EXAMINING THE EFFECTS OF ECOLOGICAL AND POLITICAL BOUNDARIES ON THE POTENTIAL FOR WATER QUALITY TRADING: LESSONS FROM TWO SOUTHEASTERN TRADING FRAMEWORKS

by

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(Under the Direction of Jeffrey D. Mullen)

ABSTRACT

Water quality trading as a means to improve water quality has become a popular instrument considered by environmental policy makers. Although the U.S. Environmental Protection Agency lists more than forty current trading programs in the U.S., only a few active markets exist. The literature identifies several hurdles to trading, overcoming which requires a deeper understanding of the interaction between local environmental, legal, and economic conditions. Particular challenges include thin markets, uncertainty related to the course and fate of nutrient flows, varying degrees of political support, and high transaction costs. These hindrances often arise from and contribute to the confinement of trading to tight ecological and political boundaries. This research explores the effect of these boundaries on the potential for trading for two southeastern reservoirs. Results show that tight ecological and political boundaries have a negative effect on the potential for trading in Lake Allatoona, GA and Weiss Lake, AL respectively.

INDEX WORDS: Water quality trading, Phosphorus trading, Nutrient trading, Water policy, Pollution markets, Environmental economics

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B.A., The University of Virginia, 2003

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2009

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August 2009

DEDICATION

To Ashley, Mom, Dad, and Amy

ACKNOWLEDGEMENTS

First and foremost, I would like to thank the Department of Agricultural and Applied Economics at the University of Georgia for the financial support that made my return to graduate school possible. In particular, thanks to Nathan Smith for providing me the opportunity to serve as a research assistant over the last two years. It has been a wonderful experience and I am truly thankful for your support.

In addition, I owe a great deal of thanks to the many faculty members and researchers that made this research possible. I would especially like to thank Jeff Mullen for his support and guidance as my major advisor. Many thanks are in order for sparking my interests in environmental economics, allowing me the freedom to pursue a fascinating research topic, and always taking the time to lend an ear. Thanks to John Bergstrom for advancing my interests in environmental economics and providing the necessary support to help make my future doctoral pursuits possible. I am also grateful for the time and effort of my committee members David Radcliffe, Mark Risse, and Laurie Fowler. I owe them special thanks for their invaluable insights into the interdisciplinary aspects of my research. In addition, I would like to acknowledge Kristin Rowles, Zhulu Lin, Elizabeth Booth, Roy Burke, and Brian Watson for their help with policy, data and willingness to explain their modeling efforts.

Finally, my studies would not be possible without the loving support of my family. Thanks to my mother, Martha, my father, Paul, and my sister, Amy, who were always encouraging of my academic pursuits. And most importantly, a special thanks to my best friend and wife, Ashley, whose constant support makes everything possible.

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LIST OF ACRONYMS

ACWP: Alabama Clean Water Partnership

BMP: Best Management Practice

CAFO: Concentrated Animal Feeding Operation

CWA: Clean Water Act

ECHO: Enforcement and Compliance History Online

EPA: Environmental Protection Agency

EPD: Environmental Protection Division

FC: Fecal Coliform

GWPPC: Georgia Water Planning and Policy Center

HUC: Hydrologic Unit Code

LA: Load Allocation

LIS: Long Island Sound

NLCD: National Land Cover Dataset

NPDES: National Pollutant Discharge Elimination System

NPS: Non-Point Source

NRCS: Natural Resource Conservation Service

O&M: Operations and Maintenance

PS: Point Source

TMDL: Total Maximum Daily Load

UGA: University of Georgia

USDA: United States Department of Agriculture

WLA: Waste Load Allocation

WWSSB: Water Works and Sanitary Sewer Board

CHAPTER 1

INTRODUCTION

1.1. Background

As one of the world's most precious resources, fresh water serves a multitude of vital human and ecological purposes that range from drinking water supply to fish and wildlife habitat. However, a variety of man-made sources of pollution threaten the health of the rivers and lakes that supply this resource. As a consequence, water quality issues stand as a significant environmental challenge throughout the United States (U.S.) and the world.

With the Clean Water Act (CWA) of 1977, U.S. environmental policy makers took significant steps to curb water pollution through strict command and control regulations of direct, or point source (PS), dischargers. Although significant improvements resulted from these policies, a large percentage of U.S. water bodies remain impaired (U.S. Environmental Protection Agency 2009). Much of the recent blame is attributed to substantial contributions from indirect, or non-point (NPS), sources of water pollution (Nguyen et al. 2006). A command and control approach struggles to adequately regulate these NPSs due to the complexity and uncertainty that underlie their discharges. Therefore, in order to realize further water quality improvements, a command and control approach needs to impose even stricter regulations on PS discharges. However, researchers argue that such an approach is not cost effective (Nguyen et al. 2006). Consequently, U.S. environmental policy makers seek new methods that engage all types of water pollution sources in order to achieve national water quality goals at reduced societal costs.

One increasingly popular policy tool, water quality trading (trading), possesses many theoretical advantages over previous approaches. Trading is a market-based approach to achieve a specified water quality standard. To attain this standard, a regulatory agency decides on a water body's allowable limit of a pollutant. The agency then distributes an initial load allocation of this limit among the water body's sources of the pollutant; Total Maximum Daily Loads (TMDLs) often define these loading limits. Stakeholders that can reduce below their load allocation can sell their excess allotment of pollution as credits. Those that wish to discharge above their limit must purchase credits that account for the additional pollutant. Trading is based on the idea that stakeholders facing high abatement costs will purchase credits from those with lower abatement costs. Thus, the desired water quality standard is realized at a lower total cost to the watershed (U.S. Environmental Protection Agency 2009f). Theoretically, trading engages NPSs with a monetary incentive since NPSs often have lower abatement costs than PSs (Nguyen et al. 2006). In these circumstances, NPSs supply pollution reduction credits to PSs at a cost that is less than what the PSs would otherwise face. Trading between PSs that face different abatement costs may also occur.

In 2003, the Environmental Protection Agency (EPA) issued "The Final Water Quality Trading Policy" to provide states with a framework for trading within their watersheds. This policy signifies EPA's growing receptiveness towards a market-based approach to achieve water quality standards required by the CWA. Although the EPA lists more than forty current trading programs in the U.S. (U.S. Environmental Protection Agency 2009d), only a few active markets exist. The literature identifies several hurdles to trading, overcoming which requires a deeper understanding of the interaction between local environmental, legal, and economic conditions. Particular challenges include thin markets (Hoag and Hughes-Popp 1997; Woodward 2003), uncertainty related to the course and fate of nutrient flows (Hall and Raffini 2005; Horan 2001), varying degrees of political support (McGinnis 2001), and high transaction costs related to market infrastructure, monitoring, and enforcement (Woodward 2003). These hindrances often arise from and contribute to the confinement of trading to tight ecological and political boundaries. This paper explores how the definition of these boundaries affects the potential for trading in two southeastern reservoirs and their respective watersheds.

1. 2. Relevant Reservoirs and Watersheds

1.2.1. Overview

This research focuses on two reservoirs and a chain of watersheds located in northwestern Georgia and northeastern Alabama. These reservoirs are Lake Allatoona and Weiss Lake; the relevant watersheds, as defined by their 8-digit Hydrologic Unit Codes (HUC), are the Conasauga (03150101), Coosawattee (03150102), Etowah (03150104), Oostanaula (03150103), and Upper Coosa (03150105). See Figure 1.1.

1. 2.2. Lake Allatoona

Lake Allatoona is located roughly thirty miles north of the city of Atlanta and sits within the Etowah watershed. An impoundment of the Etowah River in 1950 formed the lake; today it serves many purposes including flood control, hydroelectric power, public water supply, recreation, and fish and wildlife habitat (U.S. Army Corps of Engineers 2009). However, nutrient impairment threatens the health of Lake Allatoona and the continued support of its designated uses. In a 2004 TMDL, the Georgia Environmental Protection Division (GA EPD) addressed excessive chlorophyll a for a section of Lake Allatoona known as the Little River Embayment. This 2004 TMDL requires reductions in total phosphorus (P) for individual PSs, urban loadings from storm water discharges, and other NPSs. More recently, a 2009 draft TMDL from GA EPD addresses impairment from excess chlorophyll a for two additional segments of Lake Allatoona: the Etowah River Arm and Allatoona Creek Arm. The Etowah River and Allatoona Creek TMDL requires reductions in both total P and total nitrogen (N) for individual PSs, urban loadings from storm water discharges, and other NPSs. Loading limits are defined separately for the Etowah River Arm and Allatoona Creek Arm.

1. 2.3. Weiss Lake

Weiss Lake is located in northeastern Alabama approximately fifty miles to the west of Lake Allatoona. As seen in Figure 1.1, Weiss Lake resides within the Upper Coosa watershed, which straddles the Alabama and Georgia border. In 1961, an impoundment of the Coosa, Chattooga, and Little Rivers created the reservoir. Like Lake Allatoona, Weiss Lake serves a variety of purposes including hydroelectric power generation, flood control, public water supply, irrigation, recreation, and fish and wildlife habitat (U.S. Environmental Protection Agency Region 4 2008). As with Lake Allatoona, an excessive chlorophyll a concentration threatens the health of Weiss Lake. A 2008 TMDL addresses this chlorophyll a concentration through required total P reductions; it specifies a 30 percent reduction in total P loads to the lake. To achieve this goal, the TMDL outlines reductions in total P for Alabama and Georgia separately. For Alabama, reductions are defined for major PSs (≥1 Million Gallons per Day (MGD)), minor PSs (< 1 MGD), and NPS loads. Limits for Georgia are defined by aggregate loads from the

Coosa and Chattooga Rivers at the Georgia state line. In addition to the Upper Coosa, the TMDL identifies the Conasauga, Coosawattee, Oostanaula, and Etowah as watersheds that drain to Weiss Lake.

1. 2.4. Lake Allatoona and Weiss Lake Trading Research

Trading frameworks for Lake Allatoona and Weiss Lake are in their investigate states. This means that no market structures or formal plans for trading exist for either lake; no trades have occurred. For Lake Allatoona, researchers at the University of Georgia's College of Agriculture and Environmental Science and School of Ecology conduct research that examines the potential for trading. Of particular importance, researchers recently modeled the spatial distribution of P loads to the lake (Lin et al. 2009; Radcliffe et al. 2009). However, only modest progress has been made to investigate the economic components of a Lake Allatoona trading framework. There are no known frameworks for trading for Weiss Lake and its applicable watersheds.

This research addresses the missing economic component in Lake Allatoona's P trading framework and expands the analysis to include Weiss Lake. Lake Allatoona's TMDL specifications for separate segments of the lake provide an opportunity to examine the effects of ecological boundaries on trading. In particular, this research explores the effects of restricting trading for Lake Allatoona to tightly defined sub-watersheds versus allowing trading to occur over a more broadly defined ecological boundary (the lake's greater watershed). The fact that state lines divide Weiss Lake and its relevant watersheds provides the opportunity to examine the effects of political boundaries on trading.

1.3. Objectives

The primary objective of this research is to answer the question: What are the effects of ecological and political boundaries on the potential for trading in Lake Allatoona and Weiss Lake respectively? In pursuing an answer to this question, the following objectives will also be met:

- Establish the economic foundation for P trading and identify challenges facing this policy tool.
- Review and summarize the environmental and legal frameworks for trading.
- Identify preliminary market participants for Lake Allatoona and Weiss Lake.
- Estimate the costs of P abatement for relevant PSs and NPSs.
- Identify economically favorable, or “alpha trades”, for each framework.
- Through a sensitivity analysis, determine the effects that changes to market assumptions, PS and NPS abatement calculations, and nutrient flow estimates have on findings.

1. 4. Overview of Thesis

This thesis is composed of five chapters. Chapter 2 establishes the economic foundation for trading and summarizes the current status of programs within the U.S. A review of the literature is given to identify the success and failures of other trading frameworks. Chapter 3 summarizes the environmental and legal elements of trading and identifies previous research applicable to trading in the Lake Allatoona and Weiss Lake watersheds. The data and methodology for this research is presented in Chapter 4. Chapter 5 presents the results of all scenarios and summarizes these findings. The thesis is concluded with a discussion regarding the implication of these findings and suggestions for future research.

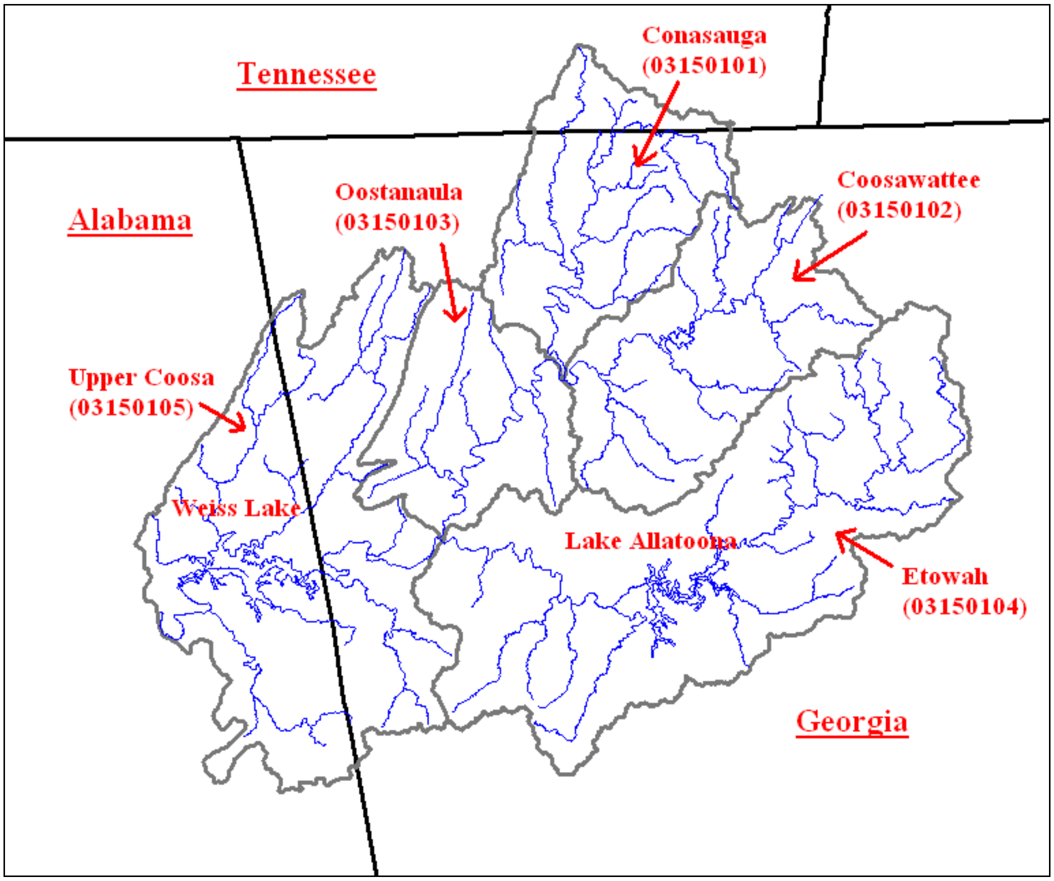

Figure 1.1. Lake Allatoona, Weiss Lake and Relevant Watersheds

CHAPTER 2

ECONOMIC FOUNDATION AND REVIEW OF TRADING RESEARCH

This chapter aims to more fully define water quality trading and outline its theoretical foundation and fundamental components. The first section provides a definition of trading. The second section summarizes the key economic principles that form the theoretical foundation. Lastly, the essential components of trading are explored with examples of its application from the literature. Chapter 3 continues this discussion by providing a summary of the legal and environmental frameworks necessary for trading.

2.1. Definition

As defined in Chapter 1, water quality trading is a market-based approach to achieve a specified water quality standard. To attain this standard, a regulatory agency decides on a water body's allowable limit of a pollutant. The agency then distributes an initial load allocation of this limit among the water body's sources of the pollutant; Total Maximum Daily Loads (TMDLs) often define these loading limits. Stakeholders that can reduce below their load allocation can sell their excess allotment of pollution as credits. Those that wish to discharge above their limit must purchase credits that account for the additional pollutant. Trading is based on the idea that stakeholders facing high abatement costs will purchase credits from those with lower abatement costs. Thus, the desired water quality standard is realized at a lower total cost to the watershed (U.S. Environmental Protection Agency 2009f). Theoretically, trading engages non-point sources (NPSs) with a monetary incentive since NPSs often have lower abatement costs than point sources (PSs) (Nguyen et al. 2006). In these circumstances, NPSs supply pollution reduction credits to PSs at a cost that is less than what the PSs would otherwise face. Trading between PSs that face different abatement costs may also occur.

2.2. Theoretical Foundation

Trading's theoretical foundation arises from a few fundamental economic principles. These principles, their relevant terms, and subsequent theories are discussed below.

2.2.1. Externalities

In a trading framework, pollution is the commodity of exchange. Through this commoditization economists address what they think of as an externality. An externality is a cost or benefit of an economic transaction borne by someone/something not party to that transaction and whose cost or benefit is not governed by a price mechanism or contract. In the case of pollution, the externality is a negative externality because the cost of the pollution is borne by someone/something other than the polluter. For water pollution, these costs are borne by a variety of parties: local governments that have to pay to clean their drinking water; land owners near polluted water whose property values fall; water recreation companies that can no longer sell their services; a rise in health care costs due higher levels of water contaminants. Since the producers of this pollution do not have to pay for these external costs, they pollute more than they otherwise would. Often, this excess pollution is more than what is considered socially optimal (Nguyen et al. 2006). However, determining what is optimal for society is a difficult and often contentious undertaking. To address this task, Nguyen et al. (2006) propose two key questions that environmental policy makers must ask: “by how much should pollution be reduced (the goal), and what policy should be used to achieve this goal (the instrument)”. Avenues through which policy makers can address these questions: environmental standards (the goal) and cost-effectiveness (the instrument) are discussed below.

2.2.2. Environmental Standard – Pareto Efficiency

Pareto efficiency is a standard that economists often employ in public policy decisions. This Pareto criterion states that, “a policy change is socially desirable if, by the change, everyone can be made better off, or at least some are made better off, while no one is made worse off” (Just, Hueth, and Schmitz 2004). Public policy decisions that result in this reallocation of goods such that one person is made better off without making anyone worse off is defined as a Pareto Improvement. Economists use this criterion since, “conditional on the existing distribution of income, it makes the ‘economic pie’ as big as possible. In fact, at the efficient outcome, the net monetary benefits produced by the economy will be maximized” (Goodstein 1995).

The Pareto efficiency standard (efficiency standard), in the context of this research, is an environmental policy standard that is based on finding a level of water pollution that maximizes net monetary benefits (benefits minus costs) to society. In the context of water pollution, a producer’s ability to operate, and thus pollute, generates both benefits and costs to society. For example, society benefits from agricultural lands that produce food, chicken processing plants that employ local workforces, and wastewater treatment plants that process sewage. However, the pollution byproducts from these processes impose costs on society in many forms including increased healthcare costs, reduced recreational opportunities, and decreased land values. The efficiency standard seeks a level of water pollution where net benefits are greatest.

Although economists often strive for efficiency, calculating the efficient level of pollution is often very difficult. Nguyen et al. (2006) recognize this difficulty and thus state:

> So, in practice, policy makers rarely seek to exactly achieve the economically efficient level of water pollution. Instead they focus on rough benefit-cost test, rules of thumb, qualitative water quality standards, and/or general guidelines such as safety standards for human or ecological health.

When the efficiency standard is impractical to implement, policy makers often turn to other standards. Two of these standards, safety and ecological are discussed below.

2.2.3. Environmental Standards – Safety, Ecological

As mentioned in the quote above, human and ecological standards are also means by which policy makers set standards for water quality. The safety standard, or human standard, is an environmental policy standard that is based on the thought that no excessive harm should be done to humans. Regulatory agencies frequently define safe pollutant levels where there is a cancer risk of less than 1 in 1 million (Goodstein 1995). The ecological standard is similar to the safety standard, but has an ecological rather than anthropological focus. This environmental policy standard is based on the thought that no excessive harm should be done to ecosystems. As stated previously, these human and ecological standards are often used to establish pollutant caps due to the difficulty in calculating the Pareto efficient level. TMDLs often reflect these human and ecological limits.

2.2.4. Cost-Effectiveness

After determining the optimal level of pollution, one must consider what policy instrument is best for reaching this goal. The economic notion of cost-effectiveness is a criterion by which economists judge policy instruments. Cost-effectiveness is defined as the state where the marginal cost of pollution abatement is equal for all pollution sources (Goodstein 1995).

Following Nguyen et al. (2006), this idea is illustrated. Suppose two wastewater treatment plants operate within the same watershed. Due to accelerated eutrophication, a regulatory agency deems that phosphorus (P) loads must be capped at 800 pounds per year. Each plant produces 600 pounds and thus an aggregate reduction of 400 pounds is needed. Each plant has the capability to reduce loads by 100 pounds at a time, but doing so results in various costs. These costs are captured in Table 2.1.

There are several abatement options available to these two plants in order to achieve the required four units of reduction. Plant A's abatement costs show that it is fairly cheap for A to abate the first three units but then costs jump up to $600 for the fourth unit. Plant B's abatement costs are generally higher than A's, but Plant B's first unit of abatement is cheaper than Plant A's fourth unit. If a central planner could minimize costs using a combination of abatements between Plant A and Plant B, these options would be as shown in Table 2.2.

As one can see, the cheapest option for society would be Option 2. This option is cost-effective: Plant A and Plant B meet their regulatory obligations by reducing individually to levels where their marginal costs of abatement are equal: $200. Trading derives its support from this economic concept as it is often more cost-effective than other policy tools. But this example does not address how the two plants come to the agreement that Plant A reduces three units and Plant B reduces one unit. A theorem known as the Coase Theorem helps explain this process through trading.

2.2.5. Coase Theorem

The Coase Theorem, named after the economist Ronald H. Coase, states that regardless of the distribution of initial property rights, if polluters and those affected by this pollution are able to negotiate freely, they arrive at the efficient level of pollution (Goodstein 1995). For example, if society (as represented by government) owns all the rights to pollution, society has an incentive to sell rights to those that pollute up to the point where the marginal benefit to the polluter equals the marginal cost of pollution to society. The reverse is also true. A corollary to the Coase Theorem addresses its application to trading and cost-effectiveness:

> If there is a well-functioning permit market, a cost-effective outcome will be achieved by a marketable permit system regardless of the initial ownership of the permits.
> (Goodstein 1995)

The Coase Theorem, its relevant corollary, and the ability to achieve cost-effectiveness form the theoretical foundation of trading. This isn't to say that trading is the only or always best approach. However, trading does offer advantages over alternative methods. Two of these alternative methods are summarized below.

2.2.6. Alternative Approaches – Command and Control, Pigovian Taxes

Command and Control:

The command and control approach is based on strict laws and regulations that state mandatory standards for pollution control (Nguyen et al. 2006). For example, these standards could prescribe only one type of technology that all smokestacks must use to filter mercury from the air, or that all wastewater treatment plants must use a specific filtration method and no other. For water pollution, the command and control approach has been very widely used since water pollution was first regulated with the Water Pollution Control Act of 1948 (Nguyen et al. 2006).

Today, policy makers recognize that, "it has been quite effective reducing point-source water pollution…(but) has left largely ignored the non-point source pollution problem" (Nguyen et al. 2006). This result is due to the fact that it is much easier to regulate PSs than NPSs. Pollution loads from NPSs are subject to much more uncertainty, and thus command and control approaches are more difficult to implement. Trading offers a means to engage these NPSs and account for the uncertainty of pollution loads through trading ratios. Details of trading ratios are discussed later in this chapter.

In addition to engaging NPSs, the main advantage of trading over a command and control approach is its ability to achieve a cost-effective solution. With a command and control approach, cost-effectiveness is difficult to attain. Recalling the previous example on cost-effectiveness, suppose regulation calls for 400 pounds of P reductions. A command and control approach may require uniform reductions of 200 pounds of P for each plant. This approach is reflected in Option 3; this option results in a higher total cost, $700, than the cost-effective solution Option 2, with a total cost of $650. Due to presence of heterogeneous abatement cost curves among stakeholders in a watershed, a cost-effective solution will often be impossible to achieve under command and control regulations.

Pigovian Taxes:

A Pigovian tax, or a pollution tax, is a fee that is charged for each unit of pollution that is discharged (Nguyen et al. 2006). In the example of the two wastewater treatment plants, each of these plants abates to the point where the cost of abatement is higher than the cost of the tax. Ideally, the regulatory agency sets the tax to a level which results in the desired abatement. Taxes offer a few advantages: they are fairly easy to administer and they provide a source of revenue to the regulatory agency. However, a major difficulty with Pigovian taxes is determining the appropriate tax level. To achieve efficiency or cost-effectiveness, optimal tax levels need to be determined for each polluter. However, a tax that is too low will result in more pollution than is desired since polluters have the incentive to pollute and pay the tax rather than abate at a higher cost. A tax that is too high may require polluters to abate to a level that is economically unfeasible for them. Again, due to the heterogeneity in stakeholder abatement costs, uniform taxes make it almost impossible for society to reach an efficient or cost-effective solution.

2.2.7. Challenges of Trading

Theoretically, trading is a cost-effective solution that offers advantages over alternatives such as command and control approaches and Pigovian taxes. However, this is not to say that trading is a panacea for all water quality issues. There are disadvantages to trading and obstacles that make its implementation difficult. Particular challenges include thin markets, uncertainty related to the course and fate of nutrient flows, varying degrees of political support, and high transaction costs related to market infrastructure, monitoring, and enforcement. These challenges are discussed in more detail in the next section as they arise with respect to specific elements of trading.

2.3. Essential Components

The EPA's "Water Quality Trading Assessment Handbook" and other trading overviews, such as Nguyen, et al.'s (2006) "A Guide to Market-Based Approaches to Water Quality", generally provide the same essential components to a trading framework. These fundamentals play a key role in this research, as well as in the literature, in understanding barriers to trading. Much of the literature surrounding trading is focused on analyzing the reasons why actual trading markets are still scarce. Where applicable, references to this research are included in the sections below.

2.3.1. Trading Frameworks - Where?

Ecological Boundaries:

So long as it meets other qualifying conditions, "The USEPA states that the trading area, where polluters can trade with each others, should be within a watershed or an area with a TMDL approval" (Nguyen et al. 2006). This criterion establishes broad ecological boundaries for trading, but remains vague with respect to how tightly these watersheds should be defined. The purpose for confining markets to a watershed level is to ensure that trades result in acceptable water quality standards. Several authors recognize the limiting effect that ecological boundaries have on trading. Hoag and Hughes-Popp (1997) state that large exchanges are unfeasible for water quality markets since, "The geographic size of a typical nutrient trading market is limited". Woodward (2003) recognizes the limiting effect as well:

> First, the number of potential participants in an effluent trading market is usually quite restricted because water pollution is confined to a watershed. As a result, polluters have limited ability to find suitable trades and a few traders can manipulate prices in the resulting "thin" markets.

Although these authors recognize the theoretical effects of tight ecological boundaries, the literature lacks an example of an actual market that is impacted by how the ecological boundary is defined.

Political Boundaries:

The majority of the trading frameworks in the U.S. are delineated within state lines. However, as in the case of this research, watersheds do not necessarily fit neatly within political boundaries. As a result, there are a few interstate trading programs in place today, most notably the Chesapeake Bay trading framework (Delaware, Maryland, Pennsylvania, Virginia, West Virginia, Washington, D.C.). Other interstate frameworks include the Long Island Sound (Connecticut, New York), Bear River Watershed (Idaho, Utah, Wyoming), Truckee Watershed and Lake Tahoe (California, Nevada), and the Colorado River Basin (Arizona, California, Colorado, New Mexico, Nevada, Utah, Wyoming).

Although these frameworks address an interstate water body, each state drafts its own and separate legislation to address trading. As a result, political boundaries can create barriers to trading when trading is confined to state boundaries or thwarted by lack of political support. McGinnis (2001) reviews several key trading frameworks and their development. One of these frameworks is for the Long Island Sound (LIS). LIS is threatened from excessive nitrogen loadings from the states of Connecticut and New York. Trading has been slow to develop due to interstate political hurdles. Although Connecticut officials fully support trading, "New York officials have been hesitant to commit to an integrated trading program" (McGinnis 2001). In his review, McGinnis (2001) notes that New York officials prefer to maintain separate responsibilities for load reductions. These officials fear that interstate trading may lead to an increased administrative and legal burden. As McGinnis (2001) states, "the cooperation required to develop a trading program in an interstate region such as the Long Island Sound watershed has slowed even the most enthusiastic water quality officials". The LIS trading framework is an example where political boundaries to trading exist.

U.S. Trading Frameworks:

In the U.S., the EPA website lists 48 water quality trading frameworks in 28 states. This list can be found at http://www.epa.gov/owow/watershed/trading/tradingmap.html. A map of these trading programs is provided in Figure 2.1.

2.3.2. Defining a Tradable Pollutant – Type/Form, Impact, Timing, and Quantity

Trading pollutants is similar in theory to trading any commodity on an exchange. For a determined price, a seller agrees to transfer ownership of a particular item to a buyer. Barring unusual circumstances, the process of buying and selling in traditional markets has been refined so that commodities can be easily seen, measured, graded, and/or transferred. However, in environmental markets it is often more difficult to clearly identify the commodity. EPA addresses this need for a more definable commodity by outlining, "four key trading suitability factors – Type/Form, Impact, Time, and Quantity" (U.S. Environmental Protection Agency 2004). By reviewing these factors, one can establish whether or not the pollutant of concern, "can be sufficiently controlled, measured, and traded by sources…in the watershed or targeted market area" (U.S. Environmental Protection Agency 2004). For the purposes of this research, the EPA does acknowledge that, "Pilot projects have demonstrated that nutrients such as phosphorus and nitrogen can be successfully traded" (U.S. Environmental Protection Agency 2004). This statement is not a catch-all to say that P trading will always work, but rather offers support for the potential for P trading markets.

Type/Form:

The first step in defining a tradable pollutant is to identify the type and form of the pollutant. This identification relies on ecological analyses that outline the pollutants responsible for water quality impairment. It may sound simple, but if P is the limiting pollutant, then P should be identified as the pollutant commodity. A discharger of selenium would not be able to purchase the rights to discharge more selenium from a source that agrees to reduce its P. As the EPA states in its handbook, "potential trading partners should not trade 'apples and oranges'" (U.S. Environmental Protection Agency 2004). However, the EPA does recognize that, "In some cases, different pollutant types (e.g., total phosphorus and dissolved oxygen) can be traded using a defined translation ratio based on the quantities of each that have an equivalent overall effect on water quality" (U.S. Environmental Protection Agency 2004).

In addition to the type of pollutant traded, the EPA handbook suggests that a pollutant should be traded in an agreed upon form. They give the example that market participants may be able to trade total P, but would be unable to trade soluble for non-soluble forms of P. One of the barriers to trading is the amount of uncertainty that exists regarding the impacts of various forms of a pollutant. Defining a single pollutant in a common form serves the purpose of removing some of this uncertainty.

Impact:

Much the ecological uncertainty surrounding the flow and fate of nutrients is captured by this trading factor. Understanding the impact that a pollutant has on a watershed is a critical piece of any trading framework. Does a reduction of X pounds of a pollutant at location Y have the same impact as X pounds reduced at location Z? Does a certain practice reduce a pollutant with the same certainty as another practice? These are all types of impact questions that should be addressed when creating a market. As discussed later, trading ratios address some of these questions regarding the impact uncertainty. Overall, the EPA states that impact should be addressed through equivalence, or trading ratios so, "that the water quality impact of trading will be equivalent to, or better than, the pollutant reductions that would have occurred without trading" (U.S. Environmental Protection Agency 2004).

Timing:

As is the same with other traditional markets, trading must include a time component that states when a commodity will be delivered. The EPA handbook suggests two time dimensions of trading:

> First, purchased reductions should be produced during the same time period that a buyer was required to produce them (e.g., during the permit compliance reporting period or during the same season when the permit limit was applicable). Second, the schedule for achieving pollutant reduction targets should align among trading partners.
> (U.S. Environmental Protection Agency 2004)

The nature of watershed participants may introduce difficulties in adhering strictly to these timing suggestions. For example, agricultural sources may experience higher loads in the growing season, urban sources may fluctuate with precipitation levels, and wastewater treatment plants may face constant discharges throughout the year. Market designs should account for the ecological impact resulting from variations in the time period for trades.

Quantity:

In its handbook, the EPA states, "Overall supply and demand should be reasonably aligned" (U.S. Environmental Protection Agency 2004). A variety of trading factors such as the pollutant cap, trading ratios, the initial allocation of credits and stakeholder participation play a significant factor in determining the supply and demand for credits. Market designs should account for the impact of these additional factors when aiming to satisfy the criteria of sufficient supply and demand.

2.3.3. Defining Market Parameters – Cap, Initial Allocation, Baselines

Cap:

A cap is a total limit placed on the amount of pollutant allowed in a market. TMDLs often serve to establish this cap to achieve the desired improvement in water quality. However, the cap must be carefully chosen as it serves as a driving force for both ecological improvement and trading. If the cap is too high, polluters are afforded a high degree of freedom with the amount of pollutant they discharge. They will likely lack an economic incentive to reduce to the level needed to achieve water quality standards. In this instance, the few stakeholders that do need to reduce may face thin markets that diminish the opportunities for trade. A very stringent limit, although ecologically favorable, may be economically and politically unfeasible. Previous research addresses the importance of this cap, often citing nonexistent or very lenient caps as reasons for why trading does not occur more often (Hall and Raffini 2005; King 2005).

Initial Load Allocation:

Once a cap is established, a regulatory agency must allocate the initial rights to pollute. Again, the TMDL often designates this initial load distribution among sources. This allocation can be specified in either quantity or concentration form; the goal of both is to achieve a level of discharge that falls within the cap. The implementation of initial load limits can be very controversial. For example, suppose a watershed contains three wastewater treatment plants that must meet regulatory obligations. In this example, a market is established with a cap of 300 lbs of P. The regulatory agency could divide the initial permits evenly and allow each plant to discharge the same amount of P. The method seems fair enough. But what if one of wastewater treatment plants serves a population that is twice the size of the populations served by the other treatment plants? Should the initial allocation take this factor into account? These types of questions obviously have no one right answer. However, Nguyen, et al. (2006) provide examples of two of the most common methods for distributing this initial allocation. These methods and their main advantages and disadvantages are discussed below. Economists often strive to implement the method that best meets the Pareto efficient criterion discussed earlier.

Two methods of initial allocation include:

1). Grandfathered Allowances – allocate the permits in proportion to what stakeholders have emitted historically. Nguyen, et al. (2006) give the example that if an overall 20 percent reduction in pollutants is desired, then each regulated entity receives permits equal to 80 percent of what they historically discharged. Grandfathered allowances have the advantage that they are more politically feasible since the method distributes according to historical standards. Nguyen et al (2006), state that, “Grandfathering is seen as a fair approach, and therefore generally receives greater support from stakeholder groups”. A disadvantage of grandfathering is the inability to determine an initial market price for permits; auctions address this deficiency.

2). Auctions – rather than handing out permits to stakeholders, auctions require stakeholders to bid for permits. In this manner, stakeholders bid for permits until their marginal price of abatement equals the price of the permit. Nguyen et al. (2006) discuss two main advantages of auctions which include an auction’s ability to determine an initial market price for permits and an auction's ability to generate revenue for a regulatory agency or local government. Auctions are based on, "the idea that society holds the right and polluters have to pay for that right" (Nguyen et al. 2006). In this manner, stakeholders pay for the right to pollute as they would with a Pigovian tax. For this reason, Nguyen et al. (2006) state that auctions, "do not gain political support from the affected industries and have not been widely adopted as a way to distribute all allowances".

A study of the Tar-Pamlico trading framework (Hoag and Hughes-Popp 1997) is a great example of how load allocations can have a drastic effect on trading. Hoag and Hughes-Popp (1997) analyzed the implementation of a two phase trading program. In the first phase, the regulatory agency focused on PS reductions. An association for PSs was created where, in aggregate, the association was required to meet strict load reductions. In this phase, if the association could not meet the specific load reductions, they could purchase NPS credits at a fixed price by contributing money to an agricultural best management practice (BMP) fund. This phase saw a significant reduction in the amount of nutrient loads.

A second phase shifted the focus of reductions to NPSs and relaxed the limit on PSs as well as the fixed price for the BMP fund. This move was essentially a shift in the load allocation from PSs to NPSs. Hoag and Hughes-Popp (1997) criticize this move since the relaxation of PS standards likely resulted in a lack of demand and a thin market. This move also alienated certain stakeholder groups and resulted in a protest by the North Carolina Environmental Defense Fund that forced the delay of the program. These decisions demonstrate the vulnerability of trading programs to load allocation choices.

Baselines:

Trading can include stakeholders that are both PSs and NPSs. For PSs, establishing baselines is fairly straightforward since loads can be easily measured. However, due to the difficulty of monitoring loads and load reductions from NPSs, "the use of clearly defined allowances is usually not possible" (Nguyen et al. 2006). In this case, baseline practices are established for NPSs. Any improvement that NPSs make beyond these baseline practices can be sold as credits. Again, numerous questions surround the establishment of these baselines as environmental advocates and NPSs may have different views as to what practices are needed. Nguyen et al. (2006) recognizes this point: "The setting of the baseline, therefore, is of critical importance both to the environmental integrity of the program and its political viability".

2.3.4. Defining Market Parameters –Trading Ratios, Delivery Ratios, Retirement Ratios

Trading Ratios:

As discussed previously, trading ratios play an important role as parameters that address uncertainty surrounding the flow and fate of pollutants. These ratios may be set for any number of trading characteristics. However, the most commonly discussed ratio is between PS and NPS reductions. Technology exists to easily measure pollutant discharges from PSs, as their effluent is often discharged straight from a pipe into the applicable watershed. Therefore, PS reductions can be measured with a high degree of certainty. However, NPSs have a high degree of uncertainty surrounding the effectiveness of the BMP's that are used to reduce the flow of pollutants to a watershed.

To account for this difference in certainty, trading ratios can be established where estimated reductions by NPSs are equivalent to lower estimated reductions by PSs. This is often done to ensure, "the pollution reduction goal is actually achieved" (Nguyen et al. 2006). For example, a market may choose to set two pounds of NPS pollution abatement equivalent to one pound of PS abatement. These trading ratios are often expressed as NPS:PS. In this example a market-wide NPS:PS trading ratio equals 2:1. In addition to general NPS:PS ratios, markets may specify various NPS:PS conversions according to the specific BMP. For example, conservation tillage practices may have a different NPS:PS ratio than the creation of a riparian buffer.

It is important to note the consequences of these trading ratios. A ratio that is too small may not properly account for the uncertainty regarding pollution from NPSs and result in a greater level of pollution than is desired. However, trading ratios that are too high may squeeze participants out of markets. A NPS may have the ability to reduce one unit of pollution cheaper than a PS can reduce one unit; however, a NPS may not be able to reduce four, five, or six units of pollution cheaper than a PS can reduce one unit. Horan (2001) shows that these ratios are often established to be politically optimal, not necessarily economically optimal, since it may be politically costly to trade certain reductions of PSs for uncertain reductions in NPSs.

Several authors show that trading is limited by the use of trading ratios greater than 1:1 for NPS:PS (Hoag and Hughes-Popp 1997; Horan 2001). These trading ratios limit trading by increasing costs and thinning markets. By requiring PSs to purchase more than a 1:1 reduction from NPSs, costs of credits increase and the number of available credits decrease. Several studies cite general trading ratios that are implemented in trading frameworks. These ratios often specify a 2:1 ratio for NPS:PS, but range from greater than 1:1 to 3:1 (Horan 2001).

Delivery Ratios:

Delivery ratios are another important component of calculating credits for trading frameworks. Once a pollutant enters a waterway, this ratio represents the percentage of the pollutant that eventually reaches an applicable water body (i.e. a lake). The location of a discharger can play an important role in the impact of its effluent on a water body. For example, agricultural lands close in proximity to a lake may see 90 percent of their discharge reach an impaired lake, whereas a farm further upstream only contributes 40 percent. In determining trading credits, delivery ratios account for the spatial impact of a stakeholder. Credit calculation spreadsheets such as those provided by the State of Pennsylvania include delivery ratios when determining NPS credit calculations (Pennsylvania Department of Environmental Protection 2009). Delivery ratios are often calculated based on the results of a hydrologic model that is chosen to map the flow and fate of pollutants in a certain watershed.

Retirement Ratios:

Retirement ratios like trading ratios account for uncertainty regarding the fate and flow of pollutants in a watershed. These ratios determine the percent of generated credits that must be set aside in a reserve. These reserves are established to guarantee that water quality goals are met even if credit generation practices fail to produce the estimated abatement. For example, the trading framework in the State of Pennsylvania describes credit reserves as, "Credits set aside by the Department to address nutrient and sediment reduction failures, uncertainty, and to provide liquidity in the market" (Pennsylvania Department of Environmental Protection 2009). When retirement ratios are in place, a market participant that generates Y tradable credits must also produce rY credits that are set aside by a regulatory agency, where r represents the retirement ratio, or percentage. The P credit calculation spreadsheet on the State of Pennsylvania's trading website includes a 10 percent retirement ratio (Pennsylvania Department of Environmental Protection 2009). In the same fashion as NPS:PS ratios that are greater than 1:1, retirement ratios increase the cost of credits and decrease overall supply.

2.3.5. Stakeholder Participation

The potential quantity of a pollutant that can be traded within a market is an important factor to consider when establishing a trading framework. Stakeholder participation plays a key role in determining this supply and demand of credits. For various reasons, stakeholders may decide to participate or withdraw from trading. These reasons may include fundamental beliefs for or against trading, the cost of participation, or level of difficulty in meeting regulatory obligations. The EPA, "recognizes that water quality trading requires the participation of certain parties" (Nguyen et al. 2006). Research has focused on understanding the objectives of stakeholders and how to better engage them. Previous theories of pure cost-minimization or profit maximization objectives may not hold (Breetz et al. 2005; King 2005; Woodward 2003). The EPA handbook provides a few methods for engaging these stakeholders.

2.3.6. Market Structure

Choosing a market structure that best suits a particular trading framework is not a simple task. Nguyen et al. (2006) suggest picking the most efficient market structure available. This efficiency standard, often employed by economists, is discussed earlier in this chapter. Nguyen et al. (2006) recognize that, "While market designers should strive for an efficient market; expectations must be realistic". In an example from the literature, Hoag and Hughes-Popp

(1997) analyze the effects of market structure on the Tar-Pamlico trading framework in North Carolina. As stated previously, an association for PSs was created where, in aggregate, the association was required to meet strict load reductions. In this phase, if the association could not meet the specific load reductions, they could purchase NPS credits at a fixed price by contributing money to an agricultural BMP fund. This market structure resulted in significant load reductions for the watershed by reducing administrative costs. However, as a tradeoff, achieving an efficient solution is not possible with a fixed price structure for BMP's. As Hoag and Hughes-Popp (1997) note, "a fixed price, based on average cost, eliminated the marginal cost benefits that are crucial for efficient trading".

Fluid markets, or exchanges, that provide the most efficient type of market structure, "have yet to arise for the case of water quality trading" (Nguyen et al. 2006). Other common types of market structures that have emerged for trading are as follows:

1). Bilateral Negotiations – direct negotiations between buyers and sellers of pollution credits.

2). Clearinghouse – a third party acts as a broker for those selling to buy and sell credits

3). Sole-source Offsets – trading between parties does not take place, but rather market participants, "are given the opportunity to find alternative ways of reducing their environmental impact on the watershed through, for example, creek restoration" (Nguyen et al. 2006). Determining which market structure is best for the watersheds in this research is a question that should be addressed after a review of the potential for trading is performed.

