Nutrient Trading in the Upper Chattahoochee Watershed:
A Feasibility Analysis

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Abstract

With 57% of the state's rivers and streams only partially supporting or not supporting water quality standards, the costs of restoring Georgia's waters will be high. Any policy tool that can improve the cost effectiveness of water quality expenditures deserves serious consideration. Water quality trading is an innovative approach that offers the potential for substantial cost savings, among other benefits. However, trading markets are affected by a broad range of economic, environmental, social, and political factors. Implementation is complex, and the potential benefits can only be realized when trading is implemented under appropriate conditions.

Water quality trading has been piloted in several states, but not yet in the state of Georgia. The purpose of this paper is to provide an initial assessment of the feasibility of water quality trading as a means of controlling water phosphorus pollution in the Upper Chattahoochee watershed. The severity of nutrient pollution in the Upper Chattahoochee has resulted in strict and costly limitations for the wastewater treatment facilities of communities in the region. Water quality trading could provide these communities with a tool for complying with regulatory requirements as they grow, if the appropriate conditions to support trading exist.

This paper presents the benefits of trading and the issues of concern. The potential application of water quality trading in the Upper Chattahoochee is assessed against five factors: environmental suitability, regulatory incentive, availability of participants, economic incentive, and stakeholder response. The results of this preliminary assessment indicate that the Upper Chattahoochee has several characteristics

that support the feasibility of WQT.   Further research efforts are warranted to provide for informed decision making about the future of water quality trading in the Upper Chattahoochee, as well as the rest of Georgia.

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I. Introduction

Market-based approaches to environmental policy are increasingly being used to achieve water quality goals in the U.S. In 2003, the U.S. Environmental Protection Agency (EPA) published a water quality trading policy to encourage and guide the development of tradable permit programs for water pollutants in the U.S. The following factors have helped to stimulate increasing interest in water quality trading (WQT):

- The success of trading programs under the Clean Air Act has demonstrated that trading can be used to achieve environmental goals.
- Recent efforts across the U.S. to implement total maximum daily load (TMDL) requirements have brought the focus of water policy to the watershed scale. A watershed approach and the setting of watershed budgets for pollutants help to lay the foundation and create a regulatory incentive for WQT.
- The proliferation of pilot WQT projects across the U.S. has generated interest the use of this approach. A 1999 report to the EPA identified 37 water quality trading initiatives in the U.S. (Environomics, 1999), and several new initiatives have started each year since then. In 2003, the EPA awarded grants for 11 new trading projects.

Water quality trading has been identified as a priority for funding by the EPA Watershed Initiative and the USDA Conservation Innovation Grants programs. To date, however, there have been no WQT initiatives in Georgia.

Although trading has not yet been developed in a Georgia watershed, it is a subject of research at both Georgia State University and the University of Georgia. In 2002 and 2003, the Andrew Young School of Policy Studies (AYSPS) at Georgia State University issued two working papers that proposed the use of WQT in Georgia. Research on water quality trading at AYSPS has continued through collaboration with the Warnell School of Forestry at the University of Georgia. This research includes this report, which addresses the potential for WQT in the Upper Chattahoochee river basin. Elsewhere in the state, researchers from the University of Georgia are studying the potential use of WQT in the Lake Allatoona watershed in northern Georgia.

As described by Morrison, WQT could offer the state of Georgia a means of accommodating growth while preserving, and possibly improving, water quality (Morrison, 2002). The success of WQT hinges on a broad range of factors. Despite its complexity, trading can offer a tool for enhancing the cost effectiveness of water quality expenditures. With 57% of the state's rivers and streams only partially supporting or not supporting water quality standards, the costs of restoring Georgia's waters will be high (GA EPD, 2003). Any policy tool that can improve the cost effectiveness of water quality protection deserves serious consideration.

The purpose of this paper is to provide an initial assessment of the feasibility of WQT as a means of controlling phosphorus pollution in the Upper Chattahoochee watershed. The paper begins with an overview of the benefits and concerns associated with WQT. Then, it reviews the recent EPA policy on WQT and its implications for trading projects. Next, the paper describes the condition of the Upper Chattahoochee with an emphasis on the issue of nutrient over-enrichment. The remainder of the paper provides an analysis of the feasibility of applying WQT to nutrient pollution in the Upper Chattahoochee. This analysis is not a final analysis, but it serves as an initial assessment of the issue. The paper concludes with a discussion of further research needs.

Case Example: Dillon Reservoir, Colorado

Dillon Reservoir in Colorado is an important recreational resource and a staging reservoir for Denver's water supply system. In the early 1980's, the watershed was experiencing rapid growth, and water quality was declining. Concerns about increasing phosphorus levels led the state to establish a phosphorus concentration standard that translated into maximum load of 4,610 kilograms per year.

A stakeholder group initiated the development of a water quality trading project to comply with the loading limit. The trading project was codified by the state in 1984. The trading project allows point sources to receive 1 kg of credit for every 2 kg of nonpoint source phosphorus removed. Trades were required to meet a 2:1 trading ratio to provide a margin for environmental safety. Point source discharge permits include requirements that each trade record the credit amount, specified construction requirements for nonpoint source controls, monitoring and reporting requirements for nonpoint source best management practices (BMPs), and operation and maintenance requirements for BMPs.

Very few trades have occurred to date under this project because the wastewater plants reduced their phosphorus loading from 3,748 kg/year to 529 kg/year between 1981 and 1991, primarily through increased operating efficiency. Despite a lack of trades to date, the cooperative approach that grew out of developing the trading project is believed to have been in part responsible for success in phosphorus control in the watershed.

II. Overview of Water Quality Trading[1]

The costs of pollution reduction are not uniform. Different pollutant sources have different costs, and costs also vary with the level of pollutant reduction. Water quality trading allows pollutant sources to trade among themselves to allocate pollutant reduction efficiently. When trading is an option, a pollutant source can choose to reduce its own pollutant load or to pay a source with lower costs to reduce its pollutant load.

Water quality trading often takes advantage of large differences in pollution reduction costs between point sources and nonpoint sources of pollution. The cost of pollutant reduction from point sources is frequently much higher than for nonpoint sources. Most point sources have already implemented the least cost methods of reducing pollution. Further reductions by point sources come at increasing costs, while nonpoint source reductions can often be achieved relatively inexpensively. Trading allows point sources to reduce pollutant loads at a lower cost through exchanges with nonpoint sources. Moreover, the shift of pollutant reductions to nonpoint source loads through trading helps to address the primary cause of water quality impairment in the U.S.: nonpoint source pollution.

In the Tar-Pamlico watershed in North Carolina, nutrient loadings are managed through a WQT initiative. If dischargers in the watershed do not meet their aggregate limit ("cap") for nutrient reductions, they are required to purchase nutrient reduction credits for nonpoint source reductions. The program was initiated in 1991 by dischargers who estimated that cost savings of complying with new nutrient reduction requirements through trading could be as high as 7 to 1. Furthermore, they noted that their high cost compliance efforts would address only a small portion of the watershed's total nutrient

[1] Water quality trading is also referred to as effluent trading, offset trading, and offset banking.

loadings. WQT would help to address the primary source of nutrients to the watershed: agricultural nonpoint sources.

Trading projects can allow exchanges between different types of pollutant sources. For example, in addition to point-nonpoint, trading also can occur between different types of point sources. A source with lower costs can sell pollutant reductions to a source with higher costs. This type of trading also has occurred in the Tar-Pamlico. Point-point source and point-nonpoint source trading are currently the most common types of WQT in the U.S., but nonpoint-nonpoint and pretreatment permit trading also exist (Environomics, 1999). Nonpoint-nonpoint trading may become more common with increased regulation of nonpoint sources, such as recent efforts to increase urban runoff controls through National Pollutant Discharge Elimination System (NPDES) regulation of municipal stormwater. Mixed media trades between air and water sources of the same pollutant and cross-pollutant trades of related pollutants have also been considered.

Trading works best with conservative pollutants that degrade slowly and create impacts as a result of their total accumulation in a water system (Ribaudo et al., 1998). An example of this type of pollutant is phosphorus. This type of pollutant is well suited to management on a watershed scale. EPA policy supports trading that involves nutrients and sediment loads, as well as cross-pollutant trading for oxygen-related pollutants. The policy does not currently support trading involving persistent bioaccumulative toxics, although a few projects are attempting to reduce metal pollutants through trading on a pilot basis. Because trading can shift the pollutant load in a watershed, the potential for the development of localized "hotspots" must be addressed (see page 12). Most trading programs currently target nutrient reductions, while some target other parameters including sediment, temperature, pH, and biological oxygen demand (BOD) (Environomics, 1999).

Often, water quality traders are required to purchase credits at a premium. For example, a point source that chooses to trade with a nonpoint source may be required to pay the nonpoint source to reduce its pollutant load at a ratio of greater than 1:1. If the trading ratio is 2:1, a discharger that chooses to trade must purchase two pounds of pollutant reduction from another source for each pound of pollutant reduction that it avoids at its own facility. In the Tar-Pamlico, the trading ratio is 2:1 with a 10% administrative fee. The trading ratio can be used to address issues of uncertainty by creating a margin of safety. It can also be used to achieve environmental improvement.

Initiating WQT is a complex scientific and political process. It requires the involvement of scientists, policy makers, local officials, dischargers, landowners, environmentalists, and other members of the public from the earliest stages of the process. The development of a trading program requires watershed modeling and monitoring to support the development of trading rules. Accountability requires the development of an institutional structure and process that is trusted by the stakeholders and participants in the trading market. Without careful attention to the concerns of stakeholders, the benefits of trading may not be realized.

A. Benefits of Water Quality Trading

The primary benefit of WQT is the increased cost effectiveness of water pollution control. Trading seeks to increase the environmental benefit per dollar spent on pollution control by using a market mechanism to provide pollution reduction at the lowest incremental cost. The potential cost savings offered by trading are large. In its WQT policy, the EPA estimates that flexible approaches to water quality, including trading, could save $900 million annually. In Connecticut, it has been estimated that trading in nitrogen reduction credits among point sources to Long Island Sound will provide $200 million in cost savings (EPA, 2003a).

Environmental benefits can result from WQT when a trading project is designed to provide for environmental improvement by reducing pollution beyond current regulatory limits. Trading ratios are usually set to provide a margin of safety with respect to scientific uncertainty, but some trading projects have also set trading ratios at an additional premium to provide a net environmental benefit with each trade. Another mechanism to provide environmental improvement through trading is by instituting a pollutant loading cap that declines over time. Trading can be used to improve water quality while still allowing for growth by providing a flexible means to meet the overall pollutant cap. Also, if a trading project allows for independent groups to participate, independent participants can purchase pollutant credits to secure an environmental benefit, rather than using them as offsets for a pollutant load.

Traditional regulation of water quality emphasizes the installation of particular abatement technologies. Trading shifts the emphasis to water quality. By focusing on performance, trading can stimulate technological innovation. Firms will seek the most efficient means of compliance. Trading provides an incentive to invest in developing abatement technology innovations because they can anticipate revenue through the sale of pollutant reduction credits (Rousseau, 2001).

