the first component of this qualitative model, stricter standards may serve as an action-forcing mechanism that encourages both dischargers and regulatory agencies to actively support effluent trading. Once an ETP has been established for a particular watershed, standards, which are assumed to be protective of water quality, can be used to determine the maximum pollutant loading (loading cap) and individual discharge allocations. When evaluating proposed trades, ETP administrators should review modeling predictions to ensure that trading will not violate relevant standards, thus indicating unacceptable environmental impacts. Monitoring data for both individual trades and the overall watershed can also be compared with water quality standards in order to evaluate ETP performance.

If quantified, watershed management goals or objectives may serve the same function as ambient water quality standards. For example, if the management goal is to reduce algal growth in a lake, the corresponding numeric goal may be a fifty percent reduction in phosphorus loadings. Even if goals or objectives are not quantified, an ETP can be evaluated regarding its role in improving water quality in the direction of the goals or objectives. The same is true for the evaluation of individual proposed trades.

2. Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so?

The development of active ETPs may be limited by water quality management laws that do not address effluent trading, thus increasing the uncertainty and perceived risk associated with ETP participation. For example, since the Clean Water Act in the United States does not explicitly authorize effluent trading as an acceptable compliance option, most sources may prefer other options that are not subject to potential legal challenge, particularly when making long-term control decisions. As another example, public utilities, like POTWs, may be reluctant to participate in trading programs unless their governing regulations include provisions concerning the distribution of trading profits and losses. This reluctance may severely limit the potential for point-nonpoint ETPs since POTWs may be the major purchasers (or leasers) of PRCs in most watersheds. In order to reduce this uncertainty and increase ETP participation, relevant laws should clearly support, or be amended to support, effluent trading as an acceptable compliance alternative.

3. Is there an existing agency with sufficient authority to implement and enforce an ETP, can such authority be conferred on an existing agency, or can such an agency be created?

The agency administering the ETP must have sufficient legal authority to establish trading program boundaries, to determine the maximum allowable pollutant loading (loading cap), to allocate the maximum loading among dischargers, to review proposed trades, to conduct pre- and post-trade water quality monitoring and inspections, and to enforce the provisions of trading agreements. The agency should also have the authority to modify individual trading agreements or the ETP itself if the program is not functioning properly. In order to reduce transaction costs and ETP complexities, a single, preferably local, agency should administer the trading program. If such an agency does not exist, a new agency could be created to administer the ETP, but that decision may be politically unpopular, particularly if responsibilities from existing agencies are reassigned to the new ETP agency. Alternatively, the responsibilities for ETP management could be distributed among several different agencies; in order to reduce complexities, the agencies should be carefully coordinated and their authorities and responsibilities clearly delineated.

4. Does the implementing agency have sufficient authority to require all contributing sources to meet their discharge allocations?

In order for an ETP to result in water quality improvement, all sources encompassed by the program must receive a discharge allocation that they are required to meet by installing pollution abatement equipment, changing production processes, and/or by purchasing or leasing PRCs. Waivers, variances, and other arrangements that allow sources to exceed their discharge allocations, thereby increasing pollutant loadings to the watershed, may negatively affect water quality. In addition, by reducing the number of potential participants in the trading market, such arrangements decrease the economic incentives to participate in an

ETP. The availability of grants and subsidies from governmental agencies or other programs, particularly for unregulated nonpoint sources, may also decrease the incentive to participate in an ETP. To maximize ETP effectiveness, program planners should ensure that all sources are legally required to meet their allocations and that program "loopholes" are eliminated.

Administrative Acceptability and Capability

The fifth component of the model, administrative acceptability and capability, contains three criteria questions that were based on the following factors: (1) the acceptability of the program to industries, municipalities, regulators, and the public, as identified in parts 2 and 3 of the literature review; (2) the administering agency, identified in part 3; (3) data availability, identified in all three parts; and (4) resource availability, identified in part 3 of the literature review.

1. Does the administering agency have sufficient knowledge and information to designate the maximum allowable pollutant loading (loading cap) for the watershed, to allocate portions of that loading to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades as well as the overall trading program?

Large amounts of data are required to design and operate effective ETPs. For example, information needed to establish the maximum allowable pollutant loading (loading cap) and allocate portions of the loading to dischargers includes, but is not limited to: (1) all sources that discharge the pollutant(s) of interest, including background sources, and their relative contributions to the total pollutant loading; (2) applicable control technologies for each source and the resulting marginal abatement costs; (3) pollutant chemistry; and (4) hydrological characteristics of the trading area water body. Information regarding water quality standards, goals, and objectives, and modeling results are also needed to predict the environmental impacts of proposed trades, while source and ambient water quality monitoring data are needed to evaluate the effects of approved trades as well as the overall effectiveness of the ETP. Monitoring data may also be needed to calibrate generic predictive models or to create a watershed-specific model. Therefore, the costs of planning an ETP, if the necessary information is unavailable, may be prohibitive. Alternatively, ETP planners may be able to reduce information collection costs by using a "phased" approach, meaning that initial pollutant loadings and discharge allocations are refined as additional monitoring data become available.

2. Is the administering agency willing to use effluent trading as a management strategy to supplement traditional regulation?

Administering agency staff may be reluctant to encourage effluent trading if they believe more familiar approaches to water quality management, such as technology-based and water quality-based effluent limitations, are more likely to yield the desired environmental results. In addition, ETPs tend to increase administrative workloads, particularly during program planning and implementation. After the trading program has been established, the regulatory burden varies according to the program's specific rules. For example, programs that require trading applications to include pre-trade modeling and post-trade monitoring may reduce regulatory burdens, while programs with reduced requirements for program participants may require the administering agency to increase its own monitoring and enforcement efforts. In order for an ETP to function successfully, regulators must actively promote the trading program as an acceptable compliance alternative. Regulators may even be able to reduce transaction costs by identifying potential trading partners.

3. Does the administering agency have sufficient resources to design and implement an ETP?

Like any regulatory program, ETPs require sufficient staff and funding to function successfully. The "core" staff needed to plan and operate an ETP would typically include an attorney, a water chemist, an aquatic biologist, and an environmental engineer. Depending upon the scope of the ETP, additional staff or special consultants may also be needed; consultants could include additional attorneys, agricultural engineers, economists, geographic information system specialists, foresters, hydrologists, meteorologists, information specialists, and/or public participation specialists.

Funds for an ETP feasibility study or demonstration project could come from governmental allocations or from special grants from non-governmental organizations (NGOs) or the private sector. For example, the Organization for Economic Co-operation and Development might fund a study to determine the potential for effluent trading for Lake Geneva between Switzerland and France. Funding sources for ETP planning and implementation could include governmental agency allocations, additional grants based on the results of a feasibility study or demonstration project, and/or collaborative funding from affected point and nonpoint sources in the watershed. ETP operations, including staff salaries, monitoring, and inspections, would probably be funded through governmental agency allocations although, as an additional source of funding, trade review fees and/or annual operating fees could be assessed to trading partners.

Specific Policies, Procedures, and Trading Rules

The sixth model component, specific policies, procedures, and trading rules, contains four criteria questions and eleven sub-questions. The questions were based on the following factors that may affect ETP performance: (1) clearly defined trading rules, as identified in all three parts of the literature review; (2) the environmental impact of proposed trades, identified in parts 1 and 3; (3) the establishment of a "baseline" or maximum allowable pollutant loading for the trading program, identified in all three parts; (4) the initial allocation of discharge rights, also identified in all three parts; (5) tradeable pollutants, identified in parts 1 and 3; (6) trading ratios, identified in parts 2 and 3; and (7) transaction costs, identified in all three parts of the literature review.

1. If nonpoint sources are to be included in the ETP, do policies or procedures account for their inherent variability?

In general, pollutant loadings from nonpoint sources are much less predictable than loadings from point sources; stated differently, these sources have greater uncertainty. Temporal causes of nonpoint source pollutant loading variations include precipitation rate, the total quantity of the precipitation event, antecedent precipitation, and when the event occurs in relation to time variations in land use characteristics. Causes of spatial variations in nonpoint source pollutant loadings include area size, the distance to receiving waters, and site-specific factors such as topography, slope, cover, land use, soil type, and pre-existing BMPs. Because of this variability, determining nonpoint source contributions to total pollutant loading, allocating discharge rights to individual nonpoint sources, and quantifying PRCs generated by nonpoint source control projects, may be both technically difficult and characterized by uncertainty.

If adequate data are available, ambient water quality modeling for different flow conditions can be used to select the most appropriate maximum allowable pollutant loading (loading cap) and to allocate portions of that loading to all affected dischargers. ETP rules can incorporate the inherent variability of nonpoint source pollutant loadings in the following ways: (1) by using trading ratios which include a margin of safety based on nonpoint source uncertainty; (2) by granting variances to nonpoint sources who fail to meet their loading reduction requirements in atypical years; (3)

by using monitoring protocols designed specifically to determine the variations associated with nonpoint source loadings and BMP effectiveness; and (4) by establishing different pollutant loading limits for point sources, based on whether or not proposed nonpoint source reductions are successfully achieved. If sufficient information concerning nonpoint source variability is unavailable, ETP planners may need to use the phased approach as mentioned earlier.

2. Have procedures been clearly defined for the following aspects of the ETP?

(a) determination of the maximum allowable pollutant loading (loading cap) for the watershed

Determining the maximum allowable pollutant loading, or loading cap, that will achieve water quality standards or water-related goals and objectives, is essential to ETP development for two reasons. First, the loading cap is used to specify each source's individual discharge allocation; such allocations may also be made to a reserve pool where they can be permanently banked or assigned to new and expanding sources within the watershed. Second, compliance with the loading cap can be used as one of the criteria to evaluate overall ETP performance. The USEPA's Total Maximum Daily Load (TMDL) procedure establishes precedents for determining maximum allowable pollutant loadings (USEPA, 1991). The USEPA procedure provides the technical details for determining loadings; however, these details will not be described herein. To avoid potential legal challenges, the procedures and data used to establish the maximum pollutant loading should be verified and clearly documented. In addition, all pertinent stakeholders should be able to participate in the "determination process."

(b) allocating portions of the loading cap to all sources within the watershed that discharge the pollutant(s) of interest

All sources in the ETP area should receive a portion of the loading cap, which determines the quantity of pollutants that they may discharge into receiving waters. ETP planners may also allocate a portion of the cap to a reserve pool in order to accommodate future growth and development or to account for uncertainties associated with pollutant loadings or pollutant removal efficiencies. Discharge allocations can be based on the number and characteristics of existing sources, or a portion can be auctioned; however, they should probably be based on existing regulations and historical discharges since these methods should be the most acceptable to ETP participants. The use of "paper" PRCs, which are created when a source's initial allocation exceeds its current discharge levels, should be prohibited whenever using such PRCs may result in water quality deterioration.

In the United States, allocations for point sources can be based on wasteload allocations established by the TMDL procedure. Each point source then uses its wasteload allocation as a baseline to determine its most cost-effective compliance alternative. The determination of a baseline allocation for nonpoint sources, which are largely unregulated by federal and state authorities, may be more technically difficult and controversial. For example, ETP planners could choose to credit any reduction in nonpoint source loadings, to exclude reductions that are fully or partially supported by other programs, or to require minimum reductions in pollutant loadings before a nonpoint source would be eligible to participate in the trading program. Once again, stakeholder support is crucial to the success of this element qf the ETP.

(c) types of trades that will be allowed

Effluent trading may occur among outfalls at a single industrial facility (intra-plant trading), among point sources (point-point source trading), among point sources that discharge to the same POTW (pretreatment trading), among point and nonpoint sources (point-nonpoint source trading), and/or among nonpoint sources (nonpoint-nonpoint trading). Assuming that reductions in pollutant loadings from background sources are impossible, the types of trading that will be most appropriate in a particular watershed are determined primarily by the relative contributions of point and nonpoint sources. For example, point-point source trading would be preferred if most point sources discharge directly to receiving waters, while pretreatment trading would be preferred if most point sources discharge their effluent to POTWs. Large industries with more than one outfall may prefer intra-plant trading, which reduces many of the administrative complexities and uncertainties associated with other types of ETPs. If there are significant sources of nonpoint source pollution in the watershed, point-nonpoint source trading programs may be the most cost-effective option, particularly if point sources are already strictly controlled and have higher marginal abatement costs than for nonpoint sources. Finally, nonpoint-nonpoint source ETPs may be used to improve BMP efficiency or to mitigate the effects of population growth and economic development.

(d) trading ratio(s)

Trading ratios, which determine the rate-of-exchange for PRCs, may be based on: (1) the relative environmental effects of different pollutants; (2) the relative effects of different forms of the same pollutant; and (3) the uncertainties associated with inter-pollutant trading, trading different forms of the same pollutant, and estimating nonpoint source pollutant loadings and BMP effectiveness. ETP planners may also establish trading ratios to provide margins of safety, to encourage progress toward relevant water quality standards, or to offset nonpoint source loadings from new development. For example, under the trading ratio of 2:1 specified in the Lake Dillon (Colorado) ETP rules, a point source that exceeds its phosphorus discharge allocation by 10 pounds may meet its compliance obligations by reducing nonpoint source phosphorus loadings to the watershed by 20 pounds (Apogee Research, Inc., 1992). As another example, prices for nonpoint source PRCs in the Tar-Pamlico River Basin ETP, which can be purchased by point sources that exceed their nutrient allocation, are based on trading ratios of 3:1 for cropland BMPs and 2:1 for animal BMPs. In general, as the potential for negative environmental impacts or the level of uncertainty increases, trading ratios should also increase. However, since high trading ratios may reduce or eliminate economic incentives to trade, ETP planners must consider both environmental and economic issues when selecting appropriate ratios.

Once a trading ratio has been selected, it should be periodically reviewed and revised as necessary. For example, a trading ratio may need to be increased if monitoring data for individual trades and/or the overall watershed indicate that reasonable further progress toward achieving water quality standards, goals, and objectives is not being made. Alternatively, if monitoring data indicates that water quality standards, goals, and objectives are being exceeded, the trading ratio could probably be decreased, thus encouraging more trading activity by increasing the economic incentives to participate in an ETP. As another example, trading ratios that are based largely on the uncertainties associated with nonpoint sources can be reduced when additional information becomes available.

3. Have rules or procedures been clearly defined for the following operational aspects of the ETP?

(a) quantifying and certifying PRCs

Sources must be able to accurately determine their baselines (allocations) as well as their current discharge levels in order to calculate the amount of PRCs they are eligible to sell, lease, or purchase. In general, each source's discharge allocation, established by the ETP agency, will be its baseline. Since most point sources are already required to monitor their effluent, determining their discharge levels should also be relatively simple. However, determining current discharge levels may be more difficult and controversial for nonpoint sources, so trading rules must clearly establish the procedures to be followed. In addition, PRCs must be enforceable, assignable to a specific source, and last throughout the life of the trading agreement (Kerns and Stephenson, 1996). To reduce the uncertainty of ETP participation, particularly for the purchaser of PRCs, and to ensure that trading program goals are met, PRCs should also be certified. PRCs could be certified as a part of the trade approval process, or a source could purchase previously certified credits from other sources or a "PRC bank."

(b) quantifying the environmental impacts of trades

The environmental impacts of proposed trades can be predicted by using generic or watershed-specific water quality models or by reviewing the effects of similar trades in similar watersheds. The information that can be obtained from general models or analogs, however, may be fairly limited due to differences in topography, meteorology, and other site-specific conditions. If the impacts of a proposed trade are highly uncertain or could be potentially of concern due to hotspot creation, ETP administrators may even require demonstration projects or laboratory studies as part of the trade review process. Trading rules could also require pre- and post-trade monitoring, with subsequent reporting of monitoring results to the administering agency. Such monitoring data could be used to evaluate the environmental effects of individual trades, to evaluate the overall effects of the ETP, to evaluate similar proposed trades, to calibrate water quality models, and to periodically refine the pollutant loading cap and discharge allocations. The impact of trading on other effluent components should also be considered; for example, if Source A discharges phosphorus and Source B discharges phosphorus and cyanide, transferring a portion of Source B's control responsibility to Source A via a purchase or lease may inadvertently increase cyanide loadings in the watershed.

(c) application procedures for proposed trades

Clearly defined application procedures are needed to ensure ETP consistency and uniformity and to simplify administrative review. In addition, specific application procedures, which allow potential trading partners to ascertain the likelihood that their proposal will be approved, help to reduce uncertainty and transaction costs for program participants. The contents of an application for trade approval should include, but are not limited to, information concerning the following items: (1) current loading allocations for all potential trading partners; (2) each partner's current compliance status, which may include other media or even other facilities that would not be directly involved in the proposed trade; (3) each partner's current compliance costs; (4) the alternatives that could be used to meet the discharge allocation; (5) coordination between trading partners; (6) the proposed trade and its anticipated environmental impacts; (7) current recordkeeping, monitoring, and reporting requirements and any modifications resulting from the trade; (8) legal agreements specifying the duties of each partner and assigning liability if one or more partners violate the terms of the trading agreement; (9) changes to discharge allocations as a result of the trade; and (10) coordination with other agencies, such as the local agricultural service or water conservation district, that may also be affected by the proposed trade.

(d) administrative procedures for the evaluation of proposed trades

Administrative procedures for the review of a trading application are also needed for ETP consistency and to reduce uncertainty. Review procedures should be thoroughly documented and illustrated, perhaps through a "flow chart," to delineate the different phases of the application review. For example, the review process could be divided into the following five steps. First, the ETP agency could briefly review the entire application for its completeness; if a portion of the required information was not submitted, the agency could request the additional information or return the application to the proposed trading partners for appropriate modification. Second, the technical aspects of the proposed trade, including the calculation of PRCs, the potential environmental impacts, and the necessary modifications to loading allocations, could be reviewed. The technical review may also include the solicitation of comments from other agencies that would be affected by the proposed trade. Third, the legal components of the trading application, including reporting and recordkeeping requirements and enforcement provisions, could be reviewed. In the fourth stage, the proposed trade application, or portions thereof as appropriate, would be made available to the public for their review and comments. In the final stage of the proposed trade review, the application would be revised, if necessary, based on the reviews described above, and the ETP agency would either approve, approve with conditions, or reject the trading application.

(e) time periods that trades remain in effect

In general, short-term trades (e.g., 1 or 2 years) may be difficult for the administering agency to monitor and enforce, while long-term trades (e.g., greater than 5 years) may prevent a source from responding to changes in the marketplace, thus decreasing its economic incentives to trade. Alternatively, sources may reject short-term trades due to high transaction costs and the uncertainties associated with frequent renegotiations. The length of time that trades will be effective should be clearly stated in ETP rules, and, during the application review process, ETP administrators should ensure that control technologies or BMPs that were used to create PRCs will be effective throughout the trading cycle. In general, trades could be valid for a specified time, say five years, subject to annual compliance reviews. Trades could also be approved for shorter times under special circumstances; for example, a source planning to install abatement equipment in three years could purchase or lease PRCs to cover its current discharges, or sources could purchase PRCs to cover discharges due to abatement equipment failure or unanticipated bypasses.

The ETP agency would also need to establish procedures for renewing a trade approval when an existing trade expires or when modifying a trade during the approved trading period. In order to reduce uncertainty, the ETP agency's ability to modify approved trades should apply only if the individual trade is causing significant environmental damage or if the necessary pollutant abatement measures are not functioning properly.

(f) treatment of banked or shutdown credits

ETP rules should also establish provisions regarding the treatment and use of banked credits, which are generated when a source reduces its discharge below its allocation and saves the excess PRCs for its own future use or sale or lease to other sources. Since "banking efforts" provide economic incentives to install more efficient abatement equipment and/or pollution prevention technologies, ETPs should include rules prohibiting the discounting or confiscation of banked credits. Without such rules, dischargers may have less flexibility in their use or sale or lease of PRCs and, consequently, less incentive to create them. However, in order to protect local water quality, an "effluent trading bank" within the trading area may need to establish supplementary rules regarding the use of banked PRCs. For example, the use of banked PRCs when river flows are low and temperatures are high could be prohibited or subject to the same review procedures as for proposed trades.

ETP rules should also address the disposition of shutdown credits, which are generated when a source closes part or all of its operations. Since selling shutdown credits would provide windfall profits to the facility, it is recommended that the credits be reassigned to a reserve pool. A new or expanding source could then withdraw credits from the reserve pool, subject to application review and approval by the ETP agency.

(g) reporting and recordkeeping requirements

Reporting and recordkeeping requirements are needed to demonstrate source compliance with discharge allocations and trading agreements, to ensure ETP consistency, to reduce the uncertainties associated with ETP participation, and to aid in ETP evaluation. Such rules should apply to all trading partners and should be specified, in writing, as part of the trading agreement. Reporting rules should identify each item of information that should be provided to the ETP agency as well as how quickly such information must be reported. For example, routine results from weekly monitoring could be reported to the ETP agency every quarter, while accidental spills may need to be reported immediately. Recordkeeping rules should identify the documents that must be kept, the length of time they must be retained, and where the documents should be sent if one, or both, trading partners close their facilities.

In general, since point sources are already subject to reporting and recordkeeping requirements, participating in effluent trades should only slightly increase their administrative burdens. However, administrative burdens for nonpoint sources, which are not currently subject to such requirements, may increase dramatically. If uncertainties regarding pollutant reductions from nonpoint sources are high, it may also be necessary to require more frequent reporting in the initial time period following an approved trade. After sufficient information has been collected, reporting and recordkeeping requirements for nonpoint sources could be reduced to match point source requirements.

4. Will non-dischargers, such as environmental groups, be allowed to purchase and retire PRCs?

Allowing non-dischargers, such as NGOs, environmental groups, or citizens, to purchase and retire PRCs represents a policy decision. In theory, if non-dischargers retire all of the PRCs within a watershed, dischargers' compliance costs will increase, and economic development and population growth will probably become restricted. In practice, however, non-dischargers are only likely to purchase a small percentage of the available PRCs, so their participation in the ETP will be mainly symbolic. As an alternative, the ETP agency could decease the maximum allowable pollutant loading by a certain amount, say 20 percent, to create a margin of safety and/or to preserve a portion of the total loading for future growth and development. The resulting PRCs could be placed in a reserve pool and allocated to new or expanding sources within the watershed trading area as needed. Such an alternative may also decrease administrative complexity since the trading market would not be expanded to include non-dischargers.

Pre- and Post-Trade Monitoring

The seventh component of the qualitative model, which addresses pre- and post-trade monitoring, contains three criteria questions based on the factors related to clearly defined trading rules and transaction costs; these factors were identified in all three parts of the literature review.

1. Are responsibilities for pre- and post-trade source and ambient water quality monitoring clearly defined?

Source and ambient water quality monitoring data are needed to determine compliance with discharge allocations, the environmental effects of individual trades, and the effectiveness of the overall ETP. In order to ensure consistency, to reduce uncertainty, and to eliminate duplication of effort, the responsibilities for such monitoring should be clearly distributed among trading partners, the ETP agency, and other pertinent governmental agencies. Point sources should be held responsible, either through provisions in their discharge permits or trading agreements, for monitoring pollutants in their effluent. Nonpoint source monitoring could be performed by the owners or operators of nonpoint sources, by point sources involved in trades with nonpoint sources, by the ETP agency, or by other agencies (e.g., the local agricultural service), that may be involved in nonpoint source control activities.

Comprehensive ambient water quality monitoring programs should be coordinated by the ETP agency although other pertinent agencies, NGOs, and citizens' groups may also be involved. In addition, point and nonpoint sources could also be required to conduct focused ambient water quality monitoring as a condition of trade approval.

2. Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for both source and ambient water quality monitoring?

Monitoring protocols are also needed to reduce uncertainty and to ensure ETP consistency. Protocols should specify the type and form of the pollutant(s) to be monitored, monitoring frequency, sampling locations, reporting and recordkeeping requirements, and quality assurance and quality control procedures for sample collection, transport, and analysis. Protocols should also specify the initial and continuing training required for all personnel involved in sample collection and analysis.

Since source monitoring requirements are already included in point source permits, the administering agency must only determine if additional monitoring will be necessary as a result of the trade. Nonpoint source monitoring programs may include sampling to determine pollutant loadings before and after BMP installation, as well as visual inspections of BMP installation, operation, and maintenance. In order to reduce the costs of nonpoint source monitoring and inspection, the ETP agency could use demonstration studies, based on representative watershed conditions and BMPs, to establish "typical" pollutant loading reductions for approved BMPs. Alternatively, published literature could be used to estimate BMP effectiveness; however, such information may be too general to allow the calculation of site-specific loading reductions. Ambient water quality monitoring programs should be designed to identify localized environmental effects from trades in addition to the overall water quality impacts of the ETP.

3. Will source monitoring requirements discourage trading activity?

Additional source monitoring requirements associated with effluent trading do increase transaction costs, which may discourage trading activity. However, such requirements are essential to ensure the protection of water quality and the achievement of ETP goals. Therefore, although monitoring requirements should not be overly extensive, sources should consider them as an integral part of the effluent trade when selecting their most cost-effective control alternatives. Further, monitoring costs will probably be less than the costs of additional pollutant abatement equipment required in the absence of an ETP.

Enforcement Mechanisms

The eighth component, enforcement mechanisms, contains two criteria questions which were based on concerns related to enforcement procedures identified in parts 2 and 3 of the literature review.

1. Can trading agreements be effectively enforced for each source category?

Enforcement of the ETP ensures that water quality standards and/or water quality goals and objectives are met and that trading partners are fulfilling the terms of their trading agreements. In general, the administering agency must verify that all sources are complying with their discharge allocations (including PRC purchases, leases, or sales) and meeting their monitoring, reporting, and recordkeeping requirements. This determination may be based on ambient or source water quality monitoring, reports submitted by the trading partners, field inspections of control technologies and BMPs, and audits of the records of the trading partners.

Enforcement provisions related to trading can probably be incorporated as addenda to discharge permits for point sources. Enforcement for nonpoint sources, however, is more difficult for several reasons. First, the majority of nonpoint sources do not have discharge permits than can be modified to include trading. Second, since nonpoint source loadings and BMP effectiveness are so site-specific, specific enforcement provisions may have to be designated for each nonpoint source. Finally, nonpoint pollutant loadings are highly dependent on storm events, making them difficult to monitor; and many different BMPs may be distributed over different areas, thus making them difficult to inspect.

ETP planners must also address concerns related to the default of one or more trading partners. For example, in the event that a nonpoint source fails to generate PRCs that it has already sold to a point source, trading rules must specify who is responsible for the pollutant loading reduction. The point source could be held liable, an approach which would protect water quality but reduce the incentives for point sources to engage in trades. This problem may be alleviated by allowing point sources to purchase PRCs through payments to a nonpoint source control fund, which would then be used by the ETP agency or another agency to support the installation, operation, maintenance, and inspection of BMPs. The agency administering the BMP fund would then assume the responsibility for generating sufficient PRCs.

2. Should uncontrollable circumstances for both point and nonpoint sources be considered in the enforcement process?

Circumstances that cannot be controlled for point sources, such as pump failure, and for nonpoint sources, like an unusually heavy rainfall, may result in a short-term violation of trading agreements. However, penalizing sources for such violations would increase the risks associated with ETP participation, thus discouraging trading activity. Instead, violations due to uncontrollable circumstances should be reported to the administering agency and corrected as soon as possible. The trading partners may also be held responsible for repairing any environmental damage caused by the violation. Sources who failed to comply with these rules would then be subject to the full range of enforcement provisions.

Program Evaluation

The ninth component, program evaluation, contains three criteria questions based on the following factors: (1) acceptability of the program to industries, municipalities, regulators, and the public (identified in parts 2 and 3 of the literature review); (2) clearly defined trading rules, identified in all three parts; and (3) data availability, also identified in all three parts of the literature review.

1. Are responsibilities for evaluating ETP performance clearly defined?

ETP performance should be evaluated in order to ensure that the trading program is both protecting or improving existing water quality and reducing environmental compliance costs. If the program is not functioning successfully, or if circumstances within the watershed trading area have changed, the program may need to be modified. Sources of data for program evaluation include reports submitted to the ETP agency by trading partners, water quality monitoring results, inspections conducted by the ETP agency, and water quality modeling. In general, the ETP agency should have primary responsibility for conducting the evaluations although selected trading partners, other agencies that may be affected by the trading program, NGOs, and external auditors could also be involved. A report documenting the results of the evaluation should be published by the administering agency and distributed to all stakeholders, made available to the general public, and discussed at one or more public meetings.

2. How often will the ETP be reviewed?

Administrative reviews of ETP performance should be done, and brief reports issued, annually. In addition, more thorough reviews, based on the aggregate of the annual administrative reviews and additional monitoring data, should be done periodically, perhaps every three to five years. In addition to evaluating ETP performance, periodic reviews should also address modifications to ETP policies, procedures, and trading rules that may be needed to clarify existing rules or to address specific circumstances within the trading area. For example, new water quality standards or management goals could necessitate the revision of maximum allowable pollutant loadings and discharge allocations. Changes in the ETP may also be required due to temporal trends, such as economic development and population growth, within the program area.

3. Have the criteria that will be used to evaluate ETP performance been specified?

To simplify the administrative burden, trading program rules should clearly specify the criteria to be used to evaluate ETP performance. Using specified criteria will also standardize ETP evaluations over time, thus allowing the comparison of criteria across different review cycles. Potential evaluative criteria include, but are not limited to: (1) the number of point and nonpoint sources that are in compliance with their discharge allocations; (2) whether the conditions of trading agreements are being met; (3) whether ambient water quality standards are being met or reasonable progress toward their attainment can be demonstrated; (4) enforcement statistics; (5) the level of trading activity; (6) the presence of other factors, such as improved monitoring, stakeholder alliances, and the use of pollution prevention equipment, that may be directly or indirectly attributable to the ETP; (7) public perception of and involvement in the ETP; (8) the financial status of the ETP; (9) the time required to process trading applications; (10) the administrative costs of trade reviews; and (11) the extent of educational and information dissemination activities.

<u>Public Involvement</u>

The final component of the qualitative model, public involvement, contains three criteria questions based on the factors of acceptability of the program to industries, municipalities, regulators, and the public, and transaction costs. These factors were identified in parts 2 and 3 and all three parts of the literature review, respectively.

1. Was the public, including industries and municipalities, actively involved in ETP design and operation?

In some cases, public participation in ETP design (planning) and operation may be required by law. However, such participation is recommended in all cases in order to encourage program participation, to decrease controversy, and to minimize the potential for negative publicity. Industries, municipalities, NGOs, and the general public may be able to aid the ETP planning process by identifying issues that could affect program performance. In addition, in order to increase the program's acceptability, as many stakeholders as possible should be involved in making policy decisions, particularly when clearly preferable options do not exist. During ETP operation, members of the public should be involved in all aspects of ETP administration, and individual trading proposals should always be subject to public review and comment before approval. Special committees consisting of members from various publics could be used to facilitate such participation.

2. In general, did industries, municipalities, government agencies, and the public support the development of the ETP?

Support from industries, municipalities, government agencies, and the public (including NGOs) is essential to the success of any

ETP. In general, industries and municipalities are more likely to participate in an ETP that they helped to design, particularly when their compliance costs under command-and-control regulation are extremely high. Industries and municipalities may also be able to supply information for program design, such as estimates of their marginal abatement costs, that would be difficult for the ETP agency to obtain. Clear support from the administering agency, as well as other agencies that may be affected by the trading program, also encourages ETP participation. Industries and municipalities could be reluctant to participate in ETPs if the public views such programs as "selling the right to pollute." Ensuring public support of the ETP, perhaps through educational and outreach efforts, minimizes the risk of negative publicity, thus encouraging trading activity.

3. Does the ETP include any educational and/or outreach efforts designed to increase public support?

Educational and outreach programs, by eliminating the perception that ETPs are selling the "right to pollute" and by increasing awareness of the ETP as a compliance alternative, play a crucial role in encouraging ETP participation. Educational programs, based on general descriptions of effluent trading principles, examples of ETPs in other watersheds, and/or the potential use of ETPs to manage site-specific water quality problems, should be provided to potential trading partners, other affected agencies, and the general public as the trading program is developed. Such programs should be tailored to the specific audience; for example, industries and municipalities may be more interested in the cost-saving aspects of an ETP, while NGOs and citizens' groups may be more concerned about the potential environmental effects of trading. Information dissemination efforts should continue after the ETP is operational and could include periodic reports, press releases, telephone information lines, an active Web site, fact sheets for individual trades, displays in public buildings, and public meetings. Information should also be made available, perhaps through presentations at local, regional, and national conferences or via responses to information requests, to interested parties outside the ETP area.

TESTING OF MODEL

The next step in the development of the model for designing and implementing ETPs described herein is the evaluation of the model and, if necessary, its alteration and/or expansion. Model testing will be divided into two phases. In the first phase, the model will be used to evaluate 12 existing or proposed ETPs that were identified through a comprehensive literature review and personal contacts with national and regional offices of the USEPA, state environmental agencies, Environment Canada, the Environment Protection Agency of New South Wales in Australia, the World Resources Institute, and the Organization for Economic Co-operation and Development.

In the second phase of testing, the basic qualitative model will be used to conduct three in-depth case studies. Two case studies were chosen to review the use of the model for evaluating existing ETPs and to identify unique issues associated with point-point and point-nonpoint source trading (Tar-Pamlico River Basin ETP, North Carolina), and point-nonpoint and nonpoint-nonpoint source trading (Lake Dillon ETP, Colorado). Such unique issues may need to be addressed in the model. In the third case study, the qualitative model will be applied to the Lake Geneva watershed in order to assess the potential applicability of an ETP and, if the potential for effluent trading is high, to suggest elements that should be included in the site-specific ETP. The third case also incorporates transboundary issues since Switzerland and France border Lake Geneva.

After the basic qualitative model has been tested, it will be applied to the Stillwell Canning Company (Oklahoma) in order to assess the feasibility of intraplant ETPs and to identify elements that should be considered when designing and implementing such ETPs. Similarly, the basic model will be applied to the Industrial Pretreatment Program in Stillwater (Oklahoma) in order to assess the feasibility of pretreatment ETPs and to identify elements that should be considered in pretreatment ETP design and implementation. It is anticipated that sub-models specific to intraplant and pretreatment ETPs will be developed as a result of these applications.

CONCLUSIONS

This chapter has described a qualitative model, containing 37 criteria questions divided into ten components, for evaluating existing ETPs and/or designing and implementing new ETPs. Criteria questions were designed to highlight and to reduce or eliminate factors, which were identified through a comprehensive literature review, that may negatively affect ETP performance in a specific watershed. The component rating scheme allows users of the qualitative model evaluating existing programs to compare both the relative performance of model components for a single ETP as well as the relative performance of two or more ETPs. Alternatively, stakeholders could use the qualitative model to determine if effluent trading is a feasible option for water quality management in a defined area and to plan a specific ETP for the area. The model is expected to be adjusted as a result of reviews of existing and proposed ETPs, the conduction of three in-depth case studies, and its application to intraplant and pretreatment ETPs.

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CHAPTER 6

COMPARATIVE REVIEW OF EFFLUENT TRADING PROGRAMS

INTRODUCTION

The limited use to date of effluent trading programs (ETPs) for water quality management may be due, at least in part, to technical, institutional, and administrative factors that increase uncertainty and the costs associated with ETP participation or administration. Use of the qualitative model for designing and implementing ETPs, which was described in Chapter 5, should reduce or eliminate the negative influence of such factors, thus minimizing these barriers to the planning and implementation of ETPs (Edwards and Canter, 1998). Therefore, the primary purpose of this chapter is to evaluate the 10-component qualitative model through a comparative review of 11 existing and one proposed point-point, point-nonpoint, and nonpoint-nonpoint source ETPs. In addition, this chapter highlights "state-of-practice" information on the reviewed ETPs. Model evaluation will be continued through in-depth case studies of existing ETPs in Lake Dillon in Colorado and the Tar-Pamlico River Basin in North Carolina; and a potential ETP for Lake Geneva in Switzerland and France (Chapters 7, 8, and 9, respectively). Summary information from the Lake Dillon and Tar-Pamlico ETP is included herein since both were subjected to this comparative review.

Chapter 6 begins with sections including brief descriptions of the 12 reviewed ETPs, and summary descriptive statistics. In the third section, the 10 components of the qualitative model are used to review the characteristics of each ETP. The fourth section summarizes other factors or issues that may need to be included in the model. The final section contains the conclusions from this comparative review.

DESCRIPTIONS OF THE REVIEWED ETPs

Twelve ETPs, listed in alphabetical order and briefly summarized in Table 6.1, were selected for inclusion in this comparative review based on the following two criteria: (1) current ETP policies and rules in the United States allow only point-point, point-nonpoint, and/or nonpoint-nonpoint source trading; and (2) the ETP itself was either operational or in the final stages of development in June, 1998. Twelve trading programs meeting these criteria were identified through literature review and personal contacts with national and regional offices of the U.S. Environmental Protection Agency (USEPA), state environmental agencies, the World Resources Institute, Environment Canada, the Organization for Economic Cooperation and Development (France), the Environment Protection Authority of New South Wales (Australia), and other governmental and non-governmental organizations (NGOs). Specific information on the 12 ETPs was obtained through further literature review and personal contacts with relevant stakeholders, including completed questionnaires for 7 of the 12 programs returned by ETP managers. This section briefly highlights key information related to each ETP.

Bear Creek Watershed, Colorado

Water quality problems in the Bear Creek watershed in northern Colorado include periodic algal blooms and low dissolved oxygen conditions that have eliminated most of the cold water aquatic habitat during the summer months (Water Quality Control Commission, 1997a). In order to address these problems, the Colorado Water Quality Control Commission adopted the "Bear Creek Watershed Control

Table 6.1: Summary Information on the 12 Reviewed ETPs

Program Title and Location	Effective Date	Tradeable Pollutant(s)	Type(s) of Trades[a]	Brief Description of ETP
Bear Creek Watershed, Colorado, USA	1992	TP[b]	PS-PS	Small wastewater treatment plants may exceed applicable effluent limitation if they obtain phosphorus reduction credits from other point sources in the watershed (trading ratio 1:1).
Chatfield Reservoir, Colorado, USA	1989	TP	PS-PS PS-NPS	Regulations allow trading of phosphorus reduction credits among point sources (trading ratio 1:1) and point and nonpoint sources (trading ratio 2:1 -- 2 credits from a nonpoint source required to meet 1 credit need for a point source)
Cherry Creek Reservoir, Colorado, USA	1985	TP	PS-PS PS-NPS	Regulations allow one point source to transfer some or all of its wasteload allocation to another point source in the watershed. Under specific conditions, point sources can also increase their wasteload allocation by obtaining phosphorus reduction credits from nonpoint sources (trading ratio 1.3:1 to 3:1).
Chesapeake Bay, Maryland, USA	Proposed (in 1997)	TN[c], TP	PS-PS PS-NPS	Proposal allows the exchange of nutrient reduction credits among point sources (trading ratio 1:1) or point and nonpoint sources (trading ratio 2:1).
Fox River, Wisconsin, USA	1981	BOD[d]	PS-PS	Regulations allow point sources (15 pulp-and-paper mills and 6 publicly owned treatment works) on the Fox River to trade BOD allocations among themselves in order to meet water-quality based wasteload allocations.
Hunter River Salinity Trading Scheme, Australia	1995	Saline water	PS-PS	Selected point sources (coal mines, power stations, and an ash emplacement facility) can trade credits to discharge saline waters into "high flow" river blocks.

Table 6.1 (continued):

Program Title and Location	Effective Date	Tradeable Pollutant(s)	Type(s) of Trades[a]	Brief Description of ETP
Lake Dillon, Colorado, USA	1984	TP	PS-NPS NPS-NPS	Publicly owned treatment works may increase their phosphorus allocations by reducing phosphorus loadings from urban nonpoint sources that existed as of July 30, 1984 (trading ratio 2:1). New nonpoint sources may also obtain phosphorus reduction credits from urban nonpoint sources in order to offset their phosphorus loadings (trading ratio 1:1).
Minnesota River, Minnesota, USA	1997	TP, $CBOD_5$[c]	PS-NPS	Permit requires Rahr Malting Company to offset its actual discharges of $CBOD_5$ with phosphorus reduction credits from upstream nonpoint sources (trading ratio 1:8).
Murray-Darling Basin, Australia	1988	Salinity	NPS-NPS	"Salt credits," which are generated by projects that reduce salinity levels in the Murray River, can be used to offset debits associated with land management projects or traded among participating states.
South Creek Bubble License, Australia	1996	TN, TP	PS-PS	The license establishes an aggregate nutrient loading cap for three wastewater treatment plants in the South Creek area; the program will eventually be expanded to include other point and nonpoint sources in the watershed.
Tar-Pamlico River Basin, North Carolina USA	1990	TN, TP	PS-PS PS-NPS	Point source members of the Tar-Pamlico Basin Association may meet annual nutrient loading caps by trading nutrient reduction credits among themselves or by purchasing such credits from the Agricultural Cost Share Program -- the ACSP finds best management practices (BMPs) for agricultural nonpoint sources.

Table 6.1 (continued):

Program Title and Location	Effective Date	Tradeable Pollutant(s)	Type(s) of Trades[a]	Brief Description of ETP
Williamsburg Stormwater Management Plan, Virginia, USA	1998	TP	NPS-NPS	Developers are allowed to purchase phosphorus reduction credits from regional BMPs in their respective drainage areas in lieu of implementing on-site stormwater BMPs; developers may also exceed limitations on site imperviousness by purchasing "open space" credits in the appropriate drainage area.

[a]PS-PS = point-point source trades; PS-NPS = point-nonpoint source trades; NPS-NPS = nonpoint-nonpoint source trades
[b]TP = total phosphorus
[c]TN = total nitrogen
[d]BOD = biochemical oxygen demand
[e]$CBOD_5$ = 5-day carbonaceous biochemical oxygen demand

Regulation" in 1992. The regulation indicated that point source operators must comply with a specified effluent limitation, expressed in mg/l total phosphorus as a 30-day average, and a wasteload allocation expressed in pounds of total phosphorus per year.

However, operators of existing wastewater treatment plants (WWTPs) with a design capacity of 20,000 gallons per day or less are allowed to exceed the applicable effluent limitation if they obtain phosphorus reduction credits, using a trading ratio of 1:1, from other point sources in the watershed. In effect, small WWTPs in the Bear Creek watershed are eligible to participate in point-point source trades. Such trades must be submitted to the Bear Creek Watershed Association for review and comment, approved by the Colorado Water Quality Control Division, included as conditions in the discharge permits of both facilities, and reviewed annually. In addition, the point source that reduces its phosphorus loading must demonstrate that it has generated sufficient phosphorus reduction credits to offset the increased loading from its trading partner.

Chatfield Reservoir, Colorado

The "Chatfield Reservoir Control Regulation" was adopted by the Colorado Water Quality Control Commission in 1989. Its provisions are designed to facilitate the attainment of the ambient water quality standard for total phosphorus and to maintain the beneficial uses of Chatfield Reservoir (Water Quality Control Commission, 1997b). Point source operators in the watershed must comply with a specified effluent limitation, expressed in mg/l total phosphorus as a 30-day average, and a wasteload allocation expressed in pounds of total phosphorus per year.

In an effort to provide flexibility for point sources while also protecting reservoir water quality, the regulation allows trading of phosphorus reduction credits among point sources and between point and nonpoint sources. For example, a point source can increase its wasteload allocation by obtaining equivalent phosphorus reduction credits from another point source in the watershed (trading ratio of 1:1). Point-point source trades must be reviewed by the Chatfield Basin Authority, approved by the Colorado Water Quality Control Division, incorporated into discharge permits, and revised annually. The regulation also allows point source operators to increase their phosphorus allocations by one pound for every two pounds of phosphorus reduction credit they obtain from nonpoint source operators (trading ratio of 2:1). Nonpoint source reduction credits must be verified by the Chatfield Basin Authority and the Colorado Water Quality Division, and point-nonpoint trades must be incorporated into existing discharge permits as appropriate. Proposed regulatory amendments, which should go into effect in late 1999, include additional provisions related to effluent trading; however, the amendments are not addressed herein (Clayshulte, 1999a).

Cherry Creek Reservoir, Colorado

The "Cherry Creek Reservoir Control Regulation" was designed to protect beneficial water uses in this reservoir in southeast Denver (Draft Trading Update, 1997a). In addition to daily maximum and 30-day average effluent concentration limitations for total phosphorus, each point source operator in the watershed must comply with an individual wasteload allocation, expressed in pounds of total phosphorus per year (Water Quality Control Commission, 1998). Regulatory provisions allow the Cherry Creek Basin Water Quality Authority (CCBWQA) to transfer some or all of one source's wasteload allocation to another source, thus effectively authorizing point-point source trading.

Since 1985, the regulation has also allowed point source operators to increase their wasteload allocation by obtaining phosphorus reduction credits from nonpoint sources (Draft Trading Update, 1997a; and Water Quality Control Commission, 1998). To encourage such trading, the CCBWQA developed a point-nonpoint source trading provision within the ETP; this provision was approved by the Colorado Water Quality Control Commission in 1997 (Jaeger and Sandquist, 1998). Subject to CCBWQA approval, point sources can purchase phosphorus reduction credits from nonpoint source control projects owned and operated by the CCBWQA or private entities (Water Quality Control Commission, 1998). Unique trading ratios, which are established in relation to each nonpoint source control project, may range from 1.3:1 to 3:1.

Chesapeake Bay, Maryland

Nitrogen loadings to Chesapeake Bay and its tributaries must be reduced in order to meet state and federal water quality goals (Eskin and Kearny, 1997). In an effort to simultaneously reduce nutrient loadings and accommodate regional population growth and economic development, in 1997 the Maryland Department of the Environment (MDE) and other state agencies proposed a point-point and point-nonpoint source ETP for nutrient sources in ten watersheds associated with the Bay. The proposed ETP would only allow trading among sources in the same watershed or that discharge their effluent to the same tributary. The proposed program also specifies point-point and point-nonpoint trading ratios of 1:1 and 2:1, respectively. All nutrient reduction credits must be surplus, quantifiable through monitoring or modeling, enforceable, and in effect for the duration of the trading agreement. Proposed point-nonpoint source trades are to be subject to additional review and documentation due to the site-specific variability of nonpoint sources. The MDE has also proposed that point sources can purchase nutrient reduction credits from the existing Maryland Agricultural Cost Share Program, thus simplifying point-nonpoint source trading and encouraging ETP participation.

Fox River, Wisconsin

In 1981, the Wisconsin Department of Natural Resources (WDNR) implemented one of the first ETPs in the United States for the Fox River in the eastern part of the state (Downing and David, 1998). This ETP allows point source operators, including 15 pulp-and-paper mills and six publicly owned treatment works (POTWs), to trade 5-day biochemical oxygen demand (BOD) allocations among themselves in order to meet water quality-based wasteload allocations. However, despite predicted annual cost savings of $6 million, only one trade has occurred to date, thus the Fox River ETP is generally regarded as a failure. Table 6.2 summarizes several factors which have been identified as contributing to the lack of an active ETP for the Fox River. It should be noted that these factors have been included in the qualitative model to be tested herein. Finally, despite these deterrents, the option of effluent trading remains available to point source operators in the watershed as an "unused but necessary safety valve" (Downing and David, 1998).

Hunter River Salinity Trading Scheme, Australia

The Hunter River Salinity Trading Scheme, developed by the New South Wales Environment Protection Authority (NSWEPA) and other stakeholders, was designed to minimize the environmental impacts of saline discharges in the watershed and reduce environmental compliance costs (New South Wales Environment Protection Authority, 1995). Initiated on January 1, 1995, the Trading Scheme applies to point sources, including coal mines, two power stations, and an ash emplacement facility. The Department of Land and Water Conservation in New South Wales is responsible for determining the flow classification (low, high, or flood) of each river "block" (segment); the classification is based on the amount of water that passes a base reference point during any 24-hour period, as well as the corresponding maximum allowable salt loading. In general, saline

Table 6.2: Deterrent Factors Associated with the Fox River ETP

(1) Simply reducing transaction costs is not a sufficient inducement for ETP participation. To illustrate, the specified policy of the Fox River ETP has been that the firm that purchases BOD credits must demonstrate need based on new production, increased production, or the inability of its existing WWTP to meet the applicable wasteload allocation (Downing and David, 1998; and Wisconsin Department of Natural Resources, 1986). Such "needs demonstration" can be problematic.

(2) Trades are in effect for a minimum of one year and a maximum of five years. As a result, BOD credits cannot be used to meet short-term compliance needs, such as unanticipated bypasses or equipment failure. In addition, firms may be reluctant to rely on effluent trading to meet their long-term compliance needs due to the uncertainty and expense associated with more frequent trade negotiations resulting from the limited trade periods (Downing and David, 1998).

(3) The potential trading market is divided into three clusters of five pulp-and-paper mills and two POTWs (David, 1992). Trading is only allowed within each cluster, thus discouraging trading activity by reducing the market size. Furthermore, firms may prefer to "bank" BOD credits to accommodate their own future growth, particularly when potential trading partners are direct competitors (Industrial Economics, Inc., 1993).

(4) Point source operators in the Fox River watershed have been able to comply with their wasteload allocations by using existing abatement equipment for meeting technology-based effluent limitations (Downing and David, 1998). Therefore, point source operators have little incentive to participate in the ETP. In addition, since the compliance cost savings associated with trading represent less than one percent of their production costs, the pulp-and-paper mill operators have almost no economic incentive to trade.

(5) The Fox River ETP does not include specific mechanisms to provide information to potential trading partners or to reduce transaction costs (Downing and David, 1998).

(6) Submitting proposed trades to the WDNR for regulatory approval is perceived as being both time-consuming and expensive (David, 1992).

discharges are prohibited during low flow conditions, while minimal restrictions apply during flood flows.

The Trading Scheme also allocated discharge credits to participating point source operators. These credits, each representing 0.1 percent of the maximum allowable loading for any given river block, are to be used to discharge saline water during high flow conditions. Point source operators can trade credits with each other as long as no exceedances occur regarding maximum allowable salt loadings and tributary protection limits designed to prevent localized water quality effects, and trades are approved by the NSWEPA and properly recorded. Trading Scheme rules also specify monitoring, reporting, and recordkeeping requirements for trading partners.

Lake Dillon, Colorado

Lake Dillon, a manmade impoundment located approximately 70 miles west of Denver in Summit County, Colorado, is an important source of drinking water for the Denver metropolitan area and supports many water-related recreational activities in the watershed, including skiing, sailing, and fishing (Apogee Research, Inc., 1992; and Zander, 1991). Excessive phosphorus loadings from POTWs, runoff from towns and ski areas, and inadequate septic tank systems, began to threaten the quality of lake water in the early 1980s (Draft Trading Update, 1997b). A "Clean Lakes" study of Lake Dillon, sponsored by the USEPA and completed in 1983, concluded that phosphorus was the primary pollutant; Lake Dillon would likely become eutrophic if phosphorus loadings increased above 1982 levels; and even if point source discharges of phosphorus were completely eliminated, Lake Dillon could still become eutrophic if nonpoint source phosphorus loadings associated with population growth and economic development were not reduced (Anderson, 1995).

As a result of the USEPA study, the Colorado Water Quality Control Commission (WQCC) asked local agencies to develop a comprehensive phosphorus reduction strategy that would prevent eutrophication while still allowing development (Apogee Research, Inc., 1992). The Northwest Colorado Council of Governments formed a multi-stakeholder committee, which subsequently evolved into the Summit Water Quality Committee (SWQC), to address these issues. The SWQC's plan, which was adopted by the WQCC in 1984, established a total phosphorus loading cap for all sources in the watershed, assigned individual phosphorus loading caps to POTWs, and established the nation's first point-nonpoint source ETP (Apogee Research, Inc., 1992). The Lake Dillon ETP allows POTW operators to increase their phosphorus allocations by reducing phosphorus loadings from urban nonpoint sources that existed as of July 30, 1984 (Water Quality Control Commission, 1997c). A 2:1 trading ratio both offsets nonpoint source loadings due to growth and provides a safety factor (Zander, 1991).

By the end of 1996, only two point-nonpoint trades had been documented for the Lake Dillon ETP (Water Quality Control Commission, 1997c). Improved treatment efficiencies at POTWs and decreased population growth rates in the late 1980s virtually eliminated the need for point-nonpoint source trades during this time period (Apogee Research, Inc., 1992). However, the basinwide phosphorus loading cap may ultimately constrain watershed population growth and economic development by indirectly limiting nonpoint source phosphorus loadings. Therefore, the focus of the Lake Dillon ETP has now shifted from point-nonpoint to nonpoint-nonpoint source trading. In general, new nonpoint sources must meet local requirements for new development and offset any remaining increases in phosphorus loadings with phosphorus reduction credits from existing urban nonpoint sources, thus implying a trading ratio of 1:1. As a result, two nonpoint-nonpoint trades were implemented in the early 1990s (Apogee Research, Inc., 1992).

Minnesota River, Minnesota

In an attempt to reduce its environmental compliance costs, the Rahr Malting Company (RMC) in Shakopee, Minnesota, proposed to construct and operate its own WWTP and discontinue discharges into a local POTW (Senjem, 1997). However, the loading cap for 5-day carbonaceous biochemical oxygen demand ($CBOD_5$) in the lower Minnesota River had already been fully allocated to existing sources in the watershed. Therefore, in addition to stringent effluent limitations, the Minnesota Pollution Control Agency (MPCA) incorporated effluent trading provisions into RMC's WWTP permit. These provisions require RMC to obtain phosphorus reduction credits from upstream nonpoint sources in order to offset its $CBOD_5$ discharges. The MPCA used several studies of the Minnesota River which related phosphorus to chlorophyll and chlorophyll to $CBOD_5$ to determine that one pound of phosphorus discharged upstream was equivalent to eight pounds of $CBOD_5$ discharged at Shakopee; thus a trading ratio of 1:8 was established (Senjem, 1997). Additional provisions in RMC's permit specify five types of BMPs that can be used to reduce phosphorus loadings from nonpoint sources, as well as detailed procedures for estimating BMP effectiveness. In conclusion, the RMC is involved in the only documented point-nonpoint source trade in the Minnesota River watershed to date; however, similar permits incorporating point-nonpoint trades may be developed for new or expanding point sources.

Murray-Darling Basin, Australia

The Murray-Darling watershed contains portions of the states of New South Wales, South Australia, and Victoria in southeastern Australia (Murray-Darling Basin Ministerial Council, 1988). Urban, industrial, and agricultural water uses are potentially limited by high salinity levels in the Murray River, while agricultural land uses in the watershed are affected by salinization and waterlogging. Unfortunately, many land management practices for reducing salinization and waterlogging would increase salinity loadings to the Murray River. Accordingly, the "Salinity and Drainage Strategy" proposed by the Murray-Darling Basin Ministerial Council in 1988 was designed to balance land use and water quality concerns.

Under terms of the Strategy, any proposed project that may affect salinity levels in the Murray River must be assessed using a model developed by the Murray-Darling Basin Commission (Department of Water Resources, 1992). Projects predicted to reduce salinity levels receive credits, while projects that may increase such levels receive debits (Murray-Darling Basin Ministerial Council, 1988). States must have sufficient credits to offset the debits associated with their land management projects; accordingly, net increases in salinity loadings to the Murray River are prohibited. States initially received 15 credits in return for partially funding several ground water interception projects. Additional credits can be generated through private or other state-sponsored salinity control projects (Department of Water Resources, 1992). Finally, salinity credits can be traded among participating states.

South Creek Bubble License, Australia

The Hawkesbury-Nepean River System, located near Sydney, Australia, provides drinking water to more than 3.5 million people (Davies, 1996). Other beneficial uses of the System include wastewater disposal, sand and gravel extraction, commercial fishing, and recreation. However, the majority of these uses are in jeopardy due to excessive nutrient loadings from point and nonpoint sources in the watershed. As part of its efforts to reduce such loadings from WWTPs, the Environment Protection Authority of New South Wales (NSWEPA) implemented the "South Creek Bubble License." The License, which went into effect in 1996, established an aggregate nutrient loading cap for three WWTPs (Quakers Hill, Riverstone, and St. Marys) owned by the Sydney Water Company. This approach basically allows point-point source trades since the WWTPs can reallocate their nutrient discharges in the most cost-effective manner, as long as the aggregate loading cap is not exceeded. According to the NSWEPA, the trading program is expected to be expanded to include other point and nonpoint sources of nutrients in the watershed.

Tar-Pamlico River Basin, North Carolina

The Tar-Pamlico River Basin, a 5,400 square-mile watershed in eastern North Carolina, contains portions of 17 counties and over 2,300 miles of rivers and streams (Apogee Research, Inc., 1992; and Hall and Howett, 1995). The River supplies drinking water to eight municipalities, while the Pamlico Estuary provides valuable wildlife habitat and supports boating, swimming, and recreational and commercial fishing (U.S. Environmental Protection Agency, 1993). The most significant land uses in the watershed, based on their size, include agriculture, consisting primarily of row-crop cultivation and confined livestock operations, and forestry.

Water quality problems in the Pamlico Estuary have been attributed to excessive nutrient loading from point sources, such as POTWs and industrial WWTPs, and nonpoint sources, such as agricultural, silvicultural, and urban runoff (U.S. Environmental Protection Agency, 1993). In response, in 1989, the North Carolina Environmental Management Commission (EMC) designated the Tar-Pamlico watershed as having "Nutrient Sensitive Waters," an action which required the Division of Environmental Management (DEM) to develop a basin-specific nutrient management plan. The Tar-Pamlico Basin Association (TPBA), a group consisting of the operators of 12 POTWs and one WWTP, worked with the North Carolina Environmental Defense Fund, the Pamlico-Tar River Foundation, and DEM to develop a cost-effective nutrient management plan. The final plan, approved by the EMC in 1989, allows both point-point source trading among TPBA members and point-nonpoint source trading between the TPBA and agricultural nonpoint sources.

During the first phase of the ETP, which lasted from 1990 through 1994, members of the TPBA were jointly responsible for meeting an annual nutrient loading cap (Hall and Howett, 1995). If the loading cap was exceeded, the TPBA was then required to purchase nonpoint source nutrient reduction credits, at a rate of $56 per kilogram, from the state's Agricultural Cost Share Program (ACSP). During Phase I the TPBA also hired an engineering firm to evaluate member POTWs, contributed funds to the ACSP and the agency that administers the ACSP, and financially supported the development of a site-specific estuarine water quality model.

Phase II, which began in 1995 and continues through 2004, was approved by the EMC in 1994 (Hall and Howett, 1995). The water quality model was used to establish nutrient reduction goals for all point and nonpoint sources in the watershed as well as specific loading caps for total nitrogen and total phosphorus for the TPBA. Finally, based on watershed-specific studies, the cost of purchasing nonpoint nutrient reduction credits was reduced from $56 to $29 per kilogram.

Williamsburg Stormwater Management Plan, Virginia

The City of Williamsburg's stormwater management plan was designed to protect water quality and reduce environmental compliance costs associated with land development (City of Williamsburg, 1997). The plan allows developers to purchase phosphorus reduction credits from regional BMPs in lieu of implementing on-site stormwater controls, thus effectively authorizing nonpoint-nonpoint source trading. Purchasing such credits is less expensive than implementing on-site BMPs and, because smaller individual BMPs are often poorly designed, constructed, or maintained, this approach is more likely to yield the desired phosphorus reductions. The plan also allows developers to exceed limitations on "new site imperviousness" if they purchase "open space" credits in the appropriate drainage area; such credits are generated from land which is permanently protected from development under the Chesapeake Bay Preservation Act. Funds from the purchase of both types of credits will be used by the City of Williamsburg to design, construct, and maintain regional BMPs and to purchase land for conservation purposes.

SUMMARY DESCRIPTIVE STATISTICS ON THE REVIEWED ETPs

Table 6.3 presents summary descriptive statistics for the 12 ETPs subjected to this comparative review. The reviewed ETPs are located in either the United States (75.0%) or Australia (25.0%). Of the nine ETPs in the United States, four are located in Colorado, while the remaining ones are in five states (Maryland, Minnesota, North Carolina, Virginia, and Wisconsin). Two ETPs in Australia are located in New South Wales, while the third one encompasses portions of New South Wales, South Australia, and Victoria.

The "cluster" of ETPs in Colorado may be attributed, at least in part, to two factors. First, since all of them are designed to reduce phosphorus loadings to reservoirs, the trading program rules are similar, thus reducing the administrative burden of ETP development. Second, once USEPA regional officials, state regulatory agencies, and local stakeholders become familiar with effluent trading in one watershed, they tend to support trading as an acceptable water quality management alternative in other watersheds. Similar factors may explain the prevalence of ETPs in New South Wales in Australia.

The years that the ETPs first went into effect range from 1981, when the Fox River ETP was implemented, to 1998. For purposes of this analysis, the years were divided into approximately two decades:

Table 6.3: Summary Descriptive Statistics on the Reviewed ETPs[a]

Location of ETP	
United States	9 (75.0%)
Colorado	4 (33.3%)
Maryland	1 (8.3%)
Minnesota	1 (8.3%)
North Carolina	1 (8.3%)
Virginia	1 (8.3%)
Wisconsin	1 (8.3%)
Australia	3 (25.0%)
New South Wales	2 (16.7%)
New South Wales, South Australia and Victoria	1 (8.3%)
Date the ETP went into Effect	
1981 - 1990	6 (50.0%)
1991 - 1998	5 (41.7%)
Proposed	1 (8.3%)
Tradeable Pollutant(s)	
Intra-Pollutant ETPs	11 (91.7%)
Total Phosphorus	5 (41.7%)
Nutrients[b]	3 (25.0%)
Salinity	2 (16.7%)
BOD	1 (8.3%)
Inter-Pollutant ETPs	1 (8.3%)
Total Phosphorus and $CBOD_5$	1 (8.3%)
Types of Trades	
Single Type of Trades	7 (58.3%)
Point-Point Source	4 (33.3%)
Point-Nonpoint Source	1 (8.3%)
Nonpoint-Nonpoint Source	2 (16.7%)
Multiple Types of Trades	5 (41.7%)
Point-Point Source and Point-Nonpoint Source	4 (33.3%)
Point-Nonpoint Source and Nonpoint-Nonpoint Source	1 (8.3%)

[a]Percentages may not sum to 100 due to rounding error.
[b]Nutrients include total nitrogen and total phosphorus.

(1) 1981 through 1990; and (2) 1991 through 1998. Of the 11 existing ETPs, six (50.0%) were implemented during the first decade, while five (41.7%) were started during the second decade. It was anticipated that ETP design and implementation would increase dramatically in the United States after 1996, the year the USEPA published its "Draft Framework for Watershed-Based Trading" (U.S. Environmental Protection Agency, 1996). However, the approximately 10 programs that are in the early stages of development as a result of the USEPA's guidance were excluded herein due to the selection criterion that specified that ETPs must be operational or in the proposed stage of development in June, 1998. One reason for this exclusion was that the programs in early planning will probably be refined prior to their formal proposal.

Intra-pollutant ETPs allow source operators to exchange pollutant reduction credits for the same pollutant(s), while inter-pollutant ETPs allow source operators to exchange credits for different pollutants. For example, a POTW in an inter-pollutant ETP might offset its BOD loading by purchasing phosphorus reduction credits from other sources. Eleven of the 12 reviewed ETPs (91.7%) allow intra-pollutant trades, while only one ETP (8.3%) allows inter-pollutant trades. This result was expected since intra-pollutant trading programs are generally easier to design, administer, and enforce. In addition, it is simpler to predict the water quality and aquatic ecological effects of trades involving the same pollutant, thus encouraging trading activity by reducing associated monitoring and modeling costs. The majority of the identified ETPs are also designed for pollutants whose environmental effects depend primarily upon total loading. Two examples are total phosphorus and total nitrogen. Once again, this result was expected since ETPs are not generally recommended for pollutants with acute or localized effects which may be primarily dependent on pollutant concentration.

Of the seven ETPs (58.3%) that allow only one type of trade, four involve point-point source trades, two encompass nonpoint-nonpoint source trades, and one involves point-nonpoint source trades. Of the five ETPs (41.7%) that allow multiple types of trades, four include point-point and point-nonpoint source trades, while one involves point-nonpoint and nonpoint-nonpoint source trades. Ten of the reviewed programs are focused on allowing point sources to reduce their environmental compliance costs and to offset increases in pollutant loadings associated with population growth and economic development. Finally, while eight ETPs include nonpoint sources, due to the site-specific variability of nonpoint pollutant loadings and BMP effectiveness, nonpoint source reduction credits may be more difficult to quantify than for point sources.

USE OF THE QUALITATIVE MODEL FOR REVIEW OF THE ETPs

The qualitative model for designing and implementing ETPs contains 10 components and 37 associated criteria questions (Edwards and Canter, 1998). The components include: (1) watershed suitability; (2) pollutant type; (3) trading market size and characteristics; (4) legal authority; (5) administrative acceptability and capability; (6) specific policies, procedures, and trading rules; (7) pre- and post-trade monitoring; (8) enforcement mechanisms; (9) program evaluation; and (10) public involvement. The associated criteria questions are in Table 6.4. The model can be used for in-depth evaluations of existing ETPs and comparisons of their respective features. Alternatively, the first five components can be used to assess the feasibility of effluent trading in a particular watershed, while the remaining five can be used to aid in a site-specific ETP design.

As part of the model verification process, the 10 listed components were used in this relatively cursory comparative review of the 12 identified ETPs. The results of this evaluation are discussed

Table 6.4: Criteria Questions for Each Component of the Qualitative Model for Designing and Implementing Effective ETPs (Edwards and Canter, 1998)

Watershed Suitability	
1.	Does the watershed (or watershed segment or estuarine zone) have a clearly defined geographic boundary? What is the basis for defining the watershed, segment, or zone?
2.	Are temporal variations in flow well understood?
3.	Do existing water quality conditions or other circumstances within the watershed encourage the use of an ETP?
4.	Are there circumstances within the watershed that would discourage the use of an ETP?
Pollutant Type	
1.	Are the pollutant(s) of interest classified as conservative, non-conservative, or toxic?
2.	Will inter-pollutant trading be allowed? What is the basis for the decision to permit or prohibit inter-pollutant trading?
3.	Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality?
4.	Do the environmental effects of the pollutant(s) of interest result more from total loading over time than local, short-term toxic effects?
5.	Can mass- or concentration-based limits be established for the pollutant(s) of interest?
Trading Market Size and Characteristics	
1.	Have all sources of the pollutant(s) of interest been identified?
2.	Are the relative contributions of all source categories (point, nonpoint, and background) known?
3.	Are temporal variations in loadings of the pollutant(s) of interest well understood?
4.	Are there significant differences in marginal abatement costs among sources in the same category and/or sources in different categories?
5.	Could sources and/or governmental entities within the watershed be potentially unwilling to trade?
6.	Are there unique circumstances that may influence the behavior of market participants?
Legal Authority	
1.	Are there water quality standards, goals, and/or objectives that can be used as a basis for the ETP?
2.	Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so?
3.	Is there an existing agency with sufficient authority to implement and enforce an ETP, can such authority be conferred on an existing agency, or can such an agency be created?
4.	Does the implementing agency have sufficient authority to require all contributing sources to meet their discharge allocations?
Administrative Acceptability and Capability	
1.	Does the administering agency have sufficient knowledge and information to designate the maximum allowable pollutant loading (loading cap) for the watershed, to allocate portions of that loading to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades as well as the overall trading program?
2.	Is the administering agency willing to use effluent trading as a management strategy to supplement traditional regulation?
3.	Does the administering agency have sufficient resources to design and implement an ETP?

Table 6.4 (continued):

<u>Specific Policies, Procedures, and Trading Rules</u>		
1.	If nonpoint sources are to be included in the ETP, do policies or procedures account for their inherent variability?	
2.	Have procedures been clearly defined for the following aspects of the ETP?	
	(a)	determination of the maximum allowable pollutant loading (loading cap) for the watershed
	(b)	allocating portions of the loading cap to all sources within the watershed that discharge the pollutant(s) of interest
	(c)	types of trades that will be allowed
	(d)	trading ratio(s)
3.	Have rules or procedures been clearly defined for the following operational aspects of the ETP?	
	(a)	quantifying and certifying PRCs
	(b)	quantifying the environmental impacts of trades
	(c)	application procedures for proposed trades
	(d)	administrative procedures for the evaluation of proposed trades
	(e)	time periods that trades remain in effect
	(f)	treatment of banked or shutdown credits
	(g)	reporting and recordkeeping requirements
4.	Will non-dischargers, such as environmental groups, be allowed to purchase and retire PRCs?	
<u>Pre- and Post-Trade Monitoring</u>		
1.	Are responsibilities for pre- and post-trade source and ambient water quality monitoring clearly defined?	
2.	Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for both source and ambient water quality monitoring?	
3.	Will source monitoring requirements discourage trading activity?	
<u>Enforcement Mechanisms</u>		
1.	Can trading agreements be effectively enforced for each source category?	
2.	Should uncontrollable circumstances for both point and nonpoint sources be considered in the enforcement process?	
<u>Program Evaluation</u>		
1.	Are responsibilities for evaluating ETP performance clearly defined?	
2.	How often will the ETP be reviewed?	
3.	Have the criteria that will be used to evaluate ETP performance been specified?	
<u>Public Involvement</u>		
1.	Was the public, including industries and municipalities, actively involved in ETP design and operation?	
2.	In general, did industries, municipalities, government agencies, and the public support the development of the ETP?	
3.	Does the ETP include any educational and/or outreach efforts designed to increase public support?	

in the following sub-sections. The primary bases for the discussions include information obtained through the review of published literature on each ETP, personal contacts with ETP managers and other stakeholders, and written responses to a questionnaire. Questionnaire responses were received for 7 of the 12 trading programs: Bear Creek Watershed (Clayshulte, 1999b); Chatfield Reservoir (Clayshulte, 1999c); Hunter River Salinity Trading Scheme (Smith, 1999a); Lake Dillon (Ray, 1999); Minnesota River (Senjem, 1999); Murray-Darling Basin (Sharma, 1999); and South Creek Bubble License (Smith, 1999b).

Watershed Suitability

The watershed suitability component was included to ensure that the geographic and temporal boundaries of the ETP area are clearly defined; such boundaries are required in order to calculate the maximum allowable pollutant loading, to identify the area subject to post-trade ambient water quality monitoring, and to identify pollutant sources eligible to participate in the trading program. The criteria questions within this component are related to geographic boundaries, flow variations, and conditions encouraging or discouraging effluent trading (Edwards and Canter, 1998).

All 12 ETPs addressed one or more of the criteria questions associated with watershed suitability. For example, geographic boundaries have been delineated for all 12 trading programs. However, although temporal variations in flow were presumably considered in the establishment of maximum allowable pollutant loadings, most of the trading programs do not explicitly document this issue. Exceptions include the Cherry Creek Reservoir and Lake Dillon ETPs, where annual flows are compared to a selected "reference" year, and the Hunter River Salinity Trading Scheme, where river flows are determined on a daily basis (Water Quality Control Commission, 1998; Ray, 1999; and New South Wales Environment Protection Authority, 1995).

The following general conditions which are conducive to ETP design and implementation were identified: (1) the presence of an extant watershed management organization (Clayshulte, 1999b); (2) a pressing need to accommodate population growth and economic development without violating federal, state, and local water quality standards, goals, and objectives (Eskin and Kearny, 1997); (3) current or anticipated significant uses of the available water resources (Apogee Research, Inc., 1992); and (4) differences in marginal abatement costs, particularly among point and nonpoint source categories (Apogee Research, Inc., 1992). Another positive condition regarding ETP development is when watersheds are managed as single units and when pertinent stakeholders are willing to cooperate and adopt innovative water quality management strategies (Apogee Research, Inc., 1992). Finally, because the 12 reviewed ETPs were either operational or in the proposal stage, it was assumed that deterrent factors are either negligible or have been overcome through appropriate trading program design.

Pollutant Type

The pollutant type component was designed to identify pollutant characteristics that may affect ETP development and operation. Therefore, criteria questions are related to pollutant classification (conservative, non-conservative, or toxic) and its associated physical-chemical form. Other criteria questions are designed to ensure that the environmental effects of tradeable pollutants are primarily due to total loading and that mass- or concentration-based limits can be established, thus facilitating the quantification of pollutant reduction credits. ETP designers must also decide if program rules will allow inter-pollutant trading.

Although none of the reviewed ETPs explicitly addressed this component, related information on the identified tradeable pollutants (total phosphorus, total nitrogen, salinity, BOD, and $CBOD_5$) address the relevant criteria questions. For example, effluent limitations for phosphorus, nitrogen, and BOD can be expressed in mg/l or pounds per year, while salinity loadings can be expressed in mg/l or electrical conductivity units. In addition, the environmental effects of the tradeable pollutants depend primarily upon total loading, thus simplifying ETP design and implementation.

Only one program, the Minnesota River ETP, currently allows inter-pollutant trading (Senjem, 1999). The potential for inter-pollutant trading is not addressed by the other ETPs, although three ETP managers out of the seven questionnaire respondees did indicate that inter-pollutant trading is extremely unlikely, due in part to the absence of sufficient information on pollutant interactions. The three ETPs include Chatfield Reservoir, Hunter River Salinity Trading Scheme, and South Creek Bubble License (Clayshulte, 1999c; Smith, 1999a; and Smith, 1999b).

Trading Market Size and Characteristics

The trading market size and characteristics component was focused on identifying all sources of the pollutant(s) of interest in the designated trading area and their relative contributions over time to the total pollutant loading. This information is needed to determine the maximum allowable pollutant loading, to allocate portions of this loading among dischargers, and to maximize the number of potential trading partners, thus increasing an economic incentive to participate in trading. This component also addresses other characteristics, such as differences in marginal abatement costs, the presence of direct competitors within the trading area, or unique circumstances, that may affect ETP activity.

All 12 reviewed ETPs address one or more of the criteria questions associated with this component. For example, sources of tradeable pollutants have been identified in all cases, and the relative contributions of point, nonpoint, and background source categories have been identified for most. In general, this information is based on effluent monitoring for point sources and on ambient water quality modeling related to both point and nonpoint sources, as well as background sources.

Anticipated differences in marginal abatement costs, both within and among source categories, are expected to provide the primary economic incentive to participate in trading, and this review supports this assumption. For example, the Tar-Pamlico River Basin ETP was developed, in part, due to differences in marginal abatement costs among point sources resulting from facility sizes and the resulting economies of scale, and between point and agricultural nonpoint sources (Riggs, 1993). Significant differences in marginal abatement costs have also been identified for small POTWs with low influent concentrations of phosphorus in the Minnesota River watershed, and BMPs designed to reduce soil erosion, to control runoff from livestock feedlots, and to protect "critical areas" from stream scouring (Senjem, 1999).

Other market-related characteristics may also affect trading activity. For example, the lack of activity in the Fox River watershed has been partially attributed to the presence of direct competitors (Downing and David, 1998). Further, some operators of POTWs may be reluctant or even unable to participate in ETPs because they are governed by public utility commissions. However, this was not a major factor in this review since POTWs are major participants in 8 of the 12 reviewed programs.

Legal Authority

The legal authority component was included to identify water quality standards, goals, or objectives that may be used as the basis for an ETP, and to ensure that the trading program agency has sufficient legal authority to administer and enforce the program. In addition, this component addresses whether existing laws and regulations fully support, or could be amended to support, the development and operation of an ETP, thus reducing the uncertainty and possible perceived risk associated with program participation. Finally, the component was designed to identify grants, variances, waivers, and other "loopholes" that may negatively affect trading activity by reducing the number of potential trading partners.

All 12 of the ETPs are specifically related to ambient water quality standards and/or pollutant reduction goals. In the United States, state regulations, local ordinances, or binding agreements signed by watershed stakeholders provide the necessary legal authority. Similarly, legal authority for the Hunter River Salinity Trading Scheme and the South Creek Bubble License is provided by laws adopted by the Parliament of New South Wales, while authority for the Murray-Darling Basin's Salinity and Drainage Strategy is provided by a binding agreement signed by the three participating states (Smith, 1999a; Smith, 1999b; and Sharma, 1999).

The reviewed ETPs are administered by one or more regulatory agencies. In general, designating a single, local agency to administer the ETP should encourage effluent trading activity. However, in Colorado, several watershed management organizations play a key role. Further, the presence of multiple administering agencies for the Tar-Pamlico River Basin ETP does not seem to have affected the trading program, perhaps because program responsibilities are clearly delineated for the agencies and individual point sources interact primarily with the TPBA (Apogee Research, Inc., 1992). Finally, since variances, grants, and waivers that may adversely affect ETP activity were not identified for the study group, it was assumed that such loopholes are insignificant in the 12 reviewed programs.

Administrative Acceptability and Capability

The administrative acceptability and capability component identifies whether the administering agency has a sufficient knowledge base, information, and financial resources to design, implement, and operate an ETP. This component also focuses on determining if agency staff are willing to use effluent trading as an alternative to the command-and-control approach for environmental management.

Although criteria questions related to this component were not specifically addressed in any of the reviewed ETPs, all 12 program were either in existence (11 programs) or in the proposed stage (one program). Therefore, it was assumed that a sufficient knowledge base and information existed for designing and implementing the ETPs, that agency staff were willing to support effluent trading as a compliance alternative, and that sufficient technical and financial resources were available for ETP administration.

For most of the 12 cases, trading program or other water quality regulations include modeling and monitoring requirements designed to provide additional watershed-specific information. Funds for ETP design and operation have been provided by the general operating budgets of environmental agencies, application and/or annual fees assessed to trading partners, and grants provided by the USEPA and NGOs. In general, trading rules that are integrated with existing permitting procedures are expected to be less expensive to implement and more acceptable to agency staff.

Specific Policies, Procedures, and Trading Rules

Specific policies, procedures, and trading rules are needed to reduce uncertainty, to minimize regulatory and administrative burdens, and to reduce transaction costs associated with actual trades. Procedures for calculating the maximum allowable pollutant loading, allocating portions of this loading to sources within the watershed, determining the types of allowable trades, and establishing appropriate trading ratios should be clearly defined during trading program design. Program rules should also address the following operational aspects: (1) quantifying and certifying pollutant reduction credits (PRCs); (2) quantifying the environmental impacts of trades; (3) application procedures for proposed trades; (4) evaluation of proposed trades; (5) time periods that trades remain in effect; (6) treatment of banked or shutdown credits; and (7) reporting and recordkeeping requirements. Other criteria questions address the inherent variability of nonpoint sources, which should be thoroughly addressed if such sources are to be included in the ETP, and the participation of non-dischargers via their purchase of PRCs.

The eight ETPs that include nonpoint sources address their variability in different ways. Most programs quantify nonpoint source PRCs through modeling, monitoring, and/or visual inspections. However, the Cherry Creek Reservoir ETP allows point source operators to purchase PRCs from large-scale BMPs in the watershed (Water Quality Control Commission, 1998), while the Williamsburg Stormwater Management Plan allows developers to purchase credits from regional BMPs in lieu of implementing on-site stormwater control projects (City of Williamsburg, 1997). These large-scale or regional BMPs are more cost-effective than smaller, individual BMPs because the latter are often poorly designed, installed, or maintained. Accordingly, the regional approach frequently yields greater improvements in ambient water quality.

Nonpoint source variability can also be considered by allowing point sources to purchase PRCs from existing governmental programs designed to encourage agricultural BMPs. For example, members of the TPBA can purchase nutrient reduction credits from the Agricultural Cost Share Program administered by the North Carolina Division of

Soil and Water Conservation (DSWC) (Hall and Howett, 1995). Purchasing such credits simplifies ETP participation and, because DSWC assumes the responsibility for generating sufficient nutrient reduction credits, reduces the risks borne by the initiator of trading. Similar provisions for purchasing nutrient reduction credits are included in the proposed ETP for Chesapeake Bay (Eskin and Kearny, 1997).

All 12 ETPs have established maximum allowable pollutant loadings, allocated portions of this loading to relevant sources, identified the types of approvable trades, and set trading ratios. Trading ratios for intra-pollutant trading programs vary from 1:1 to 3:1. In general, trading ratios for point-nonpoint source ETPs are higher due to the difficulties associated with quantifying nonpoint source pollutant loadings and uncertainties related to BMP effectiveness. The one inter-pollutant trading program (Minnesota River) uses a 1:8 ratio (one credit of phosphorus for eight credits of $CBDO_5$).

The detail with which the operational aspects of ETPs are addressed varies widely between the 12 programs. At a minimum, proposed trades are simply subject to approval by the relevant regulatory agency and/or watershed management organization (Water Quality Control Commission, 1997a, and 1997b). In contrast, the Cherry Creek Reservoir ETP and the Hunter River Salinity Trading Scheme include extensive regulatory provisions and supplemental guidelines (Cherry Creek Basin Water Quality Authority, 1998; Water Quality Control Commission, 1998; and New South Wales Environment Protection Authority, 1995). Trading provisions in several ETPs supplement existing point source permitting procedures, thus decreasing transaction costs and reducing regulatory and administrative burdens. Finally, none of the ETPs address nondischarger participation, probably because such participation is expected to be minimal and have little influence on trading activity.

Pre- and Post-Trade Monitoring

Pre- and post-trade water quality monitoring data are needed to determine compliance with discharge allocations, the environmental effects of individual trades, and the effectiveness of the overall ETP. In order to ensure consistency, to reduce uncertainty, and to eliminate duplication of effort, the responsibilities for such monitoring should be clearly delineated and protocols for both source discharge and ambient water quality monitoring should be established. This component was also used to determine if any additional source discharge monitoring requirements would adversely affect trading activity by significantly increasing the transaction costs.

Although monitoring requirements exist within all 12 reviewed ETPs, most of the requirements were not designed specifically to identify the environmental effects of each trade. Monitoring responsibilities are typically distributed among trading partners, watershed management organizations, and regulatory agencies. For example, in the Tar-Pamlico River Basin ETP, operators of POTWs are responsible for monitoring the levels of phosphorus and nitrogen in their effluent, the North Carolina DEM is responsible for compliance and surface water quality monitoring, and the North Carolina DSWC is responsible for monitoring BMP effectiveness (Apogee Research, Inc., 1992). To serve as a second example, point source operators in the Bear Creek Watershed ETP are responsible for monitoring phosphorus concentrations in their effluent, while local agencies are responsible for ambient water quality monitoring (Water Quality Control Commission, 1997a).

In general, point source operators, whether or not they participate in ETPs, are responsible for monitoring their effluent flow and pollutant concentrations. This permit-related information should be sufficient to quantify pollutant loadings and PRCs, thus simplifying trading participation. Furthermore, additional monitoring requirements associated with proposed trades can be incorporated into existing discharge permits, thus simplifying ETP enforcement. Nonpoint source PRCs, which are more difficult to quantify due to the site-specific variability of sources and BMP effectiveness, are typically quantified by modeling and verified by "before-and-after" water quality monitoring. However, in the Minnesota River ETP, nonpoint source PRCs are quantified solely through modeling (Senjem, 1999).

Since none of the available information on the 12 ETPs specifically addressed monitoring protocols, it was assumed that appropriate protocols have been previously established in conjunction with existing monitoring requirements. In addition, the 12 ETPs do not address the transaction costs associated with increased monitoring requirements, probably because such costs are expected to be relatively insignificant and, in order to protect ambient water quality, must be considered as an integral part of effluent trading.

Enforcement Mechanisms

Enforcement mechanisms are required to ensure that water quality standards and/or trading program goals are met, and that trading partners fulfill their trading agreements. This component was also designed to ensure that ETP planners address considerations related to the default of one or more trading partners, and the consequences of uncontrollable circumstances, such as pump failure or unusually heavy rainfall, that may result in short-term violations of trading agreements.

All 12 ETPs included provisions to ensure that effluent trades can be effectively enforced. Since trading provisions for point sources are typically incorporated into existing discharge permits, it was assumed that administrative, civil, and/or criminal penalties for any permit violation would also be applied to trading violations. Requirements for nonpoint source controls are generally enforced through local ordinances and land use regulations. None of the ETPs addressed uncontrollable circumstances that may result in temporary violations of trading agreements; however, amending trading rules to address such possibilities, or negotiating minimal penalties for such violations on an individual basis, could encourage trading, particularly if nonpoint sources are involved.

Program Evaluation

Periodic evaluations of ETP effectiveness are necessary to ensure that the program is protecting, or improving, water quality while reducing environmental compliance costs. Such evaluations are also useful for identifying necessary modifications of existing rules or addressing specific emerging circumstances within the trading area. Criteria questions associated with this component were related to responsibilities for ETP evaluation, the frequency of reviews, and the criteria that will be used to evaluate program effectiveness.