2.3.7. Transaction Costs – Monitoring, Enforcement, and Liability Issues

One of the primary obstacles facing trading is the existence of high transaction costs. Economists define transaction costs as the additional costs of an economic transaction. In the case of trading, some of the most prevalent transaction costs include the cost to establish a market, monitor discharge levels, enforce trades, and resolve disputes among parties. Several authors recognize the impact of high transaction costs on trading and focus on the effects of market structures, property rights, and regulatory choices on these costs (Fang F., Easter, and Brezonik 2005; Hoag and Hughes-Popp 1997; Horan 2001; Woodward 2003). Few studies have actually estimated and published these costs (Fang F., Easter, and Brezonik 2005). These costs are accounted for in this analysis by determining the market's general ability to handle high transaction costs under various scenarios.

Table 2.1. Cost Effectiveness Example – Abatement Costs

i^{th} unit of reduction*	Plant A (Additional Cost)	Plant B (Additional Cost)
1^{st}	$100	$200
2^{nd}	$150	$250
3^{rd}	$200	$300
4^{th}	$600	$400

*1 Unit = 100 lbs

Table 2.2. Cost Effectiveness Example – Abatement Options

Plant	Option 1 (units)	Option 2 (units)	Option 3 (units)	Option 4 (units)	Option 5 (units)
A	4	3	2	1	0
B	0	1	2	3	4
Total Cost	**$1,050**	**$650**	**$700**	**$850**	**$1,150**

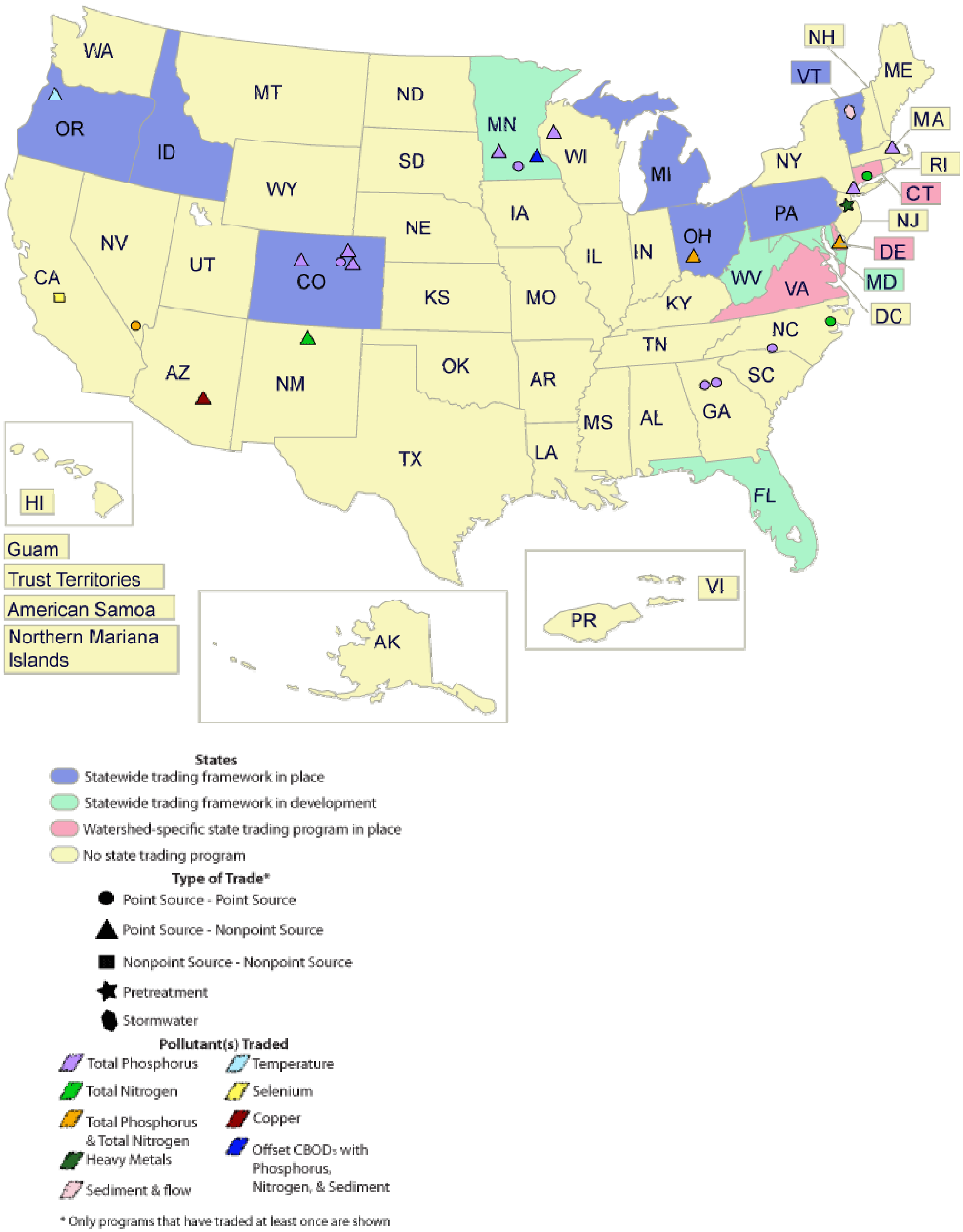

Figure 2.1. Water Quality Trading Programs in the U.S.
(U.S. Environmental Protection Agency 2009d)

CHAPTER 3

LEGAL AND ENVIRONMENTAL FRAMEWORKS

Although this thesis primarily explores trading from an economic perspective, it is imperative to recognize the environmental and legal aspects of trading. This chapter establishes the basic environmental and legal framework for phosphorus (P) trading in the Lake Allatoona and Weiss Lake watersheds. The first section of this chapter explores the federal regulations and agencies that govern trading. As a result of the U.S. regulatory framework, the implementation and enforcement of these regulations is often left up to state governments (Goodstein 1995). Sections 2 and 3 of this chapter summarize the status of initiatives, including legislative action, in the states that comprise the primary areas of focus: Georgia and Alabama. The next four sections of this chapter provide information on watershed characteristics and the health of Lake Allatoona and Weiss Lake. This information is provided to garner a better understanding of the environmental problems facing these watersheds and the incentives for research.

3.1. Federal Regulations and Agencies

3.1.1. The Clean Water Act and Environmental Protection Agency

The primary body of federal legislation that governs surface water quality in the United States (U.S.) is known as the Clean Water Act (CWA). The CWA was originally the Federal Water Pollution Control Act of 1948, but was extensively reworked in 1972, amended again in 1977 and subsequently became known as the CWA (U.S. Environmental Protection Agency

2009e). These revisions sought new standards for surface water quality through stricter regulations of pollutants discharged into U.S. waters. The new measures were taken, “to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters” (U.S. Environmental Protection Agency 2009c). The Environmental Protection Agency (EPA) was the federal agency tasked with implementing the CWA (Goodstein 1995).

The 1972 and 1977 amendments, “Made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions” (U.S. Environmental Protection Agency 2009b). The EPA’s new authority resulted in regulations that focused primarily on point source (PS) dischargers such as wastewater treatment facilities. The permitting system that arose is known as the National Pollutant Discharge Elimination System (NPDES).

Although improvements to surface water quality were made as a result of the CWA, many impaired waters were unable to achieve water quality standards through PS regulation alone. As a consequence, Congress passed further legislation with the Water Quality Act of 1987 to address growing contributions from non-point sources (NPSs) of pollution. This act required states to implement best management practices (BMPs) to control water pollution from industrial and agricultural sites (Goodstein 1995). However, the same, “centralized, technology-based regulation(s)” (Goodstein 1995) used to control PSs are often impossible to implement for NPSs. As a result, the EPA now considers, “more holistic watershed-based strategies” (U.S. Environmental Protection Agency 2009c) in order to achieve water quality standards. Water quality trading is one such strategy that receives considerable attention. As discussed in the next part of this section, any measures taken to improve water quality through trading must be consistent with the standards set forth in the CWA (U.S. Environmental Protection Agency 2003).

3.1.2. Final Water Quality Trading Policy (2003)

From a federal regulatory perspective, the EPA supports trading as a potential policy tool for water quality improvement. The document that outlines the EPA's current support for trading is the Final Water Quality Trading Policy. This policy, issued by EPA in 2003, attempts to resolve issues that arise from previous trading guidelines. These previous guidelines are, "EPA's January 1996 Effluent Trading In Watersheds Policy and May 1996 Draft Framework for Watershed-Based Trading" (U.S. Environmental Protection Agency 2003). To date, this Final Water Quality Trading Policy remains the regulatory foundation for trading within the United States.

With this policy, the EPA intends, "to encourage states, interstate agencies and tribes to develop and implement water quality trading programs for nutrients, sediments and other pollutants where opportunities exist to achieve water quality improvements at reduced costs" (U.S. Environmental Protection Agency 2003). The support for trading is based on EPA's recognition of the benefits of market-based approaches to environmental regulation. Within this policy, EPA states, "market-based approaches such as water quality trading provide greater flexibility and have potential to achieve water quality and environmental benefits greater than would otherwise be achieved under more traditional regulatory approaches" (U.S. Environmental Protection Agency 2003). The advantages of market-based approaches from an economics point of view are explored in Chapter 2.

Throughout the Final Water Quality Trading Policy, the EPA outlines its specific objectives for trading and the necessary requirements for trading programs. In particular, these objectives, "encourage voluntary trading programs that facilitate implementation of TMDLs, reduce the costs of compliance with CWA regulations, establish incentives for voluntary reductions and promote watershed-based initiatives" (U.S. Environmental Protection Agency 2003). The main requirements for trading fall into the following general categories: CWA Requirements, Trading Areas, Pollutants and Parameters Traded, Baselines for Water Quality Trading, When Trading May Occur, Alignment with the CWA, Common Elements of Credible Trading Programs, and EPA's Oversight Role. The consistent element throughout these categories is that, "Water quality trading and other market-based programs must be consistent with the CWA" (U.S. Environmental Protection Agency 2003). The EPA's regulatory role in trading is to ensure that this primary requirement regarding the CWA is met.

3.1.3. United States Department of Agriculture

Due to the impact that agricultural systems have on water quality, the United States Department of Agriculture Natural Resource Conservation Service (USDA - NRCS) and EPA partner to promote the development of successful trading frameworks. This partnership was formally stated in an agreement released on October 13, 2006. The agreement states that, "Cooperative management and technical assistance efforts can improve resources management and protection; improve public services; accelerate implementation where appropriate; provide better understanding of the Agencies goals, objectives, and programs; and help minimize conflicts" (U.S. Environmental Protection Agency 2006). The agreement recognizes the importance of the NRCS and its ability to verify agricultural water quality credits. Verification of credits is very important to the success of trading, and this cooperative management between NRCS and EPA can help minimize barriers to trading.

3.2. Georgia

3.2.1. Legislative Action

As in many other states in the country, trading is currently under consideration as a potential policy tool in Georgia. With over half, "of the state's rivers and streams only partially supporting or not supporting water quality standards, the costs of restoring water quality in Georgia's waters will be high" (Rowles 2005). With the adoption of the Georgia Comprehensive Statewide Water Management Plan in 2008, the Georgia General Assembly formally recognized trading as a policy tool for its potential to reduce these costs of restoration (Rowles 2008). The Georgia Environmental Protection Division (GA EPD) is tasked with the implementation of this plan and must, "...partner with state and local government agencies, regulated entities, and other appropriate stakeholders involved in land and water management to review the practice of pollutant allocation trading to determine the potential for use of this tool in Georgia" (Rowles 2008). Efforts by GA EPD are still in the initial phases. Although it is not an exact measurement of their progress, it is worth noting that the GA EPD makes no mention of trading in the "Water" section of its website as found here: http://www.gaepd.org/Documents/wpb.html. Programs that are listed include matters related to wastewater permitting, wastewater engineering and support, NPSs, drinking water compliance, as well as a multitude of other water quality and quantity related subjects.

3.2.2. Trading Initiatives

Although GA EPD has just recently been tasked with the evaluation of trading, two initiatives in the state have been in place since the early 2000's. The Georgia Water Planning and Policy Center (GWPPC) with the help of the University of Georgia's Warnell School of Forestry manages the research project, "Building a Foundation for Water Quality Trading in Georgia" (Rowles 2008). GWPPC's research takes a state-wide approach to analyze the feasibility for trading in Georgia's watersheds. Several of their analyses are used in this research; their estimation regarding the cost of P abatement by wastewater treatment facilities is particularly valuable. The GWPPC continues to have a strong voice with respect to trading research and should be an integral part of future efforts. The other major initiative in Georgia is a component of this research and examines the potential for trading exclusively in the Lake Allatoona watershed. This research, "A Framework for Trading Phosphorus Credits in the Lake Allatoona Watershed" is described later in this chapter.

It should also be noted that one Georgia water group, the Georgia Water Coalition takes a strong stance against the implementation of trading within Georgia's watersheds. The Georgia Water Coalition describes itself as, "a group of individuals and organizations working to ensure that the waters of the state continue to belong to the people of the state"(Georgia Water Coalition 2009); its website lists a current partner count of 175. The Georgia Water Coalition's 2008 report states one of its recommendations as, "Recognize that water pollution trading will not work in Georgia"(Georgia Water Coalition 2008). Since stakeholder participation is an important component of trading, that some stakeholders in Georgia have already drawn strong beliefs against the potential for trading.

3.2.3. Executed Trades

Although formal markets do not exist in Georgia, two basic trading agreements have occurred. Both of these trading structures operate in the Chattahoochee River Basin. They are similar in that each framework has a utility that manages two wastewater treatment plants that share an aggregate P limit. In each case, the aggregate limit provides a degree of flexibility in how the utility chooses to comply with its discharge limits. The first of these trading arrangements is between the Cobb County R.L. Sutton Water Reclamation Facility and the South Cobb Water Pollution Control Facility in Cobb, GA. Although the facilities share an aggregate limit, the flexibility of the Cobb County utility is constrained by permitting language that requires each facility to meet certain operating standards (Rowles 2008). With these technology based restrictions, the Cobb utility has a harder time achieving the cost-effective goal advocated by trading. The other trading framework is between Newnan's Wahoo Creek Water Pollution Control Plant and Mineral Springs Water Pollution Control Plant operated by the City of Newnan in Coweta County (Rowles 2008). The permitting language for the City of Newnan's utility is, "notably less restrictive in specifying how the facilities will comply with these limits" (Rowles 2008). In this case, the utility of the City of Newnan is freer to cost-effectively allocate its abatement than the utility in Cobb County.

These permitting agreements possess some characteristics of trading since the utilities, "can allocate compliance investments among (their) facilities" (Rowles 2008) and hypothetically operate at a level where the marginal costs of abatement are the same at both facilities. Due to the simplified nature of these trades and the noted restriction for Cobb County, these frameworks are not necessarily precursors for future successful trading programs in Georgia. Nonetheless, these efforts are worth noting since they may provide a stepping-stone for trading in Georgia.

3.3. ALABAMA

3.3.1. Legislative Action

At this time, it appears that the Alabama legislature has not made any formal statements regarding trading as a policy tool. The website for the Alabama Department of Environmental Management, which is the state department responsible for water quality standards, makes no mention of trading.

3.3.2. Trading Initiatives

In 2002-2003, the EPA provided partial funding for a research project in the Tallapoosa River Basin to explore the potential for trading. The Water Works and Sanitary Sewer Board (WWSSB) of Montgomery, Alabama provided the additional funding (Breetz et al. 2004). The WWSSB website states that it, “is investigating the benefits of developing a market for pollutant load trading” (Montgomery Water Works and Sanitary Sewer Board 2009). This project is intended to, “help position the Board during TMDL developments and permit applications and renewals” (Montgomery Water Works and Sanitary Sewer Board 2009). However, it appears that no trades have been executed at this time.

In addition, the Alabama Clean Water Partnership (ACWP) lists trading as a potential policy tool in their “Tallapoosa River Basin Management Plan” from March 2005. The ACWP identifies itself as, “a "neutral" entity” (Alabama Clean Water Partnership 2009) that brings together, “individuals, companies, organizations and governing bodies in order to educate the public and put projects on the ground to protect and preserve Alabama's incredible water resources and aquatic ecosystems” (Alabama Clean Water Partnership 2009). This management plan for the Tallapoosa River Basin recognizes the potential for trading as an “Emerging

Opportunit(y) for Program Support" (CH2MHILL 2005), but offers no other opinions for or against trading in the Tallapoosa River Basin.

In all, it appears that Alabama is not pursuing the potential for trading with the same efforts as Georgia. It is worth noting that even though funding has been provided for the Montgomery WWSSB project, the EPA does not list Alabama as state in which a trading project is underway. This EPA list, last updated September 2008, is presented in Chapter 2.

3.4. Lake Allatoona Watershed - Characteristics

3.4.1. Lake Location and Size

Lake Allatoona is in northwestern Georgia, 30 miles north of Atlanta (See Figure 3.1). The lake has a surface area of 12,010 acres, 270 miles of shoreline, and a volume of approximately 367,500 acre-feet (U.S. Army Corps of Engineers 2009). With respect to size, Lake Allatoona is the seventh largest lake in the state of Georgia (Great Lakes of Georgia 2004).

3.4.2. Lake History and Uses

As discussed in Chapter 1, Flood Control Acts of 1941 and 1944 led to the impoundment of the Etowah River in 1950 for flood control and hydroelectric power. The lake is currently managed by the U.S. Army Corps of Engineers (U.S. Army Corps of Engineers 2009). In addition to flood control and hydroelectric power, Lake Allatoona serves a variety of purposes including public water supply, recreation, and fish and wildlife habitats (Dirnberger J. M., Rascati, and Msimanga 1993). The U.S. Army Corps of Engineers list the lake as, "one of the most frequently visited Corps of Engineers lakes in the nation" (U.S. Army Corps of Engineers 2009) with approximately 6 million visitors a year. In all, it is estimated that the local economy receives roughly $250 million annually from these activities (U.S. Army Corps of Engineers 2009).

3.4.3. Applicable Watersheds and Tributaries

This research uses the same watershed delineation that Radcliffe et al. (2009) and Lin et al. (2009) provide. This watershed, The Lake Allatoona Watershed, is a portion of the larger Etowah Watershed as outlined by the Hydrologic Unit Code (HUC) boundary in Figure 3.2. The Lake Allatoona Watershed delineates the major inflows into Lake Allatoona. The six sub-watersheds shown in Figure 3.2 are used by Radcliffe et al. (2009) and Lin et al. (2009) to model P loads to the lake. These six sub-watersheds are comprised of six primary tributaries and five secondary tributaries. The six primary tributaries are the Etowah River, Shoal Creek, Little River, Noonday Creek, Lake Acworth discharge, and Stamp Creek (Radcliffe et al. 2009). The five secondary tributaries are Owl Creek, Kellogg Creek, Tanyard Creek, Allatoona Creek, and Rowland Spring Branch. In all, these tributaries comprise over 99.5% of the inflows into Lake Allatoona (Radcliffe et al. 2009). Of these tributaries, the "Etowah River...is the largest source of inflow, sediment, and nutrients to the lake" (Radcliffe et al. 2009). Figure 3.3 displays the entry point for these tributaries into Lake Allatoona.

3.4.4. Counties

The Lake Allatoona Watershed crosses over several Georgia counties. A map of the Etowah Watershed from EPA Basins 4.0 is superimposed over these counties in Figure 3.4. The counties that fall within the Lake Allatoona Watershed include Bartow, Cherokee, Cobb, Dawson, Fannin, Forsyth, Fulton, Gilmer, Lumpkin, Paulding, Pickens, and Union. It is important to keep in mind that these county governments will have various interests in mind with respect to actions in the watershed. If trading is shown to be economically favorable, further analysis will be needed to understand potential stakeholder participation. These local governments should be an integral part of that discussion. Please refer to Chapter 4 for further details regarding land use for these counties.

3.5. Lake Allatoona Watershed - Health

3.5.1. Phase I Clean Lakes Diagnostic Feasibility Study

A principal report on the ecological health of Lake Allatoona is the Lake Allatoona Phase I Clean Lakes Diagnostic Feasibility Study (Allatoona Clean Lakes Study). This study examined water quality in Lake Allatoona in the 1990's with funding from two Clean Lakes Section 319 projects. The main finding from the Allatoona Clean Lakes Study is that Lake Allatoona is, "in transition between mesotrophic and eutrophic, with P being the primary limiting nutrient for algal growth" (The University of Georgia River Basin Center 2003). It concludes, "that unless measures were taken to control P inputs to the lake, it would be unfit for drinking or recreational purposes within ten years" (The University of Georgia River Basin Center 2003). P loads are restricted as a result of these findings. GA EPD strives to limit these loads to no more than 1.3 lb/acre-ft of lake volume per year.

3.5.2. Section 303(d) and TMDL Development

Even with the GA EPD imposed P load restriction, the water quality of Lake Allatoona continued to deteriorate. As a result, GA EPD developed a TMDL in 2004 to address excessive P loads for the Little River Embayment (The Georgia Department of Natural Resources 2004).

The TMDL requires reductions in total P for individual PSs (categorized as WLA), urban loadings from storm water discharges associated with MS4s (WLAsw), and other NPSs (LA). MS4s are defined as, "small municipal separate storm sewer systems…that serve populations of 50,000 or more"(The Georgia Department of Natural Resources 2009) . Total 2001 existing loads were listed at 35,369 lbs of total P per year. The WLA load was 18,250 lbs/yr, WLAsw was 6,050 lbs/yr, and LA was 5,2000 lbs/yr. The TMDL for 2001 was 29,500 lbs of total P per year.

Due to continued water quality impairment, "In 2006, the entire lake was placed on the state's 303(d) list due to excessive chlorophyll-a" (Radcliffe, Lin, and Risse 2007). Section 303(d) of the CWA requires that all states must list impaired water bodies that do not meet their designated use (Weiss Lake TMDL 2008). The listing of these impaired water bodies, "and the development of Total Maximum Daily Loads (TMDLs) for those water bodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130)" (U.S. Environmental Protection Agency Region 4 2008). The purpose of Section 303(d) and the development of a TMDL is to provide a means for achieving water quality standards as set forth in the CWA.

As discussed in Chapter 1, GA EPD is in the process of developing a TMDL for two additional segments of Lake Allatoona to address this lake-wide 303(d) listing. These arms are the Etowah River Arm and Allatoona Creek Arm. The Etowah River and Allatoona Creek draft TMDL requires reductions in both total P and total nitrogen (N) for individual PSs (categorized as WLA), urban loadings from storm water discharges associated with MS4s (WLAsw), and other NPSs (LA). Loading limits are defined separately for the Etowah River Arm and Allatoona Creek Arm. The current total P load for the Etowah River Arm is listed as 12,719 lbs/day; this total is further broken into 36 lbs/day for WLA, 79 lbs/day for WLAsw, and 10,015 lbs/day for LA. The TMDL for the Etowah River Arm is 10,131 lbs/day; this limit requires a reduction of 20 percent in total P loads. The current total P load for the Allatoona Creek Arm is listed as 880 lbs/day; this total is further broken into 4 lbs/day for WLA, 155 lbs/day for WLAsw, and 373 lbs/day for LA. The TMDL for the Allatoona Creek Arm is 532 lbs/day; this limit requires a reduction of 40 percent in total P loads.

3.5.3. Addressing the Problem Through Phosphorus Trading

In addition to the actions of GA EPD, several organizations and local governments contribute efforts to protect Lake Allatoona's water quality. In particular, researchers at the University of Georgia's College of Agriculture and Environmental Science and School of Ecology play an integral role in addressing the water quality concerns of Lake Allatoona. One of the research projects is to establish a framework for trading P credits in the Lake Allatoona Watershed. A proposal for this framework was introduced in 2003.

The long term goal of the trading framework, "is to prevent the degradation of water quality in Lake Allatoona by meeting the P load restrictions that have been imposed by the GA EPD and further reductions that are likely to be imposed in a TMDL to be developed by the end of 2003" (The University of Georgia River Basin Center 2003). In order to develop this framework, the proposal lists several tasks for completion:

1. Estimate the annual using (sic) load of P, sediment, and FC (Fecal Coliform) entering Lake Allatoona using historical stream and water quality data and data collected as part of this project. We will use upstream and downstream sampling around common agricultural operations to develop region-specific estimates of pollutant loads.
2. Calibrate a semi-distributed watershed mode (Hydrological Simulation Program - Fortran, HSPF) using the monitoring data and use it to identify the spatial distribution of the current point and nonpoint sources of P, sediment, and FC entering Lake Allatoona.

3. Develop scientifically-based trading ratios using uncertainty analysis of the model for all of the best management practices that are likely to be used by agricultural and forestry nonpoint sources. These ratios will vary spatially in that best management practices implemented in the upper reaches of the watershed are likely to require a higher trading ratio than practices implemented near the lake.
4. Perform a cost analysis to see if trading between point and nonpoint sources is likely to occur. We will do this by comparing the cost that a point source would incur through a direct reduction in P load (by upgrading water treatment, for example) compared to the cost of buying credits from a nonpoint source.
5. Investigate different frameworks for trading ranging from unregulated trading between individual parties to a supervised fund from which trading credits can be purchased and best management practices funded.
6. Establish an advisory council consisting of stakeholders and all of the potential trading partners within the watershed. This council will meet regularly and we will help the UGA research team develop and present our findings regarding the water quality status of the lake, probable sources of pollutants, and how a trading program could work to improve water quality.
7. Sponsor a pollutant trading conference and workshop in the last year of the study.

(The University of Georgia River Basin Center 2003)

Significant progress has been made to address several objectives, especially with regards to modeling P loads to the lake. Radcliffe et al. (2009) and Lin et al. (2009) provide results that capture the spatial distribution of these loads to the lake. Chapter 4 utilizes these studies. Although progress has been made with respect to P load modeling, only modest efforts have been made to investigate the economic components of this framework. This research aims to fill this gap by providing information that addresses the fourth objective listed above. In particular, this research aims to identify potential trading partners by identifying major stakeholders and their potential needs and costs for P abatement. Understanding the cost differences between potential trading partners will help determine the economic feasibility of a trading program, and in turn, open the door for further research into other facets of trading. These other aspects of a trading framework include the determination of trading ratios (objective 3 above) and the establishment of trading frameworks (objective 5 above).

3.5.4. Other Initiatives

The Lake Allatoona and greater Etowah watershed receive considerable attention from environmental groups and agencies in the state of Georgia. Some of these organizations include UGA's RBC (http://www.rivercenter.uga.edu/index.htm), the Etowah Aquatic Habitat Conservation Plan (http://www.etowahhcp.org/background.htm), the Upper Etowah River Alliance (http://www.etowahriver.org/), and the Georgia River Network (http://www.garivers.org/). These groups research a multitude of environmental issues for these watersheds. If trading moves forward, these organizations will undoubtedly request a voice in its implementation.

It should also be noted that Carters Lake, sits to the north of Lake Allatoona in the Coosawattee watershed. Like Lake Allatoona, Carters Lake is listed on Georgia's 303(d) list for not meeting designated uses due to excessive chlorophyll a. GA EPD is currently developing a model of nutrient loads to the lake and plans to prepare a TMDL in 2010. Future trading efforts for Lake Allatoona could also be expanded to include Carters Lake.

3.6. Weiss Lake Watersheds - Characteristics

3.6.1. Lake Location and Size

Weiss Lake is located in northeastern Alabama near the Georgia border as shown in Figure 3.5. At normal water levels, the lake has a surface area of 30,200 acres with 447 miles of shoreline. Storage capacity at normal elevation is 306,311 acre-feet (U.S. Environmental Protection Agency Region 4 2008).

3.6.2. Lake History and Uses

Weiss Lake was created in 1961 by an impoundment of the Coosa, Chattooga, and Little Rivers (U.S. Environmental Protection Agency Region 4 2008). Alabama Power Company manages the lake for its primary use of hydroelectric power generation. Other uses for the lake include, "flood control, public water supply, maintenance of downstream water quality, irrigation, swimming and other recreation. The lake also serves as an excellent habitat for fish and wildlife" (U.S. Environmental Protection Agency Region 4 2008).

Researchers at Kennesaw State College and Florida State University conducted an analysis on the impact of Weiss Lake on the local economy for the year 1994. They estimated Weiss Lake's total impact at $291 million for the local economy of Cherokee County (Kennesaw State College 1996).

3.6.3. Applicable Watersheds and Tributaries

Weiss Lake is located within the Upper Coosa watershed (HUC# 03150105). This watershed receives flow from four upstream watersheds: Conasauga (HUC# 03150101), Coosawattee (HUC# 03150102), Oostanaula (HUC# 03150103), and Etowah (HUC#03150104) (Tetra Tech Inc. 2007). The lake and its watersheds are shown in Figure 3.6.

The major tributaries to Weiss Lake include the Coosa River, Little River, and Chattooga River. As shown in Figure 3.7, the Etowah and Oostanaula join at the city of Rome, GA to form the Coosa River. Other minor tributaries and creeks in northern Cherokee County include Yellow, Ballplay, Wolf, Spring, Mills, and Culstigh creeks (Alabama Department of Environmental Management 1997). The tributaries in southern Cherokee County that drain north to Weiss Lake include Spring, Cowan, Frog, Mud, and Big Nose creeks. A closer look at

Weiss Lake and these minor tributaries is provided in Figure 3.8. This map also shows the location of the Weiss Powerhouse Dam referenced in the TMDL discussion.

3.6.4. Counties

Weiss Lake is located primarily in Cherokee County, AL. A map of the counties within the Upper Coosa, Conasauga, Coosawattee, Oostanaula, and Etowah watersheds is shown in Figure 3.9. As one can see, the primary Alabama Counties that surround Weiss Lake include Cherokee, DeKalb, Calhoun, and Cleburne. Georgia counties closest to Weiss Lake include Chattooga, Floyd, and Polk. A more detailed examination of the land use from all applicable counties is explored in Chapter 4.

3.7. Weiss Lake Watersheds - Health

3.7.1. Phase I Clean Lakes Diagnostic Feasibility Study

Similar to Lake Allatoona, a Phase I Clean Lakes Diagnostic Feasibility Study was performed for Weiss Lake (Weiss Clean Lakes Study). This study was finalized in 1993 and based on data from 1991 and 1992 (U.S. Environmental Protection Agency Region 4 2004). As stated in the study, "The diagnostic study of Weiss Lake revealed two basic problems; cultural eutrophication and toxic contamination. Both of these problems are caused by point and nonpoint source pollution from within the basin" (Alabama Department of Environmental Management 1997). To address eutrophication, the authors presented two main recommendations to restore the water quality to a level where, "lake waters (would) be suitable for fishing, swimming, and public water supply" (Alabama Department of Environmental Management 1997).. These recommendations were:

1. Monthly reports of Total P and Total Nitrogen (N) discharges by major PSs (>0.5 MGD). This includes PSs in the Coosa River Basin that discharge upstream of the Weiss Lake dam.

2. The listing of chlorophyll a as a, “water quality criteria used to protect, maintain and improve the quality of Weiss Lake” (Alabama Department of Environmental Management 1997).

The toxic contamination finding addressed in the report was based on excessive concentrations of PCBs found in Coosa River fish in the 1970’s. Although the majority of these PCB’s were banned in 1979, “the stability of PCBs (50-300 times more persistent than DDT) will prolong the period of concern for these contaminants” (Alabama Department of Environmental Management 1997). The study’s authors recommended annual monitoring to address the PCB toxins.

3.7.2. 303(d) Listing

As a result of the Weiss Clean Lakes Study and continued monitoring, forty miles of Weiss Lake between the dam powerhouse in Alabama and the Georgia state line were placed on Alabama’s Section 303(d) list in 1996 for, “not supporting its designated use as a fishing water”(U.S. Environmental Protection Agency Region 4 2004). This 303(d) listing was, “due to priority organics, nutrients, pH and organic enrichment/dissolved oxygen (OE/DO)” (U.S. Environmental Protection Agency Region 4 2008). In 2000 and 2004, OE/DO and pH were removed respectively as causes for the 303(d) listing due to, “monitoring data that showed that the water quality standards for DO and pH were being attained in Weiss Lake” (U.S. Environmental Protection Agency Region 4 2008). Nonetheless, the continued 303(d) listing provided the motivation for TMDLs in 2004 and 2008 in order to address P’s role in Weiss Lake’s poor water quality.

3.7.3. TMDL Development - 2004 and 2008

In 2004, EPA established a TMDL for nutrient impairment in Weiss Lake. This 2004 TMDL utilized a chlorophyll a target for its water quality goal. This target was intended to, "allow for sufficient productivity in the reservoir to maintain the fisheries, but on the other hand, reduce the risk of nuisance blooms of algae and reduce the hypolimnetic oxygen deficit, thereby improving fish habitat" (U.S. Environmental Protection Agency Region 4 2004). A new TMDL for Weiss Lake was released in 2008; this TMDL supplants the previous 2004 document with updated P load restrictions. The 2008 TMDL uses the same chlorophyll a target concentration and focuses primarily on P reductions to achieve this goal. Total N loads were considered in the modeling process; however, EPA determined their reductions were not necessary to achieve the water quality goals. As stated in the TMDL, "EPA has determined that reductions in phosphorus, without concurrent reductions in nitrogen, are expected to result in the attainment of the Weiss Lake chlorophyll a criteria" (U.S. Environmental Protection Agency Region 4 2008). The 2008 TMDL states that the total P loads to the lake averaged 3,210 kg/day for the years 1991-2005. Of these loads to the lake, NPSs contributed 2,280 kg/day (71 percent), and wastewater treatment facilities contributed 930 kg/day (29 percent).

As discussed in Chapter 1, the 2008 TMDL specifies a 30 percent reduction in total P loads to the lake. To achieve this goal, the TMDL outlines reductions in total P for Alabama and Georgia separately. For Alabama, reductions are defined for major PSs (≥1 MGD), minor PSs (< 1 MGD), and NPS loads. Limits for Georgia are defined by aggregate loads from the Coosa and Chattooga Rivers at the Georgia state line. In addition to the Upper Coosa, the TMDL identifies the Conasauga, Coosawattee, Oostanaula, and Etowah as watersheds that drain to Weiss Lake.

3.7.4. Addressing the Problem through Phosphorus Trading

To date, no known efforts have been made to study the feasibility for trading in Weiss Lake. However, as more fully explained in Chapter 2, a TMDL is an important first step in establishing a trading framework. This research aims to begin the initial steps of assessing the economic potential for trading for Weiss Lake and determine how defining trading boundaries will impact the potential for trades.

3.7.5. Other Initiatives

Weiss Lake and the Upper Coosa Watershed receive attention from various environmental groups and agencies in both Georgia and Alabama. Some of these organizations include the ACWP (http://www.cleanwaterpartnership.org/), Coosa River Basin Initiative (http://www.coosa.org/), Alabama Rivers Alliance (http://www.alabamarivers.org/), Weiss Lake Conservation Task Force with Jackson State University (http://epic.jsu.edu/weisslake.html), and the Georgia River Network (http://www.garivers.org/). These groups research a multitude of environmental issues in these watersheds. As stated in the Lake Allatoona section, if trading goes forward, these organizations will undoubtedly request a voice in the details of its implementation.

Figure 3.1. Location of Lake Allatoona
(Geology.com 2009)

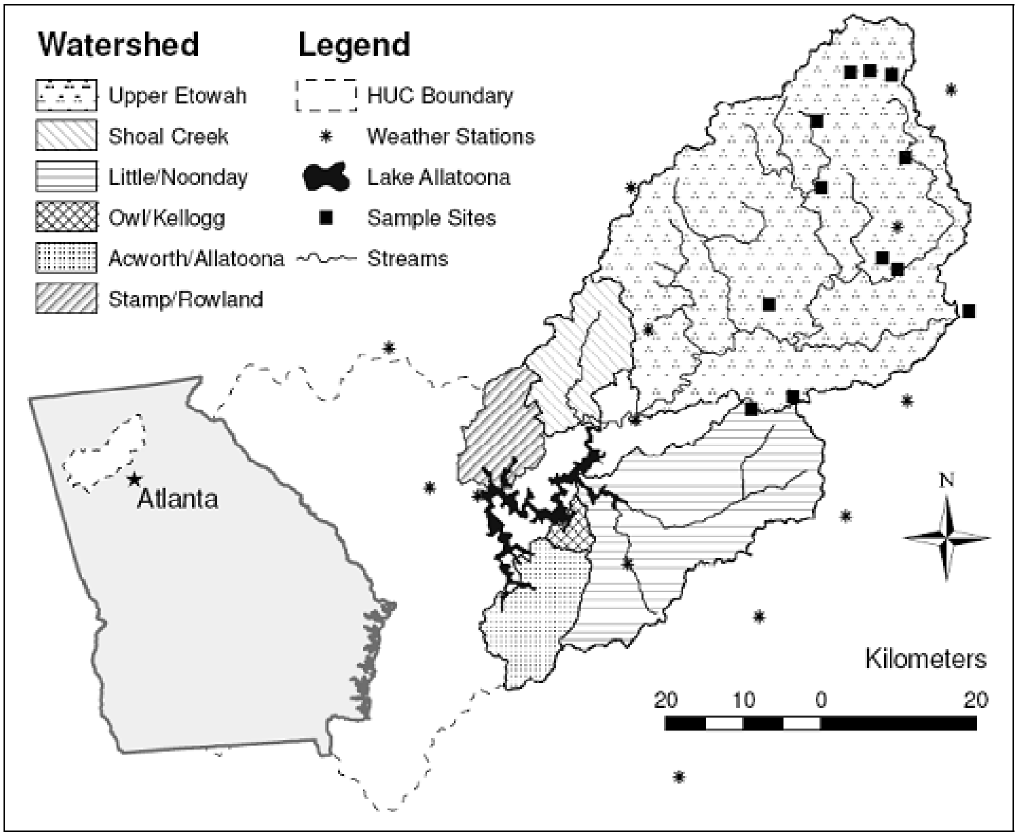

Figure 3.2. Lake Allatoona's Six Sub-watersheds
(Radcliffe et al. 2009)

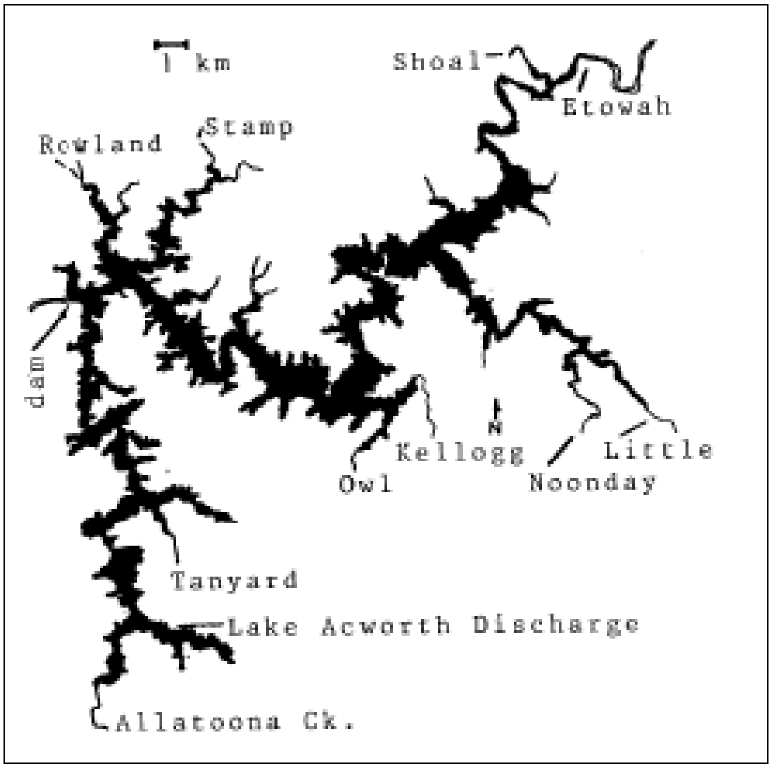

Figure 3.3. Primary and Secondary Tributaries to Lake Allatoona (Dirnberger J. M., Rascati, and Msimanga 1993)

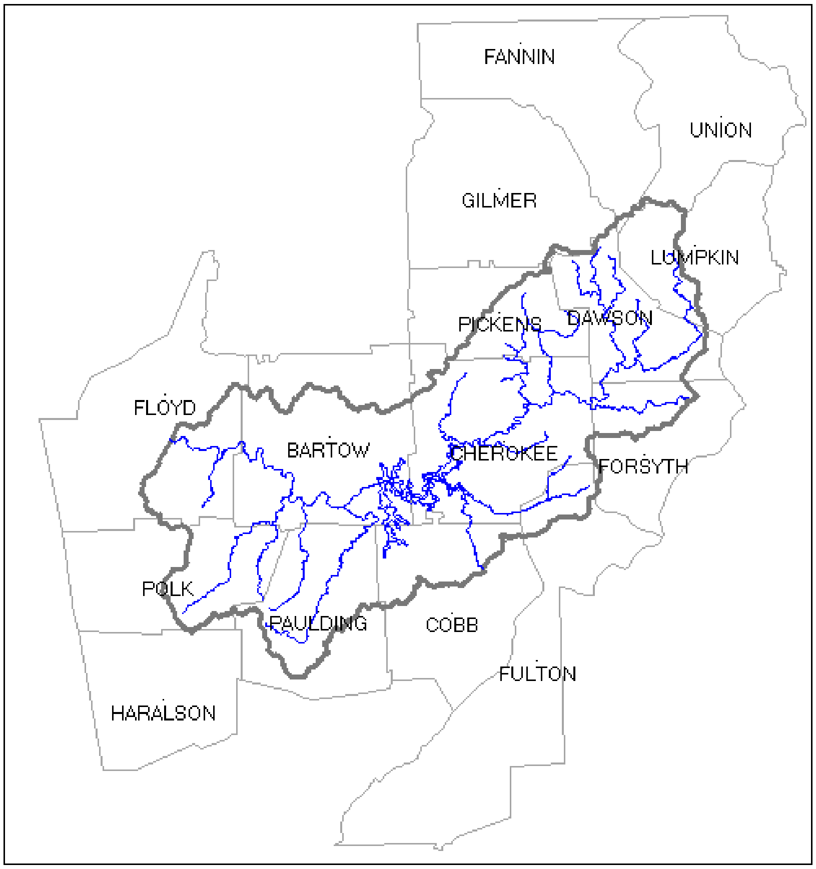

Figure 3.4. Counties in Lake Allatoona Watershed

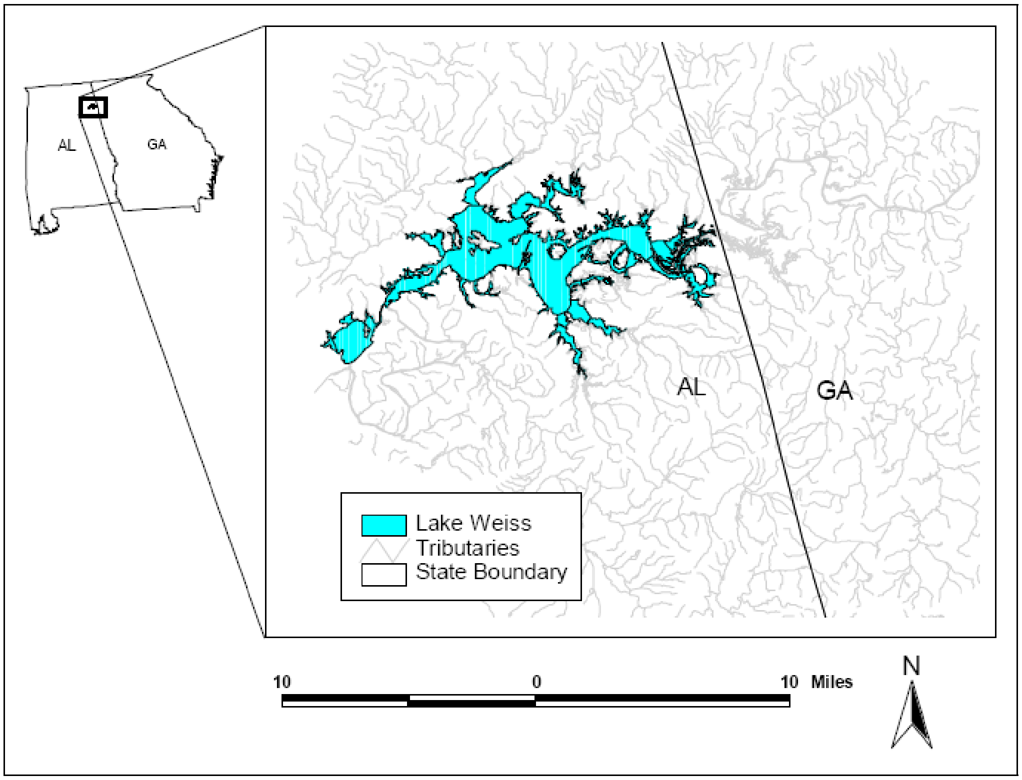

Figure 3.5. Location of Weiss Lake
(U.S. Environmental Protection Agency Region 4 2008)