Point-nonpoint trading focuses pollution control efforts on the primary cause of water quality impairment in the U.S.: nonpoint source pollution. The 2000 National

Water Quality Inventory reports that runoff from agricultural lands accounts for 48% and urban stormwater accounts for 13% of water quality impairment in U.S. rivers and streams, while municipal point sources account for 10%. In lakes, agricultural runoff accounts for 41% and urban stormwater accounts for 18%, while municipal point sources account for 12% (EPA, 2002). In the U.S., water quality policy has generally involved strict regulation of point sources of pollution and voluntary or incentive-based programs for nonpoint sources of pollution. As water quality policy shifts toward an emphasis on watershed scale management (i.e., watershed planning, TMDLs), the need to address nonpoint sources is becoming a critical issue. Federal, state, local, and private resources are increasingly being directed at addressing nonpoint sources of pollutants. Trading between point and nonpoint sources of pollution creates a mechanism for directing more pollution control expenditures toward reducing nonpoint pollution loads.

Another benefit of WQT can arise through the development of partnerships and cooperative arrangements among pollution sources and other stakeholders. The creation of a trading project requires a cooperative approach that engages a wide range of stakeholders. The resulting partnerships lay the foundation for further cooperative work to achieve environmental goals.

In summary, the primary benefit of water quality trading is enhanced cost-effectiveness. However, trading can provide additional environmental and economic benefits. Trading can be designed to enhance environmental outcomes, and it can be used to target control of nonpoint sources. It provides flexibility, it emphasizes performance objectives over technology objectives, and it can stimulate investment in abatement technology. Finally water quality trading can contribute to the development of strong watershed partnerships.

B. Issues of Concern

A number of issues arise in the consideration of any WQT project. Although trading can provide many benefits, the complexity of developing and implementing a trading project requires careful attention to concerns that could diminish its success. Some concerns could create barriers to project development, while others may create difficulties during implementation. The following is a summary of potential issues of concern.

1. Scientific uncertainty

In practice, WQT is complex because it combines natural systems with human behavior under conditions of uncertainty. The development of a trading project is dependent upon environmental modeling of the natural system to predict the effects of trading. Models are used to develop trading rules and ratios and to evaluate the conditions necessary for successful achievement of environmental goals. While environmental modeling is the best tool available and while we are continuously improving our ability to model natural systems, inherent uncertainty exists in our ability to predict the effects of our actions on a natural system.

Uncertainty is particularly pronounced in evaluating nonpoint source loading. While current monitoring techniques are effective in quantifying point sources loads, pollutant loading from nonpoint sources and load reductions provided by Best Management Practices (BMPs) are difficult to measure directly. Nonpoint pollution control by BMPs is affected by a number of factors, including weather, soil type, soil permeability, slope of the land, and land use practices. Because of the variability of BMP performance, uncertainty is a substantial concern in estimating BMP effects on pollutant loads. As a result, the effects of BMPs on pollutant loading are usually estimated rather than measured, and as a result, water quality trades are usually defined by activity-based criteria, rather than performance-based criteria.

Nonpoint sources are difficult to manage for several reasons, including: (1) difficulties in monitoring and enforcement of diffuse sources, (2) multiple jurisdictions and conflicting objectives in nonpoint sources management, (3) uncertainty about the performance of nonpoint source controls, and (4) uncertainty about the fate and transport of nonpoint source pollutants. It is important to note, however, that these concerns apply to the management of nonpoint sources with or without WQT. In evaluating the challenges that nonpoint sources raise in WQT, the appropriate question to consider is: what additional problems related to nonpoint source control are created by WQT? (Letson et al, 1993).

Trading projects can be designed to address scientific uncertainty through improvements in modeling, evaluation of a range of scenarios, and through trading rules. Some trading projects have altered trading ratios to create a margin of safety in any trade in order to address uncertainty.

While uncertainty is a concern, we must be careful to consider only the marginal uncertainty introduced by trading. Traditional environmental regulation is also dependent upon information about which there is not complete certainty. Uncertainty affects the implementation of any policy. The decision to proceed with uncertainty is usually made when the benefits of the policy appear to outweigh the costs, including the costs created by uncertainty.

2. *Economic and policy uncertainty*

On top of uncertainty about the natural environment, we add uncertainty about the prediction of human behavior. Uncertainty arises in the economic and policy aspects as well as the scientific aspects of WQT. How will policy change in the future? How will a region grow? How will land be used in the future? How can we effectively compel compliance with regulations?

Uncertainty about policy issues has been a barrier to WQT in pilot trading projects in Wisconsin. In addition to confusion over how to quantify pollutant credits generated and uncertainty over nutrient delivery rates and appropriate trading ratios, participants were hindered by uncertainty about the implementation of WQT policies. A recent report (Kramer, 2003) identifies several types of policy uncertainty that caused problems for traders in that state:

- Point sources were uncertain that trading credits would be valid for compliance with NPDES requirements.
- Point sources were uncertain whether pre-TMDL reductions made to generate trading credits would be used to set more restrictive limits when permits were renewed. They were also concerned that anti-backsliding would prohibit them from returning to their previous discharge level if they chose to stop generating credits.
- Point sources were concerned about their potential liability for non-performance by nonpoint sources from which they purchased credits.

- Point sources anticipated high transaction costs because they were unfamiliar with using trading credits for compliance.
- All sources were uncertain about potential political repercussions and negative publicity as a result of engaging in trading.

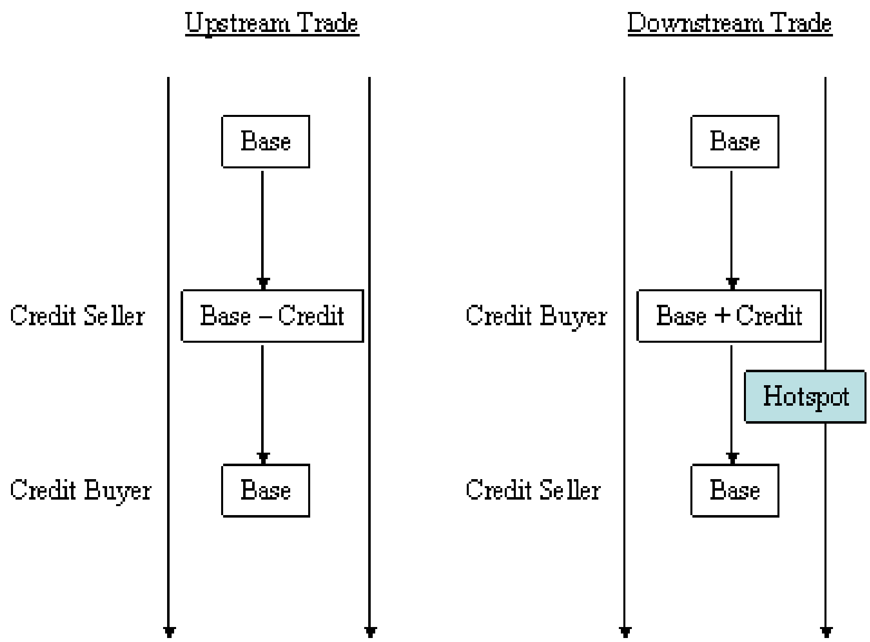
The EPA WQT Trading Policy issued in 2003 helped to reduce several of these sources of uncertainty. However, unfamiliarity with trading still leaves some issues unresolved. Additional experience with WQT should help to reduce these sources of uncertainty over time.

3. Localized impacts

Some water quality trades have the potential to create adverse localized impacts while still resulting in decreased pollutant loadings at the aggregate level. "Hot spots" are localized areas with high levels of a pollutant. A "hot spot" might be created, for example, when a pollution source pays a source downstream for pollutant reductions through trading (see Figure 1). Pollutant loads in the stream segment between the two sources could become too high. Generally, upstream trades are preferable. When a buyer of pollutant credits pays an upstream source for pollutant reductions, water quality in the segment between the two sources is improved and the risk of creating a "hot spot" is greatly reduced.

Factors that can contribute to the creation of "hot spots" include characteristics of the pollutant, availability of assimilative capacity in the stream segment, low flow or long retention periods, and interaction with other pollutants. Trading projects need to be designed with appropriate trading rules and water quality monitoring to address the potential for localized impacts.

Figure 1 : Changes in Pollutant Loads in Water Quality Trading:
Creation of Hotspot in Downstream Trade



Note: A 1:1 trading ratio is assumed in this diagram.

4. Transaction costs

Trading will not occur when the costs of completing a trade are prohibitively high. Transaction costs include the costs of finding trading partners, bargaining, collecting information needed to evaluate the trade, monitoring, complying with accountability requirements, and accepting liability for the actions of a trading partner. These can be categorized into three types of transaction costs: (1) search and information, (2) bargaining and decision, and (3) monitoring and enforcement (Stavins, 1995).

An important determinant of transaction costs is the number and size of participants. In markets with too few participants or numerous small participants, transaction costs may be a barrier to trading (Crutchfield and Letson, 1994). The costs of finding a suitable trading partner in a limited market or the costs of bargaining with multiple small trading partners in an extensive market may outweigh the benefit of trading. On the other hand, markets with numerous participants can help to ameliorate transaction costs by reducing search costs if the participants are suitably large. Furthermore, a large number of participants can generate a great number of transactions, and frequent transactions generate information useful for other potential trades and reduce uncertainty and related transaction costs (Stavins, 1995).

Water quality trading creates new markets, and new markets often lack the infrastructure to operate smoothly. The costs of trading need to be evaluated. Some institutional arrangements for trading will be less costly to traders than others. Accountability is critical to the success of trading, but if compliance with requirements to ensure accountability is too costly, trading will not occur. Potential transaction costs must be carefully considered the design of WQT.

5. Baseline for nonpoint sources

A guiding principle for WQT is additionality, which requires that pollutant reduction credits can only earned for reductions that would not have occurred in the absence of trading. The baseline for valid credits excludes any practices that a source performs through a "green payment" program or is required to perform by law. As a result, government programs can affect the supply of trading credits. Moreover, practices eligible for credits are likely to be more costly, more risky, and more difficult to validate because government programs are likely to have already addressed the least cost options (King and Kuch, 2003).

Setting the baseline for point sources is relatively straight-forward. Credits can only be earned for "over-compliance" with the discharge permit limits. For agricultural non-point sources, setting the baseline is more complex. Baseline requirements will penalize farmers who have already implemented pollution reducing practices because their existing practices will be ineligible. The baseline can be defined by the performance of specific minimum practices; only practices that exceed the baseline are eligible to generate credits. This policy has the benefit of reducing the penalty for farmers who have already undertaken conservation measures, but it does not eliminate their penalty. It would also reduce the availability of low cost credits and affect the cost-effectiveness of WQT (if the farmers do not receive credits for practices above the baseline that were put into place prior to WQT). Alternatively, if nonpoint sources were held to regulatory standards for pollutant reduction, the baseline would be set at the regulatory standard, as it is for point sources. Farmers would have access to the same credit pool as point sources to meet their regulatory obligation (Faeth, 2000). The determination of the nonpoint source baseline is an important issue that affects the efficiency of WQT.