In most cases, individual effluent trades are reviewed as part of the permit renewal process (5-year cycle), and the ETPs themselves are subject to regularly scheduled reviews and revisions, as appropriate. For example, all water quality regulations in Colorado, including those implementing the Bear Creek Watershed ETP, the Chatfield Reservoir ETP, the Cherry Creek Reservoir ETP, and the Lake Dillon ETP, are subject to triennial review (Water Quality Control Commission 1997a, 1997b, 1997c, and 1998). Further, the Cherry Creek Reservoir ETP is subject to annual review by the Colorado Water Quality Control Commission, while the Tar-Pamlico River Basin ETP is reviewed every five years as part of the basinwide water quality management plan (Water Quality Control Commission, 1998; and North Carolina Division of Environmental Management, 1995). Watershed management organizations typically meet much more frequently to discuss various aspects of water quality management, including ETPs; for example, the SWQC associated with the Lake Dillon ETP meets every month (Ray, 1999). Unfortunately, none of the 12 ETPs delineated specific criteria that should be used to review the individual program.

Public Involvement

Public and stakeholder involvement throughout ETP design and implementation is needed to encourage participation in the trading program, to decrease controversy, and to minimize negative publicity. Criteria questions associated with this component were primarily related to ensuring that the public and relevant stakeholders support the ETP and are actively involved in its design and operation. The final question was related to educational and/or outreach efforts to increase public support by minimizing the perception that ETPs are "selling the right to pollute" and by increasing awareness of trading as an acceptable compliance alternative.

Most of the 12 ETPs involved the public and relevant stakeholders in ETP design and operation, at least to some degree. The primary participants were watershed management organizations; for example, the Bear Creek Watershed Authority, the Hunter Catchment Management Trust, the Summit Water Quality Committee, the Coalition for a Clean Minnesota River, the Minnesota Center for Environmental Advocacy, the North Carolina Environmental Defense Fund, and the Pamlico-Tar River Foundation were extensively involved in the design of their respective ETPs (Clayshulte, 1999b; Smith, 1999a; Ray, 1999; Senjem, 1999; and Hall and Howett, 1995). Industrial stakeholders, like the Rahr Malting Company, power stations, and coal mines, have also been involved in ETP design and implementation (Hall and Howett, 1995; Senjem, 1999; and Smith, 1999a). Since all 12 reviewed ETPs were either in effect or in the proposed stage, it was assumed that public support for such programs is sufficient. However, at least three programs (Chatfield Reservoir, Fox River, and Lake Dillon) identify limited public participation as a potential longer-term concern (Clayshulte, 1999c; Downing and David, 1998; and Ray, 1999).

Educational and outreach efforts to date in the 12 ETPs have been fairly limited and, when present, targeted primarily to potential trading partners. The only trading program which specifically addresses such efforts is the proposed Chesapeake Bay ETP, which recommends that brochures explaining the ETP be distributed by involved state agencies and placed on the MDE's website (Eskin and Kearny, 1997). In addition, the MDE, in conjunction with the state Departments of Natural Resources and Agriculture, and farm organizations, is expected to "market" the trading program and to identify potential trading opportunities.

OTHER FACTORS THAT MAY AFFECT ETP PLANNING AND IMPLEMENTATION

In addition to considering their ETPs relative to each of the 10 components of the qualitative model, program managers were asked to identify other factors that may have affected design, implementation, and/or operation. This request was included in the questionnaire so that such factors could be incorporated into the qualitative model as appropriate. Four completed questionnaires included suggestions for additional factors to be included in the qualitative model. These suggested factors were primarily related to the difficulties associated with nonpoint source participation in ETPs (Clayshulte, 1999b; and Senjem, 1999). Other suggested factors included ETP funding and the adequacy of water quality models for quantifying pollutant loadings, PRCs, and the environmental effects of trades (Ray, 1999; and Clayshulte, 1999c). However, since specific questions relative to point-nonpoint source trading, program funding, and water quality modeling have already been incorporated into the qualitative model, no modification of the qualitative model was deemed to be necessary. This conclusion was reached following careful examination of the questions in Table 6.4 and how they could lead to the consideration of the suggested factors.

Six of the 7 returned questionnaires also listed scientific, economic, and institutional barriers that may have affected ETP development and/or effectiveness. Scientific barriers included: (1) determining current and future maximum allowable pollutant loadings (Ray, 1999; and Smith, 1996b); (2) difficulties associated with measuring reductions in nonpoint source loadings (Senjem, 1999); (3) establishing ETP rules, including trading ratios, to ensure that point and nonpoint source reductions are equivalent (Senjem, 1999); and (4) limitations on the quantity and/or quality of data required to evaluate the environmental effects of trades (Sharma, 1999). Economic barriers, including modeling costs and the lack of sufficient staff to administer trading programs, were identified for the Bear Creek Watershed ETP, the Chatfield Reservoir ETP, and the Murray-Darling Basin's Salinity and Drainage Strategy (Clayshulte, 1999b, 1999c; and Sharma, 1999). Institutional barriers included acceptance by local stakeholders and environmental groups and the time constraints associated with the public notice requirements for discharge permits (Senjem, 1999; and Clayshulte, 1999b). However, again following careful review of the questions in Table 6.4, it was concluded that each of these barriers have been addressed within the qualitative model, thus its modification was not required.

CONCLUSIONS

This chapter provides "state-of-practice" information on ETPs which existed as of June, 1998. Twelve such ETPs were reviewed, with the included programs allowing point-point, point-nonpoint, and/or nonpoint-nonpoint source trades. The 12 programs were either actually in effect (11) or in the final proposal stage (one). All 12 trading programs involve nutrients or other pollutants whose environmental effects are primarily dependent upon total loading. However, since only 12 programs could be identified, it can obviously be concluded that very few ETPs exist. Further, actual trading activity in extant programs has also been limited. In some cases, such limitations have occurred because source operators do not need to rely on PRCs to meet their wasteload allocations. Scientific, economic, and institutional barriers have also contributed to lack of ETP development and the limited usage of trading.

This chapter was also designed to evaluate the qualitative model described in Chapter 5 through its application to actual ETPs. The first five model components (watershed suitability; pollutant type; trading market size and characteristics; legal authority; and administrative acceptability and capability) were designed to assess the feasibility of effluent trading in a particular watershed. Some of the criteria questions associated with these components were specifically addressed in the rules and/or guidelines for the 12 ETPs, while other questions, particularly those related to pollutant type and administrative acceptability and capability, must have been considered during program design. In any case, since the reviewed ETPs are either active or in the proposed stage, it can be concluded that the trading programs were feasible and had successfully addressed the issues associated with the first five model components.

The remaining five model components (specific policies, procedures, and trading rules; pre- and post-trade monitoring; enforcement mechanisms; program evaluation; and public involvement) can be used to aid in site-specific ETP design. Based on the results of this comparative review, it was noted that the level of detail with which these components are addressed in extant ETPs varies greatly. Most trading program components, including pre- and post-trade monitoring and enforcement mechanisms, are based on existing permitting procedures for point sources, thus simplifying ETP operation. However, due to difficulties in quantifying nonpoint source pollutant loadings, BMP effectiveness, and related PRCs, increased monitoring, modeling, reporting, and recordkeeping requirements are typically associated with nonpoint source trades. Furthermore, the regulations and guidelines for ETPs should be fairly detailed in order to reduce the uncertainty, perceived risk, and administrative burdens associated with trading program participation.

Issues and related criteria questions which were included in the qualitative model described in Chapter 5 but not specifically addressed in any of the 12 ETPs included: (1) the participation of non-dischargers in the ETP; (2) specific monitoring protocols; (3) additional monitoring requirements associated with trades; (4) uncontrollable circumstances that may result in short-term violations of trading agreements; and (5) detailed topics to be addressed in the periodic review of ETP effectiveness. However, these issues and their related criteria questions should be retained in the qualitative model since they may be significant as trading activity increases or in the design and implementation of future ETPs.

Finally, based on this comparative review of 12 ETPs in relation to the 10-component qualitative model, the following two conclusions can be drawn: (1) the reviewed ETPs incorporate both generic principles as well as appropriate site-specific features which should, in the longer term, provide opportunities for effluent trading to become a successful water quality management strategy; and (2) the qualitative model is adequate as a planning tool for trading program design and implementation, and for conducting comparative reviews of such programs.

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CHAPTER 7

USE OF THE QUALITATIVE MODEL FOR EVALUATING THE EFFLUENT TRADING PROGRAM FOR LAKE DILLON, COLORADO

INTRODUCTION

Effluent trading programs (ETPs) are being developed as a cost-effective means of achieving water quality goals, standards, and objectives within selected watersheds. In addition, such programs encourage pollution prevention, promote the development and installation of more efficient abatement technologies, and may even reduce pollutant loadings from previously unregulated sources, thus improving the overall water quality management efforts within the watersheds. However, experience with similar market-related programs, primarily for air quality management in the United States, has indicated that the success of ETPs may be limited by technical, institutional, and administrative factors that increase the uncertainty and expense associated with ETP participation or administration. In order for ETPs to realize their full potential, such factors must be identified, and trading programs must be designed and periodically evaluated to minimize or eliminate their negative influence.

This chapter illustrates the application of the qualitative model for designing and implementing ETPs to the Lake Dillon ETP, an existing point-nonpoint and nonpoint-nonpoint source trading program in a watershed near Denver, Colorado. This study was designed to test the applicability of the model for an existing ETP and to identify any necessary revisions. The chapter begins with brief descriptions of the Lake Dillon watershed and the development and current status of the ETP. The major section herein highlights the actual application of the model to the Lake Dillon ETP. The chapter concludes with a discussion of effluent trading as a management tool for the Lake Dillon watershed, the use of ETPs in similar situations, and the use of the qualitative model for reviewing extant ETPs.

DESCRIPTION OF LAKE DILLON WATERSHED AND ETP

Lake Dillon, which is a manmade impoundment covering more than 1,800 surface acres, is located approximately 70 miles west of Denver in Summit County, Colorado. Summit County had one of the highest growth rates in the United States in the 1970s (Water Quality Control Commission, 1997; and Apogee Research, Inc., 1992). As shown in Figure 7.1, the key communities within the watershed include Breckenridge, Copper Mountain, Dillon, Frisco, and Keystone. In addition to its prominence within the watershed, Lake Dillon is an important source of drinking water for the Denver metropolitan area (Zander, 1991). Further, the lake supports many recreational activities, including water skiing, sailing, and fishing. The total value of Lake Dillon to the regional economy, including both market and non-market components, has been estimated to exceed $15.6 million annually (Water Quality Control Commission, 1997).

Excessive phosphorus loadings to Lake Dillon, which were due in part to lack of phosphorus removal in publicly owned treatment works (POTWs), runoff from towns and ski areas, and inadequate septic tank systems, began to threaten lake water quality in the early 1980s (Draft Trading Update, 1997). Accordingly, the U.S. Environmental Protection Agency (USEPA) funded a "Clean Lakes Program" study of Lake Dillon, which was completed in 1983 (Apogee Research, Inc., 1992). The study concluded that phosphorus was the primary pollutant of concern and that the lake would become eutrophic if phosphorus loadings increased above 1982 levels (Anderson, 1995). In addition, it was noted that even if point source discharges of phosphorus were

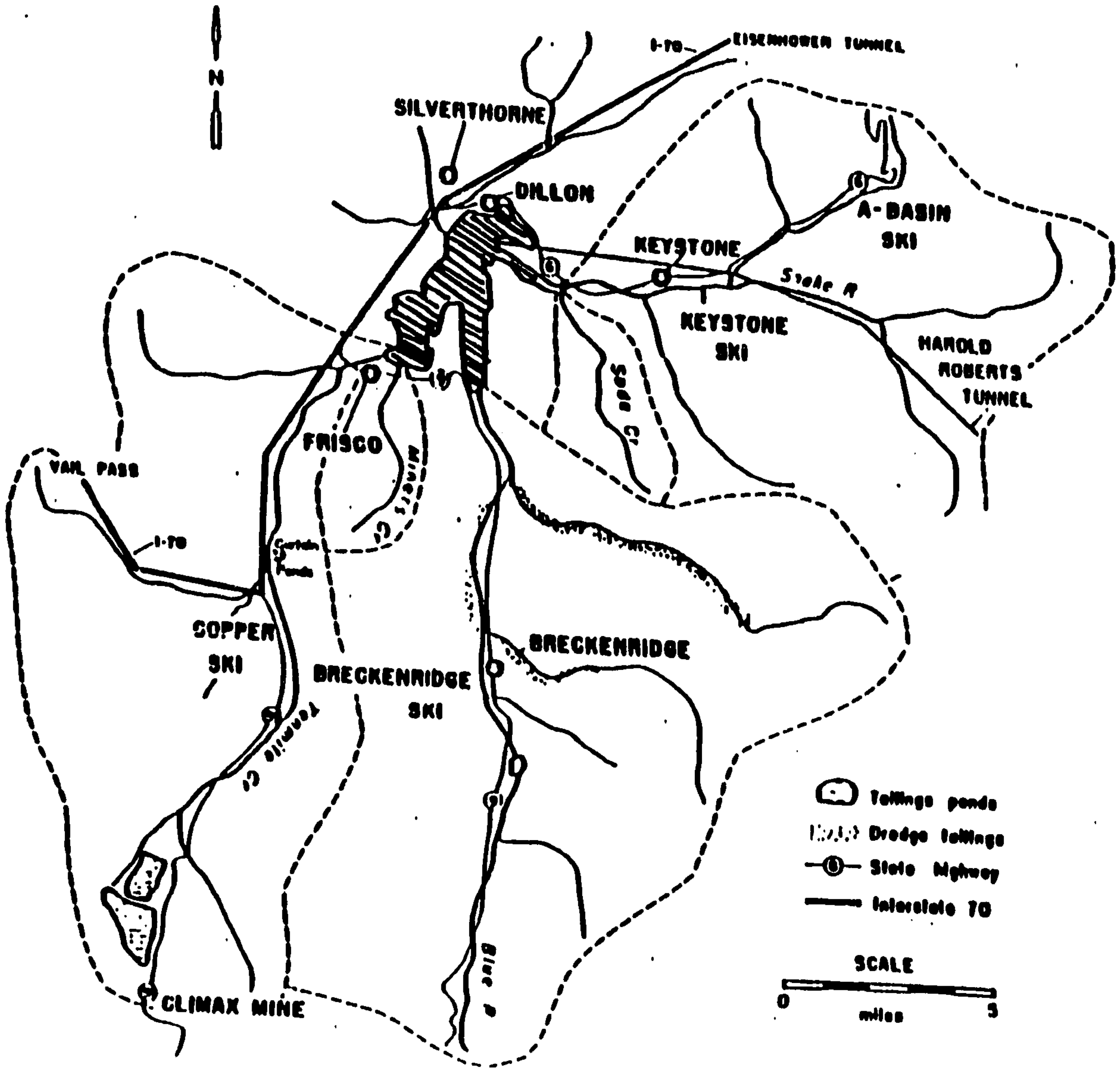

Figure 7.1: Lake Dillon Watershed (Apogee Research, Inc., 1992)

completely eliminated, the lake could still become eutrophic unless nonpoint source phosphorus loadings associated with population growth and economic development were controlled.

As a consequence of the Lake Dillon study, the Colorado Water Quality Control Commission (WQCC) encouraged agencies within the watershed to develop a comprehensive phosphorus reduction strategy that would prevent eutrophication while still allowing controlled future development (Apogee Research, Inc., 1992). The Northwest Colorado Council of Governments (NWCCOG) formed a committee, which subsequently evolved into the Summit Water Quality Committee (SWQC), to address these issues. Committee membership included representatives from the state and Summit County, six municipalities, two ski developments, three sanitation districts, one mining company, the Denver Water Board (which owns and operates the reservoir), environmental advocacy groups, and USEPA.

The SWQC's plan, which was entitled the "Dillon Water Quality Management Plan" and adopted by the WQCC in 1984, established a total phosphorus loading cap for all sources in the watershed, assigned individual phosphorus loading caps to POTWs, and created the first point-nonpoint source ETP in the United States (Apogee Research, Inc., 1992). The Lake Dillon ETP allows operators of POTWs to increase their phosphorus allocations by more cost-effectively reducing phosphorus loadings from urban nonpoint sources that existed as of July 30, 1984, the date the Dillon Water Quality Management Plan went into effect (Water Quality Control Commission, 1997). An adopted trading ratio of 2:1, which requires point source operators to reduce nonpoint source phosphorus loadings by two pounds for every pound of phosphorus reduction credit they receive, both offsets nonpoint source loadings due to growth and provides a "eutrophication safety factor" (Zander, 1991). However, as of 1997, only two point-nonpoint trades had been documented. In both cases, the Breckenridge

Sanitation District received phosphorus reduction credits for removing facilities from individual septic tank systems and connecting them to its sewer system (Water Quality Control Commission, 1997).

The Lake Dillon ETP was initially focused on point-nonpoint trading, thus allowing continued population growth in the watershed while maintaining phosphorus water quality in the lake. However, development activities in the watershed slowed in the late 1980s, and the POTW operators were able to significantly decrease their phosphorus loadings by making minor plant alterations which significantly improved the operating efficiencies of existing treatment processes (Apogee Research, Inc., 1992). As a result, only 2 percent of the current total phosphorus loading to Lake Dillon is attributed to point sources, and, even if the watershed is developed to its maximum population density, POTWs should not exceed their phosphorus loading allocations. However, the phosphorus loading cap for nonpoint sources, which can be determined by subtracting the sum of point source and background phosphorus allocations from the total basinwide loading cap, may ultimately constrain growth and development in the watershed. Therefore, the focus of the Lake Dillon ETP has now shifted from point-nonpoint source trading to nonpoint-nonpoint source trading. In general, operators of new nonpoint sources of phosphorus must meet local requirements for new development and offset any remaining increases in phosphorus loadings with phosphorus reduction credits from existing urban nonpoint sources.

Two nonpoint-nonpoint trades have also been implemented (Apogee Research, Inc., 1992). In the first trade, the Frisco Sanitation District generated phosphorus reduction credits by improving its stormwater management. These credits will be applied, using a trading ratio of 1:1, to offset the increase in phosphorus loading associated with a planned golf course in Frisco. In the second trade, the Snake River Wastewater Treatment Facility generated phosphorus reduction credits by re-routing Soda Creek through a detention structure. Some of these credits will be applied, also using a trading ratio of 1:1, to partially offset the expected increase in Lake Dillon phosphorus loading associated with the Denver Water Board's plan to divert another stream from outside the watershed into the lake. More detailed information regarding specific elements of the Lake Dillon ETP will be discussed in the following sections as each component of the applied qualitative model is evaluated.

THE QUALITATIVE MODEL

As part of this research effort, a qualitative model comprised of ten components and 37 criteria questions was developed as a basis for designing and implementing ETPs (Edwards and Canter, 1998). Each model component and its importance relative to successful ETPs are summarized in Table 7.1, while the criteria questions associated with the components are listed in Table 7.2. The qualitative model can be used to evaluate existing or proposed ETPs by answering each criteria question with program-specific information and then rating each component according to the compliance information shown in Table 7.3. Although the resulting ratings should not be averaged to yield a single score, they can be used to compare the relative features of different components, to identify components that may need to be modified, and to compare the characteristics of two or more ETPs. Alternatively, the model can be used to evaluate the potential for an ETP in a particular watershed and, if the potential is sufficient, to then aid in watershed-specific ETP design.

The qualitative model has been applied to 12 extant ETPs, including more in-depth case studies of Lake Dillon and the Tar-Pamlico River Basin in North Carolina. Further, it has been used to

Table 7.1: Components of the Qualitative Model and Their Importance to Successful ETPs (Edwards and Canter, 1998)

Component of Qualitative Model	Rationale for Inclusion in the Qualitative Model
Watershed Suitability	This component is designed to ensure that the geographic and temporal boundaries of the ETP are clearly defined. In addition, circumstances within the watershed (or trading area) that either encourage or discourage effluent trading must be identified and addressed.
Pollutant Type	This component is designed to identify pollutants that may be suitable for inclusion in an ETP. ETP designers must also decide if program rules will allow inter-pollutant trading.
Trading Market Size and Characteristics	This component is designed to identify all sources of the pollutant(s) of interest in the ETP area, their relative contributions to total pollutant loading, and differences in their marginal abatement costs that may promote effluent trading. This component is also focused on identifying market characteristics, such as the presence of direct competitors, that may influence trading activity.
Legal Authority	This component is included to identify whether existing laws and regulations fully support, or could be amended to support, the development and operation of an ETP.
Administrative Acceptability and Capability	This component is used to identify whether the administering agency has sufficient knowledge and information to design and implement an ETP. This component is also for determining whether agency staff are willing to use effluent trading as an alternative to more traditional forms of regulation.
Specific Policies, Procedures, and Trading Rules	Specific policies, procedures, and rules are needed to reduce uncertainty, to minimize regulatory and administrative burdens, and to reduce transaction costs. Such rules should encompass all aspects of an ETP, from determining the maximum allowable pollutant loading to reviewing proposed trades to penalizing trading partners who violate their trading agreements.
Pre- and Post-Trade Monitoring	Pre- and post-trade monitoring is required to determine the environmental effects of individual trades and of the overall ETP.

Table 7.1 (continued):

Component of Qualitative Model	Rationale for Inclusion in the Qualitative Model
Enforcement Mechanisms	Enforcement mechanisms are required in order to ensure that water quality standards and/or ETP goals are met and that trading partners fulfill the terms of their agreements.
Program Evaluation	Periodic evaluations of ETP performance are necessary in order to ensure that the ETP is protecting, or improving, water quality while reducing environmental compliance costs. Periodic evaluation of the ETP itself is also recommended in order to identify any necessary modifications.
Public Involvement	Public and stakeholder involvement throughout ETP design and operation is needed in order to encourage participation in the trading program, to decrease controversy, and to minimize the potential for negative publicity.

Table 7.2: Criteria Questions for Each Component of the Qualitative Model for Designing and Implementing ETPs (Edwards and Canter, 1998)

Watershed Suitability 1. Does the watershed (or watershed segment or estuarine zone) have a clearly defined geographic boundary? What is the basis for defining the watershed, segment, or zone? 2. Are temporal variations in flow well understood? 3. Do existing water quality conditions or other circumstances within the watershed encourage the use of an ETP? 4. Are there circumstances within the watershed that would discourage the use of an ETP?
Pollutant Type 1. Are the pollutant(s) of interest classified as conservative, non-conservative, or toxic? 2. Will inter-pollutant trading be allowed? What is the basis for the decision to permit or prohibit inter-pollutant trading? 3. Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality? 4. Do the environmental effects of the pollutant(s) of interest result more from total loading over time than local, short-term toxic effects? 5. Can mass- or concentration-based limits be established for the pollutant(s) of interest?
Trading Market Size and Characteristics 1. Have all sources of the pollutant(s) of interest been identified? 2. Are the relative contributions of all source categories (point, nonpoint, and background) known? 3. Are temporal variations in loadings of the pollutant(s) of interest well understood? 4. Are there significant differences in marginal abatement costs among sources in the same category and/or sources in different categories? 5. Could sources and/or governmental entities within the watershed be potentially unwilling to trade? 6. Are there unique circumstances that may influence the behavior of market participants?
Legal Authority 1. Are there water quality standards, goals, and/or objectives that can be used as a basis for the ETP? 2. Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so? 3. Is there an existing agency with sufficient authority to implement and enforce an ETP, can such authority be conferred on an existing agency, or can such an agency be created? 4. Does the implementing agency have sufficient authority to require all contributing sources to meet their discharge allocations?

Table 7.2 (continued):

<u>Administrative Acceptability and Capability</u> 1. Does the administering agency have sufficient knowledge and information to designate the maximum allowable pollutant loading for the watershed, to allocate portions of that loading to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades as well as the overall trading program? 2. Is the administering agency willing to use effluent trading as a management strategy to supplement traditional regulation? 3. Does the administering agency have sufficient resources to design and implement an ETP?
<u>Specific Policies, Procedures, and Trading Rules</u> 1. If nonpoint sources are to be included in the ETP, do policies or procedures account for their inherent variability? 2. Have procedures been clearly defined for the following aspects of the ETP? (a) determination of the maximum allowable pollutant loading for the watershed (b) allocating portions of the loading cap to all sources within the watershed that discharge the pollutant(s) of interest (c) types of trades that will be allowed (d) trading ratio(s) 3. Have rules or procedures been clearly defined for the following operational aspects of the ETP? (a) quantifying and certifying pollutant reduction credits (PRCs) (b) quantifying the environmental impacts of trades (c) application procedures for proposed trades (d) administrative procedures for the evaluation of proposed trades (e) time periods that trades remain in effect (f) treatment of banked or shutdown credits (g) reporting and recordkeeping requirements 4. Will non-dischargers, such as environmental groups, be allowed to purchase and retire PRCs?
<u>Pre- and Post-Trade Monitoring</u> 1. Are responsibilities for pre- and post-trade source and ambient water quality monitoring clearly defined? 2. Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for both source and ambient water quality monitoring? 3. Will source monitoring requirements discourage trading activity?
<u>Enforcement Mechanisms</u> 1. Can trading agreements be effectively enforced for each source category? 2. Should uncontrollable circumstances for both point and nonpoint sources be considered in the enforcement process?

Table 7.2 (continued):

<u>Program Evaluation</u> 1. Are responsibilities for evaluating ETP performance clearly defined? 2. How often will the ETP be reviewed? 3. Have the criteria that will be used tc evaluate ETP performance been specified?
<u>Public Involvement</u> 1. Was the public, including industries and municipalities, actively involved in ETP design and operation? 2. In general, did industries, municipalities, government agencies, and the public support the development of the ETP? 3. Does the ETP include any educational and/or outreach efforts designed to increase public support?

Table 7.3: Rating Scheme for Each Component of Qualitative Model (Edwards and Canter, 1998)

Degree of Compliance With Criteria Questions for Each Component	Rating
Compliant from all perspectives	4
Compliant from majority of perspectives	3
Compliant from only a few perspectives	2
Compliant from no perspectives	1
Degree of compliance with perspectives depends upon specific ETP design	0

examine the feasibility for an ETP for Lake Geneva on the boundary between Switzerland and France. The model has also been applied to a hypothetical canning plant in Oklahoma in the United States, and a local pretreatment program, also in Oklahoma. The model can be modified, as necessary, to reflect concerns unique to intra-plant and pretreatment ETPs, respectively.

APPLICATION OF THE QUALITATIVE MODEL TO THE LAKE DILLON ETP

The answers to the criteria questions associated with each component of the qualitative model are summarized in the following sections. Responses were based on watershed- and program-specific information obtained through a literature review and telephonic interviews with relevant stakeholders. The summary for each model component indicates its assigned rating, and the associated rationale, and includes a discussion of any implications and/or resultant needs. Summary information on the ratings for each of the ten components is shown in Table 7.4.

WATERSHED SUITABILITY

Geographic Boundaries

The geographic boundary of an ETP provides information needed to determine the maximum allowable pollutant loading, to identify the area subject to post-trade ambient water quality monitoring, and to identify the point and nonpoint pollutant sources that will be eligible to participate in the trading program. The boundaries of the Lake Dillon ETP encompass the 212,900 acres in the watershed, including land located between the Continental Divide and the lake as well as the lake itself (Ray, 1999). Accordingly, the geographical boundaries of the ETP are clearly delineated.

Flow Variations

Information regarding flows into and from Lake Dillon is needed to determine the maximum allowable pollutant loading and to convert

Table 7.4: Summary of Ratings of Qualitative Model Components Regarding the Lake Dillon ETP

Component of Qualitative Model	Rating of Degree of Compliance[a]	Rationale for Assigned Compliance Rating	Implications and Resultant Needs
Watershed Suitability	4	The geographic boundaries of the watershed have been clearly defined, temporal variations in flow have been addressed, and circumstances within the watershed encouraged the development of an ETP. In addition, the ETP has been expanded to include nonpoint-nonpoint source trading.	ETP rules may need to be revised as a result of the shift in program focus from point-nonpoint source trading to nonpoint-nonpoint source trading.
Pollutant Type	3	The environmental impacts of phosphorus are primarily related to total loading, effluent limits can be readily established, and phosphorus can be easily classified as a non-conservative pollutant. However, the Lake Dillon ETP apparently fails to recognize the varying environmental effects that different physical and chemical forms of phosphorus may exhibit.	As additional monitoring data becomes available and the Lake Dillon water quality model is updated to become more technically sophisticated, ETP rules should probably be expanded to include provisions addressing the various forms of phosphorus.
Trading Market Size and Characteristics	4	All sources of phosphorus have been identified, their relative contributions to total loading have been determined, and temporal variations in pollutant loadings have been addressed. In addition, there are differences in marginal abatement costs that may encourage point-nonpoint or nonpoint-nonpoint trading.	Data concerning the annual phosphorus budget in the watershed and the marginal abatement costs of point and nonpoint sources should be continuously collected, thus allowing for more in-depth evaluations of ETP performance and refinement of the ETP.
Legal Authority	3	The relevant ambient water quality standard for phosphorus serves as the basis for the ETP, and regulations adopted by the WQCC provide sufficient legal authority to implement and enforce all point-nonpoint source trading activities. In addition, ETP rules designated the Water Quality Control Division (WQCD) of the Colorado Department of Public Health and Environment as the agency primarily responsible for ETP administration, and there are no apparent loopholes that would discourage trading activity. However, similar concerns for nonpoint-nonpoint source trades were not addressed in ETP rules.	Nonpoint-nonpoint source trading provisions should be included in future revisions of ETP regulations.

Table 7.4 (continued):

Component of Qualitative Model	Rating of Degree of Compliance[a]	Rationale for Assigned Compliance Rating	Implications and Resultant Needs
Administrative Acceptability and Capability	3	Both federal and state agencies support effluent trading for water quality management, and sufficient information was available, both to design the ETP and to evaluate its performance. However, the lack of designated funds for ETP operation may be problematic.	Additional funds for ETP operation could be provided through governmental allocations, grants, or initial and annual fees assessed to trading partners.
Specific Policies, Procedures, and Trading Rules	3	Most of the criteria questions are addressed in the Lake Dillon ETP rules. In addition, some of the questions that are not directly addressed, such as recordkeeping requirements and the length of time that trades will be effective, can be inferred from existing permitting procedures. However, ETP rules fail to address the use and disposition of banked credits and the mechanics of nonpoint-nonpoint source trading.	In order to encourage trading activity, provisions addressing banked credits and nonpoint-nonpoint source trading issues should be included in future revisions of ETP rules.
Pre- and Post-Trade Monitoring	4	Monitoring responsibilities have been clearly assigned, monitoring protocols have been specified, and the additional monitoring required by program rules should not adversely affect ETP participation.	Monitoring data should be continuously collected in order to evaluate ETP performance and to refine the Lake Dillon water quality model.
Enforcement Mechanisms	3	Enforcement mechanisms are sufficient to ensure that both point and nonpoint sources meet their trading obligations and that lake water quality will be protected, even if BMPs fail to generate the anticipated phosphorus reduction credits. However, ETP rules do not address how nonpoint-nonpoint source trading agreements will be enforced.	In order to encourage trading activity, ETP rules should be modified to address enforcement of nonpoint-nonpoint source trades. In addition, ETP rules may need to be modified to distinguish between deliberate violations of trading agreements and violations that are due to uncontrollable circumstances within the watershed.
Program Evaluation	3	The responsibility for evaluating ETP rules has been clearly assigned and the frequency of ETP review has been determined. However, specific criteria to evaluate ETP performance were not identified.	The use of specific criteria to evaluate ETP performance is recommended in order to simplify the administrative burden of ETP review and to standardize ETP evaluations over time.

Table 7.4 (continued):

Component of Qualitative Model	Rating of Degree of Compliance[a]	Rationale for Assigned Compliance Rating	Implications and Resultant Needs
Public Involvement	3	Relevant stakeholders were directly involved in ETP design and can participate in ETP operation, either by joining the SWQC or by submitting comments to the WQCC during the triennial review process. However, only limited public information regarding the ETP is available.	In order to encourage trading activity, educational and outreach efforts should be intensified, particularly as the need for nonpoint-nonpoint source trading increases.

[a]4 = compliant from all perspectives; 3 = compliant from majority of perspectives; 2 = compliant from only a few perspectives; 1 = compliant from no perspectives; 0 = degree of compliance with perspectives depends upon specific ETP design

concentration-based phosphorus limits to pollutant loadings. Sufficient data regarding such flows were available to support the development of a computerized water quality model for Lake Dillon as part of the USEPA's Clean Lakes Program study (Apogee Research, Inc., 1992). Such information was also used in planning the ETP. Subsequent variations in annual hydrology are adjusted by using the 1982 flow conditions as a reference point (Ray, 1999).

Conditions Encouraging Effluent Trading

Three conditions in the Lake Dillon watershed that were conducive to the development and implementation of an ETP were identified in this review. First, the failure to develop an effective phosphorus reduction strategy would have severely affected future growth in the neighboring communities and point sources in the watershed. For example, if Lake Dillon became eutrophic, the surrounding communities could have lost more than $2 million annually in recreational and economic benefits, and local officials might have been required to reduce nonpoint phosphorus loadings by restricting development (Water Quality Control Commission, 1997; and Zander, 1991). Similarly, point sources may have been required to spend as much as $1.5 million annually to remove phosphorus from their effluent (Water Quality Control Commission, 1997). Second, the Lake Dillon ETP provides the basis for cost-effective mechanisms to reduce phosphorus loadings from urban nonpoint sources. Such reductions are essential, even if point source phosphorus discharges are completely eliminated, to ensure that the overall phosphorus loading cap for the watershed is not exceeded (Apogee Research, Inc., 1992). Third, multiple stakeholders in the watershed, including dischargers, federal and state regulators, and environmental advocacy groups, were willing to cooperate and invest personnel and monetary resources in the development of the ETP.

Conditions Discouraging Effluent Trading

Due to reduced rates of development in the watershed beginning in the late 1980s and improved phosphorus removal efficiencies at POTWs in the early 1990s, point sources have not needed to rely on point-nonpoint source trading to achieve their phosphorus allocations (Apogee Research, Inc., 1992). In addition, since POTWs have become minor contributors to the total phosphorus loading, nonpoint source discharges can no longer be effectively controlled through point-nonpoint source trading activities. However, the presence of an overall phosphorus loading cap for Lake Dillon, which essentially requires new nonpoint sources of phosphorus to obtain phosphorus reduction credits from existing nonpoint sources, has encouraged nonpoint-nonpoint source trading.

Summary of Watershed Suitability

The watershed suitability component of the qualitative model was assigned a rating of "4," as shown in Table 7.4, since the geographic boundaries of the watershed have been clearly defined, temporal variations in flow have been ascertained, and circumstances within the watershed encouraged the development of an ETP. Even in the absence of an active point-nonpoint source trading market, the program can be judged a success since the participating POTWs have dramatically reduced their phosphorus loadings, and existing water quality levels in the lake have been preserved (Apogee Research, Inc., 1992). In addition, the ETP has been expanded to include nonpoint-nonpoint source trading, thus maintaining lake water quality while allowing continued population growth and economic development in the watershed. However, trading program rules need to be revised as a result of the shift in ETP focus.

POLLUTANT TYPE

Pollutant Classification

The classification of the transport and fate characteristics of the pollutant(s) of interest must be determined in order to select appropriate water quality models and predict pollutant-generated water quality effects. The Lake Dillon ETP is designed to prevent future water quality deterioration by reducing phosphorus loading from the watershed (Apogee Research, Inc., 1992). Phosphorus is considered to be non-conservative due to biological incorporation in algae, sorption, and chemical precipitation. While it is beyond the scope of this case study, it should be noted that considerable information is available on phosphorus behavior in lake systems.

Inter-pollutant Trading

The rules governing the Lake Dillon ETP are applicable to a single pollutant; that is, total phosphorus (Water Quality Control Commission, 1997). As a result, inter-pollutant trading, which would allow sources in the watershed to exchange pollutant reduction credits (PRCs) for different pollutants, is not possible at this time.

Pollutant Forms

The water quality and aquatic ecosystem impacts of a given pollutant depend upon the form in which it is released into the environment and its related transport and fate characteristics. For example, only the soluble inorganic forms of phosphorus, such as phosphate, are readily available for incorporation into algae. Therefore, even though particulate phosphorus loadings from nonpoint sources may be an order of magnitude greater in quantity, soluble phosphorus loadings from POTWs, which are primarily in the phosphate form, may have the greater environmental impact (Reckhow, et al., 1980). The current Lake Dillon ETP rules apply only to total phosphorus (Water Quality Control Commission, 1997). While this requirement may neglect some of the environmental effects associated with the physical and/or chemical form of phosphorus, it encourages trading activity by limiting the number of regulated pollutants, thus reducing associated water quality modeling and monitoring costs.

Environmental Effects

Although trading programs are designed to improve overall water quality, pollutant discharges at specific locations may increase as a result of trading. However, since the environmental effects of phosphorus are primarily due to total loading, rather than site-specific concentrations, such localized increases should be of lesser concern.

Pollutant Limits

ETP participants must be able to quantify their discharges of total phosphorus relative to either mass- or concentration-based limits, or both. Concentration-based effluent limitations and annual mass-based loadings have been established for point sources in the Lake Dillon ETP (Water Quality Control Commission, 1997). Such limits are a fundamental requisite for an ETP to be successful.

Summary of Pollutant Type

As shown in Table 7.4, the pollutant type component of the qualitative model received a rating of "3" based on considerations related to the facts that the environmental impacts of phosphorus are primarily related to total loading, pollutant limits can be readily established, and phosphorus can be appropriately classified as a non-conservative pollutant. However, since loading allocations were for total phosphorus, the Lake Dillon ETP apparently fails to recognize the varying environmental effects that different forms of phosphorus may exhibit. As additional information becomes available and the Lake Dillon water quality model is further refined in its technical sophistication, trading program rules should be expanded to include provisions related to the various forms of phosphorus.

TRADING MARKET SIZE AND CHARACTERISTICS

Pollutant Sources

All point and nonpoint sources of phosphorus in the watershed must be identified in order to establish an accurate annual lake budget and to determine the most effective control strategies. In addition, identifying all sources maximizes the number of potential trading partners, thus increasing the possible economic incentive to trade. The USEPA's Clean Lakes Program study of Lake Dillon identified the following sources of phosphorus (Apogee Research, Inc., 1992): (1) background sources, including precipitation, ground water, and natural runoff; (2) anthropogenic nonpoint sources, including seepage from inadequate septic tank systems and runoff from parking lots, golf courses, ski developments, and construction sites; and (3) point sources, including four POTWs associated with the communities of Breckenridge, Copper Mountain, Frisco, and Keystone. Only regulated point sources and nonpoint sources that existed as of July 30, 1984, are eligible to participate in point-nonpoint source trading, while the nonpoint-nonpoint source trading provisions apply to both pre-and post-1984 nonpoint sources.

Relative Contributions

As part of the Clean Lakes Program study, data from 1982 were used to determine the relative contributions of point, nonpoint, and background sources to the total phosphorus loading in Lake Dillon (Apogee Research, Inc., 1992). As shown in Table 7.5, more than 50 percent of the loading was attributable to background sources, while nonpoint and point sources contributed approximately 20 and 18 percent of the loading, respectively. Since background sources are essentially impossible to control, the Lake Dillon ETP initially

Table 7.5: Annual Phosphorus Budget for Lake Dillon Based on the 1983 Clean Lakes Program Study by the USEPA (Apogee Research, Inc., 1992; Ray, 1999; and Summit Water Quality Committee, 1995)

Source Category	Percent of TP[a] Loading[b]	Examples of Sources in Category	Comments
Background	>50	Precipitation, ground water, and natural runoff	Unusually high due to snowmelt from mountain slopes; extremely difficult to control
Nonpoint	20	Inadequate septic tank systems and runoff from paved lots, golf courses, ski developments, and construction sites	Can be controlled using best management practices (BMPs) such as detention ponds, grassed swales, and filter strips; the most cost-effective BMP is sewering areas that were previously on septic tank systems
Point	18	POTWs at Breckenridge, Copper Mountain, Frisco, and Keystone	Subsequently reduced to 2 percent of the TP loading through improved operating efficiencies at POTWs

[a]Total Phosphorus

[b]Based on 1982 lake water levels, stream and river flows, and phosphorus concentrations

focused on point-nonpoint source trading. However, since point sources have drastically reduced their phosphorus loadings through improved treatment efficiencies, point-nonpoint source trading is no longer technically nor economically feasible, thus the ETP has evolved to include nonpoint-nonpoint source trading.

Temporal Variations

ETP designers need information concerning temporal variations in pollutant loadings in order to determine the maximum allowable pollutant loading and to maximize the effectiveness of source discharge and ambient water quality monitoring programs. Phosphorus allocations for point sources were based on their 1982 discharge levels, while nonpoint source loadings are adjusted to reflect 1982 conditions (Apogee Research, Inc., 1992). These allocations included considerations of the temporal variations of phosphorus loadings.

Marginal Abatement Costs

Unlike most ETPs, the Lake Dillon trading program was not specifically designed to reduce environmental compliance costs within the watershed. Instead, it was designed to protect water quality without sacrificing population growth and economic development in the watershed (Apogee Research, Inc., 1992). Nonetheless, a USEPA study did estimate that the difference in marginal abatement costs between POTWs and urban nonpoint sources could be as high as $663 per pound of total phosphorus, thus providing another incentive to participate in the ETP (Apogee Research, Inc., 1992). However, the actual difference in marginal abatement costs is probably much less since the USEPA's estimate was based on assumptions that dramatically overestimated phosphorus loadings from POTWs. In addition, their estimate did not account for the 2:1 trading ratio and the individual wasteload allocations specified in the Lake Dillon ETP rules. Similarly, although there are differences in the marginal abatement costs for phosphorus reductions between best management practices (BMPs), the nonpoint-nonpoint source trading provisions of the ETP have been primarily utilized to allow continued growth and development in the watershed (Summit Water Quality Committee, 1995).

Unwillingness to Trade

The economic theory and associated implications underlying ETPs indicate that both point and nonpoint source operators may be unwilling to participate in an ETP if trading will significantly reduce the environmental compliance costs of their competitors. Source operators with excess pollutant reduction credits may also prefer to save them in order to meet future water quality standards or to allow future expansion, particularly if the trading program activity is minimal. Although it is extremely unlikely that the current POTWS will need to increase their phosphorus allocations through trading, the unwillingness of POTW operators to trade is not expected to affect the Lake Dillon ETP since the POTWs are not direct economic competitors. In addition, both point and nonpoint sources in the watershed have an incentive to meet the overall phosphorus loading cap.

Unique Circumstances

The economic theory underlying ETPs also indicates that all dischargers will seek to minimize their environmental compliance costs; however, this may not always apply to POTWs and nonpoint sources. This situation should not affect the Lake Dillon ETP since the current emphasis is on accommodating growth and development in the watershed, not reducing environmental compliance costs. In addition, since three of the four POTWs have engaged in trades, it was assumed that local community regulations did not prohibit their participation in ETPs (Apogee Research, Inc., 1992).

Summary of Trading Market Size and Characteristics

The trading market size and characteristics component of the qualitative model was assigned a rating of "4," as shown in Table 7.4, since all phosphorus sources have been identified, their relative contributions to the total loading have been determined, and temporal variations in pollutant loadings have been addressed. In addition, even though the Lake Dillon ETP is not designed specifically to reduce environmental compliance costs, there are differences in marginal abatement costs that encourage point-nonpoint source trading or nonpoint-nonpoint source trading. It is recommended that data concerning the annual phosphorus budget for Lake Dillon and the marginal abatement costs for phosphorus removal from point and nonpoint sources in the watershed be continuously collected, thus allowing for more in-depth evaluations of ETP performance and appropriate refinements as necessary.

LEGAL AUTHORITY

Standards, Goals, and/or Objectives

The ambient water quality standard for total phosphorus in Lake Dillon, which is 7.4 $\mu g/l$ in the top 15 meters as a "growing season" average, was used to determine the maximum allowable pollutant loading. This loading then served as the technical basis for development of the ETP (Water Quality Control Commission, 1997). In addition, the standard for total phosphorus can be used to evaluate the environmental effects of trades as well as the overall ETP performance. More general goals and objectives for Lake Dillon included minimizing lake eutrophication and maintaining an acceptable water source for Denver.

Legal Support

In order to reduce the uncertainty and perceived risk associated with ETP participation, existing laws or regulations should clearly support effluent trading as a compliance alternative. The "Dillon Reservoir Control Regulation," which was first adopted by the Colorado WQCC in 1984, provides such support for the Lake Dillon ETP (Water Quality Control Commission, 1997).

Administering Agency

The agency or agencies administering the ETP must have sufficient legal authority to implement and enforce all aspects of the trading program; for example, from establishing the maximum allowable pollutant loading to enforcing the provisions of trading agreements. The necessary legal authority for the Lake Dillon ETP is shared among three entities: the Colorado WQCC, the Colorado Water Quality Control Division (WQCD) within the Colorado Department of Public Health and Environment, and the Regional Office of the USEPA located in Denver. The WQCC is responsible for adopting regulations to govern the ETP, while the WQCD is responsible for issuing discharge permits that incorporate point-nonpoint source trades, quantifying phosphorus reduction credits, and evaluating applications for proposed trades (Water Quality Control Commission, 1997). The USEPA's Regional Office reviews proposed trades to ensure that they will not violate applicable regulations or negatively affect lake water quality (Apogee Research, Inc., 1992).

In general, distributing ETP authority among several different agencies would be anticipated to increase the costs and uncertainty associated with effluent trading, thus decreasing trading activity. In the Dillon ETP, however, potential trading partners interact primarily with the WQCD, and point-nonpoint source trades are simply incorporated into the existing permitting process for point sources. Both provisions should simplify ETP participation, thus encouraging trading activity. Finally, it should be noted that a permit program does not exist for nonpoint sources in the watershed.

Agency Authority

In order for an ETP to result in water quality improvement, all point and nonpoint sources in the watershed must receive a discharge allocation that they are required to meet by either continuing current operations, installing pollution abatement equipment, changing production processes, and/or purchasing pollutant reduction credits (PRCs). Otherwise, potential "loopholes," such as waivers, variances, grants, and subsidies, could negatively affect ETP performance by increasing the total phosphorus loading and reducing the size of the trading market. No such loopholes were identified within the Lake Dillon ETP; for example, provisions in their discharge permits require POTWs to meet their phosphorus allocations, either by upgrading their own facilities or by obtaining PRCs from existing urban nonpoint sources in the watershed (Water Quality Control Commission, 1997). Specific provisions and requirements for nonpoint sources have not been thoroughly developed.

Summary of Legal Authority

As shown in Table 7.4, the legal authority component of the qualitative model was rated as a "3." The relevant ambient water quality standard for total phosphorus serves as the basis for the ETP, and regulations adopted by the WQCC provide sufficient legal authority to implement and enforce all point-nonpoint source trading activities. In addition, ETP rules designated the WQCD as the agency primarily responsible for ETP administration, and there were no apparent loopholes that would discourage trading activity. However, similar issues for nonpoint-nonpoint source trades have not yet been addressed within the ETP rules. Given the recent shift in program focus from point-nonpoint source trading to nonpoint-nonpoint source trading, such provisions should be included in future revisions of ETP regulations.

ADMINISTRATIVE ACCEPTABILITY AND CAPABILITY

Knowledge and Information

Considerable data are required to design and operate effective ETPs. Sufficient information for the design of the Lake Dillon program was provided by: (1) the USEPA's Clean Lakes Program study; (2) a demonstration project for urban runoff control; and (3) a study comparing the costs of nonpoint source BMPs to advanced wastewater treatment technologies (Apogee Research, Inc., 1992). Additional sources of information include the Lake Dillon water quality model, also developed as part of the Clean Lakes Program study, and discharge and receiving water monitoring data collected by point sources as a condition of their discharge permits, by the SWQC, and by sources that participate in the ETP (Apogee Research, Inc., 1992; Summit Water Quality Committee, 1995; and Water Quality Control Commission, 1997).

Willingness to Use ETPs

In order for point and nonpoint sources in the Lake Dillon watershed to be willing to rely on effluent trading to meet their compliance obligations, the relevant governmental agencies must actively promote the trading program as an acceptable alternative to more traditional source-oriented command and control strategies for water quality management. It was assumed that relevant state and federal agencies, along with local governmental entities and stakeholders, supported the Lake Dillon ETP since they actively participated in its design (Zander, 1991). In addition, the Colorado WQCC promulgated regulations authorizing the trading program (Water Quality Control Commission, 1997).

Resources

Similar to any regulatory program, ETPs require sufficient staff and funding to function successfully. Funding for initial studies used to establish the ETP was provided by the USEPA (Apogee Research, Inc., 1992). Subsequent ETP rules did not specifically address funding for ETP operations (Water Quality Control Commission, 1997). However, since point-nonpoint source trading provisions are incorporated into existing discharge permits, it was assumed that the current technical and financial resources of the WQCD would be sufficient to support the ETP, particularly if trading activity remains limited. Finally, the SWQC provides approximately $70,000 annually for water quality monitoring and other related projects in the Lake Dillon watershed (Ray, 1999).

Summary of Administrative Acceptability and Capability

As shown in Table 7.4, the administrative acceptability and capability component of the qualitative model was assigned a rating of "3" since federal, state, and local agencies support effluent trading as a strategy for water quality management. In addition, the USEPA's studies provided sufficient information to design the Lake Dillon ETP, while the site-specific water quality model and monitoring data collected by multiple affected sources are available to evaluate ETP effectiveness. Although funding was available for ETP design and has continued for lake water quality monitoring, the absence of designated funds for ETP operation could be problematic, particularly if nonpoint-nonpoint source trading activity increases. Additional funds for ETP operation could be provided through governmental allocations, grants, and/or initial and annual fees assessed to trading partners.

SPECIFIC POLICIES, PROCEDURES, AND TRADING RULES

Nonpoint Source Variability

Nonpoint source phosphorus loadings, as well as the potential effectiveness of BMPs used to control them, vary with local meteorological, topographical, and land use conditions. As a result, accurately determining the number of nonpoint source PRCs available for trading may be difficult. The Lake Dillon ETP accounts for this variability in several ways. First, PRCs must be quantified using either site-specific data or appropriate water quality modeling techniques (Water Quality Control Commission, 1997). In addition, the determinations must be reviewed and approved by the WQCD. Second, since 1982 was an unusually wet year, adjusting estimates of nonpoint source loadings to 1982 conditions represents a "worst-case" scenario for nonpoint source phosphorus loadings to Lake Dillon (Apogee Research, Inc., 1992). Finally, the on-going lake water quality monitoring program, which is sponsored by the SWQC, provides important information regarding current nonpoint source loadings and BMP effectiveness.

ETP Procedures

Maximum Allowable Pollutant Loading

Establishing the maximum allowable phosphorus loading, or loading cap, that is necessary for achieving the Lake Dillon ETP goals is essential due to the following reasons: (1) the loading cap can be used to establish the total amount of phosphorus from all sources (background, nonpoint, and point) that can be discharged in the watershed; (2) the loading cap can be used to specify individual discharge allocations for point and nonpoint sources; and (3) compliance with the loading cap can be used as one criterion to evaluate overall ETP effectiveness.

The phosphorus loading cap for Lake Dillon was established at 10,162 pounds per year; this amount was determined using the Lake Dillon water quality model. The cap represents the maximum quantity of total phosphorus that the lake can receive without violating the ambient water quality standard of 7.4 μg/l (Apogee Research, Inc., 1992; and Water Quality Control Commission, 1997).

Loading Allocations

Loading allocations determine the quantity of phosphorus that each point source and identifiable nonpoint source may discharge into receiving waters. By comparing their current discharges to their loading allocations, and considering pertinent marginal abatement costs for additional phosphorus reductions, source operators can determine their most cost-effective compliance alternatives. The Lake Dillon ETP rules specify individual wasteload allocations for POTWs, shown in Table 7.6, that were based on their total phosphorus loadings in 1982 (Water Quality Control Commission, 1997; and Apogee Research, Inc., 1992). ETP rules also include phosphorus allocations for other domestic wastewater dischargers, including large septic tank systems and small mechanical wastewater treatment plants that are required to have discharge permits (Water Quality Control Commission, 1997; and Summit Water Quality Committee, 1995). However, because these facilities do not discharge directly to Lake Dillon, they are not considered point sources for the purpose of this case study.

Types of Trades

The Lake Dillon ETP allows point-nonpoint source trading among POTWs and urban nonpoint sources that existed as of July 30, 1984 (Water Quality Control Commission, 1997). In addition, the program has recently expanded to include nonpoint-nonpoint source trading. Current trading program rules do not address intra-plant or pretreatment trading, and a proposal to allow point-point source trading was rejected by the WQCC during a recent review of ETP rules.

Trading Ratio(s)

The Lake Dillon ETP rules specify a point-nonpoint source trading ratio of 2:1, which requires point sources to reduce nonpoint source phosphorus loadings by two pounds for every pound of

Table 7.6: Wasteload Allocations for Total Phosphorus Discharge (Water Quality Control Commission, 1997)

Phosphorus Source	Loading Allocation (lb/yr)
POTWs	
Breckenridge Sanitation District	675.5
Copper Mountain Water and Sanitation District	165
Frisco Sanitation District	341
Snake River Wastewater Treatment Facility	340
Subtotal	1,521.5
Minor Domestic Sources[a]	59.9
Grand Total	1,581.4

[a]Includes allocations for Bekkedal Subdivision, French Creek Industrial Park, High Country Lodge, Keystone A-Basin, Keystone Summit House, McDill Placer Subdivision, Skier's Edge/Quandry Condominiums, South Blue River Sanitation Company, Summit Motor Inn, Tiger Run Resort, Vail Pass Rest Stop, and Valley of the Blue Condominiums.

phosphorus reduction credit they receive (Water Quality Control Commission, 1997). This trading ratio was designed to offset nonpoint source phosphorus loadings due to population growth and economic development and to provide a margin of safety (Zander, 1991). After meeting local requirements for new development, new nonpoint sources must offset any remaining increases in phosphorus loadings with equivalent reductions from existing urban nonpoint sources, thus implying a nonpoint-nonpoint source trading ratio of 1:1 (Apogee Research, Inc., 1992).

Trading ratios should be reviewed periodically and revised as necessary. For example, as POTWs in the watershed become even more efficient, trading ratios may need to be increased in order to fully offset the nonpoint source phosphorus loading associated with growth and development (Apogee Research, Inc., 1992). Alternatively, if nonpoint source BMPs become more cost-effective, trading ratios could be reduced, thus increasing the economic incentive for point source-nonpoint source trading.

Operational Aspects

Quantifying and Certifying PRCs

Participating point and nonpoint source operators in an ETP must be able to accurately determine their discharge allocations and current discharge levels in order to calculate the PRCs they are eligible to sell, lease, or purchase. According to the Lake Dillon ETP rules, PRCs for phosphorus must be calculated using site-specific data or appropriate water quality modeling, and they must be approved by the WQCD (Water Quality Control Commission, 1997).

Environmental Impacts

The Lake Dillon water quality model, which was initially used to determine the overall phosphorus loading cap for the watershed, can be used to predict changes in phosphorus loadings resulting from proposed trades (Apogee Research, Inc., 1992). Further, the model can be used to predict the water quality and aquatic ecosystems impacts of proposed trades, as well as the overall impacts of the ETP. Ambient water quality monitoring data can also be used to determine the environmental impacts of trades.

Application Procedures

Clearly defined application procedures are needed to ensure ETP consistency and uniformity, to simplify administrative review, and to reduce uncertainty and transaction costs for program participants. According to the Lake Dillon ETP rules, a point source interested in trading must submit an application to the WQCD which contains the following information (Water Quality Control Commission, 1997): (1) design specifications for the nonpoint source BMP; (2) the quantity of total phosphorus that will be removed; (3) proposed construction requirements; (4) proposed operation and maintenance requirements to ensure continued BMP effectiveness; and (5) proposed monitoring and reporting requirements. However, corresponding requirements for nonpoint-nonpoint source trading applications have not yet been developed.

Evaluation of Proposed Trades

Administrative procedures for the review of proposed trades are also needed for ETP consistency and to reduce stakeholder uncertainty. Since specific review procedures are not identified in the Lake Dillon ETP rules, it was assumed that the existing review process for discharge permits would also apply to trading applications. In addition, ETP rules do state that such applications must comply with any regulations or guidelines for nonpoint source BMPs that have been adopted by the WQCC (Water Quality Control Commission, 1997). Finally, before granting PRCs, the WQCD must ensure that local governments in the watershed have enacted regulations to reduce phosphorus loadings from new nonpoint sources.

Time Periods

In order to reduce the uncertainty associated with ETP participation, the length of time that a trade will be in effect should be specified. Since the Lake Dillon ETP rules did not specifically address time periods for trading, it was assumed that the effective period for each trade would be determined independently and, since such trades are included in discharge permits, that all trades would be reviewed at least once every five years as part of the permit renewal process (Water Quality Control Commission, 1997). However, the point-nonpoint source trades that have occurred to date are permanent since they involved sewering areas that previously relied on septic tank systems.

Banked or Shutdown Credits

The rules for the Lake Dillon ETP do not address the documentation and use of "banked credits," which are generated when a source saves excess PRCs for its own future use or sale to other sources, or "shutdown credits," which are generated as a result of a source operator closing part or all of its phosphorus discharge activities.

Reporting and Recordkeeping

Reporting and recordkeeping provisions are needed to demonstrate source compliance with discharge allocations and trading rules, and to aid in overall ETP evaluation. The Lake Dillon ETP rules include trade-specific monitoring and reporting requirements as a condition of point-nonpoint source trade approval (Water Quality Control Commission, 1997). In addition, the WQCD must report the results of BMP inspections to the WQCC and local governments, and the SWQC issues periodic reports on Lake Dillon water quality management efforts, including trading, to the WQCC (Water Quality Control Commission, 1997; and Draft Trading Update, 1997). Recordkeeping provisions are not addressed in the current ETP rules, presumably because they are already included in discharge permits for point sources. Reporting and recordkeeping requirements need to be developed for nonpoint-nonpoint source trading.

Non-dischargers

Provisions that would allow non-dischargers, such as non-governmental organizations, environmental groups, or individual citizens, to purchase and retire PRCs were not identified in the Lake Dillon ETP rules. In fact, since trading requirements are so closely associated with point source discharge permits, even nonpoint-nonpoint source trades that do not directly involve a POTW, like the re-routing of Soda Creek mentioned earlier, must be sponsored by a point source operator, thus discouraging direct nonpoint-nonpoint source trading activity in the watershed.

Summary of Specific Policies, Procedures, and Trading Rules

The specific policies, procedures, and trading rules component of the qualitative model was assigned a rating of "3," as shown in Table 7.4, since most of the included criteria are addressed by the Lake Dillon ETP rules. In addition, some of the criteria that are not directly addressed, such as recordkeeping requirements and the length of time that trades will be in effect, can be inferred from existing point source permitting procedures. However, the ETP rules did fail to address two issues which may significantly affect trading activity. First, since POTWs do not currently need PRCs to increase their wasteload allocations, any PRCs they generate will probably be banked for future use or sale. In the absence of rules governing the use and disposition of such banked credits, POTWs may be reluctant to engage in point-nonpoint source trades. Second, the Lake Dillon ETP rules include very little information regarding the mechanics of nonpoint-nonpoint source trading, thus increasing the uncertainty and perceived risk of ETP participation for operators of these sources. In order to encourage trading activity, provisions addressing both of the issues should be included in future revisions of the ETP rules.

PRE- AND POST-TRADE MONITORING

Monitoring Responsibilities

Source discharge and ambient water quality monitoring data are needed to determine compliance with discharge allocations, the environmental effects of individual trades, and the effectiveness of the overall ETP. In order to ensure consistency, to reduce uncertainty, and to eliminate duplication of effort, the responsibilities for such monitoring should be clearly distributed among trading partners and pertinent governmental agencies. In the Lake Dillon ETP, monitoring responsibilities have been assigned to trading partners, the WQCD, and the SWQC. Point sources are required to monitor for total phosphorus at least once per month, while monitoring requirements for nonpoint sources are specified in permits authorizing point-nonpoint source trades (Water Quality Control Commission, 1997). The WQCD may inspect nonpoint source BMPs, and the SWQC sponsors an ongoing lake water quality monitoring program (Water Quality Control Commission, 1997; and Apogee Research, Inc., 1992). Therefore, it can be concluded that monitoring responsibilities are delineated, with the overall monitoring efforts including several features.

Monitoring Protocols

Monitoring protocols are also needed to reduce uncertainty and to ensure ETP consistency. According to Lake Dillon ETP rules, monitoring protocols for nonpoint sources must be based on guidelines and regulations adopted by the WQCC (Water Quality Control

Commission, 1997). Monitoring protocols for POTWs are included in their discharge permits; and any ambient water quality monitoring conducted by the WQCD or the SWQC is in accordance with standardized procedures, including appropriate quality assurance/quality control (QA/QC).

Monitoring and Trading Activity

Additional monitoring requirements associated with effluent trading do increase transaction costs. However, such requirements are essential to ensure the protection of water quality and the achievement of the Lake Dillon ETP goals. In general, pre- and post-trade monitoring requirements are not expected to affect the Lake Dillon ETP since the program's primary focus is toward allowing population growth and economic development within the watershed. In addition, water quality data collected by the WQCD and the SWQC can probably be used to reduce specific monitoring requirements for trading partners.

Summary of Pre- and Post-Trading Monitoring

As shown in Table 7.4, the pre-and post-trade monitoring component of the qualitative model received a rating of "4" since monitoring responsibilities have been clearly assigned and relevant protocols have been specified. Furthermore, the additional monitoring required by the trading rules should not adversely affect ETP participation. Source discharge and ambient water quality monitoring data should be routinely collected in order to evaluate ETP performance and to refine the Lake Dillon water quality model.

ENFORCEMENT MECHANISMS

Effective Enforcement

Effective enforcement of an ETP can help to ensure that included water quality goals are met and trading partners are fulfilling the terms of their trading agreements. According to the

Lake Dillon ETP rules, POTW operators who participate in point-nonpoint source trades receive discharge permits specifying: (1) the amount of PRCs they will receive; (2) construction, operation, and maintenance requirements for nonpoint BMPs; and (3) monitoring and reporting requirements (Water Quality Control Commission, 1997). In addition, their discharge permits are modified to include two limits for total phosphorus. The first limit represents the POTW's allocation if the trade is not implemented or is unsuccessful, while the second limit represents the increased allocation associated with a successful trade (Apogee Research, Inc., 1992). If nonpoint source BMPs do not generate sufficient PRCs, the first, more stringent limit automatically applies. While this provision ensures that trades involving nonpoint sources can be adequately enforced and that water quality will be protected, it may discourage trading activity, particularly if there are uncertainties regarding nonpoint source phosphorus loadings and BMP effectiveness.

The Lake Dillon ETP rules do not address how trades involving two or more nonpoint sources not holding discharge permits will be enforced (Water Quality Control Commission, 1997). Requiring that such trades be sponsored by POTWs in the watershed would simplify enforcement but, by increasing the difficulty and expense of negotiating trading agreements, it could eliminate much of the incentive for nonpoint source operators to participate in the ETP.

Uncontrollable Circumstances

Circumstances that cannot be controlled for point sources, such as pump failure, and for nonpoint sources, such as unusually heavy rainfall, may result in the violation of trading agreements. The Lake Dillon ETP rules do not consider uncontrollable circumstances for point-nonpoint source trades; in fact, point sources are automatically subject to more stringent phosphorus limits if nonpoint source BMPs do not generate sufficient PRCs (Apogee Research, Inc., 1992). Rules for addressing nonpoint-nonpoint trades subject to uncontrollable circumstances are not currently included in the Lake Dillon ETP (Water Quality Control Commission, 1997).

Summary of Enforcement Mechanisms

As shown in Table 7.4, the enforcement mechanisms component of the qualitative model was assigned a rating of "3." Current enforcement mechanisms are sufficient to ensure that both point and nonpoint sources meet their trading obligations and that lake water quality will be protected, even if BMPs fail to generate the anticipated PRCs. However, ETP rules do not address how nonpoint-nonpoint source trading agreements will be enforced. In order to encourage trading activity, particularly as nonpoint source loadings associated with development activities increase, trading program rules should be modified to incorporate features related to the enforcement of nonpoint-nonpoint source trades. In addition, ETP rules may need to be modified to distinguish between deliberate violations of trading agreements and violations that are due to uncontrollable circumstances within the watershed.

PROGRAM EVALUATION

Responsibilities for ETP Evaluation

ETP performance should be periodically evaluated to ensure that the program is both protecting, or improving, existing water quality and reducing environmental compliance costs. If the program is not functioning successfully, or if conditions within the watershed have changed since the ETP design, the program may need to be modified. Responsibility for reviewing the rules governing the Lake Dillon ETP has been assigned to the WQCC (Water Quality Control Commission, 1997). However, no routine performance evaluations of the ETP are specified within the rules.

Review Frequency

Similar to all water quality regulations in the state of Colorado, the Lake Dillon ETP rules are reviewed every three years (Ray, 1999). In addition, the SWQC meets monthly to discuss the ETP and other issues pertaining to Lake Dillon water quality management.

ETP Performance Criteria

The Lake Dillon ETP rules do not specify the review criteria that should be used to evaluate trading program performance. However, for the purposes of this case study, it was assumed that past review criteria were informal and included the environmental effects of trading, the economic advantages and disadvantages of trading, and continued willingness to participate in or to administer the ETP.

Summary of Program Evaluation

The program evaluation component of the qualitative model was assigned a rating of "3," as shown in Table 7.4, since the responsibility for evaluating ETP rules has been clearly assigned and the frequency of ETP review has been determined. However, specific criteria to evaluate ETP performance were not identified. The development of such criteria is recommended in order to simplify the administrative burden of ETP review and to standardize ETP evaluations over time.

PUBLIC INVOLVEMENT

Active Involvement

Public participation is recommended in order to encourage program participation, to decrease controversy, and to minimize the potential for negative publicity. Relevant stakeholders, including municipalities, ski developments, sanitation districts, one mining company, the Denver Water Board, and environmental advocacy groups were involved with ETP design, and they continue to review operations, primarily through their membership in the SWQC (Apogee

Research, Inc., 1992). The SWQC proposed the original point-nonpoint source ETP and currently sponsors water quality monitoring programs and other related projects in the Lake Dillon watershed (Zander, 1991; and Ray, 1999). In addition, the Committee holds monthly meetings, which are open to the public, to discuss Lake Dillon water quality management issues (Ray, 1999). Stakeholders may also submit comments on ETP rules to the WQCC as part of the Commission's triennial review process.

Public Support

In general, regulatory agencies, point source operators, and the general public have supported the development and use of the Lake Dillon ETP. Stakeholders in the watershed are expected to continue to support the ETP as a mechanism to prevent eutrophication of Lake Dillon, thus preserving the recreational and economic benefits associated with the lake without restricting growth and development in the watershed. Explicit support for the ETP was demonstrated by the WQCD and the Denver Regional Office of the USEPA, who helped to design the ETP, and by the WQCC, who promulgated regulations implementing the trading program (Zander, 1991; and Water Quality Control Commission, 1997). In addition, since three of the four POTWs who are eligible to participate in the ETP have engaged in trades, it was assumed that the POTW operators are also supportive of the trading program (Apogee Research, Inc., 1992).

Educational and/or Outreach Efforts

Educational and outreach programs encourage ETP participation by eliminating the perception that ETPs are "selling the right to pollute" and increasing awareness of the ETP as an environmental compliance alternative. No specific educational or outreach efforts were identified in the Lake Dillon ETP rules. However, the monthly meetings of the SWQC are open to the general public, and the NWCCOG, which serves as administrative staff for the Committee, can fulfill requests for information regarding the Lake Dillon ETP (Ray, 1999; and Apogee Research, Inc., 1992). In addition, several articles and reports on the Lake Dillon ETP have been published in both trade journals and peer-reviewed technical journals.

Summary of Public Involvement

The public involvement component of the qualitative model was given a rating of "3," as shown in Table 7.4, since relevant stakeholders were directly involved in ETP design. In addition, stakeholders can participate in operational issues either by joining the SWQC or by submitting comments to the WQCC during their triennial review process. However, information regarding the Lake Dillon ETP is not widely distributed within the watershed. Therefore, in order to encourage trading activity, educational and outreach efforts should be intensified. Since nonpoint source operators may be unaware of both the ETP and the cost-effectiveness of BMPs for phosphorus control, such efforts may become particularly important as the need increases to offset phosphorus loadings associated with population growth and economic development.

CONCLUSIONS

An active point-nonpoint source trading market within the Lake Dillon ETP has yet to develop, primarily because POTWs in the watershed substantially reduced their phosphorus discharges in the late 1980s and early 1990s by improving their operating efficiencies. Ambient lake water quality has been maintained, and, based on the extant point-nonpoint source trades, ETP rules appear to be sufficient to review, monitor, and enforce trades (Apogee Research, Inc., 1992). Therefore, relative to water quality management planning for the watershed, the ETP has been successful. In addition, the trading program will allow POTWs to increase their phosphorus loading allocations in the future; and this may become necessary dependent on population growth and economic development in Summit County and surrounding areas in the watershed. POTWs may also need to rely on PRCs from nonpoint sources if they are unable to maintain their current operating efficiencies (Summit Water Quality Committee, 1995).

In addition, the Lake Dillon ETP has been expanded to include nonpoint-nonpoint source trading, thus further encouraging growth and development in the watershed. However, the absence of specific policies, procedures, and trading rules for nonpoint-nonpoint source trades may negatively affect trading activity. For example, if the rules applying to each trade must be negotiated separately, the incentive to trade may be reduced or eliminated, particularly if multiple regulatory agencies are involved. As another example, nonpoint-nonpoint source trades may be difficult to enforce since trading provisions cannot be incorporated into existing discharge permits. To date, nonpoint-nonpoint trades have been sponsored by a POTW, an approach which, while increasing the probability of effective enforcement and protecting lake water quality, increases the transaction costs and uncertainties of trading.

Based on the results of this evaluation, it can be concluded that ETPs would be applicable to watersheds that are experiencing water quality impairment due to total phosphorus loadings, particularly if the associated river, lake, or estuary provides significant economic or recreational benefits to the region, and stakeholders are willing to work together. However, since specific rules for the Lake Dillon ETP will probably not be directly applicable to other watersheds, ETPs in other watersheds should be adjusted to site-specific conditions.

This case study was designed to evaluate the applicability of the qualitative model for designing and implementing ETPs to the existing Lake Dillon trading program and to identify any necessary modifications in the model or the Lake Dillon ETP. Since all ten model components received scores of "3" or "4," the qualitative model indicated that the Lake Dillon ETP should be successful; and this conclusion has been supported by the various reviews of the trading program itself (Apogee Research, Inc., 1992; and Zander, 1991). In addition, this review did not identify any necessary modifications to the qualitative model. To some degree, this result was expected because the qualitative model itself was primarily developed based on reviews of existing point-point, point-nonpoint, and nonpoint-nonpoint source ETPs. As a result, the model already included many of the specific issues addressed in the Lake Dillon ETP.

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CHAPTER 8

USE OF THE QUALITATIVE MODEL FOR EVALUATING THE EFFLUENT TRADING PROGRAM IN THE TAR-PAMLICO RIVER BASIN

INTRODUCTION

Effluent trading programs (ETPs) have been proposed as a cost-effective means for achieving water quality goals, standards, and objectives within specific watersheds. In addition, such programs encourage pollution prevention, promote the development and installation of more efficient abatement technologies for point sources, and may even lead to the reduction of pollutant loadings from previously unregulated sources (nonpoint sources), thus enhancing overall water quality management efforts within the watersheds. However, experience with similar trading programs, for example, emissions trading in air quality management in the United States, has indicated that the success of ETPs may be limited by technical, institutional, and administrative factors that increase uncertainty, and initial and operational costs associated with ETP participation or administration. In order for ETPs to realize their full potential, such limiting factors must be identified, and trading programs must be designed to minimize or eliminate their negative influence.

This chapter summarizes the application of a qualitative model for designing, implementing, and evaluating ETPs to the Tar-Pamlico River Basin ETP, an existing point-point and point-nonpoint source trading program in eastern North Carolina. This case study was designed to test the applicability of the model for evaluating existing ETPs and to identify any necessary revisions.

This chapter begins with brief descriptions of the Tar-Pamlico River Basin, the initial development of the ETP, and Phases I and II of the trading program. The next section summarizes features of the qualitative model. The major section addresses the application of the model to the Tar-Pamlico ETP. The chapter concludes with a discussion of the use of effluent trading as a management tool for the Tar-Pamlico River Basin, the use of ETPs in similar situations, and any necessary modifications to the qualitative model.

DESCRIPTION OF THE TAR-PAMLICO RIVER BASIN

The Tar-Pamlico River Basin, which is a 5,400 square-mile watershed in eastern North Carolina, contains portions of 17 counties and over 2,300 miles of rivers and streams (Apogee Research, Inc., 1992; and Hall and Howett, 1995). As shown in Figure 8.1, the Tar River flows from the western edge of the watershed and widens to form the Pamlico River just east of Washington, North Carolina. The Pamlico River, in turn, widens to form the Pamlico River Estuary and ultimately flows into Pamlico Sound, which is part of the second largest estuary in the United States (Hall and Howett, 1994). The Pamlico Estuary provides valuable wildlife habitat and supports boating, swimming, and recreational and commercial fishing (U.S. Environmental Protection Agency, 1993). In addition, the Tar-Pamlico River supplies drinking water to eight cities and towns in central and eastern North Carolina. The most significant land uses in the watershed are for agriculture, primarily row-crop cultivation and confined livestock operations, and forestry.

Water quality problems in the Pamlico Estuary include diseased fish, fish kills, phytoplankton blooms, low levels of dissolved oxygen, and losses of submerged aquatic vegetation. These problems have been attributed, at least in part, to excessive nutrient loading from both point sources, such as publicly owned treatment works (POTWs) and industrial wastewater treatment plants (WWTPs), and

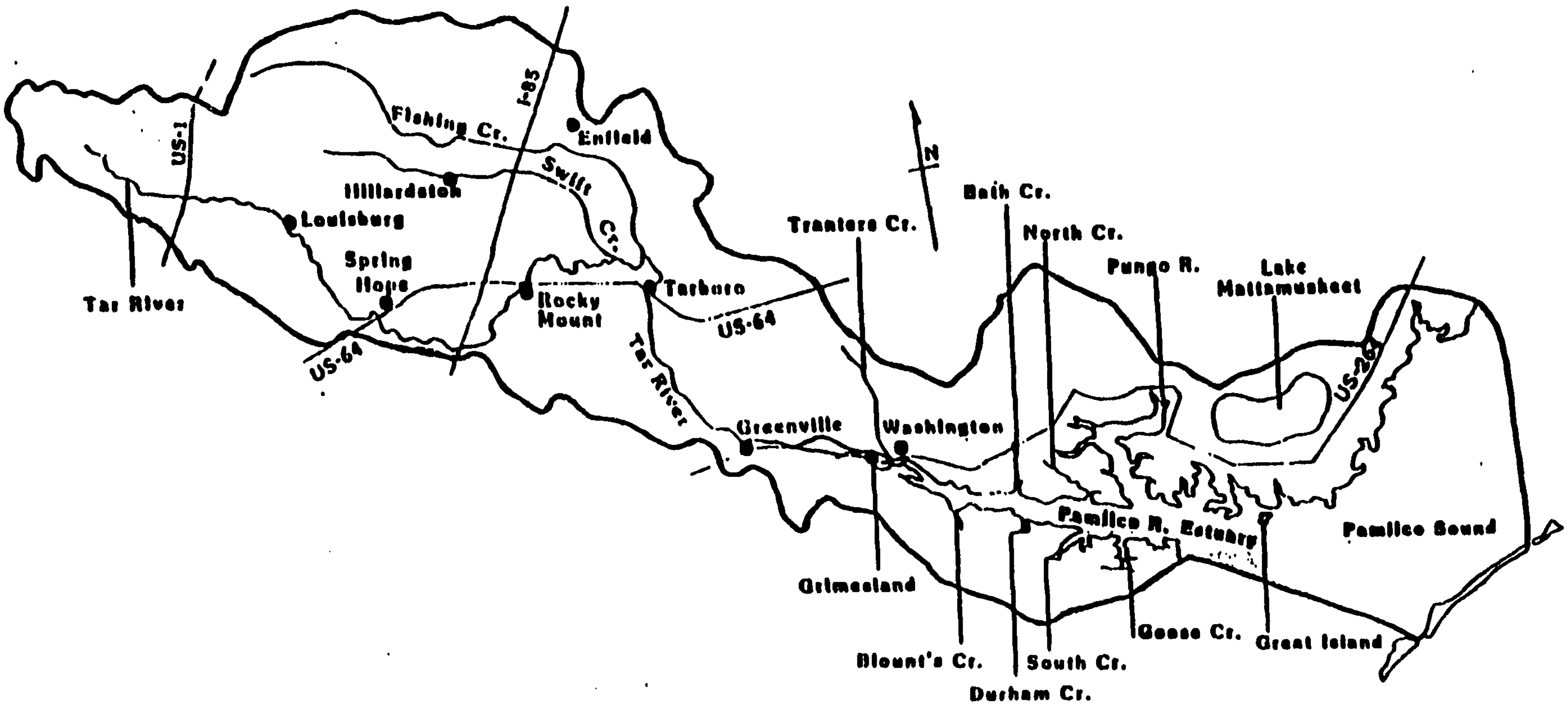

Figure 8.1: Tar-Pamlico Watershed (Apogee Research, Inc., 1992)

nonpoint sources, such as agricultural, silvicultural, and urban runoff (U.S. Environmental Protection Agency, 1993). In response to these problems, in 1989 the North Carolina Environmental Management Commission (EMC) designated the Tar-Pamlico watershed as containing "Nutrient Sensitive Waters" (NSW). Consequently, the Division of Environmental Management (DEM), part of the North Carolina Department of Environment, Health, and Natural Resources (DEHNR), was required to design and implement a basin-specific nutrient management plan.

DEM's draft management plan established the following nutrient-related effluent limitations for new and expanding point sources in the watershed (U.S. Environmental Protection Agency, 1993): (1) 2 mg/l total phosphorus; (2) 4 mg/l total nitrogen in the summer; and (3) 8 mg/l total nitrogen in the winter. Point source operators in the watershed were opposed to DEM's strategy and effluent limitations because of expected significant increases in their environmental compliance costs. In addition, since point sources were responsible for only 17 percent of the total nitrogen loading, such effluent limitations, although strict, were expected to have relatively little effect in reducing the overall nutrient loading to the Tar-Pamlico riverine system (Hall and Howett, 1995). Environmental groups also opposed the DEM's strategy and effluent limitations, in part because they did not contain specific nutrient reduction targets and did not adequately address nonpoint nutrient sources.

The Tar-Pamlico Basin Association (TPBA), a group of 12 POTWs and one industrial WWTP that were jointly responsible for 80 percent of the total permitted effluent flow in the watershed, worked with the North Carolina Environmental Defense Fund, the Pamlico-Tar River Foundation, and the DEM to develop a cost-effective alternative to the DEM's original nutrient management plan. The alternative plan, which was entitled the "Tar-Pamlico NSW Implementation Strategy" and which incorporated point-point source and point-nonpoint source trading, was approved by the EMC in December, 1989.

During the first phase of the NSW implementation strategy, which lasted from 1990 through 1994, the TPBA agreed to the following major provisions (Hall and Howett, 1995):

(1) Members of the TPBA (with the exception of National Spinning -- the one industrial WWTP) were jointly responsible for meeting a nutrient loading cap, which decreased annually as shown in Table 8.1. A member POTW could reduce its nutrient loading by installing additional abatement equipment or by engaging in point-point source trading with another member POTW.

(2) If the nutrient loading cap was exceeded, the TPBA was required to purchase nonpoint source reduction credits, at a rate of $56 per kilogram, from the State of North Carolina's Agricultural Cost Share Program (ACSP). Payments to the ACSP would then be used to implement agricultural best management practices (BMPs) in the Tar-Pamlico watershed, thus decreasing nonpoint nutrient loadings.

(3) The TPBA agreed to hire an engineering firm to evaluate each member POTW and to recommend minor improvements that would reduce nutrient loadings. National Spinning, the only industrial member of the TPBA, was required to conduct a similar evaluation. Implementing these recommendations enabled TPBA members to meet their loading caps without purchasing nonpoint source reduction credits.

(4) TPBA contributed $500,000 to the ACSP to ensure a minimum level of BMP funding. In addition, the TPBA contributed $150,000 to the Division of Soil and Water Conservation (DSWC), the section of the North Carolina DEHNR that administers the ACSP, to fund additional staff to manage BMPs in the Tar-Pamlico watershed.

(5) TPBA also funded the development of an estuarine computer model, which was to be used to refine nutrient loading caps for Phase II of the implementation strategy.

(6) TPBA members (except National Spinning) were required to monitor their total nitrogen and total phosphorus effluent loadings on a weekly basis. The results of these monitoring efforts were then aggregated and presented as an annual report to the DEM.

Phase II of the implementation strategy, which began in 1995 and continues through 2004, was approved by the EMC on December 8, 1994 (Hall and Howett, 1995). Phase II was based on the use of the estuarine model, developed during Phase I, to establish nutrient reduction goals for all point and nonpoint sources in the Tar-Pamlico

Table 8.1: Tar-Pamlico Basin Association's Nutrient Reductions for Phase I of the NSW Implementation Strategy (Hall and Howett, 1995)

Year	Total Allowable Loading (kg/yr)	Measured Total Nitrogen (kg)	Measured Total Phosphorus (kg)	Measured Total Nutrients (kg)
1991	525,000	396,916	64,478	461,394 (-12%)[a]
1992	500,000	386,014	50,113	436,128 (-13%)
1993	475,000	371,336	45,881	417,217 (-12%)
1994	425,000	319,578	51,623	371,201 (-12%)

a: measured total is 12% lower than the total allowable loading watershed, as well as specific loading caps for total nitrogen and total phosphorus for the TPBA. Phase II included adding another TPBA member, the Tarboro POTW. Further, the cost of purchasing nonpoint nutrient reduction credits was reduced from $56 to $29 per kilogram during Phase II. However, the North Carolina Environmental Defense Fund and the Pamlico-Tar River Foundation did not endorse Phase II due to concerns about the annual loading cap and the strategy's ability to address nonpoint sources (Draft Trading Update, 1997).

More detailed information regarding specific elements of the Tar-Pamlico Basin NSW Implementation Strategy, including features of the ETP, will be presented in subsequent sections as each component of the qualitative model for ETPs is addressed.

THE QUALITATIVE MODEL

As part of this study, a qualitative model for designing and implementing ETPs was developed; the model contains ten components and 37 criteria questions (Edwards and Canter, 1998). Each model component and its importance related to successful ETPs are summarized in Table 8.2, while the component-related criteria questions are listed in Table 8.3. The qualitative model can be used to evaluate existing or proposed ETPs by answering each criteria question with program-specific information and then rating each component based on the summary comparisons listed in Table 8.4. Although the resulting rating should not be averaged to yield a single score, they can be used to compare the relative performance of different components, to identify components that may need to be modified, and to compare the features of two or more ETPs. Alternatively, the model can be used to evaluate the potential for an ETP in a particular watershed and, if the potential for trading is high, to aid in the design of the site-specific ETP.

In addition to this application for evaluating the existing ETP in the Tar-Pamlico River Basin in North Carolina, the qualitative

Table 8.2: Components of Qualitative Model and Their Importance to Successful ETPs

Component of Qualitative Model	Rationale for Inclusion in the Qualitative Model
Watershed Suitability	This component is designed to ensure that the geographic and temporal boundaries of the ETP are clearly defined. In addition, circumstances within the watershed (or trading area) that either encourage or discourage effluent trading must be identified and addressed.
Pollutant Type	This component is designed to identify pollutants that may be suitable for inclusion in an ETP. ETP designers must also decide if program rules will allow inter-pollutant trading.
Trading Market Size and Characteristics	This component is designed to identify all sources of the pollutant(s) of interest in the ETP area, their relative contributions to total pollutant loading, and differences in their marginal abatement costs that may promote effluent trading. This component is also focused on identifying market characteristics, such as the presence of direct competitors, that may influence trading activity.
Legal Authority	This component is included to identify whether existing laws and regulations fully support, or could be amended to support, the development and operation of an ETP.
Administrative Acceptability and Capability	This component is used to identify whether the administering agency has sufficient knowledge and information to design and implement an ETP. This component is also for determining whether agency staff are willing to use effluent trading as an alternative to more traditional forms of regulation.
Specific Policies, Procedures, and Trading Rules	Specific policies, procedures, and rules are needed to reduce uncertainty, to minimize regulatory and administrative burdens, and to reduce transaction costs. Such rules should encompass all aspects of an ETP, from determining the maximum allowable pollutant loading to reviewing proposed trades to penalizing trading partners who violate their trading agreements.
Pre- and Post-Trade Monitoring	Pre- and post-trade monitoring is required to determine the environmental effects of individual trades and of the overall ETP.