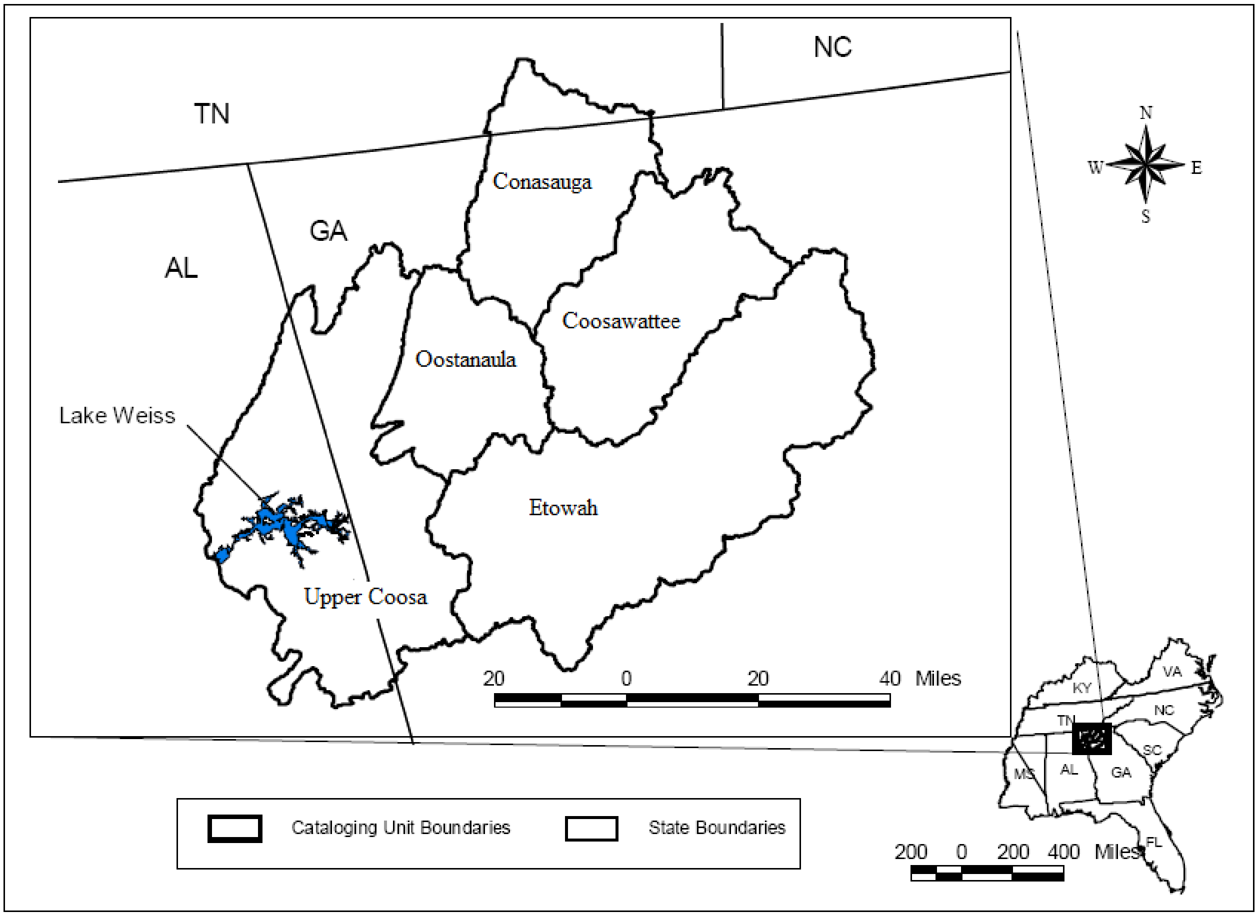

Figure 3.6. Watersheds of Weiss Lake
(U.S. Environmental Protection Agency Region 4 2008)

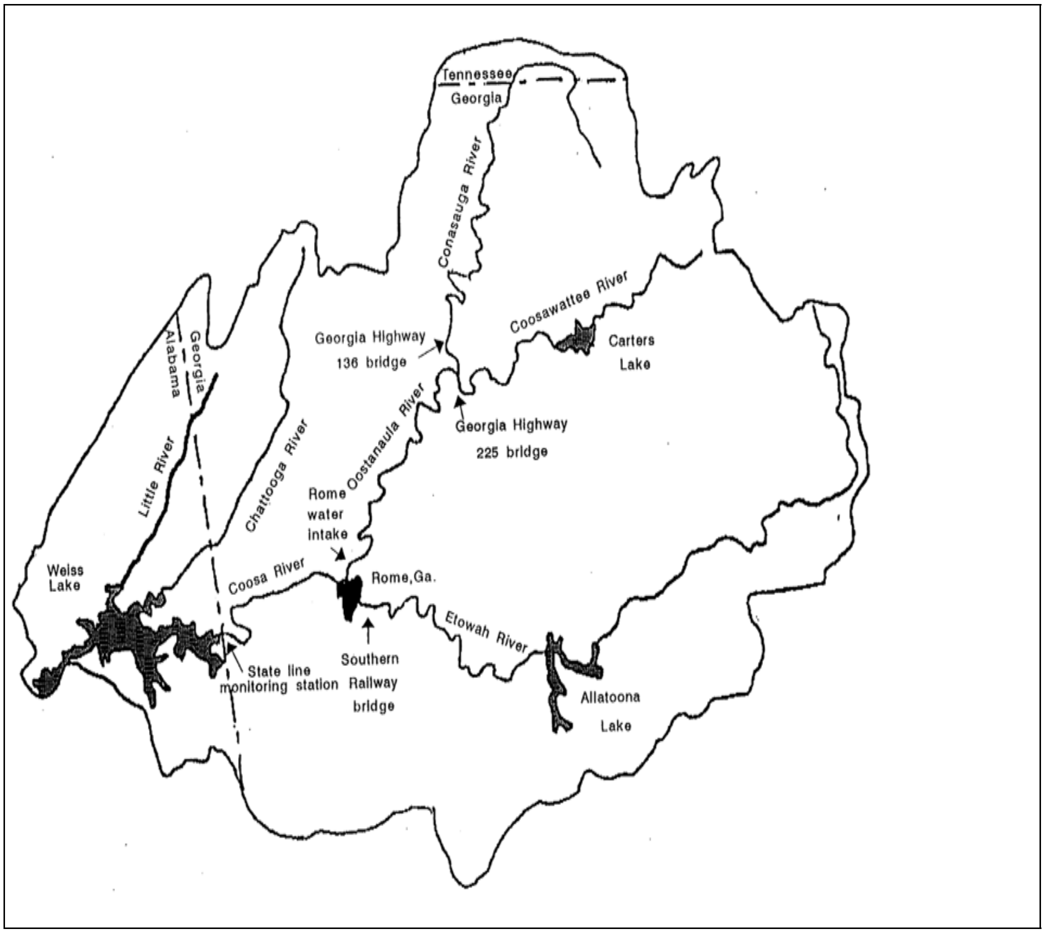

Figure 3.7. Major Tributaries for Weiss Lake
(Alabama Department of Environmental Management 1997)

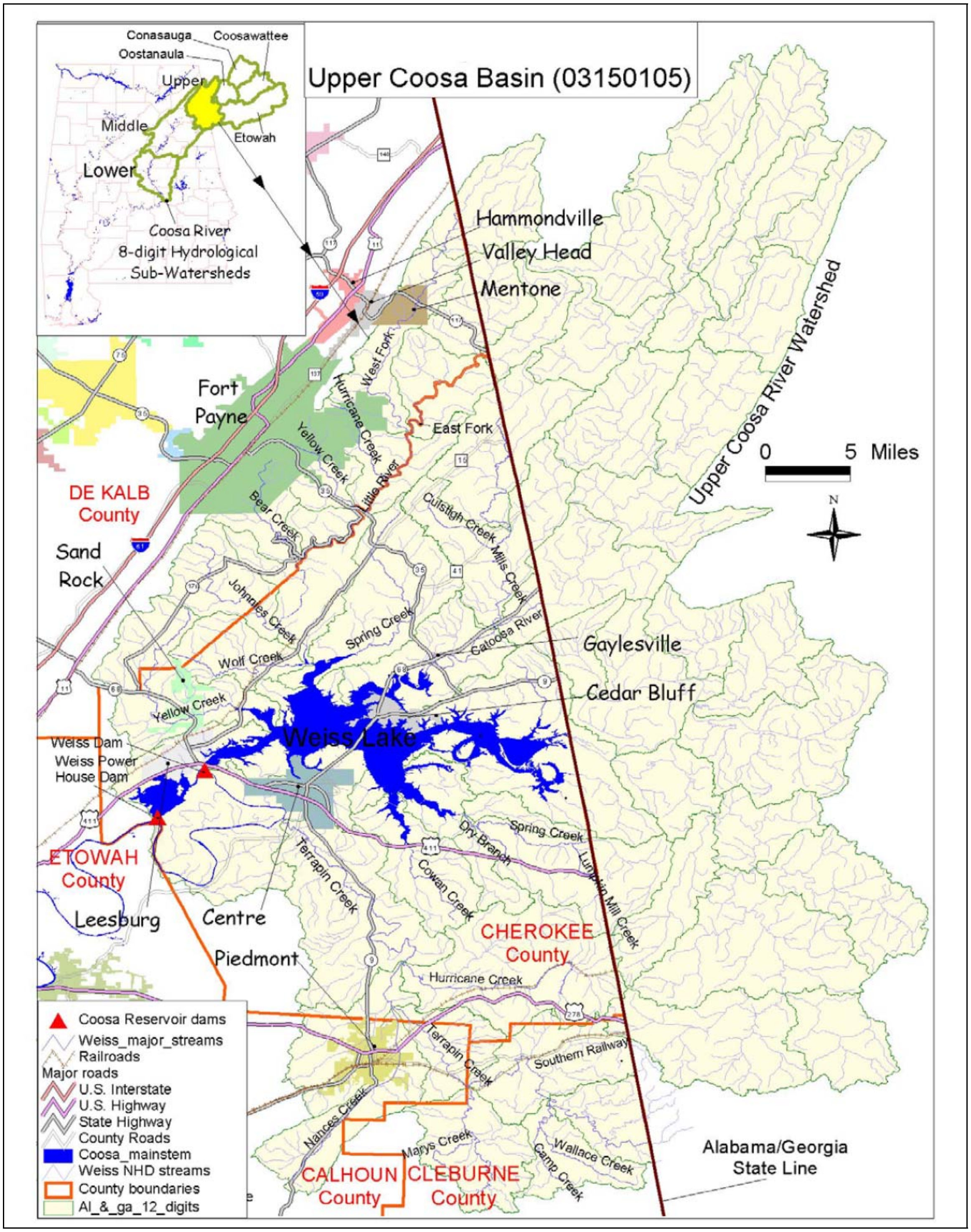

Figure 3.8. Weiss Lake Detail
(Alabama Clean Water Partnership 2004)

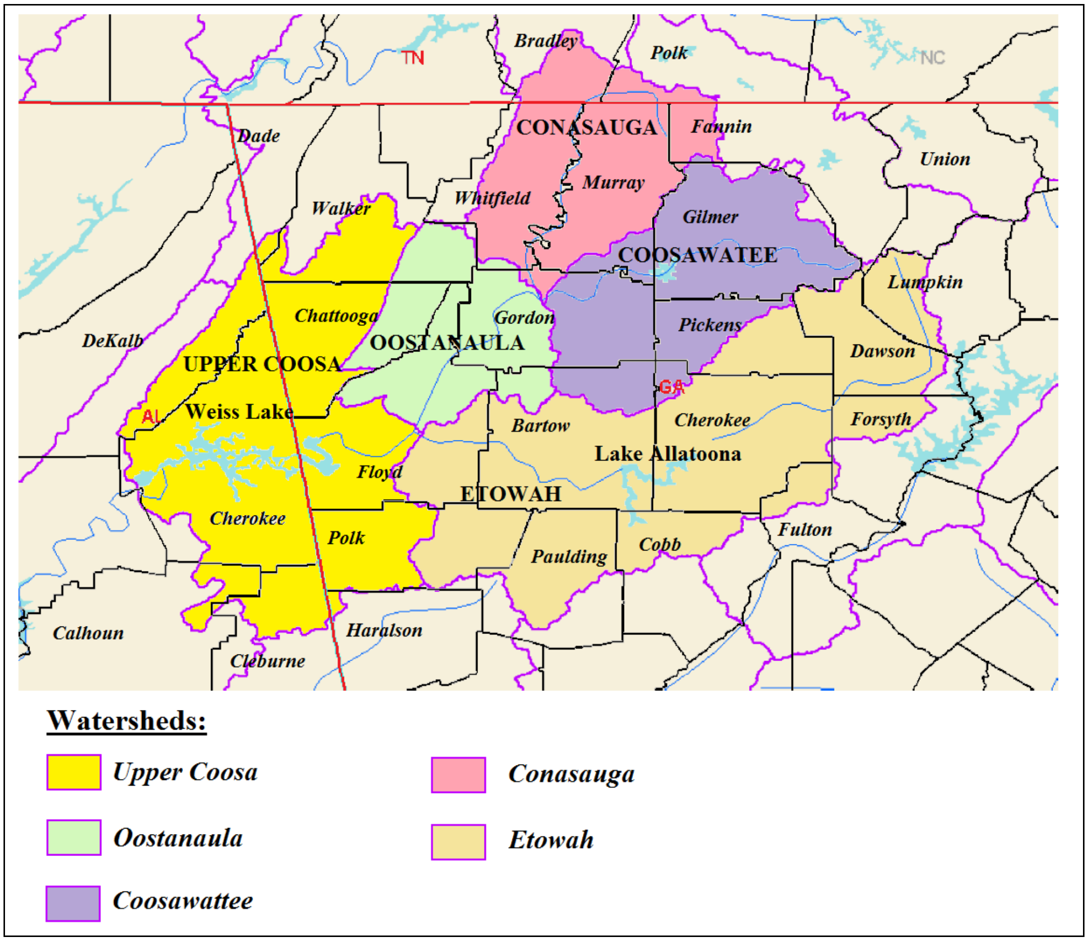

Figure 3.9. Weiss Lake Counties
(U.S. Environmental Protection Agency 2009a)

CHAPTER 4

DATA AND METHODOLOGY

4.1. OVERVIEW

The methodology follows similar steps to those outlined in EPA's "Water Quality Assessment Handbook" (U.S. Environmental Protection Agency 2004). Released in 2004, this handbook serves as a guideline to analyze the potential for trading in a watershed. In particular, the chapters on Pollutant Suitability and Financial Attractiveness provide a framework to define a tradable pollutant, characterize the fate and flow of this pollutant, and identify potentially viable trades (alpha trades). From this framework, the impacts of ecological and political boundaries on alpha trades are examined.

Discussed in more detail in the following sections, this analysis makes a few key assumptions for trading. These assumptions present baseline cases to examine trading for Lake Allatoona and Weiss Lake. A sensitivity analysis addresses the impacts of changes to these assumptions as well as other trading parameters and credit estimates.

- The tradable pollutant is total phosphorus (P)[1].
- Point sources (PSs) must comply with loadings limits as defined by TMDLs.
- Non-point sources (NPSs) do not face loading limits.
- A tradable credit is defined as the annual reduction in 1 pound (lb) of total P delivered to the relevant lake (Lake Allatoona or Weiss Lake).

[1]Although the Lake Allatoona 2009 draft TMDL also requires reductions in total N, only total P is considered at this time, as information regarding the flow and fate of N is limited.

- NPS:PS trading ratio for all participants equals 2:1.
- Delivery ratios discount NPS credit calculations based on modeled flow and fate of total P to the relevant lake (no discounts for PSs).
- No retirement of credits.
- All costs are in 2008 U.S. dollars.

4.2. Markets and Loading Profiles

4.2.1. Markets

The ecological boundaries for trading are defined by the TMDLs for Lake Allatoona, Lin et al. (2009) and Radcliffe et al.'s (2009) studies of Lake Allatoona, and the 2008 TMDL for Weiss Lake. The Alabama-Georgia and Georgia-Tennessee state lines serve as the relevant political boundaries. Using these boundaries seven trading markets are defined and referred to as the Allatoona-All, Allatoona-Creek, Allatoona-Etowah, Allatoona-Little, Weiss-Alabama, Weiss-Georgia, and Weiss-Tennessee markets.

Radcliffe et al. (2009) and Lin et al. (2009) delineate the Lake Allatoona watershed as that which contains the major inflows into Lake Allatoona. Within the Lake Allatoona watershed these studies further define six sub-watersheds: Acworth/Allatoona, Little/Noonday, Owl/Kellogg, Shoal Creek, Stamp/Rowland, and Upper Etowah. As a broad ecological boundary, the Lake Allatoona watershed defines the Allatoona-All market (See Figure 3.2 from Chapter 3). Individually, the sub-watersheds Acworth/Allatoona, Upper Etowah, and Little/Noonday sub-watersheds outline the Allatoona-Creek, Allatoona-Etowah, and Allatoona-Little markets respectively. These three markets are chosen since they represent the selected arms of Lake Allatoona in the 2009 draft TMDL. Since Lake Allatoona and its greater watershed are in the state of Georgia, there is no relevant political boundary for this trading framework.

Watersheds that drain to Weiss Lake are grouped into three separate markets by their respective states. The Weiss-Alabama market includes the Alabama portion of the Upper Coosa watershed that drains to Weiss Lake. The Georgia portions of the watersheds that drain to Weiss Lake compose the Weiss-Georgia market. These watersheds are: a.) The Coosawattee and Oostanaula, b.) The southwestern portion of the Etowah watershed that is distinct from the Lake Allatoona watershed, c.) The portion of the Conasauga watershed located within the state of Georgia, and d.) The portion of the Upper Coosa watershed located within the state of Georgia. The Weiss-Tennessee market includes the Tennessee portion of the Conasauga watershed. A broad ecological boundary, as defined by the combination of these watersheds, delineates the entire Weiss framework.

4.2.2. Total P and Loadings Profile

Next, loadings profiles define the location and quantity of total P that the primary PSs and NPSs discharge in each market. PSs are identified individually. NPSs are summarized by watershed by land cover or land use. These profiles serve as lists of primary market participants.

Lake Allatoona Market(s):

Individual PSs and corresponding discharge data are identified from the 2009 draft TMDL (See Table 4.1)[2]. Lin et al.'s (2009) list of major PSs within all six sub-watersheds corresponds to that of the draft TMDL. There are no additional major PSs for Owl/Kellogg, Shoal Creek, or Stamp/Rowland. Although listed in the TMDL, individual MS4s are not

[2] For purposes of trading, municipal and industrial PS's with permitted flows greater than 0.1 MGD are included.

included as individual participants since the 2009 draft TMDL notes that, "the portion of each watershed that goes directly to a permitted storm sewer and that which goes through non-permitted point sources, or is sheet flow or agricultural runoff, has not been clearly defined"(The Georgia Department of Natural Resources 2009). Since future phases of TMDLs, "will attempt to further define the sources of pollutants and the portion that enters the permitted storm sewer system"(The Georgia Department of Natural Resources 2009), future analyses may incorporate these MS4 loadings as PSs rather than grouping them with NPS loadings as below. In addition, the 2009 draft TMDL discusses Concentrated Animal Feeding Operations (CAFOs) as PSs. However, the TMDL does not outline specific P loads for these individual CAFOs, and thus aggregate loads from these CAFOs are captured by the more broadly defined NPS categories below.

To classify NPS loadings, this analysis uses results from Lin et al. (2009) since they provide modeled results on the loads by land cover type. These categories are: Row Crop, Less Developed Urban, Highly Developed Urban, Pasture Receiving Litter, Pasture Not Receiving Litter, and Forest. Also included in Lin et al.'s (2009) analysis are P loads from Cows in Stream. See Table 4.2 for a loadings profile of NPSs. In addition, Lin et al. (2009) provide delivery ratios by sub-watershed; these ratios represent the estimated percent of total P loads delivered to Lake Allatoona from each sub-watershed (See Table 4.3).

Corresponding land cover area for Row Crop, Urban, Pasture, and Forest come from the 2001 National Land Cover Dataset (NLCD). Less Developed Urban represents less than 20 percent imperviousness and Highly Developed Urban includes urban areas with greater than or equal to 20 percent imperviousness. Lin et al. (2009) estimate area for Pasture Receiving Litter by overlaying aerial photos of poultry houses in the Lake Allatoona watershed with pasture acreage from the NLCD data and assuming a 0.75 kilometer radius for each poultry house. The area for Pasture Receiving Litter is assumed as area for cattle grazing; Lin et al. (2009) estimate cows in the Lake Allatoona watershed with, "a grazing density of one cow per 0.8 ha of litter-amended pasture" (Lin et al. 2009). See Table 4.4 for Lake Allatoona land cover area.

Weiss Markets:

A combination of sources is used to create a PS loadings profile for the Weiss-Alabama, Weiss-Georgia, and Weiss-Tennessee markets. As a starting point, the 2008 TMDL for Weiss Lake lists 14 major dischargers in the watersheds that flow directly to the Coosa River and Weiss Lake. Discussions with GA EPD regarding their Coosa River Modeling Project yield additional relevant PSs. All loadings are updated to reflect available 2008 National Pollutant Discharge Elimination System (NPDES) data from EPA's Enforcement & Compliance History Online (ECHO). See Table 4.5 for a PS loadings profile. The Tennessee-Weiss market contains no PSs. As with the Lake Allatoona market, MS4 loadings are not considered as individual PSs for this analysis due to the uncertainty of their individual loadings.

Unfortunately, a current limitation to this analysis is that P loads by land cover type by watershed are not available for Weiss Lake. Through discussions with GA EPD and Tetra Tech, a consulting firm, a Weiss Lake watershed model that should provide insights similar to that of Lin et al. (2009) is expected by July 2009. Land cover data for each Weiss market is gathered from 2001 NLCD data to gain a better picture of what land use may look like in the Weiss markets (See Table 4.6)[3].

[3] Data is not available for Pasture Receiving Litter; however, the quantity of litter applied in the Weiss markets is estimated in the section "Poultry Litter Transfer Quantity and Cost Estimates".

4.3. ABATEMENT QUANTITY AND COST CALCULATIONS

4.3.1. Point Sources

Abatement to Meet Loading Limits:

For individual Lake Allatoona PSs, required abatement in annual lbs of total P is:

(1) $a^{pA}_i = (d_i * 365) – WLA_i$,,

where a^{pA}_i is the reduction in annual lbs of total P from PS i to meet annual Waste Load Allocation WLA_i; d_i is PS i's current average daily total P discharge in lbs. See Table 4.7 for calculations.

For Weiss Lake, the 2008 TMDL specifies limits of a total P concentration of 1.0 milligrams/liter (mg/l) for major PSs in Alabama and a max of 8.34 lbs of P per day for minor PSs. Since all Alabama PSs are currently minor, required total P reductions are:

(2) $a^{pW}_i = (d_i – 8.34) * 365$,

where a^{pW}_i is the reduction in annual lbs of total P from PS i to meet TMDL compliance; d_i is PS i's average daily total P discharge in lbs. Since the Weiss Lake TMDL only specifies aggregate reductions for Georgia PS loads, potential reductions are estimated based on the Alabama criteria[4]. For major PSs in Georgia, required total P reductions are:

(3) $a^{pG}_{ij} = \{d_i –[(m_j * k) * f_i * g]\} * 365$,

where a^{pG}_{ij} is the reduction in annual lbs of total P from PS i to meet total P concentration limit j mg/l; d_i is PS i's average daily P discharge in lbs; m_j is total P concentration limit j in mg/l; k is 2.20462262 lbs per kg; f_i is PS i's average flow in MGD; g is 3.7854118 liters per gallon. For minor PSs in Georgia, required total P reductions are calculated the same as (2) and referred to as a^{pG}_i. See Table 4.8 for calculations.

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[4] Applying this criterion reduces total Georgia PS discharge by approximately 75%. The results of the Coosa River Modeling Project will provide insight into what percentage of this discharge reaches the Alabama-Georgia border. The study will provide insight into the adequacy of applying Alabama loading limits to Georgia PS's.

Abatement Costs:

Jiang et al.'s (2005) estimation of costs of adapting existing wastewater treatment facilities for P removal is used to approximate the abatement costs of wastewater treatment plants in the Lake Allatoona and Weiss markets. Their simulation upgrades a base-case treatment plant for a range of total P concentration limits: 0.05, 0.13, 0.5, 1.0, and 2.0 mg/l. This base-case plant utilizes an Activated Sludge process with a total P influent of 6.34 mg/l. In addition, they present three alternative upgrade options for each limit. For each concentration limit and design combination, Jiang et al. estimate total P abatement and total annual economic costs[5] for facilities of five different capacities: 1, 10, 20, 50 and 100 MGD. Their goal is to provide estimates for P removal costs as part of greater study into the feasibility for offset banking schemes within Georgia's watersheds (Jiang et al. 2005). Although the wastewater treatment plants in the Lake Allatoona and Weiss Lake frameworks do not exactly match the baseline case used by Jiang et al., the estimates provide a good starting point to estimate Georgia and Alabama wastewater abatement costs.

Each Allatoona wastewater treatment plant is assumed to choose the upgrade that minimizes costs of compliance:

(4) Minimize $z^{pA}{}_{i} = C_{ij}(s_i, ch_i)$, subject to:

(5) $b^{p}{}_{ij} \geq a^{pA}{}_{i}$,

where $z^{pA}{}_{i}$ is the cost of compliance for Lake Allatoona wastewater treatment plant i; $C_{ij}(s_i, ch_i)$ is the total annual economic cost function to upgrade facility i in order to meet a total P concentration of j; these costs vary depending on PS i's capacity s_i (MGD)[6] and treatment choice

[5] Total annual economic costs equal the sum of annualized capital cost and annualized operations & maintenance costs but exclude land costs.

[6]When a facility's capacity does not exactly match one of the 5 simulated by Jiang et al., a weighted average of costs and abatement quantity is calculated using the lower and higher bounds in which the facility's capacity falls. For

ch_i. Upgrading facility i to concentration j results in b^{p}_{ij} lbs of total P abatement; the upgrade choice is constrained by the requirement that b^{p}_{ij} must be greater than or equal to the required abatement a^{pA}_{i}. These costs are included with the credit calculation results in Chapter 5.

Similarly, the costs of abatement for Weiss treatment plants are estimated. Each minor Weiss-Alabama wastewater treatment plant i facing required abatement a^{pW}_{i} is assumed to choose the upgrade that minimizes abatement costs z^{pW}_{i} as above. Similarly, the cost of compliance for each minor Weiss-Georgia wastewater treatment plant i is z^{pG}_{i}. Each major Weiss-Georgia wastewater treatment plant i chooses the upgrade that minimizes abatement costs z^{pG}_{ij} to comply with concentration limit j (1.0 mg/l). These costs are included with the credit calculation results in Chapter 5. Wastewater treatment facilities comprise 30 of the 36 PSs within the Lake Allatoona and Weiss markets[7]. For the additional 6 PSs, abatement cost estimates are not available at this time. The impact of excluding these 6 additional PSs is low considering that they account for only approximately 2 percent of the total P loads in the Lake Allatoona market and 6 percent of the total P loads in the Weiss markets.

Credits for Trading:

For purposes of trading, the total yearly quantity of credits demanded and supplied by each Lake Allatoona PS are:

(6) $Q^{pAd}_{i} = a^{pA}_{i}$

(7) $Q^{pAs}_{i} = (b^{p}_{ij} - a^{pA}_{i})$,

where Q^{pAd}_{i} is the total number of credits per year demanded by PS i; Q^{pAs}_{i} is the total number of credits supplied by PS i. It is assumed that PSs only supply credits if they choose to upgrade

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facilities with operating capacity less than 1 MGD, abatement costs and quantity are assigned values from the 1 MGD simulation. Where capacity information is missing, average daily flow is assumed for capacity.

[7] Wastewater treatment facilities were those with EPA designation of "Sewerage Systems".

their facility and have additional units of abatement[8]. Delivery ratios are not used to calculate the credits demanded or supplied by PSs since their regulation is currently defined by discharge quantities and concentrations, not by the quantity of P that is delivered to the lake. Where available, the corresponding prices per credit demanded and supplied by Lake Allatoona PSs are:

(8) $p^{pAd}{}_i = z^{pA}{}_i / a^{pA}{}_i$

(9) $p^{pAs}{}_i \geq 0$,

where $p^{pAd}{}_i$ is maximum cost PS i is willing to pay for a credit of total P abatement; $p^{pAs}{}_i$ is greater than or equal to zero since $Q^{pAs}{}_i$ are the additional units of total P abatement that result from the choice to upgrade; in a completely competitive market $p^{pAs}{}_i$ will equal the market price for credits. Similarly, the credits demanded and supplied by Weiss PSs are: $Q^{pWd}{}_i$ (Weiss-Alabama demanded), $Q^{pWs}{}_i$ (Weiss-Alabama supplied), $Q^{pGd}{}_{ij}$ (Weiss-Georgia demanded), $Q^{pGs}{}_{ij}$ (Weiss-Georgia supplied). Corresponding prices are: $p^{pWd}{}_i$ (Weiss-Alabama demanded), $p^{pWs}{}_i$ (Weiss-Alabama supplied), $p^{pGd}{}_{ij}$ (Weiss-Georgia demanded), $p^{pGd}{}_{ij}$ (Weiss-Georgia supplied). All credit results are included in Chapter 5.

4.3.2. Non-Point Source Abatement – Quantity and Cost Estimates

Overview:

Potential P abatement quantities for NPSs are calculated for a range of best management practices (BMP's). These calculations use current loadings, land cover data, and estimates for total P removal efficiencies. The percentage of each county's area that falls within each applicable watershed or sub-watershed is taken from the same NLCD 2001 data using EPA Basins 4.0. For county data, see Tables 4.9 and 4.10 for Lake Allatoona and Weiss Lake

[8] This assumption rules out the possibility where a PS currently operating under its TMDL sells credits of abatement to other PS's seeking compliance, resulting in little to no total watershed reduction in total P.

respectively. Available cost and P removal efficiencies for BMP's are identified with data provided by the Georgia office of the Natural Resources Conservation Service (GA NRCS) (Georgia Natural Resources Conservation Service 2007) and information from CH2M HILL's analysis of a potential trading framework for North Carolina's Jordan Lake watershed (CH2MHILL 2008). In the same fashion as the CH2M Hill analysis, cost and P removal efficiencies for urban BMP's as specified by EPA (U.S. Environmental Protection Agency 1999) are employed. No abatement quantities are calculated for the Forest land cover type. Land costs are estimated using www.georgiastats.uga.edu (The University of Georgia 2009). Details regarding these land costs are outlined below.

Abatement Quantity:

For each Lake Allatoona agricultural NPS type i (i = Row Crop, Pasture Receiving Litter, Pasture Not Receiving Litter, Cows in Stream) using applicable BMP j (j = 50 Foot Riparian Buffer, Cattle Exclusion, Cattle Exclusion with 50 Foot Riparian Buffer, Cover Crop, Grassed Waterway, Land Conversion: Cropland to Forest, Cropland to Pasture, Pastureland to Forest) in sub-watershed t (t = Acworth/Allatoona, Little/Noonday, Owl/Kellogg, Shoal Creek, Stamp/Rowland, and Upper Etowah), the potential abatement per acre per year is:

(10) $a^{na}_{ijt} = r^{a}_{j} * (x^{a}_{it} / ar^{a}_{it})$,

where a^{na}_{ijt} is the annual reduction in lbs of total P per acre by agricultural NPS type i with BMP j in sub-watershed t; r^{a}_{j} is the reduction efficiency in lbs of total P removed per acre by agricultural BMP j; x^{a}_{it} is the annual average lbs of total P discharged by agricultural NPS type i in sub-watershed t; ar^{a}_{it} is the area (acres) of agricultural NPS type i in sub-watershed t. Total potential abatement for each agricultural NPS is:

(11) $A^{na}_{ijt} = a^{na}_{ijt} * ar^{a}_{it} = r^{a}_{j} * x^{a}_{it}$,

where A^{na}_{ijt} is the reduction in annual lbs of total P if BMP j is implemented on all acres of agricultural type i in sub-watershed t. It is unrealistic to assume BMP's can be implemented on 100 percent of the agricultural land cover; however, these quantities provide an upper bound on the number of agricultural credits available for supply by land cover type by sub-watershed. See Tables 4.11.A – 4.11.D for calculations.

Similarly, for each Lake Allatoona urban NPS type i (i = Less Developed Urban, Highly Developed Urban) using applicable BMP j (j = Bioretention, Dry Extension Basin, Filter Strip, Grassed Swale, Infiltration Devices, Restored Riparian Buffer, Sand Filter, Stormwater Wetlands, Wet Detention Basin) in sub-watershed t (t = Acworth/Allatoona, Little/Noonday, Owl/Kellogg, Shoal Creek, Stamp/Rowland, and Upper Etowah), the available abatement per acre is:

(12) $a^{nu}_{ijt} = r^{u}_{j} * (x^{u}_{it} / ar^{u}_{it})$,

where a^{nu}_{ijt} is the annual reduction in lbs of total P per acre by urban NPS type i with BMP j in sub-watershed t; r^{u}_{j} is the reduction efficiency in lbs of total P removed per acre by urban BMP j; x^{u}_{it} is the annual average lbs of total P discharged by urban NPS type i in sub-watershed t; ar^{u}_{it} is the area (acres) of urban NPS type i in sub-watershed t. Total abatement by urban NPS type is:

(13) $A^{nu}_{ijt} = a^{nu}_{ijt} * ar^{u}_{it} = r^{u}_{j} * x^{u}_{it}$,

where A^{nu}_{ijt} is the reduction in annual lbs of total P if urban BMP j is implemented on all acres of urban land cover type i in sub-watershed t. Again, it is unrealistic to assume BMP's can be implemented on 100 percent of the urban land cover; however, these quantities provide an upper bound on the number of urban credits available for supply by land cover type by sub-watershed. See Tables 4.12.A – 4.12.C for calculations.

Since Weiss NPS modeling data is not available, abatement by land cover type for the Weiss markets is not calculated. Instead, poultry litter transfer is used to estimate the potential NPS component of trading for the Weiss markets.

Abatement Costs:

Using a combination of cost estimates from GA NRCS , CH2M HILL (CH2MHILL 2008)**,** and EPA (U.S. Environmental Protection Agency 1999), corresponding abatement costs by NPS type by BMP by sub-watershed are calculated. Unit costs of abatement are the present value estimate of capital costs and operations and maintenance (O&M) per acre over the lifetime of the BMP. Following CH2M HILL, calculations assume an interest rate of 7.5 percent, inflation rate of 5 percent, and lifetimes of 10 years for agricultural BMP's and 20 years for urban BMP's. Urban BMP's assume an EPA specified rainfall adjustment factor of 0.67 for rainfall zone 3. The EPA states, "Since the amount of regional rainfall may impact costs, further adjustment to cost is necessary" (U.S. Environmental Protection Agency 1999). This rainfall factor accounts for these cost adjustments, and is "Based on a methodology presented by the American Public Works Association (APWA, 1992)" (U.S. Environmental Protection Agency 1999). CH2M increase their cost estimates for both agricultural and NPS BMP's by 35 percent to account for design and contingency costs. This adjustment is not included in the baseline cases. Land costs are included.

For agricultural and urban BMP's respectively, the net present value factors are:

$$(14)\ npv^{a} = \sum_{t=1}^{10} (1 + r - i)^{-t}$$

(15) $npv^{u} = \sum_{t=1}^{20} (1 + r - i)^{-t}$,

where r is the interest rate 0.075, i is the inflation rate .05, and t is time period 1 to 10 for the lifetime of the agricultural BMP and 1 to 20 for the lifetime of the urban BMP.

Land costs are estimated using land price data from www.georgiastats.uga.edu. The website provides a random sample by county of land transactions in the state of Georgia for 1997-2006. These transactions are further divided into classifications that include Agriculture, Commercial, Industrial, and Residential. Agricultural land costs are calculated using land transactions captured by the Agriculture classification; highly developed urban land costs are calculated using land transactions captured by the Commercial and Industrial categories; less developed urban land costs are calculated using land transactions captured by the Residential category. Using all records with plot sizes greater than or equal to an acre, land costs, associated with implementing a bmp j on one acre of land in sub-watershed t are then calculated by summing the weighted average of one acre of land in county i by the percent of the watershed area that includes county i. Agricultural land costs, $land^{a}_{jt}$, and urban land costs, $land^{u}_{jkt}$, are then calculated by multiplying the acre land cost estimate by bl_j, the percent of an acre of land consumed by the implementation of BMP j.

Following CH2M HILL, agricultural BMP j's average annual present value cost per acre including land in sub-watershed t is:

(16) $v^{a}_{jt} = (cc_j * bl_j) + (om_j * bl_j * npv^{a}) + land^{a}_{jt}$,

where v^{a}_{jt} is agricultural BMP j's average annual present value cost per acre including land in sub-watershed t; cc_j is the average capital cost per acre for BMP j; bl_j is the percent of an acre of land consumed by the implementation of BMP j; om_j is the average annual O&M cost per acre for BMP j; npv^a is as defined above; and $land_{jt}$ is the average agricultural land cost of implementing BMP j in sub-watershed t. See Appendix A Tables A.1 – A.3 for calculations.

For each Lake Allatoona agricultural NPS type by BMP by sub-watershed, the abatement cost per acre per year is:

(17) $z^{na}_{ijt} = v^a_{jt} / a^{na}_{ijt}$,

where z^{na}_{ijt} is the annual cost per lb of P abatement by agricultural NPS type i with BMP j in sub-watershed t; v^a_{jt} is as defined above; a^{na}_{ijt} is the annual reduction in lbs of total P per acre by agriculture NPS type i with BMP j in sub-watershed t. Total abatement cost for agricultural NPS i practicing BMP j on ar^a_{it} acres of agricultural land in sub-watershed t is:

(18) $Z^{na}_{ijt} = z^{na}_{ijt} * ar^a_{it}$.

See Tables 4.11.A – 4.11.D for calculations.

Following CH2M HILL and EPA (U.S. Environmental Protection Agency 1999), average annual present value cost per acre including land for urban BMP j implemented on highly or less developed urban land cover type k in sub-watershed t is:

(19) $v^u_{jkt} = (cc_j * WQV_k / 0.67) + (om_j * WQV_k / 0.67 * npv^u) + land^u_{jkt}$,

where cc_j is the average capital cost per cubic foot of water quality volume treated by BMP j; WQV_k is the water quality volume for land cover type k; 0.67 is the rainfall adjustment factor; om_j is the average annual O&M cost per cubic foot of water quality volume for BMP j; npv^u is as defined above; $land^u_{jkt}$ is the average urban land cost of implementing BMP on urban land cover type k in sub-watershed t. See Appendix A Tables A.4 – A.11 for calculations.

For each Lake Allatoona urban NPS type by BMP by sub-watershed, the abatement cost per acre per year is:

(20) $z^{nu}_{ijkt} = v^u_{jkt} / a^{nu}_{ijt}$,

where z^{nu}_{ijkt} is the annual cost per lb of total P abatement by urban NPS type i with BMP j on urban land cover k in sub-watershed t; v^{u}_{jkt} is as defined above; a^{nu}_{ijt}, is the annual reduction in lbs of total P per acre by urban NPS type i with BMP j in sub-watershed t. Total abatement cost for urban NPS i practicing BMP j on ar^{u}_{it} acres of urban land cover type k in sub-watershed t is:

(21) $Z^{nu}_{ijkt} = z^{nu}_{ijt} * ar^{u}_{it}$.

See Tables 4.11.A – 4.11.D for calculations.

Credits for Trading:

Aggregate credits for agricultural and urban NPSs by BMP by sub-watershed are[9]:

(22) $Q^{na}_{ijt} = A^{na}_{ijt} * (e^{a}_{it} * np^{a}_{ijt} * rt^{a}_{ijt})$

(23) $Q^{nu}_{ijt} = A^{nu}_{ijt} * (e^{u}_{it} * np^{u}_{ijt} * rt^{u}_{ijt})$,

where Q^{na}_{ijt} and Q^{nu}_{ijt} represent the number of available credits per year from an agricultural or urban NPS of type i using BMP j on ar^{a}_{it} or ar^{u}_{it} acres of land in sub-watershed t; A^{na}_{ijt} and A^{nu}_{ijt} are defined as above; e^{a}_{it} and e^{u}_{it} are the delivery ratios of agricultural and urban NPSs by type i in sub-watershed t as defined by Lin et al. (2009) (See Table 4.3); np^{a}_{ijt} and np^{u}_{ijt} represent the nps:ps trading ratios of agricultural and urban NPSs by type i by BMP j in sub-watershed t; rt^{a}_{ijt} and rt^{u}_{ijt} are the retirement ratios of agricultural and urban NPSs by type i by BMP j in sub-watershed t. The only adjustment that is made to the delivery ratios from Lin et al. (2009) is to set the delivery ratio for Owl/Kellogg equal to 1.0, or 100%. Lin et al. (2009) estimate this ratio for Owl/Kellogg equal to 1.288, or 128.8%. The change is made so that the 2:1 NPS:PS ratio will still hold for credits generated from NPS stakeholders in Owl/Kellogg. The trading ratios np^{a}_{ijt} and np^{u}_{ijt} are assumed to equal 0.5 across all NPS types, BMP's, and sub-watersheds. This

[9] The trading frameworks assume that NPSs do not face enforced loading limits from a regulatory agency; thus, any NPS abatement reflects a potential supply of credits for trading.

ratio creates a NPS:PS ratio of 2:1. If PS to PS trading occurs, the PS:PS ratios equals 1:1 for all point sources. The retirement ratios rt^{a}_{ijt} and rt^{u}_{ijt} are assumed to equal 1.0 across all NPS types, BMP's, and sub-watersheds (no retirement).

The unit prices for credits supplied by agricultural and urban NPSs by type by BMP by sub-watershed t are:

(24) $p^{na}_{ijt} = Z^{na}_{ijt} / Q^{na}_{ijt}$

(25) $p^{nu}_{ijt} = Z^{nu}_{ijt} / Q^{nu}_{ijt}$,

where p^{na}_{ijt} and p^{nu}_{ijt} are the minimum prices that agricultural and urban NPSs of type i, with BMP j, in sub-watershed t are willing to accept for abatement practices that earn one credit of P reduction. Z^{na}_{ijt}, Z^{nu}_{ijt}, Q^{na}_{ijt}, and Q^{na}_{ijt} are as defined above. See Chapter 5 for all credit calculation results.

4.3.3. Poultry Litter Transfer – Quantity and Cost Estimates

Poultry litter transfer as a BMP is treated separately from other agricultural BMP's due to the unique role litter transfer may play in the Lake Allatoona and Weiss markets. As seen in Table 4.2, P loads from Pasture Receiving Litter account for 56.29 percent of all NPS loads to Lake Allatoona; the extent of litter operations in the Weiss watersheds may suggest similar results for Weiss Lake. Following Lin et al. (2009), trading frameworks assume a loading baseline that all manure generated in the watershed is currently applied in the watershed[10]. The BMP for litter transfer is defined as the quantity of manure that is generated but not applied; this analysis assumes that litter must be transported out of the borders of all markets to classify as not applied.

[10] As stated in the 2009 draft TMDL, this assumption does not account for the significant amount of litter that is currently transported out of the watershed as fertilizer for other counties in Georgia.