6. *Temporal issues*

Can pollutant reduction credits be "banked" for later use? Can a trading participant "borrow" credits and pay them back with reductions in a later period? An important issue in the design of WQT is whether trading through time will be permitted. The sulfur dioxide trading program for air pollution allows banking, but not borrowing. However, few WQT projects have allowed banking and borrowing (Rousseau, 2001).

Banking and borrowing can create temporal problems by clustering pollution loading in a certain period. When banking and borrowing are allowed, the socially optimal solution might not be attained (Kling and Rubin, 1997).

Another temporal concern is seasonality. Point sources pollution loads are generally less seasonal than agricultural nonpoint source loads. Load variability across seasons may limit the timing and duration of trades among sources.

7. *Enforcement and liability*

In a point-nonpoint source trade, who is liable if the nonpoint source credit seller does not perform as required or if their activities do not have the expected environmental results? Nonpoint source reductions are difficult to guarantee. Credit sellers might not perform the required activities or those activities might not result in the expected environmental results. The liability must be assigned or divided among the buyer and seller. Generally, buyer liability has been assumed for WQT. Buyer liability creates an incentive for monitoring by the buyer, and thereby, it can reduce government monitoring costs. It may also increase environmental efficacy by increasing the likelihood that reductions are achieved. Because buyer liability increases the costs of trading for the buyer, the demand for credits will be dampened. Seller liability does not create an obligation for monitoring by the buyer and therefore reduces transaction costs. The allocation of liability is an important factor in the efficiency of WQT (Woodward et al., 2002).

The design of a WQT project can alleviate some of the liability burden for buyers. The use of a market structure with a third party administrator[2] can transfer some or all of

[2] For an example of a market structure with a third party administrator, see the discussion of the clearinghouse market structure on page 48.

the enforcement responsibilities and liability to the market administrator, market participants in the aggregate, and taxpayers. The use of performance bonds or escrow deposits can also be used to mitigate transaction risks and compel nonpoint source compliance in WQT. A dual liability arrangement might also be considered.

In 2002, the state of Michigan adopted rules for WQT that address the issue of liability.[3] The Michigan rules create dual liability, which assigns specific responsibility to each party to the trade. If a credit seller does not perform the actions to generate the credits sold, they are subject to treble damages, meaning that they are required to obtain three times the number of insufficient credits.[4] Any credits collected as damages are retired to provide an environmental benefit. On the other hand, credit buyers are liable if they do not obtain sufficient credits to comply with their effluent limits. The credit seller has the burden of proof to demonstrate that their credits are "real, surplus, quantifiable, and sufficient." The credit buyer has the burden of proof to demonstrate proof of due diligence to comply with applicable discharge standards and effluent limitations. A dual liability arrangement corresponds with responsibilities under the trading contract. It offers an alternative that addresses inefficiencies created with a buyer liability arrangement.

8. *Paucity of trading in pilot water quality trading projects*

A major criticism of existing WQT projects is that very little actual trading has occurred to date (King and Kuch, 2003, Kramer, 2003). For example, in the case of Dillon Lake, only three trades have occurred to date. In the Tar-Pamlico, dischargers have not yet exceeded their nutrient cap, and so no trades have been completed. In both cases,

[3] See http://www.state.mi.us/orr/emi/arcrules.asp?type=dept&id=EQ&subId=1999%2D036+EQ&subCat=Admincode

[4] If the credit seller self-reports a violation, then they are provided with a 30-day "true-up" period to comply. Likewise, a credit buyer is given a 90 day "true-up" period to come into compliance if they are relying on credits that are deficient as a result of the actions of the credit seller.

point sources reduced their pollutant loadings more inexpensively than expected, and therefore the financial incentive for trading has not yet existed.

Is a lack of trading an important concern? Why are so many pilot projects leading to so little actual trading? Possible causes include transaction costs, imbalance of supply and demand for pollution credits, lack of a financial incentive to trade, and lack of a regulatory incentive to trade.

In the case of Dillon Lake, a shift from technology based to performance based standards for dischargers under the trading project allowed them to adopt new lower cost methods of controlling nutrients.[5] As a result of this shift, point sources are not expected to reach their allocations, even when the watershed is fully developed, and therefore, trading by point sources is unlikely. However, the trading initiative has evolved to focus on nonpoint sources. Local officials have instituted new regulations that require new nonpoint sources to offset their phosphorus impacts by purchasing offsets from existing nonpoint sources, in addition to meeting existing requirements for nonpoint controls (Sohngen, 1998).

In some cases, while trading is not occurring now, it will become more important as communities grow or as environmental goals become stricter and dischargers come closer to exceeding their allocations. In the Tar-Pamlico, dischargers active in the development of trading made improvements in their operations that allowed them to avoid reaching their cap and the need to trade. As the communities of the Tar-Pamlico grow, the ability to trade will allow them to continue to maintain water quality efficiently.

[5] Technology based standards for dischargers require the use of specific technologies to achieve abatement. Performance based standards set the level of abatement to be achieved without specifying the technology to be used. Discharge permits may include both types of standard. In this case, a technology based standard was replaced by a performance based standard as a result of the WQT project.

Trading will occur when the appropriate conditions exist. The question to consider is determining whether WQT should be established is whether the appropriate conditions will exist in the not too distant future.

Moreover, WQT projects have non-trading benefits. In the case of Dillon Lake, stakeholders believe that the cooperative approach that grew out of developing WQT is a key reason for their success in maintaining high water quality for more than 12 years in the face of population growth and development. Creating cooperative relationships in the pursuit of water quality goals lays the foundation for long-term watershed protection.

9. Principle of trading

Some critics of trading are simply opposed in principle to the use of market mechanisms. They believe that trading implies that a discharger owns a right to pollute, and they find this implication unacceptable. The validity of this criticism is debatable. Unless pollutant loading is required to be zero, any regulatory measure allocates pollution rights. The validity of the criticism notwithstanding, it can still be a barrier to successful engagement of stakeholders and the development of a WQT project.

10. Summary

A report from the Minnesota Pollution Control Agency identified four criteria to be used as objectives in developing WQT: efficiency, equivalence, additionality, and accountability (qtd. in Fang and Easter, 2003). Efficiency refers to the economic benefit of trading: allocation of pollutant reductions to those sources with the lowest reduction costs. Equivalence refers to the interchangeability of loadings from different sources. Trading must account for differences among sources and their environmental effects to create a common currency. Additionality requires that pollutant reduction credits are earned only for reductions that would not have occurred otherwise, in the absence of trading. Accountability refers to the need to provide information to ensure that all of the requirements of trading, including equivalence and additionality, are met.

These four criteria are useful principles to guide the development of WQT, but perhaps the greatest challenge for WQT is the difficulty of meeting all four of these criteria simultaneously (Fang and Easter, 2003). Providing equivalence, additionality, and accountability reduces efficiency, but meeting these criteria is critical to the credibility of trading. Tradeoffs among the criteria will always be present and will require careful balancing as WQT is developed.

III. EPA's Water Quality Trading Policy

In January 2003, the EPA issued a national WQT policy in an effort to encourage the use of trading, where appropriate, to meet water quality goals. The policy can be found in its entirety at the following website: (http://www.epa.gov/owow/watershed/trading/finalpolicy2003.html). The EPA believes that market-based environmental policies can offer increased flexibility and provide the potential for greater environmental benefits than might otherwise be achieved. The policy also notes, however, that trading is only appropriate under certain conditions.

The policy clarifies a number of important WQT issues. Specifically, the policy clarifies:

- Support for trading in pre-TMDL impaired waters
- Acceptable methods for defining trading baselines

- Application of anti-backsliding and anti-degradation requirements of the Clean Water Act under trading

Furthermore, the policy encourages the use of trading provisions in TMDLs and provides guidance on incorporating trading in NPDES permits. For example, permits can be written to allow for trades without the need formal modification of permits. The policy also opens the possibility for cross-pollutant trading.

The EPA policy sets objectives for WQT. The EPA believes that trading should reduce the costs of compliance with water quality regulations. The EPA also believes that trading should be able to achieve greater environmental benefits than those provided under existing regulatory programs. Benefits may include ancillary improvements such as wetlands and habitat restoration, as well as water quality maintenance and improvement.

The policy suggests the following as the elements of a credible trading project:

- Clear legal authority and mechanisms
- Clearly defined unit of trade expressed in rates or mass per unit time
- Limits on duration of credits to the same period in which they are used to comply with permit standards
- Use of standardized protocols to quantify pollutant loads and to address uncertainty
- Compliance and enforcement provisions
- Public participation and access
- Program evaluations

The policy provides guidance on issues such as limits on the trading region, when trading may occur, and parameters that may be traded. Currently, EPA supports trading in nutrient and sediment loads. The policy notes that trading in other parameters may be beneficial, but that greater risks will require higher levels of scrutiny. The EPA supports cross-pollutant trading for oxygen-related pollutants when adequate information exists to support this type of trading. For example, the EPA policy supports trading that reduces upstream nutrient levels to offset downstream biological oxygen demand or to improve in-stream dissolved oxygen levels.

One of the most important requirements of the WQT policy relates to the setting of baselines. Trading must meet the criterion of "additionality," which requires that pollution credits can only be earned for reductions that would not have occurred in the absence of a trading program. Credits cannot be earned for improvements that would have been required under a TMDL or other regulatory programs. This requirement seeks to provide true offsetting.

The trading policy states that all trading must be consistent with the Clean Water Act. It addresses several Clean Water Act issues that have been raised as possible legal issue for WQT. For example, the policy states that EPA believes that anti-backsliding provisions of the Clean Water Act are generally satisfied when a point source increases its discharge through trading in pollutant credits, if trading is conducted in a manner consistent with a TMDL or watershed plan. It also notes that if a discharger decreases its pollutant load below its effluent limitation to generate pollutant credits and later decides to discontinue generating credits, it will not violate the anti-backsliding provision as long as the total pollutant load to the receiving water is not increased.

With respect to anti-degradation, the EPA trading policy states that trading should be permitted without anti-degradation review for high quality waters. The EPA does not believe that trading will result in "lower water quality" as the term is used in the anti-degradation provisions of the Clean Water Act.

By issuing this policy, the EPA has provided an important source of guidance for the development of WQT programs. The policy will help to lower some barriers to trading. The EPA will play a role in the development of trading, and it has some oversight over trading through its approval of TMDLs and water quality standards and the review of NPDES permits. However, most of the initiative for developing trading will come from the state and local level.

IV. The Chattahoochee Watershed

The Chattahoochee River flows from the Blue Ridge Mountains in the northwest corner of Georgia, through the metropolitan Atlanta region, along the Georgia-Alabama border, and ends in Lake Seminole at the Georgia-Florida border. It is a part of the larger Apalachicola, Flint, and Chattahoochee system ("ACF"), which ultimately discharges to the Gulf of Mexico through the Apalachicola Bay on the Florida panhandle (see Figure 2).