Table 8.2 (continued):

Component of Qualitative Model	Rationale for Inclusion in the Qualitative Model
Enforcement Mechanisms	Enforcement mechanisms are required in order to ensure that water quality standards and/or ETP goals are met and that trading partners fulfill the terms of their agreements.
Program Evaluation	Periodic evaluations of ETP performance are necessary in order to ensure that the ETP is protecting, or improving, water quality while reducing environmental compliance costs. Periodic evaluation of the ETP itself is also recommended in order to identify any necessary modifications.
Public Involvement	Public and stakeholder involvement throughout ETP design and operation is needed in order to encourage participation in the trading program, to decrease controversy, and to minimize the potential for negative publicity.

Table 8.3: Criteria Questions for Each Component of the Qualitative Model for Designing and Implementing ETPs

Watershed Suitability 1. Does the watershed (or watershed segment or estuarine zone) have a clearly defined geographic boundary? What is the basis for defining the watershed, segment, or zone? 2. Are temporal variations in flow well understood? 3. Do existing water quality conditions or other circumstances within the watershed encourage the use of an ETP? 4. Are there circumstances within the watershed that would discourage the use of an ETP?
Pollutant Type 1. Are the pollutant(s) of interest classified as conservative, non-conservative, or toxic? 2. Will inter-pollutant trading be allowed? What is the basis for the decision to permit or prohibit inter-pollutant trading? 3. Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality? 4. Do the environmental effects of the pollutant(s) of interest result more from total loading over time than local, short-term toxic effects? 5. Can mass- or concentration-based limits be established for the pollutant(s) of interest?
Trading Market Size and Characteristics 1. Have all sources of the pollutant(s) of interest been identified? 2. Are the relative contributions of all source categories (point, nonpoint, and background) known? 3. Are temporal variations in loadings of the pollutant(s) of interest well understood? 4. Are there significant differences in marginal abatement costs among sources in the same category and/or sources in different categories? 5. Could sources and/or governmental entities within the watershed be potentially unwilling to trade? 6. Are there unique circumstances that may influence the behavior of market participants?
Legal Authority 1. Are there water quality standards, goals, and/or objectives that can be used as a basis for the ETP? 2. Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so? 3. Is there an existing agency with sufficient authority to implement and enforce an ETP, can such authority be conferred on an existing agency, or can such an agency be created? 4. Does the implementing agency have sufficient authority to require all contributing sources to meet their discharge allocations?

Table 8.3 (continued):

<u>Administrative Acceptability and Capability</u> 1. Does the administering agency have sufficient knowledge and information to designate the maximum allowable pollutant loading for the watershed, to allocate portions of that loading to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades as well as the overall trading program? 2. Is the administering agency willing to use effluent trading as a management strategy to supplement traditional regulation? 3. Does the administering agency have sufficient resources to design and implement an ETP?
<u>Specific Policies, Procedures, and Trading Rules</u> 1. If nonpoint sources are to be included in the ETP, do policies or procedures account for their inherent variability? 2. Have procedures been clearly defined for the following aspects of the ETP? (a) determination of the maximum allowable pollutant loading for the watershed (b) allocating portions of the loading cap to all sources within the watershed that discharge the pollutant(s) of interest (c) types of trades that will be allowed (d) trading ratio(s) 3. Have rules or procedures been clearly defined for the following operational aspects of the ETP? (a) quantifying and certifying pollutant reduction credits (PRCs) (b) quantifying the environmental impacts of trades (c) application procedures for proposed trades (d) administrative procedures for the evaluation of proposed trades (e) time periods that trades remain in effect (f) treatment of banked or shutdown credits (g) reporting and recordkeeping requirements 4. Will non-dischargers, such as environmental groups, be allowed to purchase and retire PRCs?
<u>Pre- and Post-Trade Monitoring</u> 1. Are responsibilities for pre- and post-trade source and ambient water quality monitoring clearly defined? 2. Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for both source and ambient water quality monitoring? 3. Will source monitoring requirements discourage trading activity?
<u>Enforcement Mechanisms</u> 1. Can trading agreements be effectively enforced for each source category? 2. Should uncontrollable circumstances for both point and nonpoint sources be considered in the enforcement process?

Table 8.3 (continued):

Program Evaluation 1. Are responsibilities for evaluating ETP performance clearly defined? 2. How often will the ETP be reviewed? 3. Have the criteria that will be used to evaluate ETP performance been specified?
Public Involvement 1. Was the public, including industries and municipalities, actively involved in ETP design and operation? 2. In general, did industries, municipalities, government agencies, and the public support the development of the ETP? 3. Does the ETP include any educational and/or outreach efforts designed to increase public support?

Table 8.4: Rating Scheme for Each Component of Qualitative Model

Degree of Compliance With Criteria Questions for Each Component	Rating
Compliant from all perspectives	4
Compliant from majority of perspectives	3
Compliant from only a few perspectives	2
Compliant from no perspectives	1
Degree of compliance with perspectives depends upon specific ETP design	0

model has also been tested through application to 11 other extant ETPs, including an in-depth case study of Lake Dillon in Colorado. Further, it has been used to evaluate the potential for an ETP in the Lake Geneva watershed located on the border between Switzerland and France. The model has also been applied to a hypothetical canning plant in the United States and a local pretreatment program in Oklahoma. Each of these applications are described in other chapters herein.

APPLICATION OF THE QUALITATIVE MODEL TO THE TAR-PAMLICO ETP

The answers to the criteria questions associated with each of the ten components of the qualitative model are summarized in the next sections. The included responses were based on watershed- and program-specific information obtained through a literature review and personal interviews with relevant stakeholders. The summary sub-section for each model component identifies its rating, includes a brief explanation of the rationale for the assigned rating, and a discussion of any implications and/or resultant needs. Summary information on the ratings for each component is contained in Table 8.5.

WATERSHED SUITABILITY

Geographic Boundaries

The geographic boundary of the Tar-Pamlico watershed defines the ETP area, thus providing spatial information needed to determine the maximum allowable pollutant (nutrient) loading and to identify the specific sub-areas which should be subject to post-trade ambient water quality monitoring. Such boundaries also facilitate the identification of the point and nonpoint pollutant sources that will be eligible to participate in the trading program. The actual boundaries of the Tar-Pamlico watershed had been previously established in conjunction with other hydrological and water quality studies (U.S. Environmental Protection Agency, 1993).

Table 8.5: Summary of Ratings of Components in the Qualitative Model When Applied to the Tar-Pamlico River Basin ETP

Component of Qualitative Model	Rating of Degree of Compliance[a]	Rationale for Assigned Compliance Rating	Implications and Resultant Needs
Watershed Suitability	4	Geographic boundaries have been clearly defined and sufficient information regarding flow was available. In addition, circumstances within the watershed strongly encouraged the development and use of an ETP.	Trading rules that require data collection to support future modifications of the ETP should further promote program development. In addition, the use of the site-specific model could be expanded by installing additional flow gages in the estuary.
Pollutant Type	3	The environmental impacts of nitrogen and phosphorus are primarily related to total loading, effluent limits can be established for both pollutants, and both pollutants can be classified as non-conservative.	The ETP does not currently address the varying environmental impacts associated with different forms of nitrogen and phosphorus. As additional information becomes available and watershed-specific models become more sophisticated, trading program rules should probably be expanded to include such provisions.
Trading Market Size and Characteristics	4	All nutrient sources have been identified, and their relative contributions to total loading have been determined. In addition, there are significant differences in marginal abatement costs among point sources and between point and agricultural nonpoint sources in the watershed, and sources seem willing to participate in the ETP.	Data concerning marginal abatement costs and nutrient budgets should be continuously collected, thus allowing the evaluation of ETP performance as well as the refinement of future phases of the ETP. Atmospheric deposition of nutrients to the watershed should be studied in greater detail.
Legal Authority	4	Phase I and II nutrient loading caps were based on defensible goals. Sufficient legal authority to administer the ETP is granted by binding agreements signed by key watershed stakeholders.	Since members of the TPBA have no authority over BMP selection, location, installation, or operation, they may be reluctant to rely on nonpoint source nutrient reductions to ensure ETP success. Instead, they may choose to upgrade one or more of their own facilities, which would unnecessarily increase their environmental compliance costs.
Administrative Acceptability and Capability	4	The initial lack of information was offset by dividing the ETP into multiple phases, setting interim reduction goals for each phase, and requiring extensive data collection. In addition, all pertinent regulatory agencies encouraged the use of the trading program, and generous funding was available from federal, state, and local sources.	It may be difficult to use the Tar-Pamlico watershed as a generic model for ETP design since comparable levels of funding will probably not be available in other watersheds.

Table 8.5 (continued):

Component of Qualitative Model	Rating of Degree of Compliance[a]	Rationale for Assigned Compliance Rating	Implications and Resultant Needs
Specific Policies, Procedures, and Trading Rules	3	Most of the criteria were either met or made unnecessary by the structure of the ETP. However, very little information was available regarding the mechanics of point-point source trading, and ETP rules did not directly address the use and disposition of banked and shutdown credits or the participation of non-dischargers.	Issues associated with banked and shutdown credits, the participation of non-dischargers in the ETP, and more specific rules for point-point source trading should be addressed in future phases of the ETP.
Pre- and Post-Trade Monitoring	4	Monitoring responsibilities have been assigned to key stakeholders in the watershed, and monitoring protocols, at least for TPBA members, have been specified. Furthermore, the additional monitoring required by ETP rules should not affect the economic incentive to trade.	Monitoring data should be continuously collected in order to evaluate ETP performance and to refine the estuarine water quality and nutrient loading models.
Enforcement Mechanisms	4	Enforcement mechanisms are sufficient to ensure water quality protection, to encourage TPBA members to comply with ETP rules, and to penalize those that do not.	It may be necessary to increase the number and frequency of BMP inspections, particularly after BMPs have been implemented for several years, to ensure that nonpoint nutrient reduction credits remain effective throughout their lifespan.
Program Evaluation	3	Evaluation responsibilities are clearly assigned to the DEM and the DSWC, and review frequencies are specified for the point-nonpoint source trading ratio and the overall ETP. However, specific review criteria were not identified.	Interim evaluations during Phase II would provide valuable program information to the general public, to potential trading partners, and to stakeholders in other watersheds who may be interested in ETPs.
Public Involvement	4	All pertinent stakeholders were directly involved in ETP design, and most stakeholders supported both Phases I and II of the ETP. In addition, information regarding the Tar-Pamlico ETP is readily available to both stakeholders in the watershed and others who may be interested in effluent trading.	Educational and outreach efforts should continue through Phase II and subsequent phases of the ETP.

[a]4 = compliant from all perspectives; 3 = compliant from majority of perspectives; 2 = compliant from only a few perspectives; 1 = compliant from no perspectives; 0 = degree of compliance with perspectives depends upon specific ETP design

Flow Variations

Information regarding river and effluent discharge flows is needed to determine the maximum allowable pollutant loading and to convert concentration-based limits to pollutant loadings. It is assumed that sufficient information is available regarding discharge flows from TPBA members since they have been required to monitor nutrient levels in their effluent since 1991; further, the annual loading caps established in Phase I were based on the actual and projected flows of member facilities (Hall and Howett, 1995). In addition, information regarding river flows in the Tar-Pamlico watershed was sufficient to support the use of several nutrient loading models and the development of a site-specific estuarine water quality model. As part of the Phase II strategy, additional flow data will be collected and used to recalibrate the estuarine model. Further, the applicability of the model could be expanded to include the lower portion of the watershed if additional flow gages are installed in the estuary (North Carolina Division of Environmental Management, 1995).

Conditions Encouraging Effluent Trading

Four conditions in the Tar-Pamlico watershed were conducive to the original development and implementation of the ETP. First, the Tar-Pamlico River system supports important municipal, commercial, and recreational water uses; however, such uses were being adversely affected by excess nutrient loadings. Second, point sources, which were facing abatement costs as high as $100 million to meet the effluent limitations originally proposed by DEM, actively sought a cost-effective alternative (Apogee Research, Inc., 1992). In addition, the ETP provides economic incentives for nonpoint sources to reduce their nutrient loadings. Third, many point source operators, governmental agencies, and non-governmental organizations (NGOs) were willing to work together to develop and implement the trading program. Finally, DEM's basinwide planning process allowed regulators to manage the Tar-Pamlico watershed as a single unit (Center for Environmental Analysis, 1995).

Conditions Discouraging Effluent Trading

One factor that has been previously identified as a disincentive to effluent trading is the lack of necessary information for program design and evaluation of the potential advantages of ETP participation. The Tar-Pamlico ETP minimized this problem by establishing interim nutrient loading caps in Phase I. Further, the program required intensive data collection (including weekly effluent monitoring), the development of an estuarine water quality model, and BMP demonstration projects during Phase I to support the development of Phase II (Hall and Howett, 1995). Another factor that may discourage trading is the presence of multiple jurisdictions within the ETP area. Once again, this factor does not appear to have affected the Tar-Pamlico ETP since POTWs associated with different municipalities united to form the TPBA and function as a collective unit under the provisions of the NSW implementation strategy.

Summary of Watershed Suitability

As shown in Table 8.5, the Tar-Pamlico watershed ETP was assigned a rating of "4" for the watershed suitability component of the qualitative model. Two reasons for this rating were that geographic boundaries for the ETP have been clearly defined and sufficient information regarding various flows was available, at least for TPBA members. In addition, circumstances within the watershed, particularly the large differences in marginal abatement costs between point and nonpoint sources and stakeholder willingness to work together for cost-effective water quality management, encouraged the development of the ETP. Trading rules that require data collection to support future modifications of the ETP should further promote program development.

POLLUTANT TYPE

Pollutant Classification

The classification of the pollutant(s) of interest must be determined in order to predict their environmental effects and to select or develop appropriate water quality models. The Tar-Pamlico ETP is basically designed to reduce nitrogen and phosphorus loadings to watercourses in the watershed (Apogee Research, Inc., 1992). Nitrogen is the limiting nutrient in the Pamlico Estuary, while phosphorus contributes to localized water quality problems. Both phosphorus and nitrogen are non-conservative due to their potential for biological incorporation into algae, sorption onto suspended solids, and/or chemical precipitation.

Inter-pollutant Trading

Inter-pollutant trading would allow sources in the Tar-Pamlico watershed to exchange reduction credits for two different pollutants, nitrogen and phosphorus. This type of trading was implicitly authorized by Phase I of the ETP since the annual nutrient loading caps, shown in Table 8.1, included both total nitrogen and total phosphorus (Hall and Howett, 1995). Phase II of the ETP, however, established separate loading caps for total nitrogen and total phosphorus, to be discussed later, so it can be assumed that inter-pollutant trading is no longer permitted.

Pollutant Forms

The water quality and aquatic ecosystem impacts of a given pollutant depend upon the form in which it is released into the environment and its subsequent transport and fate. However, under the Tar-Pamlico ETP rules, TPBA members are required to monitor only for total nitrogen and total phosphorus (Hall and Howett, 1995).

While this requirement may neglect some of the environmental effects associated with a particular form of nitrogen or phosphorus, it encourages ETP activity by limiting the number of forms of regulated pollutants, thus reducing the costs associated with monitoring and water quality modeling.

Environmental Effects

Although trading programs are designed to improve overall water quality, pollutant discharges at certain locations could increase as a result of trading. However, since the environmental effects of nitrogen and phosphorus are due primarily to total loading rather than site-specific concentrations, such localized increases should be insignificant. In addition, the DEM retains the authority to impose more stringent individual effluent limitations on point sources if local water quality problems develop as a result of trading (Hall and Howett, 1995).

Pollutant Limits

In order for the TPBA to determine whether its nutrient discharges have met or exceeded the annual allowable loading, operators of member facilities must be able to quantify their nutrient discharges relative to either mass-based or concentration-based limits. Both types of limits can be readily monitored for nitrogen and phosphorus.

Summary of Pollutant Type

As shown in Table 8.5, the pollutant type component of the qualitative model was assigned a rating of "3." A higher rating was initially considered since the environmental impacts of nitrogen and phosphorus are primarily related to total loading, effluent limits have been readily established for both pollutants, and they both are easily classified. However, since Phase I and Phase II loading caps were either for total nutrients or for total nitrogen and total phosphorus, respectively, the program apparently fails to take into account the varying environmental effects that different chemical or physical forms of the same pollutant may exhibit. As additional information becomes available and watershed-specific water quality models become more sophisticated, trading program rules should probably be expanded to include provisions addressing various forms of nitrogen and phosphorus.

TRADING MARKET SIZE AND CHARACTERISTICS

Pollutant Sources

All sources of the pollutant(s) of interest must be identified in order to establish an accurate nutrient budget and determine the most effective nutrient control strategies. In addition, identifying all sources maximizes the number of potential trading partners, thus increasing the economic incentive to develop trades. The categories of sources of nitrogen and phosphorus in the Tar-Pamlico watershed include (Apogee Research, Inc., 1992; Riggs, 1993; and U.S. Environmental Protection Agency, 1993): (1) POTWs and industrial WWTPs; (2) Texasgulf Industries, Inc., a phosphate mining and fertilizer company located near the mouth of the Pamlico River; (3) atmospheric deposition; (4) urban runoff; and (5) runoff from forestry and agricultural sources, including cropland and livestock operations. Only POTWs, WWTPs, and agricultural nonpoint sources were identified as eligible to participate in Phases I and II of the trading program.

Relative Contributions

Point-nonpoint source ETPs are only feasible if both point and nonpoint sources contribute significantly to pollutant loadings. Based on the nutrient budget shown in Table 8.6, the Tar-Pamlico watershed meets this criterion. For example, approximately 61 percent of the nitrogen loading is attributable to agricultural

Table 8.6: Annual Nitrogen and Phosphorus Budgets for the Tar-Pamlico River Basin in 1988 (Hall and Howett, 1995)

Nutrient Source	Percent of Nitrogen Budget	Percent of Phosphorus Budget
Atmospheric Deposition	18.6	5.5
Cropland	30.0	21.7
Forestry	21.4	19.9
Livestock	9.5	15.1
POTWs/Industrial WWTPs	14.9	25.2
Texasgulf Industries	2.0	9.1
Urban	3.6	3.5

nonpoint sources (cropland, forestry, and livestock), while 17 percent is attributable to point sources (POTWs/industrial WWTPs and Texasgulf Industries). Similarly, agricultural nonpoint sources and point sources are responsible for 57 and 34 percent of the phosphorus loading, respectively.

Temporal Variations

ETP designers need information concerning temporal variations in pollutant loadings in order to establish the maximum allowable pollutant loading and to determine the effectiveness of source discharge and ambient water quality monitoring programs. Sufficient information was available to calculate nutrient loading caps for members of the TPBA, while water quality modeling and monitoring requirements included in the NSW implementation strategy should eventually improve such determinations for nonpoint sources (Hall and Howett, 1995).

Marginal Abatement Costs

Large differences in marginal abatement costs, which exist both among point sources affiliated with the TPBA and among other point and nonpoint sources in the watershed, were the primary reason the Tar-Pamlico NSW Implementation Strategy was developed. Cost differences among TPBA point sources are related primarily to facility size; for example, two of the 13 member facilities are responsible for approximately 80 percent of the total flow (Riggs, 1993). These larger facilities, which should have lower marginal abatement costs due to economies of scale, are expected to generate nutrient reduction credits that can be used by smaller facilities with higher marginal abatement costs. Even more significant differences in marginal abatement costs exist between other point and nonpoint sources in the watershed. For example, the reduction required in DEM's original nutrient control strategy would have cost the affected point sources from $50 to $100 million, collectively, while nonpoint sources could have achieved equivalent nutrient reductions for only $11.7 million (Riggs, 1993).

Unwillingness to Trade

The economic assumptions underlying ETPs suggests that source operators may be unwilling to participate in an ETP if trading will significantly reduce the environmental compliance costs of their competitors. Source operators with excess reduction credits may also prefer to keep them in reserve against future more stringent water quality standards or to facilitate future expansion, particularly if trading program activity is minimal. However, unwillingness to trade does not appear to have affected the Tar-Pamlico ETP, probably because the members of the TPBA are not direct competitors and their participation in the ETP yields such significant economic benefits.

Unique Circumstances

The economic assumptions underlying ETPs also indicate that all dischargers will seek to minimize their environmental compliance costs. While this assumption is probably valid for industrial WWTPs, it may not always apply to POTWs and nonpoint sources. These concerns, however, do not appear to have affected the Tar-Pamlico ETP. Since all but one of the TPBA members are operators of POTWs, it was assumed that there are no regulations prohibiting or restricting their participation in the trading program. Similarly, since payments for nonpoint source reduction credits will be made directly to an existing agricultural cost-share program, it was assumed that the ETP will increase the rate of BMP implementation in the watershed.

Summary of Trading Market Size and Characteristics

The trading market size and characteristics component of the qualitative model received a score of "4," as shown in Table 8.5.

The potential trading market in the Tar-Pamlico River Basin appears ideally suited to an ETP since all nutrient sources have been identified, their relative contributions to the annual total loadings have been determined, and there are significant differences in marginal abatement costs among sources in the watershed. In addition, all source operators appeared willing to participate in the ETP, and no circumstances which could negatively affect trading activity were identified. However, it is recommended that data concerning the annual nutrient budget and the marginal abatement costs of point and nonpoint sources be routinely collected, thus allowing more sophisticated evaluations of ETP performance and refinement of future phases of the trading program. Watershed-specific studies to address the significance of atmospheric nutrient deposition, as well as potential control alternatives, have also been recommended (North Carolina Division of Environmental Management, 1995).

LEGAL AUTHORITY

Standards, Goals, and/or Objectives

Ambient water quality standards, goals, and/or objectives serve as the basis for determining the maximum allowable pollutant loading, for distributing discharge allocations, for reviewing proposed trades, and for evaluating overall ETP effectiveness. The ultimate goal of the Tar-Pamlico ETP is to prevent all violations in ambient water quality standards for nitrogen and phosphorus (Hall and Howett, 1995). As part of the effort, interim nutrient reduction goals for the TPBA were established for Phases I and II. The Phase I nutrient reduction goal of 200,000 kg/yr (180,000 kg/yr total nitrogen and 20,000 kg/yr total phosphorus) was equivalent to the loading reduction that would have been achieved if the effluent limitations for new and expanding point sources, proposed in DEM's original nutrient management plan, had been implemented. The total nitrogen loading cap for Phase II (405,256 kg/yr) represents a 30 percent reduction in total nitrogen from 1991 levels; the estuarine water quality model predicted that compliance with this cap would significantly reduce algal blooms in the Pamlico Estuary. Phase II also restricted the amount of total phosphorus that TPBA members could discharge to 1991 levels, or 69,744 kg/yr.

Legal Support

Legal authority for the Tar-Pamlico ETP is granted by two binding agreements approved by key stakeholders (Hall and Howett, 1995). The "Tar-Pamlico NSW Implementation Strategy," which established the rules and regulations for Phase I of the ETP, was signed by representatives of the DEM, the North Carolina Environmental Defense Fund, the TPBA, the Pamlico-Tar River Foundation, and the EMC. The "Tar-Pamlico NSW Implementation Strategy: Phase II" was approved by the DEM, the TPBA, the DSWC, and the EMC. Both agreements clearly support effluent trading as an acceptable compliance alternative to traditional command-and-control approaches for water quality management. In addition, the TPBA became subject to certain operational by-laws when it became a non-profit corporation in 1989.

Administering Agency

The agency or agencies administering the ETP must have sufficient legal authority to implement and enforce all aspects of the program, including establishing the maximum allowable pollutant loadings and enforcing the provisions of trading agreements. The necessary legal authority for the Tar-Pamlico ETP is shared among three entities: the DEM, the DSWC, and the TPBA (Apogee Research, Inc., 1992). DEM's responsibilities include issuing discharge permits to TPBA members, coordinating source discharge and ambient water quality monitoring, prioritizing sub-watersheds within the Tar-

Pamlico Basin for BMP implementation (in cooperation with the DSWC), determining whether the TPBA has met or exceeded its annual nutrient allowance, and establishing individual effluent limits for point sources in order to alleviate local water quality problems. The DSWC is primarily responsible for using the funds generated by the trading program to implement agricultural BMPs in the Tar-Pamlico watershed, thus reducing nonpoint nutrient loadings. Finally, the TPBA's primary responsibility is ensuring that its members either meet the annual nutrient cap or purchase nutrient reduction credits.

In general, distributing the responsibility for ETP administration among several different agencies is anticipated to increase the uncertainty and costs associated with effluent trading, thus possibly decreasing trading activity. However, even though three different entities share responsibility for administering the Tar-Pamlico ETP, the program remains relatively simple because DEM regulates the TPBA as a single unit. In addition, point source operators do not have to negotiate individual trades with multiple agricultural nonpoint source operators; instead, their responsibility for nonpoint source nutrient reductions terminates with an appropriate payment to the ACSP.

Agency Authority

In order for an ETP to result in water quality improvement, all sources in the program must receive a discharge allocation that they are required to meet by installing pollution abatement equipment, changing production processes, and/or by purchasing pollutant reduction credits (PRCs). Otherwise, potential "loopholes," such as waivers, variances, grants, and subsidies, could negatively influence ETP effectiveness by increasing the total nutrient loading and reducing the size of the trading market. No such loopholes were identified for the Tar-Pamlico ETP; for example, members of the TPBA were required either to meet the collective nutrient loading cap or purchase nutrient reduction credits from the ACSP at a rate of $56 or $29 per kilogram during Phases I and II, respectively (Hall and Howett, 1995).

Summary of Legal Authority

As shown in Table 8.5, the legal authority component of the qualitative model was assigned a rating of "4." Defensible goals exist which were used as a basis for the ETP, and sufficient legal authority for the trading program is provided by binding agreements signed by key stakeholders in the watershed. Even the negative effects potentially associated with multiple administering agencies have been eliminated through careful program design. However, although payments to the ACSP eliminate many of the complexities of point-nonpoint source trading, members of the TPBA have no authority over BMP selection, location, installation, or operation (Apogee Research, Inc., 1992). Consequently, they may be reluctant to rely on nonpoint source nutrient reductions to ensure ETP success, particularly since the TPBA will be subject to more stringent effluent limitations if the trading program fails.

ADMINISTRATIVE ACCEPTABILITY AND CAPABILITY

Knowledge and Information

Considerable data are required to design and operate effective ETPs. However, similar to most watersheds, there was not enough information about the Tar-Pamlico River Basin to initially develop a comprehensive trading program (Hall and Howett, 1995). Instead, stakeholders used existing information to develop Phase I, and, as part of Phase I, required extensive data collection and the development of a site-specific estuarine water quality model. The additional data and the model were then used to refine nutrient loading allowances in Phase II, and it will be further used to identify other provisions in subsequent phases. This "phased" approach is recommended because it does not delay the onset of trading activities, which are expected to reduce environmental costs and improve ambient water quality, while data are collected and/or site-specific water quality models are developed.

Willingness to Use ETPs

In order for point and nonpoint source operators in the Tar-Pamlico watershed to be willing to rely on effluent trading to meet their compliance obligations, the relevant governmental agencies (DEM, DSWC, and EMC) must actively promote the trading program as an acceptable alternative to command-and-control approaches to water quality management. This has been accomplished since the DEM and the DSWC supported effluent trading by agreeing to administer portions of the ETP, while the EMC approved both phases of the trading program (Hall and Howett, 1995).

Resources

Similar to any regulatory program, ETPs require sufficient staff and funding to function successfully. In general, staffing for the Tar-Pamlico ETP appears to be adequate, particularly since the TPBA funded additional staff at the DSWC to manage BMPs in the watershed (Hall and Howett, 1995). The TPBA has also hired consultants to provide specialized knowledge and skills. For example, the estuarine model was developed by HydroQual, Inc., and Owen Engineering performed the engineering evaluations of all member POTWs. The engineering evaluation was particularly beneficial to operators of smaller facilities who could not have afforded an independent evaluation (Hall and Howett, 1994).

Funding for the Tar-Pamlico ETP has been provided by the TPBA, the U.S. Environmental Protection Agency, and the State of North Carolina (Riggs, 1993; and Hall and Howett, 1995). The TPBA incurred the following expenses during Phase I of the ETP: (1) $400,000 for the development of the estuarine water quality model; (2) $40,000 for the engineering evaluation of member POTWs; (3) $150,000 to fund agricultural BMPs in the watershed; (4) $150,000 to fund additional staff at the DSWC; and (5) $50,000 in legal fees and administrative expenses. As of 1995, total funding from the U.S. Environmental Protection Agency, designated mostly for development of the water quality model and BMP demonstration projects, reached $1.4 million; this total included $350,000 that was used, along with $150,000 from the TPBA, to meet the minimum requirement for BMP funding in the Phase I agreement. State expenses include grants totaling approximately $300,000, and agency staff services, which have not been estimated.

Summary of Administrative Acceptability and Capability

The administrative acceptability and capability component of the qualitative model was assigned a rating of "4," as shown in Table 8.5, since all pertinent criteria were successfully met. The lack of information was offset by dividing the ETP in multiple phases, setting interim nutrient reduction goals for each phase, and requiring extensive data collection. In addition, all pertinent regulatory agencies supported the use of the trading program, and adequate funding was available from federal, state, and local entities. The group structure of the TPBA allowed POTW operators to pool their resources and may even have increased their likelihood of receiving grants and other external funding (Hall and Howett, 1995). However, it may not be appropriate to use the Tar-Pamlico watershed as a generic model for ETP design since comparable levels of funding will probably not be available in all watersheds.

SPECIFIC POLICIES, PROCEDURES, AND TRADING RULES

Nonpoint Source Variability

Nonpoint source variability relative to nutrient discharges does not directly affect point source operators who participate in the Tar-Pamlico ETP since such operators are simply required to purchase nutrient reduction credits from the ACSP at a pre-determined rate (Hall and Howett, 1995). However, the DEM and the DSWC require information on nonpoint source nutrient loadings in order to estimate BMP effectiveness, to periodically adjust the trading ratio, and to evaluate ETP performance. Monitoring and water quality modeling efforts, described in a subsequent portion of this section, should provide the needed information.

ETP Procedures

Maximum Allowable Pollutant Loading

Establishing the maximum allowable nutrient loading, or loading cap, that will achieve ETP goals is essential for two reasons. First, the loading cap determines the total amount of nutrients that can be discharged to the watershed. Second, compliance with the loading cap can be used as one criterion to evaluate overall ETP effectiveness. Loading caps for the TPBA have been established, and thoroughly documented, for both Phases I and II (Hall and Howett, 1995). In addition, Phase II has established overall loading caps for total nitrogen and total phosphorus that apply to all point and nonpoint sources in the watershed.

Loading Allocations

Loading allocations determine the quantity of pollutants (nutrients) that each point source and identifiable nonpoint source may discharge into receiving waters. By comparing their current discharges to their loading allocations, and considering pertinent marginal abatement costs for additional nutrient reductions, source operators can determine their most cost-effective compliance alternatives. In the Tar-Pamlico ETP, a joint nutrient loading allocation is specified for all TPBA members, thus reducing the regulatory burden and expense associated with effluent trading (Hall and Howett, 1995). The TPBA then proportions the loading allocation among member facilities based on the ratio of each facility's design flow, specified in its discharge permit, to the TPBA's total permitted flow (Riggs, 1993).

Types of Trades

The Tar-Pamlico ETP allows both point-point source trading among members of the TPBA and point-nonpoint source trading between the TPBA and agricultural nonpoint sources in the watershed (Hall and Howett, 1995). Current trading program rules do not address intra-plant, pretreatment, and nonpoint-nonpoint source trading opportunities.

Trading Ratio(s)

It was assumed that the trading ratio for point sources participating in the ETP was 1:1. Trading ratios for point and agricultural nonpoint sources were expressed in terms of the cost per kilogram of nonpoint source nutrient reduction (Hall and Howett, 1995). The trading ratio for Phase I, $56 per kilogram of nutrients, was based on the average cost of nonpoint source control in an adjacent watershed and included safety factors of 3:1 and 2:1 for cropland and animal land-use related BMPs, respectively. The ratio was also weighted to account for differences in the costs of nitrogen and phosphorus removal and adjusted to reflect the percentage of BMP costs paid by the ACSP. The trading ratio for Phase II, $29 per kilogram of nitrogen, was based on the costs of using agricultural BMPs to reduce nonpoint source nitrogen loadings in the Tar-Pamlico watershed and similar areas, and it also included a safety factor.

In addition, Phase II of the Tar-Pamlico ETP requires that the trading ratio be reviewed, and adjusted if necessary, every two years. In general, the costs of BMPs, and the corresponding trading ratio, are expected to increase over time as opportunities to implement less expensive BMPs are exhausted.

Operational Aspects

Quantifying and Certifying PRCs

Participating point and nonpoint sources in an ETP must be able to accurately determine their discharge allocations and current discharge levels in order to calculate the amount of PRCs they are eligible to sell, lease, or purchase. In the Tar-Pamlico ETP, each member of the TPBA receives an individual nutrient loading allowance based on its relative flow, and weekly monitoring data can be used to calculate discharge levels (Riggs, 1993). Therefore, information is readily available to support point-point source trading. In addition, the weekly monitoring data for all TPBA members can be aggregated and used to determine whether the TPBA has exceeded its annual nutrient allowance, and, if so, to calculate the required payment to the ACSP.

Environmental Impacts

The procedures for evaluating the environmental impacts of a single proposed trade within the Tar-Pamlico ETP are unclear. However, at least five nutrient loading models, briefly summarized in Table 8.7, have been used to develop the trading program (Hall and Howett, 1995). In addition, the estuarine water quality model, which was developed specifically for the Tar-Pamlico watershed during Phase I of the trading program, is designed to assess the relative importance of different sources of nutrients (including point sources, nonpoint sources, sediments, and atmospheric deposition) to algal growth and oxygen stress. The model can also be used to

Table 8.7: Nutrient Loading Models Used in the Tar-Pamlico ETP (after Hall and Howett, 1995)

Model Name	Model Description
Nutrient Budget Model Using Export Coefficients	Identifies the amount and source of nutrients within the watershed
FLUX Model	Uses continuous flow and nutrient grab data collected at a given point within the watershed to estimate the annual load of nutrients at that site
Generalized Watershed Loading Function (GWLF) Model	Estimates nutrient and sediment loadings from sources within the 15 sub-watersheds of the Tar-Pamlico Basin
Mass Balance Model	Quantifies nutrient sources and sinks for the upper portion of the Tar-Pamlico watershed
Geographic Information System (GIS)	Provides integrated land use and water quality data to allow agencies to preferentially select nonpoint sources for BMP implementation

determine nutrient reduction goals, and to predict the estuarine consequences of proposed trades. Finally, "before-and-after" water quality monitoring, visual inspections, and predictive modeling of demonstration projects have been used to estimate the site-specific effectiveness of agricultural BMPs.

Application Procedures

Clearly defined application procedures are needed to ensure ETP consistency and uniformity, to simplify administrative review, and to reduce uncertainty and transaction costs for program participants. No specific application procedures for point-point or point-nonpoint source trading were identified within the Tar-Pamlico ETP. However, it was assumed that the TPBA could easily use its own data to evaluate potential trades among its members, thus eliminating the need for detailed point-point source trade applications. In addition, the rules of the Tar-Pamlico ETP, which allow point source operators to purchase nutrient reduction credits in lieu of negotiating individual agreements with nonpoint sources, eliminate the need for point-nonpoint source trade applications.

Evaluation of Proposed Trades

Administrative procedures for the review of proposed trades are also needed for ETP consistency and to reduce stakeholder uncertainty. Although no specific administrative procedures for evaluating proposed point-point trades were identified, it was assumed that the TPBA would review and approve trades involving its members, particularly in the absence of local water quality effects. To participate in point-nonpoint source trading, point source operators must only ensure that they purchase the correct quantity of nutrient reduction credits from the ACSP, while the DSWC must ensure that BMPs in the watershed will appropriately offset the excess nutrient loading from involved point sources.

Time Periods

In order to reduce the uncertainty associated with ETP participation, the length of time that a trade will be in effect should be specified. Designated time periods for point-point source trades were not addressed in the Tar-Pamlico ETP rules; however, it was assumed that individual trading agreements would contain time limits that were acceptable to both trading partners and to the TPBA. The length of time that a nonpoint source nutrient reduction credit remained in effect was specifically addressed by ETP rules (Hall and Howett, 1995). Phase I credits were deemed in effect for 10 years, unless otherwise specified by the DSWC, while Phase II credits are to be in effect for 3 or 10 years, depending on whether they are generated by non-structural or structural BMPs, respectively. When BMPs are no longer in effect, their corresponding nutrient reduction credits expire and must either be retired or repurchased.

Banked or Shutdown Credits

The rules for the Tar-Pamlico ETP do not address the documentation and use of "banked credits" which are generated when a source operator saves excess PRCs for their own future use or sale to other sources, or when "shutdown credits," which are generated as a result of a source operator closing part or all of its nutrient discharge activities. The lack of provisions for the use of banked credits may be particularly significant since at least two members of the TPBA are expected to "bank" nutrient reduction credits (Riggs, 1993).

Reporting and Recordkeeping

Reporting and recordkeeping provisions are needed to demonstrate source compliance with discharge allocations and trading rules, and to aid in overall ETP evaluation. Under the rules of the Tar-Pamlico ETP, TPBA members are required to submit a joint annual report, summarizing their total nitrogen and total phosphorus loadings for the previous year, to the DEM (Hall and Howett, 1995). The DEM then uses the report to determine whether the TPBA has met or exceeded its annual nutrient loading allowance and to ascertain any required payments to the ACSP. In addition, during Phase I of the ETP, the TPBA was required to file progress reports and an annual report identifying the BMP projects funded through the ETP.

Non-dischargers

Provisions that would allow non-dischargers, such as NGOs, environmental groups, or individual citizens, to purchase and retire PRCs were not identified in Phases I and II of the Tar-Pamlico ETP.

Summary of Specific Policies, Procedures, and Trading Rules

The specific policies, procedures, and trading rules component of the qualitative model was assigned a rating of "3," as shown in Table 8.5, since most of the criteria are either met or rendered unnecessary due to the structure of the trading program. For example, the structure eliminates the need to consider many of the criteria questions relative to point-nonpoint source trading since it allows point sources to purchase credits from the ACSP. However, very little information was available regarding the actual mechanics of point-point source trading; for example, the Tar-Pamlico ETP rules did not specify a point-point source trading ratio, procedures for submitting proposed point-point source trades for approval, or the length of time that point-point source trades are to be in effect. In addition, program rules did not address the use and disposition of banked and shutdown credits or the participation of non-dischargers. These issues should be addressed in future phases of the ETP.

PRE- AND POST-TRADE MONITORING

Monitoring Responsibilities

Source discharge and ambient water quality monitoring data are needed to determine compliance with discharge allocations, the environmental effects of individual trades, and the effectiveness of the overall ETP. In order to ensure consistency, to reduce uncertainty, and to eliminate duplication of effort, the responsibilities for such monitoring should be clearly distributed among trading partners and pertinent governmental agencies. In the Tar-Pamlico ETP, monitoring responsibilities have been assigned to members of the TPBA, the DEM, and the DSWC. In general, TPBA members must conduct weekly monitoring of the total phosphorus and total nitrogen in their effluent, along with the effluent flow (Hall and Howett, 1995). The DEM is responsible for both compliance and surface water quality monitoring, while the DSWC is responsible for monitoring the effectiveness of BMPs (Apogee Research, Inc., 1992).

Monitoring Protocols

Monitoring protocols for reducing uncertainty and ensuring ETP consistency have been established for members of the TPBA (Hall and Howett, 1995). Further, it was assumed that any monitoring conducted by the DEM or the DSWC would also be in accordance with standardized procedures.

Monitoring and Trading Activity

Additional monitoring requirements associated with effluent trading do increase transaction costs, particularly for smaller facilities that do not have their own laboratories (Riggs, 1993). Such requirements are essential to ensure the protection of water quality and the achievement of ETP goals. However, even with the additional monitoring costs, effluent trading is still a cost-effective alternative to command-and-control regulation in the Tar-Pamlico watershed.

Summary of Pre- and Post-Trade Monitoring

As shown in Table 8.5, the pre- and post-trade monitoring component in the qualitative model was assigned a rating of "4." This rating was based on the facts that monitoring responsibilities have been assigned to key stakeholders and monitoring protocols, at least for TPBA members, have been specified. Furthermore, the additional monitoring required by the trading rules should not unduly affect the economic benefits of ETP participation. Monitoring data should be regularly collected in order to evaluate ETP effectiveness and to refine the estuarine water quality and nutrient loading models used to establish nutrient loading targets and identify potential BMPs.

ENFORCEMENT MECHANISMS

Effective Enforcement

Effective enforcement of an ETP can help to ensure that included water quality goals are met and trading partners are fulfilling the terms of their trading agreements. The DEM uses the TPBA's annual report to establish whether it has met or exceeded its nutrient allowance and to determine the appropriate payment to the ACSP (Hall and Howett, 1995). Fines and penalties for submitting false monitoring reports can be imposed by the DEM (Riggs, 1993). In addition, in the event of the failure of the ETP, TPBA members are subject, within 3 years, to the same effluent limitations as new facilities; these limitations are now more stringent than the effluent limitations proposed in DEM's original nutrient management strategy (Hall and Howett, 1995). DEM can also establish individual effluent limitations for point sources if localized water quality problems exist. Finally, the DSWC ensures proper implementation, operation, and maintenance of agricultural BMPs through periodic inspections (Apogee Research, Inc., 1992; Hall and Howett, 1995; and Riggs, 1993).

Uncontrollable Circumstances

Circumstances that cannot be controlled for point sources, such as pump failure, and for nonpoint sources, such as unusually heavy rainfall, may result in the violation of trading agreements. However, it was assumed that such short-term occurrences would not affect the Tar-Pamlico ETP since compliance is based solely on annual nutrient loadings.

Summary of Enforcement Mechanisms

As shown in Table 8.5, the enforcement mechanisms component of the qualitative model was assigned a rating of "4." Enforcement mechanisms are sufficient to promote water quality protection, to encourage TPBA members to comply with ETP rules, and to penalize them if they do not. However, it may be necessary to increase the number and frequency of BMP inspections, particularly after BMPs have existed for several years, to ensure that nonpoint nutrient reduction credits exist throughout their lifespan.

PROGRAM EVALUATION

Responsibilities for ETP Evaluation

ETP performance should be periodically evaluated in order to ensure that the trading program is both protecting, or improving, existing water quality and reducing environmental compliance costs. If the program is not functioning successfully, or if conditions within the watershed have changed, the program may need to be modified. Responsibilities for the periodic evaluation of the Tar-Pamlico ETP have been divided between the DEM, which determines the TPBA's compliance with its nutrient loading cap and evaluates the overall effects of the trading program, and the DSWC, which implements agricultural BMPs (Hall and Howett, 1995).

Review Frequency

Although the Tar-Pamlico ETP rules do specify that the point-nonpoint source trading ratio is to be reviewed every two years, they do not specifically address how frequently the overall trading program should be reviewed (Hall and Howett, 1995). However, it was assumed that, as part of the Tar-Pamlico River Basinwide Water Quality Management Plan, the ETP would be evaluated and updated every five years (North Carolina Division of Environmental Management, 1995).

ETP Performance Criteria

The Tar-Pamlico ETP rules do not specify the review criteria that should be used to evaluate trading program performance. However, for the purposes of this case study, it was assumed that past review criteria were informal and included the environmental effects of trading, the economic advantages and disadvantages of trading, and the continued willingness of stakeholders to participate in or to administer the ETP.

Summary of Program Evaluation

The program evaluation component of the qualitative model was assigned a rating of "3," as shown in Table 8.5. Evaluation responsibilities are clearly assigned to the DEM and the DSWC, and review frequencies are specified for both the point-nonpoint source trading ratio and the overall ETP. However, specific review criteria were not identified. Interim evaluations in the form of status reports during Phase II would provide valuable program information to the general public, to potential trading partners, and to stakeholders in other watersheds who may also be interested in the use of effluent trading for water quality management.

PUBLIC INVOLVEMENT

Active Involvement

Public participation is recommended in order to encourage program participation, to decrease controversy, and to minimize the potential for negative publicity. Relevant stakeholders, including the general public, industries and municipalities, and governmental agencies, have been actively involved in all aspects of the Tar-Pamlico ETP. For example, the trading program was originally proposed by a coalition of point source dischargers in the watershed (U.S. Environmental Protection Agency, 1993). Further, the North Carolina Environmental Defense Fund and the Pamlico-Tar River Foundation were involved in the development of both phases of the ETP and, even though they did not ultimately approve Phase II, they retain the authority to comment on individual effluent limitations that are designed to address local water quality problems (Draft Trading Update, 1997; and Hall and Howett, 1995). As a final example, all ETP rules are subject to public review and comment prior to final EMC approval.

Public Support

The TPBA, the DEM, and the DSWC have actively supported effluent trading in the Tar-Pamlico watershed (U.S. Environmental Protection Agency, 1993). The trading program benefits the TPBA because it allows member facilities to minimize their environmental compliance costs through point-point source and/or point-nonpoint source trading. DSWC supported the ETP because it increased funding to the ACSP, thus improving the BMP implementation rate and decreasing nutrient loadings to the watershed. The DEM approved the ETP because it would significantly reduce point source compliance costs and would include agricultural nonpoint sources, thus providing a more comprehensive nutrient management strategy.

Educational and/or Outreach Efforts

Educational and outreach programs encourage ETP participation by eliminating the perception that ETPs are "selling the right to pollute" and increasing awareness of the ETP as an environmental compliance alternative. This review identified multiple activities involving information dissemination on the Tar-Pamlico ETP. For example, the TPBA hired an individual familiar with all aspects of the trading program to serve as an "information broker," thus facilitating communication among TPBA members and between the TPBA and regulatory agencies, NGOs, and other external groups (Riggs, 1993). Periodic meetings of the TPBA also ensure that all member facilities receive necessary information. In addition, articles and reports on various aspects of the ETP, as well as a point-nonpoint source trading guide based on the Tar-Pamlico watershed, have been published and widely distributed.

Summary of Public Involvement

The public involvement component of the qualitative model was assigned a rating of "4," as shown in Table 8.5, since all pertinent stakeholders were directly involved in ETP design, and most stakeholders supported both phases of the program. In addition, information regarding the Tar-Pamlico ETP is readily available for stakeholders in the watershed as well as others who may be interested in effluent trading. Accordingly, it is recommended that educational and outreach efforts continue throughout Phase II and any subsequent phases of the trading program.

CONCLUSIONS

Effluent trading has proven to be a successful water quality management tool for the Tar-Pamlico River Basin since it has decreased compliance costs for TPBA members, reduced nutrient loadings from both point and agricultural nonpoint sources, and encouraged stakeholder cooperation and collaboration. The following factors have directly contributed to the program's success:

(1) Due to the initial lack of data, stakeholders used a phased approach to design and implement the ETP. In addition to establishing interim nutrient loading caps, this approach required extensive data collection and the development of a site-specific estuarine water quality model during the first phase. Therefore, since trading activities could begin before data collection was complete, stakeholders were able to realize the economic and environmental benefits of trading almost immediately. Furthermore, the additional data and the site-specific water quality model can be used to evaluate ETP effectiveness and refine future phases.

(2) Effluent limitations for total nitrogen and total phosphorus, which were proposed under DEM's original nutrient management strategy, would have significantly increased environmental compliance costs for new and expanding point sources in the watershed. Therefore, such sources had a powerful incentive to develop a more cost-effective alternative. In addition, the DEM and other stakeholders in the watershed realized that an ETP could simultaneously reduce environmental compliance costs and, by sponsoring nutrient reductions from agricultural nonpoint sources, improve ambient water quality by bringing more watershed sources under regulatory requirements.

(3) Many of the uncertainties associated with point-nonpoint source trading, such as determining nonpoint source loadings and BMP effectiveness, are eliminated by the structure of the Tar-Pamlico ETP which allows point sources to meet their nutrient reduction obligations by making payments to the ACSP. Administrative costs for nonpoint source controls are minimized by using an existing cost-share program to allocate the funds generated by the ETP.

(4) The structure of the TPBA also facilitated the development of a successful ETP. For example, DEM's administrative burden is reduced by regulating TPBA facilities as a single unit. In addition, the TPBA's structure allows POTW operators to pool their technical and financial resources and may even increase the likelihood of receiving external funding for the ETP.

Despite nutrient loading and water quality monitoring and modeling efforts, quantifying nonpoint source reductions, particularly during Phase II when the TPBA is expected to purchase additional credits from the ACSP to meet its nutrient loading cap, remains a major concern. In addition, enforcement mechanisms may be insufficient to ensure that nutrient reduction credits generated by existing agricultural BMPs remain effective throughout their lifespan. Given these uncertainties and the consequences of the failure of the ETP, TPBA members may prefer to upgrade their own facilities or trade with other point sources, thus increasing their environmental compliance costs and decreasing the funding available to the ACSP.

Based on the results of this evaluation, it can be concluded that ETPs would be applicable to other large watersheds, both in the United States and abroad, that are experiencing water quality impairment due to excessive nutrient loadings. However, such trading programs should always be adjusted to site-specific conditions and, since it is extremely unlikely that comparable levels of funding will be available, they may need to rely more heavily on related case studies, existing water quality models, and extant data.

This case study was designed to evaluate the applicability of the qualitative model for designing and implementing ETPs to the existing Tar-Pamlico ETP, and to identify any necessary modifications in the model or the ETP. Since all ten model components received scores of "3" or "4," the qualitative model indicated that the ETP should be successful. This conclusion has been supported by several technical and policy reports and the general literature on the Tar-Pamlico ETP (Hall and Howett, 1995; and U.S. Environmental Protection Agency, 1993). However, the qualitative model was based on the assumption that source operators would negotiate trades individually with other source operators. Since this assumption was not valid for point-nonpoint source trades in the Tar-Pamlico ETP, the criteria questions or portions of such questions related to nonpoint sources, could be eliminated from the model when it is used in planning such an ETP. However, the relevant questions and portions thereof were included in this case study because they are still needed to quantify nonpoint source reductions and evaluate the overall ETP effectiveness.

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CHAPTER 9

USE OF THE QUALITATIVE MODEL FOR A POTENTIAL EFFLUENT TRADING PROGRAM FOR LAKE GENEVA

INTRODUCTION

Effluent trading programs (ETPs), which allow dischargers the flexibility to select the control alternatives for their specific situations, have been proposed as a cost-effective means of achieving water quality goals, standards, and objectives within a watershed. In addition, such programs encourage pollution prevention, promote the development and installation of more efficient abatement technologies, and may even reduce pollutant loadings from previously unregulated sources, thus improving overall water quality management within the trading area (Canter, et al., 1998). However, experience with similar programs, primarily for air quality management in the United States, has indicated that the success of ETPs may be influenced by technical, institutional, and administrative factors such as quantifying pollutant loading reductions, establishing a sufficient market size and composition, and minimizing transaction costs. In order for ETPs to realize their full potential, these factors must be identified, and trading programs must be designed to minimize or eliminate their negative influence.

This chapter describes the application of a ten-component qualitative model for designing and implementing an ETP for the Lake Geneva (Leman) watershed, one of the major lakes of Western Europe. This study was designed to test the applicability of the model, as described elsewhere (Edwards and Canter, 1998), and to identify any necessary revisions. In addition, the Lake Geneva watershed study was specifically focused on examining transboundary issues that may affect ETP design and implementation (the watershed encompasses portions of Switzerland and France). Since the Lake Geneva area does not currently have an ETP, the model was used to assess both ETP feasibility and to suggest elements that should be included in a site-specific ETP.

The chapter begins with a brief description of the physical and hydrological characteristics of the Lake Geneva watershed, followed by a detailed summary of the water quality in the lake. The next three sections relate to institutional aspects of water quality management for the lake; they include a discussion of governmental agencies associated with such management efforts in the watershed, the delineation of key non-governmental organizations (NGOs) with interests in Lake Geneva, and a brief summary of the Lake Geneva action plan promulgated by the International Commission for the Protection of the Leman (Lake Geneva) Waters (also known as CIPEL). The third major portion of this paper relates to the application of the ten-component qualitative model for determining the feasibility of an ETP for Lake Geneva, and for designing such a program for this watershed. The three sections in this portion include a brief description of the model, considerations regarding the feasibility of an ETP for the watershed, and specific design considerations for such a program directed toward phosphorus reductions via point source-nonpoint source trading. The final section contained herein highlights the conclusions from this case study.

PHYSICAL AND HYDROLOGICAL CHARACTERISTICS OF THE LAKE GENEVA WATERSHED

Figure 9.1 displays the entirety of the Lake Geneva watershed, while Figure 9.2 depicts Lake Geneva itself (CIPEL, 1996). The Lake Geneva watershed encompasses 7,975 km^2, including 7,393 km^2 of land area and 582 km^2 of lake water surface area. Relative to the land area, 6,503 km^2 (88%) is in Switzerland, and 890 km^2 (12%) is in

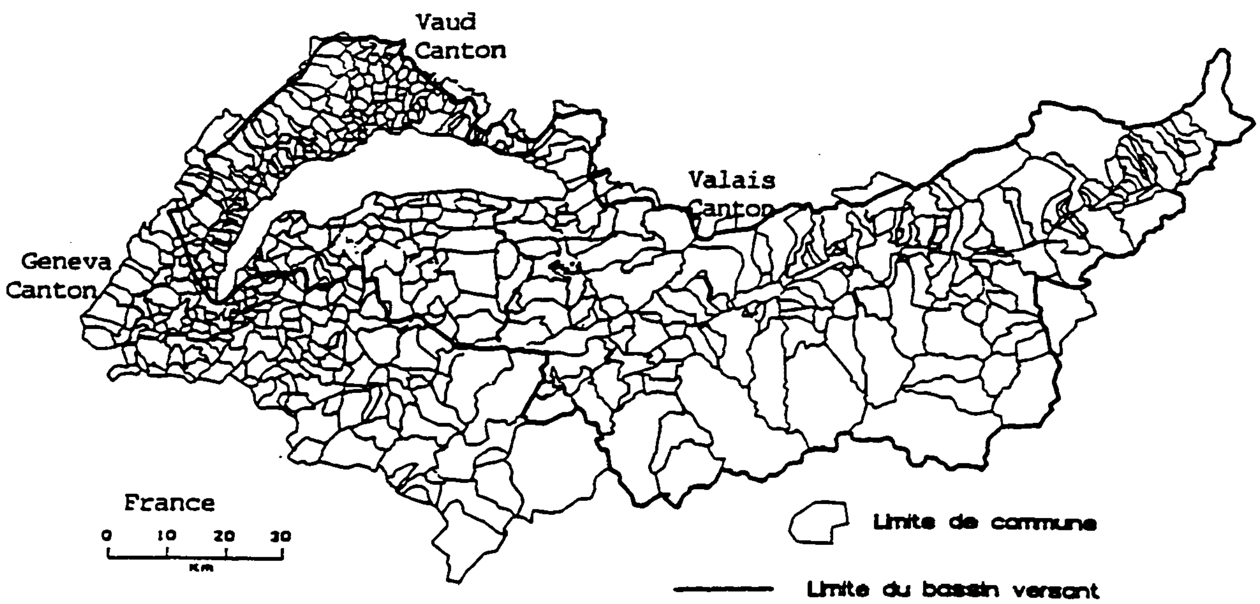

Figure 9.1: Lake Geneva Watershed (CIPEL, 1996)

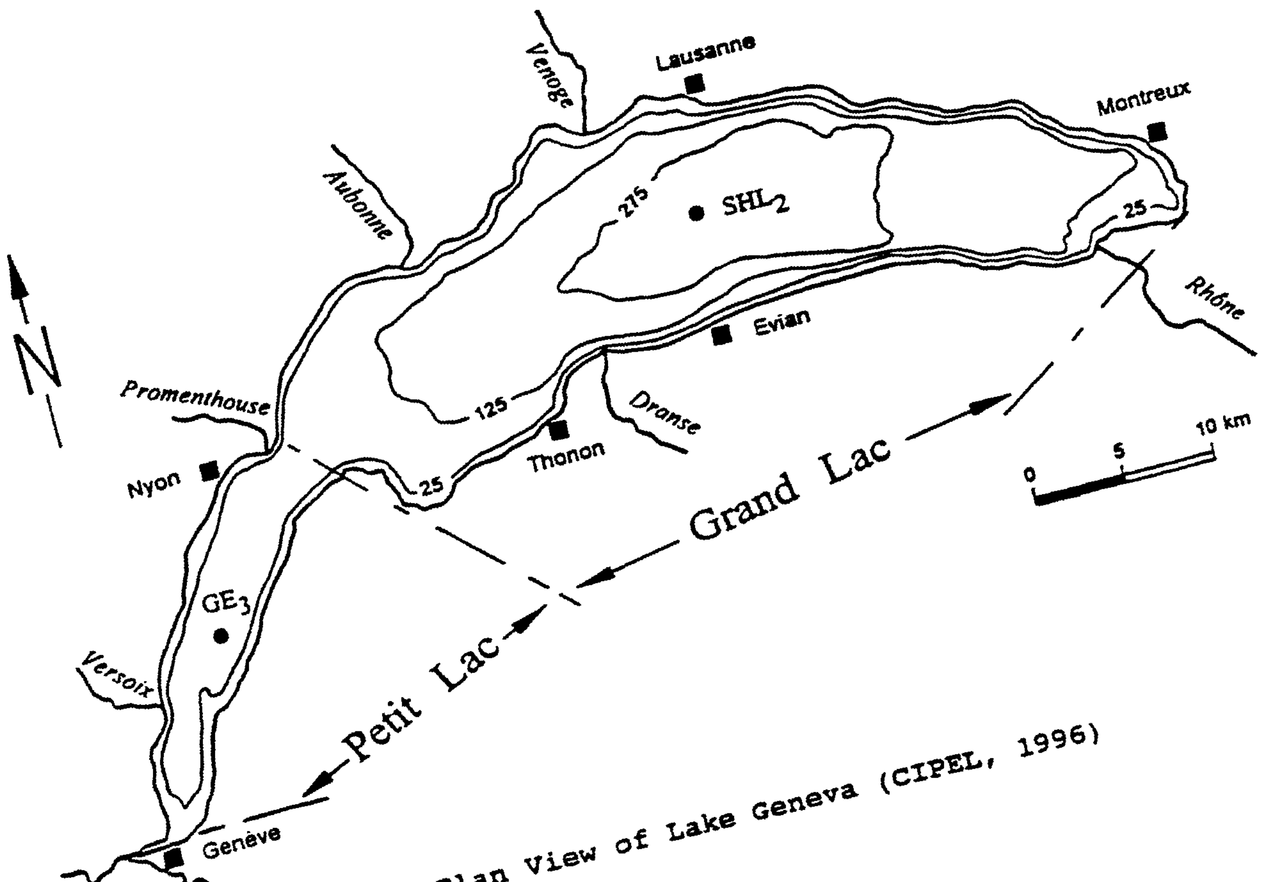

Figure 9.2: Plan View of Lake Geneva (CIPEL, 1996)

France (CIPEL, 1996). Nonurban land uses in the watershed include 20% for agricultural purposes, 23% for pastures, 22% for forests, and 35% as undeveloped. Of the total used for agricultural purposes, 64% is cropland, 6.5% is used as vineyards, 2.5% for fruit trees, 1% for vegetables, and 26% as open contiguous land (CIPEL, 1996).

Further, the resident human population in the Lake Geneva watershed was about 904,000 in January, 1995, with 778,000 (86%) in Switzerland and 126,000 (14%) in France (CIPEL, 1996). Key cities bordering the lake include Geneva, Nyon, Lausanne and Montreux in Switzerland; and Evian and Thonon in France. Facilities for about 625,000 tourists also existed in January, 1995, with 71% in Switzerland and 29% in France. The large tourist population relates to Lake Geneva water quality in two ways. First, a portion of this population is attracted to the area because of the recreational uses of the lake. However, services such as wastewater treatment must be provided for this transient population in order to maintain the overall water quality of Lake Geneva and its recreational beaches.

Figure 9.2 indicates that Lake Geneva can be considered in two parts, the Grand Lake portion and the Petit Lake portion. The characteristics of these two portions will be subsequently explored relative to water quality issues. The centerpoint of the geographical location of Lake Geneva is at 46°27′ north latitude, and 6°32′ east longitude. The mean elevation of the water surface from 1930 to 1995 was 372.05 m above mean sea level, with the maximum of 372.91 m occurring on June 17, 1937, and the minimum of 371.01 m noted on March 8, 1949 (CIPEL, 1996). These very modest changes indicate that the water surface elevation of Lake Geneva is essentially constant.

As shown in Table 9.1, the average area of the surface water of Lake Geneva is 582.4 km^2. Of this total, 348.4 km^2 (60%) is within the Swiss boundary, and 234.0 km^2 (40%) is in the French portion (CIPEL, 1996). Relative to the three included Swiss cantons, 295.7

Table 9.1: Physical Characteristics of Lake Geneva (after CIPEL, 1996)

Characteristic	Grand Lake Portion	Petit Lake Portion	Total Lake
Average area of water surface (km^2)	503.0 (86)[a]	79.4 (14)	582.4 (100)
Average area of the zone from 0 to 12 m above the lake bottom (km^2)	24.8 (56)	19.4 (44)	44.2 (100)
Mean volume of water (km^3)	86 (96)	3 (4)	89 (100)
Maximum water depth (m)	309.7	76	309.7
Mean water depth (m)	172.0	41.0	152.7
Length of longest axis (km)	49.0	23.3	72.3

Note: [a]number in parenthesis is the percentage of the listed characteristic for the total lake

km^2 (85%) is in the Vaud canton, 41.9 km^2 (12%) is in the Geneva canton, and 10.8 km^2 (3%) is in the Valais canton. Almost all of the French portion is in the Haute-Savoie department. Further, the shoreline length of Lake Geneva totals 167.0 km, with 113.9 km (68%) in Switzerland and 53.1 km (32%) in France. The Swiss shoreline length includes 83.5 km (73%) in the Vaud canton, 25.0 km (22%) in the Geneva canton, and 5.4 km (5%) in the Valais canton. Again, almost all of the French shoreline is in the Haute-Savoie department.

The mean annual flow of water into Lake Geneva from 1935 to 1994 was 249.3 m^3/sec. The maximum annual flow over this time period was 319 m^3/sec in 1982, with the minimum being 166 m^3/sec in 1976. Based upon the mean annual flow over this time period, and the mean volume of lake water as shown in Table 9.1, the average water detention time in the lake is 11.4 years (CIPEL, 1996).

Figure 9.3 depicts the locations of 12 tributaries flowing into Lake Geneva (Orand, et al., 1996). Four are considered as major (primary) tributaries (Aubonne, Venoge, Rhone, and Dranse Rivers), and eight are secondary tributaries (Versoix, Promenthouse, Dullive, Morges, Chamberonne, Veveyse, Eau Froide, and Stockalper Rivers). Figure 9.3 also shows the downstream Rhone River discharge (emissaire) from Lake Geneva. Annual mean flows for the four major tributaries into Lake Geneva are summarized in Table 9.2 for 1981 through 1995 (Orand, et al., 1996). The downstream flow of the Rhone River is also shown. Similar flow information for the eight secondary tributaries is in Table 9.3 for 1990 through 1995 (Orand, et al., 1996). Figure 9.4 contains a bar diagram summarizing these inflows to Lake Geneva and the downstream outflow (Orand, et al., 1996). As can be easily seen, the upstream Rhone River flow is the major contributor to the total inflow into Lake Geneva.

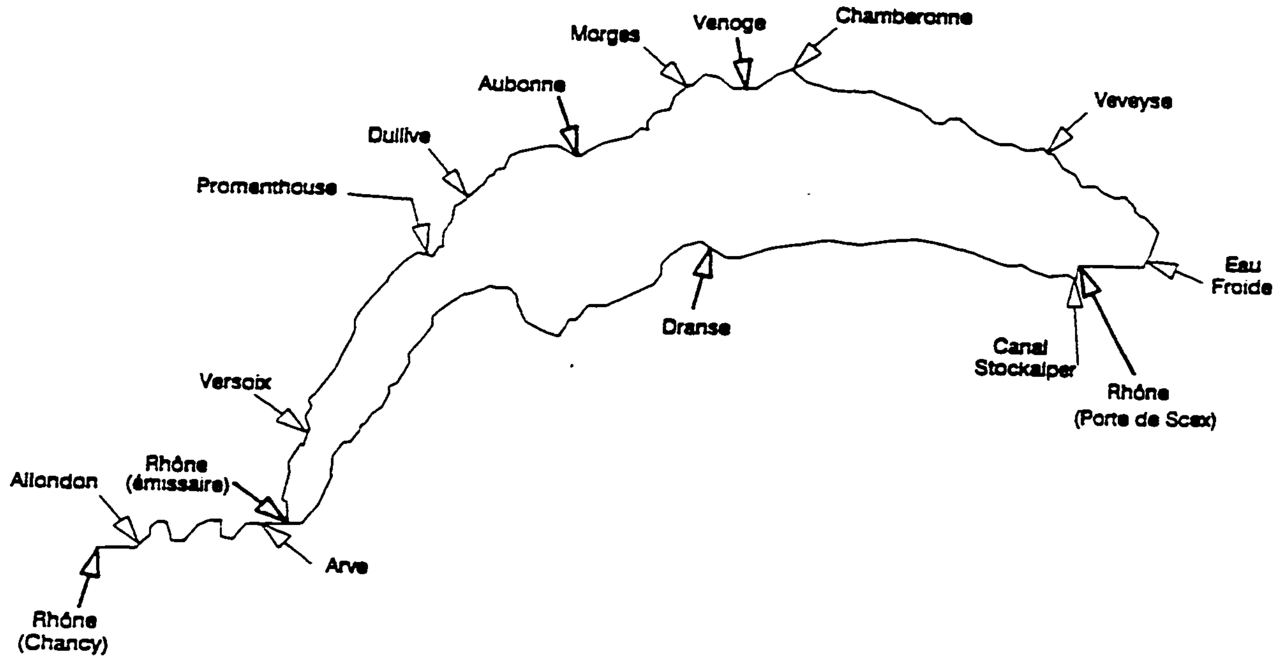

Figure 9.3: Tributary Rivers to Lake Geneva (Orand, et al., 1996)

Table 9.2: Mean Annual Flows[a] from Four Major Tributaries Into Lake Geneva, and the Rhone River Outflow (emissaire) from Lake Geneva (Orand, et al., 1996)

Year	Venoge River	Aubonne River	Dranse River	Rhone River	Rhone River (emissaire)
1981	5.2	5.3	22.2	211.0	304.0
1982	6.1	7.0	22.7	219.0	304.0
1983	5.2	6.5	22.7	206.0	268.0
1984	5.3	5.9	19.6	160.2	221.0
1985	3.4	4.6	19.7	182.7	258.0
1986	3.9	5.3	21.4	199.1	259.1
1987	4.7	6.9	23.3	198.2	276.6
1988	5.5	6.7	22.2	206.7	278.9
1989	2.3	2.9	12.1	169.6	207.2
1990	3.0	3.7	18.3	172.2	238.6
1991	3.2	5.9	14.9	173.7	201.5
1992	4.1	7.2	21.3	178.5	224.7
1993	6.6	5.6	17.3	191.2	243.2
1994	4.5	6.1	20.5	216.4	297.4
1995	5.3	6.6	27.2	210.5	303.4
Mean	4.5	5.7	20.4	193.0	259.0

a: flow expressed in m^3/sec

Table 9.3: Mean Annual Flows[a] from Secondary Tributaries Into Lake Geneva (after Orand, et al., 1996)

Year	Versoix River	Stockalper River	Veveyse River	Promenthouse River	Chamberonne River	Eau Froide River	Morges River	Dullive River
1990	3.21	NA[b]	2.78	2.39	0.79	0.27	0.35	0.22
1991	2.90	2.87	1.52	1.51	0.57	0.30	0.25	0.15
1992	4.66	3.62	2.58	1.41	0.68	0.29	0.28	0.25
1993	2.87	2.79	1.87	1.72	0.68	0.78	1.69	0.98
1994	3.17	2.41	2.40	1.30	1.07	0.53	0.48	0.28
1995	3.65	3.32	1.88	1.97	1.06	0.55	0.97	0.19
Mean	3.41	3.00	2.17	1.72	0.81	0.45	0.67	0.34

a: flow expressed in m^3/sec
b: not available

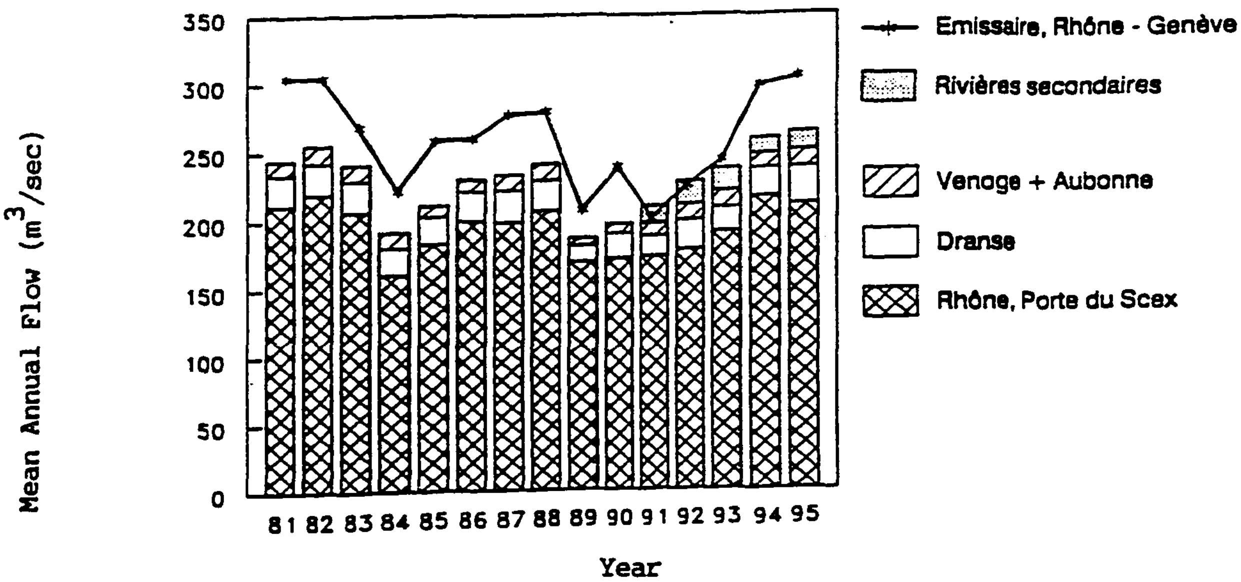

Figure 9.4: Mean Annual Flows Into and From Lake Geneva (Orand, et al., 1996)

WATER QUALITY OF LAKE GENEVA

The quality of Lake Geneva water has been of interest for several decades. As a result, numerous data have been collected and summarized by various organizations, including CIPEL -- the International Commission for the Protection of the Leman Waters (1996). This section will highlight information related to temperature, phosphorus, nitrogen, and dissolved oxygen in both the Grand Lake and Petit Lake portions of Lake Geneva. Such information provides the basis for considering an ETP. Further, the relative contributions of point and nonpoint sources to the phosphorus loading will be summarized because this information is needed to determine the potential relevance of point-point source trades and point-nonpoint source trades for this nutrient.

Water Temperatures

Figure 9.5 shows the water surface temperatures in the Grand Lake portion for 1994-1995, while Figure 9.6 illustrates the annual mean temperatures in the lower levels of the same portion from 1957-1995. Examination of Figure 9.5 indicates a summertime maximum of 26°C in the upper layers, with the lowest annual temperatures being in the range of about 6°C in the period from January through March. While it is not possible to clearly denote any long term trends from Figure 9.6, it would appear that the water temperatures at the depths of 100 meters, 200 meters, and 309 meters are beginning to exhibit an increase over the 39-year period. Because the temperatures in Figure 9.6 are in the lower levels of Lake Geneva, and due to the lack of regular lake turnovers, particularly in the decade of the 1990s, the higher temperatures in the 1990s may be reflective of this situation. Table 9.4 summarizes the mean annual temperature data at six depth zones at sampling location SHL2 in the Grand Lake portion. Examination of the temperature information for these six zones indicates a decrease in temperature with the deeper zones, and this

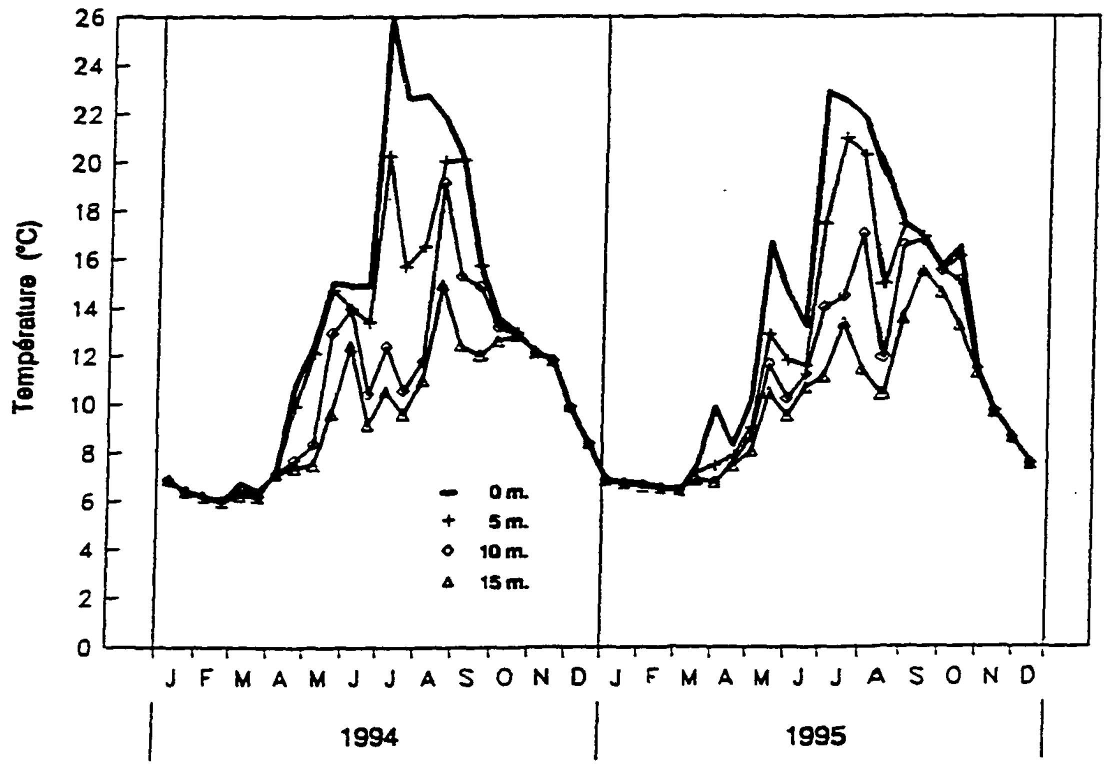

Figure 9.5: Water Surface Temperatures in the Grand Lake Portion (SHL2) of Lake Geneva (Blanc, et al., 1996)

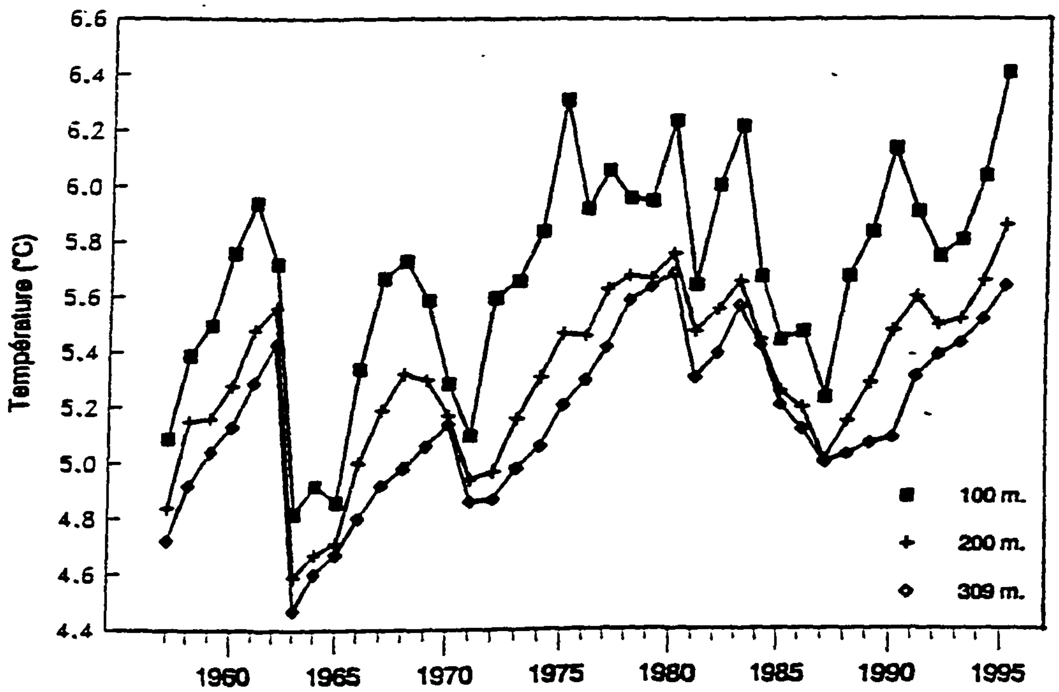

Figure 9.6: Annual Mean Temperatures in the Lower Levels of the Grand Lake Portion (SHL2) of Lake Geneva (Blanc, et al., 1996)

Table 9.4: Summary of Mean Annual Water Quality Data at Sampling Location SHL2 in the Grand Lake Portion of Lake Geneva (after Blanc, et al., 1996)

Depth Below Water Surface (m)	Water Quality Parameter	Year									
		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
0-10	Temperature (°C)	10.68	10.78	11.80	11.82	12.48	11.61	11.49	11.66	11.58	11.42
	Dissolved oxygen (mg/l)	10.75	10.96	10.71	10.72	10.79	10.86	10.53	10.64	10.85	10.75
	Nitrate (NO_3) nitrogen (μg N/l)	375	383	366	408	359	396	386	408	419	422
	Inorganic (PO_4) phosphorus (μg P/l)	30.8	24.5	17.3	15.7	12.6	13.4	11.5	11.5	9.7	9.6
	Total phosphorus (μg P/l)	47.0	41.0	31.5	29.9	26.7	25.9	24.6	22.2	20.0	18.4

Table 9.4 (continued):

Depth Below Water Surface (m)	Water Quality Parameter	Year									
		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
10-20	Temperature (°C)	8.26	8.72	9.37	9.57	9.93	9.31	9.33	9.57	9.48	9.53
	Dissolved oxygen (mg/l)	10.07	10.14	9.91	9.82	9.73	9.81	9.65	9.80	9.93	9.84
	Nitrate (NO_3) nitrogen (μg N/l)	491	485	500	513	482	502	497	502	510	501
	Inorganic (PO_4) phosphorus (μg P/l)	41.9	32.3	24.1	20.2	13.7	16.7	14.1	13.9	11.4	10.9
	Total Phosphorus (μg P/l)	54.3	45.6	34.4	30.5	24.2	27.0	24.6	22.7	20.0	18.0

Table 9.4 (continued):

Depth Below Water Surface (m)	Water Quality Parameter	Year									
		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
20-50	Temperature (°C)	6.35	6.35	6.81	7.21	7.32	7.07	7.10	6.75	7.22	7.48
	Dissolved oxygen (mg/l)	10.15	10.17	10.05	9.82	9.56	9.64	9.83	9.64	9.67	9.79
	Nitrate (NO_3) nitrogen (μg N/l)	555	568	604	602	589	581	587	601	596	586
	Inorganic (PO_4) phosphorus (μg P/l)	57.7	50.3	43.0	36.0	30.1	29.6	24.0	25.3	24.9	20.2
	Total Phosphorus (μg P/l)	67.7	60.1	50.1	42.3	37.0	36.8	32.8	32.1	30.6	25.1

Table 9.4 (continued):

Depth Below Water Surface (m)	Water Quality Parameter	Year									
		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
50-100	Temperature (°C)	5.64	5.43	5.93	6.11	6.38	6.20	6.16	5.95	6.29	6.66
	Dissolved oxygen (mg/l)	10.19	10.29	10.19	9.53	9.20	9.61	9.69	9.64	9.60	9.70
	Nitrate (NO_3) nitrogen (μg N/l)	573	589	617	629	618	601	605	615	609	610
	Inorganic (PO_4) phosphorus (μg P/l)	63.4	57.8	52.0	47.9	43.2	37.3	33.0	32.6	33.6	29.2
	Total Phosphorus (μg P/l)	72.5	65.9	58.3	52.7	49.1	43.2	40.9	38.3	38.3	32.8

Table 9.4 (continued):

Depth Below Water Surface (m)	Water Quality Parameter	Year									
		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
100-200	Temperature (°C)	5.35	5.14	5.44	5.59	5.85	5.76	5.62	5.67	5.86	6.15
	Dissolved oxygen (mg/l)	9.82	9.69	9.38	8.38	8.01	8.39	8.31	8.18	8.20	7.98
	Nitrate (NO_3) nitrogen (μg N/l)	573	592	615	628	617	602	598	602	600	600
	Inorganic (PO_4) phosphorus (μg P/l)	66.9	63.9	61.7	60.3	57.5	50.6	46.0	45.0	45.1	43.0
	Total Phosphorus (μg P/l)	75.7	7.19	68.1	65.9	63.6	56.7	54.6	51.2	49.4	46.3

Table 9.4 (continued):

Depth Below Water Surface (m)	Water Quality Parameter	Year									
		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
200-309	Temperature (°C)	5.18	5.00	5.11	5.22	5.38	5.50	5.45	5.49	5.61	5.79
	Dissolved oxygen (mg/l)	9.04	8.24	7.65	6.55	6.12	5.56	5.23	5.04	5.13	4.80
	Nitrate (NO_3) nitrogen (μg N/l)	576	592	607	612	599	577	564	562	559	551
	Inorganic (PO_4) phosphorus (μg P/l)	72.4	74.0	75.1	75.5	75.6	76.4	71.4	69.7	66.6	65.6
	Total Phosphorus (μg P/l)	80.9	82.4	81.5	82.3	81.8	82.3	80.9	76.5	71.1	69.2

would be expected. Further, and as also illustrated in Figure 9.6, the temperatures in the lower levels do suggest an increase over the ten-year period from 1986 through 1995.

Figure 9.7 displays the water surface and bottom temperatures in the shallower Petit lake portion. Peak temperatures at the surface over the ten-year period from 1986 through 1995 generally average in the range of 22°C, with the maximum value of 24°C occurring in 1990. The water temperatures at the bottom of the Petit Lake portion (70 m deep) generally average in the range of 4 to 6°C. Figure 9.8 depicts the annual mean temperatures averaged over the entire water column of Petit Lake at sampling location GE3. The general trend of information over the ten-year period suggests an increasing water temperature from approximately 9°C to one in excess of 10°C. This increasing temperature may also be reflective of the lack of annual water turnover in both portions of Lake Geneva over this time period.

A primary concern relative to increasing water temperatures in both portions of Lake Geneva is the fact that this provides an aquatic environment which is more conducive for phytoplankton (algae) growth. Further, higher temperatures lower the saturation concentration for dissolved oxygen. Lower dissolved oxygen levels can lead to chemically reducing conditions in the hypolimnion, thus causing releases of previously deposited chemicals from lake sediment. This phenomena will be illustrated for manganese in a subsequent section.