Abatement Quantity:

The total P abatement resulting from the transfer of one ton of litter out of a Lake Allatoona sub-watershed is:

(26) $a^{l}_{t} = x^{l}_{t} / mn^{l}_{t}$,

where a^{l}_{t} is the reduction in lbs of total P per ton of manure transferred from sub-watershed t; x^{l}_{t} is the average annual lbs of P delivered by pasture receiving litter to sub-watershed t; mn^{l}_{t} is Lin et al.'s (2009) estimate of tons of manure applied in sub-watershed t. Since P load data is unavailable for Weiss-markets, these markets assume a reduction in lbs of total P per ton of manure transferred equal to the average of Lake Allatoona's sub-watersheds.

Vest et al.'s estimate of 1.2 tons of manure per 1,000 broilers determines the amount of manure generated in all markets (Vest, Merka, and W.I. Segars 1994)[11]. 2007 U.S. Agricultural census data provides the number of broilers for each applicable county (U.S. Department of Agriculture 2009). These numbers are then weighted by the percent of the county that falls within each applicable watershed to determine the quantity of manure available for transport:

(27) $mn^{A}_{it} = (br_{i} * vt) * cn_{it}$,

where mn^{A}_{it} is the tons of manure generated in the portion of county i that is in Lake Allatoona sub-watershed t; br_{i} is the number of broilers (in thousands) in county i; vt is equal to Vest et al.'s estimate of 1.2 tons of litter per 1,000 broilers; cn_{it} is the percent of county i's area that falls within watershed t. Similarly, for Weiss market watersheds, these estimates are mn^{W}_{it} (Weiss-Alabama), mn^{G}_{it} (Weiss-Georgia), mn^{T}_{it} (Weiss –Tennessee).

Thus, total possible P abatement for county i in sub-watershed t is:

(28) $A^{A}_{it} = a^{l}_{t} * mn^{A}_{it}$,

[11] Lin et al. provide an estimate for manure within the Lake Allatoona market based on aerial photographs of litter houses, but as stated in the 2009 draft TMDL, the quantity of manure generated may have been overestimated.

where A^{A}_{it} is the total available abatement in annual lbs of total P resulting from litter transfer out of the portion of county i that is Lake Allatoona sub-watershed t; a^{l}_{t} and mn^{A}_{it} are as defined above. Similar to total agricultural and urban abatement estimates, this calculation estimates an upper bound for the total P that can be exported from each county. Likewise, for Weiss markets, these estimates are A^{W}_{it} (Weiss-Alabama), A^{G}_{it} (Weiss-Georgia), A^{T}_{it} (Weiss-Tennessee). See Tables 4.13 and 4.14 for Lake Allatoona and Weiss Lake calculations respectively.

Abatement Costs:

In a 2008 report, Risse et al. (2008) provide a thorough review of the potential for poultry litter transfer in the state of Georgia and develop a model that calculates incentive prices for litter transfer throughout the state. In particular, the model minimizes the cost of meeting plant nutrient needs based on crop nutrient requirements, soil tests, and 2008 fertilizer prices. Their results present the prices that counties would be willing to buy or sell a ton of litter as fertilizer for crops[12] (Risse et al. 2008). These prices serve as abatement costs for this paper since they are the incentive prices for poultry litter transfer. Abatement costs for each ton of litter transported out of county i in Lake Allatoona sub-watershed t are referred to as z^{lA}_{it}. Likewise, for Weiss markets, these costs are z^{lW}_{it} (Weiss-Alabama), z^{lG}_{it} (Weiss-Georgia), z^{lT}_{it} (Weiss –Tennessee)[13]. If a county i in sub-watershed t chooses to export all manure mn^{A}_{it}, total costs are:

(29) $Z^{lA}_{it} = z^{lA}_{it} * mn^{A}_{it}$.

[12] Scenario I results from Risse et al. (2008) provide the incentive costs for counties without excess litter based on P needs of crops. Cost differentials between Scenario I and Scenario II divided by the difference in excess litter between the two scenarios provide the incentive costs for counties with excess litter based on P needs of crops.

[13] Since Risse et al. (2008) do not calculate costs for Tennessee or Alabama counties, transport costs are estimated by comparing surrounding Georgia counties, crops grown in each county, and total manure generated.

where Z^{lA}_{it} is the total cost of transferring mn^{A}_{it} tons of litter out of county i in sub-watershed t. For Weiss markets, these costs are Z^{lW}_{it} (Weiss-Alabama), Z^{lG}_{it} (Weiss-Georgia), Z^{lT}_{it} (Weiss – Tennessee). All litter transfer costs are included in Tables 4.13 and 4.14 discussed above.

Credits for Trading:

The available credits for litter transfer are:

(30) $Q^{lA}_{it} = A^{A}_{it} * (e^{l}_{it} * np^{l}_{it} * rt^{l}_{it})$,

where Q^{lA}_{it} represents the total credits available for litter transport out of county i in watershed t; A^{A}_{it} is as defined above. e^{l}_{it} is the delivery ratio for a poultry producer in county i in sub-watershed t as defined by Lin et al. (2009) (See Table 4.3). np^{l}_{it} represents the nps:ps trading ratio for litter producers in county i and sub-watershed t; this ratio equals 0.5, which represents the 2:1 nps:ps ratio. rt^{l}_{it} is the retirement ratio of litter producers in county i and sub-watershed t; as with the agricultural and urban stakeholders, this value equals 1.0 under the baseline scenarios. For Weiss markets, the credits are defined as Q^{lW}_{it} (Weiss-Alabama), Q^{lG}_{it} (Weiss-Georgia), Q^{lT}_{it} (Weiss –Tennessee).

The price for an individual credit supplied by litter transfer from county i in Lake Allatoona sub-watershed t is:

(31) $p^{lA}_{it} = Z^{lA}_{it} / Q^{lA}_{it}$,

where p^{l}_{it} is the minimum price that a litter transporting producer in county i and watershed t is willing to accept for one credit of abatement. Z^{l}_{it} and Q^{l}_{it} are as defined above. For Weiss markets, these prices are p^{lW}_{it} (Weiss-Alabama), p^{lG}_{it} (Weiss-Georgia), p^{lT}_{it} (Weiss –Tennessee). See Chapter 5 for all credit calculation results.

4.4. ALPHA TRADES AND BASELINE SCENARIOS

4.4.1. Alpha Trades

The EPA handbook on trading defines and discusses the importance of alpha trades in the chapter on Financial Attractiveness. The handbook states that alpha trades are:

> …those trades with sufficient economic return to be viable even after water quality ratios are applied. Analyzing these trades should provide a good indication of trading viability in your watershed; if the watershed can support several Alpha Trades, trading is likely to be financially viable. Although this chapter discusses detailed calculations, a typical analysis will produce 'ballpark' estimates.
>
> (U.S. Environmental Protection Agency 2004)

The demand of credits from PSs under TMDL limits are compared with the potential supply of credits from NPSs to produce these 'ballpark' estimates of alpha trades. Total quantity demanded by individual PSs and their corresponding prices for the maximum willingness to pay for credits are calculated as described previously. For purposes of trading, it is assumed that agricultural and urban NPSs of type i in sub-watershed t can implement only one type of BMP j on land cover ar^{a}_{it} and ar^{u}_{it}. Thus, for exploring alpha trades, it is assumed that that NPS land cover types supply Q^{na}_{ijt} and Q^{nu}_{ijt} that correspond with the minimum of prices p^{na}_{ijt} and p^{nu}_{ijt} by sub-watershed t. Results summarize the potential level of credits supplied by agricultural, urban, and poultry litter transport as well as corresponding price levels.

4.4.2. Lake Allatoona Baseline Scenarios

Two baseline trading scenarios for Lake Allatoona are examined to explore the effects of ecological boundaries on the potential for trading. Scenario Allatoona-1 examines the number of alpha trades when the ecological boundary is defined by the entire watershed that drains to Lake Allatoona. In this scenario Allatoona-All is treated as one market; buyers and sellers can exchange credits with anyone in the six sub-watersheds; this scenario allows for the spatial expansion of markets across sub-watersheds. Scenario Allatoona-2 tightens ecological boundaries for trading to the sub-watershed level; Allatoona-Creek, Allatoona-Etowah, and Allatoona-Little are treated as separate markets. Buyers and sellers can only exchange credits with other stakeholders in their sub-watershed. In addition, the 2009 draft TMDL states, "If there is a new facility or an currently listed a facility *[sic]* that expands its capacity in the future and its permitted flow increases, the WLA for the facility would decrease in proportion to the flow, unless a LA can be reduced via pollutant trading". A WLA is defined as the Waste Load Allocation, or permitted discharge load, for a PS; an LA is defined as the Load Allocation, or permitted amount of discharge that NPSs can contribute. Since the 2009 draft TMDL recognizes the possibility of future PS-to-NPS trades, the impacts of ecological boundaries on the potential of future alpha trades are examined for these two scenarios.

4.4.3. Weiss Lake Baseline Scenarios

To examine the effects of political boundaries on trading, two trading scenarios for Weiss Lake are explored. Scenario Weiss-1 allows trades across state lines; Weiss-Alabama, Weiss-Georgia, and Weiss-Tennessee markets are combined into one market. Buyers and sellers can exchange credits with anyone in these three markets. Scenario Weiss-2 introduces political boundaries such that Weiss-Alabama, Weiss-Georgia, and Weiss-Tennessee markets are treated as independent markets. Buyers and sellers are restricted to trade with only those participants in their state markets. Since modeling data is currently limited, poultry litter transfer is used to estimate the NPS component of trading for Weiss markets. This BMP serves as a good measure for the quantity and price of NPS abatement options due to the volume of broilers in the Weiss markets and the fact that litter transfer has been a low hanging fruit for NPS abatement options in other trading schemes (Pennsylvania Department of Environmental Protection 2009).

4.5. Sensitivity Analysis

A few key assumptions from the baseline scenarios regarding trading parameters, abatement practices, and the fate and flow of total P are adjusted in the sensitivity analysis. Changes to these assumptions are reflected in adjustments to either PSs or NPSs; the impacts of these modifications appear in each category's credit calculations. Adjustments to PS credits are compared against baseline NPS calculations to examine the impact on alpha trades for the markets described by Allatoona-1, Allatoona-2, Weiss-1, and Weiss-2. The same thing is done for adjustments to NPSs (new credit calculations are compared against baseline PS calculations). A worst case scenario is examined by comparing the most limiting PS and NPS scenarios; similarly, a best case scenario is explored. Results provide insight into how certain modifications to baseline assumptions and estimates impact the potential for trading. All sensitivity analysis results are included in Appendices C and D.

4.5.1. Point Source Scenarios

For PSs, the sensitivity analysis addresses uncertainty related to abatement costs and quantity. Table 4.15 outlines Scenarios A-D; each scenario is run for both Lake Allatoona and Weiss Lake. As mentioned previously, Jiang et al.'s cost estimates are simulated for a baseline wastewater treatment facility. However, in all likelihood, PSs that choose to upgrade in the Allatoona and Weiss markets will likely experience deviations from these estimates. Thus, PS Scenarios A and B recalculate PS credits when Jiang et al.'s cost estimates are inflated and deflated by 35 percent respectively. This number is chosen since similar credit analyses (CH2MHILL 2008) build-in a 35 percent cost contingency.

PS Scenarios C and D examine the effects of tightening TMDL requirements to 75 and 50 percent of current loading limits. Although the 2009 draft TMDL specifies exact loading limits for each Lake Allatoona PS, these scenarios provide insight into the importance of this key policy parameter for trading and examine what trading would look like under stricter TMDL limits for PSs. For Weiss Lake, the loading limits for individual Georgia PSs are not specified. PS Scenarios C and D allow one to see how changes to these limits impact a Weiss Lake trading framework.

4.5.2. Non-Point Source Scenarios

For NPSs, the sensitivity analysis addresses uncertainty related to trading ratios, BMP cost estimates, and the flow and fate of total P by land cover type and use. Table 4.16 outlines NPS Scenarios A-M and signifies whether or not the parameter under review is pertinent to Lake Allatoona, Weiss Lake, or both. First, NPS Scenario A.1 addresses the key parameter of the NPS:PS trading ratio; this scenario examines the effects of changing the baseline trading ratio of 2:1 to 4:1 for all NPS abatement practices. This change reflects a policy belief that NPS abatement practices have greater uncertainty than reflected in the baseline scenario. Scenario A.2 examines trading when the trading ratio moves in the opposite direction from 2:1 to 1:1. This change reflects a policy belief that NPS abatement practices are just as certain as PS abatements. NPS Scenario B introduces another important trading parameter of retirement ratios. In similar trading frameworks, as discussed previously, a certain percentage of credits are “retired” to ensure water goals are reached. NPS Scenario B applies a 10 percent retirement ratio, meaning that each NPS credit accounts for an additional 10 percent reduction past the baseline reduction. Next, as with the PS sensitivity analysis, BMP cost estimates are inflated and deflated by 35 percent respectively. Again, this number is chosen since similar credit analyses (CH2MHILL 2008) build in a 35 percent cost contingency. Scenarios C and D examine these changes for both Lake Allatoona and Weiss Lake. Scenario E calculates NPS credits using a combination of increased BMP costs and the application of a 10 percent retirement ratio.

NPS Scenarios F-H address additional assumptions unique to trading for Lake Allatoona. Scenario F calculates agricultural and urban credits without land costs to see what trading looks like when only engineering costs are considered. Next, Scenario G addresses some uncertainty related to the total P loading by land cover. This scenario examines trading when 25 percent of the P loads associated with Pasture Receiving Litter are assigned to Highly Developed and Less Developed Urban loads; this allocation is weighted by the percent of total urban loads that Highly and Less Developed contributed previously. Scenario H calculates credits combining the parameter changes in Scenarios E and G.

NPS Scenarios I-M address uncertainty related to total P loads and delivery ratios for the Weiss markets due to the lack of P modeling data at this time. In the baseline scenarios for the Weiss markets, the amount of P per ton of manure is equal to the average across all Lake Allatoona loads. Scenarios I and J recalculate the credits from Litter Transfer using the minimum and maximum of Lake Allatoona estimates of P per ton of litter respectively. Similarly, the delivery ratio for all Weiss markets was set equal to the average delivery ratio of the Lake Allatoona markets. Scenarios K and L use the minimum and maximum delivery ratios respectively from Lake Allatoona. Scenario M examines trading when the minimum P per ton of

Litter and delivery ratio are both used; this scenario provides an estimate of the minimum quantity of credits available for the Weiss markets.

Table 4.1. Loadings Profile – Lake Allatoona Individual Point Sources by Sub-Watershed

Point Source[1]	**NPDES Permit No.**[1]	**Sub-watershed**	**Average Flow (MGD)**[1]	**Average Total P (mg/l)**[1]	**Average Total P (lbs/yr)**[2]
Cobb County Northwest WPCP	GA0046761	Acworth/Allatoona	6.19	0.11	2,074
				Total by sub-watershed	**2,074**
Cherokee County Fitzgerald Creek	GA0038555	Little/Noonday	1.03	1.54	4,832
Cherokee County Rose Creek	GA0046451	Little/Noonday	3.50	0.17	1,812
Cobb County Noonday Creek WPCP	GA0024988	Little/Noonday	9.78	0.21	6,256
Fulton County Little River WPCP	GA0033251	Little/Noonday	0.74	0.23	518
Woodstock Rubes Creek WPCP	GA0026263	Little/Noonday	0.72	1.34	2,939
				Total by sub-watershed	**16,357**
Big Canoe WPCP	GA0030252	Upper Etowah	0.02	0.51	33
City of Canton WPCP	GA0025674	Upper Etowah	1.77	2.79	15,042
Goldkist Poultry Byproducts	GA0000728	Upper Etowah	0.16	1.79	872
Jasper WPCP	GA0032204	Upper Etowah	0.48	-	-
				Total by sub-watershed	**15,947**
				Total for Lake Allatoona	**34,379**

[1] 2009 Draft TMDL from GA EPD (includes point sources identified in Little River Embayment TMDL); excludes Land Application Systems. For point sources greater than or equal to 0.1 MGD and for years 2000-2007.

[2] Calculated from average flow and average total P (mg/L).

Table 4.2. Loadings Profile - Lake Allatoona Non-point Sources by Land Cover
(Annual average lbs of P delivered to tributaries of each sub-watershed from 2001-2004)[1]

Sub-watershed	**Row Crop**	**Less Developed Urban**	**Highly Developed Urban**	**Pasture Receiving Litter**	**Pasture Not Receiving Litter**	**Forest**	**Cows In Stream**	**Total NPS**
Acworth/Allatoona	-	1,836	3,080	282	256	172	31	5,657
Little/Noonday	1,041	19,758	44,253	7,650	1,501	2,701	811	77,715
Owl/Kellogg	-	236	403	99	20	35	13	807
Shoal Creek	-	1,345	1,556	8,091	459	7,968	289	19,707
Stamp/Rowland	-	346	536	-	187	1,010	-	2,079
Upper Etowah	1,519	11,438	21,162	235,591	12,736	51,921	6,808	341,174
Subtotal (load to tributaries)	2,560	34,957	70,996	251,713	15,161	63,806	7,952	447,144
Delivered to lake	2,313	31,566	64,110	227,303	13,691	57,618	7,180	403,781
Percentage of NPS Load	0.57%	7.82%	15.88%	56.29%	3.39%	14.27%	1.78%	100%

[1] Loads converted to lbs/yr from kg/yr as given by Lin et al. (2009).

Table 4.3. Lake Allatoona Delivery Ratios by Sub-watershed[1]

Sub-watershed	**Delivery Ratio (%)**
Upper Etowah	93.4
Shoal Creek	99.6
Little/Noonday	76.6
Owl/Kellogg[2]	128.8
Acworth/Allatoona	89.9
Stamp/Rowland	49.1

[1] Per Lin et al. (2009).

[2] Delivery ratio set equal to 100% so that NPS:PS ratio of 2:1 still holds.

Table 4.4. Lake Allatoona 2001 NLCD Land Cover (Acres) by Type by Sub-watershed[1]

Sub-watershed	**Row Crop**	**Less Developed Urban**	**Highly Developed Urban**	**Pasture Receiving Litter[2]**	**Pasture Not Receiving Litter**	**Forest**	**Total**
Acworth/Allatoona	10	12,311	6,797	96	2,844	17,433	39,492
Little/Noonday	12	37,719	20,826	2,461	14,846	61,509	137,373
Owl/Kellogg	-	1,608	888	42	336	3,012	5,886
Shoal Creek	79	1,985	1,096	880	2,802	36,171	43,014
Stamp/Rowland	40	1,711	945	-	1,685	24,842	29,223
Upper Etowah	509	23,680	13,075	20,683	29,870	308,232	396,048
Total	650	79,014	43,627	24,162	52,384	451,200	651,036

[1] Per Lin et al. (2009).

[2] Same area assumed for cattle grazing.

Table 4.5. Loadings Profile – Weiss Lake Individual Point Sources by Designated Weiss Market

Weiss Market	**Point Source**[1]	**NPDES Permit No.**[1]	**Watershed**	**Average Flow (MGD)**[1]	**Average Total P (mg/l)**[1]	**Average Total P (lbs/yr)**[2]
Weiss-Alabama						
	Cherokee WPCP[3]	AL0057592	Upper Coosa, AL	0.06	5.70	1,042
	Piedmont WWTP	AL0024376	Upper Coosa, AL	0.59	1.35	2,421
	Town of Cedar Bluff WWTP	AL0024678	Upper Coosa, AL	0.16	0.86	425
	Town of Centre WWSB Lagoon	AL0062723	Upper Coosa, AL	0.52	4.03	6,349
				Total by Weiss Market		**10,237**
Weiss-Georgia						
	Chatsworth WPCP	GA0032492	Conasauga, GA	1.21	1.87	6,929
	Dow Chemical Co	GA0000426	Conasauga, GA	0.11	0.65	223
	Ellijay-Gilmer Water & Sewer	GA0021369	Conasauga, GA	2.04	11.54	71,613
	Cartersville WPCP	GA0024091	Lower Etowah	11.00	8.75	293,184
	City of Rockmart	GA0026042	Lower Etowah	1.20	8.86	32,490
	Dallas North WPCP	GA0026034	Lower Etowah	0.23	4.05	2,868
	Dallas West WPCP	GA0026026	Lower Etowah	0.44	3.48	4,685
	Emerson Pond	GA0026115	Lower Etowah	0.17	6.25	3,236
	Rome Blacks Bluff WPCP	GA0024112	Lower Etowah	10.89	3.10	102,817
	Adairsville South WPCP	GA0032832	Oostanaula	0.38	32.50	37,619
	Calhoun WPCP	GA0030333	Oostanaula	8.75	8.22	219,083
	City of Adairsville - North	GA0046035	Oostanaula	0.51	17.54	27,130
	OMNOVA Solutions Inc	GA0000329	Oostanaula	0.12	0.08	27
	Cave Spring WPCP	GA0025721	Upper Coosa, GA	0.15	2.00	908
	City of Cedartown	GA0024074	Upper Coosa, GA	1.82	4.27	23,694
	City of Summerville WPCP	GA0025704	Upper Coosa, GA	0.95	1.54	4,436
	Geo Specialty Chemicals	GA0001708	Upper Coosa, GA	0.26	2.73	2,158

Weiss Market	Point Source[1]	NPDES Permit No.[1]	Watershed	Average Flow (MGD)[1]	Average Total P (mg/l)[1]	Average Total P (lbs/yr)[2]
	Inland Rome (Outfall 001)	GA0001104	Upper Coosa, GA	15.98	1.08	52,724
	Inland Rome (Outfall 002)	GA0001104	Upper Coosa, GA	6.95	0.53	11,107
	Lafayette WPCP	GA0025712	Upper Coosa, GA	1.74	2.55	13,508
	Rome-Coosa WPCP	GA0024341	Upper Coosa, GA	0.55	2.47	4,106
	Trion WPCP	GA0025607	Upper Coosa, GA	5.00	3.75	57,114
					Total by Weiss Market	**971,661**
					Total for All Weiss Markets	**981,898**

[1] Point source data from EPA ECHO for NPDES data (average daily 2006-2008), GA EPD Coosa Study (2005-2006), and 2008 Weiss Lake TMDL (2005 NPDES Data). For point sources greater than or equal to 0.1 MGD

[2] Calculated from average flow and average total P (mg/L).

[3] Although average daily flow is < 0.1 MGD, Cherokee WPCP is included since Weiss TMDL lists this PS.

Table 4.6. Weiss Lake 2001 NLCD Land Cover (Acres) by Type by Market by Watershed

Market	**Sub-watershed**	**Row Crop**	**Less Developed Urban**	**Highly Developed Urban**	**Pasture**	**Forest**	**Total**
Weiss-Alabama	Upper Coosa, AL	42,076	21,827	6,640	83,248	307,905	461,696
Weiss-Georgia	Conasauga, GA	9,531	30,771	17,804	56,370	239,945	354,421
	Coosawattee	8,301	31,247	4,456	62,312	412,775	519,091
	Oostanaula	11,012	22,116	10,897	60,263	225,835	330,123
	Lower Etowah	15,119	41,052	22,666	60,900	299,921	439,659
	Upper Coosa, GA	14,267	31,911	12,471	76,189	288,754	423,592
	Total by Market	58,230	157,098	68,294	316,034	1,467,230	2,066,886
Weiss-Tennessee	Conasauga, TN	2,770	3,968	839	21,885	42,823	72,285
Total for All Weiss Lake Markets		**103,076**	**182,892**	**75,774**	**421,167**	**1,817,958**	**2,600,867**

Table 4.7. Required Reductions – Lake Allatoona Individual Point Sources by Sub-Watershed

Point Source[1]	**NPDES Permit No.**[1]	**Sub-watershed**	**Average Total P (lbs/yr)**[2]	**TMDL Total P (lbs/yr)**[1]	**Total Reduction to meet TMDL (lbs/yr)**
Cobb County Northwest WPCP	GA0046761	Acworth/Allatoona	2,074	5,601	-3,527
		Total by sub-watershed	**2,074**	**5,601**	**-3,527**
Cherokee County Fitzgerald Creek	GA0038555	Little/Noonday	4,832	4,992	-160
Cherokee County Rose Creek	GA0046451	Little/Noonday	1,812	6,575	-4,763
Cobb County Noonday Creek WPCP	GA0024988	Little/Noonday	6,256	10,960	-4,704
Fulton County Little River WPCP	GA0033251	Little/Noonday	518	1,522	-1,004
Woodstock Rubes Creek WPCP	GA0026263	Little/Noonday	2,939	760	2,179
		Total by sub-watershed	**16,357**	**24,809**	**-8,452**
Big Canoe WPCP	GA0030252	Upper Etowah	33	761	-728
City of Canton WPCP	GA0025674	Upper Etowah	15,042	2,877	12,165
Goldkist Poultry Byproducts	GA0000728	Upper Etowah	872	3,000	-2,128
Jasper WPCP	GA0032204	Upper Etowah	-	2,435	-2,435
		Total by sub-watershed	**15,947**	**9,073**	**6,874**
		Total for Lake Allatoona	**34,379**	**39,483**	**-5,104**

[1] 2009 Draft TMDL from GA EPD (includes point sources identified in Little River Embayment TMDL); excludes Land Application Systems.

[2] Calculated from average flow and average total P (mg/L).

Table 4.8. Required Reductions – Weiss Lake Individual Point Sources by Designated Weiss Market

Weiss Market	Point Source[1]	NPDES Permit No.[1]	Watershed	Average Total P (lbs/yr)[2]	TMDL Total P (lbs/yr)[1]	Total Reduction to meet TMDL (lbs/yr)
Weiss-Alabama						
	Cherokee WPCP[3]	AL0057592	Upper Coosa, AL	1,042	3,044	-2,002
	Piedmont WWTP	AL0024376	Upper Coosa, AL	2,421	3,044	-623
	Town of Cedar Bluff WWTP	AL0024678	Upper Coosa, AL	425	3,044	-2,619
	Town of Centre WWSB Lagoon	AL0062723	Upper Coosa, AL	6,349	3,044	3,304
			Total by Weiss Market	**10,237**	**12,176**	**-1,940**
Weiss-Georgia						
	Chatsworth WPCP	GA0032492	Conasauga, GA	6,929	3,698	3,231
	Dow Chemical Co	GA0000426	Conasauga, GA	223	3,044	-2,821
	Ellijay-Gilmer Water & Sewer	GA0021369	Conasauga, GA	71,613	6,203	65,410
	Cartersville WPCP	GA0024091	Lower Etowah	293,184	33,507	259,678
	City of Rockmart	GA0026042	Lower Etowah	32,490	3,669	28,821
	Dallas North WPCP	GA0026034	Lower Etowah	2,868	3,044	-176
	Dallas West WPCP	GA0026026	Lower Etowah	4,685	3,044	1,641
	Emerson Pond	GA0026115	Lower Etowah	3,236	3,044	192
	Rome Blacks Bluff WPCP	GA0024112	Lower Etowah	102,817	33,167	69,650
	Adairsville South WPCP	GA0032832	Oostanaula	37,619	3,044	34,575
	Calhoun WPCP	GA0030333	Oostanaula	219,083	26,663	192,420
	City of Adairsville - North	GA0046035	Oostanaula	27,130	3,044	24,086
	OMNOVA Solutions Inc	GA0000329	Oostanaula	27	3,044	-3,017
	Cave Spring WPCP	GA0025721	Upper Coosa, GA	908	3,044	-2,136
	City of Cedartown	GA0024074	Upper Coosa, GA	23,694	5,548	18,146
	City of Summerville WPCP	GA0025704	Upper Coosa, GA	4,436	3,044	1,392
	Geo Specialty Chemicals	GA0001708	Upper Coosa, GA	2,158	3,044	-886

Weiss Market	Point Source[1]	NPDES Permit No.[1]	Watershed	Average Total P (lbs/yr)[2]	TMDL Total P (lbs/yr)[1]	Total Reduction to meet TMDL (lbs/yr)
	Inland Rome (Outfall 001)	GA0001104	Upper Coosa, GA	52,724	48,669	4,056
	Inland Rome (Outfall 002)	GA0001104	Upper Coosa, GA	11,107	21,157	-10,050
	Lafayette WPCP	GA0025712	Upper Coosa, GA	13,508	5,291	8,217
	Rome-Coosa WPCP	GA0024341	Upper Coosa, GA	4,106	3,044	1,062
	Trion WPCP	GA0025607	Upper Coosa, GA	57,114	15,230	41,883
			Total by Weiss Market	**971,661**	**236,287**	**735,374**
			Total for All Weiss Markets	**981,898**	**248,463**	**733,435**

[1] Point source data from EPA ECHO for NPDES data (average daily 2006-2008), GA EPD Coosa Study (2005-2006), and 2008 Weiss Lake TMDL (2005 NPDES Data).

[2] Calculated from average flow and average total P (mg/L).

[3] Although average daily flow is < 0.1 MGD, Cherokee WPCP is included since Weiss TMDL lists this PS.

Table 4.9. Lake Allatoona Counties and Percent of County Area in Each Sub-watershed[1]

Sub-watershed	County	County Area in Basin (sq. miles)	County Area (sq. miles)	Percent of County Area in Basin
Acworth/Allatoona	BARTOW	1.54	470.6	0.327%
Acworth/Allatoona	CHEROKEE	2.15	434	0.496%
Acworth/Allatoona	COBB	56.21	344.5	16.316%
Acworth/Allatoona	PAULDING	3.47	315.1	1.102%
Little/Noonday	CHEROKEE	104.10	434	23.986%
Little/Noonday	COBB	61.05	344.5	17.721%
Little/Noonday	FORSYTH	2.69	247.4	1.088%
Little/Noonday	FULTON	52.55	534.6	9.830%
Owl/Kellogg	CHEROKEE	7.32	434	1.686%
Owl/Kellogg	COBB	2.28	344.5	0.663%
Shoal Creek	BARTOW	0.20	470.6	0.042%
Shoal Creek	CHEROKEE	63.95	434	14.734%
Shoal Creek	PICKENS	3.67	232.8	1.577%
Stamp/Rowland	BARTOW	40.78	470.6	8.666%
Stamp/Rowland	CHEROKEE	6.21	434	1.432%
Upper Etowah	CHEROKEE	136.64	434	31.483%
Upper Etowah	DAWSON	193.44	213.9	90.435%
Upper Etowah	FANNIN	2.45	391.5	0.627%
Upper Etowah	FORSYTH	70.81	247.4	28.620%
Upper Etowah	GILMER	6.71	431.9	1.553%
Upper Etowah	LUMPKIN	96.31	284.9	33.806%
Upper Etowah	PICKENS	114.06	232.8	48.997%
Upper Etowah	UNION	3.11	329.2	0.944%

[1] Data provided by Lin et al.; NLCD 2001.

Table 4.10. Weiss Lake Counties and Percent of County Area in Each Watershed

Sub-watershed	**County**	**County Area in Basin (sq. miles)[1]**	**County Area (sq. miles)[1]**	**County Area in Basin**
Conasauga, GA	CATOOSA	0.10	182.92	0.052%
Conasauga, GA	FANNIN	51.29	397.00	12.919%
Conasauga, GA	GILMER	3.18	430.31	0.739%
Conasauga, GA	GORDON	14.15	353.02	4.007%
Conasauga, GA	MURRAY	297.87	355.21	83.858%
Conasauga, GA	WALKER	4.07	446.27	0.913%
Conasauga, GA	WHITFIELD	234.29	287.56	81.474%
Coosawattee	BARTOW	82.42	461.76	17.850%
Coosawattee	CHEROKEE	21.79	416.86	5.227%
Coosawattee	DAWSON	1.10	212.61	0.515%
Coosawattee	FANNIN	11.49	397.00	2.895%
Coosawattee	GILMER	399.59	430.31	92.863%
Coosawattee	GORDON	179.22	353.02	50.768%
Coosawattee	MURRAY	57.34	355.21	16.142%
Coosawattee	PICKENS	107.62	224.21	47.997%
Oostanaula	BARTOW	37.88	461.76	8.204%
Oostanaula	CHATTOOGA	97.75	310.49	31.483%
Oostanaula	FLOYD	177.16	501.76	35.308%
Oostanaula	GORDON	159.66	353.02	45.225%
Oostanaula	WALKER	79.02	446.27	17.707%
Oostanaula	WHITFIELD	9.20	287.56	3.200%
Lower Etowah	BARTOW	298.94	461.76	64.738%
Lower Etowah	COBB	4.14	353.28	1.171%
Lower Etowah	FLOYD	129.36	501.76	25.781%
Lower Etowah	HARALSON	0.09	286.68	0.032%
Lower Etowah	PAULDING	193.54	323.55	59.818%
Lower Etowah	POLK, GA	140.89	324.93	43.360%
Upper Coosa, GA	CHATTOOGA	212.74	310.49	68.517%
Upper Coosa, GA	DADE	10.91	184.76	5.904%
Upper Coosa, GA	FLOYD	195.24	501.76	38.910%
Upper Coosa, GA	HARALSON	7.31	286.68	2.550%
Upper Coosa, GA	POLK, GA	174.36	324.93	53.661%
Upper Coosa, GA	WALKER	140.02	446.27	31.376%
Upper Coosa, AL	CALHOUN, AL	48.29	603.93	7.996%
Upper Coosa, AL	CHEROKEE, AL	565.53	604.14	93.608%
Upper Coosa, AL	CLEBURNE, AL	95.69	560.12	17.084%
Upper Coosa, AL	DE KALB, AL	138.14	772.00	17.893%
Upper Coosa, AL	ETOWAH, AL	2.67	568.44	0.469%
Conasauga, TN	BRADLEY, TN	82.70	331.57	24.944%
Conasauga, TN	POLK, TN	41.07	441.06	9.313%

[1] Data from EPA Basins 4.0.

Table 4.11.A. Summary Table for Lake Allatoona Agricultural BMP's

BMP[1]	Total P Removal Efficiency (lbs /acre)[2]	Average Annual Cost per Acre Treated[1] Acworth/ Allatoona	Little/ Noonday	Owl/ Kellogg	Shoal Creek	Stamp/ Rowland	Upper Etowah
50 Ft Riparian Buffer (Forested)	0.75	$87.06	$138.21	$139.07	$134.99	$110.03	$86.05
Cattle Exclusion (50 Ft Riparian Buffer)	0.82	$129.88	$181.03	$181.89	$177.81	$152.85	$128.87
Cattle Exclusion (No Buffer)	0.28	$41.73	$41.73	$41.73	$41.73	$41.73	$41.73
Cover Crop	0.11	$27.39	$27.39	$27.39	$27.39	$27.39	$27.39
Grassed Waterway	0.45	$187.15	$289.44	$291.16	$283.01	$233.09	$185.13
Land Conversion: Cropland to Forest	0.94	$3,497.98	$5,543.80	$5,578.20	$5,415.24	$4,416.75	$3,457.60
Land Conversion: Cropland to Pasture	0.80	$3,506.39	$5,552.20	$5,586.60	$5,423.64	$4,425.15	$3,466.01
Land Conversion: Pastureland to Forest	0.69	$3,509.55	$5,555.36	$5,589.76	$5,426.80	$4,428.31	$3,469.17

[1] BMP's and cost estimates follow CH2M HILL's analysis of Lake Jordan, NC; costs updated with GA NRCS data where available and reflect present value capital and O&M costs. As CH2M, costs assume an interest rate of 7.5 percent, inflation rate of 5 percent, and lifetime of 10 years for agricultural BMP's. Land costs are included and estimated for each sub-watershed from georgiastats.uga.edu.

[2] Total P removal efficiences from CH2M HILL's analyis of Lake Jordan, NC.

Table 4.11.B. Agricultural BMP's - Cropland

Sub-watershed	BMP	lb's of P removed per acre	$/lb/yr w/ Land
Acworth/Allatoona	50 Ft Riparian Buffer (Forested)	-	-
Acworth/Allatoona	Cover Crop	-	-
Acworth/Allatoona	Grassed Waterway	-	-
Acworth/Allatoona	Land Conversion: Cropland to Forest	-	-
Acworth/Allatoona	Land Conversion: Cropland to Pasture	-	-
Little/Noonday	50 Ft Riparian Buffer (Forested)	63.17	$2.19
Little/Noonday	Cover Crop	9.26	$2.96
Little/Noonday	Grassed Waterway	37.90	$7.64
Little/Noonday	Land Conversion: Cropland to Forest	79.17	$70.03
Little/Noonday	Land Conversion: Cropland to Pasture	67.38	$82.40
Owl/Kellogg	50 Ft Riparian Buffer (Forested)	-	-
Owl/Kellogg	Cover Crop	-	-
Owl/Kellogg	Grassed Waterway	-	-
Owl/Kellogg	Land Conversion: Cropland to Forest	-	-
Owl/Kellogg	Land Conversion: Cropland to Pasture	-	-
Shoal Creek	50 Ft Riparian Buffer (Forested)	-	-
Shoal Creek	Cover Crop	-	-
Shoal Creek	Grassed Waterway	-	-
Shoal Creek	Land Conversion: Cropland to Forest	-	-
Shoal Creek	Land Conversion: Cropland to Pasture	-	-
Stamp/Rowland	50 Ft Riparian Buffer (Forested)	-	-
Stamp/Rowland	Cover Crop	-	-
Stamp/Rowland	Grassed Waterway	-	-
Stamp/Rowland	Land Conversion: Cropland to Forest	-	-
Stamp/Rowland	Land Conversion: Cropland to Pasture	-	-
Upper Etowah	50 Ft Riparian Buffer (Forested)	2.24	$38.45
Upper Etowah	Cover Crop	0.33	$83.43
Upper Etowah	Grassed Waterway	1.34	$137.87
Upper Etowah	Land Conversion: Cropland to Forest	2.80	$1,232.66
Upper Etowah	Land Conversion: Cropland to Pasture	2.39	$1,451.90

Table 4.11.C. Agricultural BMP's - Pasture Receiving Litter

Sub-watershed	**BMP**	**lb's of P removed per acre**	**$/lb/yr w/ Land**
Acworth/Allatoona	50 Ft Riparian Buffer (Forested)	2.20	$39.64
Acworth/Allatoona	Cattle Exclusion (50 Ft Riparian Buffer)	0.26	$494.55
Acworth/Allatoona	Cattle Exclusion (No Buffer)	0.09	$465.40
Acworth/Allatoona	Cover Crop	0.32	$85.03
Acworth/Allatoona	Grassed Waterway	1.32	$142.03
Acworth/Allatoona	Land Conversion: Pastureland to Forest	2.02	$1,737.02
Little/Noonday	50 Ft Riparian Buffer (Forested)	2.33	$59.28
Little/Noonday	Cattle Exclusion (50 Ft Riparian Buffer)	0.27	$669.71
Little/Noonday	Cattle Exclusion (No Buffer)	0.09	$452.17
Little/Noonday	Cover Crop	0.34	$80.10
Little/Noonday	Grassed Waterway	1.40	$206.93
Little/Noonday	Land Conversion: Pastureland to Forest	2.14	$2,590.25
Owl/Kellogg	50 Ft Riparian Buffer (Forested)	1.77	$78.51
Owl/Kellogg	Cattle Exclusion (50 Ft Riparian Buffer)	0.26	$704.42
Owl/Kellogg	Cattle Exclusion (No Buffer)	0.09	$473.35
Owl/Kellogg	Cover Crop	0.26	$105.42
Owl/Kellogg	Grassed Waterway	1.06	$273.97
Owl/Kellogg	Land Conversion: Pastureland to Forest	1.63	$3,430.27
Shoal Creek	50 Ft Riparian Buffer (Forested)	6.90	$19.57
Shoal Creek	Cattle Exclusion (50 Ft Riparian Buffer)	0.27	$660.50
Shoal Creek	Cattle Exclusion (No Buffer)	0.09	$454.01
Shoal Creek	Cover Crop	1.01	$27.07
Shoal Creek	Grassed Waterway	4.14	$68.38
Shoal Creek	Land Conversion: Pastureland to Forest	6.35	$855.12
Stamp/Rowland	50 Ft Riparian Buffer (Forested)	-	-
Stamp/Rowland	Cattle Exclusion (50 Ft Riparian Buffer)	-	-
Stamp/Rowland	Cattle Exclusion (No Buffer)	-	-
Stamp/Rowland	Cover Crop	-	-
Stamp/Rowland	Grassed Waterway	-	-
Stamp/Rowland	Land Conversion: Pastureland to Forest	-	-
Upper Etowah	50 Ft Riparian Buffer (Forested)	8.54	$10.07
Upper Etowah	Cattle Exclusion (50 Ft Riparian Buffer)	0.27	$477.46
Upper Etowah	Cattle Exclusion (No Buffer)	0.09	$452.83
Upper Etowah	Cover Crop	1.25	$21.86
Upper Etowah	Grassed Waterway	5.13	$36.12
Upper Etowah	Land Conversion: Pastureland to Forest	7.86	$441.39

Table 4.11.D. Agricultural BMP's - Pasture Not Receiving Litter

Sub-watershed	**BMP**	**lb's of P removed per acre**	**$/lb/yr w/ Land**
Acworth/Allatoona	50 Ft Riparian Buffer (Forested)	0.07	$1,290.99
Acworth/Allatoona	Cover Crop	0.01	$2,768.95
Acworth/Allatoona	Grassed Waterway	0.04	$4,625.26
Acworth/Allatoona	Land Conversion: Pastureland to Forest	0.06	$56,567.55
Little/Noonday	50 Ft Riparian Buffer (Forested)	0.08	$1,822.19
Little/Noonday	Cover Crop	0.01	$2,461.96
Little/Noonday	Grassed Waterway	0.05	$6,360.24
Little/Noonday	Land Conversion: Pastureland to Forest	0.07	$79,614.88
Owl/Kellogg	50 Ft Riparian Buffer (Forested)	0.04	$3,140.52
Owl/Kellogg	Cover Crop	0.01	$4,216.91
Owl/Kellogg	Grassed Waterway	0.03	$10,958.73
Owl/Kellogg	Land Conversion: Pastureland to Forest	0.04	$137,210.86
Shoal Creek	50 Ft Riparian Buffer (Forested)	0.12	$1,099.87
Shoal Creek	Cover Crop	0.02	$1,521.41
Shoal Creek	Grassed Waterway	0.07	$3,843.15
Shoal Creek	Land Conversion: Pastureland to Forest	0.11	$48,060.99
Stamp/Rowland	50 Ft Riparian Buffer (Forested)	0.08	$1,319.35
Stamp/Rowland	Cover Crop	0.01	$2,239.05
Stamp/Rowland	Grassed Waterway	0.05	$4,658.17
Stamp/Rowland	Land Conversion: Pastureland to Forest	0.08	$57,716.80
Upper Etowah	50 Ft Riparian Buffer (Forested)	0.32	$269.09
Upper Etowah	Cover Crop	0.05	$583.92
Upper Etowah	Grassed Waterway	0.19	$964.85
Upper Etowah	Land Conversion: Pastureland to Forest	0.29	$11,791.69

Table 4.12.A. Summary Table for Lake Allatoona Urban BMP's

		Average Annual Cost per Acre Treated[1]					
		Acworth/Allatoona		**Little/Noonday**		**Owl/Kellogg**	
BMP[1]	**Total P Removal Efficiency (lbs /acre)**[2]	Highly Devel.[2]	Less Devel.[2]	Highly Devel.[2]	Less Devel.[2]	Highly Devel.[2]	Less Devel.[2]
Bioretention	0.45	$2,574.03	$1,851.37	$2,497.74	$1,843.79	$2,258.74	$1,811.69
Dry Extension Basin	0.1	$552.90	$191.56	$514.75	$187.78	$183.19	$497.74
Filter Strip	0.35	$633.13	$300.70	$598.04	$297.22	$293.00	$582.38
Grassed Swale	0.2	$2,657.55	$489.55	$2,428.68	$466.83	$439.31	$2,326.59
Infiltration Devices	0.35	$1,743.31	$1,381.98	$1,705.16	$1,378.19	$1,373.60	$1,688.15
Restored Riparian Buffer	0.35	$435.73	$103.30	$400.64	$99.82	$95.60	$384.98
Sand Filter	0.45	$2,444.45	$2,227.65	$2,421.56	$2,225.37	$2,222.62	$2,411.35
Stormwater wetlands	0.35	$932.28	$354.14	$871.25	$348.08	$340.75	$844.02
Wet detention basin	0.4	$632.37	$271.03	$594.22	$267.25	$262.66	$577.21
		Shoal Creek		**Stamp/Rowland**		**Upper Etowah**	
BMP[1]	**Total P Removal Efficiency (lbs /acre)**[2]	Highly Devel.[2]	Less Devel.[2]	Highly Devel.[2]	Less Devel.[2]	Highly Devel.[2]	Less Devel.[2]
Bioretention	0.45	$2,129.68	$1,795.25	$2,013.77	$1,779.00	$2,087.06	$1,789.00
Dry Extension Basin	0.1	$330.72	$163.50	$272.76	$155.38	$309.41	$160.38
Filter Strip	0.35	$428.73	$274.89	$375.41	$267.41	$409.12	$272.02
Grassed Swale	0.2	$1,324.48	$321.18	$976.75	$272.44	$1,196.64	$302.46
Infiltration Devices	0.35	$1,521.13	$1,353.91	$1,463.18	$1,345.79	$1,499.82	$1,350.79
Restored Riparian Buffer	0.35	$231.33	$77.49	$178.01	$70.01	$211.72	$74.62
Sand Filter	0.45	$2,311.14	$2,210.81	$2,276.37	$2,205.94	$2,298.35	$2,208.94
Stormwater wetlands	0.35	$576.79	$309.25	$484.06	$296.25	$542.70	$304.25
Wet detention basin	0.4	$410.19	$242.97	$352.23	$234.85	$388.88	$239.85

[1] BMP's, P removal efficiencies, and cost estimates follow CH2M HILL's analysis of Lake Jordan, NC and use EPA estimates (EPA, 1999). As CH2M HILL, costs assume an interest rate of 7.5 percent, inflation rate of 5 percent, and lifetime of 20 years for urban BMP's. Costs reflect present value capital and O&M costs. Land costs are included and estimated for each sub-watershed from georgiastats.uga.edu.