The Chattahoochee drainage basin is a total of 8770 square miles, of which 70% are in Georgia. The upper watershed includes the metropolitan Atlanta region. In 1990, the Chattahoochee watershed had a population of 2.6 million people, approximately 75% of which lived in the Atlanta metropolitan area. Population growth in the watershed has been rapid, with most of the growth focused in the Atlanta region. Between 1970 and 1990, growth in the watershed was 37% (Couch, 1993). Between 1990 and 1998, growth in the Atlanta metropolitan was 20%, which was faster than any other large U.S. city (CWI, 2000). Continued strong growth is projected for the watershed, especially in the

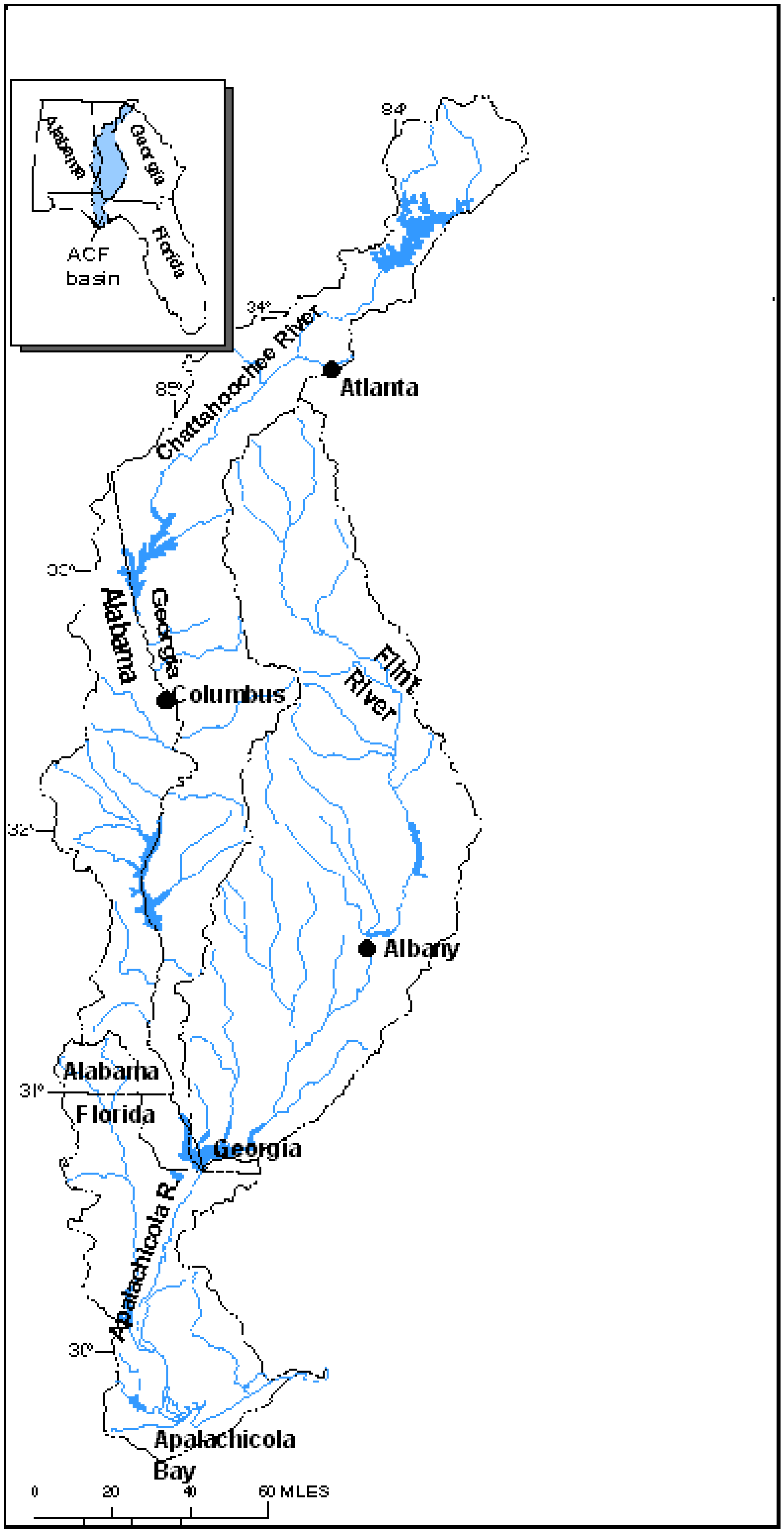


Figure 2: Apalachicola-Chattahoochee-Flint River Basin

Source: USGS

Atlanta metropolitan region, which is expected to almost double in population by 2030 (MNGWPD, 2003b).

In the state of Georgia, the Chattahoochee River watershed is the most utilized surface water source for drinking water. It provides drinking water for about 3 million people in the state. In the metropolitan Atlanta region, approximately 80% of the population relies on the Chattahoochee for its water supply (CWI, 2000). The river system is also an important source of recreation and hydroelectric power in the state.

The influence of the Atlanta region on water quality in the Chattahoochee is of critical importance. The river originates only 75 miles northeast of Atlanta. The headwaters of a river system have a limited capacity to accept and dilute pollutants, and therefore the location of Atlanta in the upper watershed makes the system particularly sensitive to water quality impacts. Furthermore, the waters of the Chattahoochee flow through two major impoundments in the Atlanta region: Lake Lanier and West Point Lake. Lakes are especially sensitive to the pollutant loads of the water that enters them. The combination of a headwaters location, the presence of environmentally sensitive lakes, and the importance of the river system as a water supply create a need for careful management of the Chattahoochee's water resources.

The effects of the Atlanta area on the river are evident in water quality data. The loads of pollutants including nutrients and sediment increase by several times as the river passes through the metropolitan region. In a study conducted from 1993 to 1998, loads of nitrogen, phosphorus, organic carbon, and suspended sediments were 8.5, 14, 37, 5.3 times greater, respectively, downstream of Atlanta than upstream of Atlanta (Frick and Buell, 1999). Although improvements in water quality have been made in the metropolitan area, many waters in the region remain impaired, and continued urban growth will place additional environmental stress on the system (CWI, 2000).

The focus of this report is the Upper Chattahoochee watershed, including all of USGS HUC 03130001 and a large portion of HUC 01310002 (see Figures 3 and 4). The area of interest is the watersheds of Lake Lanier and West Point Lake, where nutrient overenrichment is a concern.[6] Phosphorus has been the focus of pollution reduction efforts in the Upper Chattahoochee, including a phosphorus detergent ban and improvements in nutrient removal efficiency at wastewater treatment plants. As a result of these efforts, phosphorus loads in the system have decreased substantially from 1976 through 2001, despite rapid population growth during the same period (Calhoun et al, 2003). However, phosphorus loads continue to be a concern in the watershed, especially because decreasing stream flow levels, which result from urbanization, increase nutrient -concentration levels in the system (MNGWPD, 2003a). Phosphorus control to prevent over-nutrification and dissolved oxygen sags in the Chattahoochee and its impoundments are a major concern. Dischargers in the watersheds of Lake Lanier and West Point Lake are subject to strict phosphorus limits that will become more costly as wastewater flows increase with growth in the region.

Phosphorus is the limiting nutrient in Lake Lanier and West Point Lake. The Georgia Environmental Protection Division has set watershed limits for phosphorus loadings into these lakes. In Lake Lanier, the current annual load limit is 39,600 pounds

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[6] HUC 03130001 is usually referred to as the Upper Chattahoochee, while HUC 03130002 and 03130003 are referred to as the Middle Chattahoochee. However, for simplicity in this report, the region encompassing the watersheds of Lake Lanier and West Point Lake, including all of HUC 03130001 and most of HUC 03130002, will be referred to as the Upper Chattahoochee. The lower boundary of HUC 03130001 and the upper boundary of HUC 03130002 are at Peachtree Creek in Atlanta.

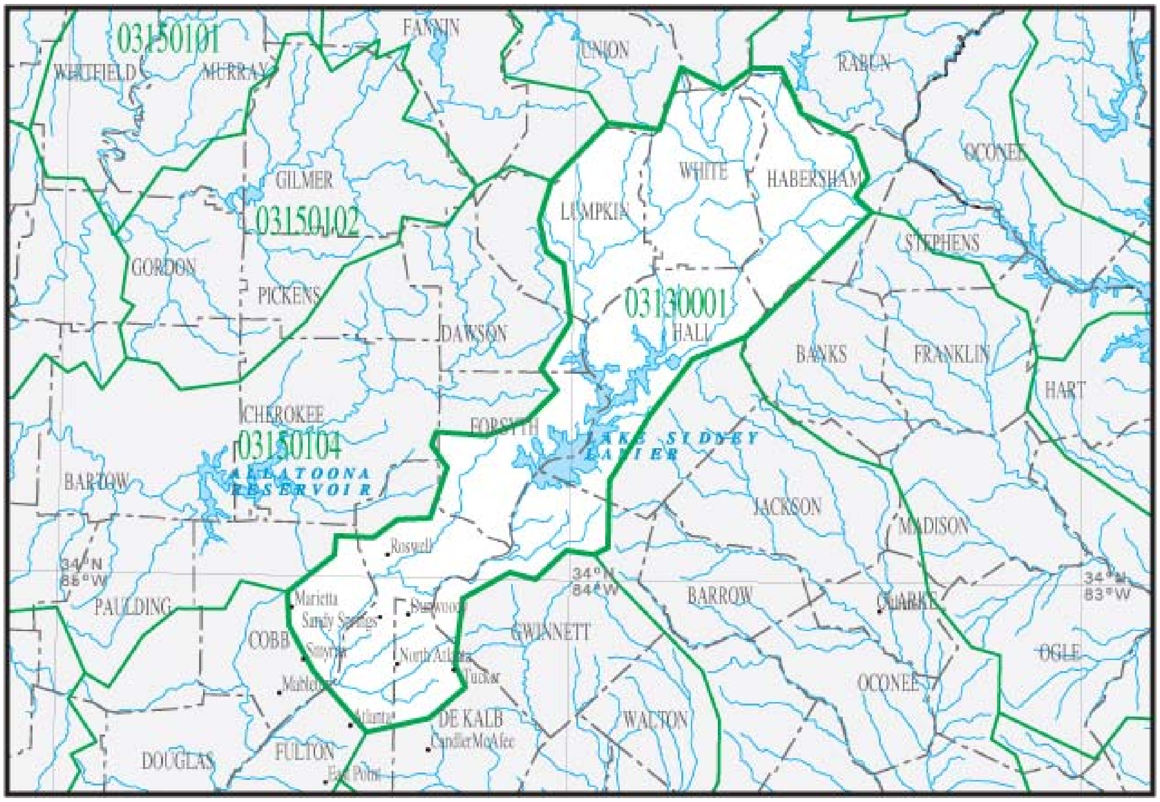

Figure 3: Map of Chattahoochee River HUC 03130001

Source: USGS

of phosphorus from point sources. For West Point Lake, the load is limited to 1,400,000 pounds of phosphorus per year from point and nonpoint sources (MNGWPD, 2003b). As wastewater flows in the watershed increase, wastewater dischargers must improve their removal efficiencies to reduce the concentration of phosphorus in their discharge in order to continue to meet these load limitations. The cost of removing phosphorus increases as the removal efficiency increases. The last one percent removed is much more costly than the first one percent removed. For most dischargers in the watershed, the cost of improving their phosphorus removal efficiency at the wastewater discharge plant to comply with phosphorus load limits will be very high.