Phosphorus Concentrations

Phosphorus has been recognized as the critical nutrient in Lake Geneva for about two decades. Of fundamental concern is the fact that excessive phosphorus concentrations can lead to greater abundances of phytoplankton which, in turn, can have other water quality implications, including the unsightly occurrence of excessive

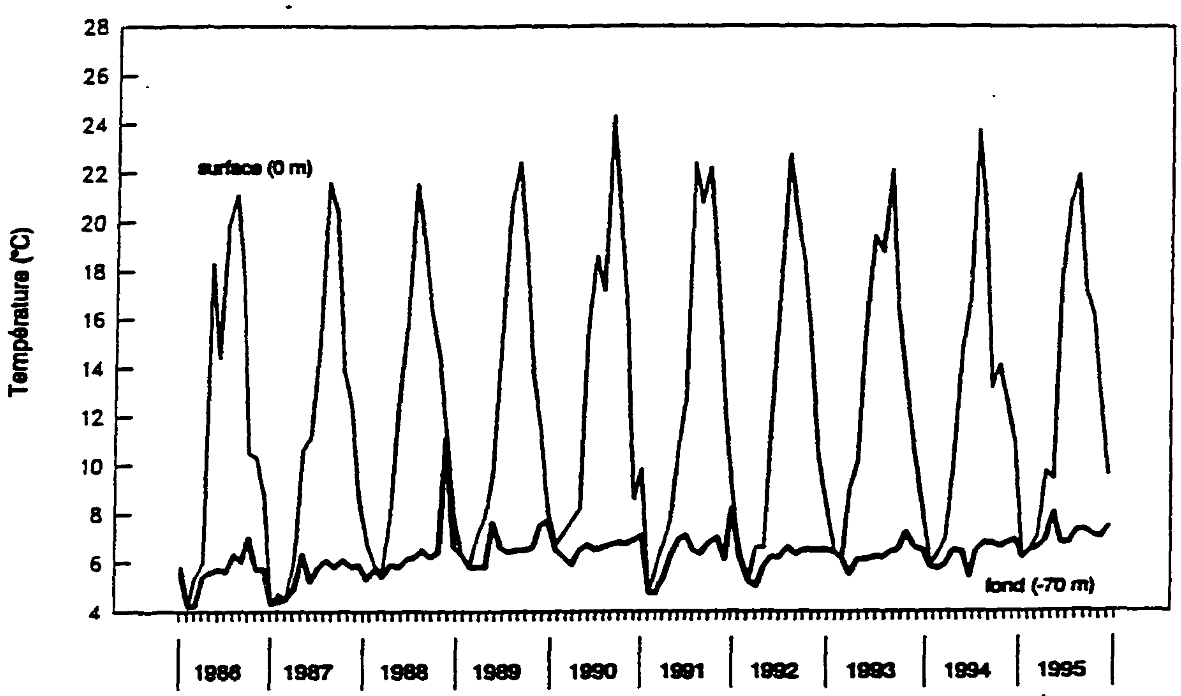

Figure 9.7: Water Surface and Bottom Temperatures in the Petit Lake Portion (GE3) of Lake Geneva (Blanc, et al., 1996)

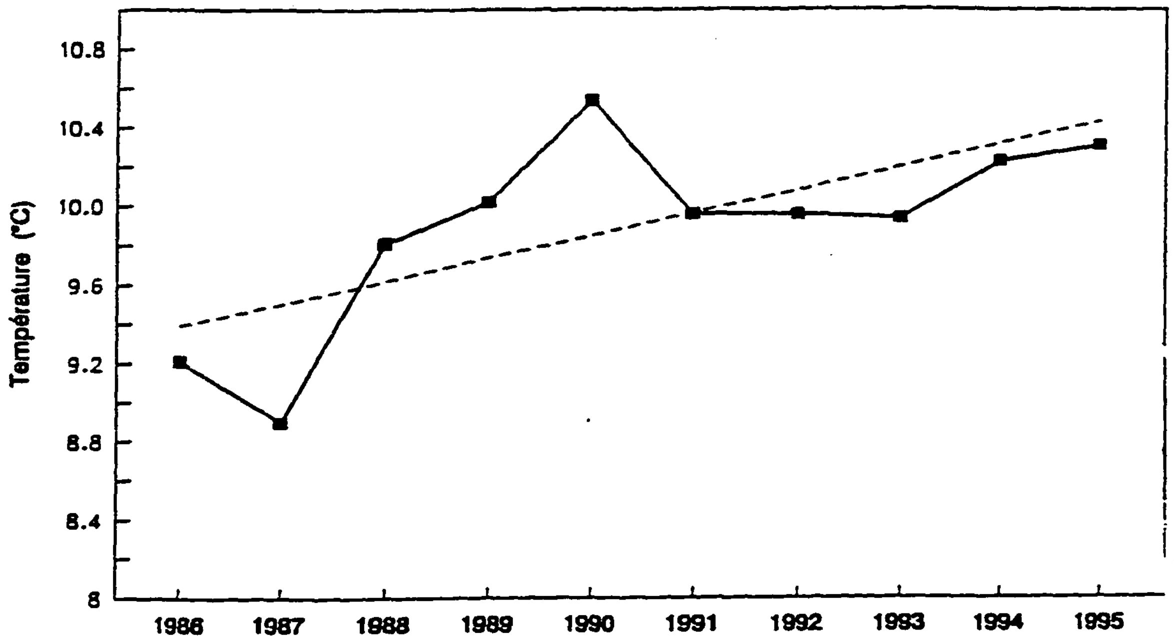

Figure 9.8: Annual Mean Temperatures in the Water Column of the Petit Lake Portion (GE3) of Lake Geneva (Blanc, et al., 1996)

algae blooms. Phosphorus concentrations can be considered from the perspective of total phosphorus, dissolved (primarily inorganic) phosphorus, and particulate phosphorus. Of primary relevance to phytoplankton productivity is dissolved phosphorus. Table 9.4 summarizes 10 years of data for total phosphorus and inorganic phosphorus for six different depth zones in the Grand Lake portion. Examination of these data indicate that the phosphorus concentrations have declined at all depths over the time period from 1986 to 1995, with these declines primarily related to the incorporation of phosphorus removal facilities at wastewater treatment plants in the Swiss portion of the watershed, as well as the promotion and sale of phosphate- free detergents in Switzerland. Further examination of Table 9.4 reveals that higher total phosphorus and inorganic phosphorus concentrations occur in the deeper zones of Lake Geneva, with the highest concentrations occurring in the bottommost zone (200 m to 309 m depth). This occurrence probably is reflective of phytoplankton production in the uppermost zones followed by their death and settling toward the lake bottom.

Figure 9.9 graphically depicts the dissolved phosphorus concentrations in the surface waters of the Grand Lake portion over the ten-year period from 1986 to 1995. This figure also reveals the decline in the maximum annual phosphorus concentrations. At the beginning of the period the maximum phosphorus concentrations were approximately 60 micrograms P per liter; however, the more recent maximum concentrations are less than 30 micrograms P per liter. Annual variations of dissolved phosphorus in the surface waters over a two-year period are shown in Figure 9.10. Peak concentrations generally occur in the months of January through March, with the lowest concentrations occurring during the summer and fall months. It should be noted that the higher concentrations coincide with

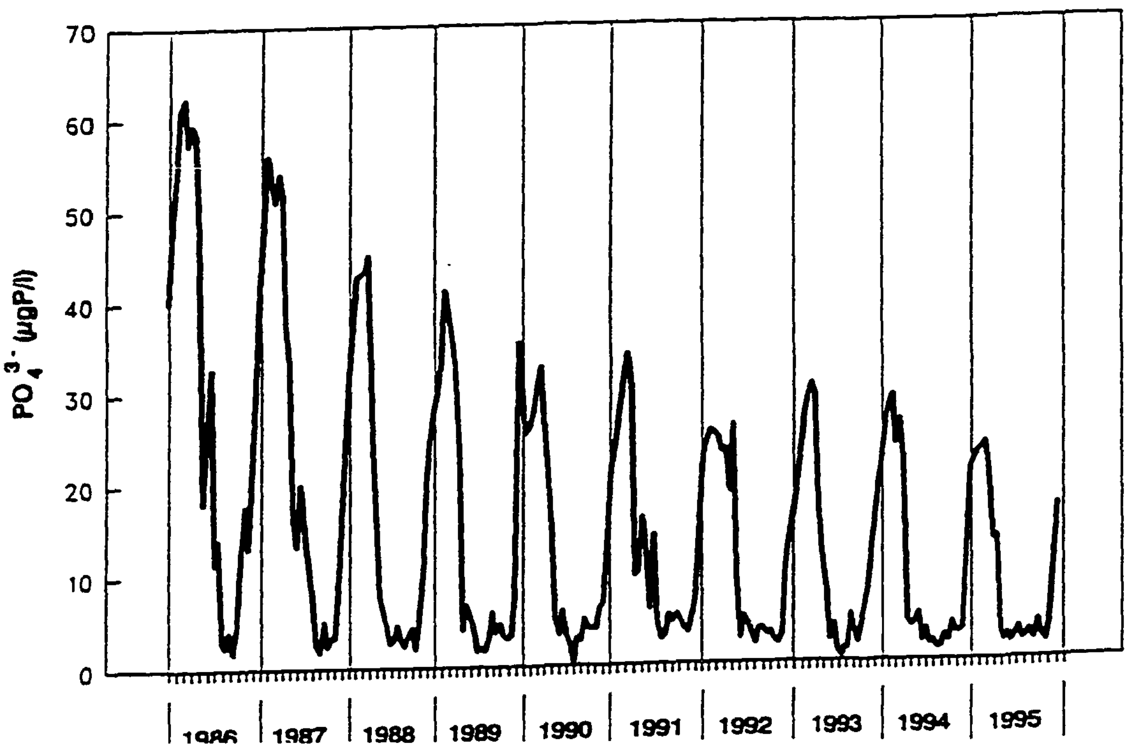

Figure 9.9: Dissolved Phosphorus (PO_4) in the Surface Waters (0-10 m) of the Grand Lake Portion (SHL2) of Lake Geneva (Blanc, et al., 1996)

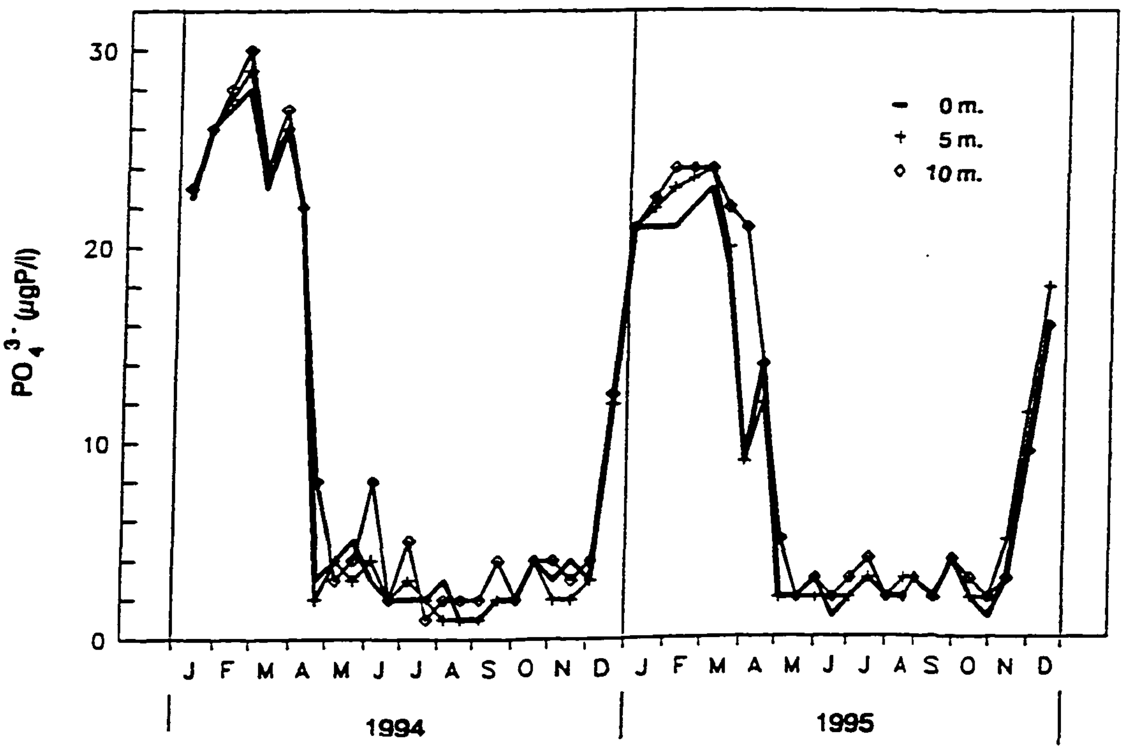

Figure 9.10: Detailed Information on the Dissolved Phosphorus (PO_4) in the Surface Waters (0-10 m) of the Grand Lake Portion (SHL2) of Lake Geneva (Blanc, et al., 1996)

higher rainfall and snowmelt, thus suggesting the influence of nonpoint sources of phosphorus.

Table 9.5 summarizes the mean annual water quality data at sampling location GE3 in the Petit Lake portion of Lake Geneva. Examination of Table 9.5 for both total phosphorus and inorganic phosphorus reveals a decline in concentrations over the ten-year time period. The inorganic phosphorus concentration declined from 43.9 micrograms P per liter to 12.4. Similarly, the total phosphorus concentration declined from 58.3 to 21.4 micrograms P per liter. Figure 9.11 summarizes the annual fluctuations of dissolved phosphorus in Petit Lake from 1986 to 1995. As can be seen, the maximum concentrations on an annual basis have declined from approximately 70 micrograms P per liter in 1986 to less than 30 in 1995. Again, and in a similar fashion to the annual fluctuations shown in Figures 9.9 and 9.10 for Grand Lake, the maximum concentrations occur in the winter months, with the lower concentrations occurring in the summer and fall months. This also highlights the influence of nonpoint sources of phosphorus in the Lake Geneva watershed.

Table 9.6 summarizes the mean annual concentrations of different forms of phosphorus at sampling location GE3 in Petit Lake. Examination of the concentrations over the time period reveals a decline of 50% or more. Further, it can be seen that the inorganic and total phosphorus concentrations are higher at the bottom of Petit Lake (approximately 70 m depth) than in the surface layers. For example, the inorganic phosphorus concentration in the bottom zone is more than double the corresponding value at the water surface. The higher concentration in the bottom zone, as well as the higher ratio of inorganic phosphorus to total phosphorus, indicates phytoplankton (algae) productivity in the upper layers followed by die-away, settling, and decomposition.

Table 9.5: Summary of Mean Annual Water Quality Data at Sampling Location GE3 in the Petit Lake Portion of Lake Geneva (after Blanc, et al., 1996)

Water Quality Parameter[a]	Year									
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Dissolved oxygen (mg/l)	11.07	11.12	10.88	10.50	10.57	10.79	10.80	10.74	10.61	10.71
Nitrate (NO_3) nitrogen (μg N/l)	469	498	473	503	487	521	542	551	497	483
Total nitrogen (μg N/l)	NA[b]	NA	NA	NA	NA	622	559	689	687	682
Inorganic (PO_4) phosphorus (μg P/l)	43.9	38.1	30.6	25.6	19.2	20.2	19.5	17.1	16.9	12.4
Total phosphorus (μg P/l)	58.3	53.9	40.8	37.8	35.3	32.6	32.0	29.9	28.1	21.4

Notes: [a]The included data are averaged over the 70 m water depth at GE3
[b]Not available

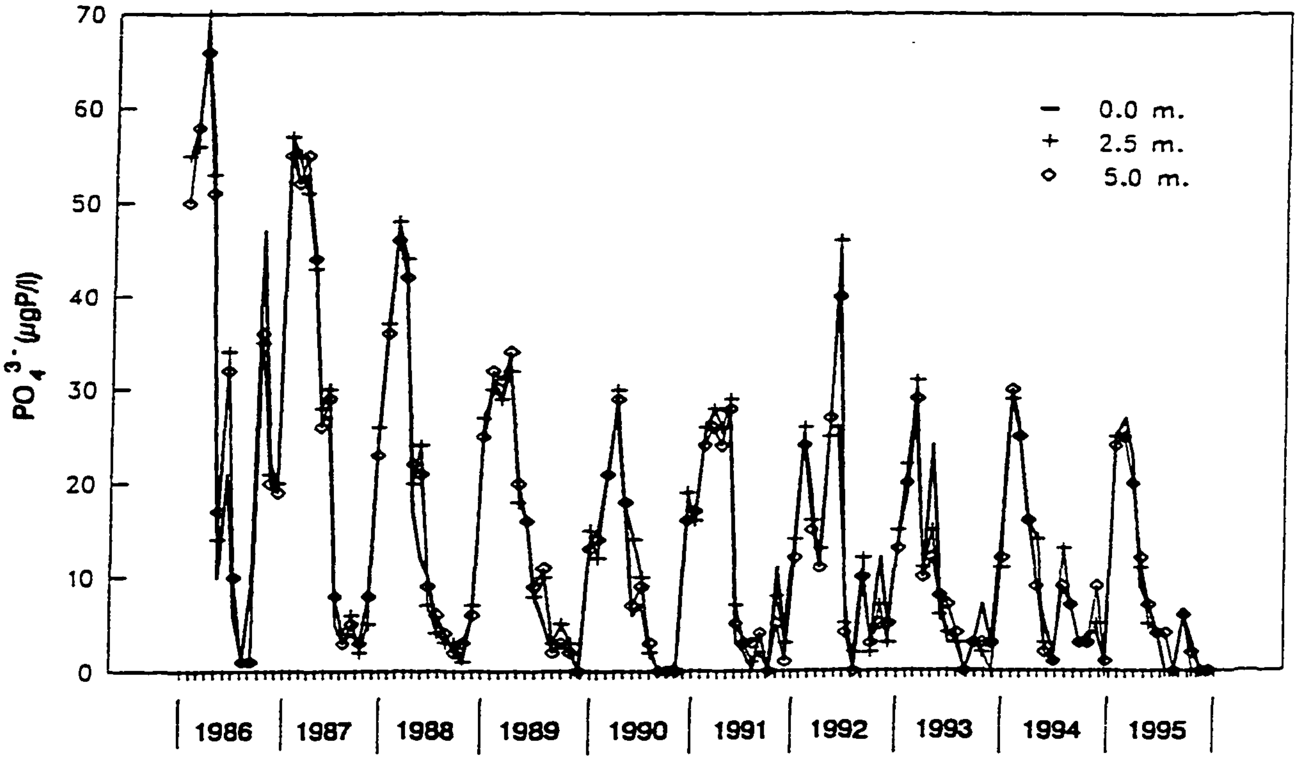

Figure 9.11: Dissolved Phosphorus (PO_4) in the Surface Waters (0-5 m) of the Petit Lake Portion (GE3) of Lake Geneva (Blanc, et al., 1996)

Table 9.6: Mean Annual Concentrations of Different Forms of Phosphorus at Sampling Location GE3 in the Petit Lake Portion of Lake Geneva (after Blanc, et al., 1996)

Year	At Water Surface (0-5 m)			At Lake Bottom (70 m)		
	Inorganic (PO_4) phosphorus (μg P/l)	Total phosphorus (μg P/l)	Ratio[a] (%)	Inorganic (PO_4) phosphorus (μg P/l)	Total phosphorus (μg P/l)	Rati
1986	30.6	48.7	62.9	64.3	75.8	84.
1987	25.9	43.6	59.5	60.7	76.3	79.
1988	18.1	30.1	60.3	51.5	60.8	84.
1989	14.0	27.3	51.2	53.3	75.7	70.
1990	10.5	25.5	41.1	41.6	76.8	54.
1991	11.9	25.8	46.1	36.8	49.5	74.
1992	13.5	25.3	53.5	36.4	51.6	70.
1993	9.5	21.6	43.9	37.0	51.9	71.
1994	9.7	21.3	43.5	36.3	45.2	80.
1995	8.4	18.9	44.8	27.8	38.3	72.

Note: [a]ratio of inorganic phosphorus to total phosphorus

Figure 9.12 summarizes the particulate phosphorus concentrations in the surface waters of the Grand Lake portion of Lake Geneva. Annual cycling is depicted; however, the peak concentrations occur in the late spring and early summer months. This is probably a result of the phosphorus which becomes associated with phytoplankton productivity. Finally, Figure 9.13 illustrates the total phosphorus at the bottom (309 m deep) of Grand Lake. While there are annual concentration fluctuations, they are in the range of 80 to approximately 140 micrograms P per liter, with no significant declines over time. The implication is that even though the phosphorus input into Lake Geneva has been declining in the last decade (to be addressed later), the buildup of phosphorus in the bottom of both portions of Lake Geneva continues to occur, with marked declines in the bottom level concentrations yet to be noted.

Nitrogen Concentrations

Another key nutrient in Lake Geneva is nitrogen, with nitrate nitrogen being the primary form of concern relative to phytoplankton productivity. Both nitrogen and phosphorus can contribute to such productivity, with the phosphorus concentrations probably representing the limiting nutrient for Lake Geneva based upon the scientific evidence to date, the emphasis given to phosphorus in numerous scientific studies, and the aggressive programs of CIPEL to reduce phosphorus inputs to the lake.

Figure 9.14 depicts the nitrate nitrogen concentrations in the surface waters of Grand Lake in 1994 and 1995. The peak nitrate nitrogen concentrations occur in the winter months of January through March, thus suggesting nonpoint contributions of this nutrient. The minimum nitrate nitrogen concentrations typically occur in the summer or early fall months. A similar pattern for nitrate nitrogen concentrations in the surface waters of the Petit Lake portion is shown in Figure 9.15 for 1986 through 1995. Mean annual

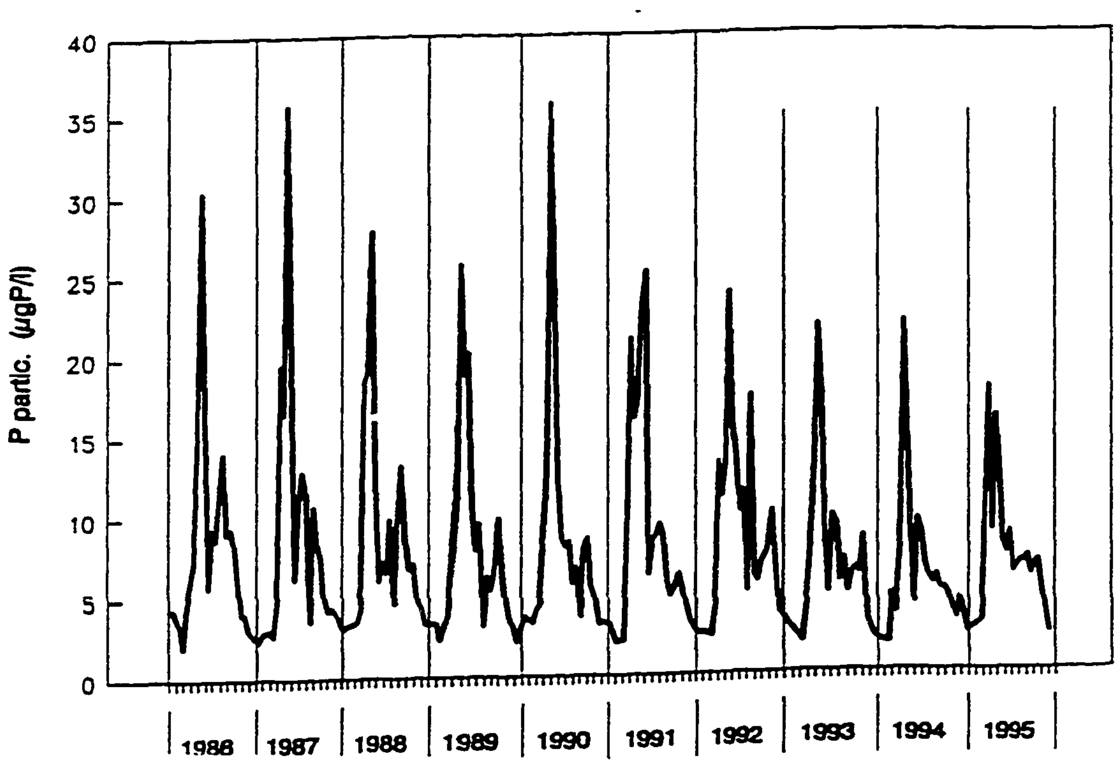

Figure 9.12: Particulate Phosphorus (PO_4) in the Surface Waters (0-10 m) of the Grand Lake Portion (SHL2) of Lake Geneva (Blanc, et al., 1996)

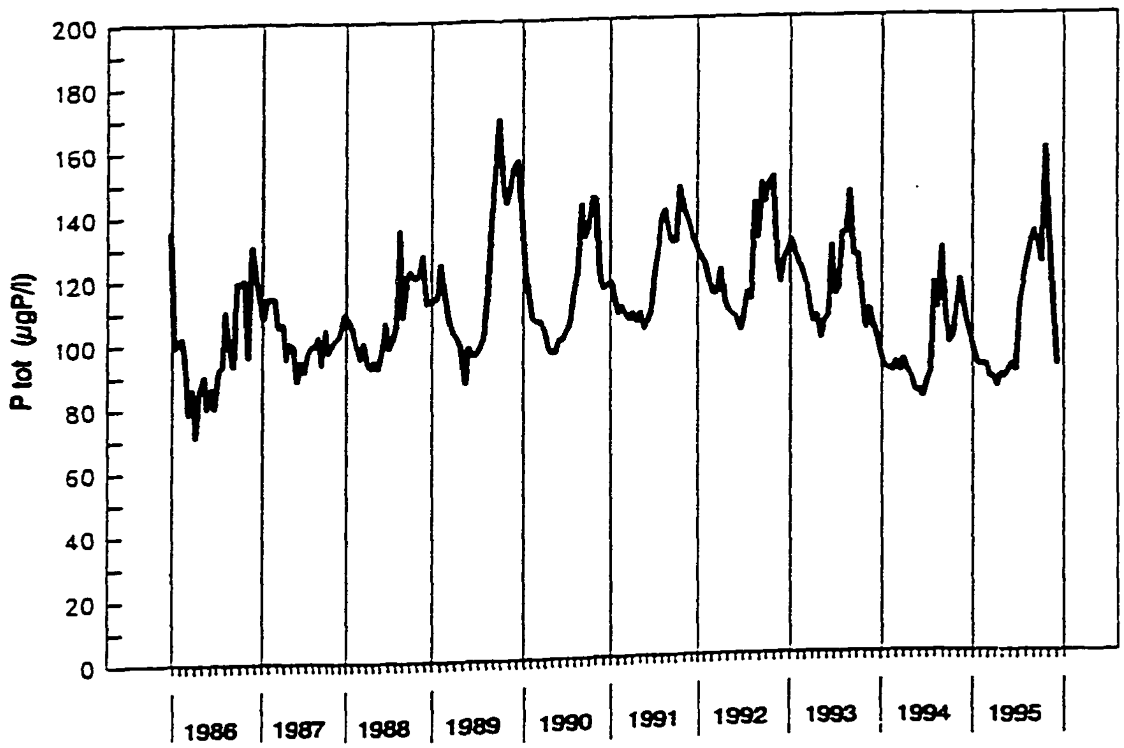

Figure 9.13: Total Phosphorus at the Bottom (309 m) of the Grand Lake Portion (SHL2) of Lake Geneva (Blanc, et al., 1996)

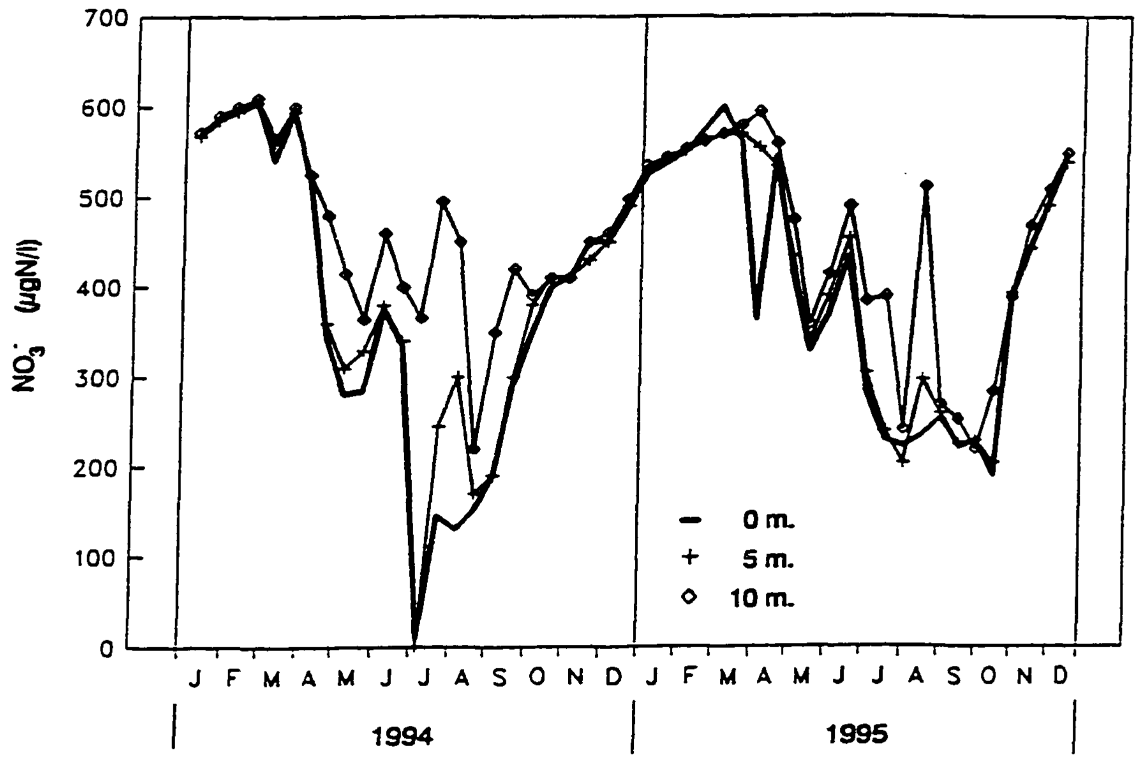

Figure 9.14: Nitrate Nitrogen in the Surface Waters (0-10 m) of the Grand Lake Portion (SHL2) of Lake Geneva (Blanc, et al., 1996)

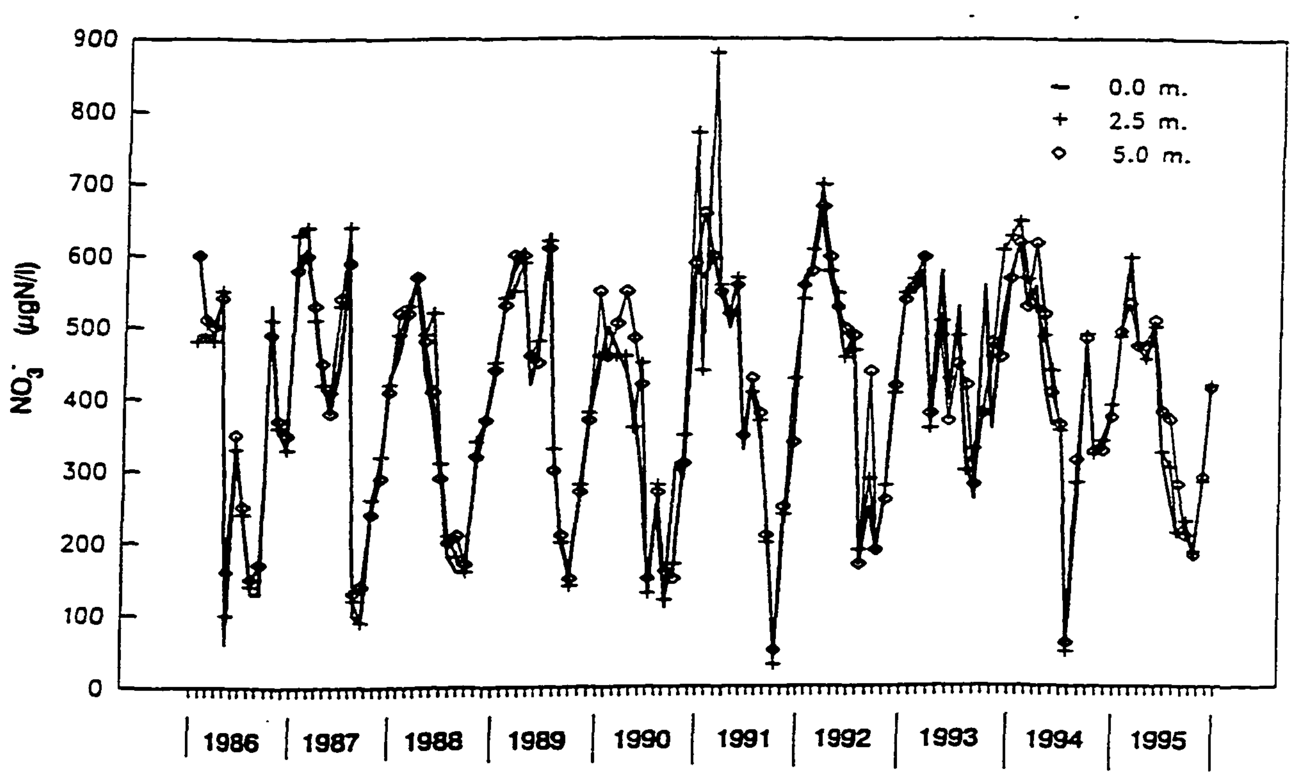

Figure 9.15: Nitrate Nitrogen in the Surface Waters (0-5 m) of the Petit Lake Portion (GE3) of Lake Geneva (Blanc, et al., 1996)

concentrations for nitrate nitrogen and total nitrogen in the Grand Lake portion of Lake Geneva are shown in Figure 9.16. The nitrate nitrogen concentrations as well as the total stock (total mass) in Grand Lake have been increasing. For example, the nitrate nitrogen concentration increased from about 300 micrograms N per liter in 1957 to almost 600 micrograms N per liter in the 1990s. Figure 9.16 also indicates that nitrate nitrogen is the primary contributor to the total nitrogen concentration in the Grand Lake portion of Lake Geneva.

Table 9.4, as shown earlier, summarizes the mean annual nitrate nitrogen concentrations in the Grand Lake portion of Lake Geneva for six water depth zones. Examination of these data indicate no significant concentration decreases in the six zones. In fact, in the shallower zones, the nitrate nitrogen concentrations appear to have experienced some small increases over the ten-year period from 1986 to 1995.

Table 9.5 summarizes both nitrate nitrogen and total nitrogen concentrations in the Petit Lake portion of Lake Geneva. Again, it can be noted that nitrate nitrogen is the primary component of total nitrogen. Further, there are small increases in the concentrations of both nitrogen forms over the depicted time periods.

Mass Loadings of Selected Chemicals

In addition to concentrations of water quality constituents, it is also instructive to consider the total mass loading of selected chemical constituents within the two portions of Lake Geneva. Accordingly, Table 9.7 summarizes this information for dissolved oxygen, inorganic phosphorus, total phosphorus, nitrate nitrogen, and total nitrogen for Grand Lake over the time period from 1986 to 1995. Table 9.8 includes similar information for the Petit Lake portion of Lake Geneva. Comparisons of the mass loadings from Tables 9.7 and 9.8 reveal that the major portion of the total mass of all five

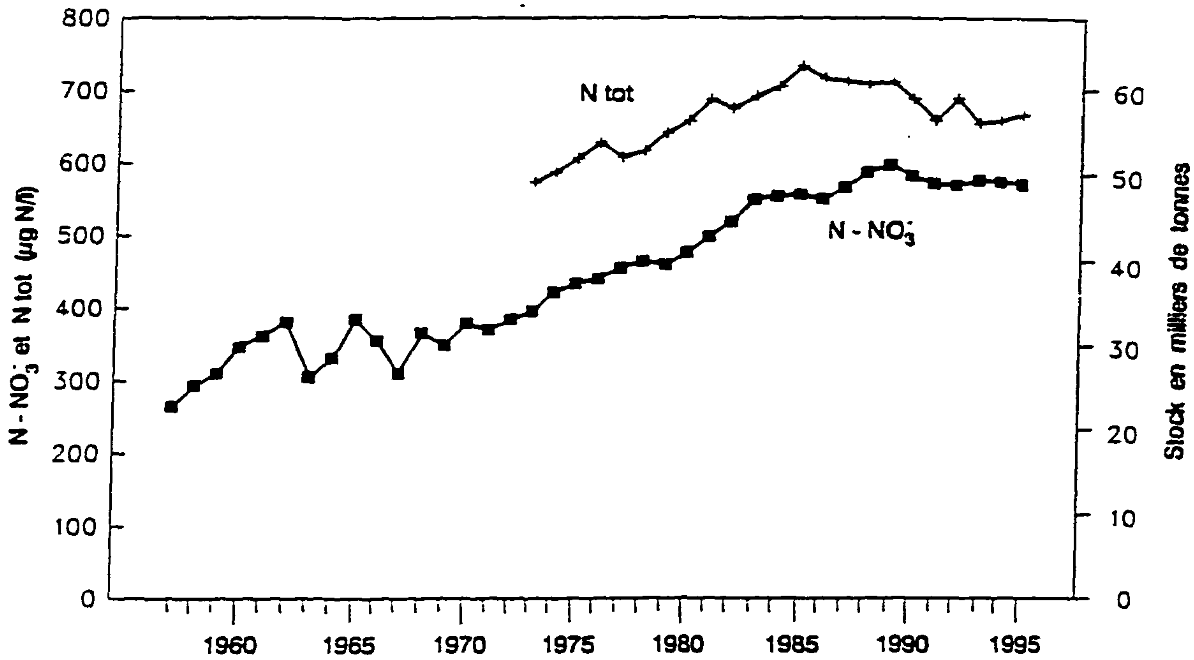

Figure 9.16: Mean Annual Measures of Nitrate Nitrogen and Total Nitrogen in the Grand Lake Portion of Lake Geneva (Blanc, et al., 1996)

Table 9.7: Summary of Total Mass of Selected Chemical Constituents in the Grand Lake Portion of Lake Geneva (after Blanc, et al., 1996)

Year	Mass of Chemical Constituents (metric tons)				
	Dissolved Oxygen	Inorganic (PO_4) Phosphorus	Total Phosphorus	Nitrate (NO_3) Nitrogen	Total Nitrogen
1986	842,600	5300	6150	47,160	61,500
1987	824,200	5000	5800	48,530	61,130
1988	799,940	4665	5290	50,350	60,750
1989	741,520	4430	4995	51,220	61,020
1990	714,200	4145	4740	49,890	59,000
1991	727,600	3880	4480	49,080	56,540
1992	721,550	3495	4275	48,820	59,150
1993	710,190	3460	4050	49,460	56,210
1994	714,183	3380	3835	49,275	56,550
1995	704,075	3170	3535	48,945	57,140

Table 9.8: Summary of Total Mass of Selected Chemical Constituents in the Petit Lake Portion of Lake Geneva (after Blanc, et al., 1996)

Year	Mass of Chemical Constituents (metric tons)				
	Dissolved Oxygen	Inorganic (PO_4) Phosphorus	Total Phosphorus	Nitrate (NO_3) Nitrogen	Total Nitrogen
1986	35,735	142	188	1512	NA[a]
1987	35,874	123	174	1607	NA
1988	35,121	99	132	1526	NA
1989	33,874	83	122	1624	NA
1990	34,120	62	114	1571	NA
1991	34,819	65	105	1682	2007
1992	34,857	63	103	1748	1803
1993	34,652	55	96	1777	2225
1994	34,228	55	91	1604	2217
1995	34,569	40	69	1558	2200

Note: [a]Not available

chemical constituents is associated with the Grand Lake portion. This was expected due to the much larger volume of Grand Lake relative to Petit Lake. Regarding dissolved oxygen, Table 9.7 indicates a significant decline (over 15%) in the total mass in the Grand Lake portion over the ten-year period, while Table 9.8 does not show a significant change for the Petit Lake portion.

Examination of the mass loading information in Tables 9.7 and 9.8 for inorganic and total phosphorus indicates decreases of about 40 to 45% in Grand Lake, and over 50% in Petit Lake. These reductions are reflective of the programs to reduce phosphorus inputs to Lake Geneva via increased phosphorus removal in wastewater treatment plants and the use of phosphate-free detergents. Both of these programs are primarily associated with the three Swiss cantons.

The mass loadings for both nitrate nitrogen and total nitrogen have had little change over the ten-year period in either portion of Lake Geneva. This is reflective of the absence of specific nitrogen reduction programs in the Lake Geneva watershed.

Figure 9.17 provides a summary of the total phosphorus concentrations and mass loading in the Grand Lake portion of Lake Geneva from 1957 through 1995. The concentration and loading increased from 1957 through the late 1970s. Beginning in the late 1970s a decline in the total phosphorus concentration and loading has been experienced. As shown in Figure 9.17, the program to reduce phosphorus in wastewater treatment plants was initiated in the early 1970s, with the emphasis on the use of phosphate-free detergents beginning around 1985. Figure 9.17 also indicates that the desired goal for the total phosphorous concentration in the Grand Lake portion of Lake Geneva is between 20 and 30 micrograms P per liter, with the resultant total mass loading being in the order of 1,800 to 2,500 metric tons. As illustrated in Figure 9.17, while significant improvements have been made relative to the phosphorus concentration

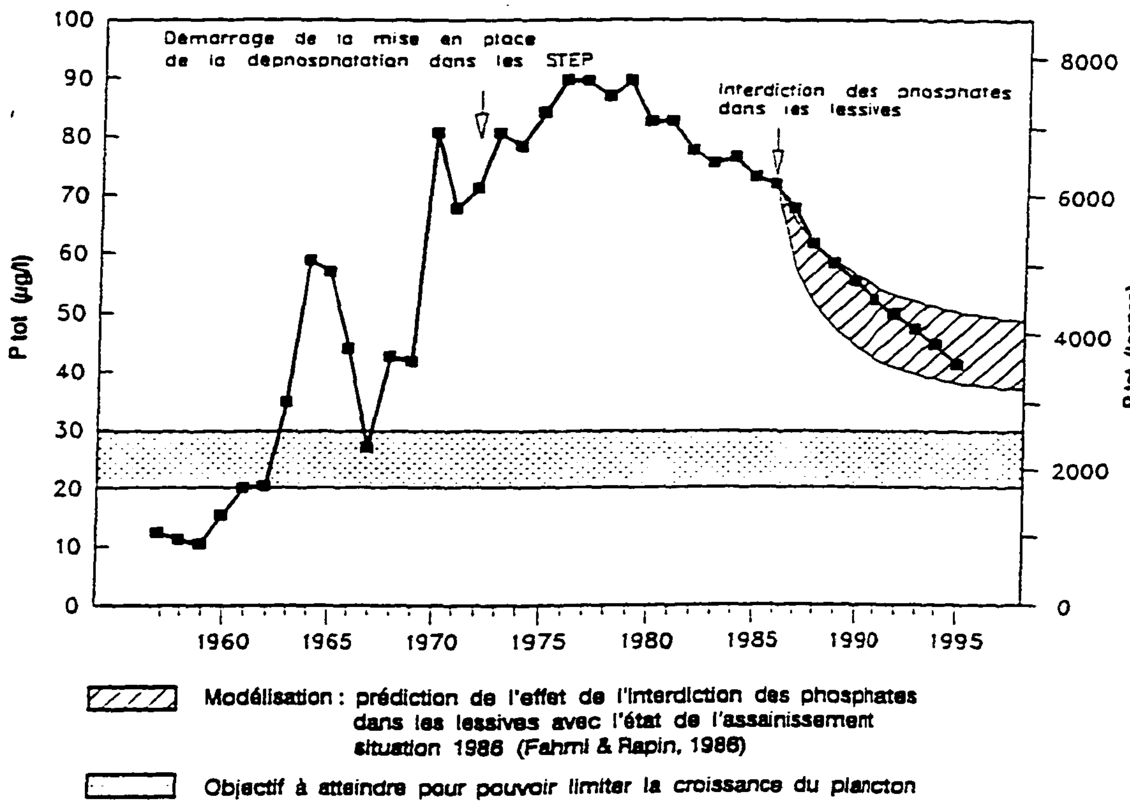

Figure 9.17: Total Phosphorus in the Grand Lake Portion of Lake Geneva (Blanc, et al., 1996)

and loading, it is questionable as to whether the goal relative to phosphorus reduction will be achieved through the use of the two action programs. This suggests that it may be necessary to explore other means of reducing phosphorus input, with one such approach involving effluent trading.

Sources of Phosphorus Input

Exploration of the possible usefulness of an effluent trading program for the Lake Geneva watershed requires not only the identification of water quality concerns (the above sections indicate that phosphorus represents the primary chemical concern), but also the delineation of the primary sources of such chemical inputs. In that regard, phosphorus contributions can be considered relative to point sources (effluents from wastewater treatment plants), nonpoint sources (runoff from urban areas, agricultural zones, and other land uses), and atmospheric deposition. Table 9.9 summarizes the phosphorus loading into Lake Geneva in 1995. The major sources of dissolved phosphorus include the four major tributary rivers and the effluent from wastewater treatment plants which discharge directly into Lake Geneva. Relative to dissolved phosphorus, effluent from wastewater treatment plants in the watershed (point sources) contribute approximately one-half of the total dissolved phosphorus input into Lake Geneva (60.2 tons per year versus 121.3 tons per year). Therefore, about one-half of the input is from nonpoint sources. Regarding the total phosphorus input into Lake Geneva, again, the four major tributaries are the major source. In summary relative to the dissolved phosphorus inputs, point sources such as wastewater treatment plants contribute an amount which is approximately the same as that from nonpoint sources. This fact suggests the possibility for implementation of a point-nonpoint source trading program for the Lake Geneva watershed.

Table 9.9: Phosphorus Loading (tons/yr) Introduced into Lake Geneva in 1995 (CIPEL, 1996)

Input Source	Dissolved Phosphorus[a]		Total Phosphorus	
	Total Loading	Effluent from WWTPs	Total Loading	Effluent from WWTPs
Four major tributaries[b]	72.6	23.5	1,569	69
Eight secondary tributaries[c]	10.3	2.3	35	6
Direct discharges from WWTPs[d] into lake	34.4	34.4	83	83
Atmospheric deposition	<4	-	<40	-
Totals	121.3	60.2	1,727	158

Notes:
[a]--dissolved PO_4 is assumed to be directly available for algal productivity
[b]--they include the Rhone, Dranse, Aubonne, and Venoge Rivers
[c]--they include the Versoix, Promenthouse, Dullive, Morges, Chamberonne, Veveyse, Eau Froide, and Stockalper Rivers
[d]--wastewater treatment plant

Figure 9.18 presents information on the annual dissolved phosphorus inputs (from 1981 to 1995) to Lake Geneva from the four major and eight secondary tributaries. Not included is the phosphorus input from direct discharges from wastewater treatment plants. Figure 9.18 indicates that the major tributaries are the primary source of phosphorus input. Further, releases of phosphorus occur via the Rhone River downstream from Lake Geneva. In the 1990s, the annual phosphorus inputs to Lake Geneva have been primarily associated with the upstream Rhone River. Downstream phosphorus releases on an annual basis have been about the same in numerical quantity as the annual inputs.

Figure 9.19 is similar to Figure 9.18 and summarizes the annual particulate phosphorus inputs from major and minor tributaries, as well as the annual downstream releases. The upstream Rhone River is the major contributor of particulate phosphorus; however, releases of particulate phosphorus downstream of Lake Geneva represent only a small fraction of the annual inputs. Figure 9.20 illustrates the total phosphorus inputs and outputs, with the comments as made for Figure 9.19 also being applicable.

Annual nitrate nitrogen inputs to, and outputs from, Lake Geneva are shown in Figure 9.21, with the major contributing tributary being the Rhone River, as was the case for the phosphorus inputs. Further, the annual downstream releases of nitrate nitrogen represent approximately 80% of the annual inputs. Figure 9.22 illustrates the annual inputs of organic nitrogen from the various tributaries, and Figure 9.23 does similarly for annual total nitrogen inputs. Both Figures 9.22 and 9.23 indicate that the upstream Rhone River is the primary contributor of these forms of nitrogen into Lake Geneva.

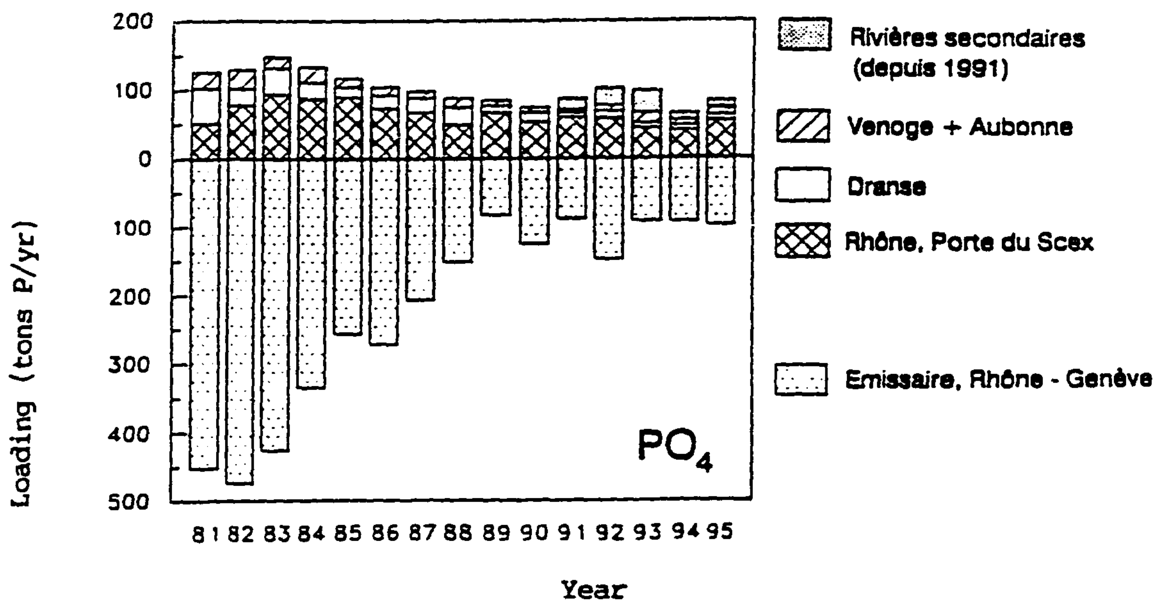

Figure 9.18: Annual Dissolved Phosphorus (PO_4) Inputs to Lake Geneva from Major and Minor Tributaries, and Annual Downstream Releases from the Lake (Orand, et al., 1996)

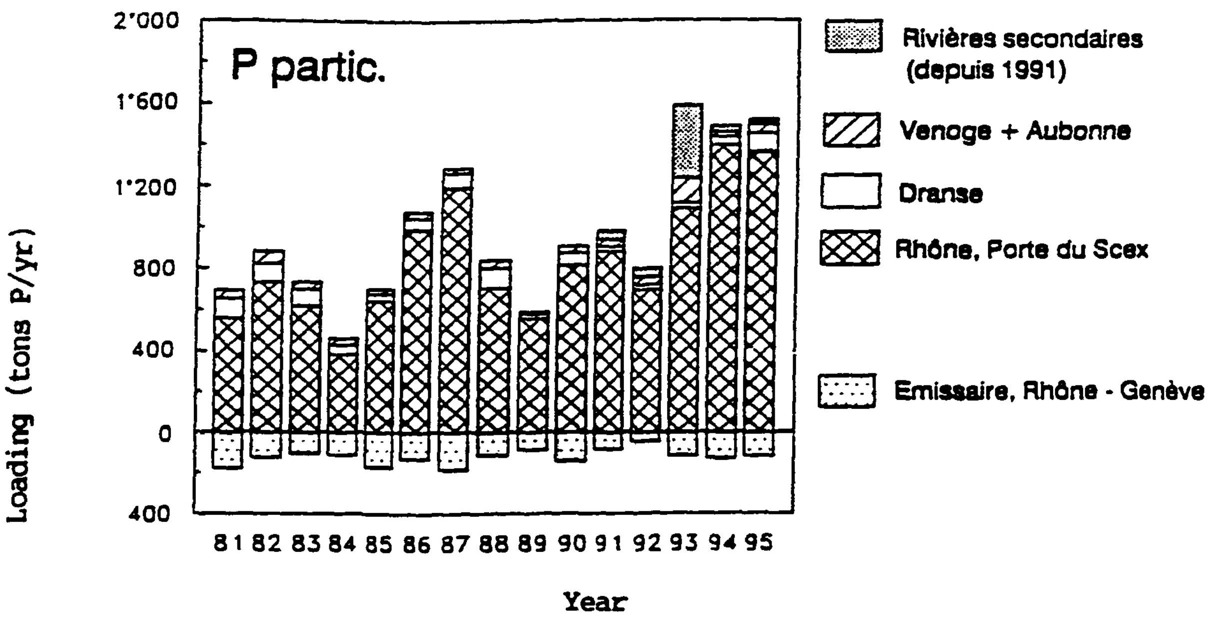

Figure 9.19: Annual Particulate Phosphorus Inputs to Lake Geneva from Major and Minor Tributaries, and Annual Downstream Releases from the Lake (Orand, et al., 1996)

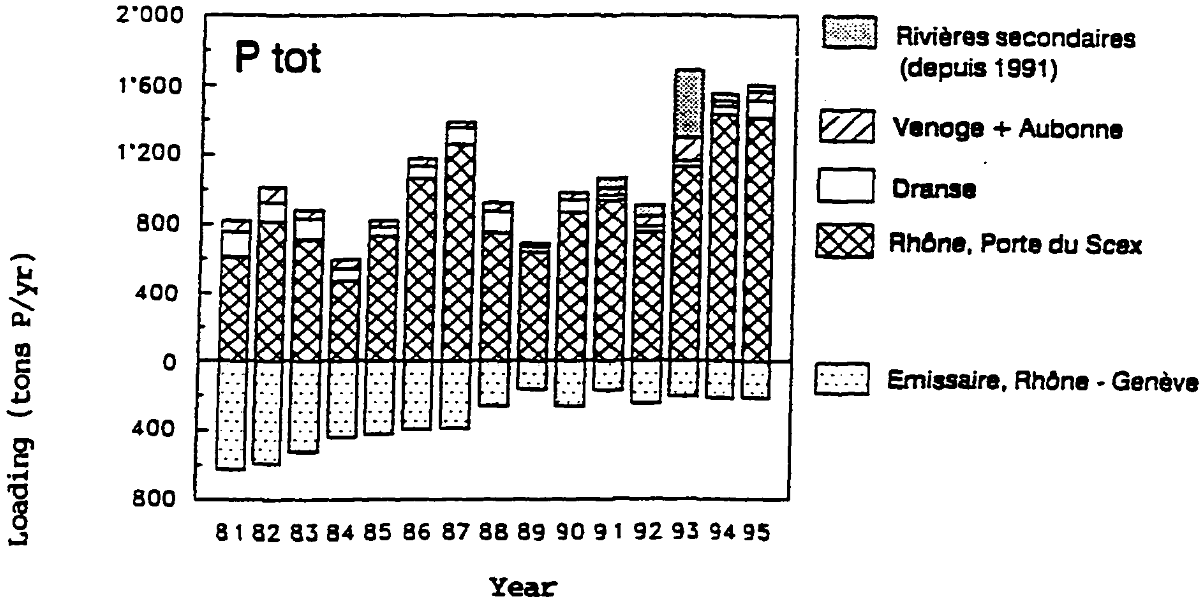

Figure 9.20: Annual Total Phosphorus Inputs to Lake Geneva from Major and Minor Tributaries, and Annual Downstream Releases from the Lake (Orand, et al., 1996)

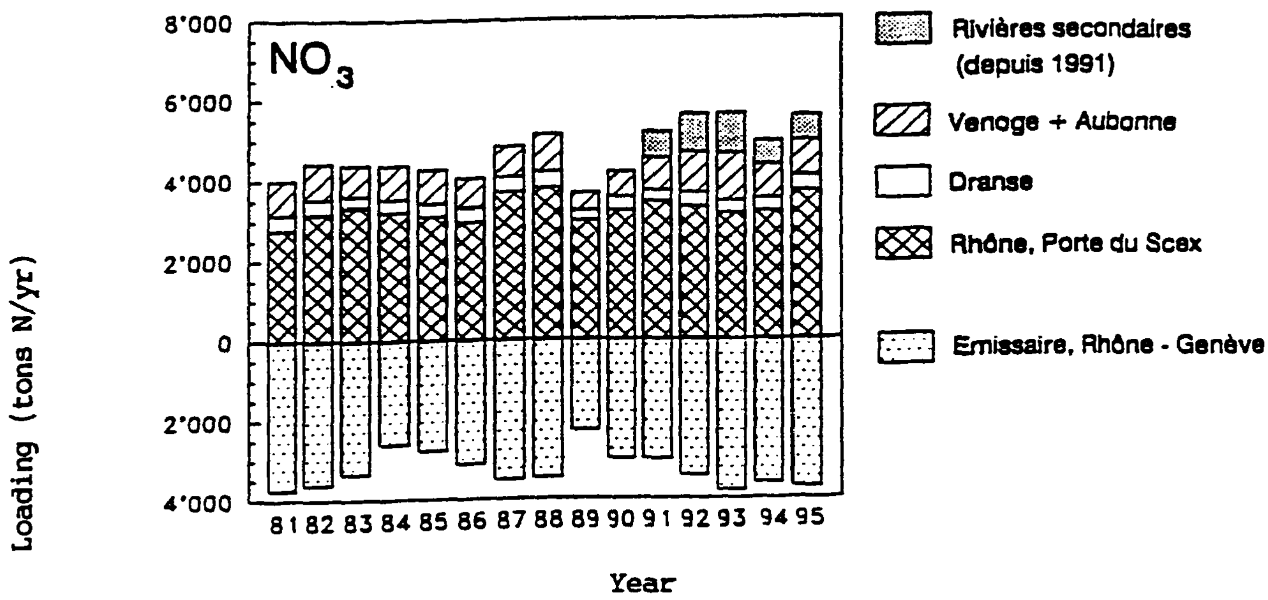

Figure 9.21: Annual Nitrate Nitrogen Inputs to Lake Geneva from Major and Minor Tributaries, and Annual Downstream Releases from the Lake (Orand, et al., 1996)

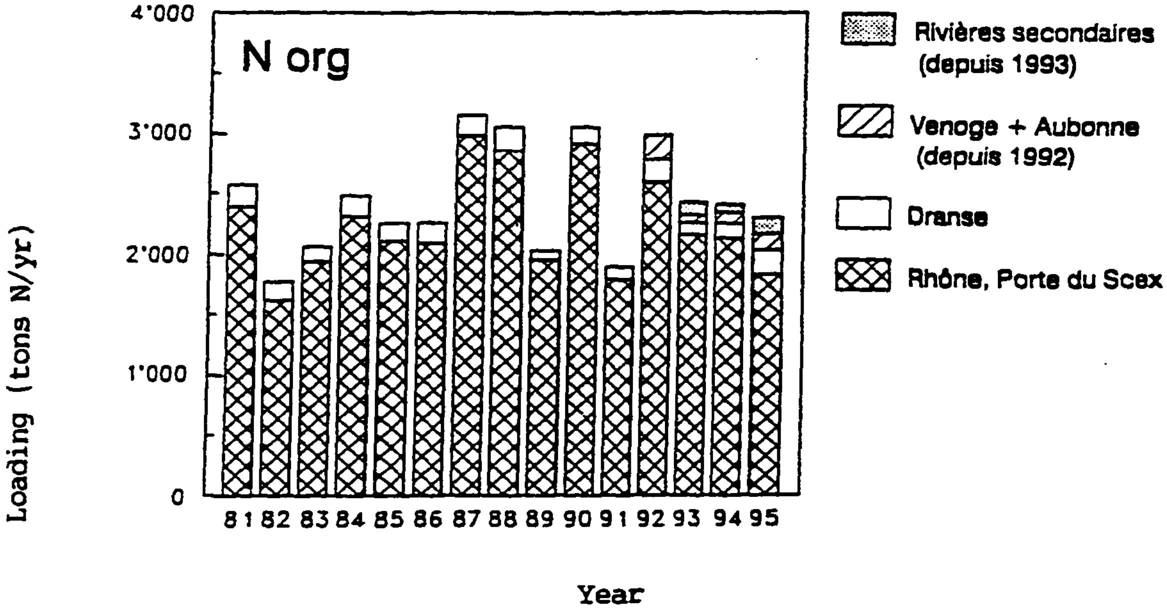

Figure 9.22: Annual Organic Nitrogen Inputs to Lake Geneva from Major and Minor Tributaries (Orand, et al., 1996)

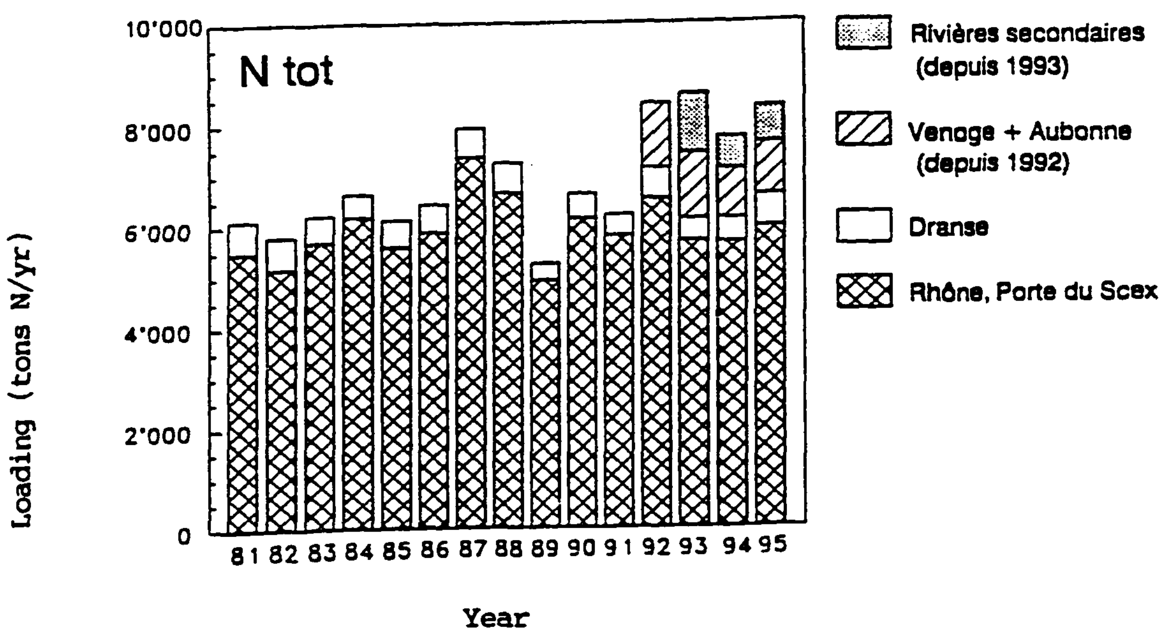

Figure 9.23:Annual Total Nitrogen Inputs to Lake Geneva from Major and Minor Tributaries (Orand, et al., 1996)

Wastewater Treatment Plants as Phosphorus Contributors

As was shown in Table 9.9, effluents from wastewater treatment plants are the primary point source contributor of both inorganic phosphorus and total phosphorus to Lake Geneva. Table 9.10 provides summary information on 156 such plants in the Lake Geneva watershed, with 131 plants incorporating phosphorus removal processes. The number of plants in the three Swiss cantons and two French Departments are listed in Table 9.10 along with their respective capacities in terms of human population equivalents. The 156 plants provide a treatment capacity for 2.47 million population equivalents. This number is considerably higher than the resident watershed population of approximately 805,000 persons, and the seasonal population of approximately 500,000 persons. Complete information on the number of industries served by these 156 wastewater treatment plants is currently not available. However, the canton of Valais identified wastewater treatment facilities serving industries with a population equivalent of 675,000.

Tables 9.11 through 9.13 summarize the organic loading, dissolved phosphorus loading, and total phosphorus loading, respectively, for the 156 wastewater treatment plants in the Lake Geneva watershed. Further, information is included in these tables on the treatment efficiencies of the plants with regard to these three wastewater constituents. Table 9.11 indicates an organic loading removal efficiency in the wastewater treatment plants in the three Swiss cantons of equal to or greater than 92.6%. Removal of the organic loading in the wastewater treatment plants in the two French departments ranged from 81.6 to 86.1%. Some of the wastewater flow and associated organic loading is directly bypassed relative to the wastewater treatment plants. When the bypassed organic loading is taken into account, the overall treatment efficiencies are reduced accordingly.

Table 9.10: Summary of WWTPs and Population Equivalents Served in 1995 (after Rapin, 1996a)

Geographical Area	Number of WWTPs[a]	Capacity of WWTPs[a,b]	Resident Population Served (persons)	Seasonal Population Served (persons)	Industries Served[c]
Vaud[d]	75(75)	978,269(977,006)	472,439	94,612	NA[f]
Valais[d]	56(49)	1,290,682(1,283,744)	233,176	277,458	675,000
Geneva[d]	4(4)	12,973(12,973)	7,242	415	NA
Haute-Savoie[e]	17(7)	160,404(148,967)	70,843	119,750	65,000
Ain[e]	4(3)	29,700(26,100)	21,170	5,358	NA
Totals	156(138)	2,472,028(2,448,791)	804,870	497,593	740,000

Notes:

a-- the first number is the total; the number in parenthesis refers to WWTPs with phosphorus removal facilities

b-- the numbers in this column reflect population equivalents based on the organic loading to the WWTPs; the loading factor used was 60 gm BOD_5/person/day

c-- population equivalents of industrial wastewater inputs to WWTPs

d-- canton in Switzerland

e-- department in France

f-- not available

Table 9.11: Summary of Organic Loading and Related Treatment Efficiency of WWTPs in 1995 (after Rapin, 1996a)

Comparison Factors	Geographical Area					Total
	Vaud	Valais	Geneva	Haute-Savoie	Ain	
Number of WWTPs[a]	75(75)	56(49)	4(4)	17(7)	4(3)	156(138)
Wastewater flow (m^3/day)						
Total	340,588	203,833	4,606	39,481	9,026	597,535
Treated	299,787	197,330	4,606	35,041	9,026	545,830
By-passed	40,802	6,504	0	4,400	0	51,705
Organic loading (kg O_2/day)						
Total	27,319	58,013	725	8,311	919	95,287
Treated	24,621	57,003	725	7,382	919	90,649
Effluent	1,814	3,479	31	1,023	169	6,516
By-passed	1,412	863	0	929	0	3,204
BOD_5 concentration (mg/l)						
Influent	80.2	284.6	157.3	210.5	101.8	159.5
Effluent	6.0	17.6	6.7	29.2	18.8	11.9
Treatment Efficiency(%)						
By WWTPs[b]	92.6	93.9	95.8	86.1	81.6	92.8
Total Loading Basis[c]	88.2	92.5	95.8	76.5	81.6	89.8

Notes:
[a]The number in parenthesis is the number of WWTPs with phosphorus removal facilities
[b]The efficiency of the WWTPs was determined by using the average organic loading treated and the average organic loading in the effluent
[c]The efficiency on a total loading basis was determined by using the total organic loading, and the sum of the effluent and by-passed organic loadings

Table 9.12: Summary of Dissolved Phosphorus (Orthophosphate--PO_4) Loading and Related Treatment Efficiency of WWTPs in 1995 (after Rapin, 1996a)

Comparison Factors	Geographical Area					Total
	Vaud	Valais	Geneva	Haute-Savoie	Ain	
Number of WWTPs[a]	75(75)	56(49)	4(4)	17(7)	4(3)	156(138)
Wastewater flow (m^3/day)						
Total	340,588	203,833	4,606	39,481	9,026	597,535
Treated	299,787	197,330	4,606	35,081	9,026	545,830
By-passed	40,802	6,504	0	4,400	0	51,705
Dissolved phosphorus loading (kg P/day)						
Total	427.1	258.8	9.5	126.3	24.4	846.0
Treated	383.2	249.2	9.5	112.4	24.4	778.7
Effluent	37.0	42.0	1.7	7.5	8.3	96.4
By-passed	30.0	8.1	0	13.9	0	52.0
Dissolved phosphorus concentration (mg P/1)						
Influent	1.25	1.27	2.06	3.20	2.70	1.42
Effluent	0.12	0.21	0.36	0.21	0.92	0.18
Treatment Efficiency(%)						
By WWTPs[b]	90.3	83.2	82.3	93.3	65.9	87.6
Total Loading Basis[c]	84.3	80.7	82.3	83.0	65.9	82.5

Notes:
[a]The number in parenthesis is the number of WWTPs with phosphorus removal facilities
[b]The efficiency of the WWTPs was determined by using the average dissolved phosphorus loading treated and the average dissolved phosphorus loading in the effluent
[c]The efficiency on a total loading basis was determined by using the total dissolved phosphorus loading, and the sum of the effluent and by-passed dissolved phosphorus loadings

Table 9.13: Summary of Total Phosphorus Loading and Related Treatment Efficiency of WWTPs in 1995 (after Rapin, 1996a)

Comparison Factors	Geographical Area					Total
	Vaud	Valais	Geneva	Haute-Savoie	Ain	
Number of WWTPs[a]	75(75)	56(49)	4(4)	17(7)	4(3)	156(138)
Wastewater flow (m^3/day)						
Total	340,588	203,833	4,606	39,593	9,026	597,647
Treated	299,787	197,330	4,606	35,193	9,026	545,942
By-passed	40,802	6,504	0	4,400	0	51,705
Phosphorus loading (kg P/day)						
Total	1274.8	711.8	19.2	269.4	41.0	2316.2
Treated	1140.3	693.7	19.2	240.0	41.0	2134.2
Effluent	90.5	119.0	3.6	38.8	15.2	267.0
By-passed	83.6	17.9	0	29.4	0	130.8
Phosphorus concentration (mg P/l)						
Influent	3.74	3.49	4.17	6.80	4.55	3.88
Effluent	0.30	0.60	0.77	1.10	1.68	0.49
Treatment Efficiency(%)						
By WWTPs[b]	92.1	82.8	81.5	83.8	63.1	87.5
Total Loading Basis[c]	86.3	80.8	81.5	74.7	63.1	82.8

Notes:
[a]The number in parenthesis is the number of WWTPs with phosphorus removal facilities
[b]The efficiency of the WWTPs was determined by using the average total phosphorus loading treated and the average total phosphorus loading in the effluent
[c]The efficiency on a total loading basis was determined by using the total of the total phosphorus loading, and the sum of the effluent and by-passed total phosphorus loadings

Table 9.12 summarizes information on the dissolved phosphorus loading and related treatment efficiencies of the 156 wastewater treatment plants in the Lake Geneva watershed. It is again noted that the treatment efficiencies relative to phosphorus removal for the plants in the Swiss cantons are greater than the associated efficiencies in the two French departments. Further, when taking into account the bypassed wastewater flow and related dissolved phosphorus loading, the overall efficiencies are reduced somewhat in each of the five geographical areas. Table 9.13 contains similar information to Table 9.12, except that the focus is on the total phosphorus loading. The same general comments can be made for Table 9.13 as were made for Table 9.12.

Table 9.14 summarizes the 1995 pollutant loadings (tons/year) for organics, total phosphorus, and dissolved phosphorus for the 156 wastewater treatment plants in the Lake Geneva watershed. Of emphasis herein is the potential contribution of these wastewater treatment plants to the annual loading inputs into Lake Geneva. From the organic loading perspective, the total tons of BOD_5 per year in the effluent and bypassed portion of the total flow is 3,548 (2378 plus 1170). The total phosphorus loading from wastewater treatment plant effluents and bypassed quantities is 145.3 tons per year. The comparable number for dissolved phosphorus is 54.2 tons per year. From a different perspective, Table 9.14 further illustrates that the wastewater treatment plants in the Lake Geneva watershed are very efficient in removing BOD_5, total phosphorus and dissolved phosphorus. This suggests that additional phosphorus removals could only be accomplished with considerably more expenditures. Stated differently, the marginal costs for additional removals of these three constituents from the watershed wastewater treatment plants (point sources) would be expected to be high.

Table 9.14: Summary of the 1995 Pollutant Loadings and Related Removals in Monitored WWTPs (after Rapin, 1996a)

Comparison Factors	Geographical Area					Total
	Vaud	Valais	Geneva	Haute-Savoie	Ain	
Number of WWTPs[a]	75(75)	56(49)	4(4)	17(7)	4(3)	156(138)
Organic loading (tons BOD_5/yr)						
Total flow	9971	21,175	265	3033	335	34,780
Effluent	662	1,270	11	373	62	2378
By-passed	515	315	0	339	0	1170
Removed in WWTPs	8794	19,590	253	2321	273	31,232
Total phosphorus (tons P/yr)						
Total flow	465.3	259.8	7.0	98.3	15.0	845.4
Effluent	33.0	43.4	1.3	14.2	5.5	97.5
By-passed	30.5	6.5	0	10.7	0	47.8
Removed in WWTPs	401.8	209.8	5.7	73.4	9.5	700.2
Dissolved phosphorus (tons P/yr)						
Total flow	155.9	94.4	3.5	46.1	8.9	308.8
Effluent	13.5	15.3	0.6	2.7	3.0	35.2
By-passed	11.0	3.0	0	5.1	0	19.0
Removed in WWTPs	131.4	76.2	2.9	38.3	5.9	254.6

Note: [a]The number in parenthesis is the number of WWTPs with phosphorus removal facilities

Table 9.15 summarizes information on the direct inputs to Lake Geneva from 8 major wastewater treatment plants that are directly discharging effluent into the lake. The dissolved phosphorus input from these eight plants is approximately 20 tons per year, with a total phosphorus input approaching 68 tons per year.

As a final comparison of the contributions of wastewater treatment plants to water quality concerns in Lake Geneva, Table 9.16 summarizes the "population equivalent factors" for wastewater characteristics in both the Swiss and French portions of the watershed. The flow rate in liters per person-day is greater in Switzerland than in France (543 compared to 350); however, the dissolved phosphorus expressed as grams P per person-day is less in Switzerland in relation to the French contribution (0.86 versus 1.50). This lower "population equivalent factor" for dissolved phosphorus in Switzerland is probably reflective of the emphasis given to the use of phosphate-free detergents.

<u>Other Water Quality Issues</u>

The primary emphasis herein has been on the phosphorus quality characteristics and related loadings in Lake Geneva. Additional water quality concerns include the total biomass and different characteristics of the phytoplankton, the relationship between lowered dissolved oxygen in the lake bottom and metals releases from lake sediments, the bacteriological quality of lake water, and the concentrations of metals and herbicides.

Summary information from 1981 through 1995 on the biomass and taxons of phytoplankton (algae) in the Grand Lake portion of Lake Geneva is available (Druart, et al., 1996). Similar information from 1986 through 1995 for the Petit Lake portion is also available, along with Shannon-Weaver biodiversity indices for the same time period (Revaclier, 1996). In general, the information for the two portions suggests seasonal variations of both biomass and phytoplankton

Table 9.15: Direct Inputs to Lake Geneva in 1995 from Eight Major WWTPs (after Rapin, 1996a)

Parameter	Location of WWTP								Totals
	Lausanne	Thonon	Vevey	Montreux	Nyon	Pully	Morges	Gland	
Capacity of WWTP (population equivalents)	412,500	102,600	83,000	62,250	50,000	40,000	38,825	17,500	806,675
Volume of treated wastewater (10^6 m^3/yr)	42.0	8.4	7.2	77.8	2.7	3.7	5.3	3.3	150.4
Volume of by-passed wastewater (10^6 m^3/yr)	12.8	1.0	0.026	0.72	NA[c]	NA	0.028	NA	14.57
Total phosphorus (tons P/yr)	37.69	14.82	4.10	5.10	0.37	0.73	3.29	1.46	67.56
Dissolved phosphorus (PO_4) (tons P/yr)	12.05	3.69	1.05	1.68	0.08	0.26	1.23	0.14	20.18
BOD_5(tons O_2/yr)	1279.7	281.8	93.3	150.4	33.6	17.5	37.2	23.0	1916.5
Suspended solids (tons/yr)	696.3	569.8	51.5	42.5	23.0	25.4	48.7	6.3	1463.5
Total inorganic nitrogen (tons N/yr)	513.9	209.4	116.9	89.1	54.8	42.7	81.7	40.4	1148.9
Organic nitrogen plus ammonia nitrogen (tons N/yr)	NA	254.0	NA	NA	NA	NA	NA	NA	254.0
Chlorides (tons/yr)	3523	634	438	325	400	240	278	202	6040

Table 9.16: Population Equivalent Factors for Wastewater Characteristics (after Rapin, 1996a)

Characteristic	Population Equivalent Factors[a]	
	Switzerland	France
Flow (liters per person-day)	543	350
BOD_5 (grams O_2 per person-day)	54.6	49.3
COD (grams O_2 per person-day)	137.9	117.9
Total phosphorus (grams P per person-day)	2.04	2.50
Dissolved phosphorus (PO_4) (grams P per person-day)	0.86	1.50
Ammonia nitrogen (grams N per person-day)	6.9	8.5
Total inorganic nitrogen[b] (grams N per person-day)	7.3	NA[c]
Organic nitrogen plus ammonia nitrogen (grams N per person-day)	NA	11.5

Notes:

[a]Developed based on 1995 monitoring data for WWTPs in the specific portions of the Lake Geneva watershed receiving municipal wastewater only
[b]Includes ammonia nitrogen plus nitrite and nitrate nitrogen
[c]NA = not available

diversity. Information on the abundance and biodiversity of benthic organisms in Lake Geneva is also available (Lang and Reymond, 1996).

Figure 9.24 summarizes indirect measurements of phytoplankton in Lake Geneva. Specifically, the transparency of the water is measured by the Secchi disk method, with the lesser depths, as expressed in meters, reflecting higher phytoplankton concentrations. For the ten-year period from 1986 to 1995, the transparency is shown to fluctuate on an annual basis in the Grand Lake portion. The lowest transparencies are typically associated with the summer months, with the highest transparencies primarily occurring in the winter months. Due to the large fluctuations in the transparency measurements, and the inexact nature of such measurements, no observations can be made regarding long-term changes in phytoplankton productivity.

One water quality concern associated with Lake Geneva is that due to the absence of overturns in the last several years, the dissolved oxygen concentration in the lower water layers are declining. Further, these lower dissolved oxygen concentrations are conducive to chemically- reducing conditions which can facilitate releases of chemical constituents from lake sediments. These phenomena are illustrated in Figures 9.25 and 9.26. Figure 9.25 shows the decline in dissolved oxygen at the bottom (-309 m) of the Grand Lake portion. The dissolved oxygen concentrations have declined from more than 10 milligrams per liter in early 1986 to concentrations in the order of 2 milligrams per liter or less. Further, the lowest concentrations in 1995 were less than 1 milligram per liter. Figure 9.26 contains an overlay plot of dissolved oxygen and manganese concentration at the bottom of Grand Lake for the four-year period from 1992 to 1995. As can be seen, the lower dissolved oxygen concentrations generally coincide with higher manganese concentrations. Releases of metals from sediments represent a longer-term water quality concern for Lake Geneva.

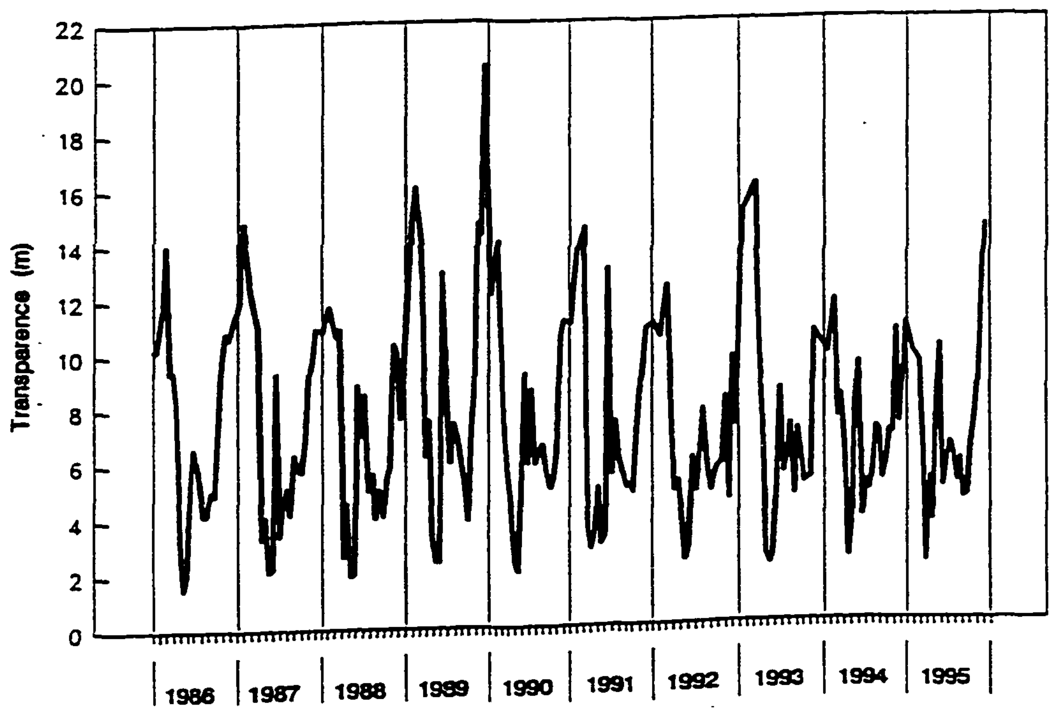

Figure 9.24: Transparency in the Grand Lake (SHL2) Portion of Lake Geneva as Measured by the Secchi Disk Method (Blanc, et al., 1996)

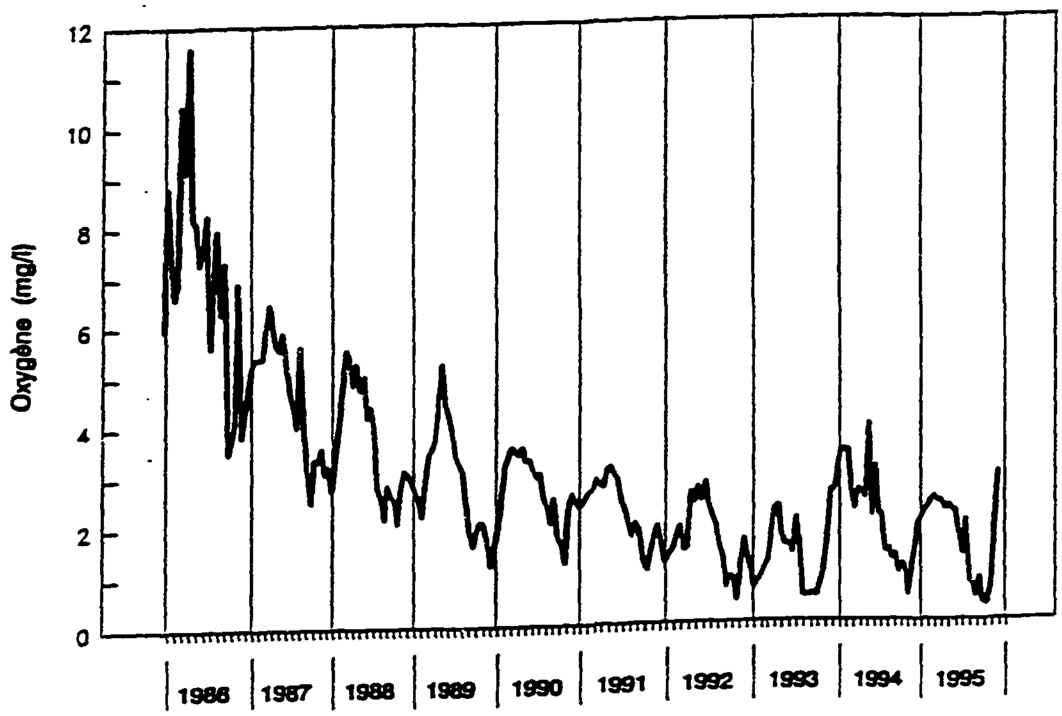

Figure 9.25: Dissolved Oxygen at the Bottom (309 m) of the Grand Lake Portion (SHL2) of Lake Geneva (Blanc, et al., 1996)

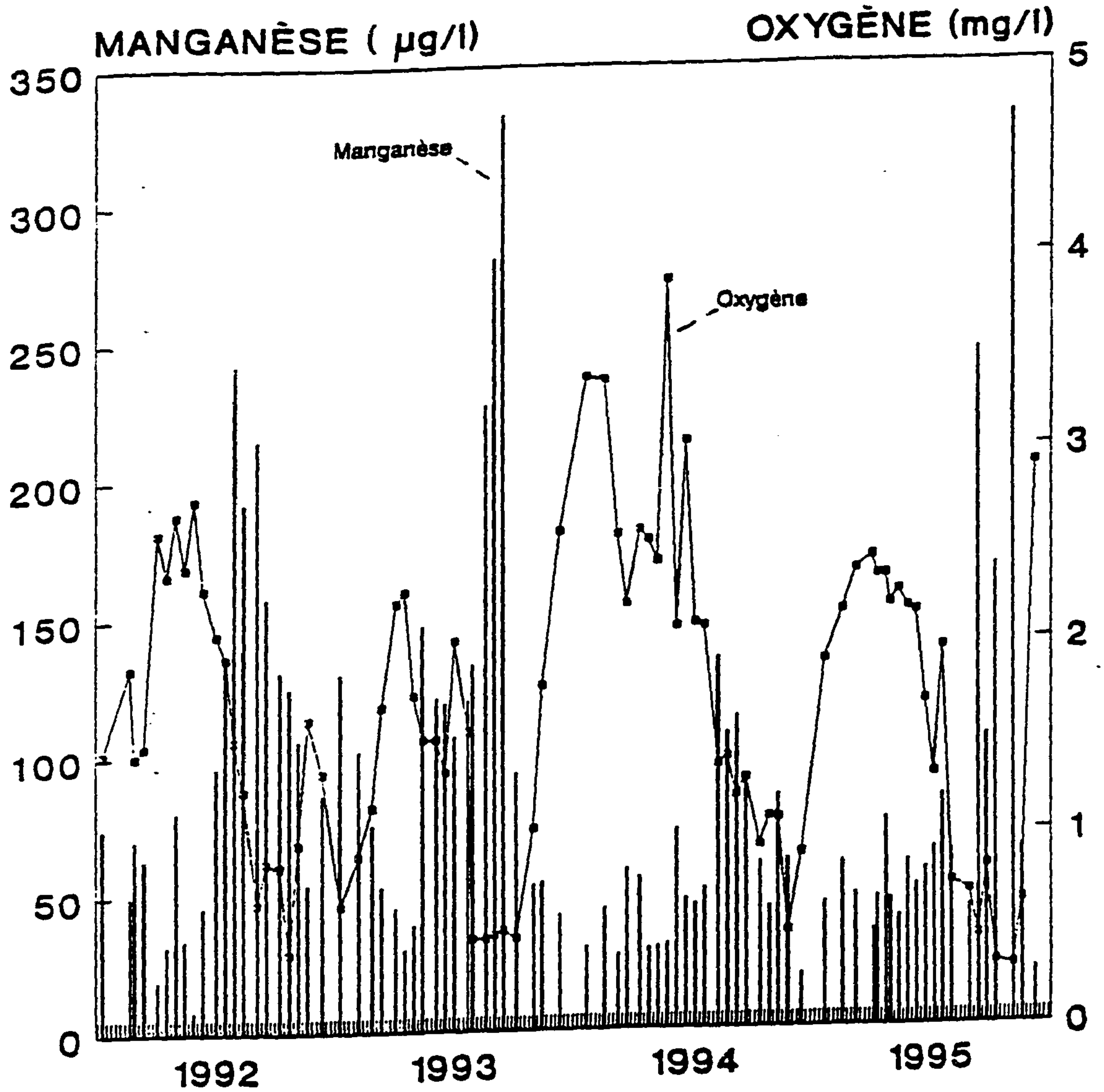

Figure 9:26: Relationship Between Dissolved Oxygen and Total Manganese at the Bottom (309 m) of the Grand Lake Portion (SHL2) of Lake Geneva (Blanc, et al., 1996)

Detailed information on the bacteriological quality of the water in the Grand Lake portion of Lake Geneva has been compiled by Revaclier, et al. (1996). Multiyear results are available from sampling station SHL2 in the Grand Lake portion for total bacteria, total coliform, Escherichia coli, enterococcus, and Clostridium. In addition, sampling of beach water quality has also been conducted at 87 locations along the shoreline, and Figure 9.27 summarizes the results for 1995/1996 (Revaclier, et al., 1996). The classification code in Figure 9.27 indicates that 51 locations (58.6%) exhibited good water quality relative to swimming, 32 (36.8%) had average water quality, 3 (3.4%) exhibited periodic pollution, and 1 (1.1%) had poor quality.