[2] Highly Developed Urban (≥20% imperviousness) and Less Developed Urban (<20% imperviousness).

Table 4.12.B. Urban BMP's - Highly Developed Urban

Sub-watershed	BMP	lb's of P removed per acre	$/lb/yr w/ Land
Acworth/Allatoona	Bioretention	0.20	$12,624.58
Acworth/Allatoona	Dry Extension Basin	0.05	$12,202.82
Acworth/Allatoona	Filter Strip	0.16	$3,992.46
Acworth/Allatoona	Grassed Swale	0.09	$29,326.93
Acworth/Allatoona	Infiltration Devices	0.16	$10,993.14
Acworth/Allatoona	Restored Riparian Buffer	0.16	$2,747.67
Acworth/Allatoona	Sand Filter	0.20	$11,989.01
Acworth/Allatoona	Stormwater wetlands	0.16	$5,878.85
Acworth/Allatoona	Wet detention basin	0.18	$3,489.20
Little/Noonday	Bioretention	0.96	$2,612.09
Little/Noonday	Dry Extension Basin	0.21	$2,422.44
Little/Noonday	Filter Strip	0.74	$804.11
Little/Noonday	Grassed Swale	0.42	$5,714.71
Little/Noonday	Infiltration Devices	0.74	$2,292.72
Little/Noonday	Restored Riparian Buffer	0.74	$538.69
Little/Noonday	Sand Filter	0.96	$2,532.42
Little/Noonday	Stormwater wetlands	0.74	$1,171.46
Little/Noonday	Wet detention basin	0.85	$699.11
Owl/Kellogg	Bioretention	0.20	$11,045.57
Owl/Kellogg	Dry Extension Basin	0.05	$4,031.24
Owl/Kellogg	Filter Strip	0.16	$1,842.19
Owl/Kellogg	Grassed Swale	0.09	$4,833.65
Owl/Kellogg	Infiltration Devices	0.16	$8,636.29
Owl/Kellogg	Restored Riparian Buffer	0.16	$601.07
Owl/Kellogg	Sand Filter	0.20	$10,868.94
Owl/Kellogg	Stormwater wetlands	0.16	$2,142.39
Owl/Kellogg	Wet detention basin	0.18	$1,445.01
Shoal Creek	Bioretention	0.64	$3,332.93
Shoal Creek	Dry Extension Basin	0.14	$2,329.08
Shoal Creek	Filter Strip	0.50	$862.65
Shoal Creek	Grassed Swale	0.28	$4,663.80
Shoal Creek	Infiltration Devices	0.50	$3,060.72
Shoal Creek	Restored Riparian Buffer	0.50	$465.46
Shoal Creek	Sand Filter	0.64	$3,616.92
Shoal Creek	Stormwater wetlands	0.50	$1,160.58
Shoal Creek	Wet detention basin	0.57	$722.19
Stamp/Rowland	Bioretention	0.26	$7,893.37
Stamp/Rowland	Dry Extension Basin	0.06	$4,811.20
Stamp/Rowland	Filter Strip	0.20	$1,891.91
Stamp/Rowland	Grassed Swale	0.11	$8,614.26
Stamp/Rowland	Infiltration Devices	0.20	$7,373.85
Stamp/Rowland	Restored Riparian Buffer	0.20	$897.09
Stamp/Rowland	Sand Filter	0.26	$8,922.68
Stamp/Rowland	Stormwater wetlands	0.20	$2,439.50
Stamp/Rowland	Wet detention basin	0.23	$1,553.24
Upper Etowah	Bioretention	0.73	$2,865.42
Upper Etowah	Dry Extension Basin	0.16	$1,911.63
Upper Etowah	Filter Strip	0.57	$722.19
Upper Etowah	Grassed Swale	0.32	$3,696.56
Upper Etowah	Infiltration Devices	0.57	$2,647.51
Upper Etowah	Restored Riparian Buffer	0.57	$373.74
Upper Etowah	Sand Filter	0.73	$3,155.51
Upper Etowah	Stormwater wetlands	0.57	$957.98
Upper Etowah	Wet detention basin	0.65	$600.65

Table 4.12.C. Urban BMP's - Less Developed Urban

Sub-watershed	BMP	lb's of P removed per acre	$/lb/yr w/ Land
Acworth/Allatoona	Bioretention	0.07	$27,580.45
Acworth/Allatoona	Stormwater wetlands	0.05	$6,783.18
Acworth/Allatoona	Wet detention basin	0.06	$4,542.41
Acworth/Allatoona	Sand Filter	0.07	$33,186.01
Acworth/Allatoona	Restored Riparian Buffer	0.05	$1,978.64
Acworth/Allatoona	Grassed Swale	0.03	$16,409.17
Acworth/Allatoona	Infiltration Devices	0.05	$26,469.98
Acworth/Allatoona	Filter Strip	0.05	$5,759.59
Acworth/Allatoona	Dry Extension Basin	0.01	$12,842.10
Little/Noonday	Bioretention	0.24	$7,821.95
Little/Noonday	Stormwater wetlands	0.18	$1,898.60
Little/Noonday	Wet detention basin	0.21	$1,275.47
Little/Noonday	Sand Filter	0.24	$9,440.73
Little/Noonday	Restored Riparian Buffer	0.18	$544.45
Little/Noonday	Grassed Swale	0.10	$4,455.95
Little/Noonday	Infiltration Devices	0.18	$7,517.19
Little/Noonday	Filter Strip	0.18	$1,621.15
Little/Noonday	Dry Extension Basin	0.05	$3,584.75
Owl/Kellogg	Bioretention	0.07	$27,442.78
Owl/Kellogg	Stormwater wetlands	0.05	$16,437.74
Owl/Kellogg	Wet detention basin	0.06	$9,836.24
Owl/Kellogg	Sand Filter	0.07	$36,526.14
Owl/Kellogg	Restored Riparian Buffer	0.05	$7,497.74
Owl/Kellogg	Grassed Swale	0.03	$79,295.13
Owl/Kellogg	Infiltration Devices	0.05	$32,877.51
Owl/Kellogg	Filter Strip	0.05	$11,342.19
Owl/Kellogg	Dry Extension Basin	0.01	$33,927.93
Shoal Creek	Bioretention	0.30	$5,889.34
Shoal Creek	Stormwater wetlands	0.24	$1,304.35
Shoal Creek	Wet detention basin	0.27	$896.72
Shoal Creek	Sand Filter	0.30	$7,252.60
Shoal Creek	Restored Riparian Buffer	0.24	$326.83
Shoal Creek	Grassed Swale	0.14	$2,370.72
Shoal Creek	Infiltration Devices	0.24	$5,710.56
Shoal Creek	Filter Strip	0.24	$1,159.42
Shoal Creek	Dry Extension Basin	0.07	$2,413.70
Stamp/Rowland	Bioretention	0.09	$19,547.46
Stamp/Rowland	Stormwater wetlands	0.07	$4,185.20
Stamp/Rowland	Wet detention basin	0.08	$2,903.08
Stamp/Rowland	Sand Filter	0.09	$24,238.60
Stamp/Rowland	Restored Riparian Buffer	0.07	$989.11
Stamp/Rowland	Grassed Swale	0.04	$6,735.54
Stamp/Rowland	Infiltration Devices	0.07	$19,012.40
Stamp/Rowland	Filter Strip	0.07	$3,777.83
Stamp/Rowland	Dry Extension Basin	0.02	$7,682.85
Upper Etowah	Bioretention	0.22	$8,230.85
Upper Etowah	Stormwater wetlands	0.17	$1,799.76
Upper Etowah	Wet detention basin	0.19	$1,241.46
Upper Etowah	Sand Filter	0.22	$10,162.89
Upper Etowah	Restored Riparian Buffer	0.17	$441.38
Upper Etowah	Grassed Swale	0.10	$3,130.99
Upper Etowah	Infiltration Devices	0.17	$7,990.38
Upper Etowah	Filter Strip	0.17	$1,609.06
Upper Etowah	Dry Extension Basin	0.05	$3,320.50

Table 4.13. Lake Allatoona Litter Transfer - Manure Quantity and Cost Estimates[1]

County	Sub-Watershed	Manure Applied (tons)	Costs of Litter Transfer ($/ton)
BARTOW	Acworth/Allatoona	123	$13
CHEROKEE	Acworth/Allatoona	63	$13
COBB	Acworth/Allatoona	-	-
PAULDING	Acworth/Allatoona	89	$13
	Total by sub-watershed	**275**	
CHEROKEE	Little/Noonday	3,045	$13
COBB	Little/Noonday	-	-
FORSYTH	Little/Noonday	163	$23
FULTON	Little/Noonday	-	$100
	Total by sub-watershed	**3,208**	
CHEROKEE	Owl/Kellogg	214	$13
COBB	Owl/Kellogg	-	-
	Total by sub-watershed	**214**	
BARTOW	Shoal Creek	16	$13
CHEROKEE	Shoal Creek	1,870	$13
PICKENS	Shoal Creek	538	$13
	Total by sub-watershed	**2,424**	
BARTOW	Stamp/Rowland	3,256	$13
CHEROKEE	Stamp/Rowland	182	$13
	Total by sub-watershed	**3,438**	
CHEROKEE	Upper Etowah	3,997	$13
DAWSON	Upper Etowah	34,323	$15
FANNIN	Upper Etowah	36	$62
FORSYTH	Upper Etowah	4,297	$23
GILMER	Upper Etowah	1,459	$14
LUMPKIN	Upper Etowah	5,472	$20
PICKENS	Upper Etowah	16,701	$13
UNION	Upper Etowah	-	$62
	Total by sub-watershed	**66,285**	
	Total Lake Allatoona	**75,844**	

[1] Vest et al.'s estimate of 1.2 tons of manure per 1,000 broilers determines the amount of manure generated in all markets; broiler data from US Agricultural Census (2007) weighted by percent of county in each sub-watershed. Cost per ton from Risse et al.

Table 4.14. Weiss Lake Litter Transfer - Manure Quantity and Cost Estimates[1]

Market	County	Sub-Watershed	Manure Applied (tons)	Costs of Litter Transfer ($/ton)
Weiss-Alabama				
	CALHOUN, AL	Upper Coosa, AL	1,225,097	$81
	CHEROKEE, AL	Upper Coosa, AL	14,750,735	$81
	CLEBURNE, AL	Upper Coosa, AL	4,092,303	$19
	DE KALB, AL	Upper Coosa, AL	21,379,402	$19
	ETOWAH, AL	Upper Coosa, AL	121,196	$19
		Total by Weiss Market	**41,568,732**	
Weiss-Georgia				
	CATOOSA	Conasauga, GA	7	$17
	FANNIN	Conasauga, GA	745	$62
	GILMER	Conasauga, GA	694	$14
	GORDON	Conasauga, GA	3,486	$32
	MURRAY	Conasauga, GA	21,273	$21
	WALKER	Conasauga, GA	432	$21
	WHITFIELD	Conasauga, GA	26,673	$21
	BARTOW	Coosawattee	6,707	$13
	CHEROKEE	Coosawattee	664	$13
	DAWSON	Coosawattee	196	$15
	FANNIN	Coosawattee	167	$62
	GILMER	Coosawattee	87,274	$14
	GORDON	Coosawattee	44,170	$32
	MURRAY	Coosawattee	4,095	$21
	PICKENS	Coosawattee	16,360	$13
	BARTOW	Oostanaula	3,082	$13
	CHATTOOGA	Oostanaula	-	-
	FLOYD	Oostanaula	7,969	$100
	GORDON	Oostanaula	39,348	$32
	WALKER	Oostanaula	8,376	$21
	WHITFIELD	Oostanaula	1,048	$21
	BARTOW	Lower Etowah	24,324	$13
	COBB	Lower Etowah	-	-
	FLOYD	Lower Etowah	5,819	$100
	HARALSON	Lower Etowah	7	$62
	PAULDING	Lower Etowah	4,838	$13
	POLK, GA	Lower Etowah	7,880	$81
	CHATTOOGA	Upper Coosa, GA	-	-
	DADE	Upper Coosa, GA	349	$21
	FLOYD	Upper Coosa, GA	8,782	$100
	HARALSON	Upper Coosa, GA	566	$62
	POLK, GA	Upper Coosa, GA	9,752	$81
	WALKER	Upper Coosa, GA	14,842	$21
		Total by Weiss Market	**349,921**	
Weiss-Tennessee				
	BRADLEY, TN	Conasauga, TN	9,080,921	$21
	POLK, TN	Conasauga, TN	669,573	$35
		Total by Weiss Market	**9,750,495**	
		Total from All Weiss Markets	**51,669,148**	

[1] Vest et al.'s estimate of 1.2 tons of manure per 1,000 broilers determines the amount of manure generated in all markets; broiler data from US Agricultural Census (2007) weighted by percent of county in each watershed. Cost per ton from Risse et al.

Table 4.15. Point Source Sensitivity Analyses

Scenario	**Description**
A	PS Costs Inflated 35%
B	PS Costs Deflated 35%
C	TMDL Requirements Tightened to 75% of Current
D	TMDL Requirements Tightened to 50% of Current

Table 4.16. Non-point Source Sensitivity Analyses

Scenario	**Description**	**Lake Allatoona**[1]	**Weiss Lake**[1]
A.1	NPS:PS changed to 4:1	x	x
A.2	NPS:PS changed to 1:1	x	x
B	Retirement Ratio: 10%	x	x
C	NPS Costs Inflated 35%	x	x
D	NPS Costs Deflated 35%	x	x
E	NPS Costs Inflated 35%; Retirement Ratio: 10%	x	x
F	No Land Costs for NPS	x	
G	25% of Litter P Loads Accounted for by Urban Loads	x	
H	NPS Costs Inflated 35%; Retirement Ratio: 10%; 25% of Litter P Loads Accounted for by Urban Loads	x	
I	P-Loads per Ton Manure (Min from Allatoona)		x
J	P-Loads per Ton Manure (Max from Allatoona)		x
K	Delivery Ratio (Min from Allatoona)		x
L	Delivery Ratio (Max from Allatoona)		x
M	P-Loads per Ton Manure (Min from Allatoona); Delivery Ratio (Min from Allatoona)		x

[1] "X" signifies scenario run for selected framework.

CHAPTER 5

RESULTS & CONCLUSIONS

5.1. BASELINE SCENARIOS

5.1.1. Lake Allatoona

For Scenarios Allatoona-1 and Allatoona-2, the credits demanded and corresponding compliance costs for point sources (PSs) are summarized in Table 5.1 and Figure 5.1. As shown, only 2 of the 10 PSs in the Lake Allatoona markets need to reduce their loadings in order to meet TMDL standards. Woodstock Rubes Creek WPCP (Woodstock) needs 2,179 credits to meet compliance. If Woodstock decides to upgrade its facility, it would face a compliance cost of approximately $34 per credit, or a total annual cost of $73,096. The other Lake Allatoona facility, City of Canton WPCP (Canton), needs 12,165 credits to meet compliance. If Canton decides to upgrade its facility, it would face a compliance cost of approximately $157 per credit, or a total annual cost of $1,906,039. For non-point source (NPS) credits, litter transfer abatement (Table 5.3 and Figure 5.3) generally dominates agricultural and urban abatement options (Table 5.2 and Figure 5.2) in terms of the number of credits supplied and price.

For Scenario Allatoona-1, Woodstock and Canton can choose to upgrade or purchase credits from any source in any sub-watershed. As Table 5.3 shows, litter transfer from several counties in the Etowah sub-watershed provides a cheap source of NPS credits. There are six counties in the Etowah sub-watershed with an estimated credit price of $12 or less; these counties supply a total of 129,519 credits. Even if only a quarter of these credits are available

(32,380), there is still a sufficient supply of credits to meet demand from Woodstock and Canton at a substantial cost savings to those PSs. At $12 a credit, Woodstock gains from trade and saves approximately $47,000 per year in phosphorus (P) abatement costs. For Canton, the savings are even higher at approximately $1.8M per year. Figure 5.4 displays these cost savings at various levels of litter transfer prices. Of course, these cost savings depend on what price the market sets for credits. The optimal strategy for litter producers is to sell credits at the highest possible price, since their gains from trade depend on the market price for credits. As the difference between the market price and the cost for which they can supply credits increases, the gains realized from trade for these litter producers increase as well. Since the number of potential suppliers (litter producers) far exceeds the two consumers (PSs), competition will likely drive market price downward toward this $12 credit level. If, however, it turns out that only a limited number of producers supply credits, these suppliers may have more market power to drive credit prices higher. In this situation, profits from selling credits will rise for suppliers as costs savings for PSs fall. In either case, in Scenario 1, alpha trades clearly exist between the PSs (Woodstock, Canton) and poultry litter transfer producers.

For Scenario Allatoona-2, Woodstock and Canton must choose to upgrade or purchase credits from NPSs within their sub-watershed. For Canton, the alpha trades with litter transfer producers in the Upper Etowah sub-watershed remain the same as in Scenario 1 since Canton is a PS within the Upper Etowah sub-watershed. Since the number of potential suppliers far exceeds the one consumer in this scenario, competition will likely drive market price downward toward the $12 credit level. Again, however, if it turns out that only a limited number of producers supply credits, these suppliers may have more market power to drive credit prices higher. At a higher market price, profits from selling credits will rise for suppliers as costs savings for Canton fall. For Woodstock, a PS within the Little/Noonday sub-watershed, alpha trades are no longer available. Riparian Buffers on Cropland in the Little/Noonday sub-watershed provide a cheap source of credits ($6 per credit), but even if this best management practice (BMP) is implemented on all acres of cropland, it only produces 299 credits. The only litter transfer option that is cheaper than the upgrade cost is litter transfer from Cherokee County (1,332 credits at $29 per credit); even at this maximum supply level, the number of credits is less than the 2,179 credits Woodstock needs for compliance. Thus, the best option for Woodstock would be to upgrade its facility.

PS- to-PS trading is not feasible for either Scenario 1 or 2. For Scenario 1, Woodstock would be the supplier of credits in a PS-to-PS trading framework since it faces a lower abatement cost than Canton ($34 vs. $157). However, if Woodstock chooses to upgrade, it would be unable to provide the number of credits that Canton demands (See Table 5.1). PS-to-PS trading is ruled out in Scenario 2 because the two PS's are in different sub-watersheds. Since trading is restricted to the sub-watershed level in Scenario 2, current PS-to-PS trading is not viable. The initial market assumptions rule out the possibility of PSs that currently discharge below their TMDL to participate in trading. If this assumption is relaxed so that reductions past current loads count as credits, these PSs are still unlikely to participate in the market since they are currently abating to very low concentrations of total P. Further upgrades will likely be very expensive, and thus credit prices would be higher than either Canton or Woodstock is willing to pay.

Regardless of the scenario, the cap of total P in the market and the establishment of baselines will play a large role in determining ecological and economic consequences for the watershed. Under the market assumptions for this analysis, baselines do not exist for NPSs.

However, in order to ensure the ecological integrity of the watershed, the regulatory agency will need to define clear baselines and an aggregate total P cap for these stakeholders. If no cap is established, new NPSs may have the incentive to enter the markets (especially those sub-watersheds with high demand and little supply for Scenario 2), contribute new P pollution to the watershed, and then get paid to supply credits for abatement. Likewise, if baselines are not clearly defined for current NPSs, they may have the incentive to produce more pollution in order to generate additional credits to sell. Thus, clearly defining a cap on NPS loads and their baselines is important to ensure the ecological goals of trading are met. On the other hand, policy makers must realize that establishing these caps and baselines will likely have economic consequences for stakeholders in the watershed. As discussed in Chapter 2, as caps and baselines are tightened, they increase costs of abatement for stakeholders, and thus increase the price at which these stakeholders are willing to supply credits.

5.1.2. Weiss Lake

For Scenarios Weiss-1 and Weiss-2, the credits demanded and corresponding compliance costs for PSs are summarized in Table 5.4 and Figure 5.5. For Alabama, only Town of Centre WWSB Lagoon (Centre) needs to reduce current loadings. To meet compliance, Centre needs 3,304 credits; if it chooses to upgrade the facility, compliance costs are $23 per credit, or $76,685 per year. For the Georgia markets, the current limits require that 16 of the 22 PSs reduce loadings. A total of 754,460 credits are needed at an average cost of $60 per credit and a total annual cost of $31,053,363. Cartersville WPCP (Cartersville) and Calhoun WPCP (Calhoun) account for the largest number of required credits (60%). If Cartersville upgrades, it faces total annual abatement costs of $7,851,456 at $30 per credit. Calhoun faces total annual compliance costs of $9,960,462 at $52 per credit. The NPS component of trading for Weiss Lake is summarized in Table 5.5 and Figure 5.6. As one can see, the majority of credits for poultry transfer are in the Weiss-Alabama market (80% of the total across all markets). When examining just the Weiss-Alabama and Weiss-Georgia markets, poultry litter credits from Weiss-Alabama comprise 99% of the total number of credits.

In Scenario Weiss-1, PSs are allowed to purchase credits across all markets. Although there are cheaper credits available in the Weiss-Georgia market, De Kalb County, AL supplies the largest number of credits (19,288,751) at a competitive price ($21). The number of credits supplied from De Kalb is more than enough to meet demand; even if only a quarter of De Kalb litter transfer producers participate, the supply of credits (4,822,188) still far exceeds total demand (757,765). Due to the volume and price of credits from De Kalb, $21 is used as the price for determining alpha trades for PS-to-NPS. In Scenario Weiss-1, only two PSs (Rome Blacks Bluff WPCP and Lafayette WPCP) do not benefit from trades with litter transfer producers in De Kalb County. These PSs, if they upgrade, face unit compliance costs of $10 and $11 respectively. If PS-to-PS trading is allowed, these PSs have the incentive to upgrade and sell additional credits at, or below, market price. However, total supply from Rome and Lafayette (23,953) falls substantially short of total demand (757,765). If all other PSs are able to purchase NPS credits at $21 per credit, the total cost savings would be $16,170,371. It should be noted that not all of these PSs face significant alpha trades since some unit costs to upgrade are close in costs to the approximate $21 litter transfer cost; nevertheless, there are 11 facilities with a $10 or greater unit cost differential between the cost to upgrade and a $21 litter estimate. These results suggest that significant alpha trades exist between PSs and NPS litter transfers when trading is allowed across all borders. Figure 5.7 shows cost savings for PSs at various levels of litter transfer prices. As with the Lake Allatoona results, these cost savings will depend on the market price of credits. Since the number of potential suppliers (litter producers in Alabama) far exceeds the number of consumers (PSs in Georgia), competition will likely drive market prices downward toward this $21 credit level. If, however, it turns out that only a limited number of producers supply credits, these suppliers may have more market power to drive credit prices higher. At a higher market price, profits from selling credits will rise for suppliers as costs savings for PSs fall.

In Scenario Weiss-2, trading is restricted by state lines. Under these conditions, the potential for alpha trades diminishes significantly. For the Weiss-Alabama market, these conditions do not affect the decision for Centre. As before, the cost differential between the unit cost to upgrade and litter transfer is marginal ($2). However, the alpha trades for Weiss-Georgia PSs are significantly impacted by the restriction of markets. Even if all litter transfer credits are produced, this number of 315,703 credits falls short of the 754,460 credits demanded. Thus, PS-to-NPS trading would not be able to meet all PS compliance needs. In Georgia, PS-to-PS trading has the potential to take place since there are cost differences among wastewater treatment facilities in the Weiss-Georgia market. However, the market price will likely be set higher than $21 since average unit cost of compliance is $60 among these PSs. Since there is no longer an excess of cheap litter credits in the market, GA litter producers that choose to participate in the Weiss-Gerogia market have the incentive to supply credits at or near the higher market price of credits. In this scenario, litter producers in Georgia realize greater gains from trade than in Scenario 1. At a higher market price, cost savings fall for PSs in Georgia, particularly those that purchase credits from other PSs or Georgia litter producers. PSs in Georgia that supply credits may be able to offset some of the increased cost of abatement through profits from selling credits. The political boundaries in Scenario 2 clearly impact the number of alpha trades for PS-to-NPS trading. Since these boundaries eliminate the cheapest abatement option for the majority of participants, the watershed moves further from the cost-effective solution.

As with Lake Allatoona, the cap of total P in the market and the establishment of baselines will play a large role in determining ecological and economic consequences for the watershed. In order to ensure the ecological integrity of the watershed, the regulatory agency will need to define clear baselines and an aggregate total P cap for these stakeholders. However, as discussed above, policy makers must realize that establishing these caps and baselines will likely have economic consequences for stakeholders in the watershed.

5.2. Lake Allatoona – Sensitivity Analysis

Appendix Tables C.1 – C.4 summarize the results for PSs for each Lake Allatoona sensitivity analysis scenario. Appendix Tables D.1 – D.17 summarize the NPS results. As Chapter 4 describes, these tables represent available credits under various policy and cost scenarios. The implications of changing these select parameters are summarized below. PS scenarios are summarized individually and compared against the baseline case for NPSs for determining the impact on alpha trades. The same steps are performed for NPSs. A worst case scenario is described.

5.2.1. Allatoona PSs

PS Scenario A: PS Costs Inflated 35%

Table C.1 displays the credit summary for Scenario A. Inflating PS abatement costs make trading an even more attractive option in terms of cost savings to Woodstock and Canton.

The main implications of trading in Allatoona-1 and Allatoona-2 still hold; expanding trading across all six sub-watersheds improves the number of alpha trades available, while restricting trading to individual sub-watersheds hinders Woodstock's ability to find trades. Poultry litter transfer from the Upper Etowah sub-watershed is the best NPS BMP available in terms of alpha trades. Agricultural and urban BMP's are still priced too high to be an attractive trading option for Woodstock and/or Canton.

PS Scenario B: PS Costs Deflated 35%

Table C.2 displays the credit summary for Scenario B. As expected, deflating PS abatement costs reduce savings from trading. If Woodstock is able to purchase credits at $12, the annual cost savings now drops to $21,366 from $46,949 with the baseline PS case. The trading implications for Canton remain the same as under the baseline case; cost savings, although lower, are still very high at $1,092,940 per year with a $12 unit cost for credits. Even with lower cost savings the main implications of trading in Allatoona-1 and Allatoona-2 still hold; spatial expansion of markets allows for Woodstock to find alpha trades that would otherwise not exist in the Little/Noonday sub-watershed.

Figure C.1 shows the total credits demanded in the Lake Allatoona markets as these PS costs are deflated from 100 percent of baseline costs to 0 percent, assuming a credit price of $12. The first drop-off in credits demanded occurs once PS costs fall to 35 percent of their current estimates (a 65 percent decrease); at this point, the market loses 15 percent of the credits demanded. The next drop-off, at 6 percent of current cost estimates, is where credits demanded falls to 0. These results show that the main implications of trading in Allatoona-1 vs. Allatoona-2 are fairly resilient to changes in PS cost estimates; even with significant decreases in PS cost estimates, a trading framework that allows trades across sub-watersheds supports a larger number of alpha trades than individual sub-watershed markets. These results also show that the Upper Etowah sub-watershed is a functional market even if PS cost estimates are far off the mark.

PS Scenario C: TMDL Requirements Tightened to 75% of Current

Table C.3 displays the credit summary for Scenario C. Tightening the TMDL limits on PSs would require reductions from one additional PS, Cherokee County Fitzgerald Creek (Cherokee). With a high compliance cost of $61 per credit, Cherokee benefits from trading under Scenario Allatoona-1; a $12 credit cost would save Cherokee $53,237 in annual compliance costs. As a PS in the Little/Noonday sub-watershed, the implications for trading for Cherokee in Scenario Allatoona-2 is the same as Woodstock. Limiting trading to individual sub-watersheds restricts Cherokee's ability to find alpha trades. One interesting implication of this scenario is that the cost savings versus the baseline case is lower for Woodstock and Canton. Since PSs must upgrade in a block structure, a stricter TMDL results in a lower unit cost of compliance. These cost savings are relatively small, and thus, the implications for trading are the same for PSs in Allatoona-1 and Allatoona-2 as under the baseline scenario.

PS Scenario D: TMDL Requirements Tightened to 50% of Current

Table C.4 displays the credit summary for Scenario D. As seen in Scenario C, tightening the TMDL limits on PSs would require reductions from Cherokee. In Scenario D, an additional PS must also reduce loadings: Cobb County Noonday Creek WPCP (Cobb). With unit compliance costs of $28 and $260 respectively, Cherokee and Cobb benefit from trading with a

$12 unit cost for credits. The new total demand for credits for all PSs, 19,274, can still be met by cheap poultry litter transfer credits in the Upper Etowah sub-watershed. The effects of restricting trading to a sub-watershed level are even more pronounced under this PS scenario since the majority of PSs requiring credits are in the Little/Noonday sub-watershed; their ability to find a sufficient supply of cheap NPS credits is very limited. The costs savings are again lower for Woodstock and Canton as in Scenario C, but the difference in savings are not large enough to alter the implications of trading in Allatoona-1 vs. Allatoona-2.

5.2.2. Allatoona NPSs

NPS Scenario A.1: NPS:PS changed to 4:1

Tables D.1 and D.2 show the NPS credit supply if the baseline case is adjusted with a NPS:PS ratio of 4:1. As one can see, doubling this trading ratio cuts the supply of credits in half and doubles the price per credit. As in the baseline case, poultry litter transfer is still the preferred NPS source of credits for trading. There are still a large number of relatively cheap poultry litter transfer credits available in the Upper Etowah sub-watershed; there are 55,210 credits available at a unit price of $15 or less. Alpha trades still exist when trading is expanded across all sub-watersheds in Scenario Allatoona-1. The implication of this NPS change is that alpha trades become more expensive relative to the baseline case, but doubling the trading ratio is not enough to restrict trading.

NPS Scenario A.2: NPS:PS changed to 1:1

Tables D.3 and D.4.A show the NPS credit analyses for NPS Scenario A.2. As one can see, using a trading ratio of 1:1 results in a doubling of the quantity of NPS credits available and cuts the price per credit in half from the baseline case. However, even with this new ratio, poultry litter transfers from the Upper Etowah sub-watershed are still the best source of credits to meet the demand from PSs. Little/Noonday does not produce enough credits at a price that Woodstock would be willing to pay. This scenario does not influence whether trading will or will not occur, but rather, increases the cost savings to PSs in the watershed. Thus, the basic findings from the baseline case still hold: a trading framework that expands across sub-watersheds allows for more alpha trades than a framework that restricts trading to individual sub-watersheds.

NPS:PS 1:1 to 30:1 for Upper Etowah Litter Producers

Figure D.1 and Table D.4.B show how the supply of credits for Litter producers in the Upper Etowah sub-watershed changes as this NPS:PS ratio is adjusted from 1:1 up to 30:1. These producers are analyzed since they represent the most likely supply component for alpha trades in the Allatoona markets. Also included in the figure are corresponding average credit prices for these producers and total market demand at each ratio. The supply of credits from these producers falls below the demand of credits at the 21:1 NPS:PS ratio. This very high NPS:PS ratio suggests that the Allatoona market's ability to supply the required number of credits is very resilient to changes in the NPS:PS ratio. As seen in Figure D.1, the average credit price increases linearly with increases in these ratios. At NPS:PS of 6:1, the credit price increases above the $34 credit price that Woodstock is willing to pay (also see Figure D.2). However, Canton with a max demand price of $157 is willing to pay for credits all the way up to the 27:1 NPS:PS ratio. Since actual markets rarely include trading ratios above 4:1, these results suggest that the Allatoona markets' ability to support trading should not be significantly impacted by increases in the NPS:PS ratio. However, as stated above, these ratios do have consequences for the cost savings of PSs; higher NPS:PS ratios decrease cost savings for PSs. If the NPS:PS ratio is adjusted in the opposite direction towards 1:1, there is no change to the number of alpha trades since both Canton and Woodstock participate in trading at 2:1.

NPS Scenario B: Retirement Ratio: 10%

Tables D.5 and D.6 show the NPS credit analyses for NPS Scenario B. As one can see, applying this retirement ratio cuts the supply of credits by 10 percent and increases the price per credit by 10 percent. However, the application of this ratio does not substantially alter the baseline implications of trading in Allatoona-1 vs. Allatoona-2. As with NPS Scenario A.1, the only implication of this policy change is a decrease in the cost savings associated with trading.

NPS Scenario C: NPS Costs Inflated 35%

Tables D.7 and D.8 show the NPS credit analyses for NPS Scenario C. Since this scenario only alters costs, the credits supplied by NPSs are of the same quantity as those in the baseline case. As in NPS Scenarios A.1 and B, the increase in BMP costs does not substantially alter the implications of trading under Allatoona-1 vs. Allatoona-2. A spatial expansion of markets provides an opportunity for alpha trades for Woodstock where they would otherwise not exist. The $12 credit price for examining alpha trades with litter producers in the Upper Etowah sub-watershed would need to increase by 183 percent for Woodstock to no longer participate in trading and by 1,208 percent for Canton to no longer participate; a discussion regarding the price level at which these two PSs trade is included above in the section regarding NPS:PS trading ratios from 1:1 to 30:1.

NPS Scenario D: NPS Costs Deflated 35%

Tables D.9 and D.10 show the NPS credit analyses for NPS Scenario D. Like NPS Scenario C, this scenario only alters costs and so the quantity of credits supplied by NPSs is the same as those in the baseline case. The cheaper credit costs in this scenario make the alpha trades for PSs even more attractive; however, there are no differences in the implications for trading in Scenarios Allatoona-1 vs. Allatoona-2. A market that allows trading over all six sub-watersheds allows for trading opportunities with litter producers in the Upper Etowah. The costs for agricultural and urban credits are still not cheap enough to allow for a sufficient quantity of viable alpha trades in the other five sub-watersheds. Deflating the $12 credit cost used for examining alpha trades with litter producers in the Upper Etowah sub-watershed has no effect on trading since Woodstock and Canton already participate at the baseline cost estimate.

NPS Scenario E: NPS Costs Inflated 35% and Retirement Ratio 10%

Tables D.11 and D.12 show the NPS credit analyses for NPS Scenario E. This scenario alters both NPS credit quantities and costs. However, even with the combination of a retirement ratio and higher BMP costs, there is still an abundant supply of cheap credits from poultry litter transfer in the Upper Etowah sub-watershed. As with Scenarios B and C, these changes do not change the implications for trading under Scenarios Allatoona-1 vs. Allatoona-2. The increase in costs and decrease in supply are not enough to restrict trading. The only impacts these changes have are on the cost savings to PSs that participate in trading.

NPS Scenario F: No Land Costs for NPS

Table D.13 shows the NPS credit analysis for NPS Scenario F. This scenario decreases the cost of agricultural and urban BMP's that use a certain percentage of land. Since poultry litter transfer as a BMP does not use land, these costs are the same as the baseline case. Removing land costs results in several cheap sources of agricultural BMP credits. In particular, the credit costs for Forested Riparian Buffer BMP's on Cropland, Pasture Receiving Litter, and Pasture without Litter in the Upper Etowah are all estimated at less than $2 per credit. The annual supply of these credits is fairly large at 87,508 credits. The implications for Scenario Allatoona-1 are the same as in the baseline case because Woodstock and Canton have a large number of available alpha trades with either these agricultural BMP's or poultry litter transfers. The implications for Scenario Allatoona-2 remain the same as under baseline case. In this NPS scenario, 2,928 agricultural credits under $12 are available in the Little/Noonday sub-watershed. Although this number is higher than Woodstock's required reduction of 2,179, one must keep in mind that the 2,928 credits represent the maximum number of credits available if the select BMP's are implemented on 100 percent of the applicable land cover. Thus, it is unlikely that Woodstock would be able to find enough of these credits to meet its demand. The main implications for this NPS scenario are that PSs may choose to make alpha trades with agricultural land owners rather than litter transfer producers.

NPS Scenario G: 25% of Litter P Loads Accounted for by Urban Loads

Tables D.14 and D.15 show the NPS credit analyses for NPS Scenario G. This scenario reassigns total P loads from Pasture Receiving Litter to Highly and Less Developed Urban. This scenario increases the number of agricultural and urban credits and decreases the respective unit costs. The number of poultry litter transfer credits decrease and respective unit costs increase. However, the changes in the number of credits available and respective prices do not significantly alter the implications for trading under the baseline cases for Allatoona-1 and Allatoona-2.

NPS Scenario H: NPS Costs Inflated 35%, Retirement Ratio 10%, and 25% of Litter P Loads Accounted for by Urban Loads:

Tables D.16 and D.17 show the NPS credit analyses for NPS Scenario H. This scenario examines trading for Lake Allatoona when the conditions from NPS Scenarios E and G exist together. The results suggest that the implications for trading are the same as those under the baseline cases. Alpha trades with poultry litter transfer producers in the Upper Etowah sub-watershed are still available and offer the best options for PSs. When trading is restricted to the individual sub-watershed level in Allatoona-2, alpha trades are unavailable for Woodstock. Although these factors decrease the overall cost savings to the watershed, they alone do not restrict trading.

Worst Case Scenario:

The PS scenario that provides the least favorable conditions for trading is PS Scenario B. This scenario estimates the lowest unit compliance costs for both PSs. Woodstock is primarily impacted since its unit cost of compliance under these conditions ($22) is fairly close in price to the available NPS credits. The NPS case that provides the worst conditions for trading is NPS Scenario A.1 with a trading ratio of 4:1. However, even if these two scenarios both existed, trading would still occur under Allatoona-1. There are a large number of poultry litter credits available in the Upper Etowah sub-watershed with a unit price less than or equal to $15. In this case, as well as the baseline case, restricting trading to individual sub-watersheds eliminates the possibility of trading for Woodstock, but still leaves Canton with a functioning market.

Best Case Scenario:

The PS scenario that provides the most favorable conditions for trading is PS Scenario D. This scenario introduces an additional two PSs into the market and has the highest demand of credits, 19,274. The NPS case that provides the best conditions for trading is NPS Scenario A.2 with a trading ratio of 1:1. This case provides double the number of credits for supply for half the price as under the baseline case. However, the spatial expansion of markets across all sub-watersheds must be allowed for these conditions to be favorable for the three PSs in the Little/Noonday sub-watershed. In this best case scenario, as well as the baseline scenarios, restricting trading to individual sub-watersheds eliminates the possibility of trading for PSs in the Little/Noonday sub-watershed, but still leaves Canton with a functioning market in the Upper Etowah sub-watershed.

5.3. Weiss Lake – Sensitivity Analysis

Similar to the Lake Allatoona analysis, Appendix C Tables C.5 – C.8 summarize the results for PSs for each Weiss Lake sensitivity analysis scenario; NPS results are summarized in Appendix D Tables D.18 – D.28. The implications of changing these select parameters are summarized below. As done for Lake Allatoona, PS scenarios are summarized individually and compared against the baseline case for NPSs for determining the impact on alpha trades. The same steps are performed for NPSs. A worst case scenario is described.

5.3.1. Weiss PSs

PS Scenario A: PS Costs Inflated 35%

Table C.5 displays the credit summary for Scenario A. Increased PS costs increase the unit cost of abatement, but do not change any of the fundamental implications for trading in Weiss-1 vs Weiss-2 as seen in the baseline case. Conditions in PS Scenario A just increase the cost savings PSs realize through trading. As before, limiting trading to state boundaries in Weiss-2 restricts trading, whereas expansion across these borders provide opportunities for alpha trades. Rome Blacks Bluff and Lafayette are the only PSs with credit prices less than alpha trade level of $21 and comprise approximately 10 percent of the credits demanded in the Weiss markets. PS costs would have to increase approximately 110 percent from the baseline costs to entice these PSs into trading with Alabama litter producers.

PS Scenario B: PS Costs Deflated 35%

Table C.6 displays the credit summary for PS Scenario B. Due the fall in unit compliance costs, the case for an interstate trading framework is not quite as strong as in the baseline case. Many of the Georgia PSs now have unit compliance costs that are very close to the Alabama litter transfer price of $21. At a credit price of $21, total savings for Georgia PSs falls from $26.2M in the baseline case to $4.4 M in this PS scenario. Of the two PSs with the greatest need for credits (Calhoun and Cartersville), only Calhoun still benefits from trades with Alabama poultry litter transfers. The cost savings for Calhoun is still significant at $2,433,479 per year. Even with these conditions, an interstate trading framework does allow for significant cost savings for select PSs, where a market that restricts trading to state boundaries limits trading for Georgia PSs.

Figure C.2 shows the total credits demanded in the Weiss markets as these PS costs are deflated from 100 percent of baseline costs to 0 percent, assuming a credit price of $21. The first major drop-off in credits demanded occurs once PS costs fall to 69 percent of their current estimates; at this point, total credits demanded decreases by 39 percent from the baseline case. The next big drop-off in credits demanded is at 40 percent of current cost estimates; at this point, total credits demanded decreases by 89 percent from the baseline case. These results show that the main implications of trading in Weiss-1 vs. Weiss-2 are fairly resilient to changes in PS cost estimates; even with significant decreases in PS cost estimates, an interstate trading framework supports a large number of alpha trades.

PS Scenario C: TMDL Requirements Tightened to 75% of Current

Table C.7 displays the credit summary for PS Scenario C. Tightening the TMDL limits on PSs would require reductions from two additional PSs: Piedmont WWTP and Dallas North WPCP. The total credits demanded across all markets increases to 809,226 per year. As with similar PS scenarios for Lake Allatoona, tightening TMDL regulations decreases unit compliance costs for PSs that required reductions in the baseline scenario. Again, this decrease in cost is attributed to the block structure of PS upgrades. The unit cost decrease is not great enough to change the implications of trading in Weiss-1 vs Weiss-2 as seen in the baseline scenario. An interstate trading framework provides opportunities for trading where they otherwise may not exist.

PS Scenario D: TMDL Requirements Tightened to 50% of Current

Table C.8 displays the credit summary for PS Scenario D. Further tightening of TMDL requirements requires reductions from the same additional PSs as Scenario C: Piedmont WWTP and Dallas North WPCP. As in PS Scenario C, cost savings from trading fall for PSs that required reductions in the baseline scenario. However, the majority of Georgia PSs still benefit from Alabama poultry litter transfer credits. The main implications from the baseline scenario still hold.

5.3.2. Weiss NPSs

NPS Scenario A.1: NPS:PS changed to 4:1

Table D.18 shows the NPS credit supply if the baseline case is adjusted with a NPS:PS ratio of 4:1. This change doubles NPS credit prices and cuts the supply in half. In the baseline scenario, litter transfers from Alabama are cheap enough (at $21 per credit) to provide a good source of alpha trades for Georgia PSs. In this NPS scenario, the increase in NPS credit prices limit the number of alpha trades available for several Georgia PSs. However, large Georgia PSs such as Rockmart and Calhoun still benefit from an interstate trading framework under this NPS scenario. Thus, although the conditions limit some trades, the implications for trading under Weiss-1 vs Weiss-2 remain the same; expansion of markets across state lines allows for trades where they would otherwise not exist.