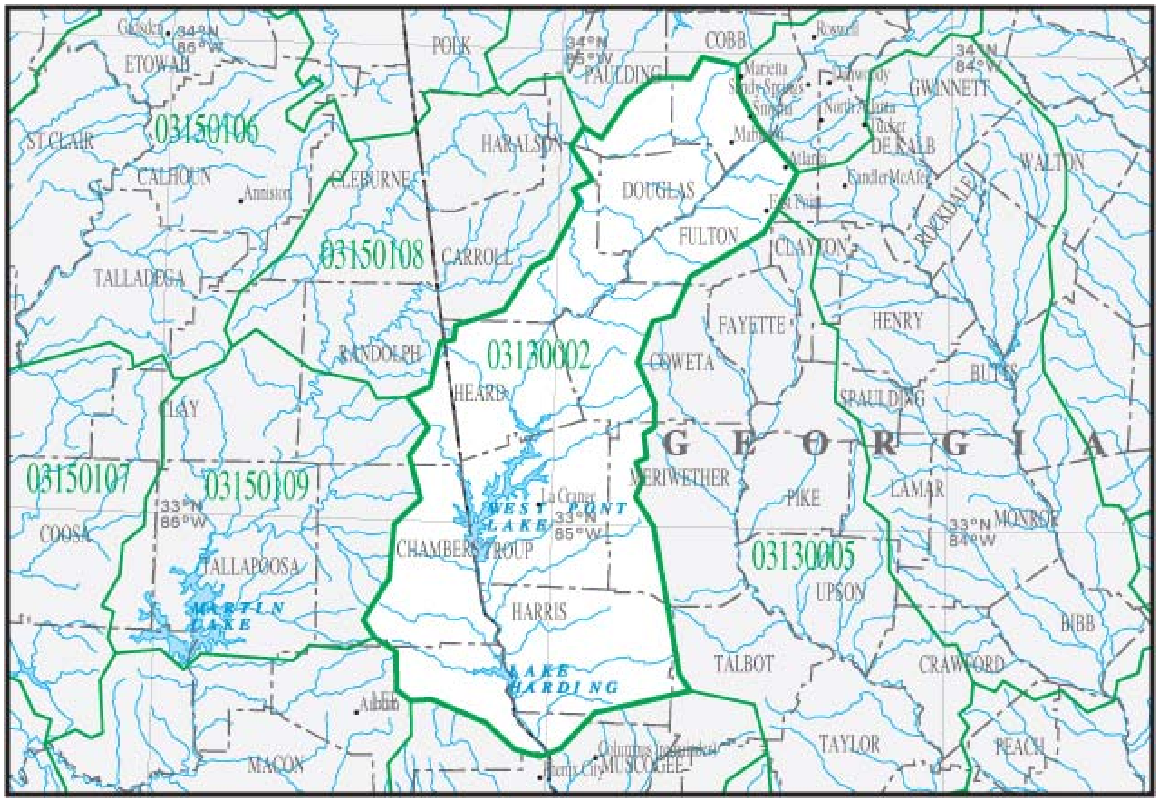

Figure 4: Map of Chattahoochee River HUC 03130002

Source: USGS

Nonpoint sources are also an important contributor to phosphorus loading in the Upper Chattahoochee watershed. Analysis of water quality data indicates that urban and agricultural lands in the watershed are significant sources of nutrients in the watershed (Frick and Buell, 1999). Modeling conducted for the Metropolitan North Georgia Water Planning District estimated the relative phosphorus loads of point and nonpoint sources in the watershed. In the portion of HUC 03130001 that is within the metropolitan area, modeling estimates that approximately 20% of phosphorus loading comes from point sources, and 80% comes from nonpoint sources. In the portion of the HUC 03130002 that is within the metropolitan area, approximately 40% of the phosphorus loading comes from point sources, and 60% comes from nonpoint sources (MNGWPD, 2003a).

By these estimates, while point sources are an important source of phosphorus, nonpoint sources are responsible for more than half of phosphorus loadings in the metropolitan area. It is expected that they account for an even larger share outside of the metropolitan area. Nonpoint source loadings are generally not subject to regulation, aside from recent efforts to control stormwater in urban areas through the NPDES permit program. Furthermore, nonpoint controls are usually less expensive than point source controls.

This cost difference is the primary driver behind point-nonpoint source trading. The potential to reduce nonpoint loadings more cost effectively than point source loadings creates the opportunity for trading. However, many other factors influence the success or failure of WQT. Does the economic incentive for WQT in phosphorus exist in the Upper Chattahoochee? What other factors affect the feasibility of WQT in the Upper Chattahoochee? These questions are explored in the analysis below.

V. Feasibility of Nutrient Trading in the Upper Chattahoochee

The simplicity of the basic concept of WQT is underlain by a complex set of factors that affect its implementation. These factors range from scientific to economic to political. The following analysis examines the factors would affect trading in the Upper Chattahoochee watershed and evaluates the watershed in terms of its suitability for nutrient trading.

A. Environmental suitability

1. Pollutant

Over-nutrification is a serious and growing water quality issue in the U.S. The EPA is developing in-stream nutrient standards for all U.S. waterbodies, and it will encourage all states to adopt and implement these standards. It is expected that these standards will be adopted by the states over the next five to ten years. The adoption of in-stream nutrient standards is likely to create a new impetus for WQT in watersheds where nutrients were previously unregulated.

The state of Georgia does not currently have in-stream nutrient standards, but it has set nutrient loading limits in the watersheds of several lakes in the state that have been affected by eutrophication, including Lake Lanier and West Point Lake in the Upper Chattahoochee. These limits provide a baseline for trading in phosphorus in the Upper Chattahoochee.

WQT works best with conservative pollutants that degrade slowly and that create impacts as a result of their total accumulation in a water system (Ribaudo et al., 1998). This type of pollutant is well suited to management on a watershed scale. Phosphorus meets these criteria. Trading in nutrients is supported by the EPA Water Quality Trading Policy (EPA, 2003a). Nutrients are generally well-suited to trading, and phosphorus is the most common focus of existing WQT projects (Environomics, 1999). The fate and transport of phosphorus are sufficiently understood and the watershed models used for phosphorus are sufficiently well developed to support the reasonable estimation of environmental equivalence relationships among phosphorus sources. Phosphorus can also be readily measured as necessary to support trading. It is also possible to reasonably estimate reductions of phosphorus by agricultural Best Management Practices (BMPs). If conservative assumptions are used, these estimates can be used to evaluate the environmental equivalence of the effects of BMPs and to set a tradable value on their phosphorus reductions (EPA, 2003b). Furthermore, existing phosphorus trading projects provide a precedent for the modeling and estimation on which new phosphorus trading programs can be built.

One potential concern in trading phosphorus is equivalence among different types of phosphorus. Phosphorus is often measured as Total Phosphorus (TP), which consists of two forms of phosphorus, soluble and nonsoluble. Soluble phosphorus is more available for biological uptake and can contribute to rapid algal growth more readily than non-soluble phosphorus. Non-soluble phosphorus is bound in the sediments, but it has the ability to become biologically available over time. Most TMDLs for phosphorus address Total Phosphorus. However, if the composition of phosphorus loads varies substantially among sources in a watershed, adjustments in trading ratios and procedures may be needed to account for differences in the types of phosphorus. A translation ratio between the types of phosphorus can be developed to make adjustments as needed (EPA, 2003b).

Trading ratios for phosphorus are also likely to be affected by the characteristics of the water system. Some water segments have a greater retentiveness for phosphorus than others. Low flow and impounded streams have a high retentiveness for phosphorus, and trading ratios may need to be increased to account for the retention of phosphorus. The phosphorus load in the sediments, substrate stability, and light must also be considered (EPA, 2003b). These issues are likely to be of particular concern in the Upper Chattahoochee.

Seasonality can also be a concern with phosphorus. Point sources loads are generally less seasonal than agricultural nonpoint source loads of phosphorus (EPA, 2003b). Load variability across seasons may limit the timing and duration of trades among sources.

Thus, trading in phosphorus in the Upper Chattahoochee is possible based upon the characteristics of the pollutant. Adjustments for the composition of phosphorus loads, phosphorus retention in the water system, and seasonality of loading would need to be addressed in the design of a trading project.

2. *Geography*

Trading is also best suited to water bodies with long pollutant residence times. In this type of water system, pollutant loads are less subject to fluctuations as a result of weather. Thus, trading is most appropriate for water systems involving lakes and estuaries (Ribaudo et al., 1998). Trading in the Upper Chattahoochee would be focused on phosphorus loading to lakes.

However, the geography of the Upper Chattahoochee raises two issues that would need to be addressed in the design of a trading project. The first issue is the location of Buford Dam in the middle of the watershed. Impoundments affect the dynamics of phosphorus retention. They create a barrier to the transport of nonsoluble phosphorus. It is difficult to predict how a change in loading above the impoundment will affect phosphorus levels below the dam. Subsequently, it is difficult to estimate environmental equivalence for trades involving sources on opposite sides of the impoundment, and therefore, permitting trading across the impoundment may not be possible. If trading between sources on opposite sides of Buford Dam is not permitted, then two separate markets must be considered: the watershed of Lake Lanier, above Buford Dam, and the watershed of West Point Lake, below Buford Dam.[7]

The other geographical concern is the size of the water system. The watersheds of both lakes are sufficiently large that some sources will be separated by substantial distances. Distance between trading partners is an important factor in determining environmental equivalence. The size of the watersheds in the Upper Chattahoochee is likely to require variations in trading ratios based on distance, and additionally, limits on trading distances may be necessary. This concern should be evaluated through modeling.

B. Regulatory incentive

The development of a market for WQT is dependent upon sufficient regulatory pressure to interest potential traders in creating and participating in the market. The need for a sufficient regulatory incentive has been demonstrated by existing WQT pilot projects. In Dillon Lake, CO, interest in WQT was driven by the threat of a moratorium on all new connections to the sewer system in the watershed (Bruce Zander, EPA, personal communication, 2004). On the other hand, in the Fox-Wolf Basin in Wisconsin, no trading has occurred as a result of a lack of a regulatory incentive. In that watershed, before WQT was established, point sources had recently upgraded to meet a new phosphorus effluent limit of 1mg/l. Without a requirement for further reductions, point

[7] This division does not correspond with the HUC boundaries in the Chattahoochee. The Lake Lanier watershed includes all of HUC 03130001 above Buford Dam. The West Point Lake watershed includes the portion of HUC 03130001 from Buford Dam to Peachtree Creek in Atlanta and most of HUC 03130002, excluding the lower portion of the HUC between West Point Lake and Lake Harding. Because most data is available by HUC, this limits the ability to use existing data for analysis. Existing data are used herein where possible. In some cases, data from the Metropolitan North Georgia Water Planning District were used. These analyses include most of the watersheds of Lake Lanier and West Point Lake, but exclude the upper and lower parts of these watersheds, which are not included in the metropolitan district's jurisdiction. The metropolitan district data, however, provides a good proxy for data for the lake watersheds because it includes most of the major point sources and the region that will be most affected by the need to control nutrient loading as a result of growth.

sources had no regulatory incentive to participate in trading. Trading is unlikely to occur in this pilot project until limits are tightened, wastewater plants seek expansion, or new wastewater facilities are proposed (Kramer 2003).