Finally, while it is not the primary water quality concern addressed herein for Lake Geneva, information from two sampling dates in 1995 (April 3 and September 19) at station SHL2 in the Grand Lake portion is available for several metals (manganese, lead, cadmium, chromium, copper, iron, aluminum, and mercury) and three herbicides (atrazine, simazine, and terbutylazine). Very low herbicide concentrations were noted, and the detected concentrations of the metals were below applicable water quality standards (Corvi and Khim-Heang, 1996).

Key Findings Regarding Water Quality

The following key findings can be highlighted from this extensive review of the water quality situation in Lake Geneva:

(1) Due to the aesthetic and recreational importance of Lake Geneva, the transnational boundaries of the lake involving Switzerland and France, and the international character of the City of Geneva, the quality of Lake Geneva water has been of public interest and economic concern for several decades. As a result, there is a considerable body of cumulative scientific data and information on the physical, chemical, biological, and bacteriological characteristics of lake water quality. Numerous special studies and on-going monitoring programs provide an excellent basis for assessing lake water quality and the effectiveness of existing water quality

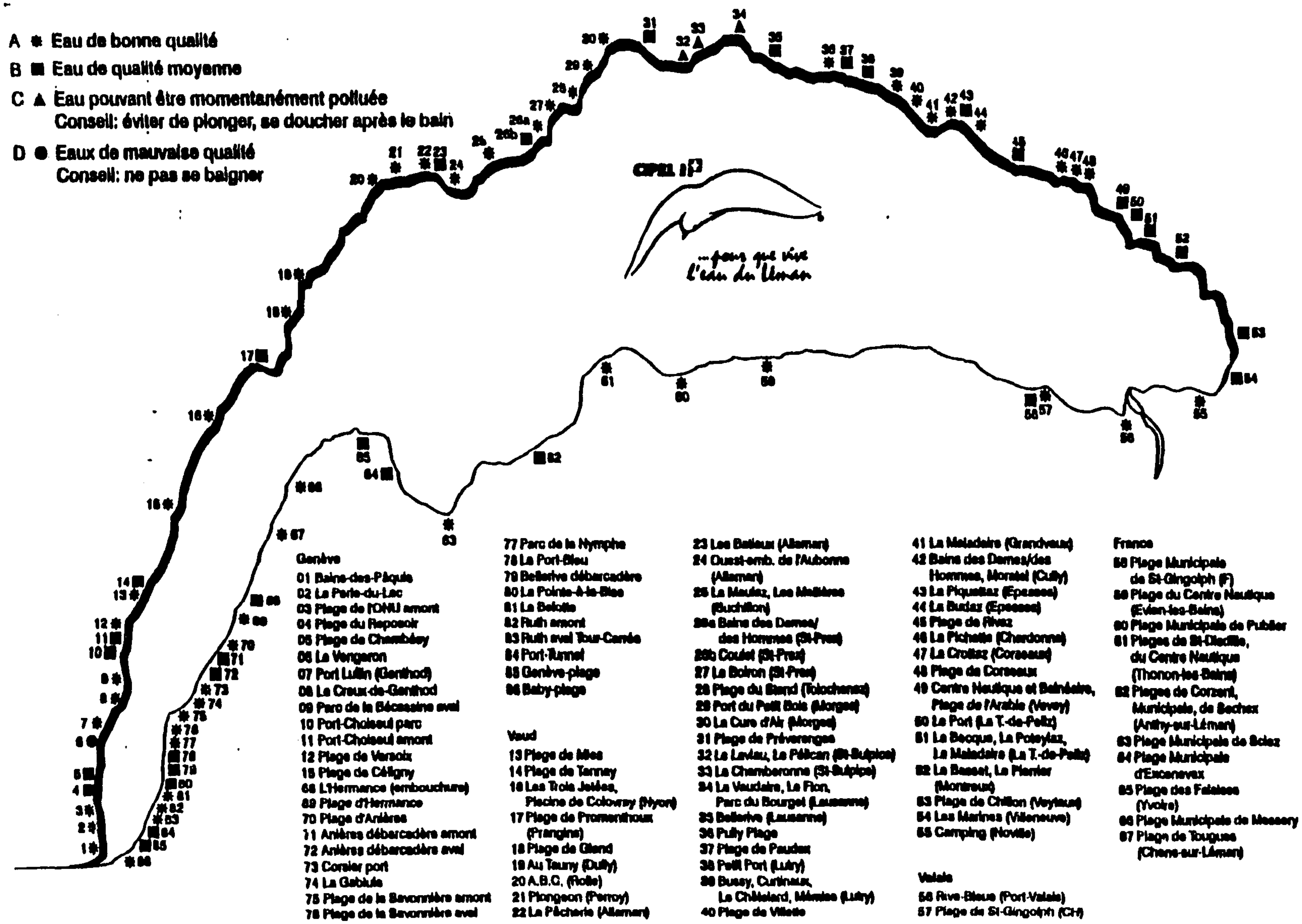

Figure 9.27: Quality of Water Near Swimming Beach Areas (Revaclier, et al., 1996)

management programs (such as the Lake Geneva Action plan described in a subsequent section).

(2) The primary water quality issue in Lake Geneva is associated with nutrient inputs resulting in excessive production of phytoplankton. While both phosphorus and nitrogen are contributing nutrients, dissolved phosphorus represents the critical concern relative to algae production. Accordingly, efforts have been on-going for over two decades to reduce phosphorus inputs from the watershed to the lake. Such efforts have focused on phosphorus removal in WWTPs in the watershed (138 of 156 WWTPs currently have phosphorus removal provisions); and on the use of phosphate-free detergents in the Swiss portion of the watershed. To date, phosphorus inputs and lake mass loadings have been reduced by about 50%; however, attainment of earlier described goals for both the total phosphorus concentration (20 to 30 micrograms P per liter) and mass loading (1800 to 2500 metric tons) in the Grand Lake portion appears to be problematic. Therefore, to overcome the high marginal abatement costs associated with additional phosphorus removal in the WWTPs, it may be more cost-effective to develop a phosphorus-targeted point source-nonpoint source trading program for the watershed.

(3) A fundamental requisite for an ETP for phosphorus is the presence of multiple point sources and nonpoint sources of discharge in the watershed. Considerable data exists on multiple point sources, including dissolved phosphorus treatment efficiencies and effluent mass loadings for the 156 WWTPs in the watershed. From such information, it appears that point sources and nonpoint sources each contribute about 50% of the annual dissolved phosphorus loading to Lake Geneva. However, essentially no site-specific information exists on the multiple nonpoint sources in the watershed. Such information will be needed to develop site-specific marginal abatement costs and to determine the economic feasibility of potential trades.

AGENCIES ASSOCIATED WITH WATER QUALITY MANAGEMENT IN THE LAKE GENEVA WATERSHED

Numerous agencies are involved in the management of water in the Lake Geneva watershed, including agencies in both France and Switzerland, and at both regional and local levels. This large number of agencies can result in a lack of coordination between them -- with the duplication of programs and actions -- and also a lack of transparency from the public's perspective. Moreover, in 1994, the Economic Commission for Europe promulgated a convention for managing transboundary watercourses and internal lakes (Economic Commission for Europe, 1994). Among many requirements, the convention particularly noted the importance of effluent standards for point sources of wastewater discharge, and the use of appropriate management practices for reducing nutrient inputs from nonpoint sources such as agricultural land uses. Accordingly, because of the multiple institutional involvements and requirements, this section highlights the various water management agencies in Switzerland and France and their responsibilities (Ferrier, 1998).

Transboundary Institutions (Joint Swiss and French Agencies)

Four transboundary (transfrontier) institutions are found in the Lake Geneva (Leman) region, but only two of them are active in water issues: CIPEL and CRFG. The other two are COTRAO -- Work Community for the Western Alps, and the Leman Council. The latter two agencies have conducted a few actions on environmental protection, including protecting the Alps environment, waste management, and natural landscape protection on the shores of Lake Geneva. However, these two agencies are not very active today.

CIPEL (International Commission for the Protection of the Leman Waters)

Created in November, 1960, CIPEL is composed on an equal basis of French and Swiss representatives. With an annual budget of 900,000 SF (Swiss francs), a small secretariat (2 persons), and several technical commissions, CIPEL investigates the pollution of Lake Geneva and its tributaries in order to maintain or restore the ecological quality of the water for its use as drinking water, for fishing and for leisure (boating and sailing) activities. CIPEL makes recommendations to both the Swiss and French governments; they have included recommendations on the construction of wastewater treatment plants (WWTPs), promotion of the sale and use of phosphate-free detergents, improvements in sewage collection networks, especially in rural areas, and in the development of countermeasure procedures for use in the event of accidental pollution. CIPEL also conducts public information campaigns. Of importance relative to a possible ETP in the Lake Geneva watershed, in 1991 CIPEL initiated an action plan entitled "Leman Demain" (Leman Tomorrow) which was focused on reducing phosphate concentrations in the lake by 50% by the year 2000 (by the end of 1996, this concentration had been reduced by 26%).

CRFG (Franco-Geneva Regional Committee)

Created in 1974, CRFG has the authority to address any community or infrastructure issue in the Geneva area (transportation, housing, etc.). This consultative institution is composed of four separate commissions, including one dealing with the environment and land planning. CRFG also conducts scientific investigations and defines procedures in the case of accidental pollution. It is also responsible for the watershed area downstream of Lake Geneva (including the Rhone River basin downstream of the lake to the western border of the canton of Geneva with France). CRFG has conducted many investigations on transboundary rivers in the Lake Geneva watershed, and some of its recommendations are now being applied. In September, 1997, an agreement was signed between the canton of Geneva and the Republic of France to improve, in a coherent manner, the quality of rivers in the Lake Geneva watershed. This agreement represents an important step towards the rational integrated management of transboundary water in the region.

Swiss Institutions

Switzerland is a federal state, with most of the governmental programs assigned to individual cantons, including water management programs. However, the key Swiss federal law regarding wastewater discharges, water quality standards, and water management is SR814.20 (Federal Assembly of the Swiss Federation, 1997). Cantons are analogous to states within the United States. Individual water management programs can also exist at the municipal level within the cantons.

Cantons

Governmental administrations within cantons are characterized by a large number of services dealing with different aspects of water management. The cantons of Geneva, Vaud and Valais, which are in the Swiss part of the Lake Geneva watershed, have recently reorganized their multiple services. However, these changes have not resulted in the simplification of the division of responsibilities between the different services. In general, the services in charge of drinking water are different from the ones responsible for pollution control and water quality in the rivers, tributaries, and ground water in the Lake Geneva watershed. In the Geneva canton, for instance, SIG (Geneva Industrial Services) is responsible for pumping and distributing drinking water, whereas another service, the Service for Water Treatment, is responsible for wastewater and its treatment. In the Valais canton, two distinct services are in charge of drinking water: the Service of Water and Environmental Protection, and the Cantonal Laboratory. Table 9.17 summarizes the various water-related services of the three cantons in the Swiss portion of the Lake Geneva watershed.

Municipalities

Each canton can assign part of its water-related responsibilities to local municipalities. In the Swiss portion of the Lake Geneva watershed, a total of 385 municipalities in Vaud, and 163 municipalities in Valais, have some responsibilities regarding water management. In Valais for instance, municipalities are responsible for drinking water quality and WWTPs. As such, they can levy taxes to finance sewage collection networks and WWTPs. Local water management responsibilities have not been assigned to the 45 municipalities in the Geneva canton.

Table 9.17: Administrative Services of Swiss Cantons Dealing with Water in the Lake Geneva Region[1]

Geneva	Vaud	Valais
Department of the Interior, Agriculture, Environment and Energy •Cantonal service of "ecotoxicology" (recreational water, program evaluation, expertise, public information) •Service of forests, nature and landscape protection (fishing) •Cantonal service of geology (ground water) •Service of the lake and rivers •Service of water treatment (sewage water, clear water, WWTPs, and sewage network) Department for Social Action and Health •Cantonal chemist (control of drinking waters) SIG (Geneva Industrial Services) •Drinking water networks	Department for Security and Environment •Service of water and environmental protection -Administration (administrative police, hydroelectricity) -Protection of underground water -Water economy (hydrology, security, water amounts, rivers) -Waste management (WWTPs, water quality) -Laboratory (WWTPs, ground water quality, industrial effluents, pollution prevention) •Cantonal laboratory -Water inspection (distribution and control of drinking water, beaches and swimming pools) -Laboratory of chemistry and microbiology (drinking water analysis)	Department for Transport, Infrastructure, and Environment •Service of water and environmental protection •Service of roads and rivers •Service of forests and landscape •Cantonal laboratory Department of Security and Institutions •Service of land-planning •Service of hunting and fishing Department of Health, Social Affairs and Energy •Service of hydraulic forces (hydropower) Department of Finance and Economy •Service of agriculture (irrigation)

[1]Only major services are listed herein

French Institutions

Even though considerable accomplishments have occurred since 1982 regarding the decentralization of French national authorities, the central government in Paris still plays a key role in any public governmental programs, including water quality protection and management. However, since enactment of the first laws on decentralization in 1982, regional and local authorities in France have been assigned increasing responsibilities in public affairs. The Republic of France is currently divided into three major types of entities, including (in decreasing size order): (1) 22 regions, created in 1982, with the regions promoting regional economic development; (2) 90 departments which were originally created by Napoleon in the nineteenth century, with such departments mainly in charge of social and rural affairs; and (3) 36,763 municipalities.

In 1964 the first comprehensive French law on water management was adopted; it was then modified by a new law in 1992. As a result, the Republic of France has established an original and complex system for the management of water which involves the participation of all concerned stakeholders (from major companies to individuals, and from central government to regional entities to small municipalities). A key aspect of this water management system is that watersheds are considered as the fundamental water management units.

Regional and Local Representation of the Central Government

Regional and local representation of the central government is achieved via prefets, regional agencies, and local level departments. A prefet refers to an environmental agency administrator who has responsibilities for water quality and water uses, including use as a water supply and for recreational activities. A prefet plays an important planning role and can authorize necessary measures in case of an accident (including industrial chemical spills), or to control water usage during a drought, or to release waters during a flood.

At the regional level, the DIREN (Regional Directorate for the Environment) is in charge of environmental protection, including landscape and land use protection, and the environmental aspects of land-use planning projects. The DIREN can also make proposals for the protection of water; further, this agency develops databases on the quantity and quality of water in different watersheds. A related agency at the regional level is the DRIRE (Regional Directorate for Industry, Research, and the Environment). DRIRE is responsible for managing environmental risks which have an industrial origin; an example would be a chemical spill into a river.

Three departments represent the local level counterparts of DIREN. They include DDE (Departmental Directorate for Equipment), DDAF (Departmental Directorate for Agriculture and Forests), and DDASS (Departmental Directorate for Public Health and Social Action). The DDASS has local responsibilities relative to WWTPs and drinking water quality. The prefet of each of these three departments is responsible for coordination between the departments.

Regional and Local Authorities

The geographical region of France encompassing the Lake Geneva watershed is Rhone-Alpes, with its capital in Lyon. The Rhone-Alpes Regional Council is responsible for developing and operating navigable rivers and river ports. The Council is also charged with defining regional priorities, including those related to water issues. The Council is very active in regional cooperative efforts with other European regions. Further, two local councils (departments) are found in the Lake Geneva watershed: Ain, west of the lake, and Haute-Savoie, on the south shores of the lake. The Ain Department has no direct physical access to Lake Geneva; however, some rivers from the Ain geographical area flow into the lake, including the Vengeron River, one of the most polluted rivers in the region. Regarding water use, both local departments financially assist small rural municipalities in establishing and maintaining water distribution and wastewater collection networks and treatment facilities. The local level departments representing the central government (DDE, DDAF, and/or DDASS) can also provide financial support to local municipalities for water-related projects.

Local French municipalities (or groups of municipalities) are responsible for water purification, for distributing drinking water, and for collecting and treating municipal wastewater. They can conduct appropriate scientific studies, and they are responsible for civil engineering projects. They can construct and operate WWTPs to reduce wastewater pollution levels, or dams to prevent flooding; and they can initiate measures to protect water quality and water environments. Such municipalities can delegate (and often do so) the management of water to private companies. Their autonomy and their high number make it difficult to establish a concerted action in a transboundary water basin such as the Lake Geneva watershed. However, many municipalities have grouped together and created separate institutions to manage water. Such institutions can have a variety of names and objectives. One example is SIVOM (Syndicat Intercommunal à Vocation Multiple, or inter-municipality syndicate with multiple goals), which is responsible not only for water but also for developing tourism activities and local transportation, and addressing other municipal needs.

Specific Agency: Rhone-Mediterranee-Corse Water Agency

Created in 1964 and expanded in 1992, six specific water agencies in France have responsibilities over six major watersheds, including one associated with the Lake Geneva watershed. Their collective role is to facilitate actions of common interest for the entire watershed in order to maintain the equilibrium between water resources and different uses of water, to reach quality objectives defined in different governmental regulations, and to prevent floods.

To achieve this, the agencies establish a five-year program. The boards of each agency are composed of representatives from local authorities, the central government, and water user groups.

The key agency for the Lake Geneva watershed is the Rhone-Mediterranee-Corse Water Agency. This agency, which is similar to the other five, collects taxes from water users and distributes subsidies which are mostly used to finance WWTP improvements. Each of the six agencies can also conduct research on water issues. The budget of the Rhone-Mediterranee-Corse Water Agency for the period 1997-2001 is 14 billion FF (French francs, or about 2.3 billion US dollars). This budget is used for water purification, reducing pollution from industrial activities, facilitating access to drinking water, and for understanding and restoring water environments. The Rhone-Mediterranee-Corse Water Agency funding amounts to 25 to 60% of the budgets for these individual projects and overall program efforts. Finally, the Rhone-Mediterranee-Corse Water Agency participates with CIPEL and cooperates in implementing CIPEL recommendations.

Conclusions Regarding Water Management Agencies

The following conclusions can be drawn regarding the number and focus of water management agencies in the Lake Geneva watershed:

(1) The first striking point about public agencies involved with water issues in the Lake Geneva watershed is their large number. This large number has several consequences relative to any attempt to establish a rational and integrated management program for water. First, there can be a duplication of efforts and actions between the levels of agencies. Second, there may be a lack of coordination between the different local services, even when they are part of the same administration. Finally, professionals working in these agencies typically do not know their counterparts in other cantons, departments, or regions.

(2) France and Switzerland do not address water management from the same perspective. Since 1964, France has considered the natural limits of watersheds as the fundamental management unit, irrespective of the administrative boundaries. In contrast, the water

management authorities in Switzerland may encompass entire watersheds or only portions thereof.

(3) It would be useful to establish an institution coordinating all these governmental actions and programs within the Lake Geneva watershed, not only at a technical level, as does CIPEL, but also at a political level. However, this will not be easy because agencies at all governmental levels would probably need to delegate part of their responsibilities, and this would be difficult to accomplish.

KEY NGOs WITH AN INTEREST IN LAKE GENEVA

Non-governmental organizations (NGOs) with an interest in Lake Geneva are both numerous and active. Some NGOs are large and have as their general objective the protection of the environment. Other NGOs are very small (only a few people involved) and focus their attention on only one specific river. Examples of large NGOs located in Switzerland include the World Wildlife Fund (WWF) and the Society for the Protection of the Environment (SPE). The Rhone-Alpes Federation for the Protection of Nature (FRAPNA) is a large NGO in France. An example of a small NGO is the Seymaz River Association which is interested only in this specific river in the Canton of Geneva (Ferrier, 1998). In many cases, the NGOs, be they Swiss, or French, cooperate together in environmental efforts. It would be expected that they would do so in conjunction with a possible ETP for the Lake Geneva watershed. Some of the major NGOs in the watershed are described in the following subsections.

Associations for the Protection of the Environment

ASL -- Association for Safeguarding the Leman

In 1980, a group of scientists decided to create an association to raise the awareness of the public authorities regarding the necessity of protecting Lake Geneva water. ASL was thus established as a transboundary NGO composed of groups from the three Swiss cantons and from France. It has a yearly budget of from 300,000 to 450,000 SF (Swiss francs). It is financed through member contributions and special sponsors (public institutions, private companies, municipalities, and different individuals).

Today, ASL numbers more than 6,000 members, both in Switzerland and France, and it has an aggressive environmental program. For example, in 1993, ASL lodged a complaint against 65 Swiss municipalities in the Lake Geneva watershed which were not connected to any WWTP. In 1990, ASL launched a major action program entitled "clean rivers operation." Its objective was to spot and to develop an inventory of illegal polluting discharges into the rivers in the Lake Geneva watershed. Between 1990 and 1996, about 2000 volunteers walked along 150 rivers in the watershed, the total length was about 2,500 km. The volunteers spotted 3500 discharge points and more than 2,800 garbage dumps. This successful action was also applied in September, 1996, to the shores of Lake Geneva via the "Clean Geneva Shores" operation. Anyone volunteering was asked to identify any kinds of pipes and effluents either above or below the water level.

Rivers Coordination

Since 1992, 15 Swiss and French associations, including the WWF, have worked together on water quality issues in the Lake Geneva watershed. This 15 member group is known as Rivers Coordination. The Geneva Association for the Protection of Nature (AGPN) operates the secretariat for this NGO. Rivers Coordination gives advice to its members on different actions they want to undertake, and it can act cooperatively towards educating and lobbying governmental administrations and politicians.

CLE -- Lemanic Council for the Environment

Similar to Rivers Coordination, this NGO includes several other associations; for example, WWF and FRAPNA. CLE addresses not only water issues, but other environmental issues such as nature and landscape protection, and preservation of natural and agricultural areas, with a view toward sustainable development.

SPE -- Swiss Society for the Protection of the Environment

Created in 1971, this Swiss NGO initially worked on legal aspects of environment protection. They now concentrate their efforts on developing economic instruments, partnerships and sustainable development projects. They have published several books on environmental issues, including one on water (Ferrier, 1998).

Chambers of Commerce and Agriculture

Regional and local Chambers of Commerce and Agriculture can play an important role in water management. This is illustrated by their role as an intermediary between governmental agencies and administrations on one side and farmers and industries on the other. For instance, in the canton of Geneva a project aimed at protecting rivers, and returning their original natural aspects after they had been canalized, included a 10% increase in water pricing over a 10-year period. The Geneva Chamber of Commerce played an intensive opposition lobbying role, arguing that such an increase would reduce the competitiveness of most Geneva companies. The canton government finally reduced the proposed increase.

In another example, the French Chamber of Agriculture of Haute-Savoie conducted a study of non-point sources of pollution from agriculture. The 900 breeding units of more than 15 cows each on the French side of Lake Geneva were studied in order to determine how phosphorus gets into Lake Geneva (Ferrier, 1998). This study benefitted from subsidies from the European Union.

LAKE GENEVA ACTION PLAN

The Lake Geneva action plan promulgated by CIPEL in 1991 had four key objectives (CIPEL, 1991): (1) to maintain or restore the ecological quality of the water and water environments (physical characteristics, water quality, shoreline quality, and benthic quality); (2) to facilitate the use of lake water as a drinking water supply (following simple treatment); (3) to encourage the practice of leisure activities (fishing, boating, swimming, and visual experience) under the best conditions; and (4) to promote, via natural reproduction, the predominance of "white fish" as a major faunal resource. The primary strategy for achieving the four objectives involves the reduction of phosphorus inputs into Lake Geneva by at least 50% by the year 2000. Reducing phosphorus inputs is primarily directed to source reductions rather than subsequent treatment of Lake Geneva water for phosphorus removal. The baseline (reference) condition used to define the 50% reduction was the most recent data on inputs to the lake over the period from 1987-1990, depending on the types of sources.

Specific strategies in the Lake Geneva action plan included (CIPEL, 1991): (1) reducing eutrophication; (2) reducing toxic discharges; (3) controlling microbial pollution in swimming areas and at beaches, and at intake points for water supplies; and (4) promoting an ecologically balanced aquatic ecosystem. In addition to phosphorus reductions, other measures were identified for reducing nitrogen inputs. Specific measures for reducing the nutrient inputs included encouragement for: (1) consistent treatment of municipal wastewater along with rapid repairs of disrupted treatment plants; (2) the use of phosphorus removal processes for all wastewater treatment plants (municipal and industrial); (3) industrial sources of wastewater reducing discharges via water savings, closed circuit recycling, and appropriate treatment; and (4) the use of control practices for nonpoint sources of pollution. Nonpoint source control practices included percolation of rainwater, use of storage tanks and management of manure spreading at cattle breeding operations, and the use of erosion controls in wine growing areas.

The Lake Geneva action plan is in consonance with other lake water quality management programs in Europe. For example, protection of European international lakes in terms of their water quality and water uses has been addressed via a Convention agreement (Economic Commission for Europe, 1994). Emphasis in the developed Convention was given to the need to strengthen national and international measures to abate eutrophication. Such measures include permitted limits for nutrients from wastewater discharges from industrial and municipal point sources, specification of best available treatment technologies for such sources, and development and implementation of appropriate measures and best environmental practices for the reduction of inputs of nutrients from diffuse (nonpoint) sources, especially where the main sources are from agriculture.

THE QUALITATIVE MODEL

As part of this research effort, a qualitative model for designing and implementing ETPs was developed; it contains ten components and 37 criteria questions (Edwards and Canter, 1998). Each model component and its importance to successful ETPs are summarized in Table 9.18, while the criteria questions associated with each component are listed in Table 9.19. The qualitative model can be used to evaluate existing ETPs by answering each criteria question with watershed-specific information and then rating each component according to the scheme shown in Table 9.20. Although the resulting ratings cannot be averaged to yield an overall score, they can be used to compare the relative performance of different components, to identify components that may need to be modified, and to compare the features of two or more ETPs. Alternatively, the model can be used to evaluate the potential applicability of an ETP. In this case, the first five components (watershed suitability, pollutant type, trading market size and characteristics, legal authority, and administrative acceptability and capability) can be

Table 9.18: Components of the Qualitative Model and Their Importance to Successful ETPs

Component of Qualitative Model	Rationale for Inclusion in the Qualitative Model
Watershed Suitability	This component is designed to ensure that the geographic and temporal boundaries of the ETP are clearly defined. In addition, circumstances within the watershed (or trading area) that either encourage or discourage effluent trading must be identified and addressed.
Pollutant Type	This component is designed to identify pollutants that may be suitable for inclusion in an ETP. ETP designers must also decide if program rules will allow inter-pollutant trading.
Trading Market Size and Characteristics	This component is designed to identify all sources of the pollutant(s) of interest in the ETP area, their relative contributions to total pollutant loading, and differences in their marginal abatement costs that may promote effluent trading. This component is also focused on identifying market characteristics, such as the presence of direct competitors, that may influence trading activity.
Legal Authority	This component is included to identify whether existing laws and regulations fully support, or could be amended to support, the development and operation of an ETP.
Administrative Acceptability and Capability	This component is used to identify whether the administering agency has sufficient knowledge and information to design and implement an ETP. This component is also for determining whether agency staff are willing to support the use of effluent trading as an alternative to more traditional forms of regulation.
Specific Policies, Procedures, and Trading Rules	Specific policies, procedures, and rules are needed to reduce uncertainty, to minimize regulatory and administrative burdens, and to reduce transaction costs. Such rules should encompass all aspects of an ETP, from determining the maximum allowable pollutant loading to reviewing proposed trades to penalizing trading partners who violate their trading agreements.
Pre- and Post-Trade Monitoring	Pre- and post-trade monitoring is required to determine the environmental effects of individual trades and of the overall ETP.
Enforcement Mechanisms	Enforcement mechanisms are required in order to ensure that water quality standards and/or ETP goals are met and that trading partners fulfill the terms of their agreements.

Table 9.18 (continued):

Program Evaluation	**Periodic evaluations of ETP performance are necessary in order to ensure that the ETP is protecting, or improving, water quality while reducing environmental compliance costs. Periodic evaluation of the ETP itself is also recommended in order to identify any necessary modifications.**
Public Involvement	**Public and stakeholder involvement throughout ETP design and operation is needed in order to encourage participation in the trading program, to decrease controversy, and to minimize the potential for negative publicity.**

Table 9.19: Criteria Questions for Each Component of the Qualitative Model for Designing and Implementing ETPs

<u>Watershed Suitability</u> 1. Does the watershed (or watershed segment or estuarine zone) have a clearly defined geographic boundary? What is the basis for defining the watershed, segment, or zone? 2. Are temporal variations in flow well understood? 3. Do existing water quality conditions or other circumstances within the watershed encourage the use of an ETP? 4. Are there circumstances within the watershed that would discourage the use of an ETP?
<u>Pollutant Type</u> 1. Are the pollutant(s) of interest classified as conservative, non-conservative, or toxic? 2. Will inter-pollutant trading be allowed? What is the basis for the decision to permit or prohibit inter-pollutant trading? 3. Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality? 4. Do the environmental effects of the pollutant(s) of interest result more from total loading over time than local, short-term toxic effects? 5. Can mass- or concentration-based limits be established for the pollutant(s) of interest?
<u>Trading Market Size and Characteristics</u> 1. Have all sources of the pollutant(s) of interest been identified? 2. Are the relative contributions of all source categories (point, nonpoint, and background) known? 3. Are temporal variations in loadings of the pollutant(s) of interest well understood? 4. Are there significant differences in marginal abatement costs among sources in the same category and/or sources in different categories? 5. Could sources and/or governmental entities within the watershed be potentially unwilling to trade? 6. Are there unique circumstances that may influence the behavior of market participants?
<u>Legal Authority</u> 1. Are there water quality standards, goals, and/or objectives that can be used as a basis for the ETP? 2. Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so? 3. Is there an existing agency with sufficient authority to implement and enforce an ETP, can such authority be conferred on an existing agency, or can such an agency be created? 4. Does the implementing agency have sufficient authority to require all contributing sources to meet their discharge allocations?

Table 9.19 (continued):

Administrative Acceptability and Capability 1. Does the administering agency have sufficient knowledge and information to designate the maximum allowable pollutant loading for the watershed, to allocate portions of that loading to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades as well as the overall trading program? 2. Is the administering agency willing to use effluent trading as a management strategy to supplement traditional regulation? 3. Does the administering agency have sufficient resources to design and implement an ETP?
Specific Policies, Procedures, and Trading Rules 1. If nonpoint sources are to be included in the ETP, do policies or procedures account for their inherent variability? 2. Have procedures been clearly defined for the following aspects of the ETP? (a) determination of the maximum allowable pollutant loading for the watershed (b) allocating portions of the loading cap to all sources within the watershed that discharge the pollutant(s) of interest (c) types of trades that will be allowed (d) trading ratio(s) 3. Have rules or procedures been clearly defined for the following operational aspects of the ETP? (a) quantifying and certifying PRCs (b) quantifying the environmental impacts of trades (c) application procedures for proposed trades (d) administrative procedures for the evaluation of proposed trades (e) time periods that trades remain in effect (f) treatment of banked or shutdown credits (g) reporting and recordkeeping requirements 4. Will non-dischargers, such as environmental groups, be allowed to purchase and retire PRCs?
Pre- and Post-Trade Monitoring 1. Are responsibilities for pre- and post-trade source and ambient water quality monitoring clearly defined? 2. Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for both source and ambient water quality monitoring? 3. Will source monitoring requirements discourage trading activity?
Enforcement Mechanisms 1. Can trading agreements be effectively enforced for each source category? 2. Should uncontrollable circumstances for both point and nonpoint sources be considered in the enforcement process?
Program Evaluation 1. Are responsibilities for evaluating ETP performance clearly defined? 2. How often will the ETP be reviewed? 3. Have the criteria that will be used to evaluate ETP performance been specified?

Table 9.19 (continued):

Public Involvement
1. Was the public, including industries and municipalities, actively involved in ETP design and operation?
2. In general, did industries, municipalities, government agencies, and the public support the development of the ETP?
3. Does the ETP include any educational and/or outreach efforts designed to increase public support?

Table 9.20: Rating Scheme for Each Component of the Qualitative Model

Degree of Compliance With Criteria Questions for Each Component	Rating
Compliant from all perspectives	4
Compliant from the majority of perspectives	3
Compliant from only a few perspectives	2
Compliant from no perspectives	1
Degree of compliance with perspectives depends upon specific ETP design	0

used to determine the feasibility of an ETP for a specific watershed (or trading area). If the potential for effluent trading is adequate, the remaining model components (specific policies, procedures, and trading rules, pre- and post-trade monitoring, enforcement mechanisms, program evaluation, and public involvement) can be used to aid in the specific design and implementation of an ETP.

CONSIDERATION OF THE FEASIBILITY OF AN ETP FOR THE LAKE GENEVA WATERSHED

The answers to the criteria questions associated with the first five components of the qualitative model are summarized in this section. Responses were based on watershed-specific information contained in the baseline description section. The summary for each model component contains its rating, a brief explanation of the rationale for the assignment, and a discussion of any implications and/or resultant needs. The rating and summary information for each component is shown in Table 9.21.

WATERSHED SUITABILITY

Geographic Boundaries

The geographic boundary of the Lake Geneva watershed defines the ETP area, thus providing the framework needed to determine the maximum allowable pollutant loading and to identify the locations subject to post-trade ambient water quality monitoring. Such boundaries are also used to identify the pollutant sources that will be eligible to participate in the trading program. The boundaries of Lake Geneva's watershed, which include all the land area that drains water, sediment, and dissolved material to the lake, have already been established (Dunne and Leopold, 1978; and CIPEL, 1996). However, lake water quality management may be complicated by the presence of multiple political jurisdictions within the watershed,

Table 9.21: Summary of the Feasibility of an ETP for the Lake Geneva Watershed

Component of Qualitative Model	Rating of Degree of Compliance[a]	Rationale for Assigned Compliance Rating	Implications and Resultant Needs
Watershed Suitability	3	Geographic and temporal boundaries have been clearly defined, and circumstances within the watershed, particularly the importance of Lake Geneva to tourism and recreation, should be inducements for the development of an ETP.	Special studies may be needed to determine phosphorus loadings from nonpoint sources and the effectiveness of BMPs for phosphorus removal. ETP designers must also ensure that all interested stakeholders are allowed to participate in ETP development and operation.
Pollutant Type	0[b]	Phosphorus is suitable for inclusion in the ETP because its environmental impacts are due to total loading, and appropriate concentration- and/or mass-based limits can be established.	ETP rules must address any environmental effects that may result from trading different forms of phosphorus.
Trading Market Size and Characteristics	3	The diversity of sources within the watershed and the expected differences in marginal abatement costs between point and nonpoint sources should facilitate ETP development. In addition, adequate information is available for point sources.	Special studies are needed to identify all nonpoint sources of phosphorus in the watershed, to quantify the loadings associated with each nonpoint source, to identify appropriate BMPs, and to determine the effectiveness, total cost, and marginal abatement cost of each BMP under watershed-specific conditions.
Legal Authority	2	The ETP agency could be CIPEL, an existing transboundary agency heavily focused on reducing phosphorus loadings to Lake Geneva.	Existing laws and regulations would need to be amended, both to encourage effluent trading as a compliance alternative and to grant CIPEL sufficient authority and resources to implement and enforce an ETP. Such amendments may be difficult to obtain, particularly since so many different governmental authorities are involved.
Administrative Acceptability and Capability	2	Sufficient data are available for both point sources and ambient water quality. In addition, CIPEL would be likely to support the use of effluent trading as part of an integrated water quality management program.	The lack of information on nonpoint sources and appropriate BMPs may deter the development of an ETP. The additional staff and funding required by CIPEL before it could effectively administer a trading program may also discourage ETP development.

[a]The ratings are as follows: 4 = compliant from all perspectives; 3 = compliant from the majority of perspectives; 2 = compliant from only a few perspectives; 1 = compliant from no perspectives; 0 = degree of compliance with perspectives depends upon specific ETP design
[b]With an appropriate ETP design for Lake Geneva, it would be expected that this component could be assigned a rating of 4.

particularly if such jurisdictions have incompatible water quality laws and regulations.

Flow Variations

Since the assimilative capacity of a water body varies with flow, temporal variations must be known in order to determine the maximum allowable pollutant loading. Information regarding the flows of discharges is also needed to convert concentration-based limits to pollutant loadings. Sufficient information concerning the flows of contributing rivers, wastewater treatment plants (WWTPs), and lake water balances is readily available for Lake Geneva (CIPEL, 1996). However, information on flows resulting from specific precipitation events, which are typically associated with increased pollutant loadings from agricultural, forestry, and urban nonpoint sources, may be needed.

Conditions Encouraging Effluent Trading

Four conditions in the Lake Geneva watershed that support the development and implementation of an ETP were identified. First, even though 85 percent of the WWTPs in the watershed have installed phosphorus removal technologies, total phosphorus loadings are still excessive (CIPEL, 1996). WWTPs facing extremely high marginal abatement costs for additional phosphorus removal may prefer effluent trading as a cost-effective alternative, particularly since marginal abatement costs for nonpoint sources should be relatively low. In addition, an ETP would provide economic incentives for nonpoint sources, which are largely unregulated, to reduce their phosphorus loadings. Second, lake-related tourism and recreation is extremely important to the region, so the maintenance or improvement of existing water quality, which could be accomplished through effluent trading, is critical. An ETP could also facilitate the accommodation of the expected population growth and economic development without compromising water quality. Third, an ETP could become the focal point for the multiple stakeholders interested in water quality in the Lake Geneva watershed, thus de-emphasizing differences in transboundary water management policies and practices. Finally, since eutrophication is not currently an acute problem and existing programs are successfully decreasing phosphorus loadings, stakeholders have the time to carefully consider, plan, test, and evaluate an ETP. The ETP could then be used as an additional, long-term management tool for environmentally sustainable development in the watershed.

Conditions Discouraging Effluent Trading

Several circumstances within the watershed may be deterrents to the use of effluent trading for Lake Geneva. First, since there is no apparent usage of ETPs in Europe, and only limited usage of such programs in the United States, there are only a minimal number of good analogs that can be used to aid in ETP development. Second, coordinating the large number of stakeholders in the watershed would be almost impossible, particularly if stakeholders disagree on water quality management issues. Another deterrent is the amount of time and money needed to collect basic information that would be needed to design an effective ETP. For example, basic information regarding the types of best management practices (BMPs) that could be used in the watershed, their marginal costs, and their effectiveness, would need to be developed if nonpoint sources are to be included in the trading program. In addition, it is possible that such studies could lead to the conclusion that effluent trading is not a feasible alternative. Finally, because current programs are successfully reducing phosphorus loadings, there is minimal incentive for creating alternative management options in the near term, particularly if program development costs are high and/or program results are uncertain.

Summary of Watershed Suitability

In summary relative to watershed suitability, and as shown in Table 9.21, the Lake Geneva watershed was assigned a rating of "3" for this component of the qualitative model. This rating was based on the fact that the geographic and temporal boundaries have been clearly defined and circumstances within the watershed, particularly the importance of Lake Geneva to tourism and recreation, should be inducements for the development of additional phosphorus control programs. However, the development of an ETP may be discouraged by the large number of stakeholders in the watershed, thus making it difficult to ensure that all stakeholders are able to participate in ETP development and operation. In addition, the development of point-nonpoint source trading programs, which should maximize the potential cost savings, may be initially limited by the lack of information regarding phosphorus loadings from nonpoint sources and the cost-effectiveness of various BMPs. Special studies could be done to address nonpoint issues, but such studies would be both time-consuming and expensive.

POLLUTANT TYPE

Pollutant Classification

The technical (or scientific) classification of the pollutant(s) of interest must be determined in order to qualitatively predict their environmental effects and to select appropriate water quality models for use in quantifying such effects. Since phosphorus is generally the limiting nutrient for algal growth in lakes, it is assumed that the primary objective of any ETP for Lake Geneva would be to further reduce current and potential future development-related phosphorus loadings to the watershed (Chapman and Kimstach, 1996; and Garrels, et al., 1975). Phosphorus is a non-conservative water pollutant due to biological incorporation in algae, sorption, and chemical precipitation. Nitrogen, another nutrient that promotes algal growth, could also be included in the trading program in the future; however, it is not the focus herein.

Inter-pollutant Trading

Inter-pollutant trading would allow point and/or nonpoint source operators in the Lake Geneva watershed to exchange pollutant reduction credits (PRCs) for different pollutants; for example, a pharmaceutical company may be able to increase its nitrogen loadings, and simultaneously reduce its environmental compliance costs, by purchasing phosphorus PRCs from agricultural nonpoint source operators. The decision to allow inter-pollutant trading represents a policy choice. Even then, ETP designers can require extensive modeling to document water quality equivalency before approving such trades, or require the use of trading ratios which adequately incorporate any uncertainties associated with inter-pollutant trading as well as provide a margin of safety. The policy decision should be based, at least in part, on the careful consideration of the following factors: (1) the number of sources in the trading area discharging the pollutants of interest; (2) the quantities of each pollutant discharged from each source; (3) each source's marginal abatement costs; (4) the environmental benefits of reducing the discharge of each pollutant; (5) the relevant contributions of the pollutants to current and/or future water quality concerns; (6) the strength of scientific evidence linking the pollutants to the goals of the ETP; and (7) the increased administrative burdens associated with an inter-pollutant ETP.

Pollutant Forms

The environmental effects (impacts) of a given pollutant depend upon the form in which it is released into the environment and its transport and fate characteristics. For example, only the soluble inorganic forms of phosphorus, like phosphate, are most readily available to algae. Therefore, even though particulate phosphorus loadings from nonpoint sources may be an order of magnitude greater in quantity, phosphorus loadings from WWTPs, which are primarily in the soluble phosphate form, may have greater environmental effects (Reckhow, et al., 1980). Under certain circumstances, however, such general assumptions may not be true. For example, if the hypolimnion in Lake Geneva becomes anoxic, phosphorus associated with the bottom sediments may be released as phosphate, thus becoming biologically available during lake overturn periods. The issues for consideration as described above for inter-pollutant trading also apply to trading two or more forms of the same pollutant with different environmental effects.

Environmental Effects

Although trading programs are designed to improve overall water quality, pollutant discharges at certain locations may increase over time (or not be diminished) as a result of trading. However, since the environmental effects of phosphorus in a lake are due primarily to total loading, such localized increases should be insignificant from the perspective of their potential toxic consequences. As a result, modeling and monitoring requirements for proposed trades can be relatively limited, thus simplifying ETP administration, reducing transaction costs, and encouraging program participation.

Pollutant Limits

In order for a source operator to determine the quantity of PRCs that it is eligible to sell, lease, or purchase, the operator must be able to quantify the pollutant discharges, either in mass-based units, such as kilograms per day, and/or concentration-based units, such as milligrams per liter. Both concentration- and mass-based data can be easily established for point sources of phosphorus;

however, it is expected that special studies would be required for phosphorus limits from nonpoint sources.

Summary of Pollutant Type

In summary relative to the "pollutant type," a rating of "0" was assigned, as shown in Table 9.21. This rating was assigned since this component's compliance with the above criteria questions depends heavily upon the specific ETP design. If phosphorus is the only pollutant included in the trading program, the above criteria would generally be met because phosphorus' environmental impacts are due to total loading and appropriate discharge limits can be established. However, since the forms of phosphorus are not interchangeable, ETP rules must address any environmental effects that may result from trading different forms of phosphorus. Therefore, while this component should not be a basic deterrent to the use of an ETP for the Lake Geneva watershed, additional information will be required before final decision-making regarding the establishment of an ETP.

TRADING MARKET SIZE AND CHARACTERISTICS

Pollutant Sources

All sources of the pollutant(s) of interest in the Lake Geneva watershed should be identified in order to accurately determine the maximum allowable pollutant loading and to allocate portions of the allowable loading among point and nonpoint source dischargers. Identifying all sources also maximizes the size of the trading market and the number of potential trading partners, thus increasing the economic incentive to participate in an ETP. All point sources of phosphorus (156 WWTPs) have been previously identified for the Lake Geneva watershed (Rapin, 1996a). Both the atmosphere and lake sediments were excluded from further consideration for Lake Geneva since studies have indicated that their contributions to phosphorus loadings in the lake are extremely low (Scientific Committee of

CIPEL, 1996). Unfortunately, only general information regarding nonpoint sources of phosphorus is available. As noted above, special studies would be needed to aggregate more information about phosphorus loadings associated with silvicultural and agricultural land uses in the watershed, as well as potential contributions from lakeside homes, marinas, and recreational beaches.

Relative Contributions

ETP designers must have information regarding the relative contributions of point and nonpoint sources, which vary with specific watershed characteristics, in order to determine whether effluent trading is a feasible water quality management option. Point source loadings to Lake Geneva have been fully documented; WWTPs are responsible for 9 percent of the total phosphorus loading and 50 percent of the dissolved phosphate loading (Scientific Committee of CIPEL, 1996). Corresponding information for nonpoint sources is not currently available. However, by subtracting the point source loading for total phosphorus or dissolved phosphate from the respective total loading, it was determined that 91 percent of the total phosphorus loading and 50 percent of the phosphate loading are due to nonpoint sources. However, this procedure may underestimate nonpoint loadings because it does not account for decreases in point source loadings in watershed rivers and Lake Geneva due to transport and fate processes (Reckhow, et al., 1980). Further, since both point and nonpoint sources contribute significantly to phosphate loadings, which is the most bio-available form of phosphorus, an ETP may be a particularly suitable management option for reducing the phosphorus concentrations in Lake Geneva itself.

Temporal Variations

ETP designers need information concerning temporal variations in pollutant loadings in order to determine the maximum allowable pollutant loading and to maximize the effectiveness of source and ambient water quality monitoring programs. Sufficient time-related information is available for point sources but, once again, there is limited information for nonpoint sources (CIPEL, 1996). This lack of information may be particularly critical because nonpoint source loadings are a function of several parameters that vary over time, therefore, these loadings are much more difficult to predict than point source loadings.

Marginal Abatement Costs

Differences in marginal abatement costs for additional pollutant removal from affected sources provide the major economic incentive to participate in an ETP. Specific information on such costs for point and nonpoint sources in the Lake Geneva watershed is not currently available; further, the applicability of general information which could be developed through a literature review is limited because marginal abatement costs vary with site-specific conditions, particularly for nonpoint sources. However, some information on marginal abatement costs for point sources could be generated, upon request, from WWTPs in the Lake Geneva watershed that have recently installed or upgraded their phosphorus removal capabilities. Assemblage of such information would require a special study. Nonetheless, even in the absence of site-specific data, the following conditions in the watershed indicate that there are likely to be significant differences in marginal abatement costs for phosphorus removal between point and nonpoint sources, thus promoting ETP design and implementation. The conditions include: (1) requirements for additional phosphorus removal at WWTPs are expected to be extremely expensive; (2) installing and operating BMPs should be relatively inexpensive since nonpoint sources are largely unregulated at this time; and (3) BMPs in the Lake Geneva watershed should be particularly cost-effective due to local topographic features and proximity to surface water channels (Senjem, 1997).

Unwillingness to Trade

Source operators with excess PRCs may prefer to save them in order to meet future water quality or discharge standards or to allow for future expansion, particularly if the trading program activity is minimal. Source operators may also be unwilling to sell PRCs to direct economic competitors and thus provide economic benefits in the form of reduced compliance costs to their competitors. Similarly, municipalities, states (cantons), and even countries (Switzerland and France) may prefer to retain any PRCs they create for their own future development and population expansion, particularly if the governmental entity purchasing the PRCs would receive significant economic benefits. However, because of the diversity of point and nonpoint sources, as well as the large number of government entities in the Lake Geneva watershed, hoarding of PRCs would not be expected to be a major deterrent to an effective ETP.

Unique Circumstances

The economic theory underlying ETPs requires the assumption that all dischargers in the Lake Geneva watershed will seek to minimize their environmental compliance costs. While this assumption is probably true for industrial point sources, it may not apply to all municipal WWTPs and nonpoint sources. For example, municipal WWTPs may be subject to regulations that would restrict or even prohibit effluent trading, while nonpoint sources may be less inclined to participate in ETPs if other sources of BMP funding, such as grants and subsidies, are available from governmental agencies in the applicable cantons and two countries. Before designing an ETP for the Lake Geneva watershed, information regarding any such circumstances should be collected at the municipal, cantonal (Switzerland), departmental (France), and federal (Switzerland and France) levels.

Summary of Trading Market Size and Characteristics

In summary regarding the trading market size and characteristics, and as shown in Table 9.21, this component of the qualitative model was assigned a composite rating of "3." Both the diversity of sources within the Lake Geneva watershed and the expected differences in marginal abatement costs between point and nonpoint sources are strongly conducive to the development of an ETP. In addition, adequate phosphorus loading information is either available, or could be easily obtained, for all point sources in the watershed. However, special studies are needed to identify all the nonpoint sources of phosphorus in the watershed, to quantify the resultant loadings associated with each nonpoint source, and to identify appropriate BMPs. Studies would also be needed to determine the effectiveness and cost of each potential BMP under watershed-specific conditions.

LEGAL AUTHORITY

Standards, Goals, and/or Objectives

Ambient water quality standards, goals, and/or objectives can serve as the basis for determining the maximum allowable phosphorus loading to Lake Geneva, for distributing discharge allocations to point and nonpoint sources, for reviewing proposed trades, and for evaluating the overall performance of an ETP. For example, the primary goal of Le Léman Demain, an action plan initiated by CIPEL in 1991, is to reduce phosphorus loadings to Lake Geneva by at least 50 percent by the year 2000 (CIPEL, 1991). This goal could be used as one basis for the design of an ETP, along with a phosphorus concentration limit, although any inconsistencies or incompatibilities with other water quality laws, regulations, or policies would need to be resolved.

Legal Support

Current water quality management laws in the Lake Geneva watershed do not directly address effluent trading, thus possibly increasing the uncertainty and perceived risk that would be associated with ETP participation. In order to reduce this uncertainty and increase trading activity, federal (Switzerland and France), regional (canton or department), and municipal laws would need to be amended to support effluent trading as an acceptable compliance alternative. However, the amendment process may be extremely difficult and require considerable time due to the large number of governmental agencies and other stakeholders, as described earlier, involved directly or indirectly in water quality management for Lake Geneva. In addition, ETP designers should ensure that resultant laws are consistent across geographical jurisdictions in order to prevent the "build-up" of polluting sources from economic developments and population growth in areas with less stringent water quality standards.

Administering Agency

The agency administering the ETP must have sufficient legal authority to establish trading program boundaries, to determine the maximum allowable pollutant loading, to allocate the maximum loading among dischargers, to review proposed trades, to conduct pre- and post-trade water quality monitoring and inspections, and to enforce the provisions of trading agreements. The agency should also have the authority to modify individual trading agreements or the ETP itself if the program is not functioning properly. No existing governmental agency in the Lake Geneva watershed has such authority, and creating a new agency may be politically unpopular, particularly if responsibilities from existing agencies are reassigned to the new ETP agency, or if overlaps in responsibilities occur between agencies.

Of the existing agencies in the Lake Geneva watershed, CIPEL, established in 1960 to protect or improve the quality of Lake Geneva's water, is probably the most qualified and appropriate to administer an ETP for several reasons (Ferrier, 1998). First, since CIPEL is already a transboundary agency, its Swiss and French members are accustomed to working together on watershed management activities regardless of political boundaries. Second, CIPEL already has a successful program to reduce lake phosphorus levels, so an ETP could simply be an extension to the existing action plan (CIPEL, 1991). Finally, CIPEL's technical commissions are well qualified to establish ETP rules and supervise ETP operation. However, the major drawbacks associated with designating CIPEL as the ETP agency include its extremely small secretariat (only two people) and its lack of legal authority for promoting and managing effluent trading. These two drawbacks would need to be addressed irrespective of which current agency, or new agency, was designated to administer an ETP.

Agency Authority

In order for an ETP to result in water quality improvement, all sources in the program must receive a discharge allocation that they are required to meet by installing pollution abatement equipment, changing production processes, and/or by purchasing or leasing PRCs. Once again, relevant laws at the federal, regional, and municipal levels would need to be amended to eliminate potential "loopholes," such as waivers, variances, grants, and subsidies, that could increase total phosphorus loading and/or reduce the size of the trading market.

Summary of Legal Authority

In summary for the legal authority component, and as shown in Table 9.21, it was assigned a rating of "2." Since CIPEL is an existing transboundary agency heavily focused on phosphorus reduction, its duties could be modified to include administration of an ETP. However, existing federal, regional, and municipal laws and regulations would need to be amended to encourage effluent trading as a compliance alternative, to eliminate potential loopholes and conflicts, and to grant CIPEL sufficient legal authority, personnel and monetary resources to implement and enforce the ETP. Such amendments may be difficult and time-consuming to obtain, particularly since so many different governmental authorities are involved. This difficulty may be partially alleviated if there is a strong advocate, perhaps a non-governmental organization (NGO) or an association of WWTPs, to help promote ETP development and to facilitate the necessary amendments.

ADMINISTRATIVE ACCEPTABILITY AND CAPABILITY

Knowledge and Information

Large amounts of data are required to design and operate effective ETPs. For many years, CIPEL has routinely aggregated information on river flows, point source and total phosphorus loadings, and lake water quality. Such data, along with the results of special studies focused on hydrodynamic characteristics, algal populations, and chemical cycling in Lake Geneva, are published regularly (CIPEL, 1996). However, in order to design an effective ETP, additional information would be needed on nonpoint sources of phosphorus, appropriate BMPs, and marginal abatement costs for both point and nonpoint sources. Further, more detailed information on phosphorus chemistry and bioavailability in Lake Geneva may be needed, particularly if a decrease in the input of phosphorus loading shifts the existing equilibrium to favor release of phosphorus from lake sediments. Ambient water quality models are also needed to aid in discharge allocations and to evaluate the environmental effects of proposed trades. Program designers could use a generic model, calibrated to conditions in Lake Geneva, or a new model developed specifically for the watershed. As described earlier, a phosphorus model developed for Lake Geneva by Fahrni and Rapin (1986) would provide an excellent basis for the necessary modeling in planning and operating an ETP. However, due to the need for nonpoint source data and the time required for its accumulation, it is suggested that ETP designers use a "phased" approach, meaning that initial pollutant loadings and discharge allocations can be refined as additional monitoring data become available. This approach can be used to overcome the problems associated with lack of information during the initial stages of ETP design and implementation.

Willingness to Use ETPs

In order for ETPs to function successfully, regulators must actively promote the trading program as an acceptable compliance alternative. Although it is not possible at this time to determine whether regulators in the Lake Geneva watershed would support an ETP, CIPEL's Le Léman Demain (action plan) does suggest that stakeholders are willing to use integrated water quality management to achieve phosphorus reductions. For example, in addition to "end-of-the-pipe" treatment at WWTPs, the plan includes encouragements for pollution prevention activities and the use of agricultural BMPs (CIPEL, 1991). Therefore, if a feasibility study suggested that the potential for effluent trading in the watershed was sufficient, and if CIPEL would be designated as the administrative agency, then it would be expected that CIPEL would actively encourage such trading as a cost-effective alternative to traditional command-and-control regulation.

Resources

In general, the "minimum technical core" staff needed to design and operate an ETP for Lake Geneva would include an attorney, a chemist, a biologist, and an environmental engineer. Depending upon the scope of the ETP, additional staff or special consultants may also be needed; consultants could include additional attorneys, agricultural engineers, economists, geographic information system specialists, foresters, hydrologists, meteorologists, information specialists, and/or public participation specialists. CIPEL has already established good collaboration with existing organizations on fundamental water quality issues as well as public information programs, and some professional staff at such organizations could be expected to contribute to the design of an ETP; however, a separate, dedicated staff would be needed by CIPEL or another designated agency, to administer the ETP.

Funding for an ETP feasibility study or demonstration project could come from governmental allocations, from special grants from NGOs or the private sector, or combinations thereof. For example, the Organization for Economic Co-operation and Development (located in Paris, France) might fund a study to determine the potential for effluent trading for the Lake Geneva watershed, and to develop a protocol for similar feasibility studies in Europe and elsewhere. Funding sources for specific ETP design and implementation could include governmental agency allocations, additional grants based on the results of the feasibility study or demonstration project, and/or fees paid by affected point and nonpoint sources in the watershed. ETP operations, including staff salaries, monitoring, and inspections, would probably be funded through governmental agency allocations although, as an additional source of funding, trade review fees and/or annual operation fees could be assessed to trading partners.

Summary of Administrative Acceptability and Capability

The administrative acceptability and capability component was assigned a rating of "2," as shown in Table 9.21. Sufficient data are available for both point sources and ambient water quality, and CIPEL might be receptive to supporting an ETP, particularly since such a program would provide economic incentives for unregulated nonpoint sources to reduce phosphorus loadings. The lack of information on nonpoint sources and appropriate BMPs, which could be partially overcome by using the phased approach, could deter the development of an ETP. The additional staff and funding needed by CIPEL before it could effectively administer an ETP could also be a discouragement to development of a Lake Geneva watershed ETP.

CONCLUSIONS REGARDING THE FEASIBILITY OF AN ETP FOR THE LAKE GENEVA WATERSHED

Four of the five qualitative model components used to assess ETP feasibility (watershed suitability, trading market size and characteristics, legal authority, and administrative acceptability and capability) were assigned ratings of "2" or "3," thus indicating that they were at least partially compliant with the component-specific criteria questions. The other component (pollutant type) was assigned a rating of "0" since compliance with its criteria questions is dependent on the specific ETP design. However, with an appropriate design it would be expected that this component could be assigned a rating of "4." As a result, it can be concluded that an ETP would be a feasible water quality management option for the Lake Geneva watershed. Circumstances conducive to the development and use of an ETP include the large number of sources of phosphorus in the watershed, anticipated differences in marginal abatement costs between regulated and nonregulated point and nonpoint sources of phosphorus, the presence of an existing transboundary agency (CIPEL) already committed to reducing phosphorus loadings, and Lake Geneva's importance to the regional economy and cultural heritage of both Switzerland and France. However, program development may be delayed by the lack of sufficient effluent trading legal authority; the need to provide additional professional staff and monetary resources to CIPEL to implement the ETP; and the lack of information regarding nonpoint source phosphorus loadings, specific marginal abatement costs, and BMP costs and effectiveness.

ETP DESIGN CONSIDERATIONS FOR THE LAKE GENEVA WATERSHED

The criteria questions associated with the last five model components (specific policies, procedures, and trading rules; pre- and post-trade monitoring; enforcement mechanisms; program evaluation; and public involvement) were used to identify general concerns that should be addressed when designing an ETP for the Lake Geneva watershed. The applicable criteria questions are included in Table 9.19. Whenever possible, the discussion below was based on watershed-specific information. This section was developed based on the following assumptions: (1) that effluent trading is a feasible water quality management option for Lake Geneva; (2) that phosphorus will be the only pollutant included in the ETP; and (3) that CIPEL will be the administering agency for the ETP. The following discussions highlight pertinent concerns and possible ways of addressing them in a specific ETP design for the Lake Geneva watershed.

SPECIFIC POLICIES, PROCEDURES, AND TRADING RULES

Nonpoint Source Variability

Since phosphorus loadings from nonpoint sources have received only minimal attention in the Lake Geneva watershed, determining nonpoint source contributions to total loading, allocating discharge rights to individual nonpoint sources, and quantifying PRCs generated by nonpoint source control projects can be both technically complicated and fraught with uncertainties. However, ETP rules can be developed to incorporate the inherent variability of nonpoint source loadings and control project effectiveness in the following ways: (1) by using trading ratios which include a margin of safety based on nonpoint source uncertainty; (2) by granting variances to nonpoint sources that fail to meet their loading reduction requirements in atypical hydrological periods; (3) by using monitoring protocols designed specifically to focus on the variations associated with nonpoint source loadings and BMP effectiveness; and (4) by establishing different phosphorus loading limits for point sources, based on whether or not proposed nonpoint source reductions are successfully achieved.

ETP Procedures

Maximum Allowable Pollutant Loading

Determining the maximum allowable pollutant loading, or loading cap, that will achieve water quality standards or related goals and objectives is essential to ETP development in the Lake Geneva watershed for two reasons. First, the loading cap must be used to specify each source's individual discharge allocation; allocations may also be made to a reserve pool where they can be permanently retired or assigned to new and expanding sources within the watershed on an as-needed basis. Second, compliance with the loading cap can be used as one of several criteria to evaluate the effectiveness of the trading program over time.

The U.S. Environmental Protection Agency's (USEPA's) Total Maximum Daily Load (TMDL) procedure represents a systematic and scientifically-based approach for determining maximum allowable pollutant loadings (U.S. Environmental Protection Agency, 1991). This USEPA procedure could be utilized for the Lake Geneva watershed in conjunction with available point source pollutant loading information from CIPEL (CIPEL, 1996). To avoid potential legal challenges, the specific procedures and data used to establish the maximum pollutant loadings for phosphorus should be verified and clearly documented. In addition, all pertinent stakeholders should be invited to participate in planning the TMDL study and reviewing its results.

Loading Allocations

All point and nonpoint sources in the Lake Geneva watershed should be allocated a portion of the loading cap. This allocation can be used to determine the quantity of phosphorus that each source may discharge into receiving waters. ETP designers may also choose to allocate a portion of the cap to a reserve pool in order to accommodate future population growth and development and to account for uncertainties associated with pollutant loadings or BMP removal efficiencies. Allocations should be based in part on existing regulations and historical discharges since these methods will probably be the most acceptable to ETP participants. If possible, ETP designers should also minimize the creation of "paper" PRCs which occur when a source's allocation exceeds its current discharge levels; selling or leasing PRCs created by this difference can increase pollutant loadings to the watershed, thus resulting in possible water quality deterioration in Lake Geneva.

Types of Trades

Effluent trading could be allowed between outfalls at a single industrial facility (intra-plant trading), between point sources (point-point source trading), between point sources that discharge to the same WWTP (pretreatment trading), between point and nonpoint sources (point-nonpoint source trading), and/or between nonpoint sources (nonpoint-nonpoint source trading). Assuming that reductions in phosphorus loadings from background sources in the Lake Geneva watershed are impossible, the types of trading that will be most appropriate should be determined primarily by the relative contributions of point and nonpoint sources.

A point-nonpoint source trading program was identified as the most promising type of ETP for the Lake Geneva watershed because both point and nonpoint sources contribute significantly to phosphorus loadings, marginal abatement costs for point sources are expected to be high, and nonpoint sources are mostly unregulated at the current time. Intra-plant and pretreatment trading programs may also be appropriate due to the large number of industrial facilities in the watershed. Nonpoint-nonpoint source trading could be used as an incentive to improve BMP efficiency or to mitigate the effects of population growth and economic development. Point-point source trading programs are probably irrelevant since existing standards already require phosphorus removal at all municipal and industrial WWTPs.

Trading Ratio(s)

Trading ratios, which are used to determine the rate-of-exchange for PRCs, should be established based on considering the relative water quality effects of different forms of phosphorus (inorganic and organic) and on the uncertainties associated with trading different forms of phosphorus, nonpoint source loading contributions, and BMP effectiveness. Such ratios can range from 1 to 1 to greater than 2 to 1 (the first number denotes the purchased, leased or traded PRCs, while the latter denotes the required PRCs). Trading ratios can also be used to provide margins of safety; to encourage progress toward relevant water quality standards, goals or objectives; and/or to offset nonpoint source loadings from new developments. In general, as the potential for negative environmental impacts or the level of uncertainty increases, trading ratios should also increase. However, since higher trading ratios (e.g., greater than 2 to 1) may reduce or eliminate economic incentives for trading program participation, ETP designers must consider both environmental and economic consequences when making policy decisions regarding appropriate ratios. Finally, trading ratios which have been selected for the types of trades should be periodically reviewed and revised as necessary.

Operational Aspects

Quantifying and Certifying PRCs

Source operators must be able to accurately determine their baseline conditions and current discharge levels in order to calculate the quantity of PRCs they are eligible to sell or lease, or which they need to purchase or lease. In general, each source's discharge allocation, to be established by CIPEL, will represent its baseline condition. Since most point source operators are already required to monitor their effluent, determining their discharge levels should be relatively simple. However, determining current discharge levels may be more difficult and controversial for nonpoint sources; therefore, trading program rules must clearly delineate the procedures to be followed. In addition, PRCs must be enforceable, assignable to a specific source, and extend throughout the life of the trading agreement (Kerns and Stephenson, 1996). To reduce the uncertainty associated with ETP participation, particularly for purchasers or leasors of PRCs, and to ensure that trading program goals are met, PRCs should also be certified. Such certification could be as a part of the trade approval process, or source operators could purchase or lease previously certified credits from other source operators or a PRC bank.

Environmental Impacts

The environmental impacts (effects) of proposed trades (typically involving purchases or leases) can be predicted (quantified) using generic or watershed-specific water quality and aquatic ecosystem models or by reviewing the effects of similar trades in similar watersheds. The information that can be obtained from general models or analogs, however, may be fairly limited and subject to many uncertainties due to differences in land use, topography, meteorology, and other watershed-specific conditions. However, a dynamic phosphorus cycle model for Lake Geneva has been developed by Fahrni and Rapin (1986). The model could be used to examine the influence of changes in phosphorus loadings on the spatial distribution of phosphorus concentrations in the water, algae, and sediment components of the lake. It could serve as the basic model, with modifications as appropriate pending further analysis, for examining the potential effectiveness of an overall ETP and the environmental impacts of specific trades.

"Build-out analysis" coupled with water quality modeling has been proposed as a tool for examining the environmental impacts of alternative development scenarios in watersheds (Chesapeake Bay Program, 1998). Build-out analysis refers to a method used to predict the development potential of specific land areas over future time periods. Such analyses are typically focused on questions related to the maximum amount of development which could occur, the maximum human population the area could sustain under different population density assumptions, the water and air pollutant loadings from the maximum development, and the adequacy of existing infrastructure or public services to meet the requirements of the maximum development. At least 14 such build-out analyses have been conducted in the United States in order to predict the character of future land uses in the study watersheds or counties (Chesapeake Bay Program, 1998). Several of the 14 analyses have also modeled water quality impacts that could result from the predicted changes in landscapes. Build-out analysis coupled with water quality modeling would probably be useful in examining potential longer term changes in phosphorus loadings in the Lake Geneva watershed.

If the water quality impacts of a proposed trade are highly uncertain or could be of public health concern, the ETP administrator could even require demonstration projects or laboratory studies as part of the trade review process. Trading rules could also require pre- and post-trade monitoring, with subsequent reporting of monitoring results to CIPEL. Such monitoring data could be used to evaluate the environmental effects (impacts) of individual trades, to evaluate the overall water quality effects of the ETP, to evaluate similar proposed trades, to calibrate water quality models, and to refine the pollutant loading cap and related generic or watershed-specific discharge allocations. The impact of phosphorus trading on other water quality constituents should also be considered in pre-trade modeling and post-trade monitoring efforts.

Application Procedures

Clearly defined application procedures are needed to ensure trading program consistency and uniformity and to simplify the administrative review of proposed trades. In addition, specific application procedures, which allow potential trading partners to judge the likelihood that their proposal will be approved, help to reduce both uncertainty and transaction costs for program participants. An application for trade approval should include, but not be limited to, information concerning the following items: (1) current phosphorus loading allocations for all potential trading partners; (2) each partner's current environmental compliance status, which may include other environmental media or even other facilities that would not be directly involved in the proposed trade; (3) each partner's current environmental compliance costs; (4) the alternatives that have been considered relative to meeting the discharge allocation; (5) a summary of the coordination between potential trading partners; (6) the proposed trade and its anticipated environmental impacts; (7) current recordkeeping, monitoring, and reporting requirements and any required or proposed modifications thereto resulting from the trade; (8) legal agreements specifying the duties of each partner and assigning liability if one or more partners violate the terms of the trading agreement; (9) changes to discharge allocations as a result of the trade; and (10) previous and planned coordination with other agencies, such as the local chamber of commerce or department of agriculture, that may also be affected by the proposed trade.

Evaluation of Proposed Trades

Administrative procedures for the systematic review of trade applications are also needed to facilitate consistency and reduce uncertainty. Review procedures should be thoroughly described and illustrated, perhaps through a flow chart, to delineate the different phases of the review process. For example, the review process could be divided into the following five steps. First, CIPEL technical staff could briefly review the entire application for its completeness; if some of the required information was not submitted or it is incomplete, the agency could request the additional information or return the application to the proposed trading partners. Second, the technical aspects of the proposed trade, including the calculation of PRCs, the potential environmental impacts, and the necessary modifications to loading allocations, could be reviewed by CIPEL technical staff. The technical review may also include contacts by CIPEL staff with other agencies whose water quality responsibilities or interests would be affected by the proposed trade. Third, the legal aspects and requirements of the trading application, including reporting and recordkeeping requirements and enforcement provisions, could be reviewed by CIPEL legal staff. In the fourth stage, the proposal could be made available to the general public for their review and comments. In the final stage of the trade application review, the proposed trade could be revised, if necessary, based on the reviews described above. CIPEL would then either approve, approve with conditions, or reject the trading application.

Time Periods

In general, short-term trades (perhaps of 1 to 2 years duration) may be difficult for the administering agency to adequately monitor and enforce, while long-term trade agreements (perhaps of more than 5 years in duration) may prevent a source operator from responding to changes in the marketplace, thus decreasing the economic incentives for trading. Alternatively, source operators may reject short-term trades due to high transaction costs and the uncertainties associated with the necessary frequent renegotiations. The length of time that trades will be in effect should be clearly stated in program policies and the trade application. Further, during the application review process, the trading program administrator should ensure that control technologies or BMPs that were used to create PRCs will be in use and maintained throughout the trading period. In general, trades could be valid for a specified time period, say five years, subject to annual compliance reviews. Trades could also be approved for shorter times under special circumstances; for example, a source operator planning to install abatement equipment within three years could purchase PRCs to cover its current discharges, or source operators could purchase PRCs to cover discharges due to abatement equipment failure or unanticipated bypasses.

CIPEL would also need to establish procedures for renewing trade approvals when trades expire, or for modifying trades within the approved time period. In order to reduce uncertainty, CIPEL's ability to initiate a modification of a previously approved trade should apply only if the individual trade is causing significant environmental damage (for example, localized reductions in water quality), or if the ETP itself is not functioning properly.

Banked or Shutdown Credits

ETP rules should also include provisions regarding the use of banked credits; such credits may be generated when a source operator reduces the discharge below its allocation, thus saving the PRCs for its own future use in expansion programs, or for subsequent sale or lease to other source operators. Since banking programs may provide economic incentives to install more efficient abatement equipment and/or implement pollution prevention technologies, trading programs should include rules prohibiting the discounting or confiscation of banked credits. Without such rules, dischargers may have less flexibility in their use or sale or lease of PRCs and, consequently, less incentive to create them. However, in order to protect local water quality, CIPEL could establish an effluent trading bank and develop supplementary rules regarding the use of banked PRCs. For example, the use of banked phosphorus PRCs during the summer months in the Lake Geneva watershed could be prohibited or subject to the same review procedures as proposed trades.

ETP rules should also address the disposition of shutdown credits, which are generated when a source operator closes part or all of its operations. Since selling shutdown credits would provide windfall profits to the facility (pollutant source), it is recommended that the credits be reassigned to a reserve pool. Then, the operator of a new or expanding phosphorus discharge source could purchase or lease credits from the reserve pool, subject to an application review process and approval by CIPEL.

Reporting and Recordkeeping

Reporting and recordkeeping requirements are needed to demonstrate source compliance with discharge allocations and trading agreements, to ensure consistency within the trading program, to reduce the uncertainties and possible abuses associated with program participation, and to aid in the periodic evaluation of the overall ETP. Such requirements should apply to all trading partners and should be specified, in writing, as part of individual trading agreements. Reporting requirements should identify each item of information to be provided to CIPEL, as well as the time schedule for reporting. For example, routine results from weekly monitoring could be reported every quarter, while accidental spills may need to be reported immediately. Recordkeeping rules should identify the documents that must be retained by the source operator, the length of time they must be kept, and where the documents (reports) should be sent if one, or both, trading partners close their facilities.

Non-dischargers

Allowing non-dischargers, such as the Association for Safeguarding the Leman, Rivers Coordination, or private citizens, to purchase and retire PRCs represents a policy decision. In theory, if non-dischargers would purchase and retire all of the PRCs within the Lake Geneva watershed, dischargers' compliance costs will increase, and economic development and population growth will become restricted. In practice, however, non-dischargers are only likely to purchase or lease a small percentage of the available PRCs, so their participation in the ETP would probably be mainly symbolic. As an alternative, CIPEL could decrease the maximum allowable pollutant loading by a specified amount, say 20 percent, to create a margin of safety and/or to preserve a portion of the total loading for future growth and development, or for possible sale or lease to non-dischargers. The resulting PRCs could be placed in a reserve pool and allocated to new or expanding sources within the watershed as needed, or a portion could be designated for non-dischargers. If a reserve pool is established only for future growth and development, this would decrease administrative complexity since the trading market would not be expanded to include non-dischargers.

Summary of Specific Policies, Procedures, and Trading Rules

Specific policies, procedures, and trading rules which are clear and carefully documented can be used to stimulate trading activity by decreasing the administrative burden and the uncertainties associated with trading program participation. In addition, such documents can decrease the regulatory burden associated with the trading program and make the environmental outcomes more predictable. This would then become the basis for CIPEL to actively promote effluent trading. Finally, policies, procedures, and trading rules should encompass all aspects of the ETP and be developed in conjunction with interested stakeholders.

PRE- AND POST-TRADE MONITORING

Monitoring Responsibilities

Source discharge and ambient water quality monitoring data are needed to determine compliance with phosphorus loading allocations, the environmental effects of individual trades, and to ascertain the effectiveness of the overall ETP. In order to ensure consistency, to reduce uncertainty, and to eliminate duplication of effort, the responsibilities for such monitoring should be clearly distributed among trading partners, CIPEL, and other governmental agencies with water quality responsibilities within the Lake Geneva watershed. WWTP operators should be held legally responsible for monitoring phosphorus in their effluent. Nonpoint source monitoring could be performed by the land owners (or operators) of nonpoint sources, by WWTP operators (or their staff) involved in trades with nonpoint sources, and/or by CIPEL or other relevant water or agricultural agencies that may be involved in nonpoint source control activities. Comprehensive ambient water quality monitoring programs in the Lake Geneva watershed should be coordinated by CIPEL, although other pertinent agencies, non-governmental organizations, and citizens' groups could also be involved. In addition, point and nonpoint source operators could be required to conduct localized ambient water quality monitoring as a condition of trade approval.

Monitoring Protocols

Specific monitoring protocols would be needed within the Lake Geneva watershed ETP to reduce technical uncertainty and ensure consistency within the trading program. Protocols should specify the forms of phosphorus to be monitored, monitoring frequency, sampling locations, reporting and recordkeeping requirements, and quality assurance and quality control procedures for sample collection, transport, and analysis. Protocols should also specify the minimum training required for all personnel involved in both discharge monitoring and lake or river water quality monitoring.

Since most WWTP operators are only monitoring their effluent four times per year, additional monitoring would probably be needed to determine discharge loadings and the environmental impacts of trades (CIPEL, 1996). In addition, the canton of Valais and the department of Haute-Savoie would need to expand their monitoring programs to include the 31 WWTPs for which monitoring data are currently either insufficient or non-existent. Nonpoint source monitoring programs could include sampling and analyses to determine phosphorus loadings before and after BMP installation, as well as visual inspections of BMP installation, operation, and maintenance. In order to reduce the costs of nonpoint source monitoring and inspection, CIPEL could consider the conduction of demonstration studies, based on representative watershed conditions, to establish "typical" phosphorus loading reductions for various land uses and approved BMPs. Alternatively, published literature could be used to estimate BMP effectiveness, but such information may be too general to allow the determination of watershed-specific loading reductions. Finally, since there are only two ambient water quality monitoring stations in Lake Geneva itself, additional stations may be needed to identify localized water quality changes or aquatic biological effects associated with the ETP.

Monitoring and Trading Activity

Additional source monitoring requirements associated with effluent trading will increase trading transaction costs, thus such requirements may discourage trading activity. However, monitoring is essential to ensure the protection of lake water quality and the achievement of ETP goals. Therefore, although source monitoring requirements should not be overly extensive, source operators should consider them as an integral part of the "life cycle" costs of the "trade" when selecting cost-effective control alternatives.

Summary of Pre- and Post-Trade Monitoring

Source discharge and ambient water quality monitoring programs are a crucial component of a successful ETP since they help to ensure that reducing environmental compliance costs does not correspond to increases in pollutant loadings in the watershed. In order to maximize the manpower and cost efficiency of such programs, ETP rules should clearly distribute monitoring responsibilities among CIPEL, trading program participants, other affected agencies, and interested stakeholder groups. In general, implementing an ETP for the Lake Geneva watershed would probably require the expansion of all identified existing monitoring programs, and the conduction of monitoring for nonpoint sources and for WWTPs which currently have minimal or no monitoring programs.

ENFORCEMENT MECHANISMS

Effective Enforcement

Effective enforcement of the ETP will help to ensure that water quality standards, goals, and objectives for Lake Geneva are met and that trading partners are fulfilling the terms of their respective agreements. In general, CIPEL would need to verify that all participating sources of phosphorus are complying with their revised discharge allocations and meeting their monitoring, reporting, and recordkeeping requirements. Such verifications may be based on discharge monitoring, lake water quality monitoring, reports submitted by trading partners, field inspections of point source control technologies and BMPs, and audits of the applicable records of the trading partners. Enforcement provisions related to trading can probably be incorporated directly into pre-existing discharge authorizations for WWTPs. Enforcement for nonpoint sources, however, will be more difficult for several reasons. First, the majority of nonpoint sources (and possibly all of them) do not currently have discharge permits that can be modified to include trading. Second, since nonpoint source phosphorus loadings and BMP effectiveness are so site-specific, unique enforcement provisions may have to be designated for each participating nonpoint source. Finally, nonpoint source phosphorus loads are highly dependent on the hydrological characteristics of storm events, thus making them difficult to monitor. In addition, different BMPs may be distributed over many different land uses and geographical areas, thus making them time-consuming regarding field inspections.

Trading program designers should also address the potential default of one or more trading partners. For example, in the event that a nonpoint source operator fails to generate phosphorus PRCs that have already been sold or leased to a WWTP, trading rules must specify who is responsible for the necessary pollutant loading reduction. The point source operator could be held liable, an approach which would protect water quality but reduce the incentives for point source operators to participate in trades with nonpoint source operators. This problem may be alleviated by allowing WWTPs to purchase PRCs via payments to a nonpoint source control fund. The fund could then be used by CIPEL or another pertinent governmental agency to support the installation, operation, maintenance, and inspection of BMPs. The agency administering the BMP fund would then assume the responsibility for generating sufficient PRCs from a broader range of nonpoint sources in the Lake Geneva watershed.

Uncontrollable Circumstances

Circumstances that cannot be controlled by WWTP operators, such as pump failure, and by nonpoint source operators, such as unusually heavy rainfall, may result in the violation of trading agreements. However, penalizing participating sources for such violations would represent a disincentive for ETP participation, thus discouraging trading activity. Instead, violations due to uncontrollable circumstances should be immediately reported to CIPEL and corrected as soon as possible according to an agreed time schedule. Only sources who failed to comply with these alternative provisions should be subject to the full range of enforcement provisions.

Summary of Enforcement Mechanisms

In an analogous manner to monitoring programs, enforcement mechanisms are needed to help ensure that the water quality standards, goals, and objectives for Lake Geneva are met. In addition, enforcement provisions should decrease the uncertainty associated with program participation by ensuring that trading partners comply with the provisions of their respective trading agreements. This assurance would be particularly true if the penalties for noncompliance are severe. Enforcement procedures for a Lake Geneva watershed ETP could probably be based on existing governmental enforcement mechanisms for point sources and expanded to include nonpoint sources. However, in order to maintain trading program consistency and to prevent possible abuses, program designers should ensure that enforcement provisions are equivalent across all the political jurisdictions within the Lake Geneva watershed.