NPS Scenario A.2: NPS:PS changed to 1:1

Table D.19.A shows the NPS credit analysis for NPS Scenario A.2. If the baseline case is adjusted to have a NPS:PS ratio of 1:1, the quantity of available credits doubles and the price per credit is cut in half from the baseline case. The number of Georgia NPS credits now available, 631,406 is a substantial quantity. However, even if all the manure generated is exported, this number falls below the quantity of credits demanded by Georgia PSs. Thus, this scenario may provide more opportunities for alpha trades with Georgia poultry litter transfers, but credits from Alabama or Tennessee are ultimately needed to satisfy demand. Thus, the same implications from the baseline case hold in this scenario. A spatial expansion of markets across state lines allows for a functional trading framework whereas a restriction of trading to state boundaries inhibits the ability of PSs to find sufficient supply of credits for alpha trades.

NPS:PS from 1:1 to 30:1 for Alabama Litter Producers

Figure D. 3 and Table D.19.B show how the supply of credits for Litter producers in the Alabama counties of Cleburne, De Kalb, and Etowah changes as the NPS:PS ratio is adjusted from 1:1 up to 30:1. These producers are analyzed since they represent the most likely supply component for alpha trades in the Weiss markets. The figures and table show corresponding average credit prices for these producers. The demand of credits at these average credit prices is also included. At a NPS:PS of 3:1, the credit price increases to $31, which is the credit price where the first big drop-off in credits demanded occurs (see Figure D.4). At $31, there is a decrease of 266,213 credits from the 675,842 credits demanded at the 2:1 NPS:PS ratio; this is a 39 percent decrease. The next large drop-off in credits demanded occurs at a NPS:PS ratio of approximately 5:1; at this ratio, the credit price is $52. Demand falls an additional 319,524 credits from the credits demanded at 3:1; this is a 78 percent decrease from the credits demanded at 3:1. Thus, this 5:1 NPS:PS ratio is identified as the level in which the market loses a significant number of alpha trades from the baseline case. An increase in the NPS:PS ratio to 5:1

increases NPS credit prices to a level where most Georgia PSs will no longer participate in trading with Alabama litter stakeholders.

If the NPS:PS ratio is adjusted in the opposite direction towards 1:1, Figure D.3 shows there is little change to the number of alpha trades. The credits supplied by these Alabama litter producers doubles to 46,180, but the percentage change in demand resulting from the decrease in the average credit price is only 1.2%. At 1:1, NPS credits are now cheaper than unit compliance costs for Lafayette; under the 2:1 scenario, these credits were more expensive than upgrading the facility.

NPS Scenario B: Retirement Ratio: 10%

Table D.20 shows the NPS credit analysis for NPS Scenario B. As seen with Lake Allatoona, applying this retirement ratio cuts the supply of credits by 10 percent and increases the price per credit by 10 percent. However, the application of this ratio does not substantially alter the results for trading under Weiss-1 vs. Weiss-2. The poultry litter transfer credits available in the Weiss-Alabama market still serve as the best source for alpha trades for Georgia PSs.

NPS Scenario C: NPS Costs Inflated 35%

Table D.21 shows the NPS credit analysis for NPS Scenario C. As before, this scenario only alters costs so that the credits supplied by NPSs are of the same quantity as those in the baseline case. Increased NPS costs make some alpha trades a little less likely, such as those between Cartersville ($30) and Alabama litter transfers ($28). However, as in Scenarios A.1 and B, the increase in BMP cost does not substantially alter the implications for trading under Weiss-

1 vs. Weiss-2; an interstate trading framework promotes alpha trades that would otherwise not exist. As detailed in the section above regarding trading at various NPS:PS ratios, credit prices of $31 and $52 are prices at which the volume of trading significantly decreases. The $21 credit price for examining alpha trades with litter producers in the Alabama would need to increase by 48 percent to reach the $31 credit price and 148 percent for the $52 credit price.

NPS Scenario D: NPS Costs Deflated 35%

Table D.22 shows the NPS credit analysis for NPS Scenario D. Like NPS Scenario C, this scenario only alters costs and so the credits supplied by NPSs are of the same quantity as those in the baseline case. The results show that the prices for litter transfer credits drop across the board. However, the basic implications from the baseline scenario still hold. Even though there are cheap NPS credits available in Georgia, there are not enough Georgia NPS credits to meet Georgia PS demand. As detailed in the sections above regarding changes to PS cost estimates, Rome Blacks Bluff and Lafayette are the only PSs with credit prices less than $21 and comprise approximately 10 percent of the credits demanded in the Weiss markets. NPS costs would have to decrease approximately 50 percent from the baseline costs to entice these PSs into trading with Alabama litter producers.

NPS Scenario E: NPS Costs Inflated 35% and Retirement Ratio 10%

Table D.23 shows the credit analysis for NPS Scenario E. This scenario alters both NPS credit quantities and costs. The combination of a retirement ratio and higher BMP costs decrease the number of alpha trades available to PSs in both Alabama and Georgia. However, even with a higher unit credit price for Alabama litter transfer ($31), Georgia PSs such as Calhoun realize significant cost savings with an interstate trading program. Although the number of alpha trades and PS cost savings decrease in this scenario, the main implications of trading in Weiss-1 vs. Weiss-2 still hold.

NPS Scenario I: P-Loads per Ton Manure (Min from Allatoona)

Table D.24 shows the credit analysis for NPS Scenario I. This scenario significantly impacts the ability of PSs to find alpha trades. As one can see from the results, the prices for NPS credits jump substantially. In the baseline case, the average price per credit across all markets is $42. In this scenario, the price jumps to $104. The price per credit in De Kalb, Alabama jumps to $50, which is too expensive for alpha trades for the two largest PSs, Canton and Calhoun. However, even at $50 the abundant quantity of Alabama credits allow for alpha trades with a few Georgia PSs including City of Rockmart and Trion WPCP. Although a few PSs benefit from an interstate trading framework, the lower estimate of total P per ton of manure severely limits trading for many PSs.

NPS Scenario J: P-Loads per Ton Manure (Max from Allatoona)

Table D.25 shows the credit analysis for NPS Scenario J. As one can see from the results, prices for NPS credits decrease substantially and the number of available credits increases. Although the number of GA NPS credits jumps to 620,875 from 315,703, this quantity is still below the number of credits demanded. The implications for trading in Weiss-1 vs. Weiss-2 still hold, an expansion of markets across state lines yields alpha trades where they would otherwise not exist.

NPS Scenario K: Delivery Ratio (Min from Allatoona)

Table D.26 shows the credit analysis for NPS Scenario K. As one can see from the results prices for NPS credits increase and the number of available credits decrease. However, the price increase is less than that in NPS Scenario I. Thus, the implications from the baseline scenario still hold; poultry litter transfers from Alabama still provide the best means for securing alpha trades for most Georgia PSs.

NPS Scenario L: Delivery Ratio (Max from Allatoona)

Table D.27 shows the credit analysis for NPS Scenario L. Similar to NPS Scenario J, prices for NPS credits decrease and the number of available credits increase. However, the number of NPS credits in Georgia is still lower than the demand from Georgia PSs. Thus, the implications from the baseline scenario still hold; poultry litter transfers from Alabama provide the best means for securing alpha trades for most Georgia PSs.

NPS Scenario M: P-Loads per Ton Manure (Min from Allatoona); Delivery Ratio (Min from Allatoona)

Table D.28 shows the credit analysis for NPS Scenario M. In this NPS scenario, the implications from the baseline scenario no longer hold. Calculating credits using the specified criteria make Alabama NPS credits too expensive for almost all Georgia PSs. Emerson Pond is the only Georgia PS that may still benefit from alpha trades with Alabama litter transfer producers. However, Emerson Pond is able to find a sufficient supply of credits in Georgia in Scenario Weiss-2. Other PSs in Georgia may benefit from PS-to-PS trading since the cost of a PS credit will likely be less than the extremely high NPS credit price in this scenario. Thus, in this NPS scenario, the argument for an expansion of markets across state lines no longer holds; an interstate trading framework yields no more alpha trades than a framework confined to state boundaries.

Worst Case Scenario:

As with Lake Allatoona, the PS scenario that provides the least favorable conditions for trading is PS Scenario B. This scenario estimates the lowest unit compliance costs for all PSs. The NPS case that provides the worst conditions for trading is clearly NPS Scenario M. Taken together, these conditions yield a very limited number of opportunities for interstate or even PS-to-NPS trading. The definition of trading boundaries is no longer the primary factor in determining the potential for trading.

Best Case Scenario:

As with Lake Allatoona, the PS scenario that provides the most favorable conditions for trading is PS Scenario D. This scenario provides the highest demand of PS credits. The NPS case that provides the best conditions for trading is clearly NPS Scenario A.2. Taken together, these conditions yield a very active market with a large number of credits traded. However, the definition of trading boundaries is still the primary factor for determining whether or not the demand from PSs can be met by NPS supply. Trading boundaries that are restricted to state lines particularly inhibit the ability of Georgia PSs to find sufficient alpha trades with NPSs. While PSs in Georgia may be able to find PS-to-PS trades, an interstate trading framework allows for the greatest number of PS-to-NPS alpha trades.

5.4. Conclusions

5.4.1. Lake Allatoona

Overall, findings from the baseline scenarios suggest that restricting trading to tight ecological boundaries has a negative impact on the potential for trading in Lake Allatoona. As recognized by the 2009 draft TMDL, water quality standards for Lake Allatoona cannot be achieved through further PS reductions alone. However, for PSs that face additional reductions, a trading framework that allows trades across all of Lake Allatoona's sub-watersheds offers significant cost savings. Limiting trading to individual sub-watersheds impacts the ability of one PS (Woodstock) to find alpha trades. Other PSs are not impacted by this restriction because they can either find a sufficient supply of cheap credits in their sub-watershed (Canton) or are currently discharging below their TMDL limit (all others).

The biggest impact of restricting trading to the sub-watershed level for Lake Allatoona could be on future PSs or current PSs that experience significant increases in loads. The 2009 draft TMDL offers nutrient trading as a means for offsetting these future PS loads. However, results suggest that trading options for additional PS loads could be limited if ecological boundaries for trading are defined on a sub-watershed level. Very few, if any, cheap credits are available within Acworth/Allatoona, Little/Noonday, Owl/Kellogg, Shoal Creek, and Stamp/Rowland. To meet future and/or current demand, a trading framework for Lake Allatoona will likely need to include NPS stakeholders from the Upper Etowah sub-watershed. Otherwise, new PSs or PSs with increased loads within one of these five sub-watersheds would likely face a scarcity of alpha trades.

The results from the sensitivity analysis show that the implications from the baseline scenarios still hold when fundamental market assumptions are adjusted. Even under market conditions that provide a Worst Case Scenario, trading would occur in a Lake Allatoona framework that allows trades across sub-watersheds. The results of the sensitivity analysis show that although changes to fundamental market assumptions may reduce the cost savings from trading in Lake Allatoona, these assumptions alone do not impact trading enough to eliminate alpha trades. It is the ecological definition of trading that primarily determines the potential for trading in Lake Allatoona. In this case, tight ecological boundaries provide the greatest barrier to trading.

5.4.2. Weiss Lake

For Weiss Lake, the baseline results show that restricting trading by political boundaries has a negative impact on the potential for trading. In this case, PSs in Georgia are separated from the majority of cheap NPS credits in Alabama. When trading is restricted to individual states, the majority of PSs that require reductions have limited alpha trades available with NPSs. However, the expansion of trading across these political boundaries unlocks potential trades. Further information from the Coosa River Modeling Project will provide insight into the accuracy of market assumptions and the ability of trading to meet water quality goals for the lake. Nonetheless, a large PS presence in Georgia and a large NPS supply of credits in Alabama suggest the need for an interstate trading framework. Cooperation between Alabama and Georgia policy makers could help make trading a cost-effective solution for meeting water quality standards for the lake.

The results of the sensitivity analysis for Weiss Lake show that political boundaries act as the primary barrier for trading in Weiss Lake. For almost all scenarios, an interstate trading program allows for a functional PS-to-NPS market, whereas restricting trading to state boundaries severely limits the opportunities for trades. However, as seen in NPS scenario M, changes to certain baseline assumptions can also restrict trading for Weiss Lake. In the Worst Case scenario, assumptions regarding the calculation of credits are the primary factors that restrict trading; in this case, political boundaries are no longer the primary barrier for trading. Nevertheless, for the majority of scenarios, a spatial expansion of markets across state lines allows for alpha trades that would otherwise not exist.

5.4.3. Summary

As discussed in Chapter 1, the main objective of this research is to answer the question: What are the effects of ecological and political boundaries on the potential for trading in Lake Allatoona and Weiss Lake respectively? The results clearly point to the answer that the delineation of market boundaries is the primary determinant regarding the potential for trading in Lake Allatoona and Weiss Lake. If policy makers move forward with trading frameworks for these two lakes, it is clear that the definition of market boundaries should be a primary concern.

The outcome of this research is not surprising considering previous theoretical discussions regarding the limiting effects of confining trading markets to small geographical scales. However, this research adds to the literature by providing an example of two potential trading frameworks and the crucial effects these boundaries have on potential alpha trades. Much of the literature on barriers to trading focuses on the inhibiting effects of trading ratios, market structures, and transaction costs. Although these factors are important to these two frameworks, the key element for trading stems from the definition of market boundaries. Results suggest the need for more attention to this element of trading.

These findings provide policy makers with more information regarding the potential for trading in Lake Allatoona and Weiss Lake. It is particularly worth noting that the language of the 2009 draft TMDL for Lake Allatoona suggests an expectation that nutrient trading will be able to meet future load limits. However, as seen in the results, PSs could face obstacles with regards to thin markets if trading boundaries are defined on the sub-watershed level. A TMDL that allows the expansion of markets across these ecological boundaries promotes more trading opportunities. For Weiss Lake, political boundaries limit trading opportunities; a TMDL that recognizes an interstate trading framework provides opportunities for alpha trades that otherwise do not exist. In each framework, the potential for significant cost savings should provide the impetus for further economic research into the potential for trading.

5.4.4 Suggestions for Future Research

Results provide a thorough first look at the key economic components of trading frameworks for Lake Allatoona and Weiss Lake. This step provides a launching point for a number of further trading research questions. A sample is provided below:

- Key market participants have been identified for each framework. How can these stakeholders be engaged and how likely is it that they will participate in trading?
- What should the baseline trading practices be for NPSs in each framework? What are the effects of these baselines on stakeholders? What are the effects of these baselines on the potential for trading?
- What are the implications for trading when CAFOs and MS4s are considered as potential market participants? Is it possible to have accurate data on these CAFOs and MS4s to

include them as individual market participants? What should be the baselines for these participants?

- How can other initiatives in the applicable watersheds be incorporated into trading frameworks?
- What market structure is best for each trading framework?
- How do changes in future population levels and land use affect trading in these watersheds?
- The results of the Coosa River Modeling project will allow for updates to credit calculations for Agriculture, Urban, and Litter stakeholders. Would new credit calculations affect the findings of this research?
- Can abatement estimates for primary stakeholders be improved?
- Can modeled flow and fate of nutrients be improved?
- Lake Allatoona's 2009 draft TMDL addresses total P as well as total N to the lake. In addition, Weiss Lake's TMDL mentions that reductions in total P will likely result in the necessary reductions in total N. Should a trading framework include a separate market for total N as a commodity? Do the same implications of how market boundaries are defined hold for a framework that trades total N?
- Since the Upper Etowah sub-watershed is an essential component of the Lake Allatoona trading framework, what steps would needed to establish a pilot program in this sub-watershed? Is such a pilot program feasible?
- For Lake Allatoona, litter transfer out of the Upper Etowah sub-watershed is the least cost method for reducing total P loads to the lake. Is trading the best means to reduce

these loads? Or is another policy choice a better option? What equity implications exist for each policy choice?

- Can a single trading framework unite both Lake Allatoona and Weiss Lake? Would such a framework be viable?
- Can a similar trading framework be established for Carters Lake in Georgia? Does enough ecological data exist to perform a similar economic analysis?

These questions provide an example of the number of questions still facing these trading frameworks. Estimated cost savings, especially of spatially expanded markets, suggest these questions and other continuations of this research are worth pursuing.

Table 5.1. Credit Summary - Lake Allatoona Point Sources

Point Source	Sub-watershed	Total Reduction to meet TMDL (lbs/yr)	Credits Supplied[1]	Credits Demanded[2]	Max Unit Cost for Demand[1,2]	Cost of Compliance (Upgrade Facility)	Cost Savings with Credit at $12
Cobb County Northwest WPCP	Acworth/Allatoona	-3,527	-	-	-	-	-
Total by sub-watershed (Average)		**-3,527**	**-**	**-**	**-**	**-**	**-**
Cherokee County Fitzgerald Creek	Little/Noonday	-160	-	-	-	-	-
Cherokee County Rose Creek	Little/Noonday	-4,763	-	-	-	-	-
Cobb County Noonday Creek WPCP	Little/Noonday	-4,704	-	-	-	-	-
Fulton County Little River WPCP	Little/Noonday	-1,004	-	-	-	-	-
Woodstock Rubes Creek WPCP	Little/Noonday	2,179	5,923	2,179	$34	$73,096	$46,949
Total by sub-watershed (Average)		**-8,452**	**5,923**	**2,179**	**($34)**	**$73,096**	**$46,949**
Big Canoe WPCP	Upper Etowah	-728	-	-	-	-	-
City of Canton WPCP	Upper Etowah	12,165	-	12,165	$157	$1,906,039	$1,760,054
Goldkist Poultry Byproducts	Upper Etowah	-2,128	-	-	-	-	-
Jasper WPCP	Upper Etowah	-2,435	-	-	-	-	-
Total by sub-watershed (Average)		**6,874**	**-**	**12,165**	**($157)**	**$1,906,039**	**$1,760,054**
Total for Lake Allatoona (Average)		**-5,104**	**5,923**	**14,344**	**($95)**	**$1,979,134**	**$1,807,003**

[1] Credits Supplied equals number of credits available if PS chooses to upgrade to meet TMDL compliance; cost to supply will be ≥ $0 depending on market demand. If PS chooses to upgrade and credits supplied equals 0, then Jiang et al. maximum upgrade can not meet TMDL reduction needed; demand costs reflect maximum available upgrade.

[2] Credits Demanded equals number of credits needed to meet TMDL compliance; Max Unit Cost for Demand equals unit compliance cost.

Table 5.2. Credit Summary - Lake Allatoona Non-point Sources (Agricultural and Urban)

					Range of Credit Supply[2]			Range of Credit Prices[2]		
Sub-watershed	**Land Cover**	**BMP[1]**	**Supply Credits (lbs/ year)**	**Min Credit Price (Unit Price)**	**Min (lbs/year)**	**Avg (lbs/year)**	**Max (lbs/year)**	**Min ($/credit)**	**Avg ($/credit)**	**Max ($/credit)**
Acworth/Allatoona	Cropland		-	-	-	-	-	-	-	-
Acworth/Allatoona	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	95	$88	4	45	95	$88	$1,099	$3,864
Acworth/Allatoona	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	86	$2,872	13	13	86	$2,872	$36,292	$125,845
Acworth/Allatoona	Urban (Highly)	Highly Developed: Restored Riparian Buffer	485	$6,113	138	461	623	$6,113	$23,049	$65,243
Acworth/Allatoona	Urban (Less)	Less Developed: Restored Riparian Buffer	289	$4,402	83	275	371	$4,402	$33,507	$73,829
		Total by Sub-watershed (Average)	**955**	**($3,369)**	**238**	**794**	**1,176**	**($3,369)**	**($23,487)**	**($67,196)**
Little/Noonday	Cropland	Cropland: Riparian Buffers (Forested)	299	$6	44	243	375	$6	$86	$215
Little/Noonday	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	2,197	$155	87	1,034	2,197	$155	$1,766	$6,763
Little/Noonday	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	431	$4,758	63	63	431	$4,758	$58,916	$207,872
Little/Noonday	Urban (Highly)	Highly Developed: Restored Riparian Buffer	5,932	$1,406	1,695	5,650	7,627	$1,406	$5,450	$14,921
Little/Noonday	Urban (Less)	Less Developed: Restored Riparian Buffer	2,649	$1,422	757	2,522	3,405	$1,422	$11,071	$24,649
		Total by Sub-watershed (Average)	**11,508**	**($1,549)**	**2,646**	**9,512**	**14,036**	**($1,549)**	**($15,458)**	**($50,884)**
Owl/Kellogg	Cropland		-	-	-	-	-	-	-	-
Owl/Kellogg	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	37	$157	2	18	37	$157	$1,689	$6,861
Owl/Kellogg	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	7	$6,281	1	1	7	$6,281	$77,764	$274,422
Owl/Kellogg	Urban (Highly)	Highly Developed: Restored Riparian Buffer	71	$1,202	20	67	91	$1,202	$10,099	$22,091
Owl/Kellogg	Urban (Less)	Less Developed: Restored Riparian Buffer	41	$14,995	12	39	53	$14,995	$56,707	$158,590
		Total by Sub-watershed (Average)	**157**	**($5,659)**	**35**	**125**	**188**	**($5,659)**	**($36,565)**	**($115,491)**
Shoal Creek	Cropland		-	-	-	-	-	-	-	-
Shoal Creek	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	3,022	$39	40	1,369	3,022	$39	$698	$1,717
Shoal Creek	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	171	$2,209	25	25	171	$2,209	$27,372	$96,508
Shoal Creek	Urban (Highly)	Highly Developed: Restored Riparian Buffer	271	$935	78	258	349	$935	$4,510	$9,365
Shoal Creek	Urban (Less)	Less Developed: Restored Riparian Buffer	234	$656	67	223	301	$656	$6,096	$14,563
		Total by Sub-watershed (Average)	**3,699**	**($960)**	**210**	**1,876**	**3,843**	**($960)**	**($9,669)**	**($30,538)**
Stamp/Rowland	Cropland		-	-	-	-	-	-	-	-
Stamp/Rowland	Pasture (Litter)		-	-	-	-	-	-	-	-
Stamp/Rowland	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	35	$5,374	5	5	35	$5,374	$67,142	$235,099
Stamp/Rowland	Urban (Highly)	Highly Developed: Restored Riparian Buffer	46	$3,654	13	44	59	$3,654	$20,094	$36,345
Stamp/Rowland	Urban (Less)	Less Developed: Restored Riparian Buffer	30	$4,029	8	28	38	$4,029	$40,313	$98,732
		Total by Sub-watershed (Average)	**110**	**($4,352)**	**27**	**77**	**132**	**($4,352)**	**($42,516)**	**($123,392)**
Upper Etowah	Cropland	Cropland: Riparian Buffers (Forested)	532	$82	78	433	667	$82	$1,261	$3,109
Upper Etowah	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	82,516	$22	890	37,256	82,516	$22	$514	$1,022
Upper Etowah	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	4,461	$576	654	654	4,461	$576	$7,286	$25,250
Upper Etowah	Urban (Highly)	Highly Developed: Restored Riparian Buffer	3,459	$800	988	3,294	4,447	$800	$4,028	$7,916
Upper Etowah	Urban (Less)	Less Developed: Restored Riparian Buffer	1,869	$945	534	1,780	2,404	$945	$9,024	$21,762
		Total by Sub-watershed (Average)	**92,837**	**($485)**	**3,145**	**43,418**	**94,494**	**($485)**	**($4,423)**	**($11,812)**
		Total for Lake Allatoona (Average)	**109,266**	**($2,527)**	**6,300**	**55,803**	**113,869**	**($2,527)**	**($20,233)**	**($61,462)**

[1] BMP represents the BMP with lowest credit price by land cover type.

[2] Range of Credit Supply and Credit Prices are for all BMPs by land cover type.

Table 5.3. Credit Analysis - Lake Allatoona Litter Transfer

Sub-watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Acworth/Allatoona	Litter Transport from: BARTOW	59.15	$27
Acworth/Allatoona	Litter Transport from: CHEROKEE	30.30	$27
Acworth/Allatoona	Litter Transport from: COBB	-	-
Acworth/Allatoona	Litter Transport from: PAULDING	42.85	$27
	Total by Sub-watershed (Average)	**132.31**	**($27)**
Little/Noonday	Litter Transport from: CHEROKEE	1,331.85	$29
Little/Noonday	Litter Transport from: COBB	-	-
Little/Noonday	Litter Transport from: FORSYTH	71.43	$52
Little/Noonday	Litter Transport from: FULTON	-	$0
	Total by Sub-watershed (Average)	**1,403.28**	**($41)**
Owl/Kellogg	Litter Transport from: CHEROKEE	92.84	$29
Owl/Kellogg	Litter Transport from: COBB	-	-
	Total by Sub-watershed (Average)	**92.84**	**($29)**
Shoal Creek	Litter Transport from: BARTOW	26.79	$8
Shoal Creek	Litter Transport from: CHEROKEE	3,146.59	$8
Shoal Creek	Litter Transport from: PICKENS	904.54	$8
	Total by Sub-watershed (Average)	**4,077.92**	**($8)**
Stamp/Rowland	Litter Transport from: BARTOW	-	-
Stamp/Rowland	Litter Transport from: CHEROKEE	-	-
	Total by Sub-watershed (Average)	**-**	**($0)**
Upper Etowah	Litter Transport from: CHEROKEE	7,813.69	$7
Upper Etowah	Litter Transport from: DAWSON	67,102.34	$8
Upper Etowah	Litter Transport from: FANNIN	70.64	$32
Upper Etowah	Litter Transport from: FORSYTH	8,400.74	$12
Upper Etowah	Litter Transport from: GILMER	2,853.24	$7
Upper Etowah	Litter Transport from: LUMPKIN	10,698.01	$10
Upper Etowah	Litter Transport from: PICKENS	32,650.88	$6
Upper Etowah	Litter Transport from: UNION	-	-
	Total by Sub-watershed (Average)	**129,590**	**($12)**
	Total for Lake Allatoona (Average)	**135,296**	**($19)**

Table 5.4. Credit Summary - Weiss Lake Point Sources

Weiss Market	Point Source	Watershed	Total Reduction to meet TMDL (lbs/yr)	Credits Supplied[1]	Credits Demanded[2]	Max Unit Cost for Demand[1,2]	Cost of Compliance (Upgrade Facility)	Cost Savings with Credit at $21
Weiss-Alabama								
	Cherokee WPCP	Upper Coosa, AL	-2,002	-	-	-	-	-
	Piedmont WWTP	Upper Coosa, AL	-623	-	-	-	-	-
	Town of Cedar Bluff WWTP	Upper Coosa, AL	-2,619	-	-	-	-	-
	Town of Centre WWSB Lagoon	Upper Coosa, AL	3,304	1,722	3,304	$23	$75,685	$6,292
	Total by sub-watershed (Average)		**-1,940**	**1,722**	**3,304**	**($23)**	**$75,685**	**$6,292**
Weiss-Georgia								
	Chatsworth WPCP	Conasauga, GA	3,231	6,492	3,231	$25	$79,902	$12,055
	Dow Chemical Co	Conasauga, GA	-2,821	-	-	-	-	-
	Ellijay-Gilmer Water & Sewer	Conasauga, GA	65,410	-	65,410	$35	$2,267,812	$894,202
	Cartersville WPCP	Lower Etowah	259,678	-	259,678	$30	$7,851,456	$2,398,224
	City of Rockmart	Lower Etowah	28,821	-	28,821	$89	$2,564,347	$1,959,106
	Dallas North WPCP	Lower Etowah	-176	-	-	-	-	-
	Dallas West WPCP	Lower Etowah	1,641	1,600	1,641	$32	$52,676	$18,224
	Emerson Pond	Lower Etowah	192	3,048	192	$274	$52,676	$48,636
	Rome Blacks Bluff WPCP	Lower Etowah	69,650	20,828	69,650	$10	$679,292	-$783,357
	Adairsville South WPCP	Oostanaula	34,575	-	34,575	$40	$1,378,207	$652,134
	Calhoun WPCP	Oostanaula	192,420	-	192,420	$52	$9,960,462	$5,919,641
	City of Adairsville - North	Oostanaula	24,086	-	24,086	$52	$1,249,730	$743,919
	OMNOVA Solutions Inc	Oostanaula	-3,017	-	-	-	-	-
	Cave Spring WPCP	Upper Coosa, GA	-2,136	-	-	-	-	-
	City of Cedartown	Upper Coosa, GA	18,146	295	18,146	$52	$947,030	$565,956
	City of Summerville WPCP	Upper Coosa, GA	1,392	5,090	1,392	$48	$66,289	$37,063
	Geo Specialty Chemicals	Upper Coosa, GA	-886	-	-	-	-	-
	Inland Rome (Outfall 001)	Upper Coosa, GA	4,056	-	4,056	-	-	-
	Inland Rome (Outfall 002)	Upper Coosa, GA	-10,050	-	-	-	-	-
	Lafayette WPCP	Upper Coosa, GA	8,217	3,125	8,217	$11	$86,709	-$85,856
	Rome-Coosa WPCP	Upper Coosa, GA	1,062	5,419	1,062	$62	$66,289	$43,985
	Trion WPCP	Upper Coosa, GA	41,883	-	41,883	$90	$3,750,487	$2,870,933
	Total by sub-watershed (Average)		**735,374**	**45,898**	**754,460**	**($60)**	**$31,053,363**	**$15,294,866**
	Total for Weiss Markets (Average)		**733,435**	**47,620**	**757,765**	**($58)**	**$31,129,047**	**$15,301,157**

[1] Credits Supplied equals number of credits available if PS chooses to upgrade to meet TMDL compliance; cost to supply will be ≥ $0 depending on market demand. If PS chooses to upgrade and credits supplied equals 0, then Jiang et al. maximum upgrade can not meet TMDL reduction needed; in these circumstances, demand costs reflect maximum available upgrade.

[2] Credits Demanded equals number of credits needed to meet TMDL compliance. Max Unit Cost for Demand equals unit compliance cost; costs only shown for wastewater treatment plants.

Table 5.5. Credit Analysis - Weiss Lake Litter Transfer

Market	Watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Weiss-Alabama				
	Upper Coosa, AL	Litter Transport from: CALHOUN, AL	1,105,297	$90
	Upper Coosa, AL	Litter Transport from: CHEROKEE, AL	13,308,289	$90
	Upper Coosa, AL	Litter Transport from: CLEBURNE, AL	3,692,124	$21
	Upper Coosa, AL	Litter Transport from: DE KALB, AL	19,288,751	$21
	Upper Coosa, AL	Litter Transport from: ETOWAH, AL	109,344	$21
		Total by Weiss Market (Average)	**37,503,805**	**($48)**
Weiss-Georgia				
	Conasauga, GA	Litter Transport from: CATOOSA	6	$19
	Conasauga, GA	Litter Transport from: FANNIN	672	$69
	Conasauga, GA	Litter Transport from: GILMER	626	$16
	Conasauga, GA	Litter Transport from: GORDON	3,145	$36
	Conasauga, GA	Litter Transport from: MURRAY	19,192	$24
	Conasauga, GA	Litter Transport from: WALKER	390	$24
	Conasauga, GA	Litter Transport from: WHITFIELD	24,064	$24
	Coosawattee	Litter Transport from: BARTOW	6,051	$15
	Coosawattee	Litter Transport from: CHEROKEE	599	$14
	Coosawattee	Litter Transport from: DAWSON	177	$16
	Coosawattee	Litter Transport from: FANNIN	151	$69
	Coosawattee	Litter Transport from: GILMER	78,740	$16
	Coosawattee	Litter Transport from: GORDON	39,851	$36
	Coosawattee	Litter Transport from: MURRAY	3,694	$24
	Coosawattee	Litter Transport from: PICKENS	14,760	$14
	Oostanaula	Litter Transport from: BARTOW	2,781	$15
	Oostanaula	Litter Transport from: CHATTOOGA	-	-
	Oostanaula	Litter Transport from: FLOYD	7,190	$111
	Oostanaula	Litter Transport from: GORDON	35,500	$36
	Oostanaula	Litter Transport from: WALKER	7,557	$24
	Oostanaula	Litter Transport from: WHITFIELD	945	$24
	Lower Etowah	Litter Transport from: BARTOW	21,945	$15
	Lower Etowah	Litter Transport from: COBB	-	-
	Lower Etowah	Litter Transport from: FLOYD	5,250	$111
	Lower Etowah	Litter Transport from: HARALSON	6	$69
	Lower Etowah	Litter Transport from: PAULDING	4,365	$15
	Lower Etowah	Litter Transport from: POLK, GA	7,109	$90
	Upper Coosa, GA	Litter Transport from: CHATTOOGA	-	-
	Upper Coosa, GA	Litter Transport from: DADE	315	$24
	Upper Coosa, GA	Litter Transport from: FLOYD	7,923	$111
	Upper Coosa, GA	Litter Transport from: HARALSON	511	$69
	Upper Coosa, GA	Litter Transport from: POLK, GA	8,798	$90
	Upper Coosa, GA	Litter Transport from: WALKER	13,391	$24
		Total by Weiss Market (Average)	**315,703**	**($41)**
Weiss-Tennessee				
	Conasauga, TN	Litter Transport from: BRADLEY, TN	8,192,915	$24
	Conasauga, TN	Litter Transport from: POLK, TN	604,097	$39
		Total by Weiss Market (Average)	**8,797,012**	**($42)**
		Total from All Weiss Markets (Average)	**46,616,521**	**($42)**

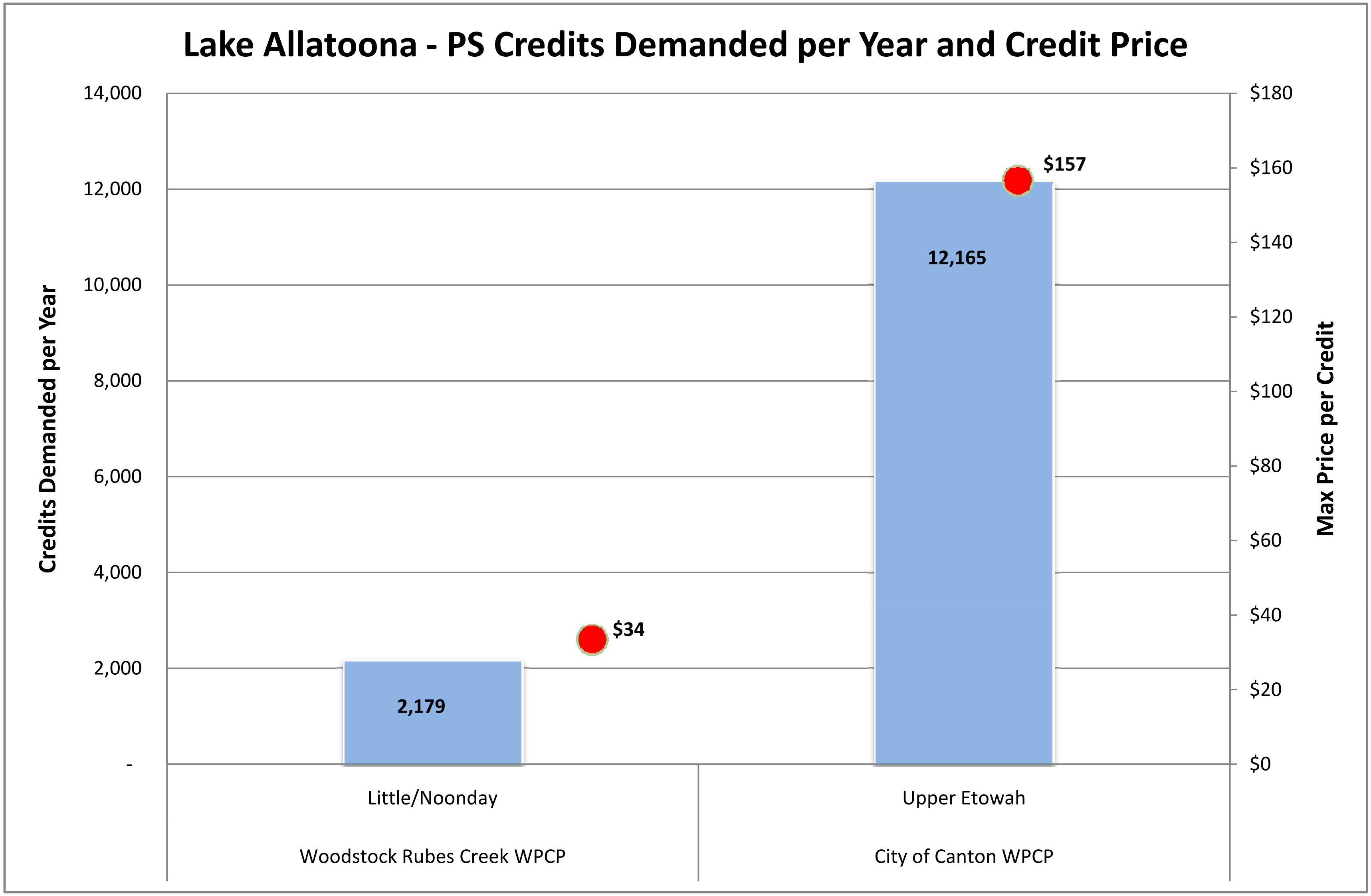

Figure 5.1. Lake Allatoona Point Source Credit Analysis

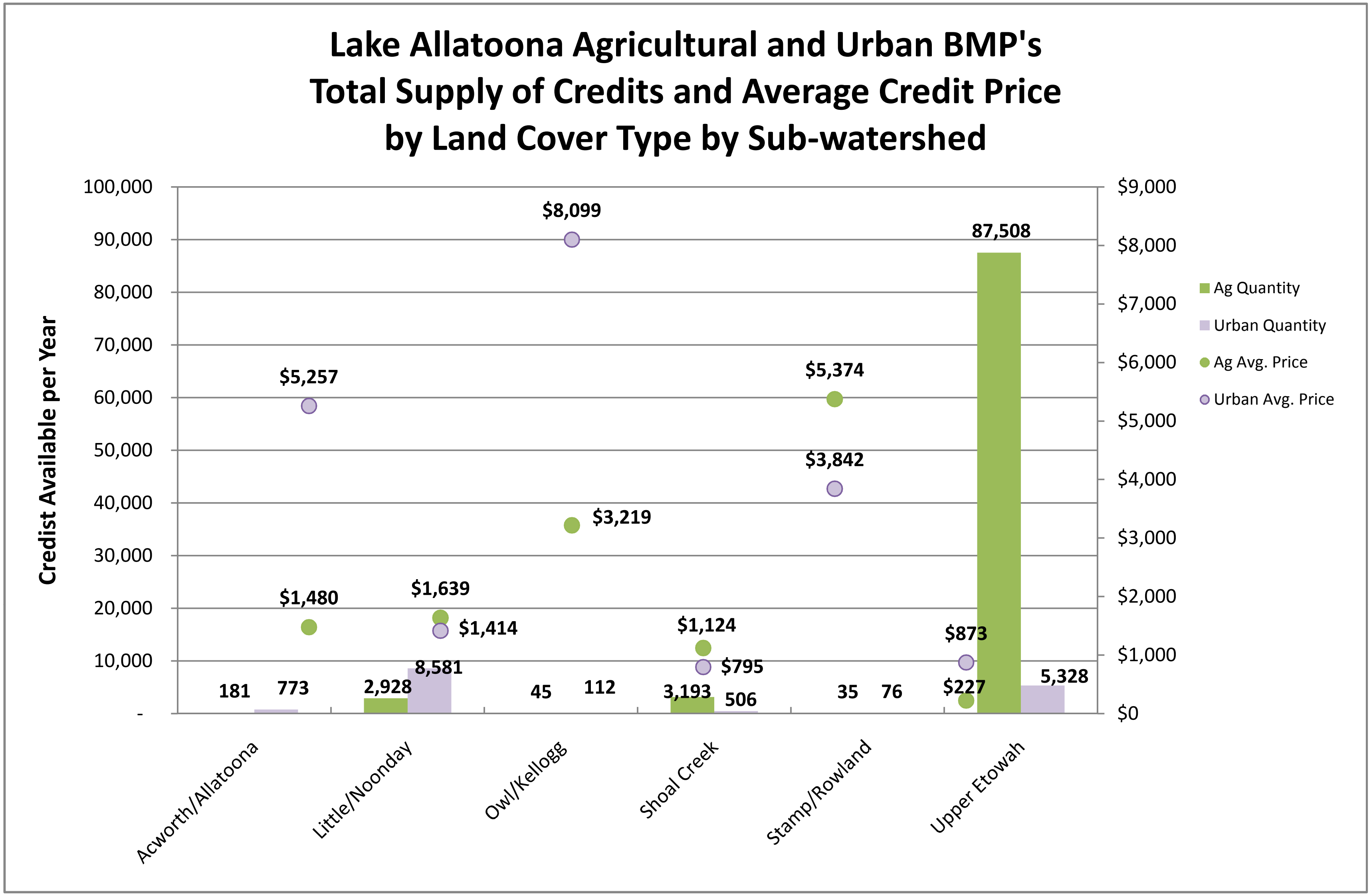

Figure 5.2. Lake Allatoona Agricultural and Urban Credit Analysis

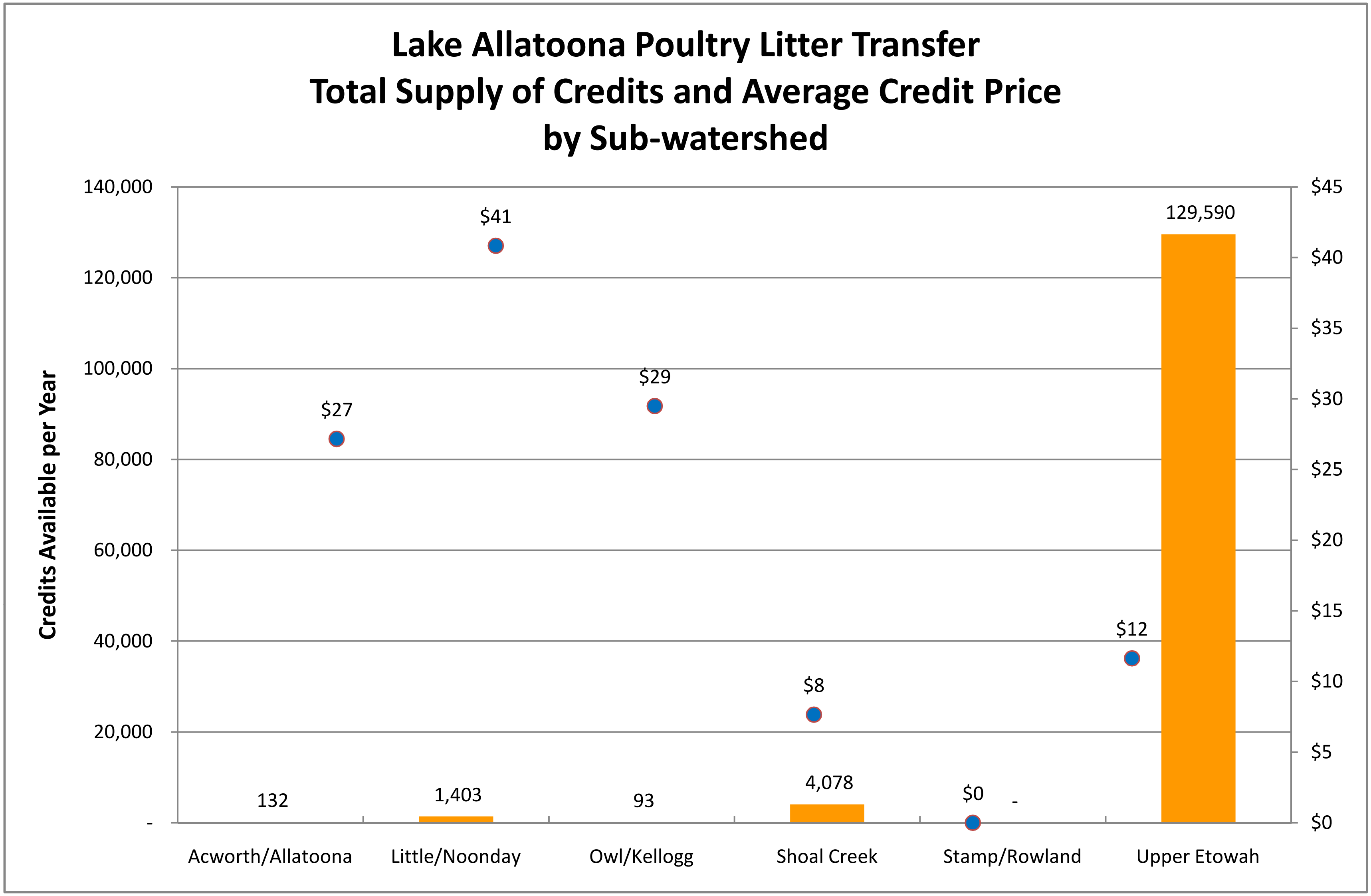

Figure 5.3. Lake Allatoona Poultry Litter Transfer Credit Analysis

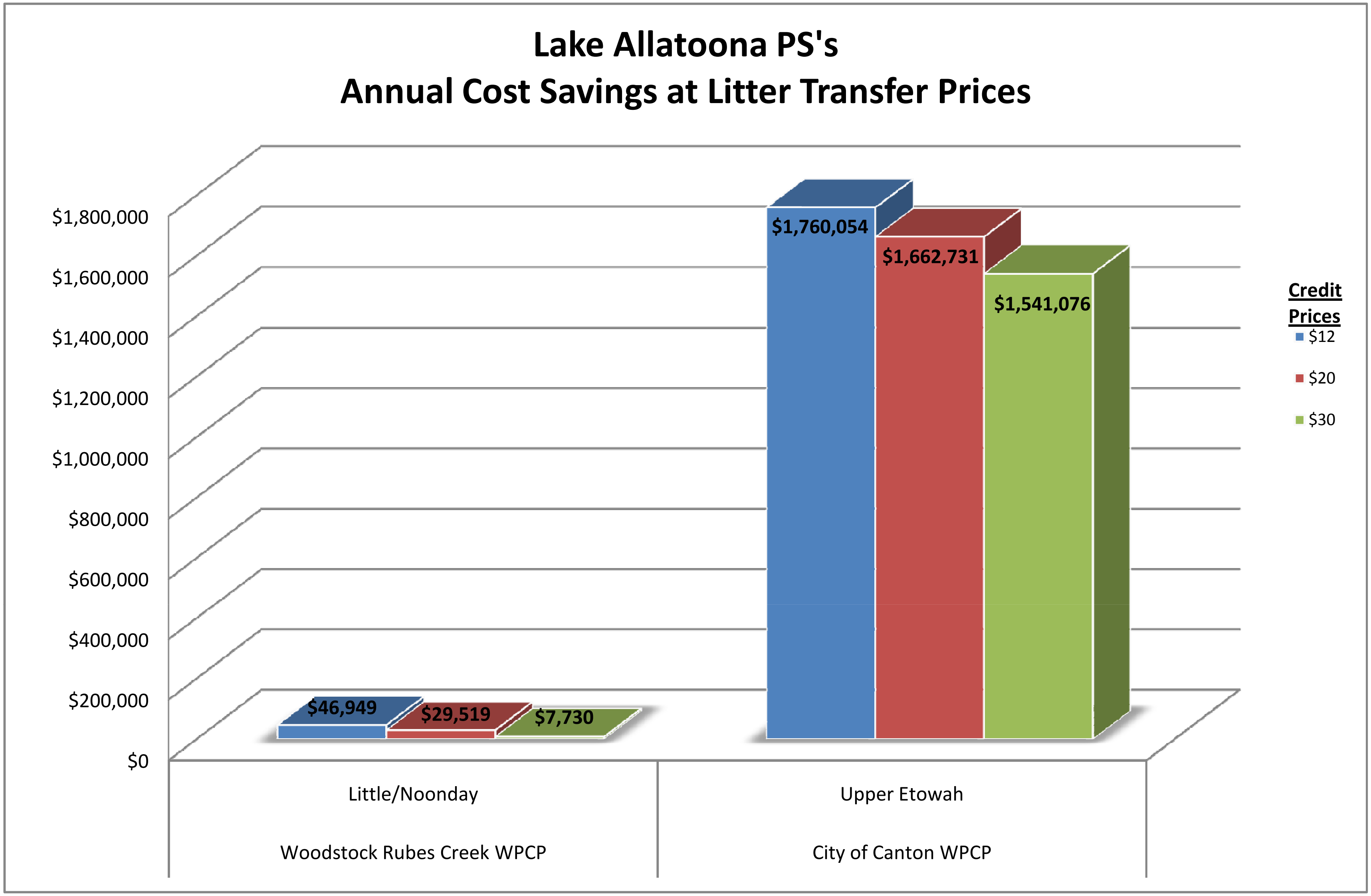

Figure 5.4. Lake Allatoona Point Source Annual Cost Savings at Litter Transfer Prices