Currently, total maximum daily loads (TMDLs) are a leading driver in the creation of WQT markets. By creating a pollutant budget for a watershed, TMDLs provide both the incentive and the scientific framework for trading (EPA, 2003b). The Upper Chattahoochee does not have a TMDL for phosphorus, but the Clean Lakes studies of Lake Lanier and West Point Lake provide a similar framework for nutrient trading. These studies created nutrient loading budgets, similar to TMDLs, for these watersheds. The loading budgets can be used to set baselines and caps for WQT in the Upper Chattahoochee.

The nutrient budgets from the Clean Lakes initiative are used to set phosphorus loading limits that are incorporated into discharge permits in the watershed. To maintain phosphorus loadings at a watershed scale while accommodating growth, dischargers have been subject to increasingly strict concentration limits for phosphorus. Currently, as dischargers renew their permits, concentration limits are being tightened. Dischargers to Lake Lanier will be held to an effluent limit of 0.13 mg/L. Dischargers to the Chattahoochee River in the metropolitan Atlanta region will be held to a standard of 0.3 mg/L and possibly lower. As flows in these wastewater plants increase, concentration limits will decrease to hold total loadings constant. Wastewater plants in Gwinnett County and the City of Gainesville are currently upgrading their phosphorus removal efficiencies to meet the 0.13 mg/L limit. Other dischargers in the watershed will follow suit as their permit limits are tightened over the next few years.

Given the strict limits on phosphorus loading, a regulatory incentive for WQT appears to exist in the Upper Chattahoochee. In preliminary interviews, several wastewater plant operators in the watershed have expressed an interest in learning more about WQT as an alternative for meeting their increasingly strict phosphorus limits. The strength of the regulatory incentive would depend on the timing of the implementation of new phosphorus limits relative to the timing of the initiation of WQT in the watershed.

C. Availability of potential participants

The availability of a suitable market of potential trading partners is critical to the success of a WQT program. Trading markets can fail if the participants are too small or too few (Letson et al., 1993, Crutchfield et al., 1994). The number and size of credit selling participants must be sufficient to supply the pollutant credits adequate to meet the load reductions sought by credit buyers. If the market consists of numerous small participants, transaction costs may be too high. To address the issue of sufficient participation, Crutchfield et al. suggest three screening criteria. Below, these screening criteria are applied to the two segments of the Upper Chattahoochee watershed.

1. Screening Level 1

Pollutant loadings from point sources and nonpoint sources should be balanced sufficiently enough that each accounts for at least 20% of the total pollutant loadings. Loading estimates for most of the watershed are available from modeling conducted for the *District-Wide Watershed Management Plan* of the Metropolitan North Georgia Water Planning District. These modeling estimates include most, but not all, of the watershed. The upper and lower portions of the watershed are not included in these estimates. By these modeling estimates, within the metropolitan area, both segments of the watershed meet the minimum 20% criteria from both point and nonpoint sources (see Table 1).

Table 1: Phosphorus Loading from Point and Nonpoint Sources in the Watershed

	% Phosphorus Loadings from Nonpoint Sources	**% Phosphorus Loadings from Point Sources**
HUC 0313001 in metro district	80%	20%
HUC 0313002 in metro district	60%	40%

This analysis was based on HUC boundaries, which do not correspond to the lake watersheds. An application of this analysis specifically to the watersheds of Lake Lanier and West Point Lake would be useful. It would be particularly important if trading in the Lake Lanier watershed is considered because it is possible that nonpoint sources account for more than 80% of the loadings in that watershed. Initial estimates made for this paper indicate that point source loadings may account for only about 10% of phosphorus loadings to the lake. This allocation may present a limitation on the potential for trading in that watershed and requires further analysis of current loadings and how loadings are expected to change with growth in the region.[8]

8 The criteria of Crutchfield et al. suggest that 10% from point sources is not enough to support a viable trading market. However, in this watershed, the pressure to accommodate growth while complying with existing mass based load limits is expected to result in high compliance costs for the region's communities. In preliminary interviews, dischargers in the Lake Lanier watershed indicated an interest in trading to meet

2. *Screening Level 2*

The second level considers the number and type of point sources in a watershed. Crutchfield et al. examined the shares of pollutant loadings contributed by the five largest point sources in a watershed. A current analysis of phosphorus loading information was not conducted for this report, but the number of large dischargers in each segment is given in Table 2 below. A major point source discharges more than one million gallons per day, serves at least 10,000 people, or discharges into a water quality limited water body. In the Lake Lanier watershed, there are currently five major dischargers, but a new major discharger will be added when the Gwinnett County F. Wayne Hill wastewater plant begins discharging to Lake Lanier, pending the resolution of an outstanding legal dispute over the discharge permit. The West Point Lake watershed has sixteen major dischargers, including eight municipal wastewater treatment plants that each has the capacity to treat more than 20 million gallons per day. It appears that there are a sufficient number of large point sources in each segment of the watershed to support a trading market.

An analysis of phosphorus loading from point sources in the Lake Lanier watershed was conducted in 1996 for the EPA Clean Lakes Program. In this analysis, five major point sources accounted for 77% of the phosphorus loading by point sources in the watershed (Richman et al, 1998). At this level, this watershed meets the Crutchfield et al. criterion for this screening level. They suggest that the top five major dischargers of a pollutant should account for 75% of the point source loadings to provide a suitable market for trading. The need for strict compliance with this criterion is questionable. The availability of a greater number of potential point source traders may be beneficial in

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future phosphorus limits. Given the continuing need for phosphorus reductions by point sources, the 10% level may be adequate to support WQT in this watershed. Further analysis of this issue is recommended.

reducing transaction costs (Stavins, 1995). However, a current application of this analysis to both segments of the watershed would be instructive.

Table 2: Number of Major Point Sources in the Upper Chattahoochee

	Number of Major Point Sources
Lake Lanier Watershed	5 (+1)
West Point Lake Watershed	16

3. *Screening Level 3*

This criterion considers the availability of potential agricultural pollutant credit sellers in a watershed. The availability of agricultural participants must be adequate to provide a sufficient supply of credit sellers to meet the regulatory requirements of credit buyers. Crutchfield et al. used the USDA Soil Conservation Service's National Resources Inventory to evaluate agricultural practices and the level to which conservation practices are already in place. This information can be used to evaluate the potential supply of pollutant reduction credits. If conservation practices are already in place to a great extent in a watershed, less potential pollutant reduction credits will be available for trading.

Within the metropolitan district, available land use data indicates that agricultural land accounts for about 15% of the land area in both segments of the watershed (MNGWPD, 2003a). It is expected that this number would be higher if the entire watershed were analyzed. A quantitative analysis of the extent of conservation practices in the watershed was not performed for this report. However, it is known that additional conservation practices, not currently in use, could be applied, including manure composting. A more thorough analysis of the need for conservation practices on agricultural lands in the watershed is warranted. However, it is important to note that non-agricultural nonpoint sources might also be potential sources of pollutant reduction credits in this watershed (i.e., stormwater runoff).

The evaluation of agricultural lands should also consider the position of potential available credits relative to point sources. If agricultural operations are predominantly downstream of point sources in a watershed, then trading between point sources and agricultural operations would be downstream trades. As discussed above (see page 12), downstream trades are less desirable because the water segment between the trading partners is not improved by the trade. Upstream trades are preferred. A cursory evaluation of land use maps in the Chattahoochee River Basin Management Plan (GA EPD, 1997) indicates that agricultural in the segment above Buford Dam is generally upstream of developed areas. In the segment below Buford Dam, most agricultural operations are downstream of the metropolitan Atlanta region, aside from some agricultural operations to the west of the city. However, a more rigorous analysis of the distribution of agricultural operations is needed.

4. Summary

The screening criteria suggested by Crutchfield et al. provide a useful tool for a preliminary evaluation of the potential market for WQT in a watershed. By the criteria for which information is available, WQT in the Upper Chattahoochee warrants further analysis. More information is needed on the balance between point sources and nonpoint sources in the Lake Lanier portion of the watershed. In the remainder of the watershed, point sources and nonpoint sources appear to be adequately balanced. A sufficient number of large point sources is available in both segments. However, more detailed analyses are needed on the relative contributions of individual point sources to watershed loadings. With respect to nonpoint sources, agricultural operations are distributed throughout the watershed and should be able to generate pollutant reduction credits through the application of conservation practices. However, a rigorous analysis of the extent of the need for additional practices should be performed. Additionally, the geographic concentration of agricultural operations is likely to limit the potential for trading in the watershed segment below Buford Dam. Other nonpoint sources, including urban stormwater and septic tanks, should be evaluated as potential credit generators.

D. Economic incentive

The primary driver of interest in WQT is usually the difference in the marginal costs of pollutant reduction between different sources. Sources with lower marginal costs of reduction can generate and sell excess pollutant reductions to sources with higher costs. For point-nonpoint trading, WQT becomes attractive when the costs of nonpoint source reduction are lower than the costs of point source reduction. Although it is often assumed that nonpoint source reductions will be less costly, some WQT projects have been initiated only to find that the cost differential was not as great as was expected. In some cases, the cost of point source reductions were lower than expected, and therefore, point sources did not seek out trades as expected (e.g., Tar-Pamlico). Therefore, it is important to analyze these costs in order to evaluate the economic incentive for WQT.

The marginal cost of phosphorus reduction varies by the individual source, but estimates have been obtained from other WQT studies. These estimates are summarized in Table 3. The estimates are not updated for inflation; note the year of publication for the source material to consider the effects of inflation.

Table 3: Estimates of the Incremental Costs of Phosphorus Reduction for Pilot Water Quality Trading Projects

Location	Cost of Phosphorus Reduction ($/pound/year)	Source
Nonpoint Sources		
Lower Boise, Idaho	$5-50	(Ross & Associates, 2000)
Upper Midwest (3 watersheds)	$6-16	(Faeth, 2000)
Chesapeake Bay	$10-100	(Camacho, 1991)
Fox-Wolf Basin, Wisconsin	$26	(Environomics, 1999)
Point Sources		
Saginaw Bay, Michigan	$24	(Faeth, 2000)
Chesapeake Bay	$14	(Camacho, 1991)
Lower Boise, Idaho	$5-200	(Ross & Associates, 2000)

Interpretation of these estimates is not simple, and “apple and orange” differences make comparisons difficult. In the nonpoint source estimates, a broad range of practices is included. The estimates for the Upper Midwest watersheds do not include animal waste best management practices (BMPs), which would be important in the Upper Chattahoochee where animal operations are the dominant form of agriculture. The real cost of implementing BMPs depends on site specific factors. The practices most likely to generate nonpoint reduction credits for WQT in the Upper Chattahoochee will depend upon the level of the baseline and the extent of existing conservation practices.