PROGRAM EVALUATION

Responsibilities for ETP Evaluation

The overall trading program for the Lake Geneva watershed should be periodically evaluated in order to ensure that it is both protecting, or improving, existing lake water quality and reducing environmental compliance costs for sources of phosphorus discharges. If the program is not functioning successfully, or if circumstances within the watershed change from initial conditions, components of the program itself may need to be modified. Data and information for program evaluation include reports submitted to CIPEL by trading partners, source discharge and ambient water quality monitoring results, inspections conducted by CIPEL staff, and the results of lake water quality modeling for a wide range of scenarios. In general, CIPEL should have the primary responsibility for conducting periodic evaluations, although selected trading partners, other governmental agencies that may be affected by the trading program, non-governmental organizations, and external auditors could also be participants. Reports documenting the results of the periodic systematic evaluations should be published by CIPEL and distributed to all stakeholders, made available to the general public, and discussed at one or more public meetings.

Review Frequency

Administrative reviews of the Lake Geneva watershed trading program should be accomplished on an annual basis, and brief reports issued to program participants, various stakeholders, and the general public. In addition, more thorough reviews, based on the aggregate of the annual administrative reviews and additional monitoring data, should be done periodically, perhaps on a three-to-five year cycle. In addition to evaluating ETP effectiveness, these more thorough reviews should also address modifications to policies, procedures, and trading rules that may be needed to clarify such requirements or to address specific water quality issues within the watershed. For example, new water quality standards or management goals could necessitate the revision of the maximum allowable pollutant loading and the adjustment of source-related discharge allocations. Changes in the trading program may also be required due to trends involving economic development and population growth within the watershed.

ETP Performance Criteria

To simplify the administrative review process, and to make it more transparent to program participants and stakeholder groups, trading program rules should clearly specify the criteria to be used for evaluating ETP performance. Using specified criteria will also standardize evaluations over time, thus allowing the comparison of program results across different review cycles. Potential evaluative criteria include, but are not limited to: (1) the number of WWTPs and nonpoint sources that are in compliance with their discharge allocations; (2) whether the conditions of trading agreements are being met; (3) whether phosphorus loadings to Lake Geneva are decreasing; (4) enforcement program statistics; (5) the level of trading activity as reflected by both the number of trades and the involved PRCs; (6) the presence of other factors, such as improved monitoring, stakeholder alliances, and the use of pollution prevention techniques, that may be directly or indirectly attributable to the ETP; (7) public perception of and involvement in the ETP; (8) the financial status of the ETP; (9) the time required to process trading applications; (10) the administrative costs of trade reviews; and (11) the extent and measured effectiveness of educational and information dissemination activities.

Summary of Program Evaluation

Periodic evaluations are needed to determine whether the trading program is an environmental and economic success, to identify elements of the program that may need to be modified, and to adapt the ETP to changing economic development activities and population trends within the Lake Geneva watershed. In addition, the reports generated as part of the ETP review process can provide valuable information to the general public, to existing and potential trading partners in the watershed, and to potential stakeholders in other European or international watersheds who may also be interested in the use of effluent trading for water quality management.

PUBLIC INVOLVEMENT

Active Involvement

To enhance the program's acceptability, as many stakeholders as possible should be involved in ETP development, particularly when clearly preferable policy options are not obvious. In addition, industries, municipalities, other governmental agencies, and the general public may be able to aid CIPEL in the design of the ETP by identifying issues that could affect program performance. During ETP operation, members of the public should be involved in various aspects of ETP administration, and individual trading proposals should always be subject to public review and comment before approval. Due to the large number of direct and indirect stakeholders in the Lake Geneva watershed, ensuring adequate opportunities for interested stakeholders to participate may be one of the most difficult aspects of ETP design and implementation.

Public Support

Support from industries, municipalities, government agencies, and the public is essential to the success of any ETP. In general, industries and municipalities are more likely to participate in a trading program that they helped to design, particularly when their marginal abatement costs for additional phosphorus control are high. Industries and municipalities may also be able to supply information needed for program design, such as estimates of their respective marginal abatement costs, that would be difficult and expensive for CIPEL to obtain otherwise. Unambiguous support from CIPEL, as well as other governmental agencies involved in various aspects of water quality management in the Lake Geneva watershed and that may be affected by the trading program, also encourages ETP participation. The negative publicity associated with the perception that ETPs are merely "selling the right to pollute" may discourage ETP participation; however, educational and outreach programs can be used to minimize such negative perceptions and thus encourage trading activity.

Educational and/or Outreach Efforts

Educational and/or outreach programs, which minimize the perception that ETPs are "selling the right to pollute" and increase awareness of effluent trading as a compliance alternative, are expected to play a crucial role in encouraging trading program acceptance and participation. Educational programs focused on general descriptions of effluent trading principles, examples of trading in other watersheds, and/or the potential use of an ETP to manage Lake Geneva water quality relative to phosphorus, should be conducted for potential trading partners, other affected governmental agencies, and the general public. Such educational/outreach programs should be tailored to the specific audience; for example, industries and municipalities may be more interested in the cost-saving aspects of an ETP, while non-governmental organizations and citizens' groups may be more concerned about the potential water quality and other environmental effects of trading.

Information dissemination efforts should continue after the ETP is operational and could include periodic evaluation reports, press releases, telephone information lines, a complete website, fact sheets for individual trades, educational displays in public buildings, and public meetings. Information should also be made available through responses to requests from parties outside the ETP area; and via presentations at local, regional, national, and transboundary water quality or environmental management conferences.

Summary of Public Involvement

Public involvement in ETP development and operation encourages program participation, decreases controversy, and minimizes the potential for negative publicity. However, due to the large number of stakeholders with varied direct and indirect interests in the Lake Geneva watershed, conducting meaningful public involvement effects may be difficult relative to scheduling and costly in both time and monetary resources. These concerns may be partially alleviated by using public participation specialists to coordinate all educational and outreach efforts. Such specialists could be included on the staff of CIPEL or they could be hired as consultants.

CONCLUSIONS REGARDING THE DESIGN OF AN ETP FOR THE LAKE GENEVA WATERSHED

This section has focused on the final five components of the qualitative model (specific policies, procedures, and trading rules; pre- and post-trade monitoring; enforcement mechanisms; program evaluation; and public involvement) to identify issues of concern and elements that should be included in the Lake Geneva watershed ETP. In general, incorporation of these elements in the planning and implementation of an ETP would be expected to encourage trading activity by reducing the uncertainties, administrative burdens, and transaction costs associated with trade participation. In addition, effective monitoring, enforcement, and evaluation programs could be used to assure that the ETP achieves its environmental goals, thus encouraging CIPEL and other affected governmental agencies to support the program.

This section also identified two additional deterrents to effluent trading in the Lake Geneva watershed. First, both source discharge and ambient water quality monitoring programs would need to be expanded since existing programs are less than complete relative to determining fluctuations in the annual phosphorus cycle as well as the environmental effects of trades. Second, the large number of stakeholders in the watershed, many with anticipated conflicting viewpoints on lake water quality management, would make public participation efforts more difficult to plan and conduct.

CONCLUSIONS FROM THIS CASE STUDY

This case study tested the applicability of the ten-component qualitative model (Table 9.18) for designing and implementing an ETP for the Lake Geneva watershed; it also was used to identify important issues that may affect transboundary ETPs in general. The first five model components were used to establish that effluent trading for phosphorus appears to be a feasible water quality management option for the watershed. The remaining five components were used to identify specific elements that should be included in a watershed-specific point-nonpoint source trading program designed to reduce phosphorus loadings in Lake Geneva and thus improve water quality and aquatic ecosystem characteristics.

It can be concluded that the ten-component qualitative model was useable both to determine ETP feasibility for the Lake Geneva watershed and to aid in the conceptual preliminary design of the possible trading program. The only identified modification needed in the qualitative model was that for transboundary programs, particularly in large watersheds like Lake Geneva, more specific criteria questions would be needed to facilitate the identification of all pertinent governmental stakeholders and their respective legal authorities and responsibilities for water quality management. The majority of the needed questions should be included in the public involvement component.

This study also identified three major constraints to the use of effluent trading for Lake Geneva water quality management; however, possible solutions were identified in each case. The constraints and possible solutions were:

(1) Initial trading program development will probably be hindered by a lack of available data or information on phosphorus chemistry in the lake, nonpoint source phosphorus loadings, BMPs that are appropriate for the watershed, and BMP cost and effectiveness. Although not addressed in this study due to inadequate information, nitrogen may also be a critical contributor to eutrophication in Lake Geneva. If so, a trading program based solely on phosphorus reduction, even if successful, may be inadequate to protect or improve existing lake quality regarding algae productivity. However, including nitrogen sources in the Lake Geneva watershed ETP would increase the size of the potential trading market, thus increasing the opportunities for compliance cost savings and the economic incentives for participation. Further, it has been determined that existing monitoring programs in the Lake Geneva watershed cannot provide the detailed information necessary to actually design, implement, and periodically evaluate an ETP. However, necessary information can be obtained through literature reviews, localized demonstration projects and special studies, and the expansion of source discharge and ambient water quality monitoring programs in the watershed.

(2) Current responsibilities for lake water management are divided among many different political jurisdictions and environmental agencies. In order to have an effective ETP, all such responsibilities should be coordinated within a single agency such as CIPEL. Accordingly, effluent trading-related responsibilities need to be assigned to CIPEL. Unfortunately, some jurisdictions and agencies may be unwilling to delegate their authority to another agency. In addition, CIPEL's charter would need to be modified, and its staffing and budgetary levels dramatically increased, in order for it to actually design, implement and enforce an ETP.

(3) There are so many governmental and NGO stakeholders in the Lake Geneva watershed that effective public participation may be difficult, particularly if

stakeholder groups have different opinions and positions regarding lake water quality management. Nonetheless, opportunities for public involvement in ETP design, operation, and evaluation could be maximized by using public participation specialists to coordinate education programs and information dissemination efforts.

Finally, phosphorus point-nonpoint source effluent trading should also be beneficial for other watersheds. In fact, since many watersheds and lakes are probably smaller than the Lake Geneva watershed, there should be fewer stakeholders and political jurisdictions involved in water quality management, and this should simplify ETP design and administration. However, other watersheds may not have been studied as intensively as Lake Geneva, so less data regarding phosphorus loadings, even from point sources, may be available. In addition, stakeholders may not necessarily be interested in innovative water quality management techniques. Therefore, an ETP for the Lake Geneva watershed, if developed, could serve as an analog for other applications, but future ETP designers for other watersheds would need to ensure that all site-specific conditions that could affect their trading program were identified and addressed via specific policies, procedures, and trading rules.

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CHAPTER 10

USE OF THE QUALITATIVE MODEL FOR INTRAPLANT TRADING

INTRODUCTION

Although effluent trading programs (ETPs) have been recommended as a cost-effective alternative to more traditional forms of surface water quality management, their success may be limited by scientific, economic, and institutional factors that increase the uncertainty and expense associated with ETP participation or administration. The qualitative model for designing and implementing ETPs, which was described in Chapter 5, was developed to minimize or eliminate the negative influences of such factors, thus encouraging effluent trading activity. However, since model development (Chapter 5) and testing (Chapters 6-9) was primarily based on point-point, point-nonpoint, and nonpoint-nonpoint source trading programs, the model may not be directly applicable to intraplant ETPs involving trades among multiple outfalls or processing lines at a single facility. Therefore, this chapter is designed to evaluate the use of the qualitative model with regard to designing and implementing intraplant ETPs.

To determine its potential for intraplant trading programs, the qualitative model was applied to the Stilwell Canning Company, a vegetable processing plant located in Stilwell in eastern Oklahoma. Accordingly, this chapter begins with summary information on the vegetable processing industry, including the characteristics of vegetable processing wastewaters and appropriate treatment and disposal methods. The second section describes specific characteristics of the Stilwell Canning Company, while the third section briefly summarizes the theoretical advantages of intraplant ETPs and their use in other industries. The next three sections describe the qualitative model for designing and implementing ETPs, the feasibility of an intraplant ETP for the Stilwell Canning Company, and site-specific design considerations, respectively. The seventh section highlights the development of a new sub-model specific to intraplant ETPs, while the final section contains relevant conclusions.

THE VEGETABLE PROCESSING INDUSTRY

The objectives of the vegetable processing industry are: (1) to preserve vegetables so that they can be stored and shipped to various markets throughout the year; (2) to change vegetables into new or more usable forms; and (3) to make vegetables easier to prepare (Luh and Woodroof, 1988). In the early 1970s, there were approximately 1,600 fruit and vegetable processing plants in the United States (National Canners Association, 1977). Collectively, these plants processed 35 million tons of raw products per year and employed more than 260,000 workers. This section provides an overview of the industry by describing the typical steps in vegetable processing, the characteristics of process wastewaters, applicable effluent quality standards, and methods of wastewater treatment and disposal. Recycling of process water, which reduces the amount of water used and thus the quantity of wastewater generated, is included as a treatment alternative.

Typical Steps in Vegetable Processing

As shown in Figure 10.1, the major steps in vegetable processing typically include: (1) harvesting; (2) transport and storage; (3) washing; (4) sorting and trimming; (5) peeling; (6) blanching; (7) size reduction; and (8) preservation. Activities which occur at multiple points during vegetable processing, such as product

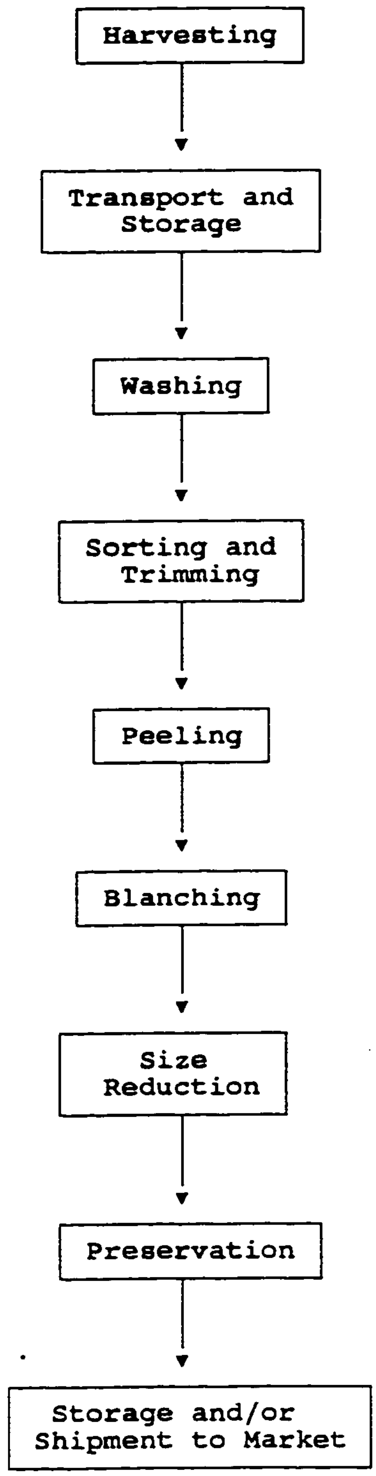

Figure 10.1: Major Steps in Vegetable Processing

conveying, cooling, and plant (equipment) cleaning, are also described herein. These activities are included because they are essential to plant operations and some conveying, cooling, or cleaning methods may generate significant quantities of wastewater.

Harvesting

Vegetables may be harvested either manually or mechanically. Manual harvesting may be required if parts of the same plant mature at different times or if mechanical harvesting would cause severe crop damage (U.S. Environmental Protection Agency, 1975). In most cases, mechanical harvesting is preferred because it is much less expensive. However, such harvesting may increase the pollutant loadings associated with vegetable processing in the following ways (U.S. Environmental Protection Agency, 1975; and Environmental Associates, 1975): (1) mechanical harvesting often results in crop damage, such as split skins, bruising, and broken ends, thus allowing soluble organics to leach into process water; (2) mechanically harvested crops often include soil, vines, leaves, and other debris that must be removed at the processing plant; and (3) such harvesting often includes vegetables that must be discarded at the processing plant because they are immature or overripe. In-field processing, which removes field debris and immature or overripe products before they are transported to the processing plant, may significantly reduce the resultant waste loading at processing plants (Montgomery, 1981).

Transport and Storage

In most cases, harvested vegetables are trucked to processing plants and processed as soon as possible (U.S. Environmental Protection Agency, 1975). However, vegetables may occasionally be stored for some length of time before they are processed. Potential reasons for such storage include: (1) the need to accumulate sufficient quantities of vegetables before processing begins; (2) the need to hold vegetables over weekends and holiday periods, when the processing plant is inactive; (3) management of the vegetable surplus during peak harvest periods; and (4) response to unanticipated equipment failure or labor shortages.

Washing

Product washing is the first step within the processing plant. The purposes of this initial wash include the removal of soil, dust, leaves, stems, silk, pesticides, microorganisms, and insects from the vegetables surfaces (Montgomery, 1981). Product washing also occurs at intermediate steps along the processing line; such washing may be designed to: (1) remove solubles or insolubles that form during cutting, peeling, and blanching operations; (2) cool vegetables, particularly after blanching; and (3) extract preservative salts or acids. Common types of washers include spray, flood or immersion, rotary or reel, and brush. Washer selection depends upon product type, and combinations of different types of washers are frequently used in a single processing plant to maximize washing effectiveness.

Sorting and Trimming

Sorting removes unsuitable whole vegetables from the processing line, while trimming removes only the blemished, bruised, or overripe portions (U.S. Environmental Protection Agency, 1977b). In addition, vegetables may be sorted, based on their size, density, appearance, or texture, to facilitate subsequent processing operations such as peeling and can filling (U.S. Environmental Protection Agency, 1975). To reduce pollutant loadings in plant wastewater, the use of water for sorting and trimming operations should be minimized, and water should not be used to transport solid residuals.

Peeling

Vegetable products that must be peeled during processing include beets, carrots, garlic, onions, sweet potatoes, tomatoes, and white potatoes. Peeling technologies include (U.S. Environmental Protection Agency, 1977b): (1) steam peelers, which use heat to loosen vegetable peels; (2) mechanical peelers, including mechanical knives and abrasive peelers; (3) chemical peelers; and (4) dry-caustic peelers, which minimize water usage by depending on lye or other caustics to soften peels prior to their removal by abrasive peelers. Peeling operations frequently produce large quantities of organic wastes which should be excluded from process water or wastewater streams in order to reduce pollutant loadings; however, in older plants considerable wastewater can be produced via steam peeling. In some cases, peeling wastes with minimal associated water may be suitable for use as animal feed (Montgomery, 1981).

Blanching

Blanching involves exposing vegetables to heat for a given period of time to (Montgomery, 1981): (1) remove air from plant tissues; (2) remove solubles that may affect the clarity of packing liquids; (3) fix pigments; (4) inactivate or destroy enzymes; (5) protect flavor; (6) leach undesirable flavors or components from processed vegetables; (7) shrink tissues; and (8) raise temperature. Although hot water and steam blanching are the most common, these methods often cause large quantities of soluble organics to leach from blanched vegetables, thus contributing significantly to the total pollutant loadings in processing plant wastewater. Pollutant loadings may be reduced by recycling water or steam within the blanching equipment or by using a different blanching medium such as hot air, microwave, or infrared radiation.

Size Reduction

Many vegetables are mechanically sliced, diced, or otherwise cut into smaller pieces before packing (U.S. Environmental Protection Agency, 1977b). Such operations produce waste fragments which must be separated from the processed vegetables. Size reduction also increases the exposed surface area, thus facilitating additional leaching of soluble organics from cut vegetables.

Preservation

Methods of vegetable preservation include canning or retorting, freezing, dehydration, and chemical preservation. The latter three, less frequently used methods are briefly summarized in Table 10.1.

The canning process itself is designed to destroy microorganisms and to prevent recontamination (Luh and Woodroof, 1988). In the first step, the cans or glass containers are cleaned with hot water, steam, or air. Second, the containers are manually or mechanically filled with processed vegetables, and, depending upon vegetable type, packing liquids or other ingredients are added. Next, the headspace gases are exhausted in order to obtain a vacuum in the containers; the vacuum extends the shelf life of canned vegetables, reduces strain on containers during thermal processing, and prevents bulging at the sides or ends of the containers. Containers are usually sealed immediately after exhausting.

In the next step, the cans or containers are exposed to heat in order to destroy microorganisms that may cause spoilage. The required temperature and length of exposure vary with product type and container size. For example, at a temperature of 121°C, the processing times for cream-style and whole-kernel corn are 81 and 22 minutes, respectively. The three major thermal processing methods include conventional canning, the hot-fill method, and the high-temperature short-time method. In conventional canning, the sealed cans are placed in pressure cookers (retorts), sterilized with steam,

Table 10.1: Other Methods of Vegetable Preservation (after Luh and Woodroof, 1988)

Method	Description
Freezing	Freezing inhibits microorganisms that cause spoilage at ordinary temperatures. In addition, freezing does not significantly alter vegetable appearance, odor, or flavor.
Dehydration	Dehydration involves the removal of water from vegetables, primarily through the application of heat or other forms of energy. Dehydration both prevents spoilage and decreases product weight, thus reducing packing, handling, storage, and transportation costs. In freeze-drying, frozen foods are placed under high vacuum in order to remove water by sublimation. Advantages of freeze-drying include reduction in product weight and retention of product quality.
Chemical Preservation	Methods of chemical preservation include pickling and fermenting. In both cases, foods are primarily preserved through acidification.

and slowly cooled. This type of canning is generally applicable to vegetables with neutral or high pH values. In the hot-fill method, containers are heated in atmospheric steam or hot-water cookers. This method is most suitable for acidic foods since low pH values inhibit microbial growth, thus allowing lower processing temperatures than conventional canning. In the high-temperature short-time method, containers are briefly exposed to high temperatures and cooled, usually by immersion in cold water. This rapid cooling is designed to prevent overcooking and physical damage to the canned vegetables.

In the final step of the canning process, cans or containers are washed and dried, labeled, and packed into shipping cartons.

Product Conveying

Manual, hydraulic, mechanical, and pneumatic methods may be used to transport products and residuals throughout a vegetable processing plant (U.S. Environmental Protection Agency, 1977b). Except for visual inspections, manual conveying within processing plants has been virtually eliminated. Fluming, or hydraulic transport, improves plant sanitation, simplifies operations, and permits conveying, cooling, and washing operations to be combined (Montgomery, 1981). However, fluming requires large quantities of water and leaches soluble organics from transported vegetables, thus increasing both wastewater flows and pollutant loadings. Hydraulic and water pollutant loadings from a processing plant may be partially reduced by recycling flume water, although some water treatment prior to recycling is usually required to maintain sanitary standards. Mechanical conveyors include belts, vibrators or oscillators, rollers, buckets, screws or augers, and drags (U.S. Environmental Protection Agency, 1977b). Since mechanical conveyors use water only for sanitation and for surface lubrication, they eliminate many of the problems associated with fluming. Pneumatic systems may be designed to convey products or residuals by positive or negative air pressure; however, such systems may not be suitable for all types and sizes of vegetables.

Cooling

Water is needed to cool refrigeration equipment, vegetables after blanching, and containers after thermal processing (Montgomery, 1981). Cooling waters represent a significant percentage of the total quantity of water used within vegetable processing plants; therefore, water consumption may be reduced by recycling cooling waters within the same process. Depending upon water quality requirements, cooling waters may also be reused in other processes.

Plant Cleaning

Cleaning at the end of each shift or product run is required in order to maintain sanitary conditions within a vegetable processing plant. In general, each item of equipment should be washed with detergents and bactericides, while plant walls and floors should be washed in order to remove solid wastes from sorting, trimming, cutting, and peeling operations (Montgomery, 1981). In some cases, within-shift or even continuous cleaning may be necessary (U.S. Environmental Protection Agency, 1977b).

Characteristics of Vegetable Processing Wastewaters

Large quantities of water are an essential component of many of the processing steps described above. Although water may occasionally be consumed as an ingredient, process water generally becomes wastewater and must be appropriately treated and discharged to receiving waters, publicly owned treatment works (POTWs), or land.

Vegetable processing wastewaters are frequently characterized by their organic loading, defined in terms of 5-day biochemical oxygen demand (BOD_5) and total suspended solids (TSS), and their hydraulic loading (U.S. Environmental Protection Agency, 1977a). Together, the hydraulic and organic loadings comprise the untreated wastewater load. The BOD_5 and TSS parameters are briefly described in Table 10.2 along with several other parameters that may be used to determine the characteristics of vegetable processing wastewaters. Parameters of lesser significance, which could become important in specific situations, include temperature, total solids, dissolved solids, chlorides, and nutrients. For example, since temperature is inversely proportional to dissolved oxygen concentrations, discharging large quantities of heated wastewater may negatively affect ambient water quality in receiving streams. As another example, it may be necessary to add nutrients to vegetable processing wastewaters in order to optimize biological treatment.

The quality characteristics of vegetable processing wastewaters are highly variable. As shown in Table 10.3, some of this variability may be attributed to the types of vegetables being processed. Additional causes of such variability include (U.S. Environmental Protection Agency, 1977b): (1) raw product condition, which may be influenced by maturity, injury, harvest conditions, and weather; (2) methods of harvesting and transport; (3) product style, with peeled, sliced, and diced vegetables contributing more significantly to raw waste loads; (4) types of processing equipment; (5) water usage; (6) percentage of used plant capacity; and (7) housekeeping procedures. Untreated wastewater characteristics may also be affected by plant size as well as the types and ages of processing plant equipment (National Canners Association, 1977).

Effluent Quality Standards

The effluent quality standards that apply to a particular vegetable processing plant are based on its method(s) of wastewater disposal, which may include direct discharge to receiving waters, indirect discharge to POTWs, or land application. For example, a plant that discharges its effluent directly to a stream, river, lake, or other "waters of the United States" must have a National Pollutant

Table 10.2: Parameters That Can Be Used to Characterize Vegetable Processing Wastewaters (after U.S. Environmental Protection Agency, 1975; and U.S. Environmental Protection Agency, 1977a)

Parameter	Definition and/or Significance
Flow	Determines the volume of wastewater subject to treatment and/or discharge
Biochemical oxygen demand (BOD_5)	Represents the amount of oxygen required for biological oxidation of the pollutants in wastewater; indicates wastewater strength
Chemical oxygen demand (COD)	Represents the amount of oxygen required for chemical oxidation of the pollutants in wastewater; indicates wastewater strength
Settleable solids (SS)	Represents the quantity of material in wastewater that will settle, under quiescent conditions, due to gravity
Total suspended solids (TSS)	Represents the quantity of suspended material in wastewater that can be removed by laboratory filtration; indicates wastewater strength
pH	Represents the hydrogen ion concentration of wastewater; wastewaters with high or low pH values may need to be neutralized before they are treated and/or discharged
Dissolved oxygen (DO)	Represents the amount of oxygen dissolved in water; may be needed to determine the effects of wastewater discharge on receiving waters or to design biological treatment systems

Table 10.3: Untreated Wastewater Characteristics for Different Types of Vegetables (after U.S. Environmental Protection Agency, 1977b)

Vegetable Type	Average Flow (1000 gallons/ton[a])	Average BOD (pounds/ton)	Average TSS (pounds/ton)
Asparagus	8.6	5	7.5
Dry Bean	9.8	75	59
Snap Bean	4.7	20	7.0
Beet	4.0	44	26
Broccoli	8.8	16	NA[b]
Cauliflower	11.0	18	NA
Carrot	4.0	31	17
Corn	1.9	27	12
Lima Bean	7.3	58	50
Mushroom	9.6	20	10
Okra	5.0	NA	NA
Onion	6.8	NA	NA
Pea	4.7	38	12
Peppers	4.6	32	58
Pickle	4.6	NA	NA
Potato	4.3	52	44
Pumpkin	2.9	32	6.7
Sauerkraut	1.4	6.0	0.6
Spinach	7.3	13	4.6
Sprouts	10.1	25	NA
Squash	6.0	20	14
Sweet Potato	4.0	60	34
Tomato	1.7	8.6	8.4
Turnip	7.3	NA	NA

[a]Tons denotes tons of the type of vegetable processed
[b]Not available

Discharge Elimination System (NPDES) permit from the U.S. Environmental Protection Agency (USEPA) or the authorized state agency (Gallagher, 1997). NPDES permits for medium and large processing plants must specify technology-based effluent limitations for BOD_5, TSS, and pH (U.S. Environmental Protection Agency, 1998). In addition, all vegetable processing plants may be subject to more stringent water quality-based effluent limitations if receiving waters violate state water quality standards (Gallagher, 1997). NPDES permits also include monitoring, reporting, and recordkeeping requirements.

Vegetable processing plants that discharge their wastewaters to POTWs are not required to obtain NPDES permits (Gallagher, 1997). Instead, these plants must comply with general and specific discharge prohibitions that are designed to protect the POTW's operations from "pass-through" or "interference." Such processing plants may also be required to comply with local pretreatment limits that are more stringent than federal standards or that apply to pollutants not included in federal standards. Local limits may be established by POTWs in order to comply with their NPDES permits or to protect their operations, including worker health and safety. Similar requirements exist for land application of vegetable processing wastewaters.

Treatment and Disposal Methods for Vegetable Processing Wastewaters

This section begins with a discussion of water recycling, which can be used to maximize operating efficiency and to reduce wastewater generation, thus reducing treatment costs. Next, alternative methods for wastewater treatment and disposal are summarized. This section concludes with a brief description of the treatment and disposal alternatives that are available for waste solids from vegetable processing plants, including product residuals and sludges from wastewater treatment.

Water Recycling

Water reuse or recycling may decrease the amount of water used in vegetable processing plants by 50 to 70 percent, thus decreasing water supply and wastewater treatment costs (Montgomery, 1981). In countercurrent recycling systems, waters are reused in different unit processes. Since the waters flow in a direction opposite to that of the vegetable products, the products continuously contact higher quality water until the final processing step, when fresh waters are used. In modular recycling systems, waters are reused within the same process until concentrations of BOD_5, TSS, or other contaminants reach unsatisfactory levels. The advantages of modular recycling systems include reduced water usage, heat reclamation, and recovery of products or by-products. For example, recycling hot water in blanching units saves energy and, because leached solids are recycled, this reduces leaching from incoming products. Complete reuse of wastewaters is also possible, but such reuse is expected to be cost-prohibitive due to the extensive treatment that would be required to meet sanitary standards. Factors that may be used to determine the appropriate types of recycling for a specific vegetable processing plant include, but are not limited to, product type(s), pollutant type(s), water availability, company environmental and conservation policies, and pertinent federal, state, and local laws and regulations.

Treatment and Disposal Methods for Vegetable Processing Wastewaters

Table 10.4 summarizes various treatment processes that can be used to remove pollutants from vegetable processing wastewaters. In general, these treatment processes can be divided into the following four categories although some methods, like sedimentation and dissolved air flotation, may be classified in multiple categories (Montgomery, 1981; and U.S. Environmental Protection Agency, 1977c):

Table 10.4: Treatment Methods for Vegetable Processing Wastewaters (after Montgomery, 1981; and U.S. Environmental Protection Agency, 1977c)

Treatment Method	Stage[a]	Description
Screening	P	Screens are used to separate solids and/or suspended solids from process water or wastewater streams
Sedimentation	P 1	Suspended solids that are denser than water are removed from wastewater due to gravitational settling
Dissolved Air Flotation	P 1 3	Air bubbles attach to solids in wastewater and the solids rise to the surface, where they are removed by skimmers
Neutralization	P	pH adjustment for acidic or alkaline wastewaters
Flow Equalization	P	Large variations in wastewater flows are eliminated, thus simplifying wastewater treatment
Chemical Treatment	1 3	Chemicals are added to wastewater in sedimentation tanks in order to increase solids removal
Stabilization Ponds	2	Bacteria and algae degrade the organic matter in wastewater under aerobic conditions; oxygen is provided by algal photosynthesis and surface transfer
Aerated Lagoons	2	Similar to stabilization ponds except oxygen is provided by mechanical agitation or compressed air
Activated Sludge	2	After microorganisms in an aeration tank have degraded the organic matter in wastewater, they are discharged to a sedimentation tank, where they are either returned to the aeration tank or "wasted"
Anaerobic Lagoons	2	Similar to stabilization ponds except no oxygen is present
Anaerobic Filters	2	Microorganisms degrade the organic matter in wastewater under anaerobic conditions

Table 10.4 (continued):

Treatment Method	Stage[a]	Description
Filtration	3	Filters made of sand, coal, and/or other media are used to remove fine or colloidal particles from wastewater streams
Carbon Adsorption	3	Granular activated carbon is used to remove trace organic compounds from wastewater streams
Ion Exchange	3	Ion exchange resins are used to remove undesirable ions from wastewater streams
Reverse Osmosis	3	Wastewater is forced through semi-permeable membranes, thus removing dissolved salts from wastewater streams
Chlorination	3	Chlorine or chlorine-containing compounds are added to wastewaters in order to disinfect them, to reduce slime formation on processing equipment, and/or to control odors

[a]P = pretreatment; 1 = primary treatment; 2 = secondary treatment; and 3 = tertiary treatment

(1) Pretreatment processes generally include removal of soil and coarse solids, pH neutralization, and flow equalization. Pretreatment may be required to maximize the efficiency of subsequent treatment processes or to protect such processes from damage. Alternatively, pretreatment may be required to comply with local pretreatment limits, to reduce sewer use charges, or to accommodate increases in production.

(2) Primary treatment processes are designed to partially remove TSS and BOD_5 from processing plant wastewaters. In general, primary treatment removes 20 to 70 percent of the TSS and 10 to 30 percent of the BOD_5 associated with vegetable processing wastewaters.

(3) Secondary treatment processes are designed to remove dissolved and suspended solids from wastewaters. These processes are mediated by bacteria, algae, and other microorganisms, and may occur in the presence (aerobic) or absence (anaerobic) of oxygen.

(4) Tertiary treatment processes are designed to remove additional amounts of TSS and BOD_5 and/or other pollutants that are not removed during primary or secondary treatment. Such treatment processes are rarely applied to vegetable processing wastewaters.

Methods of wastewater disposal include direct discharge to receiving waters, indirect discharge to POTWs, or land application. Discharge to POTWs generally requires pretreatment, while discharge to receiving waters requires secondary treatment in an industrial wastewater treatment facility at a processing plant. In some cases, tertiary treatment may also be required to meet specific water quality-based effluent limitations.

The third method of wastewater disposal, land application, may be considered as a form of secondary or tertiary treatment (Montgomery, 1981). There are three types of land application systems (Meyer, et al., 1981): (1) irrigation, where the wastewater is applied to land in order to support plant growth; (2) infiltration/percolation, in which wastewater is treated by physical, chemical, and biological processes in soil as it percolates to ground water; and (3) overland flow, where the wastewater is treated by soil and vegetative processes as it flows across the land's surface. System selection should be based on the wastewater's hydraulic and pollutant loadings as well as land-specific and site-specific characteristics such as elevation, topography, hydrology, and soil type.

Solid Waste Treatment and Disposal

Vegetable processing plants generate two types of solid wastes: (1) residuals, which are whole vegetables or portions of vegetables that are unsuitable for inclusion in final products; and (2) sludges, which are generated by wastewater treatment processes (U.S. Environmental Protection Agency, 1977c). These wastes must be managed appropriately in order to protect environmental quality and to comply with pertinent laws and regulations. In some cases, residuals can be reused; for example, residuals from citrus, corn, pineapple, and potato processing plants have been used as animal feed, while other residuals have been used to produce charcoal, alcohol, and vinegar (U.S. Environmental Protection Agency, 1977c; and U.S. Environmental Protection Agency, 1975). The quantities of sludge generated at a particular processing plant depend upon its treatment processes and untreated wastewater loading (U.S. Environmental Protection Agency, 1977c). Wastewater sludges may be subject to: (1) digestion, which is defined as aerobic or anaerobic degradation by microorganisms; (2) thickening to reduce sludge volume and increase solids concentration; and/or (3) dewatering. Methods for final disposal of both residuals and treated sludges include landfilling and land application.

THE STILWELL CANNING COMPANY

The Stilwell Canning Company, located in Adair County in eastern Oklahoma, cans and/or freezes sweet potatoes, Irish potatoes, and other fruits and vegetables (Oklahoma Economic Development Foundation, Inc., 1971) (see Note 1). The annual production schedule shown in Table 10.5, illustrates seasonal variations. For example, fruits and vegetables are processed from March through December,

Table 10.5: Annual Production Schedule for the Stilwell Canning Company (Oklahoma Economic Development Foundation, Inc., 1971)

Month	Products	Cases[a]
May	Spinach, Mustard Greens, Collard Greens, Turnip Greens, Strawberries, and Irish Potatoes	NA[b]
June	Irish Potatoes, Green Beans, Squash, Peas, and Blackberries	235,923
July	Irish Potatoes, Green Beans, Okra, Peas, and Squash	253,565
August	Irish Potatoes, Sweet Potatoes, Okra, and Peas	263,925
September	Sweet Potatoes, Irish Potatoes, Okra, Peas, Butter Beans, Green Beans, and Squash	295,541
October	Sweet Potatoes, Irish Potatoes, Okra, Peas, Butter Beans, Lima Beans, Squash, Turnip Greens, and Mustard Greens	271,198
November	Sweet Potatoes, Collard Greens, Turnip Greens, and Spinach	179,452
December	Spinach	17,606

[a]One case equals 24 No. 303 cans or 15 pounds of frozen product

[b]Not available

while the months of January and February are designated for plant repair and modification. In 1970, peak employment was approximately 550 people, representing 21 percent of Stilwell's population, with an annual payroll exceeding $1.0 million.

Prior to the construction of its own wastewater treatment plant (WWTP), the Stilwell Canning Company used its potato processing wastewaters to irrigate a neighboring orchard. This irrigation was discontinued when several fruit trees died; the deaths may have been caused by chemicals added to the wastewater to control odors. Wastes from the remaining processing lines were discharged to Stilwell's POTW. However, the capacity of the POTW was insufficient to treat the cannery's wastewater in addition to the city's domestic wastewater. As a result, large quantities of untreated or partially treated domestic and cannery wastewater were discharged to Caney Creek resulting in extremely low dissolved oxygen concentrations and numerous complaints from the general public. In addition, since Caney Creek flows into nearby Lake Tenkiller, the cannery's wastewater threatened a major recreational area in the region.

Stilwell Canning Company's WWTP, which became operational in May, 1969, includes four treatment processes. First, wastewater is screened to remove large suspended particles, which are then trucked to a landfill. Second, the wastewater enters an aeration unit, where more than 50 percent of the soluble COD (chemical oxygen demand) is removed. Third, the wastewater is then pumped to two extended aeration units, operated in parallel, that are designed for aerobic sludge digestion and effluent polishing. In the final step, the wastewater enters a clarifier designed for additional solids removal; and the effluent is discharged to a small spring-fed stream. When necessary, excess sludge is pumped to existing sludge retention ponds for anaerobic digestion. The WWTP was originally designed to treat 1.5 million gallons per day (mgd) with an average BOD_5 of 1,500 mg/l.

However, its capacity can be doubled by adding primary treatment and sludge disposal systems.

The cannery's average and peak water usages are 1.7 and 2.6 mgd, respectively, while the corresponding average and peak wastewater flows are 1.5 and 2.4 mgd. These wastewater flows already equal or exceed the WWTP's design flow, which indicates that the WWTP may be hydraulically overloaded and thus unable to meet effluent quality standards. In addition, the Stilwell Canning Company is planning to increase production levels by 25 percent. Such an expansion would require an additional 0.7 mgd of water, which could be readily supplied by the City of Stilwell's water treatment plant. However, the increase would also generate an additional 0.6 mgd of wastewater, thus further overloading the cannery's WWTP.

In 1970, the Oklahoma Economic Development Foundation, Inc., funded a study to identify sources, quantities, and characteristics of process wastewaters at the Stilwell cannery. The study's ultimate objective was to identify methods of water conservation and reuse that could be used to reduce water consumption, thus decreasing corresponding wastewater flows and allowing processing plant expansion without the construction of additional wastewater treatment facilities. Flow measurements and water quality data were collected during the fall canning season (September through December) in 1970.

Although there were only six processing lines within the cannery, different vegetables and styles were processed at different times, resulting in the following distinct wastewater flows: (1) sweet potatoes; (2) Irish potatoes; (3) turnips; (4) greens, including turnip greens, mustard greens, collard greens, and kale; (5) spinach (east processing line); (6) spinach (west processing line); (7) peas and beans; (8) whole okra; and (9) cut okra. Since wastewater flows were not combined until they reached the final screening sump, data concerning hydraulic and pollutant loadings from each product line, including COD and TSS, could be readily collected. This information is summarized in Table 10.6.

The study also identified two additional wastewater streams: (1) cooling waters from the retort area, where cans and containers were cooled after thermal processing; and (2) cooling waters associated with the compressors required for in-plant refrigeration. Flow rates in the retorts varied from 2.8 to 259 gallons per minute (gpm), with an average flow of 87.6 gpm; compressor flows were fairly constant and ranged from 13.3 to 19.2 gpm. Both cooling processes generated high quality wastewater that was suitable for reuse within the processing plant.

INTRAPLANT EFFLUENT TRADING

Intraplant ETPs allow an industrial facility to allocate pollutant loadings among multiple outfalls or processing lines in a cost-effective manner as long as the resultant loadings are equal to or less than the loadings that would have been permitted in the absence of trading (U.S. Environmental Protection Agency, 1996). Intraplant trading for point sources can be readily incorporated into extant NPDES permitting procedures, thus simplifying ETP implementation, administration, and enforcement. In addition, transaction costs for intraplant ETPs are relatively low since trades occur within a single facility and much of the information needed to evaluate trading opportunities is contained in discharge monitoring reports. If necessary, supplemental information can be obtained through plant-specific studies.

To date, iron and steel facilities are the only industrial category which has been allowed to use formal intraplant ETPs to meet technology-based effluent limitations (Kashmanian, et al., 1995). Trading activity has been extremely limited; for example, of the 235 iron and steel facilities potentially eligible for intraplant ETPs in 1994, only ten had engaged in such trades. Based on data from seven

Table 10.6: Summary of Production Rates and Wastewater Characteristics for the Stilwell Canning Company (Oklahoma Economic Development Foundation, Inc., 1971)

Processing Line	Production Rate[a]	Flow[b]	COD[c]	Suspended Solids[c]
Sweet Potatoes	448	61,030	1,272	2,014
Irish Potatoes	237	86,470	1,607	1,498
Turnips	269	38,100	318	288
Greens	397	50,200	52	108
Spinach (East)	327	69,700	93	133
Spinach (West)	440	38,400	26	185
Peas and Beans	218	41,300	106	33
Whole Okra	240	31,700	36	10
Cut Okra	216	45,300	26	10

[a]Expressed in average number of cases per hour; one case equals 24 No. 303 cans or 15 pounds of frozen product

[b]Expressed in gallons per 1,000 cases

[c]Expressed in pounds per 1,000 cases

of the ten facilities, savings in capital, operation, and maintenance costs through 1993 ranged from $3.3 to $69.8 million per facility, while the total cost savings exceeded $122.8 million.

Permit limits at all ten iron and steel facilities included pollutant loading reductions that were equal to or greater than those which could be cost-effectively achieved without trading, and the administrative effects of intraplant trading were negligible. However, since the ten facilities had previously reduced their pollutant loadings below the applicable limits, trading did not encourage the installation of additional control technology (Kashmanian, et al., 1995). In fact, since dischargers were allowed to reallocate existing reductions to outfalls that would have otherwise required control, trading may actually have allowed pollutant loadings to increase over those which would have occurred with a strict command-and control approach. Alternatively, intraplant trading may encourage long-term compliance by providing continuous economic incentives to create and maintain pollutant reduction credits (PRCs).

Informal intraplant ETPs may be used in lieu of the formal intraplant ETPs discussed above. For example, NPDES permits that establish facility-wide discharge limits for pollutants from multiple processes or outfalls indirectly authorize intraplant trading, particularly if such limits are based on the sum of all applicable effluent limitations (Veil, 1997). To illustrate, effluent quality guidelines for the petroleum refining industry allow permit writers to establish plant-wide limits for pollutants; refineries can then allocate their discharges among outfalls in the most cost-effective manner. Similarly, effluent guidelines for the electric power and coal industries allow permit writers to establish permit limits by combining effluent limitations for different wastewater streams, thus also encouraging informal intraplant trading activity.

THE QUALITATIVE MODEL

As part of this research effort, a qualitative model for designing and implementing ETPs was developed (Edwards and Canter, 1998). Each of the 10 model components and its importance to successful ETPs are summarized in Table 10.7, while the criteria questions associated with each component are listed in Table 10.8. The qualitative model can be used to evaluate existing ETPs by answering each criteria question with program-specific information and then rating each component according to the scheme shown in Table 10.9. Alternatively, the model can be used to evaluate the potential applicability of an ETP. In this case, the first five components (watershed suitability, pollutant type, trading market size and characteristics, legal authority, and administrative acceptability and capability) can be used to determine the feasibility of an ETP for a specific watershed or trading area. If the potential for effluent trading is adequate, the remaining model components (specific policies, procedures, and trading rules; pre- and post-trade monitoring; enforcement mechanisms; program evaluation; and public involvement) can be used to aid in the design and implementation of a site-specific ETP.

CONSIDERATION OF THE FEASIBILITY OF AN INTRAPLANT ETP FOR THE STILWELL CANNING COMPANY

Responses to the criteria questions associated with the first five components of the qualitative model are summarized herein. Such responses were limited to the feasibility of an intraplant ETP and based on industry- and plant-specific information described earlier. The summary for each model component contains its rating, a brief explanation of the rationale for the assignment, and a discussion of any implications and/or resultant needs. The rating and summary information for each component are included Table 10.10.

Table 10.7: Components of Qualitative Model and Their Importance to Successful ETPs

Component of Qualitative Model	Rationale for Inclusion in the Qualitative Model
Watershed Suitability	This component is designed to ensure that the geographic and temporal boundaries of the ETP are clearly defined. In addition, circumstances within the watershed (or trading area) that either encourage or discourage effluent trading must be identified and addressed.
Pollutant Type	This component is designed to identify pollutants that may be suitable for inclusion in an ETP. ETP designers must also decide if program rules will allow inter-pollutant trading.
Trading Market Size and Characteristics	This component is designed to identify all sources of the pollutant(s) of interest in the ETP area, their relative contributions to total pollutant loading, and differences in their marginal abatement costs that may promote effluent trading. This component is also focused on identifying market characteristics, such as the presence of direct competitors, that may influence trading activity.
Legal Authority	This component is included to identify whether existing laws and regulations fully support, or could be amended to support, the development and operation of an ETP.
Administrative Acceptability and Capability	This component is used to identify whether the administering agency has sufficient knowledge and information to design and implement an ETP. This component is also for determining whether agency staff are willing to use effluent trading as an alternative to more traditional forms of regulation.
Specific Policies, Procedures, and Trading Rules	Specific policies, procedures, and rules are needed to reduce uncertainty, to minimize regulatory and administrative burdens, and to reduce transaction costs. Such rules should encompass all aspects of an ETP, from determining the maximum allowable pollutant loading to reviewing proposed trades to penalizing trading partners who violate their trading agreements.
Pre- and Post-Trade Monitoring	Pre- and post-trade monitoring is required to determine the environmental effects of individual trades and of the overall ETP.

Table 10.7 (continued):

Component of Qualitative Model	Rationale for Inclusion in the Qualitative Model
Enforcement Mechanisms	Enforcement mechanisms are required in order to ensure that water quality standards and/or ETP goals are met and that trading partners fulfill the terms of their agreements.
Program Evaluation	Periodic evaluations of ETP performance are necessary in order to ensure that the ETP is protecting, or improving, water quality while reducing environmental compliance costs. Periodic evaluation of the ETP itself is also recommended in order to identify any necessary modifications.
Public Involvement	Public and stakeholder involvement throughout ETP design and operation is needed in order to encourage participation in the trading program, to decrease controversy, and to minimize the potential for negative publicity.

Table 10.8: Criteria Questions for Each Component of the Qualitative Model for Designing and Implementing ETPs

Watershed Suitability

1. Does the watershed (or watershed segment or estuarine zone) have a clearly defined geographic boundary? What is the basis for defining the watershed, segment, or zone?
2. Are temporal variations in flow well understood?
3. Do existing water quality conditions or other circumstances within the watershed encourage the use of an ETP?
4. Are there circumstances within the watershed that would discourage the use of an ETP?

Pollutant Type

1. Are the pollutant(s) of interest classified as conservative, non-conservative, or toxic?
2. Will inter-pollutant trading be allowed? What is the basis for the decision to permit or prohibit inter-pollutant trading?
3. Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality?
4. Do the environmental effects of the pollutant(s) of interest result more from total loading over time than local, short-term toxic effects?
5. Can mass- or concentration-based limits be established for the pollutant(s) of interest?

Trading Market Size and Characteristics

1. Have all sources of the pollutant(s) of interest been identified?
2. Are the relative contributions of all source categories (point, nonpoint, and background) known?
3. Are temporal variations in loadings of the pollutant(s) of interest well understood?
4. Are there significant differences in marginal abatement costs among sources in the same category and/or sources in different categories?
5. Could sources and/or governmental entities within the watershed be potentially unwilling to trade?
6. Are there unique circumstances that may influence the behavior of market participants?

Legal Authority

1. Are there water quality standards, goals, and/or objectives that can be used as a basis for the ETP?
2. Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so?
3. Is there an existing agency with sufficient authority to implement and enforce an ETP, can such authority be conferred on an existing agency, or can such an agency be created?
4. Does the implementing agency have sufficient authority to require all contributing sources to meet their discharge allocations?

Table 10.8 (continued):

<u>Administrative Acceptability and Capability</u> 1. Does the administering agency have sufficient knowledge and information to designate the maximum allowable pollutant loading for the watershed, to allocate portions of that loading to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades as well as the overall trading program? 2. Is the administering agency willing to use effluent trading as a management strategy to supplement traditional regulation? 3. Does the administering agency have sufficient resources to design and implement an ETP?
<u>Specific Policies, Procedures, and Trading Rules</u> 1. If nonpoint sources are to be included in the ETP, do policies or procedures account for their inherent variability? 2. Have procedures been clearly defined for the following aspects of the ETP? (a) determination of the maximum allowable pollutant loading for the watershed (b) allocating portions of the loading cap to all sources within the watershed that discharge the pollutant(s) of interest (c) types of trades that will be allowed (d) trading ratio(s) 3. Have rules or procedures been clearly defined for the following operational aspects of the ETP? (a) quantifying and certifying pollutant reduction credits (PRCs) (b) quantifying the environmental impacts of trades (c) application procedures for proposed trades (d) administrative procedures for the evaluation of proposed trades (e) time periods that trades remain in effect (f) treatment of banked or shutdown credits (g) reporting and recordkeeping requirements 4. Will non-dischargers, such as environmental groups, be allowed to purchase and retire PRCs?
<u>Pre- and Post-Trade Monitoring</u> 1. Are responsibilities for pre- and post-trade source and ambient water quality monitoring clearly defined? 2. Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for both source and ambient water quality monitoring? 3. Will source monitoring requirements discourage trading activity?
<u>Enforcement Mechanisms</u> 1. Can trading agreements be effectively enforced for each source category? 2. Should uncontrollable circumstances for both point and nonpoint sources be considered in the enforcement process?

Table 10.8 (continued):

<u>Program Evaluation</u> 1. Are responsibilities for evaluating ETP performance clearly defined? 2. How often will the ETP be reviewed? 3. Have the criteria that will be used to evaluate ETP performance been specified?
<u>Public Involvement</u> 1. Was the public, including industries and municipalities, actively involved in ETP design and operation? 2. In general, did industries, municipalities, government agencies, and the public support the development of the ETP? 3. Does the ETP include any educational and/or outreach efforts designed to increase public support?

Table 10.9: Rating Scheme for Each Component of Qualitative Model

Degree of Compliance With Criteria Questions for Each Component	Rating
Compliant from all perspectives	4
Compliant from majority of perspectives	3
Compliant from only a few perspectives	2
Compliant from no perspectives	1
Degree of compliance with perspectives depends upon specific ETP design	0

Table 10.10: Summary of the Feasibility of an Intraplant ETP for the Stilwell Canning Company

Component of Qualitative Model	Rating of Degree of Compliance[a]	Rationale for Assigned Compliance Rating	Implications and Resultant Needs
Watershed Suitability	3	Most circumstances encourage the development and implementation of an intraplant ETP, and criteria questions related to geographic boundaries and flow variations do not apply. However, the lack of information regarding abatement technologies and pollution prevention measures, as well as the variability of vegetable processing wastewaters, may discourage ETP development.	Providing information on abatement technologies and pollution prevention measures to vegetable processing plants, perhaps through demonstration projects or industry-specific clearinghouses, may encourage the development and implementation of intraplant ETPs.
Pollutant Type	4	Sufficient information is available to quantify pollutant loadings, while criteria questions related to pollutant classification, inter-pollutant trading, pollutant forms, and environmental effects do not apply.	Intraplant ETPs may be simpler to design, implement, and operate than other types of ETPs. Evaluating potential trading opportunities should also be simpler, thus encouraging ETP participation.
Trading Market Size and Characteristics	4	All pollutant sources and their relative contributions to total pollutant loadings have been identified, information regarding temporal variations in pollutant loadings is available, and differences in marginal abatement costs among product lines are anticipated. Criteria questions related to unwillingness to trade and unique circumstances do not apply.	Intraplant ETP design, implementation, and participation may be simplified because all trades occur within the boundaries of individual facilities. However, data on wastewater flows and pollutant loadings may need to be collected during several different canning seasons in order to accurately quantify PRCs.
Legal Authority	3	The ETP can be based on NPDES permit limitations, facility managers have sufficient authority to implement the trading program, and no "loopholes" which could negatively affect ETP performance have been identified. However, ETPs have not been formally recognized in the Clean Water Act as an acceptable compliance alternative.	Intraplant ETPs may be simpler to design and implement than other types of ETPs because effluent limitations have already been established and because such programs can be administered internally or by the existing permitting authority. In addition, amending the Clean Water Act to explicitly support effluent trading may increase trading activity.

Table 10.10 (continued):

Component of Qualitative Model	Rating of Degree of Compliance[a]	Rationale for Assigned Compliance Rating	Implications and Resultant Needs
Administrative Acceptability and Capability	3	Sufficient information is available to identify potential trading opportunities, and resources should be available to support intraplant trading activities. In addition, both permitting authorities and facility managers are expected to promote intraplant ETPs. However, detailed information on abatement technologies and pollution prevention measures, which would be required to evaluate trading opportunities, is not readily available.	Facilities may obtain information on applicable abatement technologies and/or pollution prevention measures by sponsoring site-specific studies. Alternatively, industry-specific information could be provided by demonstration projects, special studies, and/or clearinghouses sponsored by governmental agencies, food processing organizations, or other NGOs.

[a]The ratings are as follows: 4 = compliant from all perspectives; 3 = compliant from the majority of perspectives; 2 = compliant from only a few perspectives; 1 = compliant from no perspectives; 0 = degree of compliance with perspectives depends upon specific ETP design

WATERSHED SUITABILITY

Geographic Boundaries

In an ETP involving a watershed, watershed segment, or estuarine zone, the geographic boundaries of the trading area provide information needed to determine the maximum allowable pollutant loading, to identify the area subject to post-trade ambient water quality monitoring, and to identify the point and nonpoint sources that will be eligible to participate in the trading program. However, since intraplant ETPs involve multiple outfalls and/or processing lines at a single facility, this question does not apply.

Flow Variations

Since intraplant ETPs are based on applicable effluent limitations instead of the receiving water body's assimilative capacity, information concerning temporal variations in ambient water quality flows is not required. Therefore, this criteria question does not apply.

Conditions Encouraging Effluent Trading

Three conditions that should encourage the development and implementation of an intraplant ETP at the Stilwell Canning Company were identified. First, in the absence of such an ETP, the proposed production increase would require the construction of additional wastewater treatment facilities, thus possibly reducing or even eliminating the economic benefits of processing plant expansion. Second, there may be large differences in marginal abatement costs among product lines due to economies of scale and other factors. Third, maintaining or reducing pollutant loadings to Caney Creek, which ultimately flows into Lake Tenkiller, is vital in protecting water-related recreational activities in the region and in preventing complaints from the general public.

Conditions Discouraging Effluent Trading

This review also identified two conditions which may discourage the development and implementation of an intraplant ETP at the Stilwell Canning Company. First, although information on wastewater flows and pollutant loadings has already been collected, there is a lack of detailed information on the types of abatement technologies and/or pollution prevention techniques that could be used to create PRCs within or following the processing plant. Although some information is available through literature review, such information may be too general to support the site-specific cost-effectiveness estimates that would be needed to evaluate trading opportunities. Alternatively, detailed estimates could be developed through special studies, but such studies may be cost-prohibitive. Second, since the characteristics of vegetable processing wastewaters are highly variable, calculating the quantity of PRCs that are generated, or required, by a specific product line during a given time period may be subject to both variability and uncertainty.

Summary of Watershed Suitability

As shown in Table 10.10, the watershed suitability component of the qualitative model was assigned a rating of "3," since most circumstances at the Stilwell Canning Company encourage the development and implementation of an intraplant ETP. Further, it was determined that criteria questions regarding geographic boundaries and flow variations do not apply. However, the lack of information regarding pertinent abatement technologies and pollution prevention measures, as well as the variability of vegetable processing wastewaters at the processing plant, may discourage ETP development. Providing information to vegetable processing plants, perhaps through demonstration projects or industry-specific clearinghouses sponsored by governmental agencies, food processing organizations, or other non-governmental organizations (NGOs), may partially alleviate this barrier to intraplant trading.

POLLUTANT TYPE

Pollutant Classification

In most ETPs, the classification of the pollutant(s) of interest must be determined in order to predict their environmental effects and to select appropriate water quality models. However, since intraplant ETPs involve reallocating discharges among outfalls or processing lines within existing permitted effluent limitations, environmental impacts associated with trading are not expected and water quality modeling is not required. Therefore, this criteria question does not apply.

It was assumed that the tradeable pollutants for ETPs at vegetable processing plants would include BOD_5 and TSS since these pollutants, in addition to flow, are frequently used to characterize process wastewaters (U.S. Environmental Protection Agency, 1977a). However, based on data collected in the site-specific water conservation and reuse study, the tradeable pollutants for the Stilwell Canning Company would be TSS and COD; in general, the ratio of BOD_5 to COD varies from 0.4 to 0.7 for vegetable processing wastewaters (Oklahoma Economic Development Foundation, Inc., 1971). COD was chosen for analysis instead of BOD_5 because the analysis is quicker, less expensive, and highly reproducible (U.S. Environmental Protection Agency, 1977a).

Inter-pollutant Trading

In the context of intraplant ETPs, inter-pollutant trading would allow outfalls or processing lines to exchange PRCs for different pollutants. For example, an inter-pollutant trade at the Stilwell Canning Company might allow TSS loadings from the greens line to increase if BOD_5 loadings from the sweet potatoes line were decreased by a correspondingly adjusted amount. It was assumed that any intraplant trade, including an inter-pollutant trade, would be acceptable as long as the total loading for each pollutant did not exceed the applicable effluent limitation. Therefore, this criteria question does not apply.

Pollutant Forms

The environmental impacts of a given pollutant depend upon the form in which it is released into the environment and its subsequent transport and fate. However, with the exception of cooling waters, all wastewaters at the Stilwell Canning Company result from similar products and processing operations. As a result, different product lines are expected to discharge the same basic forms of COD and TSS, and this criteria question does not apply. However, this question may apply when considering ETPs for other industrial facilities, such as petroleum refineries and textile mills, with diverse product lines or multiple outfalls.

Environmental Effects

Since intraplant ETPs do not allow increases in total pollutant discharges to receiving waters, pollutant loadings must either remain constant or decrease. Therefore, no adverse environmental effects are expected from intraplant ETPs, and this question does not apply.

Pollutant Limits

In order to participate in an intraplant ETP, source operators must be able to quantify the pollutant loadings from each outfall or processing line in either mass- or concentration-based limits. For example, managers at the Stilwell Canning Company must be able to quantify TSS and COD loadings for each product line. This information was collected as part of the water conservation and reuse study described above (Oklahoma Economic Development Foundation, Inc., 1971). If necessary, flow information in the study can also be used to convert concentration-based effluent limitations to pollutant loadings.

Summary of Pollutant Type

As shown in Table 10.10, the pollutant type component of the qualitative model was assigned a rating of "4" since sufficient information is available to quantify pollutant loadings. Criteria questions related to pollutant classification, inter-pollutant trading, and environmental effects are not applicable to intraplant ETPs, while the criteria question related to pollutant forms may only apply to intraplant trades involving diverse outfalls or processing lines. As a result, intraplant ETPs appear be simpler to design, implement, and operate than other types of ETPs. Evaluating potential trading opportunities should also be simpler, thus encouraging ETP participation.

TRADING MARKET SIZE AND CHARACTERISTICS

Pollutant Sources

All sources of tradeable pollutants should be identified in order to establish an accurate budget and to determine the most effective control strategies. In addition, identifying all sources maximizes the number of potential trading partners, thus increasing the economic incentive to trade. In an intraplant ETP, pollutant sources may include outfalls at a single facility or, if industrial wastewater treatment is centralized, different processing lines within the facility. As shown in Table 10.6, nine different product lines at the Stilwell Canning Company have been identified as sources of COD and TSS (Oklahoma Economic Development Foundation, Inc., 1971).

Relative Contributions

ETP designers and plant managers must have information regarding the relative contributions of pollutant sources in order to determine whether intraplant ETPs are a feasible compliance alternative. Pollutant loadings from each product line at the Stilwell Canning Company have been fully documented; in addition to the average values shown in Table 10.6, information was collected on minimum and maximum wastewater flows and pollutant loadings. The highest loadings are associated with the sweet potato and Irish potato processing lines, while the lowest loadings are associated with the processing lines for whole and cut okra.

Temporal Variations

Information regarding temporal variations in pollutant loadings is required in order to determine the quantity of PRCs generated or required by a particular outfall or processing line. Such information for the Stilwell Canning Company is provided by the water conservation and reuse study. However, these data were collected during a single canning season and, due to the high variability of vegetable processing wastewaters, may have associated uncertainty.

Marginal Abatement Costs

Differences in marginal abatement costs among outfalls or processing lines provide the major economic incentive to establish an intraplant ETP. Specific information regarding marginal abatement costs for each product line at the Stilwell Canning Company is unavailable. However, since some product lines generate more wastewater and pollutants than other product lines (as shown in Table 10.6), significant differences in marginal abatement costs are anticipated due to economies of scale. Additional differences in such costs may be attributed to the varying ages of product lines and processing equipment within each line. In some cases, different abatement technologies and pollution prevention measures may also contribute to cost differences; however, such techniques are expected to be fairly similar for all vegetable processing wastewaters.

Unwillingness to Trade

The economic theory underlying ETPs indicates that sources may be unwilling to participate in an ETP for two reasons: (1) trading may reduce the environmental compliance costs of their competitors; and (2) sources may prefer to save their excess PRCs to meet more stringent effluent limitations or to accommodate their own expansion. By their nature, intraplant ETPs cannot provide economic advantages to a source's competitors. Similarly, sources that "bank" PRCs for their own future use are already participating in a form of intraplant trading. Therefore, this criteria question does not apply.

Unique Circumstances

The economic theory underlying ETPs also assumes that all dischargers will seek to minimize their environmental compliance costs. Since this assumption should be true for all industrial point sources, including the Stilwell Canning Company, this criteria question does not apply.

Summary of Trading Market Size and Characteristics

As shown in Table 10.10, the trading market size and characteristics component of the qualitative model was assigned a rating of "4," since all pollutant sources and their relative contributions to total pollutant loadings have been identified, information regarding temporal variations in pollutant loadings is available, and differences in marginal abatement costs among product lines are anticipated although not quantified. Criteria questions related to unwillingness to trade and unique circumstances do not apply to intraplant ETPs. Once again, intraplant ETP design, implementation, and participation should be simplified because all trades occur within the boundaries of individual facilities. However, due to the variability of vegetable processing wastewaters, data on wastewater flows and pollutant loadings may need to be collected during several different canning seasons before PRCs can be accurately quantified.

LEGAL AUTHORITY

Standards, Goals, and/or Objectives

Effluent limitations in NPDES permits or local pretreatment limits and associated permits can serve as the basis for designing and implementing intraplant ETPs. Since the Stilwell Canning Company's WWTP discharges its effluent directly to receiving waters, it was assumed that the cannery had received an NPDES permit, that the permit included technology-based and/or water quality-based effluent limits for COD and TSS, and that the designated limits would be used to evaluate proposed intraplant trades.

Legal Support

The Clean Water Act does not explicitly authorize effluent trading, thus increasing the uncertainty and perceived risk associated with ETP participation (U.S. Environmental Protection Agency, 1996). However, the following factors provide some legal support for intraplant ETPs (U.S. Environmental Protection Agency, 1996; and Veil, 1997): (1) facilities in the iron and steel industry have been allowed to use intraplant trading to meet technology-based effluent limitations since the early 1980s; (2) the USEPA's "Draft Framework for Watershed-Based Trading" encourages all types of ETPs, including intraplant ETPs; and (3) informal intraplant trades are allowed within the petroleum refining, electric power, and coal industries. In addition, permitting authorities are expected to approve intraplant trades since such trades do not increase pollutant discharges to receiving waters, nor do they necessarily require the development of an elaborate ETP.

Administering Agency

Since trades among outfalls may require modifications to existing NPDES permits, it was assumed that the permitting authority would administer and enforce intraplant trading programs. Similarly, intraplant ETPs based on local pretreatment limits should be administered by POTWs. Alternatively, the permitting authorities do not need to be formally involved in intraplant ETPs for facilities, such as the Stilwell Canning Company, with plant-wide effluent limitations. Instead, such trading could be administered internally by plant management.

Agency Authority

The Stilwell Canning Company is legally required to meet the effluent limitations specified in its NPDES permit. As a result, waivers, variances, and other "loopholes," which could negatively affect ETP performance by increasing total pollutant loadings and reducing the number of potential trading opportunities, were not identified.

Summary of Legal Authority

As shown in Table 10.10, the legal authority component of the qualitative model was assigned a rating of "3," since the intraplant ETP can be based on the cannery's permit limitations, facility managers have sufficient authority to administer the ETP, and no "loopholes" which could negatively affect ETP performance were identified. However, despite several federal actions which promote intraplant trading, ETPs have not been formally recognized as an acceptable compliance alternative, and the resulting risk and uncertainty associated with ETP participation may decrease trading activity. Amending the Clean Water Act to explicitly support effluent trading, or the issuance of regulatory guidelines related thereto, may increase ETP participation.

Once again, intraplant ETPs will likely be simpler to design and implement than other types of trading programs. Intraplant ETPs for facilities with multiple processing lines, like the Stilwell Canning Company, can be based on existing effluent limitations and administered by facility staff. Intraplant ETPs involving multiple outfalls at the same facility may be slightly more complex if permit modifications are required. However, since such programs can be administered by the existing discharge permitting authority and incorporated into permitting procedures, they remain relatively simple when compared to point-point, point-nonpoint, and nonpoint-nonpoint ETPs.

ADMINISTRATIVE ACCEPTABILITY AND CAPABILITY

Knowledge and Information

In general, large amounts of data are required to design and operate effective ETPs. However, such requirements can be substantially reduced for intraplant ETPs since all trading activities occur within the boundaries of a single facility. For example, the environmental effects of trades involving two or more facilities are typically evaluated through water quality modeling, source discharge monitoring, and ambient water quality monitoring. However, since intraplant ETPs do not increase pollutant loadings, increased modeling and monitoring are unnecessary, thus simplifying ETP participation and reducing transaction costs.

Sufficient information regarding wastewater flows and pollutant loadings at the Stilwell Canning Company has been collected in order to identify potential trading opportunities. However, information on applicable abatement technologies and pollution prevention techniques, which could be used to generate PRCs, is not readily available. Such information may be difficult to collect and analyze, particularly for small- or medium-sized firms with limited environmental staff and compliance budgets.

Willingness to Use ETPs

In order for sources to be willing to rely on effluent trading to meet their compliance obligations, the pertinent authorities must actively promote ETPs as an acceptable alternative to more traditional forms of water quality management. In general, it was assumed that permitting authorities would encourage intraplant trading activity since such trades reduce environmental compliance costs for regulated sources without increasing pollutant loadings or substantially increasing regulatory burdens. Intraplant trading must also be supported by plant management. Since the main objective of intraplant ETPs is to reduce environmental compliance costs, it was assumed that managers at the Stilwell Canning Company would actively promote intraplant trading, particularly if such trades could simultaneously accommodate plant expansion and eliminate the need to construct additional wastewater treatment facilities.

Resources

Like any regulatory program, ETPs require sufficient staff and funding to function successfully. Once again, however, these requirements can be minimized for intraplant ETPs. For example, since intraplant trades involving permit modifications can be readily incorporated into existing permitting procedures, it was assumed that the current technical and financial resources of the permitting authority would be sufficient to support the ETP, particularly if trading activity is limited. Intraplant trades for facilities with plant-wide effluent limitations, like the Stilwell Canning Company, could be proposed and implemented by company personnel or by specialized consultants; the anticipated savings in environmental compliance costs should offset any expenses associated with such trades. Partial funding for intraplant trades at vegetable processing plants could also be provided by the USEPA, food processing organizations, or other NGOs.

Summary of Administrative Acceptability and Capability

As shown in Table 10.10, the administrative acceptability and capability component of the qualitative model was assigned a rating of "3," since sufficient information is available to identify potential intraplant trading opportunities and resources should be available to support trading activities. In addition, both permitting authorities and plant management are expected to promote intraplant ETPs to reduce compliance costs while maintaining or improving ambient water quality. However, detailed information on abatement technologies and pollution prevention measures, which would be required to evaluate potential trading opportunities, is not readily available. Facilities may be able to overcome this burden by sponsoring site-specific studies, which could be conducted by cannery personnel and/or consultants. Alternatively, industry-specific information could be provided by demonstration projects, special studies, and/or clearinghouses sponsored by governmental agencies, food processing organizations, or other NGOs.

CONCLUSIONS REGARDING THE FEASIBILITY OF AN ETP FOR THE STILWELL CANNING COMPANY

The qualitative model components used to assess the feasibility of an intraplant ETP for the Stilwell Canning Company (watershed suitability, pollutant type, trading market size and characteristics, legal authority, and administrative acceptability and capability) were assigned ratings of "3" or 4," thus indicating that they were at least partially compliant with the component-specific criteria questions. As a result, it can be concluded that an intraplant ETP would be a feasible water quality management option for the Stilwell Canning Company. In particular, an intraplant ETP may allow the Stilwell Canning Company to increase its annual production without constructing additional wastewater treatment facilities, thus preserving the economic benefits of processing plant expansion.

However, program development may be delayed by the lack of detailed information on abatement technologies and pollution prevention measures that would be suitable for the vegetable processing lines at the Stilwell plant.

Since trading activity would be limited to product lines within the cannery, an intraplant ETP for the Stilwell Canning Company should be simpler to design, implement, and operate than other types of ETPs. The complexity, uncertainty, and transaction costs associated with intraplant ETPs are also relatively low, thus encouraging ETP participation. For example, criteria questions related to geographic boundaries, flow variations, pollutant classification, inter-pollutant trading, pollutant forms, environmental effects, unwillingness to trade, and unique circumstances can be eliminated from the general qualitative model. In addition, criteria questions related to conditions encouraging effluent trading; conditions discouraging effluent trading; relative contributions; marginal abatement costs; standards, goals, and/or objectives; administering agency; agency authority; knowledge and information; willingness to use ETPs; and resources must be modified to focus specifically on intraplant trading.

ETP DESIGN CONSIDERATIONS FOR THE STILWELL CANNING COMPANY

The criteria questions associated with the last five model components (specific policies, procedures, and trading rules; pre- and post-trade monitoring; enforcement mechanisms; program evaluation; and public involvement) were used to identify general issues that should be addressed when designing an intraplant ETP for the Stilwell Canning Company. Whenever possible, the following discussion was based on plant-specific information. In addition, the following assumptions were made: (1) intraplant effluent trading is a feasible water quality management option for the Stilwell Canning Company; (2) COD and TSS are the only pollutants to be included in the ETP; (3) the ETP would be based on facility-wide effluent limitations for COD and TSS contained in the Stilwell Canning Company's NPDES permit; and (4) the ETP would be developed in order to allow plant expansion while maintaining current discharge levels.

SPECIFIC POLICIES, PROCEDURES, AND TRADING RULES

Nonpoint Source Variability

Intraplant ETPs apply only to facilities with multiple outfalls or to facilities, like the Stilwell Canning Company, with multiple processing lines. Therefore, nonpoint sources are ineligible to participate in intraplant trading programs, and this criteria question does not apply.

ETP Procedures

Maximum Allowable Pollutant Loading

An intraplant ETP for the Stilwell Canning Company would be based on the permit limitations for COD and TSS, not the assimilative capacity of the receiving water body. Therefore, it is unnecessary to determine the maximum allowable pollutant loading in the watershed, and this sub-question does not apply.

Loading Allocations

In a point-point, point-nonpoint, or nonpoint-nonpoint source ETP, loading allocations determine the quantity of pollutants that each source may discharge into receiving waters and enable sources, by comparing their current discharges to their loading allocations, to determine their most cost-effective alternatives. However, since the effluent limitations in the Stilwell Canning Company's permit determine the quantities of COD and TSS that the cannery is allowed to discharge, this sub-question does not apply. Furthermore, only one facility will be involved in the proposed ETP.

Types of Trades

Since the current study was limited to the feasibility of intraplant trading at the Stilwell Canning Company, this sub-question does not apply. However, depending upon circumstances in the watershed, the Stilwell Canning Company may also be able to participate in point-point and/or point-nonpoint source ETPs.

Trading Ratio(s)

Trading ratios determine the rate-of-exchange for PRCs; for example, an expanding point source may be required to offset each pound of its increased pollutant loading by purchasing two pounds of PRCs from other point or nonpoint sources in the watershed. However, since all intraplant trades at the Stilwell Canning Company will occur among product lines within the same facility and the cannery's permit limitations for COD and TSS will not be violated, trading ratios are unnecessary, and this sub-question does not apply.

<u>Operational Aspects</u>

Quantifying and Certifying PRCs

In order to calculate the quantity of PRCs that can be traded, the manager of an intraplant ETP must be able to determine the applicable effluent limitations as well as the current pollutant loadings from each outfall or processing line. Effluent limitations for COD and TSS, which apply to the sum of all wastewater discharges from the cannery's product lines, are specified in the Stilwell Canning Company's NPDES permit, while information on pollutant loadings is contained in the water conservation and reuse study described above. Certification of PRCs is intended to reduce the uncertainty associated with ETP participation, particularly for purchasers or lessors of PRCs. However, since all intraplant trades occur within the boundaries of a single facility, such certification should be unnecessary.

Environmental Impacts

Since intraplant trades do not allow pollutant discharges to increase above permitted levels, no adverse environmental effects are anticipated. Therefore, ambient water quality modeling and additional discharge monitoring should not be required, and this sub-question does not apply.

Application Procedures

Since intraplant trades at the Stilwell Canning Company must occur within the constraints of established effluent limitations, it was assumed that external agencies would not be involved in the intraplant ETP and that trades would be proposed and evaluated informally within the cannery. Therefore, application procedures for proposed trades are unnecessary, and this sub-question does not apply. However, intraplant trades at facilities with multiple outfalls may require NPDES permit modifications. In these cases, application procedures for intraplant trades are expected to be similar to extant application procedures for NPDES permits.

Evaluation of Proposed Trades

Similarly, detailed administrative procedures to evaluate proposed intraplant trades at the Stilwell Canning Company are unnecessary, and this sub-question does not apply. However, such procedures may be needed for proposed intraplant trades that would require discharge permit modification. Once again, these procedures could be based on extant review procedures for NPDES permits.

Time Periods

In order to reduce the uncertainty associated with ETP participation, the length of time that a trade will be effective should be specified. Since an intraplant ETP at the Stilwell Canning Company would be based on applicable effluent limitations in the facility's NPDES permit, it was assumed that trades would remain in effect throughout the 5-year life of the permit, and then be included in subsequent permit reviews and approvals.

Banked or Shutdown Credits

The Stilwell Canning Company could generate banked credits by saving excess PRCs for its own future use and/or shutdown credits by closing part or all of a product line. In order to encourage trading activity, the Stilwell Canning Company should be permitted to use its banked or shutdown PRCs at any time as long as applicable permit limitations are not exceeded and documentation is provided to the permitting agency.

Reporting and Recordkeeping

Current reporting and recordkeeping provisions in the Stilwell Canning Company's NPDES permit should be sufficient to ensure that applicable effluent limitations are not exceeded. In addition, cannery plant staff may need to generate periodic reports documenting pollutant loadings and PRCs associated with each product line. These internal reports could then be used to evaluate ETP performance.

Non-dischargers

Intraplant ETPs apply to multiple outfalls and/or processing lines at individual facilities. Therefore, non-dischargers, such as NGOs, environmental groups, or citizens, are ineligible to participate in such programs, and this criteria question does not apply.

Summary of Specific Policies, Procedures, and Trading Rules

An intraplant ETP may be the simplest type of trading program to design, implement, and operate. For example, if the qualitative model is to be used to design an intraplant ETP for the Stilwell Canning Company, the following questions and sub-questions can be eliminated: (1) nonpoint source variability; (2) maximum allowable pollutant loading; (3) loading allocations; (4) types of trades; (5) trading ratios; (6) environmental impacts; (7) application procedures; (8) evaluation of proposed trades; and (9) non-dischargers. In addition, certification can be excluded from the sub-question related to quantifying and certifying PRCs. Although some additional sampling, reporting, and recordkeeping may be necessary in order to thoroughly document the creation and use of PRCs, it was assumed that the increased administrative burden would be relatively slight and offset by compliance cost savings from trading.

PRE- AND POST-TRADE MONITORING

Monitoring Responsibilities

Since all intraplant trades would occur among product lines at the Stilwell Canning Company, it was assumed that any required water quality monitoring would be conducted by the cannery, and this criteria question does not apply to other point sources or nonpoint sources in the watershed.

Existing discharge monitoring requirements in the Stilwell Canning Company's NPDES permit should be sufficient to ensure that the cannery does not violate its effluent limitations, with or without an intraplant ETP. However, intraplant trades may also require monitoring of wastewater flows and pollutant loadings from individual product lines. Such "internal" data would not be reported to the permitting authority but would be used to quantify the PRCs generated, or required, by each product line and to ensure that the pollution prevention techniques and/or abatement technologies used to create PRCs remained effective throughout the life of the trade.

Monitoring Protocols

Specific monitoring protocols are needed to reduce technical uncertainty and to ensure consistency within the trading program. It was assumed that protocols for collecting and analyzing water quality data that must be submitted to the permitting authority would be specified in the Stilwell Canning Company's NPDES permit. Protocols for "internal" data collection from product lines should be based on standard methods for wastewater analysis and/or the procedures established in the water conservation and reuse study (Oklahoma Economic Development Foundation, Inc., 1971).

Monitoring and Trading Activity

Additional discharge monitoring associated with intraplant ETPs, which may be necessary in order to quantify PRCs from each outfall or processing line, may increase transaction costs, thus discouraging trading activity. Since each outfall is already subject to NPDES monitoring requirements, trades involving multiple outfalls are not expected to increase transaction costs. Similarly, since only nine product lines and two pollutants would be involved in the proposed intraplant ETP for the Stilwell Canning Company, it was assumed that the increase in monitoring activity would be relatively minor. As a result, monitoring is not expected to affect trading activity, and this criteria question does not apply.

Summary of Pre- and Post-Trade Monitoring

Like the specific policies, procedures, and trading rules component of the qualitative model, this monitoring-related component may be relatively simple for intraplant ETPs, particularly in comparison to point-nonpoint and nonpoint-nonpoint source trading programs. For example, the Stilwell Canning Company has already established a monitoring program, designed to meet the conditions of its NPDES permit, that can be expanded to incorporate intraplant trades. Similarly, as the only facility involved in the ETP, the canning plant is automatically responsible for all required monitoring as well as any additional monitoring that may be needed to support an intraplant ETP; therefore, the criteria question regarding monitoring responsibilities can be eliminated from the qualitative model. In addition, since the increased monitoring requirements are expected to be relatively insignificant, the criteria question regarding monitoring and trading activity can also be eliminated.

ENFORCEMENT MECHANISMS

Effective Enforcement

Since the Stilwell Canning Company's NPDES permit contains facility-wide effluent limitations for COD and TSS, it was assumed that trades among product lines would not be individually enforced. Instead, the aggregate loadings for COD and TSS from each of the nine product lines must meet the relevant effluent limitations. Therefore, this criteria question does not apply. However, this question may apply to facilities with multiple outfalls if individual effluent limitations are specified for each outfall.

Uncontrollable Circumstances

On occasion, one or more product lines at the Stilwell Canning Company may be unable to generate the required quantity of PRCs due to uncontrollable circumstances, such as pump failure or equipment malfunction. These failures could be relatively insignificant if they do not result in permit violations and are corrected quickly. However, if these failures do result in pollutant loadings that exceed applicable effluent limitations, the Stilwell Canning Company may be subject to administrative, civil, and/or criminal penalties, depending upon the severity of the violation. Therefore, this criteria question does not apply per se in relation to the qualitative model, but the subject is applicable via violations of the discharge permit.

Summary of Enforcement Mechanisms

Intraplant trades at the Stilwell Canning Company would not be directly enforced by the permitting authority, thus simplifying ETP participation and encouraging ETP activity. However, the permitting agency would retain sufficient authority to ensure that aggregated pollutant loadings from the cannery do not increase above permitted levels, thus preserving ambient water quality. Since the cannery may be penalized for exceeding its effluent limitations, the management at the Stilwell Canning Company may wish to establish programs to monitor wastewater flows and pollutant loadings associated with each product line, as well as inspection and maintenance programs, to ensure that process and/or abatement equipment is functioning properly. Management may also wish to consider banking excess PRCs to offset unanticipated increases in pollutant loadings.

PROGRAM EVALUATION

Responsibilities for ETP Evaluation

The cannery's ETP should be periodically evaluated in order to ensure that it is successfully meeting required effluent limitations and reducing environmental compliance costs. Intraplant trades may also need to be modified if circumstances at the Stilwell Canning Company change from initial conditions; for example, if new ambient water quality standards result in lower effluent limitations, existing trades may need to be altered. Since the Stilwell Canning Company is the only facility involved in the ETP, it was assumed that the intraplant ETP would be evaluated internally by plant management. Therefore, this criteria question does not apply.

Review Frequency

Brief reviews of the intraplant ETP should be accomplished annually, while more thorough reviews could easily be incorporated into existing procedures for NPDES permit renewal on a 5-year cycle.

ETP Performance Criteria

To simplify and standardize the review process, the criteria that will be used to evaluate ETP performance should be clearly specified. Potential evaluative criteria for the intraplant ETP at the Stilwell Canning Company include: (1) whether the cannery is in compliance with its effluent limitations; (2) the level of trading activity as reflected by both the number of trades and the involved PRCs; (3) the administrative costs of ETP design, implementation, and operation; (4) the magnitude of compliance cost savings; and (5) other advantages and disadvantages of trading.

Summary of Program Evaluation

Once again, the scope of intraplant ETPs simplifies this component of the qualitative model for designing and implementing ETPs. In this case, it was assumed that the Stilwell Canning Company, as the only facility involved in the ETP, would be primarily responsible for program evaluation, thus eliminating the criteria question associated with responsibilities for ETP evaluation. In addition, program reviews can be scheduled to coincide with NPDES permit renewals. Significant review criteria include compliance with effluent limitations and reduced environmental compliance costs.

PUBLIC INVOLVEMENT

Active Involvement

In general, as many stakeholders as possible should be involved in ETP design and operation in order to encourage ETP participation and acceptance. However, since all trades occur within the boundaries of a single facility, the number of stakeholders may be significantly reduced for intraplant ETPs. For example, employees and plant management are the primary stakeholders for the Stilwell Canning Company's ETP. Other vegetable processing plants and food processing organizations may also be involved, particularly if they are interested in implementing their own ETPs. However, as long as pollutant loadings do not increase as a result of intraplant trading, permitting agencies, municipalities, and the general public are expected to remain diligent but indifferent to intraplant ETPs. As a result, the need for active involvement can be limited to facility stakeholders, and this criteria question should be modified accordingly.

Public Support

Management and staff at the Stilwell Canning Company are expected to support an intraplant ETP because it accommodates plant expansion and eliminates the need for additional wastewater treatment facilities, thus increasing profits and income. As discussed above, other stakeholders in the watershed are expected to be cognizant but indifferent to the cannery's ETP as long as ambient water quality is not adversely affected. Therefore, the need for public support can once again be limited to facility stakeholders, and this criteria question should be modified accordingly.