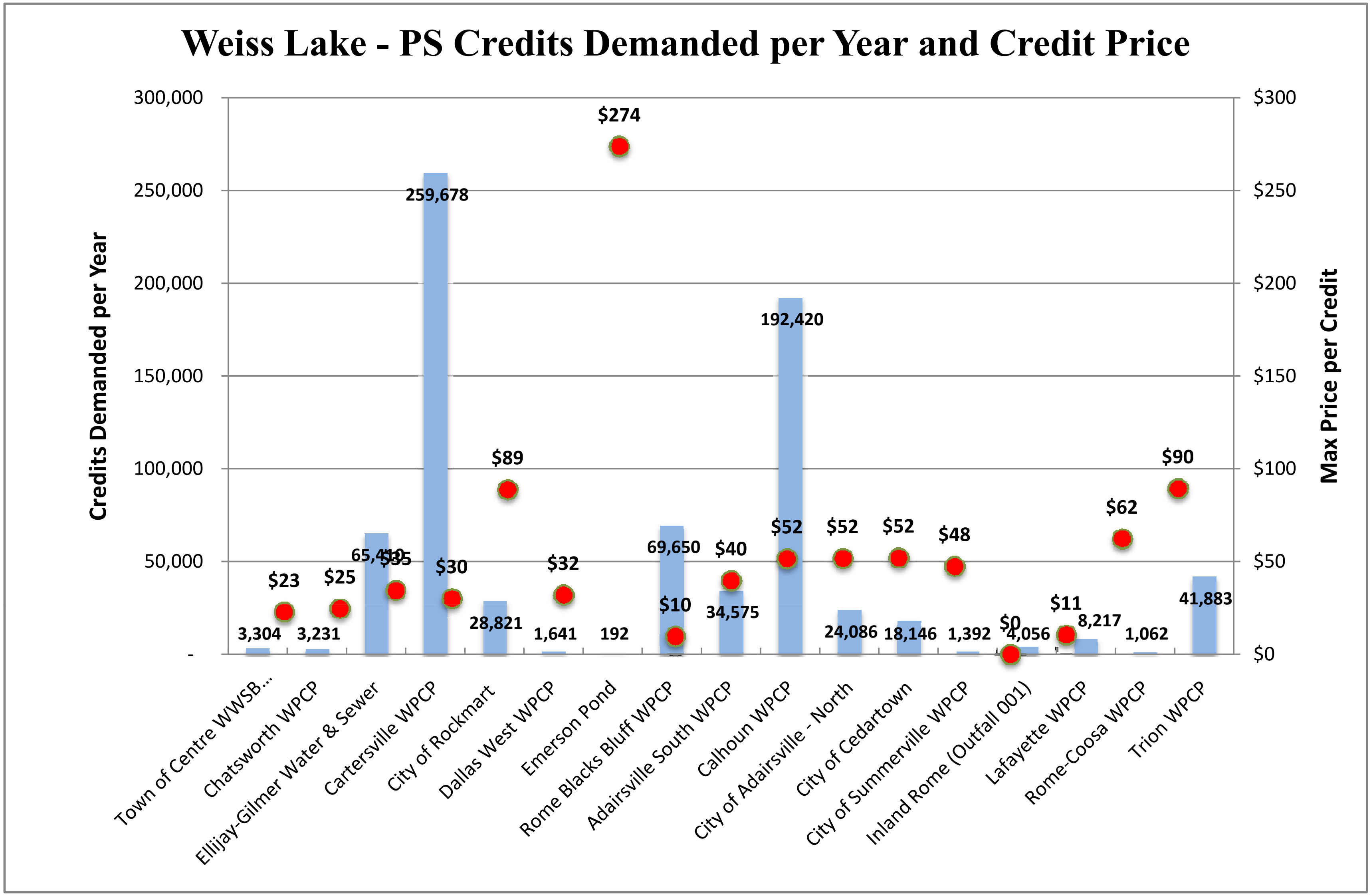

Figure 5.5. Weiss Lake Point Source Credit Analysis

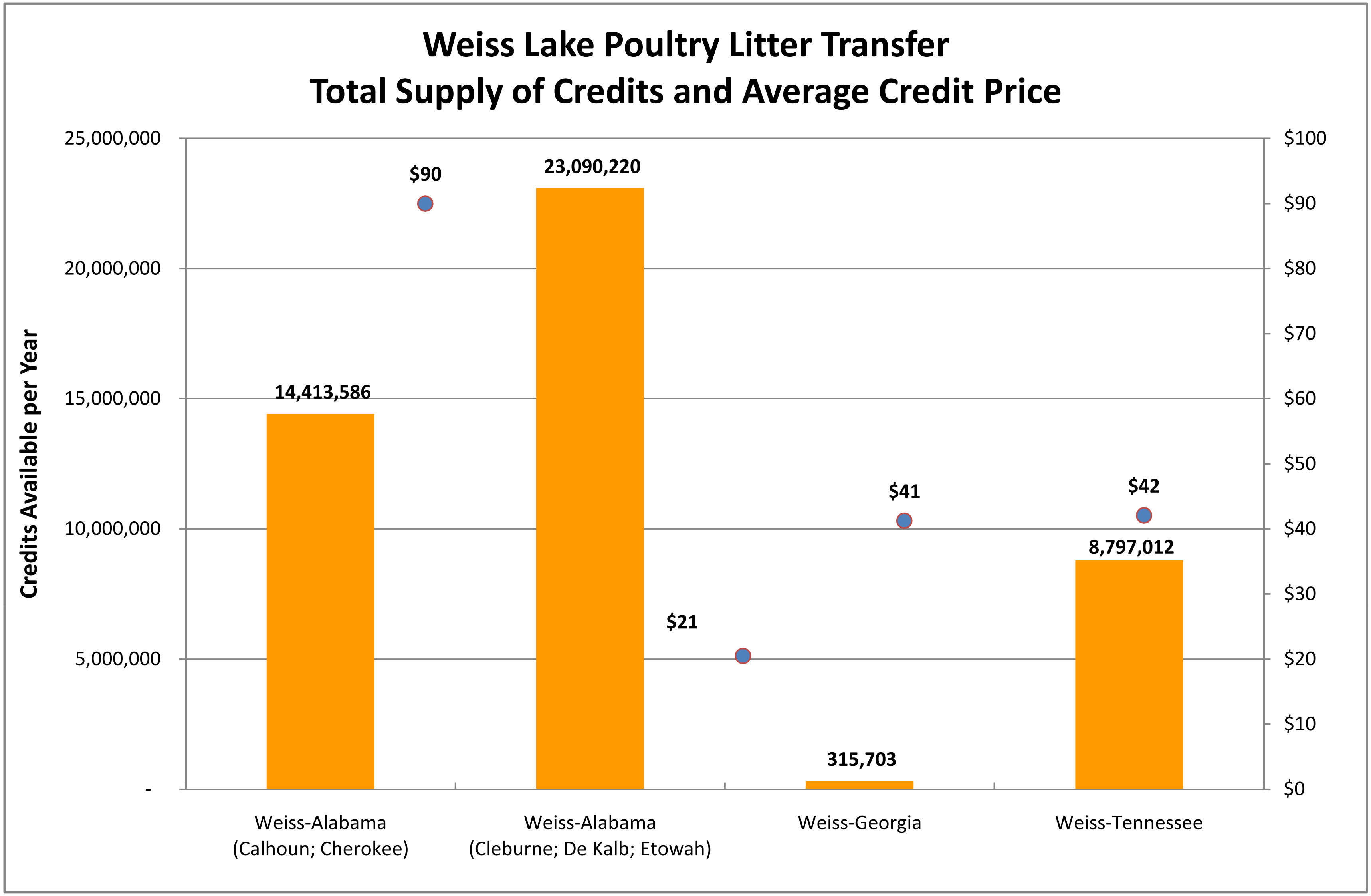

Figure 5.6. Weiss Lake Poultry Litter Transfer Credit Analysis

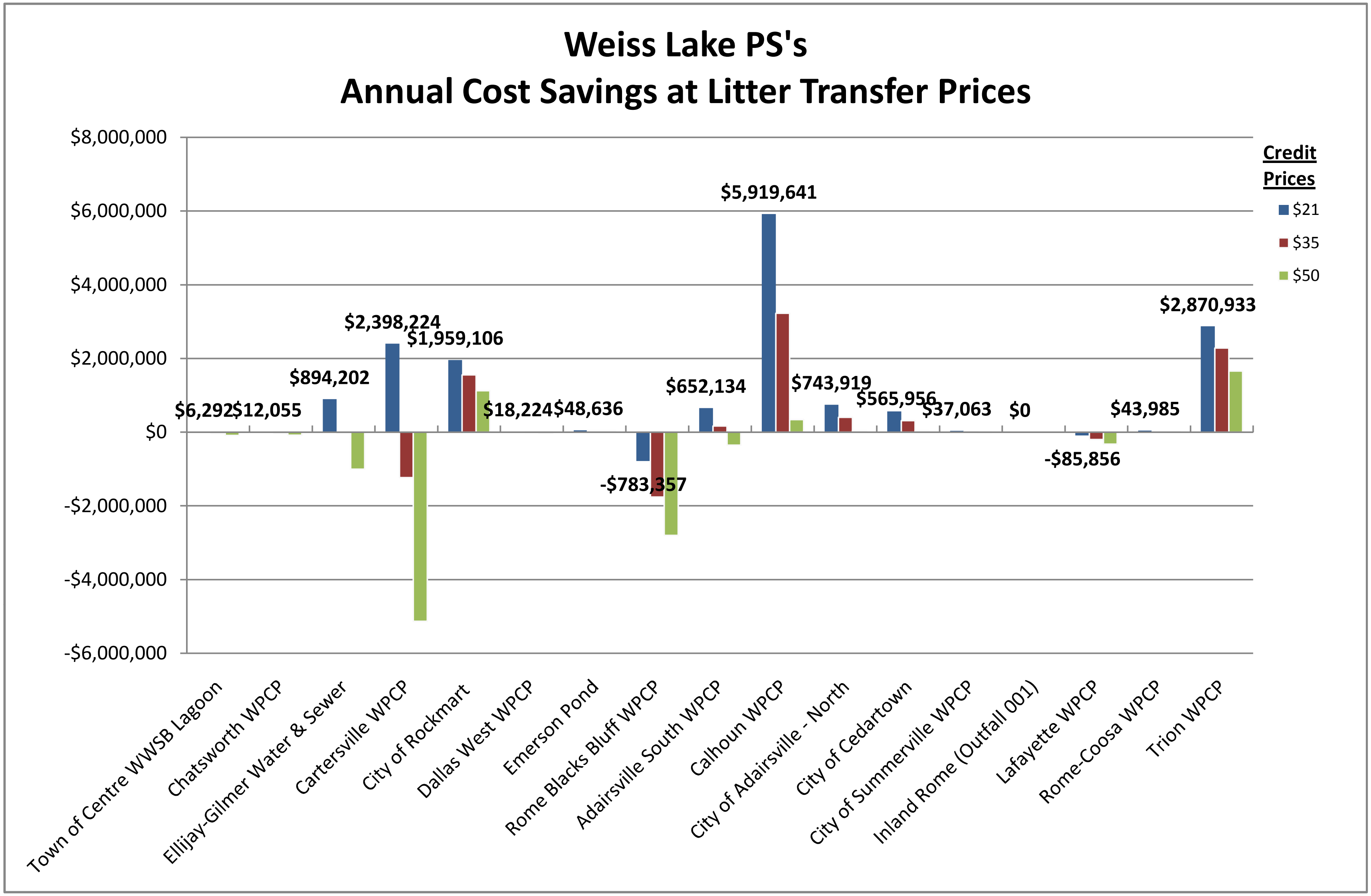

Figure 5.7. Weiss Lake Point Source Annual Cost Savings at Litter Transfer Prices

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APPENDICES

APPENDIX A

BMP CALCULATIONS

Table A.1. Agricultural BMP's - Costs

Agricultural BMPs	Capital Cost Estimate (Base$ Year if not 2008)	Capital Cost[3] (2008)	Avg. Capital Cost (2008)	O&M as % Construction or Annual Cost per ac	BMP Land Consumption (%)
50 Ft Riparian Buffer (Forested)[1]	$60 per ac of BMP (2007)	$62.58	$62.58	15%	2.5%
Cattle Exclusion (50 Ft Riparian Buffer)[2]	$179 per ac treated (2007)	$186.71	$186.71	15%	2.5%
Cattle Exclusion (No Buffer)[2]	$173 per ac treated (2007)	$180.45	$180.45	15%	-
Cover Crop[1]	$30 per acre (2007)	-	-	$31.29	-
Grassed Waterway[2]	$825 - $2,575 per ac of BMP (2008)	$825 - $2575	$1,700.00	$120.00	5.0%
Land Conversion: Cropland to Forest[2]	$85 - $175 per ac of BMP	$85 - $175 per ac of BMP	$130.00	15%	100.0%
Land Conversion: Cropland to Pasture[2]	$32.6 - $300 per ac of BMP	$300.00	$166.33	15%	100.0%
Land Conversion: Pastureland to Forest[2]	$135 - $225 per ac of BMP	$135 - $225 per ac of BMP	$180.00	15%	100.0%

[1] Costs from GA NRCS.

[2] Costs from CH2M Hill Jordan Lake Analysis.

[3] Costs inflated using Engineering News Record construction index.

Table A.2. Agricultural Land Costs - Lake Allatoona

Sub-watershed	Agriculture Land Cost Estimates[1]
Acworth/Allatoona	$34,679
Little/Noonday	$55,137
Owl/Kellogg	$55,481
Shoal Creek	$53,852
Stamp/Rowland	$43,867
Upper Etowah	$34,275

[1] Land prices from http://www.georgiastats.uga.edu/landprice.html for years 1997-2006. Prices reflect Agricultural Land greater than or equal to 1 acre. Sub-watershed values weighted by percent of county in each sub-watershed. Prices inflated using Engineering News Index to 2008 prices.

Table A.3. Agricultural BMP's - PV Total Costs Including Land by Sub-watershed

Agricultural BMPs	Acworth/Allatoona	Little/Noonday	Owl/Kellogg	Shoal Creek	Stamp/Rowland	Upper Etowah
50 Ft Riparian Buffer (Forested)	$870.60	$1,382.05	$1,390.65	$1,349.91	$1,100.29	$860.50
Cattle Exclusion (50 Ft Riparian Buffer)	$1,298.80	$1,810.25	$1,818.85	$1,778.11	$1,528.49	$1,288.70
Cattle Exclusion (No Buffer)	$417.35	$417.35	$417.35	$417.35	$417.35	$417.35
Cover Crop	$273.87	$273.87	$273.87	$273.87	$273.87	$273.87
Grassed Waterway	$1,871.47	$2,894.38	$2,911.58	$2,830.10	$2,330.85	$1,851.28
Land Conversion: Cropland to Forest	$34,979.84	$55,438.01	$55,781.97	$54,152.40	$44,167.45	$34,576.03
Land Conversion: Cropland to Pasture	$35,063.87	$55,522.04	$55,866.00	$54,236.44	$44,251.48	$34,660.06
Land Conversion: Pastureland to Forest	$35,095.48	$55,553.65	$55,897.61	$54,268.05	$44,283.09	$34,691.67

[1] BMP's and cost estimates follow CH2M HILL's analysis of Lake Jordan, NC; costs updated with GA NRCS data where available and reflect present value capital and O&M costs. As CH2M, costs assume an interest rate of 7.5 percent, inflation rate of 5 percent, and lifetime of 10 years for agricultural BMP's. Land costs are included and estimated for each sub-watershed from georgiastats.uga.edu.

Table A.4. Urban BMP's - Costs

Structural Urban Stormwater BMPs[1]	**Capital Cost Estimate**	**Capital Cost (2008)**[2]	**Avg. Capital Cost (2008)**	**O&M as % Construction or Annual Cost per ac**	**BMP Land Consumption (%)**
Bioretention	$5.30 per cu ft (1997)	$7.56	$7.56	.05 - .07	5.0%
Dry Extension Basin	$.50 to $1.00 per cu ft (1997)	$.71 - $1.43	$1.07	<.01	2.5%
Filter Strip	$0 to $1.30 per cu ft (1997)	$0 - $1.85	$0.93	$320 per acre	2.3%
Grassed Swale	$.50 per cu ft (1997)	0.713295291	$0.71	.05 - .07	15.0%
Infiltration Devices	$1.30 to $4.00 per cu ft (1997)	$1.85 - $5.71	$3.78	.05 - .20	2.5%
Restored Riparian Buffer	$600 to $950 per acre (2004)	$700 - $1110	$905.18	$9 per acre (2004)	2.3%
Sand Filter	$3 to $6 per cu ft (1997)	$4.28 - $8.56	$6.42	.11 - .13	1.5%
Stormwater wetlands	$.60 to $1.25 per cu ft (1997)	$.86 to $1.78	$1.32	.03 - .06	4.0%
Wet detention basin	$.50 to $1.00 per cu ft (1997)	$.71 - $1.43	$1.07	.03 - .06	2.5%

[1] EPA cost estimates (EPA, 1999)

[2] Costs inflated using Engineering News Record construction index.

Table A.5. Urban Land Costs - Lake Allatoona

Sub-watershed	Highly Developed Land Cost Estimates[1]	Less Developed Land Cost Estimates[1]
Acworth/Allatoona	$767,697	$132,366
Little/Noonday	$697,222	$145,543
Owl/Kellogg	$476,437	$97,524
Shoal Creek	$357,208	$81,060
Stamp/Rowland	$250,133	$50,522
Upper Etowah	$317,843	$66,966

[1] Land prices from http://www.georgiastats.uga.edu/landprice.html for years 1997-2006. Highly Developed prices reflect Commerical & Industrial land category greater than or equal to 1 acre. Less Developed prices reflect Residential land category greater than or equal to 1 acre. Sub-watershed values weighted by percent of county in each sub-watershed. Prices inflated using Engineering News Index to 2008 prices.

Table A.6. Impervious Details - Lake Allatoona

Highly Developed Category[1]	**Percent Impervious**	**Percent of Total Highly Developed**[2]
Developed High Intensity	80-100	6.65%
Developed Medium Intensity	50-79	15.47%
Developed Low Intensity	20-49	77.88%

[1] Categories for NLCD Data (2001) per http://www.mrlc.gov/nlcd_definitions.php. "Developed, Open Space" fully accounts for Less Developed Urban and is <20% imperviousness.

[2] Reflects land cover data as taken from EPA Basins 4.0.

Table A.7. Water Quality Volume (WQV) Calculations - Lake Allatoona

Impervious Category	**Percent Impervious**	**WQV[1,2]**
High Intensity (Upper Limit)	100%	3,448.50
High Intensity (Lower Limit) and Med. Intensity (UL)	80%	2,795.10
Med. Intensity (LL) & Low Intensity (UL)	50%	1,815.00
Low Intensity (LL)	20%	834.90
Developed, Open Space (Average)	10%	508.20
Developed, Open Space (Low)	5%	344.85

[1] Calculations use Schueler's Simple Method per http://h2o.enr.state.nc.us/su/documents/BMPManual_WholeDocument_CoverRevisedDec2007.pdf.

[2] Developed, Open Space values of 10 and 5 percent included to calculate WQV at various levels of less developed urban.

Table A.8. Water Quality Volume (WQV) Weights - Lake Allatoona

Impervious Category	**WQV (Weighted)[1]**
Highly Developed Urban	1,596.12
Less Developed Urban	421.99

[1] Caclulations reflect WQV estimates from Table A.7. weighted by percent of land cover category per Table A.6. Less Developed weight represent average of 20, 10, 5, and 0% imperviousness; these choices weight less developed urban below the average of 10% imperviousness.

Table A.9. Land Cost per Acre for BMP Footprint by Sub-watershed by Percent Imperviousness - Lake Allatoona

Acworth/Allatoona

Structural Urban Stormwater BMPs	Percent of Land Consumption	Percent Imperviousness 100%	80%	50%	20%	10%	5%
Bioretention	5.00%	$38,384.83	$30,707.87	$19,192.42	$7,676.97	$661.83	$330.92
Dry Extension Basin	2.50%	$19,192.42	$15,353.93	$9,596.21	$3,838.48	$330.92	$165.46
Filter Strip	2.30%	$17,657.02	$14,125.62	$8,828.51	$3,531.40	$304.44	$152.22
Grassed Swale	15.00%	$115,154.50	$92,123.60	$57,577.25	$23,030.90	$1,985.49	$992.75
Infiltration Devices	2.50%	$19,192.42	$15,353.93	$9,596.21	$3,838.48	$330.92	$165.46
Restored Riparian Buffer	2.30%	$17,657.02	$14,125.62	$8,828.51	$3,531.40	$304.44	$152.22
Sand Filter	1.50%	$11,515.45	$9,212.36	$5,757.72	$2,303.09	$198.55	$99.27
Stormwater wetlands	4.00%	$30,707.87	$24,566.29	$15,353.93	$6,141.57	$529.47	$264.73
Wet detention basin	2.50%	$19,192.42	$15,353.93	$9,596.21	$3,838.48	$330.92	$165.46

Little/Noonday

Structural Urban Stormwater BMPs	Percent of Land Consumption	Percent Imperviousness 100%	80%	50%	20%	10%	5%
Bioretention	5.00%	$34,861.12	$27,888.89	$17,430.56	$6,972.22	$727.72	$363.86
Dry Extension Basin	2.50%	$17,430.56	$13,944.45	$8,715.28	$3,486.11	$363.86	$181.93
Filter Strip	2.30%	$16,036.11	$12,828.89	$8,018.06	$3,207.22	$334.75	$167.37
Grassed Swale	15.00%	$104,583.35	$83,666.68	$52,291.68	$20,916.67	$2,183.15	$1,091.57
Infiltration Devices	2.50%	$17,430.56	$13,944.45	$8,715.28	$3,486.11	$363.86	$181.93
Restored Riparian Buffer	2.30%	$16,036.11	$12,828.89	$8,018.06	$3,207.22	$334.75	$167.37
Sand Filter	1.50%	$10,458.34	$8,366.67	$5,229.17	$2,091.67	$218.31	$109.16
Stormwater wetlands	4.00%	$27,888.89	$22,311.11	$13,944.45	$5,577.78	$582.17	$291.09
Wet detention basin	2.50%	$17,430.56	$13,944.45	$8,715.28	$3,486.11	$363.86	$181.93

Owl/Kellogg

Structural Urban Stormwater BMPs	Percent of Land Consumption	Percent Imperviousness 100%	80%	50%	20%	10%	5%
Bioretention	5.00%	$23,821.86	$19,057.48	$11,910.93	$4,764.37	$487.62	$243.81
Dry Extension Basin	2.50%	$11,910.93	$9,528.74	$5,955.46	$2,382.19	$243.81	$121.91
Filter Strip	2.30%	$10,958.05	$8,766.44	$5,479.03	$2,191.61	$224.31	$112.15
Grassed Swale	15.00%	$71,465.57	$57,172.45	$35,732.78	$14,293.11	$1,462.87	$731.43
Infiltration Devices	2.50%	$11,910.93	$9,528.74	$5,955.46	$2,382.19	$243.81	$121.91
Restored Riparian Buffer	2.30%	$10,958.05	$8,766.44	$5,479.03	$2,191.61	$224.31	$112.15
Sand Filter	1.50%	$7,146.56	$5,717.25	$3,573.28	$1,429.31	$146.29	$73.14
Stormwater wetlands	4.00%	$19,057.48	$15,245.99	$9,528.74	$3,811.50	$390.10	$195.05
Wet detention basin	2.50%	$11,910.93	$9,528.74	$5,955.46	$2,382.19	$243.81	$121.91

Table A.9. Land Cost per Acre for BMP Footprint by Sub-watershed by Percent Imperviousness - Lake Allatoona

Shoal Creek

Structural Urban Stormwater BMPs	Percent of Land Consumption	Percent Imperviousness 100%	80%	50%	20%	10%	5%
Bioretention	5.00%	$17,860.42	$14,288.33	$8,930.21	$3,572.08	$405.30	$202.65
Dry Extension Basin	2.50%	$8,930.21	$7,144.17	$4,465.10	$1,786.04	$202.65	$101.33
Filter Strip	2.30%	$8,215.79	$6,572.63	$4,107.90	$1,643.16	$186.44	$93.22
Grassed Swale	15.00%	$53,581.25	$42,865.00	$26,790.62	$10,716.25	$1,215.90	$607.95
Infiltration Devices	2.50%	$8,930.21	$7,144.17	$4,465.10	$1,786.04	$202.65	$101.33
Restored Riparian Buffer	2.30%	$8,215.79	$6,572.63	$4,107.90	$1,643.16	$186.44	$93.22
Sand Filter	1.50%	$5,358.12	$4,286.50	$2,679.06	$1,071.62	$121.59	$60.80
Stormwater wetlands	4.00%	$14,288.33	$11,430.67	$7,144.17	$2,857.67	$324.24	$162.12
Wet detention basin	2.50%	$8,930.21	$7,144.17	$4,465.10	$1,786.04	$202.65	$101.33

Stamp/Rowland

Structural Urban Stormwater BMPs	Percent of Land Consumption	Percent Imperviousness 100%	80%	50%	20%	10%	5%
Bioretention	5.00%	$12,506.64	$10,005.31	$6,253.32	$2,501.33	$252.61	$126.30
Dry Extension Basin	2.50%	$6,253.32	$5,002.66	$3,126.66	$1,250.66	$126.30	$63.15
Filter Strip	2.30%	$5,753.05	$4,602.44	$2,876.53	$1,150.61	$116.20	$58.10
Grassed Swale	15.00%	$37,519.92	$30,015.93	$18,759.96	$7,503.98	$757.83	$378.91
Infiltration Devices	2.50%	$6,253.32	$5,002.66	$3,126.66	$1,250.66	$126.30	$63.15
Restored Riparian Buffer	2.30%	$5,753.05	$4,602.44	$2,876.53	$1,150.61	$116.20	$58.10
Sand Filter	1.50%	$3,751.99	$3,001.59	$1,876.00	$750.40	$75.78	$37.89
Stormwater wetlands	4.00%	$10,005.31	$8,004.25	$5,002.66	$2,001.06	$202.09	$101.04
Wet detention basin	2.50%	$6,253.32	$5,002.66	$3,126.66	$1,250.66	$126.30	$63.15

Upper Etowah

Structural Urban Stormwater BMPs	Percent of Land Consumption	Percent Imperviousness 100%	80%	50%	20%	10%	5%
Bioretention	5.00%	$15,892.13	$12,713.70	$7,946.06	$3,178.43	$334.83	$167.41
Dry Extension Basin	2.50%	$7,946.06	$6,356.85	$3,973.03	$1,589.21	$167.41	$83.71
Filter Strip	2.30%	$7,310.38	$5,848.30	$3,655.19	$1,462.08	$154.02	$77.01
Grassed Swale	15.00%	$47,676.39	$38,141.11	$23,838.19	$9,535.28	$1,004.48	$502.24
Infiltration Devices	2.50%	$7,946.06	$6,356.85	$3,973.03	$1,589.21	$167.41	$83.71
Restored Riparian Buffer	2.30%	$7,310.38	$5,848.30	$3,655.19	$1,462.08	$154.02	$77.01
Sand Filter	1.50%	$4,767.64	$3,814.11	$2,383.82	$953.53	$100.45	$50.22
Stormwater wetlands	4.00%	$12,713.70	$10,170.96	$6,356.85	$2,542.74	$267.86	$133.93
Wet detention basin	2.50%	$7,946.06	$6,356.85	$3,973.03	$1,589.21	$167.41	$83.71

Table A.10. Land Cost per Acre for BMP Footprint by Sub-watershed by Highly or Less Developed Urban[1] - Lake Allatoona

	Acworth/Allatoona		Little/Noonday		Owl/Kellogg	
Structural Urban Stormwater BMPs	**Highly**	**Less**	**Highly**	**Less**	**Highly**	**Less**
Bioretention	$16,620.77	$2,167.43	$15,094.99	$2,015.95	$10,314.95	$1,373.95
Dry Extension Basin	$8,310.39	$1,083.71	$7,547.49	$1,007.97	$916.25	$7,207.20
Filter Strip	$7,645.55	$997.02	$6,943.69	$927.34	$842.95	$6,630.62
Grassed Swale	$49,862.31	$6,502.29	$45,284.97	$6,047.85	$5,497.52	$43,243.20
Infiltration Devices	$8,310.39	$1,083.71	$7,547.49	$1,007.97	$916.25	$7,207.20
Restored Riparian Buffer	$7,645.55	$997.02	$6,943.69	$927.34	$842.95	$6,630.62
Sand Filter	$4,986.23	$650.23	$4,528.50	$604.78	$549.75	$4,324.32
Stormwater wetlands	$13,296.62	$1,733.94	$12,075.99	$1,612.76	$1,466.01	$11,531.52
Wet detention basin	$8,310.39	$1,083.71	$7,547.49	$1,007.97	$916.25	$7,207.20

	Shoal Creek		Stamp/Rowland		Upper Etowah	
Structural Urban Stormwater BMPs	**Highly**	**Less**	**Highly**	**Less**	**Highly**	**Less**
Bioretention	$7,733.62	$1,045.01	$5,415.42	$720.06	$6,881.35	$920.17
Dry Extension Basin	$3,866.81	$522.50	$2,707.71	$360.03	$3,440.67	$460.08
Filter Strip	$3,557.47	$480.70	$2,491.09	$331.23	$3,165.42	$423.28
Grassed Swale	$23,200.87	$3,135.03	$16,246.26	$2,160.18	$20,644.05	$2,760.50
Infiltration Devices	$3,866.81	$522.50	$2,707.71	$360.03	$3,440.67	$460.08
Restored Riparian Buffer	$3,557.47	$480.70	$2,491.09	$331.23	$3,165.42	$423.28
Sand Filter	$2,320.09	$313.50	$1,624.63	$216.02	$2,064.40	$276.05
Stormwater wetlands	$6,186.90	$836.01	$4,332.34	$576.05	$5,505.08	$736.13
Wet detention basin	$3,866.81	$522.50	$2,707.71	$360.03	$3,440.67	$460.08

[1] Highly Developed Urban (≥20% imperviousness) and Less Developed Urban (<20% imperviousness).

Table A.11. Urban BMP's - PV Total Costs Including Land by Sub-watershed by Highly and Less Developed Urban

	Acworth/Allatoona		Little/Noonday		Owl/Kellogg	
Structural Urban Stormwater BMPs[1,2]	**Highly**	**Less**	**Highly**	**Less**	**Highly**	**Less**
Bioretention	$51,480.67	$37,027.33	$49,954.89	$36,875.85	$45,174.85	$36,233.85
Dry Extension Basin	$11,057.96	$3,831.29	$10,295.07	$3,755.55	$3,663.83	$9,954.77
Filter Strip	$12,662.60	$6,014.06	$11,960.74	$5,944.38	$5,860.00	$11,647.67
Grassed Swale	$53,150.98	$9,790.96	$48,573.64	$9,336.52	$8,786.19	$46,531.87
Infiltration Devices	$34,866.18	$27,639.51	$34,103.29	$27,563.77	$27,472.05	$33,762.99
Restored Riparian Buffer	$8,714.60	$2,066.06	$8,012.74	$1,996.38	$1,912.00	$7,699.67
Sand Filter	$48,888.92	$44,552.91	$48,431.18	$44,507.47	$44,452.44	$48,227.00
Stormwater wetlands	$18,645.56	$7,082.88	$17,424.93	$6,961.70	$6,814.95	$16,880.46
Wet detention basin	$12,647.36	$5,420.69	$11,884.47	$5,344.95	$5,253.23	$11,544.18

	Shoal Creek		Stamp/Rowland		Upper Etowah	
Structural Urban Stormwater BMPs	**Highly**	**Less**	**Highly**	**Less**	**Highly**	**Less**
Bioretention	$42,593.53	$35,904.91	$40,275.32	$35,579.96	$41,741.25	$35,780.07
Dry Extension Basin	$6,614.38	$3,270.08	$5,455.28	$3,107.60	$6,188.25	$3,207.66
Filter Strip	$8,574.51	$5,497.75	$7,508.14	$5,348.27	$8,182.47	$5,440.32
Grassed Swale	$26,489.54	$6,423.70	$19,534.93	$5,448.85	$23,932.72	$6,049.17
Infiltration Devices	$30,422.60	$27,078.30	$29,263.50	$26,915.82	$29,996.47	$27,015.87
Restored Riparian Buffer	$4,626.51	$1,549.75	$3,560.14	$1,400.28	$4,234.47	$1,492.32
Sand Filter	$46,222.77	$44,216.19	$45,527.31	$44,118.70	$45,967.09	$44,178.74
Stormwater wetlands	$11,535.84	$6,184.95	$9,681.27	$5,924.99	$10,854.02	$6,085.07
Wet detention basin	$8,203.79	$4,859.48	$7,044.69	$4,697.01	$7,777.65	$4,797.06

[1] BMP's, P removal efficiencies, and cost estimates follow CH2M HILL's analysis of Lake Jordan, NC and use EPA estimates (EPA, 1999). As CH2M HILL, costs assume an interest rate of 7.5 percent, inflation rate of 5 percent, and lifetime of 20 years for urban BMP's. Costs reflect present value capital and O&M costs. Land costs are included and estimated for each sub-watershed from georgiastats.uga.edu.

[2] Highly Developed Urban (≥20% imperviousness) and Less Developed Urban (<20% imperviousness).