For better estimates of the costs of credit generating BMPs for the Upper Chattahoochee, a survey of existing agriculture practices and the local costs of BMPs is needed. An alternative source of credits for the Upper Chattahoochee is off-site composting of poultry litter. This practice would eliminate the need for land application of poultry litter, and if the compost is exported from the watershed, the phosphorus in the litter would be removed from the watershed as well. The costs of this practice would depend upon the capital needs for the composting plant, the operating costs of the plant, and the market value of the compost product. For all eligible BMPs, the value of practices in terms of pollutant reduction credits needs to be evaluated by their phosphorus removal efficiency. To make this translation, better estimates of phosphorus loading from agricultural operations in the Upper Chattahoochee are needed.

The cost of point source reductions varies depending upon the size of the treatment plant and the level of phosphorus removal required. The estimates for Saginaw Bay are lower than costs are expected to be in the Upper Chattahoochee because the phosphorus removal efficiency required is not as strict. The Saginaw Bay estimate was made for point sources upgrading from 1 mg/L phosphorus to 0.5 mg/L phosphorus. Dischargers in the Upper Chattahoochee will need to meet limits as strict as 0.3mg/L or 0.13mg/L. The Chesapeake Bay estimate was made for the process of chemical addition to remove phosphorus. Dischargers in the Upper Chattahoochee will not be able use chemical addition alone to achieve their required levels of phosphorus removal. The source of estimates for the Lower Boise did not indicate what treatment methods and levels were evaluated. In summary, the point sources estimates from other WQT projects are difficult to apply to the Upper Chattahoochee.

Costs for point source phosphorus reductions are being studied as a part of this research project. Although this research is not yet complete, the cost estimation methods developed were used to provide a preliminary estimate for this report. Two cases were considered: (1) a large discharger upgrading to 0.13mg/l and (2) a small discharger upgrading to 0.13mg/l. These cases were modeled after existing plants in the watershed that are currently attaining effluent levels of 0.3 to 0.4 mg/l of phosphorus.

Based on our ***preliminary*** estimates, if these plants needed to upgrade to increase their phosphorus removal efficiencies, without increasing their flow capacity, the incremental cost of removing phosphorus would be $500 to $2,000 per pound per year (D. Russell, personal communication, 2004). The lower end of the range applies to the larger plant, while the upper end of the range applies to the smaller plant.

These estimates are much higher than those found for WQT projects elsewhere, and the reason for the difference is believed to be the level of treatment required. The incremental costs of phosphorus control increase with the level of removal efficiency. A discharge of 0.13mg/L requires a much higher level of filtration and process controls than a discharge of 1mg/L, or even 0.5 mg/L. Many dischargers in the watershed are currently meeting effluent standards below 1mg/L. Their incremental costs of phosphorus control are expected to be very high.

Several dischargers in the watershed will be held to the 0.13mg/L standard in the next several years. However, in the near term, most dischargers to the river, as opposed to the lake, will be held to a standard of 0.3mg/L. Achieving this standard will have a lower incremental cost than achieving 0.13mg/L. However, dischargers to the river expect that the 0.3mg/L standard may be tightened further in the future. A more complete analysis of costs at different levels of treatment is needed to evaluate the economic incentive for

WQT in the Upper Chattahoochee, but preliminary estimates indicate that an economic incentive exists and will increase over time.

E. Stakeholder response

Stakeholder willingness to accept and support the development of WQT is critical to its success. In the Upper Chattahoochee, stakeholder dynamics with respect to WQT would be complex. The issue of WQT must be considered within the context of multiple water issues in the Upper Chattahoochee, where water is the focus of many heated controversies.

Water supply issues have been the focus of recent attention in the Upper Chattahoochee. Failed negotiations with neighboring states over the use of the river's water have made the basin the subject of a federal legal dispute that may be resolved by the U.S. Supreme Court. The release of water from Buford Dam is an important component in this debate. If WQT were developed in the Upper Chattahoochee, water supply issues would directly affect its implementation because of the interconnected relationship between water quality and water quantity that is manifested in concerns over decreasing flows in the river, return of treated wastewater to the system, and future growth.

Another recent controversy in the Upper Chattahoochee is over the addition of the discharge of the Gwinnett County F. Wayne Hill wastewater treatment plant to Lake Lanier. The permit for this discharge has been the subject of a legal dispute. A local community organization is opposed to the discharge. A recent ruling favored Gwinnett County, but the case is on appeal.

Stakeholders in the Upper Chattahoochee will have a range of views on WQT, but some opposition can be expected. Farmers may be reluctant to participate because they are unfamiliar with trading. They may fear that WQT will create negative, and they may also fear that their participation will draw attention to their pollutant contributions and provide justification for future regulation. Point sources are likely to favor WQT, but some point sources may perceive WQT as unfair because they would be paying to mitigate the increasing nonpoint source pollutant load.

Environmental organizations do not uniformly support or oppose WQT. Some organizations, such as Environmental Defense and World Resources Institute, have been active in supporting the development of WQT as a tool for water quality improvement. Others have opposed WQT because they disagree with the principle of a market-based policy that permits sources to buy and sell the right to pollute. During the 2003 session of the Georgia Legislature, a proposal to establish transferable water rights to manage water withdrawals in the state was strongly opposed by many state environmental organizations because they disagreed with the principle of using markets to manage water quantity. They may react similarly to WQT in Georgia.

Involvement of stakeholders is one of the primary objectives suggested by the EPA for success in the development of WQT. Some of the longest standing WQT projects in the U.S. are those that were initiated by stakeholder coalitions that included representatives of various affected interests (e.g., Dillon Lake, Tar-Pamlico). Gaining the support of all affected stakeholders is unlikely, especially in a system such as the Upper Chattahoochee where water issues are particularly divisive. However, if WQT is pursued in the Upper Chattahoochee, stakeholder response will be a critical factor in determining its success, and any effort to initiate WQT in Georgia should engage all affected stakeholders in a meaningful public involvement process.

F. Summary

Table 4 identifies the primary factors that currently limit the development of WQT in the Upper Chattahoochee. The legal authority to conduct WQT is uncertain, but the new EPA WQT policy provides support at the federal level. A review of state level legal requirements is necessary. The need to divide the market at Buford Dam could limit the viability of the market on either side of the dam. The availability of agricultural credit sellers below the dam is uncertain. Above the dam, the availability of credit buyers might be a concern. Point sources appear to be adequate in number to support trading, but recent upgrades in phosphorus removal efficiencies at plants that discharge to Lake Lanier may delay the demand for additional point source reductions by several years. The regulatory incentive for WQT appears adequate, but the economic incentive is uncertain. Further analysis of the costs of phosphorus reduction in the Upper Chattahoochee is needed. A strong stakeholder response in opposition to WQT could be delay or preclude the development of WQT in the watershed. At this time, the most salient limit to WQT is the need for more information. Research needs are identified and discussed in the conclusion of this paper.

Table 4: Potential Limits to Water Quality Trading in the Upper Chattahoochee
□ Legal authority □ Stakeholder response □ Geographic limits of the market □ Possible limits on credit supply below Buford Dam □ Possible limits on credit demand above Buford Dam □ Economic incentive □ Need for more information

VI. Market Development

Water quality trading creates new markets that require supporting institutions and procedures to help them operate smoothly. The challenge in creating a WQT market is to balance the tradeoffs in achieving the objectives of efficiency, equivalence, additionality, and accountability (qtd. in Fang and Easter, 2003). Additionally, the supporting infrastructure must provide legal authority for WQT. Water quality trading is not explicitly prohibited by the Clean Water Act, and the recent EPA WQT policy helps to validate legal authority for WQT, but explicit legal authority does not exist in the federal law or in most states. The legal challenge is to authorize trading without violating existing regulations (Woodward et al., 2002).

The development of an institutional structure for the market will affect how the market operates and addresses barrier to trading. Three principal legal issues are at issue in market development: authorization for WQT, monitoring, and enforcement. How these issues are addressed determines the institutional nature of the market and affects the success of the market in terms of efficiency, concentration, and environmental efficacy (Woodward et al., 2002).

Woodward et al. (2002) suggest four possible structures for WQT markets:

1) **Exchange markets:** These most closely resemble traditional commodity markets. They operate efficiently, but work best with homogeneous goods.
2) **Bilateral negotiations:** Water quality trades are performed on a case-by-case basis. Participants negotiate terms specific to the trade. This type of market has high transaction costs, but bilateral trades are better suited to heterogeneous goods than exchange markets.
3) **Clearinghouse:** An intermediary pays for pollution reductions and then sells credits to those who need them. The intermediary eliminates the contractual link between a seller and buyer. The clearinghouse converts a product with a variable price and quality into a uniform product. The clearinghouse reduces transaction costs relative to bilateral trades.
4) **Sole-source offsets:** One party fulfills a requirement to offset its pollutant load. No actual trades occur. (Woodward et al., 2002)

The table below (Table 5) summarizes the ability of each type of market to provide market efficiency and environmental efficacy. The degree of uniformity required refers to the nature of the good being exchanged. A homogeneous commodity has a high degree of uniformity. As an economic good, water quality credits generally do not have a high degree of uniformity. Therefore, using an exchange structure may present some challenges for WQT. The exchange and clearinghouse structures have high set-up costs, but low transaction costs. These arrangements are best suited to markets with a large number of traders and active trading, and they are only appropriate when their operation costs are less than the transactions costs of bilateral trades.

Table 5: Evaluation of Market Structures for Water Quality Trading

	Exchange	**Clearinghouse**	**Bilateral negotiations**	**Sole-source offsets**
Indicators of market efficiency				
Transaction costs per trade	Lowest	Low	Highest	n/a
Initial set-up costs	High	High	Low	Lowest
Indicators of ability to ensure environmental efficacy				
Degree of uniformity required	Highest	High	Low	Lowest
Buyer liability a possibility	No	No, but clearinghouse can assume liability	Yes	n/a
Example	Sulfur dioxide market under Clean Air Act	Tar-Pamlico, NC	Lake Dillon, CO	Boulder Creek, CO

Source: Woodward et al., 2002

The clearinghouse structure offers some advantages. For example, in the Tar-Pamlico, the clearinghouse is able to target credits to increase their environmental efficacy. It also is integrated with the state agricultural cost-share program. By working through an agency familiar to farmers, this arrangement can help to reduce farmer reluctance to participate. The clearinghouse can also provide a check on equivalence when lack of uniformity is an issue. When a market is sufficiently active to support a clearinghouse, this structure should be considered for the advantages it offers for WQT.