Educational and/or Outreach Efforts

Educational and/or outreach programs are designed to promote effluent trading as a compliance alternative, thus encouraging trading program acceptance and participation. Programs addressing the concepts and benefits of intraplant trading at the Stilwell Canning Company should be specifically tailored for facility management and for employees who operate the product lines. In addition, brief reports describing the cannery's ETP should be prepared and distributed to facility stakeholders; such reports may also be distributed to other vegetable processing plants and industrial facilities to encourage intraplant trading activity. Since the support of facility stakeholders is most crucial to the success of the cannery's ETP, this criteria question should be modified accordingly.

Summary of Public Involvement

Intraplant ETPs apply to single facilities within a watershed and do not increase pollutant loadings to receiving waters. As a result, the number of concerned stakeholders decreases dramatically, and the criteria questions associated with the public involvement component of the qualitative model can be limited to facility-specific stakeholders. Management and staff at the Stilwell Canning Company are expected to support the intraplant ETP, and educational and outreach programs can easily be tailored to address the specific concerns of plant management and of employees who operate the various product lines.

CONCLUSIONS REGARDING ETP DESIGN FOR THE STILWELL CANNING COMPANY

This section has focused on the final five components of the qualitative model (specific policies, procedures, and trading rules; pre- and post-trade monitoring; enforcement mechanisms; program evaluation; and public involvement) for identifying issues of concern and elements that should be included in the Stilwell Canning Company intraplant ETP. In general, designing and implementing an intraplant ETP should be relatively simple since pollutant loadings do not increase and trading activity is limited to product lines within the cannery. As a result, the following criteria questions and sub-questions associated with the qualitative model can be eliminated: (1) nonpoint source variability; (2) maximum allowable pollutant loading; (3) loading allocations; (4) types of trades; (5) trading ratio(s); (6) environmental impacts; (7) application procedures; (8) evaluation of proposed trades; (9) non-dischargers; (10) monitoring responsibilities; (11) monitoring and trading activity; (12) effective enforcement; (13) uncontrollable circumstances; and (13) responsibilities for ETP evaluation. In addition, the following questions and sub-questions should be modified: (1) quantifying and certifying PRCs; (2) active involvement; (3) public support; and (4) educational and/or outreach efforts.

SUB-MODEL SPECIFIC TO INTRAPLANT ETPs

Based on the information summarized above, the qualitative model for designing and implementing ETPs, which originally contained 10 components and 37 criteria questions, was modified specifically for intraplant ETPs. These modifications are summarized in Table 10.11. Nine criteria questions could be incorporated directly into the model for intraplant ETPs, while 14 questions could be deleted. In general, the 14 questions could be eliminated because intraplant ETPs apply within the boundaries of a single facility and are constrained by existing effluent limitations and permit conditions. As a result, multiple trading partners are not involved and no adverse environmental effects in the receiving water are anticipated. Finally, 14 criteria questions were modified to focus solely on intraplant ETPs.

In the final step, the remaining 23 criteria questions were renumbered and divided into two new components, ETP Feasibility and ETP Design Considerations. The revised model for intraplant ETP design and implementation is shown in Table 10.12.

CONCLUSIONS FROM THIS CASE STUDY

The first objective of this case study was to test the applicability of an intraplant ETP at the Stilwell Canning Company. Accordingly, the first five components of the qualitative model were used to establish that intraplant effluent trading for COD and TSS appears to be a feasible water quality management option for the cannery. The major incentive for effluent trading is to allow the cannery's annual production to increase without installing additional

Table 10.11: Summary of Modifications to the Qualitative Model for Intraplant ETPs

Criteria Questions	Applicable[a]			Question Modified for Intraplant ETPs
	Y	N	M	
<u>Watershed Suitability</u>				
1. Geographic Boundaries		✓		
2. Flow Variations		✓		
3. Conditions Encouraging Effluent Trading			✓	Do existing conditions or other circumstances encourage the use of an ETP?
4. Conditions Discouraging Effluent Trading			✓	Do existing conditions or other circumstances discourage the use of an ETP?
<u>Pollutant Type</u>				
1. Pollutant Classification		✓		
2. Inter-pollutant Trading		✓		
3. Pollutant Forms[b]	✓			
4. Environmental Effects		✓		
5. Pollutant Limits	✓			

Table 10.11 (continued):

Criteria Questions	Applicable[a]			Question Modified for Intraplant ETPs
	Y	N	M	
Trading Market Size and Characteristics				
1. Pollutant Sources	✓			
2. Relative Contributions			✓	Are the relative contributions of all outfalls and/or processing lines known?
3. Temporal Variations	✓			
4. Marginal Abatement Costs			✓	Are there significant differences in marginal abatement costs among outfalls and/or processing lines?
5. Unwillingness to Trade		✓		
6. Unique Circumstances		✓		
Legal Authority				
1. Standards, Goals, and/or Objectives			✓	Are there effluent limitations or local pretreatment limits that can be used as a basis for the ETP?
2. Legal Support	✓			
3. Administering Agency			✓	Do the permitting agency and/or facility managers have sufficient authority to implement an ETP?
4. Agency Authority			✓	Does the permitting agency have sufficient authority to require the facility to meet all applicable effluent limitations?
Administrative Acceptability and Capability				
1. Knowledge and Information			✓	Do the permitting agency and/or facility managers have sufficient knowledge and information to design, implement, and operate an ETP?
2. Willingness to Use ETPs			✓	Are the permitting agency and/or facility managers willing to use effluent trading as a management strategy to supplement traditional regulation?
3. Resources			✓	Do the permitting agency and/or facility managers have sufficient resources to design and implement an ETP?

Table 10.11 (continued):

Criteria Questions	Applicable[a]			Question Modified for Intraplant ETPs
	Y	N	M	
<u>Specific Policies, Procedures, and Trading Rules</u>				
1. Nonpoint Source Variability		✓		
2. ETP Procedures				
(a) Maximum Allowable Pollutant Loading		✓		
(b) Loading Allocations		✓		
(c) Types of Trades		✓		
(d) Trading Ratio(s)		✓		
3. Operational Aspects				
(a) Quantifying and Certifying PRCs			✓	Have rules or procedures been clearly defined for quantifying pollutant reduction credits (PRCs)?
(b) Environmental Impacts		✓		
(c) Application Procedures[b]	✓			
(d) Evaluation of Proposed Trades[b]	✓			
(e) Time Periods	✓			
(f) Banked or Shutdown Credits	✓			
(g) Reporting and Recordkeeping	✓			
4. Non-dischargers		✓		

Table 10.11 (continued):

Criteria Questions	Applicable[a] Y	N	M	Question Modified for Intraplant ETPs
Pre- and Post-Trade Monitoring				
1. Monitoring Responsibilities		✓		
2. Monitoring Protocols	✓			
3. Monitoring and Trading Activity		✓		
Enforcement Mechanisms				
1. Effective Enforcement			✓	Can trades be effectively enforced for each outfall and/or processing line?
2. Uncontrollable Circumstances		✓		
Program Evaluation				
1. Responsibilities for ETP Evaluation		✓		
2. Review Frequency	✓			
3. ETP Performance Criteria	✓			
Public Involvement				
1. Active Involvement			✓	Were facility stakeholders actively involved in ETP design and operation?
2. Public Support			✓	In general, did facility stakeholders support the development of the ETP?
3. Educational and/or Outreach Efforts			✓	Does the ETP include any educational and/or outreach efforts designed to increase stakeholder support?

[a]Y = Question directly relates to intraplant ETPs; N = question does not relate to intraplant ETPs; M = question relates to intraplant ETPs with listed modification

[b]Indicates that the criteria question does not apply to intraplant ETPs involving multiple processing lines but may apply to intraplant ETPs involving multiple outfalls

Table 10.12: Qualitative Model for Intraplant ETP Design and Implementation

<u>ETP Feasibility</u>

1. Do existing conditions or other circumstances encourage the use of an ETP?[a]

2. Do existing conditions or other circumstances discourage the use of an ETP?[a]

3. Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality?[b]

4. Can mass- or concentration-based limits be established for the pollutant(s) of interest?

5. Have all sources of the pollutant(s) of interest been identified?

6. Are the relative contributions of all outfalls and/or processing lines known?[a]

7. Are temporal variations in loadings of the pollutant(s) of interest well understood?

8. Are there significant differences in marginal abatement costs among outfalls and/or processing lines?[a]

9. Are there effluent limitations or local pretreatment limits that can be used as a basis for the ETP?[a]

10. Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so?

11. Do the permitting agency and/or facility managers have sufficient authority to implement an ETP?[a]

12. Does the permitting agency have sufficient authority to require the facility to meet all applicable effluent limitations?[a]

13. Do the permitting agency and/or facility managers have sufficient knowledge and information to design, implement, and operate an ETP?[a]

14. Are the permitting agency and/or facility managers willing to use effluent trading as a management strategy to supplement traditional regulation?[a]

15. Do the permitting agency and/or facility managers have sufficient resources to design and implement an ETP?[a]

Table 10.12 (continued):

<u>ETP Design Considerations</u>

1. Have rules or procedures been clearly defined for the following operational aspects of the ETP?

   (a) quantifying pollutant reduction credits[a]

   (b) application procedures for proposed trades[b]

   (c) administrative procedures for the evaluation of proposed trades[b]

   (d) time periods that trades remain in effect

   (e) treatment of banked or shutdown credits

   (f) reporting and recordkeeping requirements

2. Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for both source and ambient water quality monitoring?

3. Can trades be effectively enforced for each outfall and/or processing line?[a,b]

4. How often will the ETP be reviewed?

5. Have the criteria that will be used to evaluate ETP performance been specified?

6. Were facility stakeholders actively involved in ETP design and operation?[a]

7. In general, did facility stakeholders support the development of the ETP?[a]

8. Does the ETP include any educational and/or outreach efforts designed to increase stakeholder support?[a]

[a]Indicates modified criteria question

[b]Indicates that the criteria question does not apply to intraplant ETPs involving multiple processing lines but may apply to intraplant ETPs involving multiple outfalls

wastewater treatment facilities, while the major disincentive is the lack of detailed information on abatement technologies and pollution prevention techniques that could be used within the canning plant to generate PRCs. The remaining five components were used to identify both general and site-specific concerns and elements that should be included in the proposed ETP.

Intraplant ETPs should be simpler to design, implement, and operate than other types of ETPs, particularly point-nonpoint and nonpoint-nonpoint source trading programs, for the following reasons:

(1) Since only one facility is involved in each intraplant ETP, concerns related to identifying suitable trading partners, negotiating trading agreements, and enforcing such agreements can be eliminated.

(2) Since intraplant ETPs can be based on existing effluent limitations or local pretreatment limits, determining the maximum allowable pollutant loading and loading allocations is not required. In addition, since intraplant trading activities are constrained by permit limitations, no adverse environmental effects are anticipated, and additional water quality monitoring and/or modeling requirements associated with trading can be minimized or eliminated.

(3) The administrative burden associated with intraplant trading, both for facility management and permitting agencies, is relatively minor. For example, intraplant ETPs for multiple processing lines can be administered by facility management, while intraplant ETPs for multiple outfalls can be administered by the relevant permitting authority. Furthermore, administrative procedures governing trades among multiple outfalls can be based on existing permitting procedures.

The second objective of this case study was to develop a sub-model, based on the original qualitative model (Table 10.8), that could be used to design and implement intraplant ETPs. Each criteria question was evaluated using information relative to intraplant trading and the Stilwell Canning Company and then incorporated, deleted, or modified as appropriate. The revised model for designing and implementing intraplant ETPs, which is shown in Table 10.12, contains two components (rather than 10 components) and 23 criteria questions (rather than 37). The two components are entitled ETP Feasibility and ETP Design Considerations. This model is applicable to intraplant ETPs involving multiple outfalls and/or processing lines and can be used to evaluate an existing intraplant ETP, to determine the feasibility of intraplant trading at a particular facility, and to suggest issues and concerns that should be addressed in site-specific ETP design.

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Note 1: The industrial plant case study used in Chapter 10 to examine intraplant trading is hypothetical but based on the actual results of a 1971 survey of pollutant loadings from different process lines at a vegetable cannery. The results of this 1971 survey were assumed to be transposed in time to 1999, and thus still applicable. The 1971 survey was conducted by Dr. L.W. Canter for the Oklahoma Economic Development Foundation, Inc.

CHAPTER 11

USE OF THE QUALITATIVE MODEL FOR PRETREATMENT TRADING

INTRODUCTION

Although effluent trading programs (ETPs) have been perceived as a cost-effective alternative to more traditional forms of surface water quality management, their success may be limited by technical, institutional, and administrative factors that increase the uncertainty and expense associated with ETP participation or administration. The qualitative model for designing and implementing ETPs, which was described in Chapter 5, is designed to minimize or eliminate the negative effects of such factors, thus encouraging effluent trading activity (Edwards and Canter, 1998). However, since model development and testing was primarily based on point-point, point-nonpoint, and nonpoint-nonpoint source trading programs, the model may not be directly applicable to pretreatment ETPs, which involve trades between two or more industrial facilities that discharge their effluent to the same publicly owned treatment works (POTW). Therefore, this chapter is designed to evaluate the use of the qualitative model for designing and implementing pretreatment ETPs. The evaluation is based on the Industrial Pretreatment Program in Stillwater, Oklahoma.

This chapter begins with a brief summary of federal and state pretreatment requirements. The second section highlights specific characteristics of Stillwater's Industrial Pretreatment Program, while the third section briefly summarizes the theoretical advantages of pretreatment ETPs and their use to date. The following sections describe the qualitative model, the feasibility of a pretreatment ETP for industrial users (IUs) that discharge their effluent to Stillwater's POTW, and site-specific design considerations. The penultimate section describes the development of a new sub-model specific to pretreatment ETPs, while the final section contains general conclusions.

PRETREATMENT REQUIREMENTS

Federal regulations define pretreatment as (U.S. Environmental Protection Agency, 1998a):

> the reduction of the amount of pollutants, the elimination of pollutants, or the alteration of the nature of pollutant properties in wastewater prior to or in lieu of discharging or otherwise introducing such pollutants into a POTW.

Pretreatment alternatives may include physical, chemical, and biological treatment as well as pollution prevention and waste minimization. Pretreatment is typically required to meet applicable discharge limitations, which are described in the following sub-section. However, industrial facilities may also pretreat their wastewater in order to reduce surcharges, particularly if such charges are based on pollutant loadings, and to improve their public image (Task Force on Pretreatment of Industrial Wastes, 1994).

This section summarizes the federal pretreatment regulations, which include requirements applicable to the U.S. Environmental Protection Agency (USEPA), state environmental agencies, POTWs, and IUs that discharge their effluent to POTWs. However, this review emphasizes pretreatment requirements for IUs since they would be the primary participants in pretreatment ETPs. In addition, since the qualitative model for designing and implementing ETPs will be applied to an industrial pretreatment program in Stillwater, Oklahoma, this section briefly summarizes applicable state requirements.

Federal Requirements

The current federal pretreatment regulations, which were promulgated on June 26, 1978, have three major objectives (Industrial Economics, Inc., and Science Applications International Corporation, 1994): (1) to prevent the introduction of pollutants into POTWs that may interfere with POTW operation, including the use or disposal of sewage sludge; (2) to prevent the introduction of pollutants into POTWs that may pass through the treatment works, thus negatively affecting the quality of receiving waters; and (3) to improve opportunities to recycle and reclaim municipal and industrial wastewaters and sludges.

These objectives are implemented through local pretreatment programs, which are designed and administered by the operators of POTWs, the appropriate state agency, or USEPA. POTWs with design flows greater than five million gallons per day (mgd) must develop pretreatment programs if their IUs are subject to discharge limitations, while smaller POTWs may be required to develop such programs based on the specific characteristics of their industrial influent (U.S. Environmental Protection Agency, 1998a). As shown in Table 11.1, there were approximately 1,800 pretreatment programs in the United States in 1994 (Industrial Economics, Inc., and Science Applications International Corporation, 1994).

To receive approval from the USEPA or the delegated state agency, local pretreatment programs must have sufficient mechanisms to address the following concerns: (1) exhibit sufficient legal authority to administer and enforce all aspects of the pretreatment program; (2) address technical issues, including the identification of all IUs that discharge to the POTW, and the development of local pretreatment limits, if necessary; (3) initiate procedures for implementing the local pretreatment program; and (4) ensure that sufficient technical and financial resources are available for

Table 11.1: Number of Approved Local Pretreatment Programs in February, 1994 (after Industrial Economics, Inc., and Science Applications International Corporation, 1994)

EPA Region	Approved Local Programs	POTWs in State-Run Programs[a]
1	85	93
2	81	NA[b]
3	136	NA
4	416	199
5	326	NA
6	131	NA
7	83	22
8	55	NA
9	121	NA
10	45	NA
Total	1,479	314

[a]Local pretreatment programs are administered by state officials in Alabama, Connecticut, Mississippi, Nebraska, and Vermont

[b]Not applicable

program administration and enforcement. Sources of funding for local pretreatment programs, as well as the percentage of programs funded by each source, are summarized in Table 11.2.

Finally, all local pretreatment programs must contain the following elements: (1) permitting requirements for IUs; (2) discharge limitations, including general and specific prohibitions, categorical pretreatment standards, and local pretreatment limits; (3) monitoring, reporting, and recordkeeping requirements; and (4) enforcement mechanisms.

Permitting Requirements for IUs

Operators of POTWs must issue a permit to each significant industrial user (SIU) that discharges its effluent to their treatment works (U.S. Environmental Protection Agency, 1998a). SIUs automatically include all IUs that are subject to categorical pretreatment standards (discharge limitations) as defined in the following sub-section. SIUs also include: (1) IUs that discharge 25,000 gallons per day (gpd) or more of process wastewater to the POTW; (2) IUs whose effluent represents 5 percent or more of the average dry weather hydraulic or organic capacity of the POTW; and (3) any IU that is otherwise designated as a SIU by the operator of the POTW. IU permits which are specific to each SIU are valid for a maximum of five years; such permits include discharge limitations and monitoring, reporting, and recordkeeping requirements.

It should be noted that these requirements represent federal minimums. Operators of POTWs with approved pretreatment programs can, and often do, implement local limits that are more stringent than federal pretreatment standards. The operators may also develop local limits for pollutants that are not regulated by federal standards, and/or they can expand monitoring and reporting requirements.

Table 11.2: Sources of Funding for Pretreatment Programs (Industrial Economics, Inc., and Science Applications International Corporation, 1994)[a]

Funding Sources	Percent
General Revenue	55
Industrial Surcharge	22
Other	8
Direct Monitoring and Compliance Assessments	7
Sewer Revenues	6
Permit Fees	2
Pretreatment Fines and Penalties	1

[a]Survey respondents included approximately 100 POTWs serving large cities in 1988-1989.

Discharge Limitations

All IUs are subject to general and specific prohibitions, categorical pretreatment standards, and/or local pretreatment limits. General prohibitions forbid the discharge of pollutants to the POTW that may cause "pass through" or "interference," while specific prohibitions are designed to prevent pollutant discharges that may negatively affect the POTW, the wastewater collection system, or worker health and safety (U.S. Environmental Protection Agency, 1998a). General and specific prohibitions apply to all IUs, whether or not they are classified as SIUs.

Categorical pretreatment standards refer to national technology-based effluent limitations that apply to facilities in the industrial categories listed in Table 11.3 (Industrial Economics, Inc., and Science Applications International Corporation, 1994). These standards, which represent daily maximums and/or monthly averages, are typically expressed in concentration-based limits, such as milligrams per liter. However, they may also be expressed in mass- or production-based limits, such as kilograms per day or milligrams of pollutant per kilogram of product, particularly if the applicable standard is partially based on flow reduction requirements. Categorical pretreatment standards are subject to periodic review and revision by USEPA.

Local pretreatment limits are POTW-specific discharge standards designed to meet the federal general and specific prohibitions (Industrial Economics, Inc., and Science Applications International Corporation, 1994). Unlike the national categorical pretreatment standards, local limits incorporate consideration of the unique characteristics of the POTW and its receiving waters. Local limits apply to all IUs, although non-significant IUs are generally not required to monitor their effluent and thus they cannot determine if they are in compliance.

Table 11.3: Industrial Categories Subject to Categorical Pretreatment Standards and General Pretreatment Regulations (Industrial Economics, Inc., and Science Applications International Corporation, 1994)

Aluminum Forming
Battery Manufacturing
Coil Coating
Copper Forming
Electrical and Electronic Products
Electroplating and Metal Finishing
Inorganic Chemicals Manufacturing
Iron and Steel
Leather Tanning and Finishing
Metal Molding and Casting
Nonferrous Metal Forming
Nonferrous Metal Manufacturing
Organic Chemicals, Plastics and Synthetic Fibers
Pesticide Chemicals
Petroleum Refining
Pharmaceutical Manufacturing
Porcelain Enameling
Pulp, Paper and Paperboard and Builders' Paper and Board Mills
Steam Electric (Power Plants)
Timber Products Processing

At a minimum, the operator of the POTW or the delegated state agency is required to evaluate the need for local limits for: (1) arsenic; (2) cadmium; (3) chromium; (4) copper; (5) cyanide; (6) lead; (7) mercury; (8) nickel; (9) silver; and (10) zinc. If necessary, operators of POTWs may develop local limits for still additional pollutants to protect treatment plant operations and/or sludge disposal methods.

The USEPA has developed a methodology, known as the maximum allowable headworks loading (MAHL) approach, that can be used to establish technically-based local limits. Similar to the Total Maximum Daily Load (TMDL) concept for receiving waters, the MAHL is the maximum allowable pollutant loading that a POTW can receive without pass through, interference, or resultant violations of applicable standards. The maximum allowable industrial loading (MAIL) can then be calculated by subtracting domestic and background loadings from the MAHL. The USEPA also recommends that a safety factor, usually ranging from 10 to 30 percent, be incorporated into the MAIL to account for anticipated population growth and industrial development in the POTW's service area, slug discharges, and other uncertainties (U.S. Environmental Protection Agency, 1998a).

Next, portions of the MAIL must be allocated to the IUs in the local pretreatment program. Historically, the MAIL has been divided equally among all IUs, probably because uniform limits are simplest to implement and enforce. It should be noted that an equal allocation presumes that all IUs are equal in terms of the quantity of discharged wastewater. However, uniform limits may be more stringent than necessary because they are based on the assumption that all IUs will discharge the regulated pollutants in quantities equal to the local limit. If this assumption is not true, environmental compliance costs could be reduced by using an alternative allocation method; such methods include: (1) the industrial contributory flow method, which establishes local limits for IUs that actually discharge the regulated pollutants; (2) the mass proportion method, which establishes local limits by comparing current pollutant loadings to the relevant MAHL; and (3) the selected industrial reduction method, which establishes local limits based on the specific characteristics of each industrial category. In any case, local pretreatment limits should exceed detection limits and should be achievable using existing abatement technologies and/or process controls. In addition, local limits must be approved by USEPA and the delegated state agency.

Once they have been approved, local limits should be included in both the local sewer use ordinance and in wastewater discharge permits issued to each SIU in the pretreatment program. Local limits supersede categorical pretreatment standards if they are more stringent; therefore, when SIUs are subject to both local limits and federal categorical standards, the lower (more stringent) discharge limitation is applicable.

Finally, operators of POTWs are required to review their local limits in conjunction with their discharge permit renewal; such renewals occur every 5 years under stipulation of the National Pollutant Discharge Estimation System program. In addition, according to USEPA, local limits should be reviewed whenever substantial amounts of additional data become available or when circumstances at the POTW or within its service area change.

Monitoring, Reporting, and Recordkeeping Requirements

At a minimum, SIUs must monitor all regulated pollutants in their effluent in accordance with the conditions of their local wastewater discharge permits. SIUs that are subject to categorical pretreatment standards are required to use specific sampling procedures and analytical techniques that have been identified in USEPA regulations; in addition, USEPA recommends the use of approved procedures and techniques for all pretreatment monitoring (Industrial Economics, Inc., and Science Applications International Corporation, 1994). To demonstrate their compliance with applicable pretreatment requirements, SIUs are also required to submit numerous reports, including periodic monitoring reports, to the operator of the POTW, the delegated state agency, and/or USEPA (U.S. Environmental Protection Agency, 1998a). Finally, all SIUs are required to maintain monitoring records and other documents associated with their participation in the pretreatment program for a minimum of three years.

Enforcement Mechanisms

Operators of POTWs are primarily responsible for enforcing discharge limitations and monitoring, reporting, and recordkeeping requirements associated with local pretreatment programs. As a result, local laws and/or ordinances must provide such operators with sufficient legal authority to: (1) seek injunctive relief against IUs who violate applicable pretreatment requirements, including discharge limitations; and (2) seek or assess civil and criminal penalties in the amount of $1,000 or more per violation per day (U.S. Environmental Protection Agency, 1998a). Most pretreatment programs are enforced through a combination of (Industrial Economics, Inc., and Science Applications International Corporation, 1994): (1) notices of violation (NOVs), (2) administrative compliance orders, (3) administrative penalties, (4) civil judicial enforcement, (5) criminal enforcement, and/or (6) terminating POTW services. Other enforcement techniques include public notice of noncompliance and increased monitoring requirements.

In addition, if the pretreatment program is administered by the local operator of the POTW, the relevant state agency typically retains the authority to review the pretreatment program, to evaluate local enforcement activities, and to penalize IUs for noncompliance.

Similarly, the USEPA may directly enforce the general and specific prohibitions, categorical pretreatment standards, and/or local pretreatment limits against any IU. This situation exists because, historically, some municipalities have been reluctant to penalize local industries for noncompliance. This reluctance stems from the fact that local industries are often major employers and significant sources of tax revenue. This issue has been addressed by requiring operators of POTWs to develop enforcement response plans which delineate the administrative actions and penalties associated with each anticipated violation. Further, supplemental enforcement can occur by allowing the delegated state agency and USEPA to retain such authority over all IUs.

State Requirements

Pretreatment requirements in Oklahoma, including discharge limitations and monitoring, reporting, and recordkeeping provisions, are identical to the federal pretreatment regulations (Cupples, 1999). The Oklahoma Department of Environmental Quality (ODEQ) is the state agency with responsibility for reviewing local pretreatment programs.

STILLWATER'S INDUSTRIAL PRETREATMENT PROGRAM

Stillwater's POTW, which was constructed in 1964 and extensively modified between 1979 and 1981, includes the following wastewater treatment processes (City of Stillwater, 1993): (1) primary clarifiers; (2) biological towers; (3) rock trickling filters; (4) final clarifiers; and (5) ultraviolet disinfection. Sewage sludges are anaerobically digested, dewatered, dried, and applied to agricultural land located near the POTW. The design and average flow rates of the POTW are 7.0 and 5.5 mgd, respectively. Further, it is estimated that approximately 15 percent of the average daily flow is attributable to SIUs. The characteristics of SIUs that are currently discharging their effluent to the Stillwater POTW are summarized in Table 11.4.

Under federal and state pretreatment requirements, the City of Stillwater must design, administer, and enforce a local pretreatment program. Legal authority for the pretreatment program is provided by the Stillwater Code, Chapter 30, Article IV, which is entitled "Sewers and Sewage Disposal" (City of Stillwater, 1993). As shown in Figure 11.1, responsibilities for administering the pretreatment program have been assigned to the City Manager, the City Attorney, and the Departments of Environmental and Safety Services, Water/Wastewater, and Public Works. Finally, the pretreatment program is funded through general revenues and/or fees assessed to IUs.

Technical and implementation issues associated with Stillwater's Industrial Pretreatment Program include wastewater discharge permits; discharge limitations; monitoring, reporting, and recordkeeping requirements; and enforcement mechanisms.

Wastewater Discharge Permits

All existing IUs that discharge their effluent to the Stillwater POTW are required to submit a wastewater survey form to the pretreatment coordinator every five years, while new IUs must complete the survey form when they apply for a water meter, sewer connection, or building permit (City of Stillwater, 1993). The pretreatment coordinator uses information from the forms to determine if the IU should be classified as a SIU.

SIUs are then required to obtain wastewater discharge permits from the pretreatment coordinator; in some cases, non-significant IUs may also be required to obtain discharge permits to protect POTW operations or receiving water quality. Wastewater discharge permits may be issued for a maximum of five years and, if necessary, may be modified by the pretreatment coordinator. These permits may also be

Table 11.4: Characteristics of the Significant Industrial Users (SIUs) in Stillwater's Industrial Pretreatment Program

Facility Name	Brief Description of Facility's Operations	Number of Outfalls	Categorical Pretreatment Standards	Local Pretreatment Limits	References
Armstrong World Industries, Inc.	Manufactures sheet vinyl flooring	1	No	Yes	City of Stillwater, 1994
Fractionation Research, Inc.	Experimental distillation tower uses a closed, continuously circulating feed system	1	No	Yes	City of Stillwater, 1998
Mercury Marine	Manufactures inboard marine engines, stern drive units, and jet pumps used to propel watercraft	1	Yes	Yes	City of Stillwater, 1997a
National-Standard Company	Manufactures bead wire for automobile tires and carbon steel welding wire	3[a]	Yes	Yes	City of Stillwater, 1997b
Oklahoma State University Power Plant	Provides chilled water, steam, and approximately 10 percent of the electricity used on campus	1	No	Yes	City of Stillwater, 1997c
World Color	Prints magazines and catalogs	1	No	Yes	City of Stillwater, undated

[a]Only one outfall discharges process wastewater to the POTW.

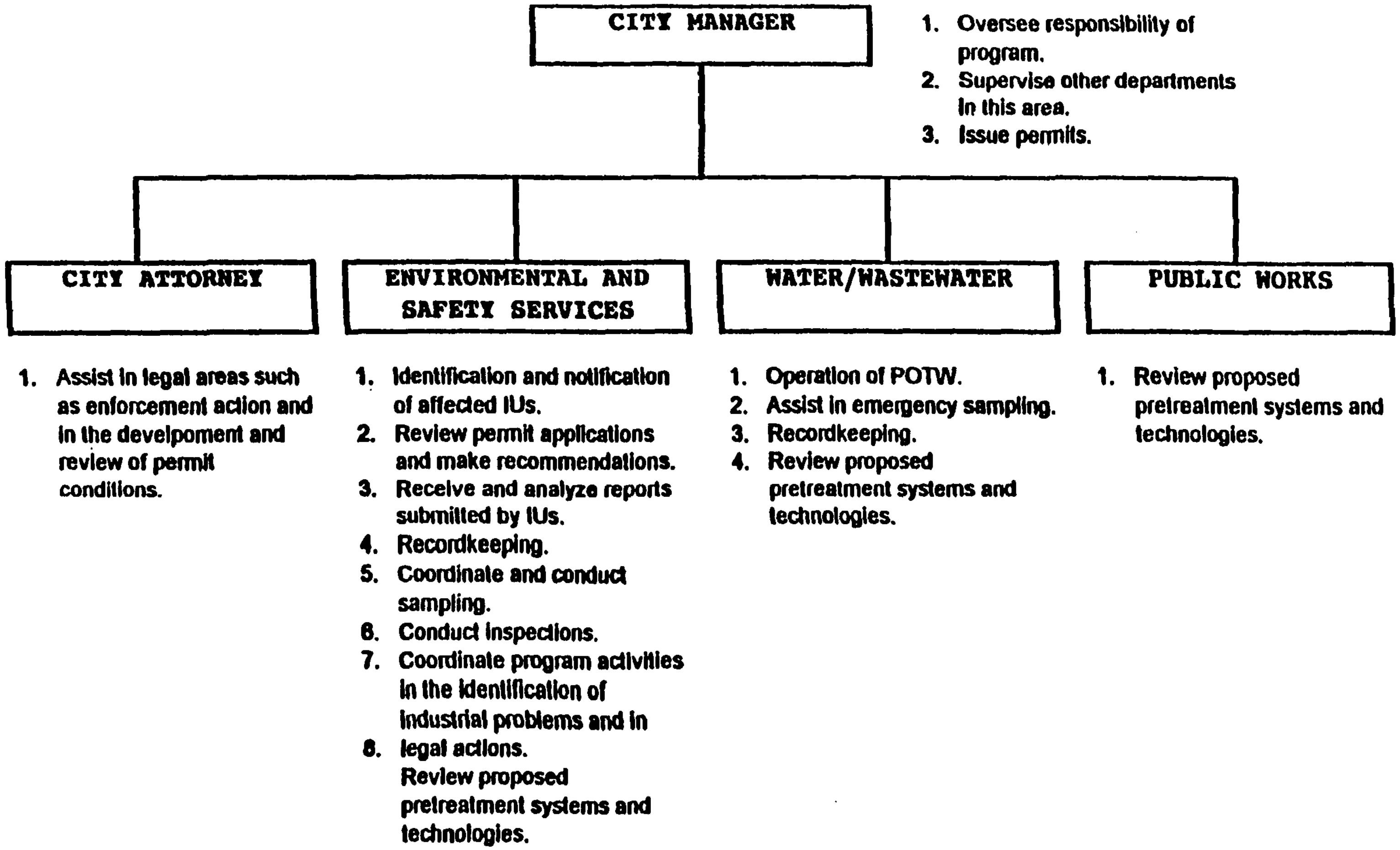

Figure 11.1: Organization of the Industrial Pretreatment Program in Stillwater, Oklahoma (City of Stillwater, 1993)

terminated under certain conditions, which include nonuse or facility closure.

Discharge Limitations

Stillwater's Industrial Pretreatment Program has incorporated the federal general prohibitions on pass through and interference, the specific prohibitions, and the categorical pretreatment standards by reference (City of Stillwater, 1993). The local sewer use ordinance also includes eight additional specific prohibitions and eleven local pretreatment limits; these limits are listed in Table 11.5. The listed limits represent instantaneous maximum allowable concentrations and apply at the point(s) where industrial effluents are discharged to the city's wastewater collection system. The pretreatment coordinator may also impose mass-based limits in addition to, or instead of, the identified concentration-based limits.

Monitoring, Reporting, and Recordkeeping Requirements

Wastewater discharge permits also specify monitoring requirements, including sampling location, frequency, and type, for each SIU in the Stillwater Industrial Pretreatment Program (City of Stillwater, 1993). All wastewater sampling and analyses must be performed in accordance with federal regulations, and laboratories must be certified by the Oklahoma Water Resources Board.

Unique reporting and recordkeeping requirements may also be specified in each SIU's wastewater discharge permit. In general, SIUs in the Stillwater Industrial Pretreatment Program must submit one "self-monitoring" report per month (City of Stillwater, 1997a, 1997b, 1997c, 1998, and undated). The exception is Armstrong World Industries, Inc., which, due to its low wastewater volume and compliance history, is not required to monitor its effluent or submit monthly reports (City of Stillwater, 1994). SIUs are required to

Table 11.5: Local Pretreatment Limits for Stillwater's Industrial Pretreatment Program[a] (City of Stillwater, 1993)

Pollutant	Limit (mg/l)
Arsenic	0.027
Cadmium	0.015
Chromium	0.540
Copper	0.900
Cyanide	0.100
Lead	0.690
Mercury	0.004
Nickel	0.340
Phenol	1.650
Silver	0.014
Zinc	4.840

[a]Local limits are instantaneous maximum allowable concentrations and apply at the point where effluent is discharged to the city's wastewater collection system leading to the POTW.

maintain monitoring records, copies of reports, and other documents pertaining to the pretreatment program for a minimum of three years. Record retention requirements may be extended if litigation is pending or upon request by the pretreatment coordinator.

In addition to the monitoring, reporting, and recordkeeping requirements for SIUs, the local pretreatment program requires the City of Stillwater to inspect each SIU and sample its effluent at least once per year. The City must also submit an annual report to ODEQ and the Region 6 office of USEPA; this report must include a current list of SIUs and their compliance status, and a summary of the City's compliance and enforcement activities. The City of Stillwater must also keep records relating to the pretreatment program for a minimum of three years, although record retention times may be extended if litigation is pending or upon request by USEPA officials.

Enforcement Mechanisms

The pretreatment coordinator and the Department of Environmental and Safety Services are primarily responsible for enforcing the provisions of the wastewater discharge permits (City of Stillwater, 1993). All identified violations must be documented in the IU's file and investigated by city officials. The following mechanisms are available to enforce permit conditions or other requirements of the pretreatment program: (1) NOVs; (2) consent orders; (3) administrative orders; (4) show cause hearings; (5) emergency suspensions; (6) termination of wastewater discharge to the POTW; (7) seeking injunctive relief; (8) seeking civil penalties; and/or (9) seeking criminal penalties in the amount of $1,000 per day per violation.

To standardize enforcement, the City of Stillwater has developed an enforcement response guide which delineates the actions and penalties associated with anticipated types of noncompliance.

Examples of the enforcement responses associated with exceeding permit limits, failure to monitor correctly, and inadequate recordkeeping are shown in Table 11.6. Additional factors, such as the IU's compliance history, the violation's effect on receiving waters, and the violation's effect on the POTW, may also be considered when establishing appropriate penalties for noncompliance.

PRETREATMENT EFFLUENT TRADING

Pretreatment ETPs allow IUs that discharge to the same POTW to exchange pollutant reduction credits (PRCs) in order to meet local pretreatment limits more cost-effectively (U.S. Environmental Protection Agency, 1996). Such trading programs may be easier to design and implement than other types of ETPs because:

(1) Pretreatment ETPs may be based on existing permitting procedures for IUs, thus simplifying ETP administration and enforcement.

(2) Since IUs are already required to monitor their effluent and submit reports to the administering POTW agency, much of the data that would be needed to design and implement a pretreatment ETP and to identify potential trading opportunities is already available.

(3) IUs discharge their effluent to a POTW instead of receiving waters. Therefore, pollutants like cyanide and heavy metals, which should not be included in point-point, point-nonpoint, and nonpoint-nonpoint source ETPs due to the potential for localized toxic effects, can be included in pretreatment ETPs. In addition, modeling and monitoring requirements associated with quantifying the effects of trades can be greatly reduced, thus encouraging ETP participation. However, trades must still be evaluated to ensure that they will not adversely affect POTW operation, the wastewater collection system, or worker health and safety.

Further, opportunities for pretreatment ETPs would increase dramatically if IUs could trade PRCs in order to meet applicable categorical pretreatment standards; however, such trading is currently prohibited by USEPA (U.S. Environmental Protection Agency, 1996). Therefore, IUs must meet these minimum requirements before they can participate in trading.

Table 11.6: Examples from the Enforcement Response Guide (City of Stillwater, 1993)

Noncompliance[a]	Nature of Violation	Enforcement Response
Exceeding Local or Federal Standard (Permit Limit)	Isolated, not significant	Phone Call NOV[b]
	Isolated, significant (no harm)	AO[c] $500 Fine
	Isolated, harm to POTW/environment	Show Cause Order $1000 Fine Civil Action
	Recurring, no harm	AO with Fine[d]
	Recurring, significant (harm)	AO with $1000 Fine Show Cause Order Civil Action Terminate Service
Failure to Monitor Correctly	Failure to monitor all pollutants as required by permit	NOV AO
	Recurring failure to monitor	AO with $500 Fine Civil Action
Inadequate Recordkeeping	Inspector finds files incomplete to missing (no evidence of intent)	NOV $250 Fine AO

[a]The following noncompliance issues are also included in the enforcement response guide: (1) unpermitted discharge; (2) nonpermitted discharge (failure to renew); (3) reporting violations; (4) improper sampling; (5) failure to install monitoring equipment; (6) compliance schedules (in permit); (7) waste streams are diluted in lieu of treatment; (8) failure to mitigate noncompliance or halt production; (9) failure to properly operate and maintain pretreatment facility; (10) entry denial; (11) illegal discharge; (12) improper sampling; and (13) failure to repeat additional monitoring.

[b]Notice of Violation

[c]Administrative Order

[d]Fines for discharge violations are based on the reported value and the permit limit. The maximum fine is $1,000 per violation.

Feasibility studies for pretreatment ETPs have been conducted by the USEPA (Industrial Economics, Inc., and Science Applications International Corporation, 1994) and the Illinois Environmental Protection Agency (undated). In addition, Veil (1997) has evaluated the potential for pretreatment trading in the energy industries, and Opaluch and Kashmanian (1985) reviewed the use of a pretreatment "bubble" to regulate cyanide and seven other metals from electroplating facilities associated with Rhode Island's jewelry industry. These studies are summarized in Chapter 4.

Only one existing pretreatment ETP has been identified; it applies to IUs that discharge to the POTW operated by the Passaic Valley Sewage Commission (PVSC) in northeastern New Jersey (U.S. Environmental Protection Agency, 1998b). This program allows IUs to meet local pretreatment limits by exchanging PRCs for arsenic, cadmium, copper, lead, mercury, nickel, and zinc. Such credits are only eligible for inclusion in the trading program if they were generated by "end-of-pipe" technologies and/or pollution prevention measures. In addition, the PRCs must be fully documented and must have been created since the local limits became effective. Once a proposed trade has been approved by the PVSC, each partner's wastewater discharge permit is revised to reflect the trade, including modified local limits. Each trading partner is then responsible for meeting its own modified limits; thus, one partner's noncompliance will not affect the other. Existing monitoring and reporting requirements for both trading partners should be sufficient to support effluent trading and thus do not need to be modified. However, despite the anticipated advantages of pretreatment trading in the PVSC service area, only one trade (for copper PRCs) has occurred to date.

Essential components of pretreatment ETPs include technically defensible local limits, sufficient legal authority, and strong enforcement programs (U.S. Environmental Protection Agency, 1998b). In addition, pretreatment ETPs must overcome barriers associated with lack of information. For example, IUs cannot participate in trades if they do not know that effluent trading is an acceptable compliance alternative or if they cannot identify suitable trading partners. This barrier may be alleviated if the POTW or other stakeholders become actively involved in identifying potential trading partners and encouraging trading activity. For example, the PVSC trading program used a "pilot team," comprised of federal and state regulators, POTW officials, and other relevant stakeholders, to facilitate initial trading activities.

THE QUALITATIVE MODEL

As part of this research effort, a qualitative model for designing and implementing ETPs, containing ten components and 37 criteria questions, was developed (Edwards and Canter, 1998). Each model component and its relevance to successful ETPs are summarized in Table 11.7, while the associated criteria questions are listed in Table 11.8. The qualitative model can be used to evaluate existing ETPs by answering each criteria question with program-specific information and then rating each component according to the scheme shown in Table 11.9. Alternatively, the model can be used to evaluate the potential applicability of an ETP. In this case, the first five components (watershed suitability, pollutant type, trading market size and characteristics, legal authority, and administrative acceptability and capability) can be used to determine the feasibility of an ETP for a specific watershed or trading area. If the potential for effluent trading is adequate, the remaining model components (specific policies, procedures, and trading rules; pre- and post-trade monitoring; enforcement mechanisms; program evaluation; and public involvement) can be used to aid in the design and implementation of a site-specific ETP.

Table 11.7: Components of Qualitative Model and Their Importance to Successful ETPs (Edwards and Canter, 1998)

Component of Qualitative Model	Rationale for Inclusion in the Qualitative Model
Watershed Suitability	This component is designed to ensure that the geographic and temporal boundaries of the ETP are clearly defined. In addition, circumstances within the watershed (or trading area) that either encourage or discourage effluent trading must be identified and addressed.
Pollutant Type	This component is designed to identify pollutants that may be suitable for inclusion in an ETP. ETP designers must also decide if program rules will allow inter-pollutant trading.
Trading Market Size and Characteristics	This component is designed to identify all sources of the pollutant(s) of interest in the ETP area, their relative contributions to total pollutant loading, and differences in their marginal abatement costs that may promote effluent trading. This component is also focused on identifying market characteristics, such as the presence of direct competitors, that may influence trading activity.
Legal Authority	This component is included to identify whether existing laws and regulations fully support, or could be amended to support, the development and operation of an ETP.
Administrative Acceptability and Capability	This component is used to identify whether the administering agency has sufficient knowledge and information to design and implement an ETP. This component is also for determining whether agency staff are willing to use effluent trading as an alternative to more traditional forms of regulation.
Specific Policies, Procedures, and Trading Rules	Specific policies, procedures, and rules are needed to reduce uncertainty, to minimize regulatory and administrative burdens, and to reduce transaction costs. Such rules should encompass all aspects of an ETP, from determining the maximum allowable pollutant loading to reviewing proposed trades to penalizing trading partners who violate their trading agreements.
Pre- and Post-Trade Monitoring	Pre- and post-trade monitoring is required to determine the environmental effects of individual trades and of the overall ETP.

Table 11.7 (continued):

Component of Qualitative Model	Rationale for Inclusion in the Qualitative Model
Enforcement Mechanisms	Enforcement mechanisms are required in order to ensure that water quality standards and/or ETP goals are met and that trading partners fulfill the terms of their agreements.
Program Evaluation	Periodic evaluations of ETP performance are necessary in order to ensure that the ETP is protecting, or improving, water quality while reducing environmental compliance costs. Periodic evaluation of the ETP itself is also recommended in order to identify any necessary modifications.
Public Involvement	Public and stakeholder involvement throughout ETP design and operation is needed in order to encourage participation in the trading program, to decrease controversy, and to minimize the potential for negative publicity.

Table 11.8: Criteria Questions for Each Component of the Qualitative Model for Designing and Implementing ETPs (Edwards and Canter, 1998)

<u>Watershed Suitability</u> 1. Does the watershed (or watershed segment or estuarine zone) have a clearly defined geographic boundary? What is the basis for defining the watershed, segment, or zone? 2. Are temporal variations in flow well understood? 3. Do existing water quality conditions or other circumstances within the watershed encourage the use of an ETP? 4. Are there circumstances within the watershed that would discourage the use of an ETP?
<u>Pollutant Type</u> 1. Are the pollutant(s) of interest classified as conservative, non-conservative, or toxic? 2. Will inter-pollutant trading be allowed? What is the basis for the decision to permit or prohibit inter-pollutant trading? 3. Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality? 4. Do the environmental effects of the pollutant(s) of interest result more from total loading over time than local, short-term toxic effects? 5. Can mass- or concentration-based limits be established for the pollutant(s) of interest?
<u>Trading Market Size and Characteristics</u> 1. Have all sources of the pollutant(s) of interest been identified? 2. Are the relative contributions of all source categories (point, nonpoint, and background) known? 3. Are temporal variations in loadings of the pollutant(s) of interest well understood? 4. Are there significant differences in marginal abatement costs among sources in the same category and/or sources in different categories? 5. Could sources and/or governmental entities within the watershed be potentially unwilling to trade? 6. Are there unique circumstances that may influence the behavior of market participants?
<u>Legal Authority</u> 1. Are there water quality standards, goals, and/or objectives that can be used as a basis for the ETP? 2. Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so? 3. Is there an existing agency with sufficient authority to implement and enforce an ETP, can such authority be conferred on an existing agency, or can such an agency be created? 4. Does the implementing agency have sufficient authority to require all contributing sources to meet their discharge allocations?

Table 11.8 (continued):

<u>Administrative Acceptability and Capability</u> 1. Does the administering agency have sufficient knowledge and information to designate the maximum allowable pollutant loading for the watershed, to allocate portions of that loading to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades as well as the overall trading program? 2. Is the administering agency willing to use effluent trading as a management strategy to supplement traditional regulation? 3. Does the administering agency have sufficient resources to design and implement an ETP?
<u>Specific Policies, Procedures, and Trading Rules</u> 1. If nonpoint sources are to be included in the ETP, do policies or procedures account for their inherent variability? 2. Have procedures been clearly defined for the following aspects of the ETP? (a) determination of the maximum allowable pollutant loading for the watershed (b) allocating portions of the loading cap to all sources within the watershed that discharge the pollutant(s) of interest © types of trades that will be allowed (d) trading ratio(s) 3. Have rules or procedures been clearly defined for the following operational aspects of the ETP? (a) quantifying and certifying pollutant reduction credits (PRCs) (b) quantifying the environmental impacts of trades © application procedures for proposed trades (d) administrative procedures for the evaluation of proposed trades (e) time periods that trades remain in effect (f) treatment of banked or shutdown credits (g) reporting and recordkeeping requirements 4. Will non-dischargers, such as environmental groups, be allowed to purchase and retire PRCs?
<u>Pre- and Post-Trade Monitoring</u> 1. Are responsibilities for pre- and post-trade source and ambient water quality monitoring clearly defined? 2. Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for both source and ambient water quality monitoring? 3. Will source monitoring requirements discourage trading activity?
<u>Enforcement Mechanisms</u> 1. Can trading agreements be effectively enforced for each source category? 2. Should uncontrollable circumstances for both point and nonpoint sources be considered in the enforcement process?

Table 11.8 (continued):

<u>Program Evaluation</u> 1. Are responsibilities for evaluating ETP performance clearly defined? 2. How often will the ETP be reviewed? 3. Have the criteria that will be used to evaluate ETP performance been specified?
<u>Public Involvement</u> 1. Was the public, including industries and municipalities, actively involved in ETP design and operation? 2. In general, did industries, municipalities, government agencies, and the public support the development of the ETP? 3. Does the ETP include any educational and/or outreach efforts designed to increase public support?

Table 11.9: Rating Scheme for Each Component of Qualitative Model (Edwards and Canter, 1998)

Degree of Compliance With Criteria Questions for Each Component	Rating
Compliant from all perspectives	4
Compliant from majority of perspectives	3
Compliant from only a few perspectives	2
Compliant from no perspectives	1
Degree of compliance with perspectives depends upon specific ETP design	0

CONSIDERATION OF THE FEASIBILITY OF A PRETREATMENT ETP FOR THE STILLWATER POTW

The answers to the criteria questions associated with the first five components of the qualitative model are summarized in this section. Responses were limited to the feasibility of a pretreatment ETP and based on site-specific information obtained through literature review and personal contacts with key stakeholders. The summary for each model component contains its rating, a brief explanation of the rationale for the assignment, and a discussion of any implications and/or resultant needs. The rating and summary information for each component are shown in Table 11.10.

WATERSHED SUITABILITY

Geographic Boundaries

In an ETP involving a watershed, watershed segment, or estuarine zone, the geographic boundaries of the trading area provide information needed to determine the maximum allowable pollutant loading, to identify the area subject to post-trade ambient water quality monitoring, and to identify the point and nonpoint sources that will be eligible to participate in the trading program. However, since the boundaries of a pretreatment ETP are based solely upon the service area of the POTW, this criteria question does not apply.

Flow Variations

Since pretreatment ETPs are based on applicable local limits instead of the receiving water body's assimilative capacity, information concerning temporal variations in ambient water quality flows in the trading area is not required. Therefore, this criteria question does not apply.

Table 11.10: Summary of the Feasibility of a Pretreatment ETP for the Stillwater POTW

Component of Qualitative Model	Rating of Degree of Compliance[a]	Rationale for Assigned Compliance Rating	Implications and Resultant Needs
Watershed Suitability	2	Criteria questions regarding geographic boundaries and flow variations do not apply, and circumstances at the Stillwater POTW both encourage and discourage the development of a pretreatment ETP. Overall, it is anticipated that trading activity will be limited due to the size of the trading market.	Pretreatment ETPs may be more appropriate for larger POTWs with more SIUs. Alternatively, elements of a pretreatment ETP could be used to meet local pretreatment program objectives more efficiently.
Pollutant Type	4	Sufficient information is available to quantify pollutant loadings, and local limits on total metals should be adequate protection against most adverse effects. Criteria questions related to pollutant classification and inter-pollutant trading are not applicable to pretreatment ETPs, while the criteria questions related to pollutant forms and environmental effects were modified to consider potential impacts on the wastewater collection system and POTW operations, respectively.	Pretreatment ETPs may be simpler to design, implement, and operate than point-point, point-nonpoint, and nonpoint-nonpoint source ETPs. Evaluating potential trading opportunities should also be simpler, thus encouraging ETP participation.
Trading Market Size and Characteristics	3	All pollutant sources have been identified, sufficient monitoring data exist to quantify relative contributions and to address temporal variations, and there are no direct competitors within the POTW's service area. In addition, the criteria question associated with unique circumstances does not apply to pretreatment ETPs. However, trading activity may be limited by lack of information on marginal abatement costs or by sources that save PRCs for their own future use.	Pretreatment ETP design, implementation, and participation may be simplified because all trades occur among SIUs that discharge their effluent to the same POTW. However, in order to provide economic incentives to trade, generic information on marginal abatement costs for each type of SIU should be collected and made available to potential trading partners. Furthermore, pretreatment ETPs may be more appropriate for larger POTWs with more SIUs, although trading activity within such programs may still be restricted if SIUs are direct competitors.
Legal Authority	3	The pretreatment ETP can be based on existing MAILs and local limits, legal authority for the ETP can be assigned to an existing agency, and no "loopholes" which could negatively affect ETP performance were identified. However, despite federal support of pretreatment trading to meet local limits, ETPs have not been formally recognized as an acceptable compliance alternative, and the resulting risk and uncertainty associated with ETP participation may decrease trading activity.	Amending the Clean Water Act and the local pretreatment program to explicitly support effluent trading may encourage ETP participation.

Table 11.10 (continued):

Component of Qualitative Model	Rating of Degree of Compliance[a]	Rationale for Assigned Compliance Rating	Implications and Resultant Needs
Administrative Acceptability and Capability	3	Sufficient information is available to design and implement a pretreatment ETP, and resources should be available to support trading activities. In addition, both permitting authorities and SIU managers are expected to promote pretreatment trading. However, detailed information on abatement technologies and pollution prevention measures, which would be required to evaluate potential trading opportunities, is not readily available.	SIUs may be able to obtain information on abatement technologies and pollution prevention measures by sponsoring site-specific studies, which could be conducted by facility personnel and/or consultants. Alternatively, generic information on abatement and pollution prevention for each type of SIU could be provided by the Department of Environmental and Safety Services, state and federal regulatory officials, trade organizations, and/or other pertinent stakeholders.

[a]The ratings are as follows: 4 = compliant from all perspectives; 3 = compliant from the majority of perspectives; 2 = compliant from only a few perspectives; 1 = compliant from no perspectives; 0 = degree of compliance with perspectives depends upon specific ETP design

Conditions Encouraging Effluent Trading

Four conditions that should encourage the development and implementation of a pretreatment ETP at the Stillwater POTW were identified in this review. First, federal regulations allow SIUs to increase their discharges above categorical pretreatment standards if the increased loading is "offset" through treatment at the POTW (U.S. Environmental Protection Agency, 1998a). Since these "removal credits" basically represent an effluent trade, the concepts associated with pretreatment trading may already be familiar to both SIUs, who would participate in an ETP, and POTW officials, who would administer it. Second, there is an existing local pretreatment program in Stillwater that could be modified to include effluent trading. Third, Environmental and Safety Services staff who are currently administering the pretreatment program are "innovative" and thus may be more willing to consider alternative compliance options such as trading (Cupples, 1999). Finally, since the SIUs are in different industrial categories, competitive pressures that would limit trading activity are unlikely.

Conditions Discouraging Effluent Trading

This review also identified three conditions which may discourage the development and implementation of a pretreatment ETP for the Stillwater POTW. Most importantly, there are only six SIUs that would be eligible to participate in an ETP, and several of the SIUs may not discharge significant quantities of regulated pollutants. Thus, the size of the potential trading market is extremely small. Second, some regulated pollutants, like pH, must be excluded from the proposed trading program due to the lack of concentration- or mass-based limits. Finally, potential trading opportunities for Mercury Marine and National-Standard Company may be restricted due to the prohibition on trading to meet categorical pretreatment standards (City of Stillwater, 1997a, and 1997b).

Summary of Watershed Suitability

As shown in Table 11.10, the watershed suitability component of the qualitative model was assigned a rating of "2," since criteria questions regarding geographic boundaries and flow variations do not apply and circumstances at the Stillwater POTW both encourage and discourage the development of a pretreatment ETP. Overall, it is anticipated that trading activity would be limited due to the size of the trading market. Therefore, a pretreatment ETP may not be a cost-effective compliance alternative for Stillwater's POTW. Pretreatment ETPs may be more appropriate for larger POTWs with more SIUs. Alternatively, elements of a pretreatment ETP could be used to meet local pretreatment program objectives more efficiently. For example, new or expanding SIUs could be required to offset their discharges by obtaining PRCs from existing SIUs, thus maintaining current pollutant loadings to the POTW.

POLLUTANT TYPE

Pollutant Classification

In most ETPs, the classification of the pollutant(s) of interest must be determined in order to predict their environmental effects and to select appropriate water quality models. However, since pretreatment ETPs either maintain or reduce total pollutant loadings to the POTW, impacts on receiving water quality associated with trading are not expected and water quality modeling is not required. Therefore, this criteria question does not apply. However, since it was assumed that all pollutants with local limits would be included in a pretreatment ETP for the Stillwater POTW, SIUs who participate in the trading program would be able to exchange PRCs for arsenic, cadmium, chromium, copper, cyanide, lead, mercury, nickel, phenol, silver, and/or zinc.

Inter-pollutant Trading

In the context of pretreatment ETPs, inter-pollutant trading would allow SIUs to exchange PRCs for different pollutants. For example, an inter-pollutant trade at the Stillwater POTW might allow Mercury Marine to increase its copper loading by purchasing lead reduction credits from National-Standard Company. It was assumed that any pretreatment trade, including an inter-pollutant trade, would be acceptable as long as the total loading for each pollutant did not exceed the relevant MAIL and there were no adverse effects on the wastewater collection system and operational efficiency of the POTW. Therefore, this criteria question does not apply.

Pollutant Forms

The environmental impacts of a given pollutant depend upon the form in which it is released into the environment and its subsequent transport and fate. Local limits for the Stillwater pretreatment program are expressed in terms of "total" metal (City of Stillwater, 1993). While using these limits as the basis for a pretreatment ETP may neglect some of the environmental effects associated with different physical and chemical forms of the same pollutant, it should encourage trading activity by limiting the number of regulated pollutants. However, proposed trades involving different forms of the same pollutant should always be reviewed in order to ensure that they will not adversely affect the wastewater collection system, POTW, or receiving water quality.

Environmental Effects

Since pretreatment ETPs do not allow increases in pollutant discharges to POTWs, total pollutant loadings must either remain constant or decrease. Therefore, no adverse effects on the environment, POTW operations, or sludge disposal practices are anticipated as a result of pretreatment trades. However, trading partners may still need to evaluate the potential effects of trades on the wastewater collection system and the POTW itself.

Pollutant Limits

To participate in a pretreatment ETP, IUs must be able to quantify pollutant loadings from each outfall in either mass- or concentration-based limits. Since SIUs are currently required to monitor effluent flows and pollutant concentrations, sufficient information should be available to quantify their pollutant loadings. In addition, provisions in the local pretreatment program allow the pretreatment coordinator to establish mass-based limits to supplement or replace the concentration-based limits listed in Table 11.5 (City of Stillwater, 1993).

Summary of Pollutant Type

As shown in Table 11.10, the pollutant type component of the qualitative model was assigned a rating of "4" since sufficient information is available to quantify pollutant loadings and local limits on total metals should be adequate protection against most adverse effects. Criteria questions related to pollutant classification and inter-pollutant trading are not applicable to pretreatment ETPs, while the criteria questions related to pollutant forms and environmental effects were modified to consider potential impacts on the wastewater collection system and POTW operations, respectively. As a result, pretreatment ETPs may be simpler to design, implement, and operate than point-point, point-nonpoint, and nonpoint-nonpoint source ETPs. Evaluating potential trading opportunities should also be simpler, thus encouraging ETP participation.

TRADING MARKET SIZE AND CHARACTERISTICS

Pollutant Sources

All sources of tradeable pollutants should be identified in order to establish pollutant loadings and determine the most effective control strategies. In addition, identifying all sources maximizes the number of potential trading partners, thus increasing the economic incentive to trade. It was assumed that SIUs would typically be the only participants in pretreatment ETPs since they are the only IUs that are required to have wastewater discharge permits. Table 11.4 summarizes the characteristics of each SIU in the Stillwater Industrial Pretreatment Program.

Relative Contributions

ETP designers and facility managers must have information regarding the relative contributions of pollutant sources to determine whether a pretreatment ETP would be a feasible compliance alternative. The relative contributions of each SIU to total pollutant loadings are not identified in this analysis of the Stillwater POTW. However, such information is contained in monthly monitoring reports that most of the SIUs are required to submit to the Department of Environmental and Safety Services; thus they should be readily available to ETP designers and/or potential trading partners (City of Stillwater, 1997a, 1997b, 1997c, 1998, and undated).

Temporal Variations

Information regarding temporal variations in pollutant loadings is required to determine the quantity of PRCs generated or required by a particular SIU. Most SIUs in the Stillwater Industrial Pretreatment Program are required to submit information on wastewater quantity and effluent concentrations as part of their monthly compliance reports (City of Stillwater, 1997a, 1997b, 1997c, 1998, and undated). Concentration data is based on laboratory analyses, while wastewater quantity data is based either on estimates (Armstrong World Industries, Inc.; Fractionation Research, Inc.; and World Color) or continuous flow meters (Mercury Marine, National-Standard Company, and the Oklahoma State University Power Plant).

Marginal Abatement Costs

Differences in marginal abatement costs among SIUs provide the major economic incentive to participate in pretreatment ETPs. Specific information regarding marginal abatement costs for each SIU in the Stillwater Industrial Pretreatment Program is unavailable. However, since the SIUs are comprised of different sizes from different industrial categories, marginal abatement costs are expected to vary. In addition, it was assumed that each SIU employs unique combinations of abatement technologies and/or pollution prevention measures to meet its applicable discharge limits, further contributing to cost differences.

Unwillingness to Trade

The economic theory underlying ETPs infers that sources may be unwilling to participate in an ETP for two reasons: (1) trading may reduce the environmental compliance costs of their competitors; and (2) sources may prefer to save excess PRCs to meet more stringent effluent limitations or to accommodate their own expansion. Since none of the SIUs in Stillwater's Industrial Pretreatment Program are direct competitors, all SIUs should be willing to participate in the ETP. However, saving PRCs for future use, which could occur in any pretreatment trading program, may adversely affect the ETP, particularly if trading activity is limited.

Unique Circumstances

The economic theory underlying ETPs also is based on the assumption that all dischargers will seek to minimize their environmental compliance costs. Since this assumption should be true for all industrial facilities, including SIUs in the Industrial Pretreatment Program, this criteria question does not apply.

<u>Summary of Trading Market Size and Characteristics</u>

As shown in Table 11.10, the trading market size and characteristics component of the qualitative model was assigned a rating of "3," since all pollutant sources have been identified, sufficient monitoring data exist to quantify relative contributions and to address temporal variations, and there are no direct competitors for the SIUs within the service area of the POTW. In addition, the criteria question associated with unique circumstances does not apply to pretreatment ETPs. However, trading activity may be limited by the lack of information on marginal abatement costs or by SIUs that save PRCs for their own future use. Overall, the greatest barrier to pretreatment trading in relation to the Stillwater POTW is probably the limited size of the potential trading market.

Once again, pretreatment ETP design, implementation, and participation would be simplified because all trades occur among SIUs that discharge their effluent to the same POTW. However, in order to provide economic incentives to trade, generic information on marginal abatement costs for each SIU should be collected, perhaps by the POTW or the delegated state agency, and made available to potential trading partners. Finally, pretreatment ETPs may be more appropriate for larger POTWs with more SIUs, although trading activity within such programs may still be restricted if SIUs are direct competitors and thus unwilling to trade.

LEGAL AUTHORITY

Standards, Goals, and/or Objectives

Existing MAILs and local pretreatment discharge limits can serve as the basis for designing and implementing a pretreatment ETP for Stillwater's POTW. It was assumed that one or more of the pollutants subject to local discharge limits would be appropriate for inclusion in the trading program and that the designated limits would be used to evaluate proposed trades among SIUs.

Legal Support

The Clean Water Act does not explicitly authorize effluent trading, thus increasing the uncertainty and perceived risk associated with ETP participation. However, according to its "Draft Framework for Watershed-Based Trading," USEPA encourages the use of effluent trading to meet local pretreatment limits (U.S. Environmental Protection Agency, 1996). In addition, although the Stillwater Industrial Pretreatment Program and the corresponding ordinance do not address pretreatment ETPs, existing procedures for issuing, administering, and enforcing SIU wastewater discharge permits could be modified to accommodate such trading. Any necessary modifications would need to be approved by the delegated state agency and/or USEPA (U.S. Environmental Protection Agency, 1998a).

Administering Agency

The City of Stillwater has the legal authority to administer and enforce the existing pretreatment program. As shown in Figure 11.1, administrative responsibilities have been divided among the City Manager, City Attorney, and the Departments of Environmental and Safety Services, Water/Wastewater, and Public Works. The pretreatment coordinator in the Department of Environmental and Safety Services is primarily responsible for program implementation. Since an ETP for SIUs could easily be integrated into the existing pretreatment program, it was assumed that the Department of Environmental and Safety Services would administer the trading program.

Agency Authority

SIUs in the Industrial Pretreatment Program are legally required to meet the effluent limitations specified in their wastewater discharge permits. As a result, waivers, variances, and other "loopholes," which could negatively affect ETP performance by increasing total pollutant loadings and reducing the number of potential trading opportunities, were not identified.

Summary of Legal Authority

As shown in Table 11.10, the legal authority component of the qualitative model was assigned a rating of "3," since the pretreatment ETP can be based on existing MAILs and local discharge limits, legal authority for the ETP can be assigned to an existing agency, and no "loopholes" which could negatively affect ETP performance were identified. However, despite federal support of pretreatment trading to meet local discharge limits, ETPs have not been formally recognized as an acceptable compliance alternative, and the resulting risk and uncertainty associated with ETP participation may decrease trading activity. Amending the Clean Water Act and the local pretreatment program to explicitly support effluent trading should encourage ETP participation.

ADMINISTRATIVE ACCEPTABILITY AND CAPABILITY

Knowledge and Information

In general, extensive data are required to design and operate effective ETPs. However, sufficient information regarding pollutant loadings for SIUs in the Industrial Pretreatment Program in Stillwater should be available in completed wastewater survey forms and monthly compliance monitoring reports. In addition, since adverse environmental effects are not anticipated as a result of pretreatment trading, information is not required to support water quality or aquatic ecosystem modeling efforts or to design effective monitoring programs. However, trades should still be evaluated to ensure that they will not affect the wastewater collection system, POTW, or worker health and safety. Trading activity may also be affected by a lack of information on applicable abatement technologies and pollution prevention techniques that could be used to generate PRCs. Such information may be difficult to collect and analyze, particularly for the small- or medium-sized SIUs with limited environmental staff and compliance budgets.

Willingness to Use ETPs

In order for sources to be willing to rely on effluent trading to meet their compliance obligations, pertinent authorities must actively promote ETPs as an acceptable alternative to more traditional forms of water quality management. For the Stillwater case, it was assumed that federal, state, and local authorities would encourage pretreatment trading activity since such trades should reduce environmental compliance costs for regulated sources without increasing pollutant loadings to the POTW or substantially increasing regulatory burdens. In particular, the Industrial Pretreatment Program staff in Stillwater are "innovative" and thus may be more willing to accept effluent trading as a compliance alternative (Cupples, 1999).

In addition to regulatory acceptance, SIU managers must support pretreatment ETPs. It was assumed that these managers would participate in the ETP if trading would reduce their environmental compliance costs. Pretreatment trades could also be used to accommodate facility expansion while eliminating the need to install additional abatement equipment.

Resources

Like any regulatory program, ETPs require sufficient technical and financial resources to function successfully. The local sewer use ordinance and the Industrial Pretreatment Program address how the current pretreatment program is to be staffed and funded (City of Stillwater, 1993). Since pretreatment trades can be incorporated into existing permitting procedures and the size of the potential trading market is limited, it was assumed that the city's current resources would be sufficient to support an ETP. In addition, ETP funding may be supplemented through application fees for proposed trades and/or annual fees assessed to trading partners.

Summary of Administrative Acceptability and Capability

As shown in Table 11.10, the administrative acceptability and capability component of the qualitative model was assigned a rating of "3," since sufficient information is available to design and implement a pretreatment ETP and technical and financial resources should be available to support trading activities. In addition, both permitting authorities and SIU managers are expected to be receptive to and promote pretreatment trading. However, detailed information on abatement technologies and pollution prevention measures, along with marginal abatement costs, which would be required to evaluate potential trading opportunities, is not readily available. SIUs may be able to overcome this burden by sponsoring site-specific studies, which could be conducted by facility personnel and/or consultants. Alternatively, general information on abatement alternatives and costs for each type of SIU could be provided by the Department of Environmental and Safety Services, state and federal regulatory officials, trade organizations, and/or other pertinent stakeholders.

CONCLUSIONS REGARDING THE FEASIBILITY OF AN ETP FOR THE STILLWATER POTW

The first five components of the qualitative model were used to assess the feasibility of a pretreatment ETP for SIUs in Stillwater's Industrial Pretreatment Program. Four components (pollutant type, trading market size and characteristics, legal authority, and administrative acceptability and capability) received ratings of "3" or "4," thus indicating partial or full compliance with the component-specific criteria questions. However, the watershed suitability component of the qualitative model received a score of "2," thus indicating only minimal compliance with the relevant criteria questions. Overall, pretreatment trading may not be a cost-effective compliance option at this time for the Stillwater POTW due to the limited size of the potential trading market. In addition, program development may be delayed by the lack of detailed information on the abatement technologies, pollution prevention measures, and marginal abatement costs that would be suitable for SIUs in the Industrial Pretreatment Program.

Even though a pretreatment ETP may not be a feasible water quality management option at this time for the Stillwater POTW, data from the Industrial Pretreatment Program were used to answer the criteria questions associated with the remaining five model components (specific policies, procedures, and trading rules; pre- and post- trade monitoring; enforcement mechanisms; program evaluation; and public involvement), thus illustrating design and implementation concerns that should be addressed in any pretreatment ETP. Since the local pretreatment program at Stillwater's POTW is primarily based on federal regulations, the identified concerns should be applicable to POTWs across the United States.

In general, pretreatment ETPs should be simpler to design, implement, and administer than point-point, point-nonpoint, and nonpoint-nonpoint source trading programs. In addition, the complexity, uncertainty, and transaction costs associated with participating in pretreatment ETPs should be relatively low, thus encouraging trading activity. For example, criteria questions related to geographic boundaries, flow variations, pollutant classification, inter-pollutant trading, and unique circumstances can be eliminated from the qualitative model. In addition, the criteria question related to environmental effects was modified to focus on impacts within the wastewater collection system, while the criteria question related to pollutant forms was modified to include potential effects on POTW operation. Finally, criteria questions related to conditions encouraging or discouraging effluent trading; relative contributions; marginal abatement costs; unwillingness to trade; standards, goals, and/or objectives; and knowledge and information were modified slightly to include terminology specific to local pretreatment programs.

ETP DESIGN CONSIDERATIONS FOR THE STILLWATER POTW

The criteria questions associated with the second five model components (specific policies, procedures, and trading rules; pre- and post-trade monitoring; enforcement mechanisms; program evaluation; and public involvement) were used to identify general concerns that should be addressed when designing a pretreatment ETP for the Stillwater POTW. Whenever possible, the discussion that follows was based on facility-specific information. In addition, the following assumptions were made: (1) pretreatment effluent trading is a feasible water quality management option for SIUs in Stillwater's Industrial Pretreatment Program; (2) arsenic, cadmium, chromium, copper, cyanide, lead, mercury, nickel, phenol, silver, and zinc are the only pollutants included in the ETP; (3) the ETP would be based on local pretreatment limits established by the Department of Environmental and Safety Services and approved by ODEQ and USEPA;

and (4) trading to meet categorical pretreatment standards would be prohibited.

SPECIFIC POLICIES, PROCEDURES, AND TRADING RULES

Nonpoint Source Variability

Pretreatment ETPs are only applicable to SIUs that discharge their effluent to POTWs. Therefore, nonpoint sources are ineligible to participate in pretreatment trading programs, and this criteria question does not apply.

ETP Procedures

Maximum Allowable Pollutant Loading

Pretreatment ETPs should be based on POTW-specific MAILs and local pretreatment discharge limits. It was assumed that the MAILs and local limits for Stillwater's pretreatment program have been developed in accordance with USEPA guidance documents and subsequently approved by ODEQ and USEPA (Industrial Economics, Inc., and Science Applications International Corporation, 1994).

Loading Allocations

Loading allocations determine the quantity of pollutants that each SIU may discharge to the POTW. Accordingly, these allocations enable SIUs, by comparing current discharges to their allocations, to determine their most cost-effective compliance alternatives. Stillwater's local pretreatment discharge limits apply to all IUs in the service area of the POTW (City of Stillwater, 1993). In addition, sufficient flow information is available to convert effluent concentrations to pollutant loadings, which should simplify ETP administration and participation. However, even though uniform concentration limits are relatively simple to develop and enforce, they may inflate environmental compliance costs for some SIUs; therefore, other allocation methods may be needed to establish an effective ETP.

Types of Trades

Since this case study was limited to the feasibility of pretreatment trading, this sub-question does not apply. However, SIUs with multiple outfalls may be eligible for intraplant ETPs, while the operators of POTWs may want to explore point-point and/or point-nonpoint source effluent trading within their specific watersheds.

Trading Ratio(s)

Trading ratios determine the rate-of-exchange for PRCs; for example, one SIU may be required to offset one pound of its pollutant loading by purchasing two pounds of PRCs from other SIUs in the service area of the POTW. Since sufficient information exists to accurately quantify pollutant loadings from the SIUs in the Stillwater Industrial Pretreatment Program, uncertainties associated with calculating PRCs are minimal, and trading ratios for pretreatment ETPs could probably be established at 1:1, assuming equal environmental concerns regarding the tradeable metals. ETP designers may wish to increase trading ratios in order to offset discharges in different parts of the wastewater collection system, to reduce total pollutant loadings to the POTW, and/or to create a "reserve pool" of PRCs that can be allocated to new or expanding SIUs. However, since trading ratios greater than 1:1 may reduce or even eliminate economic incentives to trade, such ratios should be carefully evaluated.

Operational Aspects

Quantifying and Certifying PRCs

To determine the quantity of PRCs that can be traded, sources in a pretreatment ETP must be able to compare their applicable effluent limitations and current pollutant loadings. Local pretreatment limits for each SIU are specified in its wastewater discharge permit, and sufficient monitoring data exists to determine current pollutant loadings from each SIU in the service area of the POTW. Certification of PRCs is intended to reduce the uncertainty associated with ETP participation, particularly for purchasers or lessors of PRCs. However, certification of pretreatment PRCs is probably unnecessary since uncertainties associated with quantifying such PRCs are greatly reduced due to the quantity and quality of extant data.

Environmental Impacts

Since pretreatment trades do not allow total pollutant loadings to the POTW to increase, no adverse water quality or aquatic ecosystem effects are anticipated. Therefore, ambient water quality modeling and monitoring should not be required, and this sub-question does not apply. However, proposed trades should still be evaluated in order to identify potential adverse effects to the wastewater collection system or POTW.

Application Procedures

Stillwater's Industrial Pretreatment Program and the local sewer ordinance contain procedures that must be used whenever SIUs apply for wastewater discharge permits (City of Stillwater, 1993). Therefore, it was assumed that application procedures for proposed pretreatment trades, which involve modifying each trading partner's permit to reflect changes in local limits, would be based on existing procedures. Since Environmental and Safety Services staff are already familiar with the characteristics of each SIU, the information required in the trading application may be reduced, thus encouraging trading activity.

Evaluation of Proposed Trades

Similarly, administrative procedures to evaluate proposed pretreatment trades could be based on existing policies and procedures, including public notice requirements, that are currently used to review wastewater discharge permit applications (City of Stillwater, 1993).

Time Periods

To reduce the uncertainty associated with ETP participation, the length of time that a trade will be in effect should be specified. Since a pretreatment ETP for SIUs in Stillwater's Industrial Pretreatment Program would be based on applicable local limits in the trading partners' discharge permits, it was assumed that trades would remain in effect until one, or both, permits expire (5 years) and renewals are sought. The trade could then be renewed, subject to the approval of both trading partners and Environmental and Safety Services.

Banked or Shutdown Credits

SIUs could generate banked credits by saving excess PRCs for their own future use and/or shutdown credits by closing part or all of their operations. To encourage trading activity, SIUs in the Industrial Pretreatment Program should be able to use banked or shutdown PRCs at any time as long as there will be no adverse effects on the wastewater collection system, POTW operations, or worker health and safety. In addition, ETP designers may wish to require that a certain percentage of the PRCs in each trade be banked; such credits could subsequently be re-allocated to new SIUs in the POTW's service area or retired to permanently reduce pollutant loadings to the POTW. For example, IUs that participate in the PVSC trading program described in an earlier section of this chapter, are required to bank 20 percent of the PRCs involved in a trade, and the use of shutdown credits is prohibited (U.S. Environmental Protection Agency, 1998b).

Reporting and Recordkeeping

Current reporting and recordkeeping provisions in local pretreatment regulations should be sufficient to ensure that applicable effluent limitations are not violated and other provisions of trading agreements are fulfilled (City of Stillwater, 1993). Therefore, such requirements would not need to be expanded to accommodate pretreatment trading activity.

Non-dischargers

Pretreatment ETPs apply only to SIUs that discharge their effluent to POTWs. Therefore, non-dischargers, such as non-governmental organizations (NGOs), environmental groups, and private citizens, are ineligible to participate in such programs, and this criteria question does not apply.

Summary of Specific Policies, Procedures, and Trading Rules

Pretreatment ETPs may be simpler to design, implement, and operate than point-point, point-nonpoint, and nonpoint-nonpoint ETPs because: (1) pretreatment trades should not cause or contribute to any adverse water quality or aquatic ecosystem effects; (2) sufficient information is available to accurately quantify pollutant loadings and PRCs; and (3) all potential trading partners are regulated by wastewater discharge permits containing applicable effluent limitations and monitoring, reporting, and recordkeeping requirements. If the qualitative model is to be used to design pretreatment ETPs, criteria questions and sub-questions related to nonpoint source variability, types of trades, environmental impacts, and non-dischargers can be eliminated, while most of the other sub-questions can be based on regulations, policies, and procedures that govern the existing local pretreatment program. In addition, certification can be excluded from the sub-question related to quantifying and certifying PRCs.

PRE- AND POST-TRADE MONITORING

Monitoring Responsibilities

Monitoring responsibilities for Stillwater's Industrial Pretreatment Program have been clearly assigned to SIUs and to the Department of Environmental and Safety Services (City of Stillwater, 1993, 1997a, 1997b, 1997c, 1998, and undated). SIUs are required to monitor their effluent in accordance with the terms of their discharge permits, while the Department of Environmental and Safety Services is required to inspect each SIU's facility and sample its effluent at least once per year, thus independently confirming the compliance status of each SIU. Therefore, existing monitoring requirements should be sufficient for evaluating ETP performance and ensuring that SIUs are complying with the terms of their trading agreements, including revised effluent limitations. In addition, since pretreatment ETPs should not result in any adverse environmental effects, this criteria question can be modified to eliminate responsibilities related to ambient water quality monitoring.

Monitoring Protocols

Specific monitoring protocols are needed to reduce technical uncertainty and to ensure consistency within the trading program. Wastewater discharge permits specify monitoring requirements, including sampling location, frequency, and type, for each SIU in the Stillwater Industrial Pretreatment Program (City of Stillwater, 1997a, 1997b, 1997c, 1998, and undated). In addition, all wastewater sampling and analyses must be performed in accordance with federal regulations, and laboratories must be certified by the Oklahoma Water Resources Board (City of Stillwater, 1993). Sampling and analytical techniques that are not identified in federal regulations must still be approved by USEPA. Once again, this criteria question can be modified to eliminate concerns regarding ambient water quality monitoring.

Monitoring and Trading Activity

Since potential trading partners are already required to monitor their effluent, additional monitoring should not be necessary to quantify PRCs or to determine compliance with the terms of trading agreements, thus reducing transaction costs and encouraging trading activity. Therefore, this criteria question does not apply to pretreatment ETPs.

Summary of Pre- and Post-Trade Monitoring

Like the specific policies, procedures, and trading rules component of the qualitative model, this component is also relatively simple for pretreatment ETPs. For example, under Stillwater's Industrial Pretreatment Program, monitoring responsibilities have already been assigned to SIUs and to Environmental and Safety Services, and appropriate monitoring protocols have been established. As another example, successful pretreatment trades should not cause any adverse environmental effects, thus allowing concerns related to ambient water quality monitoring to be eliminated from the criteria questions associated with monitoring responsibilities and monitoring protocols. Finally, since supplemental monitoring is not required for pretreatment trades, the criteria question regarding monitoring and trading activity can be deleted from the qualitative model.

ENFORCEMENT MECHANISMS

Effective Enforcement

Sufficient enforcement mechanisms, including a response guide developed to standardize penalties for noncompliance, exist as a basis for the enforcement of all aspects of Stillwater's Industrial Pretreatment Program. In addition, ODEQ and USEPA retain the legal authority to directly enforce violations of discharge limits or other pretreatment requirements against any IU. In general, implementing pretreatment trades would involve modifying the applicable local discharge limits for participating SIUs, but no additional monitoring, reporting, or recordkeeping would be required. Therefore, existing procedures should be sufficient as enforcement mechanisms for pretreatment ETPs.

Uncontrollable Circumstances

On occasion, one or more SIUs may exceed applicable discharge limitations due to uncontrollable circumstances, such as pump failure, abatement equipment malfunction, or unusually heavy rainfall. Both federal regulations and the local sewer use ordinance contain provisions making "upset" and "bypass" an acceptable defense for certain types of noncompliance (U.S. Environmental Protection Agency, 1998a; and City of Stillwater, 1993). However, upset provisions are limited to violations of categorical pretreatment standards, while bypass provisions are only applicable in very specific circumstances. As a result, these provisions are unlikely to apply to violations associated with pretreatment trades. However, conceptually similar provisions could be developed for pretreatment ETPs, thus reducing the risk of ETP participation and encouraging trading activity.

Summary of Enforcement Mechanisms

Once again, designing and implementing effective enforcement mechanisms for pretreatment ETPs should be relatively simple since existing procedures are assumed to be sufficient to ensure that: (1) discharge limits are not exceeded; (2) other provisions of trading agreements are met; and (3) the overall objectives of the pretreatment ETP are achieved. In addition, procedures for addressing trading violations due to uncontrollable circumstances can be based on extant upset and bypass provisions, further simplifying ETP design.

PROGRAM EVALUATION

Responsibilities for ETP Evaluation

Pretreatment trades should be periodically evaluated to ensure that they are successfully reducing environmental compliance costs while maintaining or reducing pollutant loadings to the POTW. In addition, pretreatment ETPs may need to be modified to reflect changes in the local pretreatment program. All POTWs are required to review their local limits at least once every five years as part of their permit renewal process (Industrial Economics, Inc., and Science Applications International Corporation, 1994). USEPA also recommends that local limits and/or pretreatment programs be reviewed, and revised if necessary, whenever circumstances at the POTW or within its service area change substantially.

For this case study, it was assumed that the Department of Environmental and Safety Services would be primarily responsible for evaluating and modifying local discharge limits and other pretreatment requirements. It was also assumed that evaluations of pretreatment trades and ETP performance would be incorporated into existing review procedures.

Review Frequency

It was assumed that evaluations of individual trades and overall ETP effectiveness would be incorporated into existing procedures for reviewing local discharge limits and pretreatment programs. Therefore, the pretreatment ETP would be evaluated every five years and more frequently if circumstances at the POTW or within its service area changed substantially.

ETP Performance Criteria

To simplify and standardize the review process, the criteria to be used to evaluate ETP effectiveness should be clearly specified. Potential evaluative criteria for a pretreatment ETP at Stillwater's POTW include: (1) whether all SIUs are in compliance with relevant discharge limitations and other permit conditions; (2) the level of trading activity as reflected by both the number of trades and the involved PRCs; (3) the administrative costs of ETP design, implementation, and operation; (4) the magnitude of compliance cost savings; and (5) other advantages and disadvantages of trading.

Summary of Program Evaluation

Once again, the scope of pretreatment ETPs simplifies this component of the qualitative model for designing and implementing ETPs. In this case, it was assumed that the Department of Environmental and Safety Services would be primarily responsible for ETP evaluation and modification, subject to review and approval by ODEQ and USEPA, and that program evaluations would be incorporated into extant review procedures. Potential review criteria include compliance with discharge limitations and reduced environmental compliance costs.