The market structure of WQT needs to provide a number of services to support the operation of the market. The EPA has identified the following functions for WQT market institutions (EPA, 2003b):

1) Define marketable reductions
2) Communicate among buyers and sellers
3) Ensure environmental equivalence
4) Define and execute trading process
5) Track trades
6) Assure compliance with relevant federal, state, and local requirements
7) Manage risk among parties to trades
8) Provide information to stakeholders

Determining an appropriate market structure for WQT in the Upper Chattahoochee will require an analysis of the legal authority for WQT in Georgia.[9] The selection of an appropriate institutional arrangement will require an understanding what is needed to provide the legal authority for WQT in this state. The development of WQT markets should then be guided by how the above market functions can be provided most efficiently. If the market will be sufficiently active, a clearinghouse structure should be considered. Otherwise, bilateral negotiations will most likely be adequate.

[9] This type of legal analysis is planned as a part of the 2004-2005 activities of this research project.

VII. Conclusion

In the Upper Chattahoochee, water quality trading offers an opportunity to manage and reduce phosphorus loadings cost-effectively. The greatest benefits would be likely to come as the region continues to grow. Trading would allow growing communities to maintain or decrease phosphorus loadings as their wastewater flows increase. Furthermore, at the same time, abatement investments would go toward addressing the largest source of phosphorus in the watershed: nonpoint sources. Developing a viable market mechanism that is integrated with the complex environmental dynamics of this system will require in-depth research and a careful policy development process. Several issues of concern and related areas where further research is needed were identified in this paper. Research needs are summarized in Table 6.

Several of these research needs have been discussed elsewhere in this report. The need for an analysis of the legal authority for WQT, the availability of nonpoint source credits, the timing of point source upgrades, and the costs of phosphorus control are discussed in the feasibility analysis above. Additionally, a watershed model to support WQT will be required to develop appropriate trading procedures. A model could be adapted from an existing model of the system. Better estimates of the contribution of nonpoint source loadings, specifically agricultural loadings, are needed. Analysis of phosphorus loadings from individual nonpoint sources is also needed to place a value on the pollutant reducing value of credit generating activities.

If the watershed does not have sufficient agricultural nonpoint source credit sellers to support WQT, other nonpoint sources of phosphorus could be considered. Urban stormwater control and septic tank elimination through sewer system tie-ins are two potential sources of credits. Including these sources would require additional research to determine environmental equivalence and credit values for these activities. Furthermore, setting a baseline from which to measure additionality for these sources is an issue that will require research as well.

Table 6: Research Needs
□ Analysis of legal authority
□ Availability of nonpoint source credits
□ Timing of point source upgrades
□ Analysis of the costs of phosphorus control
□ Estimation of phosphorus loadings from nonpoint sources
□ Development of watershed model to support WQT
□ Potential for trading with urban nonpoint sources
□ Potential for cross-pollutant trading
□ Analysis of joint products
□ Displacement of nonpoint source loadings
□ Potential for market exit/entry effects

In addition to considering other nonpoint sources, cross-pollutant trading should be evaluated as well. Because of the close relationship between sediment and phosphorus in phosphorus cycling, reductions of sediment pollution result in reductions of phosphorus loading. Research is needed to evaluate the environmental equivalence of sediment and phosphorus reducing activities. Additionally, cross-pollutant trading might be possible among several oxygen related parameters, including phosphorus, dissolved oxygen, biological oxygen demand, temperature, and chlorophyll a. The Snake River – Hell's Canyon TMDL developed by the states of Oregon and Idaho jointly addresses Total Phosphorus and dissolved oxygen. Under this TMDL, regulators are exploring possibility of setting a TP:dissolved oxygen translation ratio to support trading among sources with allocations for each parameter (EPA, 2003b). In the Upper Chattahoochee, exploration of cross-pollutant trading might provide the opportunity to expand WQT to include a broader range of sources and support a more viable market. With more information, cross-pollutant trading might also create opportunities for WQT in other watersheds across the state.

Several economic issues warrant exploration as WQT is considered in the Upper Chattahoochee and elsewhere:

1) Joint products: Actions taken to reduce the level of one pollutant usually also reduce the levels of other pollutants. In WQT, the joint reduction of pollutants applies to both side of a potential trade. Activities that generate credits for nonpoint

source pollutant reductions for one parameter will reduce other pollutants as well, and thus, provide additional environmental benefits.[10]

On the other hand, advanced point source control technologies reduce multiple pollutants as well, and when the installation of these technologies is avoided through trading, the joint benefits are not attained. Advanced filtration and treatment technologies may be able to remove pollutants that otherwise would not be removed from the waste stream. For example, recent analyses of wastewater discharges and water supply intakes in the Atlanta region indicated the presence of several pharmaceutical and endocrine disrupting chemicals in treated wastewater. Some of these chemicals persisted through the process of wastewater treatment, dilution in the natural system, and uptake and treatment at drinking water plants downstream (Henderson et al. 2001, Moll et al. 2001). These chemicals are not currently regulated, and the need for treatment is not known. If further research reveals the need for treatment, the advanced technologies used to reduce phosphorus might be the same technologies that would be used to remove these chemicals. The costs of phosphorus removal would be decreased if phosphorus removal is a joint product of removing these other chemicals. The reduction in cost for phosphorus would decrease the economic incentive for trading. Clearly, this issue is not well developed, and completion of the research needed to fully understand the implications will take many years. However, the provision of joint pollution reduction benefits by advanced wastewater treatment technologies is likely to have an effect on WQT at some point in the future, and this issue needs to be addressed by economists as well as natural

[10] Other pollutants that could be reduced by nonpoint control activities for phosphorus include fecal coliform and sediment, both of which are pollutants of concern in the Upper Chattahoochee.

scientists. An analysis of the joint products created or foregone through WQT would assist in evaluating the full range of benefits and costs of WQT.

2) Leakage: Pollutant reducing credits can have the effect of freeing up labor and capital on farms that receive credits. This labor and capital could be used by the farmer to add new agricultural production, and new areas of production could have new adverse environmental impacts. This effect, known as "leakage", could reduce the total environmental benefit of WQT. Another type of leakage might occur when a community uses trading to increase wastewater flows without upgrading its pollution removal efficiency. A barrier to community growth is removed, and new growth could have adverse environmental impacts. The potential for leakage as a result of WQT needs to be evaluated in order to provide a more complete understanding of the overall benefits and costs of WQT.

3) Potential for market entry/exit effects: Payments to farmers for credits provide a subsidy that they would not otherwise receive. By providing a subsidy, WQT has the potential to affect the decisions of farmers to remain in business or not. If this subsidy is sufficient to sustain operations in business that otherwise would have exited the business, then WQT will affect the composition of the regional economy. Theoretically, it also lowers barriers to entry to farming. This effect may be desirable if regional communities desire to maintain farm operations as a part of their landscape and local economy. However, the maintenance of inefficient operations may also have undesirable consequences. The effects of WQT on the regional economy may be more far-reaching than they appear on the surface, and these effects need to be understood.

Based on the analysis in this report, the Upper Chattahoochee has several characteristics that support the feasibility of WQT. However, this report also identifies several possible limits to WQT in the watershed. The research needed to support WQT would be substantial, and undertaking a WQT initiative would require the commitment of resources by environmental agencies and researchers across the state. Therefore, the decision to proceed must be made with care.

As an emerging policy tool, WQT does not have a long history on which to build, but pilot projects around the U.S. provide models and lessons for new WQT initiatives. A recent report on three pilot WQT projects in the state of Wisconsin provides a useful analysis of potential limits to WQT development. A detailed description is provided in the box on page 57. In existing pilot projects around the U.S., WQT has had only mixed success to date. However, it is an innovative approach with many potential benefits when implemented under appropriate conditions.

The severity of nutrient pollution in the Upper Chattahoochee has resulted in strict and costly limitations for the wastewater treatment facilities of communities in the region. Water quality trading could provide these communities with a tool for complying with their regulatory requirements as they grow. Water quality trading offers the potential improve cost-effectiveness in the expenditure of taxpayers' money on environmental controls. It allows communities the flexibility to focus on attaining performance-based environmental standards, rather than technology-based requirements. Water quality trading can move beyond merely maintaining environmental conditions toward improving them. For these reasons, WQT should be considered in this watershed.

Lessons Learned from Wisconsin

The state of Wisconsin has actively pursued the development of WQT through the initiation of three pilot projects. Only one of the projects has reported any trades to date. A recent analysis of Wisconsin's pilot projects (Kramer, 2003) suggests that the following have been barriers to water quality trading in one or more of the state pilot projects:

1. Lack of information: Market participants did not have access to the information that they needed to evaluate potential trades (e.g., costs, value of credits, BMP performance).
2. No regulatory incentive: A clear and impending regulatory threat that could create the motivation for trading was lacking.
3. No economic incentive: Market conditions were not as favorable as had been predicted. Point source reductions were more cost effective than expected.
4. Nonpoint source reluctance: Farmers were reluctant to participate because they were unfamiliar with trading, they wanted to avoid possible negative publicity, and they feared that participation would draw attention to their pollutant contributions and provide justification for future regulation.
5. Uncertainty: Participants' uncertainty about policy issues, liability, and trading protocols limited their participation (see page 11).
6. Communication difficulties: Participants lacked efficient means of communication with each other, particularly between different types of sources (e.g., municipal, agricultural, industrial).

The Wisconsin report makes many suggestions for alleviating these barriers, including:

- The creation of a central registry that will support information exchange among trading participants. The World Resources Institute has established NutrientNet (www.nutrientnet.org), an Internet site for sharing market information that could fill this role.
- Brokers and market administrators may also be able to ease information and communication barriers.
- TMDLs will increase regulatory and economic incentives for trading.
- Implementation of the EPA WQT policy will help to reduce uncertainty about trading policies and validate trading as a legitimate compliance option.

The barriers to WQT identified in Wisconsin are discussed in the Chattahoochee analysis in this report. Some additional factors that could help to lower barriers to WQT were identified in this report, including:

- The use of a clearinghouse market structure can decrease information and communication barriers.
- EPA's initiative to promote the adoption of nutrient standards at the state level will create an additional regulatory incentive for trading.
- Growth will enhance economic incentives for trading because dischargers will need to maintain their current loadings of phosphorus (in pounds) despite increases in wastewater flows by increasing their phosphorus removal efficiencies.

Further research efforts are warranted to determine whether the appropriate conditions exist to support water quality trading in the Upper Chattahoochee. Water quality trading is not currently in use in Georgia. This paper has focused on the Upper Chattahoochee. A new research project at UGA is focused on water quality trading for Lake Allatoona. However, water quality trading could be appropriate for other Georgia watersheds, especially if nutrient standards are adopted as expected in the next several years. In the coming year, this research project will expand to consider the application of WQT across the state. Activities will include an evaluation of the state's watersheds for WQT, an examination of the legal authority for trading in Georgia, and the development of a trading model for use in Georgia. The results of this research initiative will be useful to a number of stakeholders with an interest in water quality trading in Georgia, including state agencies, local governments, wastewater discharger permit holders, agricultural operations, environmental organizations, and the public at-large. The activities of this project aim to lay the foundation for informed decisions about the future of water quality trading in the state of Georgia.

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