PUBLIC INVOLVEMENT

Active Involvement

In general, as many stakeholders as possible should be involved in ETP design and operation in order to encourage ETP participation and acceptance. However, since all trades occur within the boundaries of a POTW's service area, the number of stakeholders may be significantly reduced for pretreatment ETPs. Major stakeholders in the Stillwater pretreatment ETP would include Environmental and Safety Services staff; the operator and staff of the POTW; and managers, engineers, and employees at each SIU in the POTW's service area. Other POTWs and municipalities may also be involved, particularly if they are interested in implementing their own ETPs. However, as long as the POTW does not violate its own NPDES permit limitations, permitting agencies, municipalities, and the general public are expected to remain relatively indifferent to pretreatment ETPs. As a result, the need for active involvement can be limited to the major stakeholders identified above.

Public Support

SIUs in the Stillwater Industrial Pretreatment Program are expected to support a pretreatment ETP because it may reduce their environmental compliance costs, while other stakeholders are expected to be indifferent as long as ambient water quality, POTW operations, the wastewater collection system, and worker health and safety are not adversely affected. In addition, Environmental and Safety Services staff, who would be charged with administering a pretreatment ETP, should be indifferent as long as trading does not significantly increase their regulatory burden. Therefore, the need for public support can once again be limited to major stakeholders.

Educational and/or Outreach Efforts

Educational and/or outreach programs should be designed to promote effluent trading as a compliance alternative, thus encouraging trading program acceptance and participation. Programs explaining the concepts and benefits of pretreatment trading should be specifically tailored for the SIUs in the Industrial Pretreatment Program. In addition, brief reports describing the POTW's ETP should be prepared and distributed to major stakeholders; such reports may also be distributed to other SIUs and municipalities in order to encourage effluent trading activity. For example, the USEPA published a report on the PVSC trading program to promote the design and implementation of pretreatment ETPs at other POTWs in the United States (U.S. Environmental Protection Agency, 1998b).

Summary of Public Involvement

Pretreatment ETPs apply to SIUs that discharge to the same POTW and do not increase pollutant loadings to receiving waters. As a result, the number of concerned stakeholders decreases dramatically, and the criteria questions associated with the public involvement component of the qualitative model can typically be limited to SIUs and relevant municipal agencies. In general, SIUs are expected to support pretreatment ETPs, and educational and outreach programs should be designed to address the specific concerns of all stakeholders.

CONCLUSIONS REGARDING ETP DESIGN FOR THE STILLWATER POTW

The previous five sections have focused on the final components of the qualitative model (specific policies, procedures, and trading rules; pre- and post-trade monitoring; enforcement mechanisms; program evaluation; and public involvement) to identify issues of concern and elements that should be included in any pretreatment ETP for the Stillwater POTW. In general, designing and implementing a pretreatment ETP should be relatively simple since total pollutant loadings do not increase, adverse environmental effects are not anticipated, and trading activity is limited to SIUs within the POTW's service area. As a result, the following criteria questions and sub-questions associated with the qualitative model can be eliminated: (1) nonpoint source variability; (2) types of trades; (3) environmental impacts; (4) non-dischargers; and (5) monitoring and trading activity. In addition, two criteria questions and one sub-question were modified to eliminate concerns relative to ambient water quality monitoring and certifying PRCs, respectively. Finally, the following criteria questions and sub-questions were slightly modified to focus specifically on pretreatment ETPs: (1) maximum allowable pollutant loading; (2) loading allocations; (3) effective enforcement; (4) uncontrollable circumstances; (5) active involvement; (6) public support; and (7) educational and/or outreach efforts.

SUB-MODEL SPECIFIC TO PRETREATMENT ETPs

Based on the information summarized in the previous sections, the qualitative model for designing and implementing ETPs, which originally contained 10 components and 37 criteria questions, was modified specifically for pretreatment ETPs. These modifications are summarized in Table 11.11. Eleven criteria questions could be incorporated directly into the model for pretreatment ETPs, while eight questions could be deleted. In general, these deleted questions occur because program participation is limited to SIUs in the POTW's service area, and because pretreatment ETPs should not cause or contribute to any adverse environmental effects. In addition, ETP policies and procedures can be based on the local pretreatment program, while existing monitoring requirements and enforcement mechanisms should be sufficient to ensure that trading program objectives are achieved. Finally, 18 criteria questions were modified. However, only four required substantial changes in content; most were only slightly modified to focus specifically on pretreatment ETPs.

The specific policies, procedures, and trading rules component of the qualitative model contains two criteria questions, ETP procedures and operational aspects, with multiple sub-questions. Sub-questions related to types of trades and environmental impacts were eliminated from the qualitative model, while the sub-question relating to quantifying and certifying PRCs was modified to eliminate certification requirements. In addition, sub-questions related to

Table 11.11: Summary of Modifications to the Qualitative Model for Pretreatment ETPs

Criteria Questions	Applicable[a]			Question Modified for Pretreatment ETPs
	Y	N	M	
Watershed Suitability				
1. Geographic Boundaries		✓		
2. Flow Variations		✓		
3. Conditions Encouraging Effluent Trading			✓	Do conditions at the POTW and/or other circumstances within the POTW's service area encourage the use of an ETP?
4. Conditions Discouraging Effluent Trading			✓	Do conditions at the POTW and/or other circumstances within the POTW's service area discourage the use of an ETP?
Pollutant Type				
1. Pollutant Classification		✓		
2. Inter-pollutant Trading		✓		
3. Pollutant Forms			✓	Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality and/or POTW operations?
4. Environmental Effects			✓	Do the pollutant(s) of interest have the potential to adversely affect the wastewater collection system or the POTW?
5. Pollutant Limits	✓			

Table 11.11 (continued):

Criteria Questions	Applicable[a] Y	N	M	Question Modified for Pretreatment ETPs
Trading Market Size and Characteristics				
1. Pollutant Sources	✓			
2. Relative Contributions			✓	Are the relative contributions of all SIUs known?
3. Temporal Variations	✓			
4. Marginal Abatement Costs			✓	Are there significant differences in marginal abatement costs among SIUs?
5. Unwillingness to Trade			✓	Could SIUs within the POTW's service area be potentially unwilling to trade?
6. Unique Circumstances		✓		
Legal Authority				
1. Standards, Goals, and/or Objectives			✓	Are there local pretreatment discharge limits that can be used as a basis for the ETP?
2. Legal Support	✓			
3. Administering Agency	✓			
4. Agency Authority	✓			
Administrative Acceptability and Capability				
1. Knowledge and Information			✓	Does the administering agency have sufficient knowledge and information to designate the MAIL, to allocate portions of the MAIL to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades as well as the overall trading program?
2. Willingness to Use ETPs	✓			
3. Resources	✓			

Table 11.11 (continued):

Criteria Questions	Applicable[a]			Question Modified for Pretreatment ETPs
	Y	N	M	
<u>Specific Policies, Procedures, and Trading Rules</u>				
1. Nonpoint Source Variability		✓		
2. ETP Procedures				Have procedures been clearly defined for the following aspects of the ETP?
(a) Maximum Allowable Pollutant Loading			✓	(a) determination of the MAIL to the POTW
(b) Loading Allocations			✓	(b) allocate portions of the MAIL to all SIUs within the POTW's service area
(c) Types of Trades		✓		
(d) Trading Ratio(s)	✓			
3. Operational Aspects				Have rules or procedures been clearly defined for the following operational aspects of the ETP?
(a) Quantifying and Certifying PRCs			✓	(a) quantifying PRCs
(b) Environmental Impacts		✓		
(c) Application Procedures	✓			
(d) Evaluation of Proposed Trades	✓			
(e) Time Periods	✓			
(f) Banked or Shutdown Credits	✓			
(g) Reporting and Recordkeeping	✓			
4. Non-dischargers		✓		

Table 11.11 (continued):

Criteria Questions	Applicable[a]			Question Modified for Pretreatment ETPs
	Y	N	M	
Pre- and Post-Trade Monitoring				
1. Monitoring Responsibilities			✓	Are responsibilities for pre- and post-trade source monitoring clearly defined?
2. Monitoring Protocols			✓	Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for source monitoring?
3. Monitoring and Trading Activity		✓		
Enforcement Mechanisms				
1. Effective Enforcement			✓	Can trading agreements be effectively enforced for each SIU?
2. Uncontrollable Circumstances			✓	Should uncontrollable circumstances for SIUs be considered in the enforcement process?
Program Evaluation				
1. Responsibilities for ETP Evaluation	✓			
2. Review Frequency	✓			
3. ETP Performance Criteria	✓			
Public Involvement				
1. Active Involvement			✓	Were SIUs, municipalities, and regulatory agencies actively involved in ETP design and operation?
2. Public Support			✓	In general, did SIUs, municipalities, and regulatory agencies support the development of the ETP?
3. Educational and/or Outreach Efforts			✓	Does the ETP include any educational and/or outreach efforts designed to increase SIU support?

[a]Y = Question directly relates to pretreatment ETPs; N = question does not relate to pretreatment ETPs; M = question relates to pretreatment ETPs with listed modification

maximum allowable pollutant loading and loading allocations were modified to include pretreatment-specific terminology.

As the final step of the pretreatment model development, the remaining 29 criteria questions were renumbered and divided into two new components, ETP Feasibility and ETP Design Considerations. The revised model for pretreatment design and implementation is summarized in Table 11.12.

CONCLUSIONS FROM THIS CASE STUDY

The first objective of this case study was to test the applicability of a pretreatment ETP for SIUs that discharge their effluent to Stillwater's POTW. Accordingly, the first five components of the qualitative model were used to evaluate the feasibility of pretreatment trading at Stillwater's POTW, while the remaining five components were used to identify general and site-specific concerns and elements which should be addressed. Despite the presence of local pretreatment discharge limits and an existing agency capable of and willing to administer an ETP, pretreatment trading is probably not a feasible water quality management option for Stillwater's POTW due to the limited size of the potential trading market. In addition, information on abatement technologies, pollution prevention techniques, and marginal abatement costs that could be used to generate PRCs is not readily available. However, pretreatment trading may be an effective alternative to traditional command-and-control regulations for other POTWs, particularly if their service areas include larger numbers of SIUs in different industrial categories.

In general, pretreatment ETPs should be simpler to design, implement, and operate than point-point, point-nonpoint, and nonpoint-nonpoint source trading programs. First, they can be based on extant policies and procedures in the local pretreatment program, thus simplifying ETP design. In addition, pretreatment ETPs can be

Table 11.12: Revised Model for Pretreatment ETP Design and Implementation

<u>ETP Feasibility</u>

1. Do conditions at the POTW and/or other circumstances within the POTW's service area encourage the use of an ETP?[a]

2. Do conditions at the POTW and/or other circumstances within the POTW's service area discourage the use of an ETP?[a]

3. Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality and/or POTW operations?[b]

4. Do the pollutant(s) of interest have the potential to adversely affect the wastewater collection system or the POTW?[b]

5. Can mass- or concentration-based limits be established for the pollutant(s) of interest?

6. Have all sources of the pollutant(s) of interest been identified?

7. Are the relative contributions of all SIUs known?[a]

8. Are temporal variations in loadings of the pollutant(s) of interest well understood?

9. Are there significant differences in marginal abatement costs among SIUs?[a]

10. Could SIUs within the POTW's service area be potentially unwilling to trade?[a]

11. Are there local pretreatment discharge limits that can be used as a basis for the ETP?[a]

12. Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so?

13. Is there an existing agency with sufficient authority to implement and enforce an ETP, can such authority be conferred on an existing agency, or can such an agency be created?

14. Does the implementing agency have sufficient authority to require all contributing sources to meet their discharge allocations?

15. Does the administering agency have sufficient knowledge and information to designate the MAIL, to allocate portions of the MAIL to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades as well as the overall trading program?[a]

Table 11.12 (continued):

ETP Feasibility, continued

16. Is the administering agency willing to use effluent trading as a management strategy to supplement traditional regulation?

17. Does the administering agency have sufficient resources to design and implement an ETP?

ETP Design Considerations

1. Have procedures been clearly defined for the following aspects of the ETP?

   (a) determination of the MAIL to the POTW[a]

   (b) allocate portions of the MAIL to all SIUs within the POTW's service area[a]

   (c) trading ratio(s)

2. Have rules or procedures been clearly defined for the following operational aspects of the ETP?

   (a) quantifying PRCs[b]

   (b) application procedures for proposed trades

   (c) administrative procedures for the evaluation of proposed trades

   (d) time periods that trades remain in effect

   (e) treatment of banked or shutdown credits

   (f) reporting and recordkeeping requirements

3. Are responsibilities for pre- and post-trade source monitoring clearly defined?[b]

4. Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for source monitoring?[b]

5. Can trading agreements be effectively enforced for each SIU?[a]

6. Should uncontrollable circumstances for SIUs be considered in the enforcement process?[a]

7. Are responsibilities for evaluating ETP performance clearly defined?

8. How often will the ETP be reviewed?

9. Have the criteria that will be used to evaluate ETP performance been specified?

Table 11.12 (continued):

ETP Design Considerations, continued	
10.	Were SIUs, municipalities, and regulatory agencies actively involved in ETP design and operation?[a]
11.	In general, did SIUs, municipalities, and regulatory agencies support the development of the ETP?[a]
12.	Does the ETP include any educational and/or outreach efforts designed to increase SIU support?[a]

[a]Question was slightly modified to accommodate pretreatment ETPs

[b]Question was substantially modified to accommodate pretreatment ETPs

implemented by local and/or state agency staff who are currently administering the pretreatment program and are already familiar with the characteristics of SIUs in the service area of the POTW. Second, sufficient information is typically available for accurately quantifying pollutant loadings and PRCs, thus allowing the evaluation of potential trading opportunities and ETP effectiveness. Finally, since IUs discharge their effluent to POTWs instead of receiving waters, pollutants with localized effects (such as metals and other toxics) may be eligible for inclusion in pretreatment ETPs, and ambient water quality modeling and monitoring requirements can be greatly reduced or eliminated, thus encouraging ETP participation.

The second objective of this case study was to develop a sub-model, based on the original qualitative model (Table 11.8), that could be used to design and implement pretreatment ETPs. Each criteria question was evaluated using general information relative to pretreatment trading and Stillwater's Industrial Pretreatment Program and then incorporated, deleted, or modified as appropriate. The revised model for designing and implementing pretreatment ETPs, which is shown in Table 11.12, contains two components, ETP Feasibility and ETP Design Considerations, and 29 criteria questions. Accordingly, this revised model can be used to evaluate existing pretreatment ETPs, to determine the feasibility of pretreatment trading for a particular POTW, and to highlight issues and concerns that should be addressed in site-specific ETP design.

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CHAPTER 12

OVERCOMING OR MITIGATING BARRIERS TO EFFLUENT TRADING PROGRAMS

INTRODUCTION

Effluent trading programs (ETPs), which allow water pollutant dischargers the flexibility to select the most cost-effective control alternatives for their specific situations, have been proposed as a market-based approach for achieving ambient water quality standards within a watershed. In addition, since pollutant reductions below mandated levels can be "banked" for future use or sold to other dischargers within the watershed, ETPs continuously encourage pollution prevention and the development and installation of more efficient and cost-effective abatement technologies. Programs involving point-nonpoint and nonpoint-nonpoint trades may even reduce pollutant loadings from previously unregulated sources, thus improving overall water quality within the watershed (Canter, et al., 1998a).

Despite these advantages, the use of ETPs to date has been relatively limited. For example, a survey conducted in mid-1998 identified only 12 existing and 8 proposed ETPs (Canter, et al., 1998a). In addition, most of the identified programs are fairly new, and their geographic distribution is limited to the United States and Australia. The application of conceptually similar programs, primarily for air quality, water quantity, and land development management in the United States, has also been fairly limited. In order for ETPs to realize their full potential, the informational and institutional barriers that may affect ETP planning and implementation must be identified and minimized.

The focus of this chapter is on barriers to ETPs and measures that could be used to overcome or mitigate such barriers. To begin, barriers which have been identified for technological innovation and pollution prevention efforts are identified. This was done since innovation and prevention represent options to traditional command-and-control technologies for water pollutant discharges, as does effluent trading. These barriers are then compared to identified barriers for ETPs, with the latter based on literature reviews related to comparable trading programs, and a recent survey of the status of ETPs. Based on this comparison, nine common barriers are identified between technological innovation, pollution prevention, and ETPs. Further, seven unique barriers exist for ETPs. The sections herein on common and unique barriers incorporate the suggested measures mentioned above.

BARRIERS TO TECHNOLOGICAL INNOVATION AND POLLUTION PREVENTION

This section is based on the hypothesis that common barriers which affect the development and use of innovative environmental technologies and pollution prevention techniques may also represent barriers to the development of ETPs. Similar barriers may exist for two reasons. First, technological innovation, pollution prevention, and ETPs are all non-traditional ways of meeting environmental compliance obligations. Second, in order to establish an active ETP, some pollutant sources in the watershed must be able to reduce their discharges below permitted levels at a relatively inexpensive cost. Therefore, sources may need to rely on pollution prevention techniques or technological innovations to attain these reductions.

Barriers to Technological Innovation

Innovation as used herein can be defined as "the first commercial use of a new technical idea" (National Advisory Council for Environmental Policy and Technology, 1992). In order for such innovation to be successful, a diffusion process must occur. This process refers to the spread and adoption of a new technical idea following its first successful commercial use (National Advisory Council for Environmental Policy and Technology, 1992). Technological innovations can be classified into process innovations, which include new or improved production techniques, or product innovations, which encompass new or improved consumer products (Kemp, et al., 1994). Technological innovations can be further subdivided into radical or incremental groups, with the former referring to innovations which are significantly different from existing practices, and the latter representing only minor improvements to such practices.

The benefits of innovative environmental technologies include reducing the quantity of pollutants released or waste generated, decreasing environmental compliance costs, and increasing production efficiency (U.S. Environmental Protection Agency, 1998b). Despite these apparent benefits, however, there is a general consensus that the current rate of innovative technology development and adoption is insufficient. A review of the financing available for environmental innovation lends support to this perspective. For example, even though the size of the environmental industry increased from $125 billion in 1988 to $181 billion in 1996, the venture capital available for investment in environmental technologies decreased from $120 million to only $30 million during the same period (U.S. Environmental Protection Agency, 1998b). Environmental mutual funds and government funding for innovation have also suffered similar declines.

The limited development and use of innovative environmental technologies may be due, at least in part, to the scientific, economic, and institutional barriers listed in Table 12.1. The listed barriers were identified in several targeted studies. The

Table 12.1: Barriers to the Implementation of Environmental Technology Innovations*

<u>Scientific Barriers:</u>

- Regulators, firms, and the public may lack information on the availability, cost, and technical performance of innovative environmental technologies.
- Regulators and firms may lack the technical expertise needed to evaluate technological innovations (National Advisory Council for Environmental Policy and Technology, 1991).
- Research on new or improved environmental technologies is limited; this limitation may be partially due to the small size of individual firms within certain industrial user groups (like dry cleaning), internal and external competition, and a lack of government funding (Environmental Law Institute, 1998).
- The lack of dedicated testing centers, demonstration sites, and approved test methods may make it difficult to adequately evaluate the performance of technological innovations.

<u>Economic Barriers:</u>

- The implementation of innovative technologies may be limited by the high capital costs of design, the costs of retrofitting, and the lack of capital turnover.
- The costs and delays associated with the testing, permitting, and use of new environmental technologies may discourage innovation.

<u>Institutional Barriers:</u>

- Technology-based standards may result in technological lock-in and provide no incentives to reduce pollutant discharges below relevant standards.
- Medium-specific environmental standards may discourage the development of innovative technologies that would reduce total pollutant discharges (Environmental Law Institute, 1998).
- The testing and development of innovative technologies may be limited by inconsistent rules and requirements among permitting jurisdictions and by a lack of coordination among different regulatory bodies.
- Unclear or inconsistent regulations, the potential for new regulations, and unpredictable government policy may limit the development and use of technological innovations.
- Innovative technology waivers and verification programs, which are designed to promote the introduction of new environmental technologies, are not effective (Environmental Law Institute, 1998). In addition, firms are reluctant to rely on technological innovations to meet their compliance obligations in the absence of "soft landing" policies, which would protect them from charges of non-compliance if the innovation failed (Derzko, 1996).

Table 12.1 (continued):

Institutional Barriers (continued):

- Current intellectual property systems may be unable to prevent the imitation of technological innovations by competitors (Kemp, et al., 1994; Derzko, 1996). In addition, the current requirements of the U.S. patent system, including the costs and time required to file a patent application, may discourage innovation.

- Statutory and regulatory requirements may allow insufficient time to test and/or implement innovative technologies (U.S. Environmental Protection Agency, 1998b; Rothwell, 1992).

- Technological innovation is negatively affected by a lack of consistent enforcement among different permitting jurisdictions and/or over time (National Advisory Council for Environmental Policy and Technology, 1991; National Environmental Technology Applications Corporation, 1990).

- Regulatory agencies may tend to deny permit applications for innovative environmental technologies because their permit writers do not have enough time to thoroughly review the application or are too inexperienced; these limitations may be due, in part, to the rapid turnover of regulatory personnel.

- In general, new technologies are not readily integrated into the permitting process (U.S. Environmental Protection Agency, 1998b).

- The conservative nature of governmental agencies and firms may make regulators and executives reluctant to assume the environmental and economic risks associated with innovative technologies (Environmental Law Institute, 1998).

- In general, there are no financial rewards or other incentives to implement or permit innovative environmental technologies.

- Vested interests, such as the local perspective of some politicians and the short-term, profit-maximizing strategies of some firms, may negatively affect the development of technological innovations (Miller, 1991). Technological innovations may also be affected by inertia, which can be described as a tendency to prefer the familiar and to accept prevailing conditions.

- Innovative environmental technologies face a "double acceptance" barrier, i.e. they must be accepted by users and by multiple regulatory agencies (Environmental Law Institute, 1998; U.S. Environmental Protection Agency, 1998b).

- The lack of public trust contributes to the costs and delays associated with permitting innovative technologies.

*Citations are included with barriers that were identified in only one or two references. Each remaining barrier was identified in at least three of the following references: (1) Derzko, 1996; (2) Environmental Law Institute, 1998; (3) Kemp, et al., 1994; (4) Moore, 1994; (5) National Advisory Council for Environmental Policy and Technology, 1991; (6) National Environmental Technology Applications Corporation, 1990; (7) Rothwell, 1992; (8) Sanchez, 1997; (9) Stephens, 1997-1998; and (10) U.S. Environmental Protection Agency, 1998b.

scientific barriers are associated with the lack of information on the availability of such technologies, their costs and performance data, and the lack of technical expertise for their evaluation. Economic barriers include the necessary costs associated with testing, permitting, and implementing new technologies. Institutional barriers include disincentives or limitations in environmental laws and regulations, the presence of multiple permitting jurisdictions (particularly if their requirements for innovative technology approval are inconsistent), the lack of consistent enforcement across permitting jurisdictions, intellectual property systems which cannot protect innovations from imitation, the tendency for regulatory agencies to avoid risk and uncertainty, the lack of incentives to approve and implement innovative technologies, and the lack of public trust.

Many of the barriers listed in Table 12.1 could be placed in more than one category. For example, the lack of research on innovative environmental technologies is both a scientific barrier, since it contributes to the lack of information on new technologies, and an economic one, since it may be due to the lack of funding. Similarly, the lack of public trust, classified as an institutional barrier in Table 12.1, may be regarded as a scientific barrier if public distrust is due to the lack of information needed to accurately predict the human health or environmental consequences of technology use. The lack of public trust could also be regarded as an economic barrier since regulators have responded to the public's concerns by increasing the requirements for, and therefore the costs of, testing and permitting innovative technologies.

In addition, the barriers identified in Table 12.1 may affect stakeholders differently. This point is illustrated by a recent survey of the perceptions of senior permit officials from state environmental regulatory agencies, managers at regulated facilities, and managers at firms which sell, lease, or recommend environmental technologies (U.S. Environmental Protection Agency, 1998b). All stakeholder groups agreed that the current regulatory and permitting system, the lack of credible information, inadequate financial resources, and historical business practices adversely affect the development and implementation of technological innovations. However, when asked to identify the most significant barrier, regulators identified the lack of credible information on technology alternatives, while vendors and users felt that inadequate financial resources and regulatory barriers were more important. Not surprisingly, stakeholders did not view barriers associated with their own activities as significant; for example, few facilities (firms) identified their own business practices, few regulators identified the permitting process, and few vendors targeted credible information on technological alternatives.

Barriers to Pollution Prevention

The U.S. Environmental Protection Agency has defined pollution prevention as "source reduction . . . and other practices that reduce or eliminate the creation of pollutants through increased efficiency in the use of raw materials, energy, water or other resources, or protection of natural resources by conservation" (National Advisory Council for Environmental Policy and Technology, 1993). This broad definition encompasses any technology or management practice which can be used to eliminate or minimize pollution before it is generated. Pollution prevention techniques range from the simple and straightforward, such as housekeeping, personnel training, and inventory control, to the use of complex technologies. Examples of more complicated techniques include the substitution of raw materials, the redesign of manufacturing processes, and the redesign or reformulation of consumer products (McDonald, et al., 1991).

The benefits of pollution prevention can include improved environmental quality, reduced environmental compliance costs, and positive employee and community relations (McDonald, et al., 1991). Firms that engage in pollution prevention projects can realize economic benefits by reducing waste treatment and disposal costs, decreasing their liability associated with waste treatment and disposal, and conserving raw materials and energy. In some cases, product quality may even be improved, thus increasing product sales. To serve as an example, the Pollution Prevention Pays program, which was initiated by 3M Corporation in 1975, illustrates economic and environmental benefits (Geffen, 1995). To be specific, over a 15 year period, 3M implemented more than 3,000 pollution prevention projects. Collectively, these projects reduced emissions of air pollutants by 120,000 tons, discharges of wastewater by one billion gallons, and the generation of solid waste by over 400,000 tons. From an economic perspective, 3M cumulatively saved almost $540 million in operating costs during this period.

However, applications research at both the federal and state levels indicates that pollution prevention programs are underutilized. This reluctance to use pollution prevention to meet or exceed environmental compliance obligations may be due to one or more scientific, economic, and institutional barriers as identified in Table 12.2. As was the case for Table 12.1, the listed barriers were identified in several targeted studies. Scientific barriers refer to the lack of information needed to identify, select, implement, and evaluate pollution prevention projects. Economic barriers include short-term economic goals that do not allow sufficient time to realize financial benefits, competition with other projects for limited resources, inaccurate market signals and cost/benefit analyses, and the concern that such projects may adversely affect sales by decreasing product quality. Institutional

Table 12.2: Barriers to Pollution Prevention*

<u>Scientific Barriers:</u>

- Firms often lack the information needed to identify, select, and implement the most appropriate pollution prevention projects.
- The lack of multi-media data collection, reporting, and analysis makes it difficult to evaluate current pollution prevention measures and to identify new opportunities for pollution prevention projects.
- Stakeholders may not believe that pollution prevention projects can provide both economic and environmental benefits.

<u>Economic Barriers:</u>

- Short-term economic goals may prevent pollution prevention projects with longer-term returns on investments.
- Major pollution prevention projects must compete with other projects, including environmental compliance projects, for limited financial resources. In particular, small and medium-sized enterprises may lack the technical staff and budgetary resources needed to evaluate pollution prevention options.
- Inaccurate market signals regarding environmental costs may mask the economic advantages of pollution prevention projects.
- Traditional cost/benefit analyses may reduce or eliminate the economic advantages of pollution prevention projects by ignoring the indirect benefits of pollution prevention or by mis-allocating costs associated with a specific process or product to generic categories.
- Firms may be concerned that pollution prevention projects will adversely affect product quality, thus reducing sales and profits. Firms may also be concerned about potential increases in equipment maintenance and downtime.

<u>Institutional Barriers:</u>

- Environmental regulations may specify the control technologies or management techniques to be used, thus precluding the consideration of pollution prevention alternatives.
- The end-of-pipe perspective of most environmental regulations tends to direct industrial and regulatory efforts toward pollution control.
- The media-specific nature of most environmental regulations may discourage the development of process-integrated programs, such as pollution prevention, that are designed to reduce total pollutant discharges.
- Uncertainty regarding future regulatory changes may discourage current pollution prevention efforts.

Table 12.2 (continued):

<u>Institutional Barriers (continued):</u>

- Statutory and regulatory inflexibility may hinder the development of facility-specific pollution prevention programs; for example, permit constraints may not allow sufficient time to implement and test new or experimental technologies.

- Pollution prevention activities may be discouraged when firms are regulated by multiple agencies at the municipal, county, state, and/or federal level, particularly if their environmental requirements are not consistent.

- Both regulators and industrial staff may lack incentives to consider pollution prevention programs. For example, the criteria frequently used to measure a regulator's performance, such as the number of inspections per year, cannot be easily adapted to incorporate pollution prevention.

- Organizational barriers may adversely affect pollution prevention programs, they include: (1) the lack of top management support and commitment; (2) the failure to ensure that all employees understand the significance of the pollution prevention policy and that all affected workers are involved in pollution prevention projects; (3) organizational structures that isolate environmental decision-making; and (4) habit and inertia.

- Technological developments in pollution prevention may be discouraged by the lack of long-term market opportunities and inadequate licensing and confidentiality provisions.

- The public may prefer more traditional methods of environmental compliance to pollution prevention projects. This preference may result from a general distrust of industry and regulatory agencies or from concerns regarding the human health or environmental consequences of failed pollution prevention projects.

- Widespread use of pollution prevention initiatives may be limited by the general perception that such initiatives apply only to large manufacturing processes and by a lack of consumer awareness.

Based on Geffen, 1995; McDonald, et al., 1991; and National Advisory Council for Environmental Policy and Technology, 1993 barriers include restrictive environmental laws and regulations, multiple permitting jurisdictions and their potential inconsistencies, the lack of environmental or economic incentives, organizational barriers, the lack of public trust, and the general perception that pollution prevention programs are only applicable to major manufacturing processes. It should be noted that many of these barriers are similar conceptually to those listed in Table 12.1.

Similar to the barriers in Table 12.1, many of the barriers in Table 12.2 could also be classified in multiple categories. For example, the failure of stakeholders to realize that pollution prevention projects can be both environmentally and economically beneficial is classified as a scientific barrier since it is probably due to lack of adequate information. However, it could be classified as an economic barrier if stakeholders consider only the expense of the projects without including the corresponding reductions in environmental compliance costs. Alternatively, if such failure is based on an entrenched attitude held by either regulated industries or governmental agencies, it could be classified as an institutional barrier. Also as was the case for the technological innovation barriers, the barriers in Table 12.2 are perceived differently by various stakeholder groups. For example, regulators may be more concerned about the quantity and quality of information available to evaluate the performance of a particular pollution prevention project, while industries may be more concerned about the costs of installing, operating, and maintaining the technology. Finally, it is important to note again that many of the barriers identified in Table 12.2 correspond to the barriers identified in Table 12.1. This result was expected because the reviewed literature focused primarily on the barriers to large pollution prevention projects which often involve the installation of innovative environmental technologies.

BARRIERS TO THE EFFECTIVENESS OF ETPs

Table 12.3 lists seventeen barriers that may influence ETP planning and performance (Edwards and Canter, 1998). They were identified through a comprehensive literature review focused on: (1) the conceptual basis for marketable permit programs; (2) the use of trading programs for air quality management, including emissions trading, lead trading, and allowance trading in the United States; and (3) the use of such programs for water quality management.

Scientific barriers occur due to inadequate information for planning and operating an ETP. Inadequate or incomplete information may also hamper ambient water quality modeling and/or the selection of monitoring techniques for predicting the environmental impacts of proposed trades. In addition, many of the institutional factors identified in Table 12.3 are heavily dependent upon data availability, or the lack thereof. For example, the information needed to allocate discharge rights includes, but is not limited to: (1) all sources that discharge the pollutant(s) of interest, including background sources, and their relative contributions to the total pollutant loading; (2) applicable control technologies for each source and their marginal abatement costs for potential tradeable pollutants; (3) pollutant chemistry in the water environment; and (4) hydrological characteristics of the trading area water body or watershed.

Economic barriers include an inadequate market size and composition; limited availability of technical and financial resources to design, implement, or participate in an ETP; and transaction costs. Transaction costs include the costs associated with: (1) identifying an appropriate trading partner; (2) negotiating a trading agreement; (3) submitting proposed trades for regulatory approval; and (4) any additional monitoring, reporting, or recordkeeping required as a trade condition.

Table 12.3: Barriers to the Effectiveness of ETPs (after Edwards and Canter, 1998)

<u>Scientific Barriers:</u> • The lack of information regarding water quality and pollutant sources in the watershed may make it difficult for agencies to design an effective ETP. Source operators may be unable to determine the advantages of participating in an ETP due to the lack of information regarding abatement alternatives, the marginal costs and performance of each alternative, and potential trading partners. • Difficulties in assessing the environmental impacts of proposed trades, approved trades, and the overall ETP may increase the uncertainties associated with ETP administration and participation.
<u>Economic Barriers:</u> • Markets that contain only a few compatible sources or direct competitors may discourage the development of active ETPs. • The lack of technical and/or financial resources may discourage ETP development. • High transaction costs may negatively influence ETP effectiveness by decreasing the economic incentives to trade.
<u>Institutional Barriers:</u> • There may be little incentive for government agencies to design, and pollutant source operators to participate in, an ETP without the presence of an action-forcing event. • The lack of explicit legal authority to administer and enforce an ETP may make some source operators reluctant to rely on effluent trading to meet their environmental compliance obligations. • Legal requirements that restrict trading opportunities may discourage ETP activity. • Trading rules that are confusing, complex, or amended frequently may also discourage ETP activity by increasing the uncertainty and expense of ETP participation. • Inadequate enforcement or enforcement procedures that do not address concerns related to the default of one or more trading partners may discourage trading activity.

Table 12.3 (continued):

Institutional Barriers (continued):
• ETP participation may be discouraged if multiple agencies at the municipal, county, state, and/or national levels are involved in program administration.
• Failure to establish the geographic and temporal boundaries of the ETP may make it impossible to determine the maximum allowable pollutant loading and to identify sources that are eligible to participate in an ETP.
• The number of potential tradeable pollutants is limited by pollutant characteristics; for example, some non-conservative pollutants or pollutants with localized toxic effects should probably be excluded from the ETP.
• Source operators may be reluctant to participate in an ETP if they feel that the baseline loading is unfair.
• Source operators may also be reluctant to participate in an ETP, and may even challenge it in court, if they feel that their discharge allocation is unfair.
• High trading ratios may eliminate the economic incentive to participate in an ETP.
• Source operators may be reluctant to participate in an ETP, thus risking increased regulatory scrutiny and negative publicity, if regulators and/or the general public seem to prefer more traditional methods of pollution control and water quality management.

Institutional considerations encompass required compliance with water quality standards that may actually "force" the development of an ETP. Existing statutes and regulations can be barriers if they do not contain sufficient authority to administer the ETP, or if they contain legal restrictions to trading. Special trading program rules or regulations can become barriers if they are overly complex and confusing. Institutional barriers can also include debate over the selection of an agency to administer the trading program; further, that agency's subsequent decisions can also create barriers. Such decisions may include determining the geographic and temporal boundaries of the trading program, establishing the maximum allowable pollutant loading, allocating discharge rights to all relevant sources in the watershed, and selecting trading ratios. A final example of an institutional barrier can occur based on whether industries, municipalities, regulators, and the public accept effluent trading as a viable alternative to more traditional forms of water quality regulation. If not, stakeholders may be reluctant to rely on trading to meet environmental compliance obligations, particularly if ETPs are mistakenly viewed as "selling the right" to pollute.

OVERCOMING OR MITIGATING COMMON BARRIERS

The information in Tables 12.1, 12.2, and 12.3 was used to identify nine common barriers that may affect both technological innovation or pollution prevention and ETP effectiveness. These common barriers include: (1) inadequate data quantity and/or quality; (2) difficulties in predicting resultant environmental impacts; (3) inadequate market size and composition; (4) insufficient technical and/or financial resources; (5) lack of an action-forcing event; (6) restrictive legal requirements; (7) lack of clearly defined rules and regulations; (8) insufficient enforcement; and (9) limited acceptability to firms, regulators, and the public. Each common barrier, including suggestions for overcoming or mitigating their negative effects on ETPs, is summarized in Table 12.4.

Inadequate Data Quantity and/or Quality

Inadequate data quantity and/or quality was identified as a barrier to technological innovation and pollution prevention in two ways. First, firms may simply be unaware of alternatives that can be used to more cost-effectively meet their compliance obligations. Second, detailed information about the cost and technical performance of alternatives may be unavailable, thus making it impossible for firms to compare new and existing technologies and select the best alternative.

Inadequate data may similarly affect ETPs. In some cases, trading activity may be limited because eligible source operators are simply unaware that an ETP exists for their watershed. For example, many indirect dischargers in northeastern New Jersey were unaware that they could use effluent trading to meet local pretreatment limits, even though they had received a mailed copy of the pertinent rule and a fact sheet from the Passaic Valley Sewerage Commission (U.S. Environmental Protection Agency, 1998a). In other cases, ETP effectiveness may be limited by the information needed to evaluate potential trading opportunities. For example, source operators considering trading among their own outfalls (intraplant trading) must have information regarding current pollutant loadings, the technical performance and costs of applicable control alternatives, the marginal abatement costs associated with each alternative, and current technology-based and water quality-based effluent limitations. Source operators contemplating trades with other source operators (point source-point source trading, point source-nonpoint source trading, nonpoint source-nonpoint source trading, and pretreatment trading) must obtain corresponding information for each potential trading partner. Determining such information for nonpoint

Table 12.4: Overcoming or Mitigating Common Barriers[a] to ETPs

Barriers to ETPs	Measures for Overcoming or Mitigating the Barriers[b]
Inadequate Data Quantity and/or Quality	• Publish information relative to effluent trading • Match potential trading partners • Sponsor research projects and demonstration studies • Use phased approach to ETP development • Require trading partners to submit pertinent information and post-trade monitoring data as a condition of trade approval • Establish QA/QC requirements for water quality data
Difficulties in Environmental Impact Prediction	• Select, with stakeholder input, the most appropriate water quality models • Use watershed-specific data to calibrate the selected models • Ensure that ETP rules incorporate model limitations • Require additional ambient water quality modeling to verify or refine modeling predictions as necessary
Inadequate Market Size and Composition	• Match potential trading partners if the market is too large • Divide extremely large trading areas into distinct trading zones • Expand the ETP to include as many different sources as possible if the market is too small or includes direct competitors
Insufficient Technical and/or Financial Resources	• Use watersheds with large quantities of pre-existing data to establish ETP demonstration projects • Reduce operating costs by standardizing trade review procedures and by requiring trading partners to submit monitoring data and other pertinent information as a condition of trade approval

Table 12.4 (continued):

Insufficient Technical and/or Financial Resources (continued)	• **Re-assign existing staff responsibilities, hire additional staff, or use external consultants to provide necessary technical expertise** • **Provide information and technical assistance to potential trading partners**
Lack of an Action-Forcing Event	• **Use an action-forcing event to encourage the development of active ETPs**
Restrictive Legal Requirements	• **Ensure that relevant laws clearly support, or are amended to support, effluent trading as an acceptable compliance alternative** • **Consider using ETPs to meet technology-based effluent standards or federal pretreatment standards** • **Require nonpoint sources to provide "reasonable assurance" that BMPs will be properly implemented**
Lack of Clearly Defined Rules and Regulations	• **Establish clearly defined rules governing ETP administration** • **Standardize ETP rules on a watershed basis** • **Announce amendments to ETP rules as early as possible** • **Amend ETP rules only after comments have been solicited from all affected parties**
Insufficient Enforcement	• **Ensure that ETP rules clearly delineate the enforcement procedures for nonpoint sources** • **Ensure that ETP rules address concerns related to the default of one or more trading partners** • **Ensure that ETP rules distinguish between the deliberate failure to generate PRCs and failure due to unforeseen circumstances**
Limited Acceptability to Firms, Regulators, and the Public	• **Include stakeholders in all aspects of ETP design, implementation, and operation** • **Ensure clear support from ETP agency staff and other affected agencies** • **Sponsor educational and outreach programs**

[a]**Common barriers refer to barriers that are common to technological innovation, pollution prevention, and ETPs.**

[b]**The listed measures will typically involve initiation and leadership by the administrators of the ETP.**

sources may be particularly difficult since nonpoint loadings, as well as the best management practices (BMPs) routinely used to reduce them, vary with local meteorological, topographical, and land use conditions. In addition, most nonpoint sources have not historically been subject to the monitoring, reporting, and recordkeeping requirements associated with point source discharges.

The ETP agency may be able to minimize some informational barriers to trading by publishing brochures explaining the basics of trading, by providing data on the cost and performance of control alternatives for facilities in the watershed, and by "matching" potential trading partners. The ETP agency could also encourage trading through mailings to potential participants, press releases, journal articles, and presentations at local, regional, or national conferences. Some of the difficulties associated with quantifying nonpoint source loadings and BMP effectiveness could be addressed via agency-sponsored research projects and demonstration studies.

The ETP agency also needs information on pollutant sources and water quality in order to determine the maximum allowable pollutant loading, to allocate portions of that loading to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades and the overall trading program. In extreme cases, the costs of actually planning an ETP and aggregating necessary information, if such information is unavailable, may be prohibitive. Alternatively, ETP planners may be able to use a "phased" approach, meaning that initial pollutant loadings and discharge allocations are refined as additional monitoring data become available. Once the ETP has been established, the burden of data collection could be partially alleviated by requiring trading partners to submit pertinent information and post-trade monitoring data as a condition of trade approval; however, the ETP agency should ensure, if possible, that monitoring requirements designed to protect water quality do not inadvertently eliminate economic incentives to trade. In addition, the ETP agency should establish quality assurance/quality control (QA/QC) requirements to ensure that water quality data are reliable.

Difficulties in Environmental Impact Prediction

As noted earlier, difficulties associated with predicting the environmental performance of a technological innovation or pollution prevention technique may act as barriers. In the absence of dedicated testing centers or demonstration sites, each facility must install and test the new alternative; however, if the alternative fails, the facility will have wasted significant resources and may even be subject to charges of non-compliance for violating discharge or ambient standards. Conversely, generic performance data may be inadequate to predict how the innovation or technique will perform under facility-specific conditions.

Regarding ETPs, water quality models are generally used to predict the environmental impacts of proposed trades. Models may be selected based on the type of receiving water body, the type of water quality problem, or one or more water quality parameters to be addressed (Canter, et al., 1998b). Typically, generic water quality models are less expensive to use, but may not address local conditions and thus be unable to predict the possible occurrence of localized toxic effects. The development of watershed-specific models, even though they would be better for predicting the environmental effects of trades, is usually cost-prohibitive, at least initially. In order to simplify and standardize impact prediction, the ETP agency should select, preferably with stakeholder input, the most appropriate models. The predictions of the selected models can then be improved by using watershed-specific data for calibration. In addition, trading rules should incorporate consideration of the models' limitations, and additional ambient water quality monitoring to verify or refine modeling predictions should be required as necessary.

Inadequate Market Size and Composition

Market size and composition was identified earlier as a barrier to technological innovation and pollution prevention. In general, opportunities for innovation or pollution prevention are very limited for small specialized markets that contain only a few facilities. In addition, such opportunities may be limited for larger industrial groups, like dry cleaning, that are composed of many small individual firms. One reason is related to inadequate information dissemination to small firms. Further, the presence of multiple state and local permitting jurisdictions may also reduce market size since technological innovations or pollution prevention techniques may need to receive approval from each permitting jurisdiction. Multiple permit applications are expensive and time-consuming, thus severely reducing or eliminating the incentives associated with developing and financing environmental innovations or pollution prevention.

The size and composition of the trading market may also affect the success of ETPs. In order to support active trading, an ETP must encompass multiple pollutant sources with compatible discharges and different marginal abatement costs. In addition, the sources included must contribute significantly to the total pollutant loading in the watershed. For example, if ETP rules allow trading between point and nonpoint sources, affected point sources must be able to purchase a sufficient number of pollutant reduction credits (PRCs) from nonpoint sources to avoid the installation of abatement equipment. Such PRCs from nonpoint sources could result from the implementation of BMPs. Similarly, point source contributions must be significant so that purchasing PRCs from nonpoint sources will result in measurable improvements in water quality. In general, a larger market size within a watershed increases the likelihood that a source operator will find a suitable trading partner, thus encouraging active ETPs. However, if the ETP is too large in terms of the number of pollutant sources, identifying potential trading partners may become cost-prohibitive.

In addition to markets that are too small or too large, direct competitors within a watershed may discourage active effluent trading. Source operators would be expected to refuse to participate in ETPs if they determine that trading will provide economic advantages to their competition. In extreme cases, major source operators may hoard excess PRCs in an attempt to prevent new competitors from locating in the watershed, and existing competitors from expanding their operations.

Several steps could be taken to eliminate or mitigate barriers associated with ETP market size and composition. If the market is too large to identify trading partners cost-effectively, the ETP agency may be able to "match" potential partners. Extremely large trading areas can also be subdivided into distinct trading zones. Alternatively, if the number of potential trading partners is too small and/or includes direct competitors, the ETP could possibly be expanded to include as many different sources as possible, thus increasing the probability of identifying a suitable trading partner and eliminating the need to trade with competitors.

Insufficient Technical and/or Financial Resources

The lack of technical and/or financial resources may discourage technological innovation and pollution prevention efforts. For example, technology vendors may lack the funds to design and test environmental innovations, and firms that would be expected to purchase such innovations may have insufficient financial resources. In addition, small and medium-sized firms often lack the resources needed to hire the in-house technical staff or external consultants that would be needed to evaluate potentially applicable technologies.

As another example, regulatory agencies involved in permitting may be unable to allocate sufficient staff resources for the timely evaluation of new environmental technologies or pollution prevention techniques.

An ETP cannot be effective if the administering agency lacks the technical or financial resources necessary for program design, implementation, and operation. Funds could come from governmental allocations, special grants from non-governmental organizations (NGOs) or the private sector, collaborative funding from affected point and nonpoint sources in the watershed, and trade review fees and/or annual operating fees assessed to trading partners. Costs associated with demonstration projects could be reduced by using information from similar watersheds with sufficient pre-existing data. Operating costs for all ETPs could be reduced by standardizing trade review procedures and requiring trading partners to submit monitoring data and other pertinent information as a continuing condition of trade approval. Potential barriers associated with limited technical expertise could be alleviated by re-assigning existing staff, hiring additional staff, or using external consultants.

Once an ETP has been established, trading activity may still be limited if potential trading partners lack the technical expertise and financial resources: (1) to determine whether they can benefit from participating in the ETP; (2) to evaluate trading opportunities; and (3) to submit trades for regulatory approval. Standardizing application procedures should reduce both the costs and time associated with submitting trades for approval, thus encouraging trading activity. The ETP agency may also be able to encourage trading by providing information and technical assistance to potential trading partners.

Lack of an Action-Forcing Event

The lack of an action-forcing event (such as more stringent environmental standards) to encourage firms to reduce pollutant discharges below permitted levels has been identified as a barrier to technological innovation and pollution prevention. For example, since most wastewater effluent limitations do not include incentives for exceeding minimum compliance obligations, firms are more likely to select less expensive technologies that just meet relevant standards over innovative technologies that may be more effective but also more expensive. Since new technologies are typically needed when, and if, regulatory agencies tighten existing standards, the continuing research and development needed for technological innovation and pollution prevention may also be discouraged (Environmental Law Institute, 1998).

Action-forcing events for ETPs may include the adoption of more stringent water quality standards, establishment of new water quality goals or objectives, or other circumstances within the watershed, such as rapid commercial and residential development that may dramatically increase pollutant loadings. In the absence of such events, regulators and source operators in the watershed may be unwilling to explore trading as a compliance alternative. However, point source operators facing extremely high marginal abatement costs as a result of an action-forcing event may be more willing to risk participation in an ETP, particularly if their additional compliance costs could be significantly reduced. Nonpoint source operators that must implement BMPs in response to an action-forcing event may also be willing to participate in an ETP in order to partially or completely offset the costs of BMP installation, operation, and maintenance. In addition, regulators or specific stakeholder groups may be more willing to assume the administrative burden associated with ETPs if prompted by one or more action-forcing events. For example, the Tar-Pamlico River Basin ETP in North Carolina was proposed by operators of publicly owned treatment works (POTWs) and state and regional environmental groups as an alternative approach for meeting new effluent standards for phosphorus and nitrogen (Apogee Research, Inc., 1992).

Restrictive Legal Requirements

Legal requirements that increase uncertainty or restrict the use of nontraditional compliance alternatives may act as barriers to technological innovation and pollution prevention. For example, technology vendors may be reluctant to invest in technology or pollution prevention development projects due to the difficulties and costs associated with obtaining regulatory approval in multiple jurisdictions. Firms may be reticent to purchase alternative technologies if they will have to obtain permits from several regulatory agencies, particularly if such agencies have different environmental requirements. As another example, technology-based standards, which specify the type of abatement equipment that must be used for a particular source, may explicitly preclude the use of innovative alternatives.

Similarly, the development of ETPs may be discouraged by water quality management laws that do not specifically address effluent trading, thus increasing the uncertainty and perceived risk associated with ETP participation. For example, since the Clean Water Act in the United States does not explicitly authorize effluent trading as an acceptable compliance option, pollutant source operators may prefer other options that are not subject to potential legal challenge, particularly when making long-term investment decisions (U.S. Environmental Protection Agency, 1996). As another example, public utilities such as POTWs may be reluctant to participate in trading programs unless their governing regulations include provisions concerning the distribution of monetary profits and losses from trading. This reluctance may severely limit the potential for point-nonpoint ETPs since POTWs are expected to be significant purchasers of PRCs in most watersheds. These types of trades may also be constrained if point sources are held liable for failures to achieve nonpoint source reductions. As a final example, limiting the use of ETPs to meeting only water quality-based effluent limitations or local pretreatment limits that are more stringent than federal standards will also reduce potential trading opportunities and cost savings within a watershed.

Eliminating legal or regulatory requirements that increase uncertainty or restrict trading should encourage the development of active trading markets. Most importantly, ETP administrators should ensure that relevant laws clearly support, or are amended to support, effluent trading as an acceptable compliance alternative. In addition, such administrators may wish to consider using ETPs to meet technology-based effluent standards or federal pretreatment standards, thus greatly expanding trading opportunities in almost all watersheds. Point-nonpoint source trading opportunities may be enhanced if nonpoint sources become subject to requirements for providing "reasonable assurance" that BMPs will be properly implemented (U.S. Environmental Protection Agency, 1996). In general, "reasonable assurance" means that the identified BMPs are: (1) technically feasible; (2) suitable for the tradeable pollutant(s); (3) implementable within a reasonable time period; and (4) supported by reliable delivery mechanisms and adequate funding.

Lack of Clearly Defined Rules and Regulations

Technological innovation and pollution prevention may be limited by incomplete, confusing, or inconsistent rules and regulations within a single permitting jurisdiction, by conflicting rules and regulations among multiple permitting jurisdictions, and by uncertainty regarding future regulatory changes. The development of active ETPs may also be limited by similar barriers. For example, the economic incentive to participate in an ETP may be eliminated if potential partners are required to submit applications for proposed trades to more than one regulatory agency with possible conflicting requirements. Frequent amendments of ETP rules can also be a disincentive to long-range planning by affected stakeholders.

Both uncertainty and transaction costs can be reduced within ETPs by establishing clearly defined policies, rules, and regulations. Examples of items that should be addressed include: (1) determination of the maximum allowable pollutant loading for the watershed; (2) allocating portions of the allowable loading to all sources in the watershed that discharge the pollutant(s) of interest; (3) types of trades that will be allowed; (4) required trading ratio(s); (5) quantifying and certifying PRCs; (6) determining the environmental impacts of trades; (7) application procedures for proposed trades; (8) administrative procedures for evaluating proposed trades; (9) time periods that trades remain in effect; (10) treatment of banked or shutdown credits; and (11) reporting and recordkeeping requirements. To further simplify ETP participation and reduce transaction costs, the trading program should be administered by a single, preferably local, agency, and policies, rules and regulations should be standardized on a watershed basis so that PRCs created in one sub-jurisdiction can be used in another without additional administrative requirements. Amendments to policies, rules, and regulations should be developed via stakeholder input, and adopted only after comments have been solicited from all affected parties and addressed as appropriate.

Insufficient Enforcement

Rigorous enforcement programs can create the expectation of successful environmental compliance, thus encouraging the development and use of innovative environmental technologies and pollution prevention techniques. Conversely, firms that are unlikely to be penalized for non-compliance may be reluctant to assume the environmental and economic risks associated with implementing technological innovations or pollution prevention programs. Variations in enforcement between permitting jurisdictions and over time, which foster unstable markets for new technologies, may also be a barrier to pollution prevention efforts.

Similarly, ETP policies, rules and regulations must be effectively enforced to ensure that water quality standards, goals, and objectives are met and that trading partners are fulfilling the terms of their trading agreements. Enforcement of trades involving point sources, which are already subject to effluent limitations as well as monitoring, reporting, and recordkeeping provisions in their discharge permits, should be relatively straightforward. However, enforcement of trades related to nonpoint sources may be more difficult for several reasons. First, the majority of nonpoint sources are not currently subject to discharge permits that can be modified to include trading. Second, since nonpoint source loadings and BMP effectiveness are site-specific, unique enforcement provisions may have to be designated for each nonpoint source. Finally, nonpoint pollutant loadings are difficult to monitor because they are highly dependent on storm events, and BMPs may be difficult to inspect if they are distributed over large areas. To reduce the uncertainty associated with nonpoint source trades, the ETP should clearly delineate how nonpoint source reductions will be enforced; for example, the ETP agency could establish a policy that only BMPs that can be readily confirmed through visual inspection are eligible for inclusion in the trading program.

ETP policies should also address concerns related to the default of one or more trading partners. For example, in the event that a nonpoint source operator fails to generate PRCs that are already sold to a point source operator, trading rules must specify who is ultimately responsible for the pollutant loading reduction. The point source operator could be held liable, an approach which would protect water quality but reduce the incentive for point source operators to participate in trading. Alternatively, point source operators could purchase PRCs through payments to a nonpoint source control fund (to be administered within the ETP agency or via a third-party agency) which would be used to support the installation, operation, maintenance, and inspection of BMPs. Fund administrators would then be held responsible for generating sufficient PRCs. ETP policies should also distinguish between the source operator's deliberate failure to generate PRCs that have been sold to another source, and failure due to unforeseen circumstances, such as equipment malfunction or unusually heavy rainfall.

Limited Acceptability by Firms, Regulators, and the Public

Another barrier to technological innovation and pollution prevention exists when firms, regulators, and the public prefer more traditional methods of environmental compliance. For example, firms may be reluctant to rely on unproven technologies or pollution prevention projects to meet their compliance obligations, while regulators may prefer to issue permits for existing technologies with well-known performance characteristics. In addition, public concern regarding the environmental risks of failed projects, as well as possible distrust of industry and regulatory agencies, may also act as deterrents.

ETP effectiveness may also be subjected to the preferences of firms, regulators, and the public. In general, compliance cost savings from ETPs have tended to be fairly modest, so firms may decline to participate, particularly when transaction costs are high and regulatory requirements are not well-defined. Regulatory staff may be reluctant to encourage effluent trading if they believe familiar approaches to water quality management, such as technology-based controls, are more likely to yield desired environmental results. In addition, ETPs can increase administrative workloads in regulatory agencies. Finally, both firms and regulators may be reluctant to risk the negative publicity associated with ETPs if the public views such programs as a means to avoid compliance with appropriate environmental requirements.

To overcome or mitigate these "acceptability barriers" the administering agency can encourage participation by including pertinent stakeholders in all aspects of program design, implementation, operation, and evaluation. For example, firms may be more likely to participate if they are actively involved in program design, while the public may be more likely to accept an ETP if all proposed trades are subject to public review during the trade approval process. Clear support from ETP agency staff, as well as other agencies that may be affected by the trading program, should also encourage ETP participation. In addition, agency-sponsored educational and outreach programs can be used to stimulate interest among potential trading partners and to reduce negative publicity.

OVERCOMING OR MITIGATING UNIQUE BARRIERS

A systematic review of Tables 12.1 through 12.3 was also used to identify the following barriers unique to ETPs: (1) excessive transaction costs; (2) inadequate legal authority and the need for designation of an administering agency; (3) delineation of geographic and temporal boundaries; (4) designation of tradeable pollutants; (5) documentation of baseline loading; (6) development of the initial allocation of discharge rights; and (7) determination of trading ratios. With the exception of transaction costs, these factors do not necessarily need to be perceived as barriers. Instead, they represent policy decisions that must be made by the appropriate governmental agency. Wise decisions can encourage the development of an active ETP, while poor decisions may indeed act as barriers by reducing or eliminating incentives to trade. Each unique barrier is discussed below; relevant measures that can be used to overcome or mitigate them and promote trading are also mentioned and listed in Table 12.5.

Excessive Transaction Costs

As previously defined, transaction costs refer to the costs associated with identifying a suitable trading partner, negotiating a trading agreement, submitting proposed trades for regulatory approval, and any additional monitoring, reporting, or recordkeeping that may be required as a condition of trade approval. Excessive transaction costs act as a barrier to ETPs by reducing or even eliminating the savings in compliance costs that can be realized through trading. Whenever possible, administering agencies for ETPs should promote the development of active trading markets by minimizing transaction costs. For example, ETP administrators could reduce such costs by "matching" potential trading partners, standardizing trade application and review procedures, and subsidizing post-trade ambient water quality monitoring.

Inadequate Legal Authority and the Need for Designation of an Administering Agency

The agency chosen to administer the ETP must have sufficient legal authority to: (1) establish program boundaries; (2) determine the maximum allowable pollutant loading; (3) allocate the maximum loading among dischargers; (4) review proposed trades; (5) conduct pre- and post-trade water quality monitoring and inspections; (6) enforce the provisions of trading agreements; and (7) modify individual trading agreements or the ETP itself if the program is not effective. In the absence of such authority, potential trading partners may feel that the legal risks associated with trading outweigh the potential environmental and economic benefits. Further,

Table 12.5: Overcoming or Mitigating Unique Barriers[a] to ETPs

Barriers to ETPs	Measures for Overcoming or Mitigating the Barriers[b]
Excessive Transaction Costs	• Minimize transaction costs whenever possible
Inadequate Legal Authority and Need for Designation of Administering Agency	• Ensure that the ETP agency has sufficient authority to administer all aspects of the trading program • Eliminate waivers, variances, subsidies, and other program "loopholes" • Designate single, preferably local, agency to administer the ETP
Delineation of Geographic and Temporal Boundaries	• Ensure that geographic and temporal boundaries are accurately delineated
Designation of Tradeable Pollutants	• Include as many pollutants in the ETP as possible, but eliminate pollutants whose characteristics or environmental effects make them unsuitable for trading • Consider the use of inter-pollutant ETPs
Documentation of Baseline Loading	• Ensure that all stakeholders agree on the baseline loading • Thoroughly document the process used to establish the baseline loading
Development of Initial Allocation of Discharge Rights	• Allow stakeholders to participate in the allocation process • Base discharge rights on existing permits or discharge levels • Thoroughly document the allocation process
Determination of Trading Ratios	• Consider both environmental and economic issues when selecting appropriate trading ratios • Review and revise trading ratios periodically

[a]Unique barriers refer to barriers that are specific to ETPs; similar barriers were not identified for technological innovation or pollution prevention.

[b]The listed measures will typically involve initiation and leadership by the administrators of the ETP.

the ETP agency should consider the elimination of waivers, variances, subsidies, and other "loopholes" to regulatory compliance, thus encouraging ETP activity by increasing the size of the potential trading market.

Operators of eligible sources may also be reluctant to participate in an ETP if they must interact with an unfamiliar regulatory agency or with multiple agencies. For this reason, a single, preferably local, agency should administer the trading program. If a suitable agency does not exist, the responsibility for administering an ETP can be distributed among several agencies as long as their authorities and duties are clearly delineated.

Delineation of Geographic and Temporal Boundaries

The geographic boundary of the watershed, watershed segment, or estuarine zone, and temporal variations in associated flows must be specifically delineated in order to accurately determine the maximum allowable pollutant loading. If the maximum loading is too low, PRC prices may be unnecessarily high, thus discouraging effluent trading. Alternatively, if the maximum loading is too high, source operators may be less inclined to create, sell, or lease PRCs, thus resulting in little or no water quality improvement. The geographic boundary of the ETP should also be used to delineate sub-areas to be subjected to post-trade ambient water quality monitoring, and to identify pollutant sources that are eligible for trading.

Designation of Tradeable Pollutants

In general, maximizing the number of tradeable pollutants in the ETP should maximize the number of potential trading partners, thus encouraging the development of active markets. However, the characteristics of some pollutants may make them unsuitable for effluent trading. For example, the economic incentive to trade nonconservative pollutants, like BOD_5 or ammonia, may be minimized by the modeling costs associated with predicting the environmental impact of such trades. As another example, extensive modeling and monitoring requirements for trades involving pollutants with potential toxic localized effects may significantly increase the costs and administrative burden of trading participation. Alternatively, if a pollutant's effects are due primarily to total loading in the watershed, modeling and monitoring requirements can probably be reduced, thus simplifying ETP administration, reducing transaction costs, and encouraging participation.

Inter-pollutant trading, which allows sources to purchase or exchange PRCs for different pollutants, may also encourage ETP participation by increasing the size of the trading market. However, since two or more pollutants are involved, technical and administrative complexities may increase significantly, and the resulting transaction costs may eliminate the potential economic advantages. In addition, it may be more difficult to predict the environmental impacts of proposed inter-pollutant trades.

Documentation of Baseline Loading

The maximum allowable pollutant loading is one of the fundamental components of any ETP. Once established, this "baseline" can be used to allocate initial discharge rights to all source operators within the watershed and to evaluate the overall effectiveness of the ETP. Information for establishing the maximum allowable pollutant loading may also be used to aid in the evaluation of proposed trades, thus reducing transaction costs. In order to avoid potential legal challenges and implementation delays, all stakeholders in the watershed should initially agree on the baseline loading, and the technical rationale and policy process should be well documented.

Delineation of Initial Allocation of Discharge Rights

Another potential barrier to ETP effectiveness is the initial allocation of discharge rights to source operators in the watershed. These initial allocations, along with current discharge levels, provide the framework to encourage each source operator to determine their most cost-effective compliance alternative, including possible participation in an ETP. The allocation of discharge rights may act as a barrier if source operators feel that their initial limits are unfair and challenge them in court. This problem may be partially alleviated by allowing stakeholders to participate in the allocation process, by basing discharge rights on existing permits or discharge levels, and by thoroughly documenting the technical and policy aspects of the allocation decisions.

Determination of Trading Ratios

Trading ratios, which establish the rate-of-exchange for PRCs, should be based on the composite consideration of the relative environmental effects of different pollutants, the relative effects of different forms of the same pollutant, and the uncertainties associated with inter-pollutant trading, trading different forms of the same pollutant, and estimating nonpoint source loadings and BMP effectiveness. ETP planners should establish trading ratios to provide a margin of safety, to encourage progress toward relevant water quality standards, or to offset nonpoint source loadings resulting from future watershed development. In general, as the potential for negative environmental impacts or the level of uncertainty increases, trading ratios should also increase. However, since high trading ratios may reduce or eliminate economic incentives to trade, ETP planners must consider both environmental and economic issues when selecting appropriate ratios. Once a trading ratio has been adopted, it should be subject to period review and revision as appropriate.

CONCLUSIONS

The purpose of this chapter was to identify measures for overcoming or mitigating barriers that may prevent the development of active effluent trading programs (ETPs). The following conclusions have been drawn from this study:

(1) Because technological innovation, pollution prevention, and effluent trading represent alternatives to traditional command-and-control regulations for surface water quality management, significant barriers to their implementation were anticipated. The results of this study confirmed this expectation by identifying multiple barriers to innovative technology (Table 12.1), pollution prevention (Table 12.2), and effluent trading (Table 12.3). In many cases, the barriers to ETPs were similar to the barriers for technology and prevention. Once again, this result was anticipated because pollutant source operators typically rely on technological innovations or pollution prevention techniques to generate pollutant reduction credits (PRCs) for trading.

(2) Barriers to technological innovation, pollution prevention, and effluent trading can be classified in many different ways. In this study, the identified barriers were divided into scientific, economic, and institutional categories. However, it is important to recognize that, in many cases, a single barrier could rationally be assigned to more than one category.

(3) Many of the identified barriers exhibit similar deterrent effects on technological innovation, pollution prevention, and ETPs. These common barriers include: (1) inadequate data quantity and/or quality; (2) difficulties in environmental impact prediction; (3) inadequate market size and composition; (4) insufficient technical and/or financial resources; (5) lack of an action-forcing event; (6) restrictive legal requirements; (7) lack of clearly defined rules and regulations; (8) insufficient enforcement; and (9) limited acceptability by firms, regulators, and the public.

(4) Seven additional barriers may affect ETP performance, although they do not appear to affect either technological innovation or pollution prevention. In most cases, these issues require policy decisions and do not represent true barriers to effluent trading unless ETPs are poorly designed. These unique barriers include: (1) excessive transaction costs; (2) inadequate legal authority and the need for designation of an administering agency; (3) delineation of geographic and temporal boundaries; (4) designation of tradeable pollutants; (5) documentation of baseline loading; (6) delineation of initial allocation of discharge rights; and (7) determination of trading ratios.

(5) Once the barriers to ETPs have been identified, pragmatic measures can be developed to overcome or mitigate their negative effects. In general, such measures are most

likely to be effective when they are initiated and supported by the agency or agencies administering the ETP.

(6) The majority of the measures for overcoming or mitigating the barriers to effluent trading can be divided into three groups: (1) gathering and communicating pertinent information; (2) incorporating stakeholder involvement in all phases of ETP planning and implementation; and (3) ensuring that the rules and regulations governing the ETP are comprehensive, clear, and standardized.

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CHAPTER 13

SUMMARY AND RECOMMENDATIONS

The hypothesis of this research was that a conceptual qualitative model could be developed to evaluate the effectiveness of existing effluent trading programs (ETPs), to identify the feasibility of effluent trading in a given watershed, and/or to develop a detailed plan for ETP design, implementation, and evaluation. Further, the model should be applicable to point-point source, point-nonpoint source, nonpoint-nonpoint source, intraplant, and pretreatment trading programs. To develop the qualitative model and test this hypothesis, the following major objectives (and tasks) were identified: (1) conduction of a literature review to identify factors that may positively or negatively influence ETP design, implementation, and/or effectiveness; (2) development of the qualitative model for designing and implementing successful ETPs; (3) accomplishment of model testing via its general application to 12 extant ETPs and its detailed application to the Lake Dillon ETP, the Tar-Pamlico River Basin ETP, and the Lake Geneva watershed where no ETP currently exists; (4) development of derived models specific to intraplant and pretreatment ETPs, with the derived models based on respective case studies; and (5) identification of methods that can be used to mitigate or overcome scientific (technical), economic, and institutional barriers to ETPs. These objectives (and tasks) were accomplished through literature review; personal contacts with the U.S. Environmental Protection Agency (USEPA), state environmental agencies, ETP managers, non-governmental organizations, and other pertinent stakeholders; and the assemblage of information on extant

ETPs. The Lake Geneva case study was conducted on-site in Geneva, Switzerland.

SUMMARY

As shown in Table 13.1, the qualitative model for designing and implementing ETPs contains 10 components and 37 criteria questions, the components include: (1) watershed suitability; (2) pollutant type; (3) trading market size and characteristics; (4) legal authority; (5) administrative acceptability and capability; (6) specific policies, procedures, and trading rules; (7) pre- and post-trade monitoring; (8) enforcement mechanisms; (9) program evaluation; and (10) public involvement. This model was primarily based on the characteristics of point-point, point-nonpoint, and nonpoint-nonpoint source ETPs and can be used to evaluate an existing ETP, to compare the features of two or more ETPs, to evaluate ETP feasibility, and to suggest elements that should be included in site-specific ETP design.

In general, it was anticipated that the applicability of point-point source ETPs would be limited since very few watersheds have multiple point sources with compatible discharges. However, if point-point source ETPs are feasible, they can be based on extant policies and procedures related to the National Pollution Discharge Elimination System (NPDES) permit program, thus simplifying ETP design, implementation, and administration. In addition, due to the lower marginal abatement costs for best management practices (BMPs) for nutrient removal from nonpoint sources, ETPs involving nonpoint sources have the greatest potential to reduce environmental compliance costs; unfortunately, nonpoint source trading activity may be limited by uncertainties and transaction costs associated with quantifying nonpoint source pollutant loadings, calculating nonpoint source pollutant reduction credits (PRCs) for different BMPs, and monitoring and enforcing nonpoint source trading agreements.

Table 13.1: Criteria Questions for Each Component of the Qualitative Model for Designing and Implementing ETPs

<u>Watershed Suitability</u> 1. Does the watershed (or watershed segment or estuarine zone) have a clearly defined geographic boundary? What is the basis for defining the watershed, segment, or zone? 2. Are temporal variations in flow well understood? 3. Do existing water quality conditions or other circumstances within the watershed encourage the use of an ETP? 4. Are there circumstances within the watershed that would discourage the use of an ETP?
<u>Pollutant Type</u> 1. Are the pollutant(s) of interest classified as conservative, non-conservative, or toxic? 2. Will inter-pollutant trading be allowed? What is the basis for the decision to permit or prohibit inter-pollutant trading? 3. Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality? 4. Do the environmental effects of the pollutant(s) of interest result more from total loading over time than local, short-term toxic effects? 5. Can mass- or concentration-based limits be established for the pollutant(s) of interest?
<u>Trading Market Size and Characteristics</u> 1. Have all sources of the pollutant(s) of interest been identified? 2. Are the relative contributions of all source categories (point, nonpoint, and background) known? 3. Are temporal variations in loadings of the pollutant(s) of interest well understood? 4. Are there significant differences in marginal abatement costs among sources in the same category and/or sources in different categories? 5. Could sources and/or governmental entities within the watershed be potentially unwilling to trade? 6. Are there unique circumstances that may influence the behavior of market participants?
<u>Legal Authority</u> 1. Are there water quality standards, goals, and/or objectives that can be used as a basis for the ETP? 2. Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so? 3. Is there an existing agency with sufficient authority to implement and enforce an ETP, can such authority be conferred on an existing agency, or can such an agency be created? 4. Does the implementing agency have sufficient authority to require all contributing sources to meet their discharge allocations?

Table 13.1 (continued):

Administrative Acceptability and Capability

1. Does the administering agency have sufficient knowledge and information to designate the maximum allowable pollutant loading for the watershed, to allocate portions of that loading to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades as well as the overall trading program?
2. Is the administering agency willing to use effluent trading as a management strategy to supplement traditional regulation?
3. Does the administering agency have sufficient resources to design and implement an ETP?

Specific Policies, Procedures, and Trading Rules

1. If nonpoint sources are to be included in the ETP, do policies or procedures account for their inherent variability?
2. Have procedures been clearly defined for the following aspects of the ETP?
   - (a) determination of the maximum allowable pollutant loading for the watershed
   - (b) allocating portions of the loading cap to all sources within the watershed that discharge the pollutant(s) of interest
   - © types of trades that will be allowed
   - (d) trading ratio(s)
3. Have rules or procedures been clearly defined for the following operational aspects of the ETP?
   - (a) quantifying and certifying pollutant reduction credits (PRCs)
   - (b) quantifying the environmental impacts of trades
   - © application procedures for proposed trades
   - (d) administrative procedures for the evaluation of proposed trades
   - (e) time periods that trades remain in effect
   - (f) treatment of banked or shutdown credits
   - (g) reporting and recordkeeping requirements
4. Will non-dischargers, such as environmental groups, be allowed to purchase and retire PRCs?

Pre- and Post-Trade Monitoring

1. Are responsibilities for pre- and post-trade source and ambient water quality monitoring clearly defined?
2. Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for both source and ambient water quality monitoring?
3. Will source monitoring requirements discourage trading activity?

Enforcement Mechanisms

1. Can trading agreements be effectively enforced for each source category?
2. Should uncontrollable circumstances for both point and nonpoint sources be considered in the enforcement process?

Table 13.1 (continued):

Program Evaluation	
1.	Are responsibilities for evaluating ETP performance clearly defined?
2.	How often will the ETP be reviewed?
3.	Have the criteria that will be used to evaluate ETP performance been specified?
Public Involvement	
1.	Was the public, including industries and municipalities, actively involved in ETP design and operation?
2.	In general, did industries, municipalities, government agencies, and the public support the development of the ETP?
3.	Does the ETP include any educational and/or outreach efforts designed to increase public support?

The qualitative model summarized in Table 13.1 was then modified specifically for intraplant ETPs, which involve trades among multiple outfalls and/or processing lines at the same industrial facility. A vegetable processing and canning plant in eastern Oklahoma was used as a case study leading to the modification of the basic model. As shown in Table 13.2, the derived model for intraplant ETPs contains two components and 23 criteria questions; the components include ETP Feasibility and ETP Design Considerations. This model can be used to evaluate existing intraplant ETPs, to determine the feasibility of intraplant trading at a particular facility, and to suggest issues and concerns that should be addressed in a site-specific intraplant trading program. Many of the criteria questions in the original model were eliminated in this derived model because intraplant ETPs are only applicable within the boundaries of a single facility and are constrained by existing discharge limitations and NPDES permit conditions. As a result, multiple trading partners are not involved and no adverse water quality or aquatic ecosystem effects are anticipated.

The qualitative model was also modified specifically for pretreatment ETPs, which involve significant industrial users (SIUs) that discharge their effluent to the same publicly owned treatment works (POTW). The existing pretreatment program in Stillwater, Oklahoma was used as a case study leading to the modification of the basic model. As shown in Table 13.3, the derived model for pretreatment ETPs contains 29 criteria questions divided into two components, ETP Feasibility and ETP Design Considerations. Similar to the models described above, this model can be used to evaluate existing pretreatment ETPs, to determine the feasibility of pretreatment trading for a particular POTW, and to suggest issues and concerns that should be addressed in a site-specific trading program. In general, pretreatment ETPs should be simpler to design, implement

Table 13.2: Qualitative Model for Intraplant ETP Design and Implementation

ETP Feasibility

1. Do existing conditions or other circumstances encourage the use of an ETP?[a]

2. Do existing conditions or other circumstances discourage the use of an ETP?[a]

3. Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality?[b]

4. Can mass- or concentration-based limits be established for the pollutant(s) of interest?

5. Have all sources of the pollutant(s) of interest been identified?

6. Are the relative contributions of all outfalls and/or processing lines known?[a]

7. Are temporal variations in loadings of the pollutant(s) of interest well understood?

8. Are there significant differences in marginal abatement costs among outfalls and/or processing lines?[a]

9. Are there effluent limitations or local pretreatment limits that can be used as a basis for the ETP?[a]

10. Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so?

11. Do the permitting agency and/or facility managers have sufficient authority to implement an ETP?[a]

12. Does the permitting agency have sufficient authority to require the facility to meet all applicable effluent limitations?[a]

13. Do the permitting agency and/or facility managers have sufficient knowledge and information to design, implement, and operate an ETP?[a]

14. Are the permitting agency and/or facility managers willing to use effluent trading as a management strategy to supplement traditional regulation?[a]

15. Do the permitting agency and/or facility managers have sufficient resources to design and implement an ETP?[a]

Table 13.2 (continued):

<u>ETP Design Considerations</u>
1. Have rules or procedures been clearly defined for the following operational aspects of the ETP? (a) quantifying pollutant reduction credits[a] (b) application procedures for proposed trades[b] (c) administrative procedures for the evaluation of proposed trades[b] (d) time periods that trades remain in effect (e) treatment of banked or shutdown credits (f) reporting and recordkeeping requirements
2. Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for both source and ambient water quality monitoring?
3. Can trades be effectively enforced for each outfall and/or processing line?[a,b]
4. How often will the ETP be reviewed?
5. Have the criteria that will be used to evaluate ETP performance been specified?
6. Were facility stakeholders actively involved in ETP design and operation?[a]
7. In general, did facility stakeholders support the development of the ETP?[a]
8. Does the ETP include any educational and/or outreach efforts designed to increase stakeholder support?[a]

[a]Indicates modified criteria question

[b]Indicates that the criteria question does not apply to intraplant ETPs involving multiple processing lines but may apply to intraplant ETPs involving multiple outfalls

Table 13.3: Revised Model for Pretreatment ETP Design and Implementation

<u>ETP Feasibility</u>

1. Do conditions at the POTW and/or other circumstances within the POTW's service area encourage the use of an ETP?[a]

2. Do conditions at the POTW and/or other circumstances within the POTW's service area discourage the use of an ETP?[a]

3. Are all forms of the pollutant(s) of interest interchangeable with regard to their impacts on ambient water quality and/or POTW operations?[b]

4. Do the pollutant(s) of interest have the potential to adversely affect the wastewater collection system or the POTW?[b]

5. Can mass- or concentration-based limits be established for the pollutant(s) of interest?

6. Have all sources of the pollutant(s) of interest been identified?

7. Are the relative contributions of all SIUs known?[a]

8. Are temporal variations in loadings of the pollutant(s) of interest well understood?

9. Are there significant differences in marginal abatement costs among SIUs?[a]

10. Could SIUs within the POTW's service area be potentially unwilling to trade?[a]

11. Are there local pretreatment discharge limits that can be used as a basis for the ETP?[a]

12. Do existing international, federal, regional, state, and/or local laws clearly support effluent trading as a compliance alternative, or could they be amended to do so?

13. Is there an existing agency with sufficient authority to implement and enforce an ETP, can such authority be conferred on an existing agency, or can such an agency be created?

14. Does the implementing agency have sufficient authority to require all contributing sources to meet their discharge allocations?

15. Does the administering agency have sufficient knowledge and information to designate the MAIL, to allocate portions of the MAIL to all dischargers, to evaluate proposed trades, and to monitor the results of individual trades as well as the overall trading program?[a]

Table 13.3 (continued):

<u>ETP Feasibility, continued</u>

16. Is the administering agency willing to use effluent trading as a management strategy to supplement traditional regulation?

17. Does the administering agency have sufficient resources to design and implement an ETP?

<u>ETP Design Considerations</u>

1. Have procedures been clearly defined for the following aspects of the ETP?
   - (a) determination of the MAIL to the POTW[a]
   - (b) allocate portions of the MAIL to all SIUs within the POTW's service area[a]
   - (c) trading ratio(s)

2. Have rules or procedures been clearly defined for the following operational aspects of the ETP?
   - (a) quantifying PRCs[b]
   - (b) application procedures for proposed trades
   - (c) administrative procedures for the evaluation of proposed trades
   - (d) time periods that trades remain in effect
   - (e) treatment of banked or shutdown credits
   - (f) reporting and recordkeeping requirements

3. Are responsibilities for pre- and post-trade source monitoring clearly defined?[b]

4. Have specific monitoring protocols, including recordkeeping and reporting procedures, been clearly established for source monitoring?[b]

5. Can trading agreements be effectively enforced for each SIU?[a]

6. Should uncontrollable circumstances for SIUs be considered in the enforcement process?[a]

7. Are responsibilities for evaluating ETP performance clearly defined?

8. How often will the ETP be reviewed?

9. Have the criteria that will be used to evaluate ETP performance been specified?

Table 13.3 (continued):

ETP Design Considerations, continued	
10.	Were SIUs, municipalities, and regulatory agencies actively involved in ETP design and operation?[a]
11.	In general, did SIUs, municipalities, and regulatory agencies support the development of the ETP?[a]
12.	Does the ETP include any educational and/or outreach efforts designed to increase SIU support?[a]

[a]Question was slightly modified to accommodate pretreatment ETPs

[b]Question was substantially modified to accommodate pretreatment ETPs

and operate than point-point, point-nonpoint, and nonpoint-nonpoint source ETPs because they can be based on local pretreatment programs, and sufficient information is typically available to accurately quantify pollutant loadings and PRCs for each SIU. In addition, pollutants with localized effects may be eligible for inclusion in pretreatment ETPs due to the indirect nature of effluent discharges. However, since two or more SIUs must always be involved in pretreatment trades, such programs would be more complex than intraplant trading programs.

The above qualitative model and two derived models were based on addressing barriers to successful ETPs. A large number of barriers have been identified; they include, but are not limited to, the following: (1) inadequate data quantity and/or quality; (2) inadequate market size and composition; (3) lack of an action-forcing event or water quality need; (4) restrictive legal requirements; (5) lack of clearly defined program rules and regulations; (6) limited acceptability by firms, regulators, and the public; (7) excessive transaction costs; (8) inadequate legal authority and the need for designation of an administering agency; (9) documentation of baseline loading; and (10) delineation of the initial allocation of discharge rights. However, despite these barriers, pragmatic measures can be developed to overcome or mitigate their negative effects on ETPs. In general, such measures are most likely to be effective when they are initiated and supported by the agency or agencies administering the ETP. The majority of the measures can be divided into three groups: (1) gathering and communicating pertinent information; (2) incorporating stakeholder involvement in all phases of ETP planning and implementation; and (3) ensuring that the rules and regulations governing the ETP are comprehensive, clear, and standardized.

RECOMMENDATIONS FOR FUTURE RESEARCH OR OTHER ACTIONS

Despite the theoretical advantages of ETPs, relatively few existing and proposed ETPs were identified during the course of this research, and trading activity appears to be extremely limited. Therefore, the qualitative model (Table 13.1) and derived models (Tables 13.2 and 13.3) were designed to reduce or eliminate the negative effects of factors that may influence ETPs, thus encouraging the development and use of trading programs for surface water quality management. Testing and validation of the models should be continued, both through evaluations of existing ETPs and their application to feasibility studies. If necessary, the models should then be refined and/or modified based on test results.

In addition, the following issues, which should also be conducive to ETP development and effectiveness, are recommended for further evaluation and study:

(1) In general, effluent trading activity is constrained by a lack of information on marginal abatement costs for both point and nonpoint sources. Quantifying nonpoint source loadings and the effectiveness of BMPs is also difficult due to variations in topography, meteorology, land use, and other site-specific conditions. Therefore, additional research should be designed to collect watershed-specific information as well as generalized data on these topics that can be applied to multiple watersheds.

(2) Agencies responsible for administering ETPs should ensure that they have effective educational and outreach programs in place. Such programs should be designed to inform potential trading partners that ETP participation is an acceptable compliance alternative and to eliminate the negative perception that ETPs are "selling the right to pollute." Research is needed on appropriate educational and outreach programs to accomplish these purposes.

(3) In most cases where ETPs have been implemented, additional information is needed to accurately quantify the environmental effects of proposed trades. For example, existing water quality monitoring networks are generally insufficient to detect localized or acute impacts associated with effluent trading activity. As a result, extant ETPs have typically been limited to pollutants, like phosphorus and nitrogen, whose primary effects are based on total loading to the waterbody. However, these pollutants could still exhibit acute or localized impacts which should be considered when

approving or renewing trades. Furthermore, expanding monitoring networks may allow additional pollutants to be included in ETPs and would provide better data to evaluate both ETP effectiveness and overall ambient water quality and aquatic ecosystem effects. Finally, efforts to refine existing ambient water quality and nutrient loading models, including calibration to site-specific conditions, should be continued. Accordingly, research is needed on the design of appropriate water quality monitoring programs to meet multiple information needs in ETPs, and to develop user-friendly models which can be used in the technical aspects of program design.

(4) The Clean Water Act, as well as applicable state and local laws and regulations, should be amended to authorize ETPs as an acceptable alternative to traditional command-and-control regulations for surface water quality management. Similarly, the USEPA, state water quality management agencies, and municipal governments should actively promote ETPs in their respective watersheds and/or service areas. Finally, amending current regulations to allow trading as a compliance alternative for technology-based effluent limitations and/or categorical pretreatment standards would greatly increase the number of potential trading markets.

(5) Since ETPs are conceptually similar to emissions and allowance trading programs, "lessons learned" from such trading programs in air quality management should be periodically reviewed and, if pertinent, applied to ETPs.

(7) Finally, strategies and methods for integrating ETPs into existing watershed planning and management activities should be developed. Potential benefits of such integration include increased stakeholder participation and reduced ambient water quality monitoring and modeling costs. For example, using water quality data that have been previously collected may reduce the administrative burden associated with ETP development, while data collected for ETP design, implementation, and evaluation could be used to support strategic environmental assessments at the watershed level. In addition, ETPs may be used as a cost-effective approach for mitigating cumulative water quality effects and/or for accommodating population growth and economic development while maintaining or improving ambient water quality. Accordingly, research efforts are needed to effectively accomplish the integration of ETPs into watershed planning and management activities.