APPENDIX B

BASELINE CREDIT CALCULATIONS

Table B.1. Agricultural BMP's - Credits per Year for Cropland

Sub-watershed	BMP	Total Credits Available	Unit Credit Cost With Land ($/lb/yr)
Acworth/Allatoona	Cover Crop	-	-
Acworth/Allatoona	Grassed Waterway	-	-
Acworth/Allatoona	Land Conversion: cropland to forest	-	-
Acworth/Allatoona	Land Conversion: cropland to pasture	-	-
Acworth/Allatoona	Riparian Buffers (Forested)	-	-
Little/Noonday	Cover Crop	43.84	$7.72
Little/Noonday	Grassed Waterway	179.34	$19.94
Little/Noonday	Land Conversion: cropland to forest	374.63	$182.83
Little/Noonday	Land Conversion: cropland to pasture	318.83	$215.16
Little/Noonday	Riparian Buffers (Forested)	298.91	$5.71
Owl/Kellogg	Cover Crop	-	-
Owl/Kellogg	Grassed Waterway	-	-
Owl/Kellogg	Land Conversion: cropland to forest	-	-
Owl/Kellogg	Land Conversion: cropland to pasture	-	-
Owl/Kellogg	Riparian Buffers (Forested)	-	-
Shoal Creek	Cover Crop	-	-
Shoal Creek	Grassed Waterway	-	-
Shoal Creek	Land Conversion: cropland to forest	-	-
Shoal Creek	Land Conversion: cropland to pasture	-	-
Shoal Creek	Riparian Buffers (Forested)	-	-
Stamp/Rowland	Cover Crop	-	-
Stamp/Rowland	Grassed Waterway	-	-
Stamp/Rowland	Land Conversion: cropland to forest	-	-
Stamp/Rowland	Land Conversion: cropland to pasture	-	-
Stamp/Rowland	Riparian Buffers (Forested)	-	-
Upper Etowah	Cover Crop	78.03	$178.66
Upper Etowah	Grassed Waterway	319.21	$295.22
Upper Etowah	Land Conversion: cropland to forest	666.80	$2,639.53
Upper Etowah	Land Conversion: cropland to pasture	567.49	$3,108.98
Upper Etowah	Riparian Buffers (Forested)	532.02	$82.33

Table B.2. Agricultural BMP's - Credits per Year for Pasture Receiving Litter

Sub-watershed	**BMP**	**Total Credits Available**	**Unit Credit Cost With Land ($/lb/yr)**
Acworth/Allatoona	Cattle Exclusion (50 ft Buffer)	11.38	$1,100.23
Acworth/Allatoona	Cattle Exclusion (No Buffer)	3.88	$1,035.36
Acworth/Allatoona	Cover Crop	13.95	$189.16
Acworth/Allatoona	Grassed Waterway	57.08	$315.97
Acworth/Allatoona	Land Conversion: pasture to forest	87.52	$3,864.34
Acworth/Allatoona	Riparian Buffers (Forested)	95.13	$88.19
Little/Noonday	Cattle Exclusion (50 ft Buffer)	254.80	$1,748.58
Little/Noonday	Cattle Exclusion (No Buffer)	87.00	$1,180.59
Little/Noonday	Cover Crop	322.30	$209.14
Little/Noonday	Grassed Waterway	1,318.48	$540.28
Little/Noonday	Land Conversion: pasture to forest	2,021.68	$6,763.05
Little/Noonday	Riparian Buffers (Forested)	2,197.47	$154.79
Owl/Kellogg	Cattle Exclusion (50 ft Buffer)	5.42	$1,408.83
Owl/Kellogg	Cattle Exclusion (No Buffer)	1.85	$946.70
Owl/Kellogg	Cover Crop	5.46	$210.85
Owl/Kellogg	Grassed Waterway	22.32	$547.94
Owl/Kellogg	Land Conversion: pasture to forest	34.23	$6,860.54
Owl/Kellogg	Riparian Buffers (Forested)	37.20	$157.03
Shoal Creek	Cattle Exclusion (50 ft Buffer)	117.94	$1,326.30
Shoal Creek	Cattle Exclusion (No Buffer)	40.27	$911.67
Shoal Creek	Cover Crop	443.22	$54.36
Shoal Creek	Grassed Waterway	1,813.19	$137.31
Shoal Creek	Land Conversion: pasture to forest	2,780.22	$1,717.11
Shoal Creek	Riparian Buffers (Forested)	3,021.98	$39.30
Stamp/Rowland	Cattle Exclusion (50 ft Buffer)	-	-
Stamp/Rowland	Cattle Exclusion (No Buffer)	-	-
Stamp/Rowland	Cover Crop	-	-
Stamp/Rowland	Grassed Waterway	-	-
Stamp/Rowland	Land Conversion: pasture to forest	-	-
Stamp/Rowland	Riparian Buffers (Forested)	-	-
Upper Etowah	Cattle Exclusion (50 ft Buffer)	2,607.01	$1,022.40
Upper Etowah	Cattle Exclusion (No Buffer)	890.20	$969.66
Upper Etowah	Cover Crop	12,102.28	$46.80
Upper Etowah	Grassed Waterway	49,509.32	$77.34
Upper Etowah	Land Conversion: pasture to forest	75,914.29	$945.17
Upper Etowah	Riparian Buffers (Forested)	82,515.53	$21.57

Table B.3. Agricultural BMP's - Credits per Year for Pasture Not Receiving Litter

Sub-watershed	BMP	Total Credits Available	Unit Credit Cost With Land ($/lb/yr)
Acworth/Allatoona	Cover Crop	12.64	$6,160.06
Acworth/Allatoona	Grassed Waterway	51.73	$10,289.78
Acworth/Allatoona	Land Conversion: pasture to forest	79.32	$125,845.49
Acworth/Allatoona	Riparian Buffers (Forested)	86.22	$2,872.05
Little/Noonday	Cover Crop	63.25	$6,428.09
Little/Noonday	Grassed Waterway	258.76	$16,606.38
Little/Noonday	Land Conversion: pasture to forest	396.76	$207,871.75
Little/Noonday	Riparian Buffers (Forested)	431.26	$4,757.68
Owl/Kellogg	Cover Crop	1.09	$8,433.81
Owl/Kellogg	Grassed Waterway	4.46	$21,917.46
Owl/Kellogg	Land Conversion: pasture to forest	6.85	$274,421.73
Owl/Kellogg	Riparian Buffers (Forested)	7.44	$6,281.04
Shoal Creek	Cover Crop	25.12	$3,055.05
Shoal Creek	Grassed Waterway	102.76	$7,717.16
Shoal Creek	Land Conversion: pasture to forest	157.57	$96,508.02
Shoal Creek	Riparian Buffers (Forested)	171.27	$2,208.58
Stamp/Rowland	Cover Crop	5.06	$9,120.35
Stamp/Rowland	Grassed Waterway	20.70	$18,974.22
Stamp/Rowland	Land Conversion: pasture to forest	31.74	$235,098.98
Stamp/Rowland	Riparian Buffers (Forested)	34.50	$5,374.12
Upper Etowah	Cover Crop	654.25	$1,250.35
Upper Etowah	Grassed Waterway	2,676.49	$2,066.06
Upper Etowah	Land Conversion: pasture to forest	4,103.96	$25,249.88
Upper Etowah	Riparian Buffers (Forested)	4,460.82	$576.20

Table B.4. Urban BMP's - Credits per Year for Highly Developed Urban

Sub-watershed	**BMP**	**Total Credits Available**	**Unit Credit Cost With Land ($/lb/yr)**
Acworth/Allatoona	Bioretention	622.98	$28,085.84
Acworth/Allatoona	Dry Extension Basin	138.44	$27,147.54
Acworth/Allatoona	Filter Strip	484.54	$8,881.99
Acworth/Allatoona	Grassed Swale	276.88	$65,243.46
Acworth/Allatoona	Infiltration Devices	484.54	$24,456.37
Acworth/Allatoona	Restored Riparian Buffer	484.54	$6,112.73
Acworth/Allatoona	Sand Filter	622.98	$26,671.88
Acworth/Allatoona	Stormwater wetlands	484.54	$13,078.65
Acworth/Allatoona	Wet detention basin	553.76	$7,762.39
Little/Noonday	Bioretention	7,627.07	$6,820.09
Little/Noonday	Dry Extension Basin	1,694.90	$6,324.90
Little/Noonday	Filter Strip	5,932.17	$2,099.49
Little/Noonday	Grassed Swale	3,389.81	$14,920.90
Little/Noonday	Infiltration Devices	5,932.17	$5,986.22
Little/Noonday	Restored Riparian Buffer	5,932.17	$1,406.49
Little/Noonday	Sand Filter	7,627.07	$6,612.06
Little/Noonday	Stormwater wetlands	5,932.17	$3,058.63
Little/Noonday	Wet detention basin	6,779.62	$1,825.34
Owl/Kellogg	Bioretention	90.78	$22,091.15
Owl/Kellogg	Dry Extension Basin	20.17	$8,062.48
Owl/Kellogg	Filter Strip	70.60	$3,684.37
Owl/Kellogg	Grassed Swale	40.34	$9,667.29
Owl/Kellogg	Infiltration Devices	70.60	$17,272.57
Owl/Kellogg	Restored Riparian Buffer	70.60	$1,202.14
Owl/Kellogg	Sand Filter	90.78	$21,737.88
Owl/Kellogg	Stormwater wetlands	70.60	$4,284.78
Owl/Kellogg	Wet detention basin	80.69	$2,890.02
Shoal Creek	Bioretention	348.80	$6,692.64
Shoal Creek	Dry Extension Basin	77.51	$4,676.87
Shoal Creek	Filter Strip	271.29	$1,732.24
Shoal Creek	Grassed Swale	155.02	$9,365.06
Shoal Creek	Infiltration Devices	271.29	$6,146.03
Shoal Creek	Restored Riparian Buffer	271.29	$934.66
Shoal Creek	Sand Filter	348.80	$7,262.89
Shoal Creek	Stormwater wetlands	271.29	$2,330.49
Shoal Creek	Wet detention basin	310.05	$1,450.18

Sub-watershed	BMP	Total Credits Available	Unit Credit Cost With Land ($/lb/yr)
Stamp/Rowland	Bioretention	59.18	$32,152.22
Stamp/Rowland	Dry Extension Basin	13.15	$19,597.54
Stamp/Rowland	Filter Strip	46.03	$7,706.35
Stamp/Rowland	Grassed Swale	26.30	$35,088.62
Stamp/Rowland	Infiltration Devices	46.03	$30,036.04
Stamp/Rowland	Restored Riparian Buffer	46.03	$3,654.13
Stamp/Rowland	Sand Filter	59.18	$36,344.94
Stamp/Rowland	Stormwater wetlands	46.03	$9,936.86
Stamp/Rowland	Wet detention basin	52.61	$6,326.83
Upper Etowah	Bioretention	4,447.23	$6,135.81
Upper Etowah	Dry Extension Basin	988.27	$4,093.42
Upper Etowah	Filter Strip	3,458.96	$1,546.45
Upper Etowah	Grassed Swale	1,976.55	$7,915.54
Upper Etowah	Infiltration Devices	3,458.96	$5,669.19
Upper Etowah	Restored Riparian Buffer	3,458.96	$800.29
Upper Etowah	Sand Filter	4,447.23	$6,756.99
Upper Etowah	Stormwater wetlands	3,458.96	$2,051.36
Upper Etowah	Wet detention basin	3,953.09	$1,286.20

Table B.5. Urban BMP's - Credits per Year for Less Developed Urban

Sub-watershed	BMP	Total Credits Available	Unit Credit Cost With Land ($/lb/yr)
Acworth/Allatoona	Bioretention	371.47	61,358.06
Acworth/Allatoona	Dry Extension Basin	82.55	$28,569.74
Acworth/Allatoona	Filter Strip	288.92	$12,813.32
Acworth/Allatoona	Grassed Swale	165.10	$36,505.38
Acworth/Allatoona	Infiltration Devices	288.92	$58,887.62
Acworth/Allatoona	Restored Riparian Buffer	288.92	4,401.87
Acworth/Allatoona	Sand Filter	371.47	73,828.72
Acworth/Allatoona	Stormwater wetlands	288.92	15,090.50
Acworth/Allatoona	Wet detention basin	330.19	10,105.47
Little/Noonday	Bioretention	3,405.26	20,422.83
Little/Noonday	Dry Extension Basin	756.72	$9,359.65
Little/Noonday	Filter Strip	2,648.54	$4,232.77
Little/Noonday	Grassed Swale	1,513.45	$11,634.33
Little/Noonday	Infiltration Devices	2,648.54	$19,627.14
Little/Noonday	Restored Riparian Buffer	2,648.54	1,421.55
Little/Noonday	Sand Filter	3,405.26	24,649.43
Little/Noonday	Stormwater wetlands	2,648.54	4,957.17
Little/Noonday	Wet detention basin	3,026.90	3,330.20
Owl/Kellogg	Bioretention	53.08	54,885.55
Owl/Kellogg	Dry Extension Basin	11.79	$67,855.85
Owl/Kellogg	Filter Strip	41.28	$22,684.38
Owl/Kellogg	Grassed Swale	23.59	$158,590.26
Owl/Kellogg	Infiltration Devices	41.28	$65,755.02
Owl/Kellogg	Restored Riparian Buffer	41.28	14,995.47
Owl/Kellogg	Sand Filter	53.08	73,052.29
Owl/Kellogg	Stormwater wetlands	41.28	32,875.49
Owl/Kellogg	Wet detention basin	47.18	19,672.48
Shoal Creek	Bioretention	301.37	11,825.98
Shoal Creek	Dry Extension Basin	66.97	$4,846.78
Shoal Creek	Filter Strip	234.40	$2,328.16
Shoal Creek	Grassed Swale	133.94	$4,760.48
Shoal Creek	Infiltration Devices	234.40	$11,466.98
Shoal Creek	Restored Riparian Buffer	234.40	656.28
Shoal Creek	Sand Filter	301.37	14,563.46
Shoal Creek	Stormwater wetlands	234.40	2,619.17
Shoal Creek	Wet detention basin	267.89	1,800.64

Sub-watershed	BMP	Total Credits Available	Unit Credit Cost With Land ($/lb/yr)
Stamp/Rowland	Bioretention	38.24	79,623.04
Stamp/Rowland	Dry Extension Basin	8.50	$31,294.72
Stamp/Rowland	Filter Strip	29.74	$15,388.32
Stamp/Rowland	Grassed Swale	16.99	$27,435.99
Stamp/Rowland	Infiltration Devices	29.74	$77,443.57
Stamp/Rowland	Restored Riparian Buffer	29.74	4,028.94
Stamp/Rowland	Sand Filter	38.24	98,731.56
Stamp/Rowland	Stormwater wetlands	29.74	17,047.67
Stamp/Rowland	Wet detention basin	33.99	11,825.16
Upper Etowah	Bioretention	2,403.61	17,624.96
Upper Etowah	Dry Extension Basin	534.14	$7,110.29
Upper Etowah	Filter Strip	1,869.47	$3,445.53
Upper Etowah	Grassed Swale	1,068.27	$6,704.48
Upper Etowah	Infiltration Devices	1,869.47	$17,110.01
Upper Etowah	Restored Riparian Buffer	1,869.47	945.14
Upper Etowah	Sand Filter	2,403.61	21,762.07
Upper Etowah	Stormwater wetlands	1,869.47	3,853.87
Upper Etowah	Wet detention basin	2,136.54	2,658.37

APPENDIX C

POINT SOURCE SENSITIVITY ANALYSIS RESULTS

Table C.1. Credit Summary - Lake Allatoona Point Sources by Sub-watershed (PS Scenario A)

Point Source	Sub-watershed	Total Reduction to meet TMDL (lbs/yr)	Credits Supplied[1]	Credits Demanded[2]	Max Unit Cost for Demand[1,2]	Cost of Compliance (Upgrade Facility)	Cost Savings with Credit at $12	Cost Savings with Credit at $20	Cost Savings with Credit at $30
Cobb County Northwest WPCP	Acworth/Allatoona	-3,527	-	-	-	-	-	-	-
Total by sub-watershed (Average)		**-3,527**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Cherokee County Fitzgerald Creek	Little/Noonday	-160	-	-	-	-	-	-	-
Cherokee County Rose Creek	Little/Noonday	-4,763	-	-	-	-	-	-	-
Cobb County Noonday Creek WPCP	Little/Noonday	-4,704	-	-	-	-	-	-	-
Fulton County Little River WPCP	Little/Noonday	-1,004	-	-	-	-	-	-	-
Woodstock Rubes Creek WPCP	Little/Noonday	2,179	5,923	2,179	$45	$98,679	$72,533	$55,102	$33,313
Total by sub-watershed (Average)		**-8,452**	**5,923**	**2,179**	**($45)**	**$98,679**	**$72,533**	**$55,102**	**$33,313**
Big Canoe WPCP	Upper Etowah	-728	-	-	-	-	-	-	-
City of Canton WPCP	Upper Etowah	12,165	-	12,165	$212	$2,573,153	$2,427,168	$2,329,844	$2,208,190
Goldkist Poultry Byproducts	Upper Etowah	-2,128	-	-	-	-	-	-	-
Jasper WPCP	Upper Etowah	-2,435	-	-	-	-	-	-	-
Total by sub-watershed (Average)		**6,874**	**-**	**12,165**	**($212)**	**$2,573,153**	**$2,427,168**	**$2,329,844**	**$2,208,190**
Total for Lake Allatoona (Average)		**-5,104**	**5,923**	**14,344**	**($128)**	**$2,671,832**	**$2,499,700**	**$2,384,946**	**$2,241,503**

[1] Credits Supplied equals number of credits available if PS chooses to upgrade to meet TMDL compliance; cost to supply will be ≥ $0 depending on market demand. If PS chooses to upgrade and credits supplied equals 0, then Jiang et al. maximum upgrade can not meet TMDL reduction needed; demand costs reflect maximum available upgrade.

[2] Credits Demanded equals number of credits needed to meet TMDL compliance; Max Unit Cost for Demand equals unit compliance cost.

Table C.2. Credit Summary - Lake Allatoona Point Sources by Sub-watershed (PS Scenario B)

Point Source	**Sub-watershed**	**Total Reduction to meet TMDL (lbs/yr)**	**Credits Supplied[1]**	**Credits Demanded[2]**	**Max Unit Cost for Demand[1,2]**	**Cost of Compliance (Upgrade Facility)**	**Cost Savings with Credit at $12**	**Cost Savings with Credit at $20**	**Cost Savings with Credit at $30**
Cobb County Northwest WPCP	Acworth/Allatoona	-3,527	-	-	-	-	-	-	-
Total by sub-watershed (Average)		**-3,527**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Cherokee County Fitzgerald Creek	Little/Noonday	-160	-	-	-	-	-	-	-
Cherokee County Rose Creek	Little/Noonday	-4,763	-	-	-	-	-	-	-
Cobb County Noonday Creek WPCP	Little/Noonday	-4,704	-	-	-	-	-	-	-
Fulton County Little River WPCP	Little/Noonday	-1,004	-	-	-	-	-	-	-
Woodstock Rubes Creek WPCP	Little/Noonday	2,179	5,923	2,179	$22	$47,512	$21,366	$3,935	-$17,853
Total by sub-watershed (Average)		**-8,452**	**5,923**	**2,179**	**($22)**	**$47,512**	**$21,366**	**$3,935**	**($17,853)**
Big Canoe WPCP	Upper Etowah	-728	-	-	-	-	-	-	-
City of Canton WPCP	Upper Etowah	12,165	-	12,165	$102	$1,238,925	$1,092,940	$995,617	$873,963
Goldkist Poultry Byproducts	Upper Etowah	-2,128	-	-	-	-	-	-	-
Jasper WPCP	Upper Etowah	-2,435	-	-	-	-	-	-	-
Total by sub-watershed (Average)		**6,874**	**-**	**12,165**	**($102)**	**$1,238,925**	**$1,092,940**	**$995,617**	**$873,963**
Total for Lake Allatoona (Average)		**-5,104**	**5,923**	**14,344**	**($62)**	**$1,286,437**	**$1,114,306**	**$999,552**	**$856,109**

[1] Credits Supplied equals number of credits available if PS chooses to upgrade to meet TMDL compliance; cost to supply will be ≥ $0 depending on market demand. If PS chooses to upgrade and credits supplied equals 0, then Jiang et al. maximum upgrade can not meet TMDL reduction needed; demand costs reflect maximum available upgrade.

[2] Credits Demanded equals number of credits needed to meet TMDL compliance; Max Unit Cost for Demand equals unit compliance cost.

Table C.3. Credit Summary - Lake Allatoona Point Sources by Sub-watershed (PS Scenario C)

Point Source	Sub-watershed	Total Reduction to meet TMDL (lbs/yr)	Credits Supplied[1]	Credits Demanded[2]	Max Unit Cost for Demand[1,2]	Cost of Compliance (Upgrade Facility)	Cost Savings with Credit at $12	Cost Savings with Credit at $20	Cost Savings with Credit at $30
Cobb County Northwest WPCP	Acworth/Allatoona	-2,127	-	-	-	-	-	-	-
Total by sub-watershed (Average)		**-2,127**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Cherokee County Fitzgerald Creek	Little/Noonday	1,088	5,394	1,088	$61	$66,289	$53,237	$44,535	$33,658
Cherokee County Rose Creek	Little/Noonday	-3,119	-	-	-	-	-	-	-
Cobb County Noonday Creek WPCP	Little/Noonday	-1,964	-	-	-	-	-	-	-
Fulton County Little River WPCP	Little/Noonday	-623	-	-	-	-	-	-	-
Woodstock Rubes Creek WPCP	Little/Noonday	2,369	5,733	2,369	$31	$73,096	$44,669	$25,719	$2,030
Total by sub-watershed (Average)		**-2,249**	**11,127**	**3,457**	**($46)**	**139,384**	**$97,906**	**$70,254**	**$35,689**
Big Canoe WPCP	Upper Etowah	-538	-	-	-	-	-	-	-
City of Canton WPCP	Upper Etowah	12,885	-	12,885	$148	$1,906,039	$1,751,423	$1,648,346	$1,519,499
Goldkist Poultry Byproducts	Upper Etowah	-1,378	-	-	-	-	-	-	-
Jasper WPCP	Upper Etowah	-1,826	-	-	-	-	-	-	-
Total by sub-watershed (Average)		**9,143**	**-**	**12,885**	**($148)**	**$1,906,039**	**$1,751,423**	**$1,648,346**	**$1,519,499**
Total for Lake Allatoona (Average)		**4,767**	**11,127**	**16,341**	**($85)**	**$2,045,423**	**$1,849,329**	**$1,718,599**	**$1,555,187**

[1] Credits Supplied equals number of credits available if PS chooses to upgrade to meet TMDL compliance; cost to supply will be ≥ $0 depending on market demand. If PS chooses to upgrade and credits supplied equals 0, then Jiang et al. maximum upgrade can not meet TMDL reduction needed; demand costs reflect maximum available upgrade.

[2] Credits Demanded equals number of credits needed to meet TMDL compliance; Max Unit Cost for Demand equals unit compliance cost.

Table C.4. Credit Summary - Lake Allatoona Point Sources by Sub-watershed (PS Scenario D)

Point Source	Sub-watershed	Total Reduction to meet TMDL (lbs/yr)	Credits Supplied[1]	Credits Demanded[2]	Max Unit Cost for Demand[1,2]	Cost of Compliance (Upgrade Facility)	Cost Savings with Credit at $12	Cost Savings with Credit at $20	Cost Savings with Credit at $30
Cobb County Northwest WPCP	Acworth/Allatoona	-726	-	-	-	-	-	-	-
Total by sub-watershed (Average)		**-726**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Cherokee County Fitzgerald Creek	Little/Noonday	2,336	4,146	2,336	$28	$66,289	$38,261	$19,575	-$3,782
Cherokee County Rose Creek	Little/Noonday	-1,475	-	-	-	-	-	-	-
Cobb County Noonday Creek WPCP	Little/Noonday	776	38,069	776	$260	$201,592	$192,280	$186,071	$178,311
Fulton County Little River WPCP	Little/Noonday	-243	-	-	-	-	-	-	-
Woodstock Rubes Creek WPCP	Little/Noonday	2,559	5,543	2,559	$29	$73,096	$42,389	$21,919	-$3,670
Total by sub-watershed (Average)		**3,953**	**47,758**	**5,671**	**($106)**	**340,976**	**$272,930**	**$227,565**	**$170,860**
Big Canoe WPCP	Upper Etowah	-348	-	-	-	-	-	-	-
City of Canton WPCP	Upper Etowah	13,604	-	13,604	$140	$1,906,039	$1,742,792	$1,633,961	$1,497,921
Goldkist Poultry Byproducts	Upper Etowah	-628	-	-	-	-	-	-	-
Jasper WPCP	Upper Etowah	-1,218	-	-	-	-	-	-	-
Total by sub-watershed (Average)		**11,411**	**-**	**13,604**	**($140)**	**$1,906,039**	**$1,742,792**	**$1,633,961**	**$1,497,921**
Total for Lake Allatoona (Average)		**14,637**	**47,758**	**19,274**	**($133)**	**$2,247,015**	**$2,015,722**	**$1,861,526**	**$1,668,781**

[1] Credits Supplied equals number of credits available if PS chooses to upgrade to meet TMDL compliance; cost to supply will be ≥ $0 depending on market demand. If PS chooses to upgrade and credits supplied equals 0, then Jiang et al. maximum upgrade can not meet TMDL reduction needed; demand costs reflect maximum available upgrade.

[2] Credits Demanded equals number of credits needed to meet TMDL compliance; Max Unit Cost for Demand equals unit compliance cost.

Table C.5. Credit Summary - Weiss Lake Point Sources (PS Scenario A)

Weiss Market	Point Source	Watershed	Total Reduction to meet TMDL (lbs/yr)	Credits Supplied[1]	Credits Demanded[2]	Max Unit Cost for Demand[1,2]	Cost of Compliance (Upgrade Facility)	Cost Savings with Credit at $21	Cost Savings with Credit at $35	Cost Savings with Credit at $50	Cost Savings with Credit at $90
Weiss-Alabama											
	Cherokee WPCP	Upper Coosa, AL	-2,002	-	-	-	-	-	-	-	-
	Piedmont WWTP	Upper Coosa, AL	-623	-	-	-	-	-	-	-	-
	Town of Cedar Bluff WWTP	Upper Coosa, AL	-2,619	-	-	-	-	-	-	-	-
	Town of Centre WWSB Lagoon	Upper Coosa, AL	3,304	1,722	3,304	$31	$102,174	$32,781	-$13,481	-$63,047	-$195,224
	Total by sub-watershed (Average)		**-1,940**	**1,722**	**3,304**	**($31)**	**$102,174**	**$32,781**	**-$13,481**	**-$63,047**	**-$195,224**
Weiss-Georgia											
	Chatsworth WPCP	Conasauga, GA	3,231	6,492	3,231	$33	$107,868	$40,020	-$5,212	-$53,674	-$182,908
	Dow Chemical Co	Conasauga, GA	-2,821	-	-	-	-	-	-	-	-
	Ellijay-Gilmer Water & Sewer	Conasauga, GA	65,410	-	65,410	$47	$3,061,546	$1,687,936	$772,197	-$208,953	-$2,825,351
	Cartersville WPCP	Lower Etowah	259,678	-	259,678	$41	$10,599,466	$5,146,234	$1,510,746	-$2,384,419	-$12,771,527
	City of Rockmart	Lower Etowah	28,821	-	28,821	$120	$3,461,868	$2,856,628	$2,453,134	$2,020,820	$867,981
	Dallas North WPCP	Lower Etowah	-176	-	-	-	-	-	-	-	-
	Dallas West WPCP	Lower Etowah	1,641	1,600	1,641	$43	$71,112	$36,661	$13,693	-$10,915	-$76,536
	Emerson Pond	Lower Etowah	192	3,048	192	$370	$71,112	$67,073	$64,380	$61,494	$53,800
	Rome Blacks Bluff WPCP	Lower Etowah	69,650	20,828	69,650	$13	$917,045	-$545,605	-$1,520,704	-$2,565,454	-$5,351,453
	Adairsville South WPCP	Oostanaula	34,575	-	34,575	$54	$1,860,579	$1,134,506	$650,457	$131,834	-$1,251,162
	City of Adairsville - North	Oostanaula	24,086	-	24,086	$70	$1,687,135	$1,181,324	$844,117	$482,824	-$480,625
	OMNOVA Solutions Inc	Oostanaula	-3,017	-	-	-	-	-	-	-	-
	Cave Spring WPCP	Upper Coosa, GA	-2,136	-	-	-	-	-	-	-	-
	City of Cedartown	Upper Coosa, GA	18,146	295	18,146	$70	$1,278,491	$897,417	$643,368	$371,172	-$354,684
	City of Summerville WPCP	Upper Coosa, GA	1,392	5,090	1,392	$64	$89,490	$60,264	$40,780	$19,905	-$35,764
	Geo Specialty Chemicals	Upper Coosa, GA	-886	-	-	-	-	-	-	-	-
	Inland Rome (Outfall 001)	Upper Coosa, GA	4,056	-	4,056	-	-	-	-	-	-
	Inland Rome (Outfall 002)	Upper Coosa, GA	-10,050	-	-	-	-	-	-	-	-
	Lafayette WPCP	Upper Coosa, GA	8,217	3,125	8,217	$14	$117,057	-$55,508	-$170,552	-$293,813	-$622,509
	Rome-Coosa WPCP	Upper Coosa, GA	1,062	5,419	1,062	$84	$89,490	$67,186	$52,316	$36,385	-$6,100
	Trion WPCP	Upper Coosa, GA	41,883	-	41,883	$121	$5,063,157	$4,183,604	$3,597,235	$2,968,982	$1,293,642
	Total by sub-watershed (Average)		**735,374**	**45,898**	**754,460**	**($81)**	**$41,922,039**	**$26,163,543**	**$15,657,878**	**$4,401,809**	**-$25,614,376**
	Total for Weiss Markets (Average)		**733,435**	**47,620**	**757,765**	**($78)**	**$42,024,214**	**$26,196,324**	**$15,644,397**	**$4,338,762**	**-$25,809,600**

[1] Credits Supplied equals number of credits available if PS chooses to upgrade to meet TMDL compliance; cost to supply will be ≥ $0 depending on market demand. If PS chooses to upgrade and credits supplied equals 0, then Jiang et al. maximum upgrade can not meet TMDL reduction needed; in these circumstances, demand costs reflect maximum available upgrade.

[2] Credits Demanded equals number of credits needed to meet TMDL compliance. Max Unit Cost for Demand equals unit compliance cost; costs only shown for wastewater treatment plants.

Table C.6. Credit Summary - Weiss Lake Point Sources (PS Scenario B)

Weiss Market	Point Source	Watershed	Total Reduction to meet TMDL (lbs/yr)	Credits Supplied[1]	Credits Demanded[2]	Max Unit Cost for Demand[1,2]	Cost of Compliance (Upgrade Facility)	Cost Savings with Credit at $21	Cost Savings with Credit at $35	Cost Savings with Credit at $50	Cost Savings with Credit at $90
Weiss-Alabama											
	Cherokee WPCP	Upper Coosa, AL	-2,002	-	-	-	-	-	-	-	-
	Piedmont WWTP	Upper Coosa, AL	-623	-	-	-	-	-	-	-	-
	Town of Cedar Bluff WWTP	Upper Coosa, AL	-2,619	-	-	-	-	-	-	-	-
	Town of Centre WWSB Lagoon	Upper Coosa, AL	3,304	1,722	3,304	$15	$49,195	-$20,198	-$66,460	-$116,026	-$248,203
	Total by sub-watershed (Average)		**-1,940**	**1,722**	**3,304**	**($15)**	**$49,195**	**-$20,198**	**-$66,460**	**-$116,026**	**-$248,203**
Weiss-Georgia											
	Chatsworth WPCP	Conasauga, GA	3,231	6,492	3,231	$16	$51,936	-$15,911	-$61,143	-$109,606	-$238,839
	Dow Chemical Co	Conasauga, GA	-2,821	-	-	-	-	-	-	-	-
	Ellijay-Gilmer Water & Sewer	Conasauga, GA	65,410	-	65,410	$23	$1,474,078	$100,468	-$815,271	-$1,796,421	-$4,412,819
	Cartersville WPCP	Lower Etowah	259,678	-	259,678	$20	$5,103,446	-$349,785	-$3,985,273	-$7,880,438	-$18,267,546
	City of Rockmart	Lower Etowah	28,821	-	28,821	$58	$1,666,825	$1,061,585	$658,091	$225,777	-$927,062
	Dallas North WPCP	Lower Etowah	-176	-	-	-	-	-	-	-	-
	Dallas West WPCP	Lower Etowah	1,641	1,600	1,641	$21	$34,239	-$212	-$23,179	-$47,787	-$113,409
	Emerson Pond	Lower Etowah	192	3,048	192	$178	$34,239	$30,200	$27,507	$24,621	$16,927
	Rome Blacks Bluff WPCP	Lower Etowah	69,650	20,828	69,650	$6	$441,540	-$1,021,109	-$1,996,209	-$3,040,959	-$5,826,958
	Adairsville South WPCP	Oostanaula	34,575	-	34,575	$26	$895,834	$169,761	-$314,287	-$832,911	-$2,215,906
	City of Adairsville - North	Oostanaula	24,086	-	24,086	$34	$812,324	$306,514	-$30,693	-$391,987	-$1,355,436
	OMNOVA Solutions Inc	Oostanaula	-3,017	-	-	-	-	-	-	-	-
	Cave Spring WPCP	Upper Coosa, GA	-2,136	-	-	-	-	-	-	-	-
	City of Cedartown	Upper Coosa, GA	18,146	295	18,146	$34	$615,570	$234,496	-$19,554	-$291,749	-$1,017,605
	City of Summerville WPCP	Upper Coosa, GA	1,392	5,090	1,392	$31	$43,088	$13,862	-$5,622	-$26,498	-$82,166
	Geo Specialty Chemicals	Upper Coosa, GA	-886	-	-	-	-	-	-	-	-
	Inland Rome (Outfall 001)	Upper Coosa, GA	4,056	-	4,056	-	-	-	-	-	-
	Inland Rome (Outfall 002)	Upper Coosa, GA	-10,050	-	-	-	-	-	-	-	-
	Lafayette WPCP	Upper Coosa, GA	8,217	3,125	8,217	$7	$56,361	-$116,205	-$231,248	-$354,509	-$683,205
	Rome-Coosa WPCP	Upper Coosa, GA	1,062	5,419	1,062	$41	$43,088	$20,784	$5,914	-$10,018	-$52,502
	Trion WPCP	Upper Coosa, GA	41,883	-	41,883	$58	$2,437,816	$1,558,263	$971,894	$343,642	-$1,331,698
	Total by sub-watershed (Average)		**735,374**	**45,898**	**754,460**	**($39)**	**$20,184,686**	**$4,426,189**	**-$6,079,476**	**-$17,335,545**	**-$47,351,730**
	Total for Weiss Markets (Average)		**733,435**	**47,620**	**757,765**	**($37)**	**$20,233,881**	**$4,405,991**	**-$6,145,936**	**-$17,451,571**	**-$47,599,933**

[1] Credits Supplied equals number of credits available if PS chooses to upgrade to meet TMDL compliance; cost to supply will be ≥ $0 depending on market demand. If PS chooses to upgrade and credits supplied equals 0, then Jiang et al. maximum upgrade can not meet TMDL reduction needed; in these circumstances, demand costs reflect maximum available upgrade.

[2] Credits Demanded equals number of credits needed to meet TMDL compliance. Max Unit Cost for Demand equals unit compliance cost; costs only shown for wastewater treatment plants.

Table C.7. Credit Summary - Weiss Lake Point Sources (PS Scenario C)

Weiss Market	Point Source	Watershed	Total Reduction to meet TMDL (lbs/yr)	Credits Supplied[1]	Credits Demanded[2]	Max Unit Cost for Demand[1,2]	Cost of Compliance (Upgrade Facility)	Cost Savings with Credit at $21	Cost Savings with Credit at $35	Cost Savings with Credit at $50	Cost Savings with Credit at $90
Weiss-Alabama											
	Cherokee WPCP	Upper Coosa, AL	-1,241	-	-	-	-	-	-	-	-
	Piedmont WWTP	Upper Coosa, AL	138	4,885	138	$435	$60,163	$57,262	$55,327	$53,255	$47,729
	Town of Cedar Bluff WWTP	Upper Coosa, AL	-1,858	-	-	-	-	-	-	-	-
	Town of Centre WWSB Lagoon	Upper Coosa, AL	4,065	961	4,065	$19	$75,685	-$9,690	-$66,606	-$127,588	-$290,206
	Total by sub-watershed (Average)		**1,105**	**5,846**	**4,204**	**($227)**	**$135,847**	**$47,572**	**-$11,279**	**-$74,333**	**-$242,477**
Weiss-Georgia											
	Chatsworth WPCP	Conasauga, GA	4,155	5,567	4,155	$19	$79,902	-$7,361	-$65,536	-$127,866	-$294,081
	Dow Chemical Co	Conasauga, GA	-2,060	-	-	-	-	-	-	-	-
	Ellijay-Gilmer Water & Sewer	Conasauga, GA	66,961	-	66,961	$34	$2,267,812	$861,635	-$75,816	-$1,080,227	-$3,758,659
	Cartersville WPCP	Lower Etowah	268,054	-	268,054	$29	$7,851,456	$2,222,314	-$1,530,448	-$5,551,264	-$16,273,439
	City of Rockmart	Lower Etowah	29,738	-	29,738	$86	$2,564,347	$1,939,844	$1,523,509	$1,077,436	-$112,093
	Dallas North WPCP	Lower Etowah	585	2,656	585	$90	$52,676	$40,387	$32,194	$23,416	$9
	Dallas West WPCP	Lower Etowah	2,402	839	2,402	$22	$52,676	$2,243	-$31,379	-$67,402	-$163,464
	Emerson Pond	Lower Etowah	953	2,287	953	$55	$52,676	$32,655	$19,307	$5,007	-$33,128
	Rome Blacks Bluff WPCP	Lower Etowah	77,942	12,536	77,942	$9	$679,292	-$957,482	-$2,048,665	-$3,217,790	-$6,335,455
	Adairsville South WPCP	Oostanaula	35,336	-	35,336	$39	$1,378,207	$636,152	$141,449	-$388,590	-$1,802,026
	City of Adairsville - North	Oostanaula	24,847	-	24,847	$50	$1,249,730	$727,938	$380,076	$7,367	-$986,522
	OMNOVA Solutions Inc	Oostanaula	-2,256	-	-	-	-	-	-	-	-
	Cave Spring WPCP	Upper Coosa, GA	-1,375	-	-	-	-	-	-	-	-
	City of Cedartown	Upper Coosa, GA	19,533	-	19,533	$48	$947,030	$536,831	$263,365	-$29,635	-$810,967
	City of Summerville WPCP	Upper Coosa, GA	2,153	4,329	2,153	$31	$66,289	$21,081	-$9,057	-$41,348	-$127,457
	Geo Specialty Chemicals	Upper Coosa, GA	-125	-	-	-	-	-	-	-	-
	Inland Rome (Outfall 001)	Upper Coosa, GA	16,223	-	16,223	-	-	-	-	-	-
	Inland Rome (Outfall 002)	Upper Coosa, GA	-4,760	-	-	-	-	-	-	-	-
	Lafayette WPCP	Upper Coosa, GA	9,540	1,803	9,540	$9	$86,709	-$113,634	-$247,195	-$390,297	-$771,902
	Rome-Coosa WPCP	Upper Coosa, GA	1,823	4,658	1,823	$36	$66,289	$28,003	$2,479	-$24,868	-$97,793
	Trion WPCP	Upper Coosa, GA	45,691	-	45,691	$82	$3,750,487	$2,790,974	$2,151,299	$1,465,932	-$361,711
	Total by sub-watershed (Average)		**794,446**	**34,675**	**805,023**	**($40)**	**$31,106,038**	**$14,541,239**	**$3,498,040**	**-$8,333,960**	**-$39,885,958**
	Total for Weiss Markets (Average)		**795,551**	**40,522**	**809,226**	**($64)**	**$31,241,886**	**$14,588,811**	**$3,486,761**	**-$8,408,293**	**-$40,128,435**

[1] Credits Supplied equals number of credits available if PS chooses to upgrade to meet TMDL compliance; cost to supply will be ≥ $0 depending on market demand. If PS chooses to upgrade and credits supplied equals 0, then Jiang et al. maximum upgrade can not meet TMDL reduction needed; in these circumstances, demand costs reflect maximum available upgrade.

[2] Credits Demanded equals number of credits needed to meet TMDL compliance. Max Unit Cost for Demand equals unit compliance cost; costs only shown for wastewater treatment plants.

Table C.8. Credit Summary - Weiss Lake Point Sources (PS Scenario D)

Weiss Market	Point Source	Watershed	Total Reduction to meet TMDL (lbs/yr)	Credits Supplied[1]	Credits Demanded[2]	Max Unit Cost for Demand[1,2]	Cost of Compliance (Upgrade Facility)	Cost Savings with Credit at $21	Cost Savings with Credit at $35	Cost Savings with Credit at $50	Cost Savings with Credit at $90
Weiss-Alabama											
	Cherokee WPCP	Upper Coosa, AL	-480	-	-	-	-	-	-	-	-
	Piedmont WWTP	Upper Coosa, AL	899	4,124	899	$67	$60,163	$41,280	$28,691	$15,204	-$20,764
	Town of Cedar Bluff WWTP	Upper Coosa, AL	-1,097	-	-	-	-	-	-	-	-
	Town of Centre WWSB Lagoon	Upper Coosa, AL	4,826	200	4,826	$16	$75,685	-$25,671	-$93,242	-$165,639	-$358,698
	Total by sub-watershed (Average)		**4,149**	**4,324**	**5,726**	**($41)**	**$135,847**	**$15,609**	**-$64,551**	**-$150,436**	**-$379,462**
Weiss-Georgia											
	Chatsworth WPCP	Conasauga, GA	5,080	4,642	5,080	$16	$79,902	-$26,776	-$97,894	-$174,093	-$377,289
	Dow Chemical Co	Conasauga, GA	-1,299	-	-	-	-	-	-	-	-
	Ellijay-Gilmer Water & Sewer	Conasauga, GA	68,512	-	68,512	$33	$2,267,812	$829,068	-$130,094	-$1,157,768	-$3,898,232
	Cartersville WPCP	Lower Etowah	276,431	-	276,431	$28	$7,851,456	$2,046,403	-$1,823,632	-$5,970,099	-$17,027,342
	City of Rockmart	Lower Etowah	30,655	-	30,655	$84	$2,564,347	$1,920,582	$1,491,405	$1,031,573	-$194,645
	Dallas North WPCP	Lower Etowah	1,346	1,895	1,346	$39	$52,676	$24,405	$5,558	-$14,635	-$68,483
	Dallas West WPCP	Lower Etowah	3,163	78	3,163	$17	$52,676	-$13,739	-$58,015	-$105,453	-$231,957
	Emerson Pond	Lower Etowah	1,714	1,526	1,714	$31	$52,676	$16,673	-$7,329	-$33,045	-$101,621
	Rome Blacks Bluff WPCP	Lower Etowah	86,233	4,244	86,233	$8	$679,292	-$1,131,607	-$2,338,873	-$3,632,373	-$7,081,705
	Adairsville South WPCP	Oostanaula	36,097	-	36,097	$38	$1,378,207	$620,171	$114,813	-$426,641	-$1,870,519
	City of Adairsville - North	Oostanaula	25,608	-	25,608	$49	$1,249,730	$711,956	$353,440	-$30,684	-$1,055,015
	OMNOVA Solutions Inc	Oostanaula	-1,495	-	-	-	-	-	-	-	-
	Cave Spring WPCP	Upper Coosa, GA	-614	-	-	-	-	-	-	-	-
	City of Cedartown	Upper Coosa, GA	20,920	-	20,920	$45	$947,030	$507,706	$214,822	-$98,981	-$935,790
	City of Summerville WPCP	Upper Coosa, GA	2,914	3,568	2,914	$23	$66,289	$5,100	-$35,693	-$79,399	-$195,949
	Geo Specialty Chemicals	Upper Coosa, GA	636	-	636	-	-	-$13,358	-$22,263	-$31,805	-$57,248
	Inland Rome (Outfall 001)	Upper Coosa, GA	28,390	-	28,390	-	-	-	-	-	-
	Inland Rome (Outfall 002)	Upper Coosa, GA	529	-	529	-	-	-$11,107	-$18,512	-$26,446	-$47,603
	Lafayette WPCP	Upper Coosa, GA	10,863	480	10,863	$8	$86,709	-$141,411	-$293,490	-$456,433	-$890,947
	Rome-Coosa WPCP	Upper Coosa, GA	2,584	3,897	2,584	$26	$66,289	$12,022	-$24,157	-$62,919	-$166,285
	Trion WPCP	Upper Coosa, GA	49,499	-	49,499	$76	$3,750,487	$2,711,015	$2,018,033	$1,275,553	-$704,394
	Total by sub-watershed (Average)		**853,518**	**20,331**	**856,926**	**($35)**	**$31,106,038**	**$13,706,779**	**$2,107,272**	**-$10,320,770**	**-$43,462,216**
	Total for Weiss Markets (Average)		**857,666**	**24,655**	**862,652**	**($36)**	**$31,241,886**	**$13,722,387**	**$2,042,722**	**-$10,471,205**	**-$43,841,678**

[1] Credits Supplied equals number of credits available if PS chooses to upgrade to meet TMDL compliance; cost to supply will be ≥ $0 depending on market demand. If PS chooses to upgrade and credits supplied equals 0, then Jiang et al. maximum upgrade can not meet TMDL reduction needed; in these circumstances, demand costs reflect maximum available upgrade.

[2] Credits Demanded equals number of credits needed to meet TMDL compliance. Max Unit Cost for Demand equals unit compliance cost; costs only shown for wastewater treatment plants.

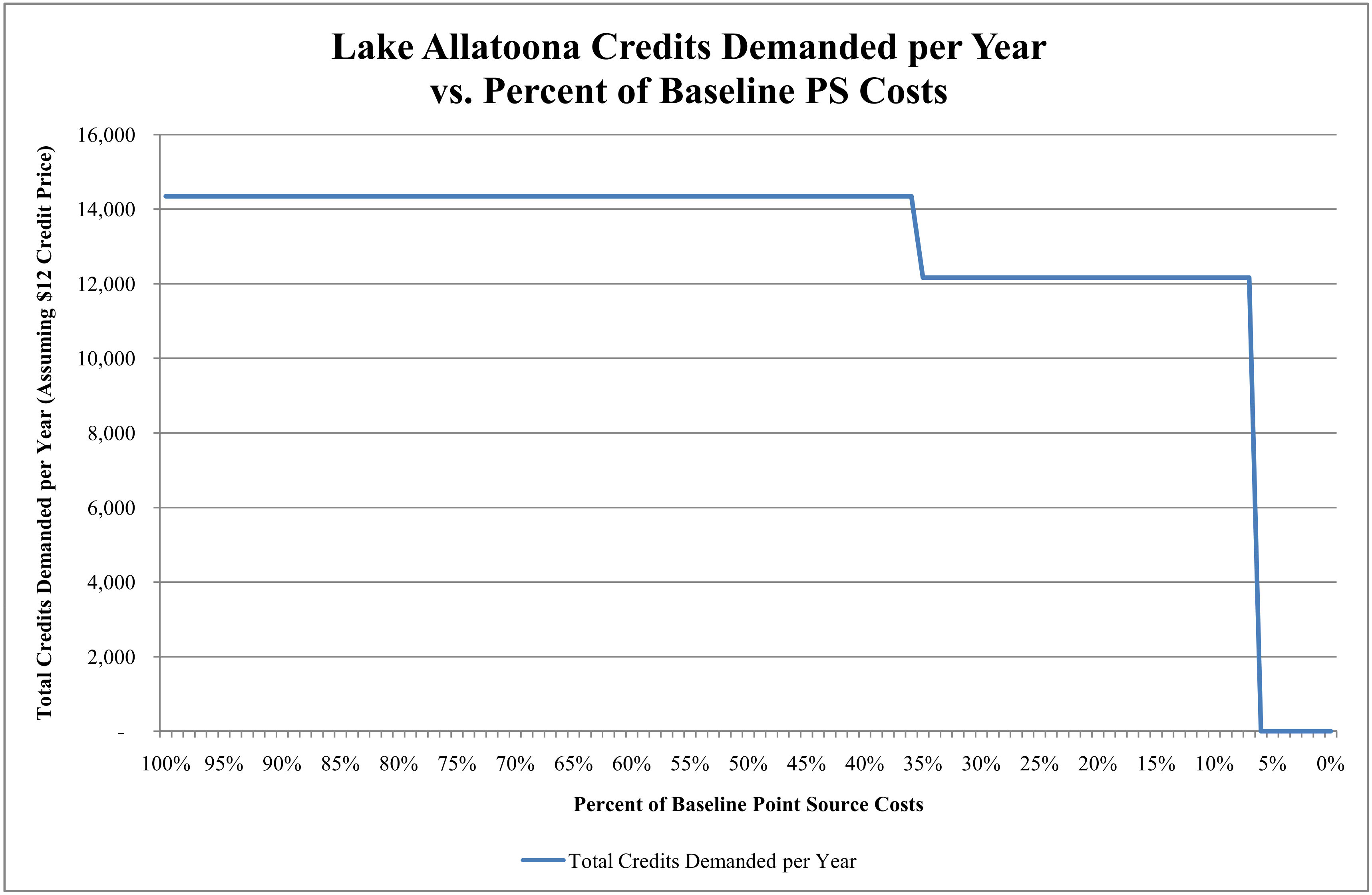

Figure C.1. Lake Allatoona Credits Demanded per Year vs. Percent of Baseline Point Source Costs

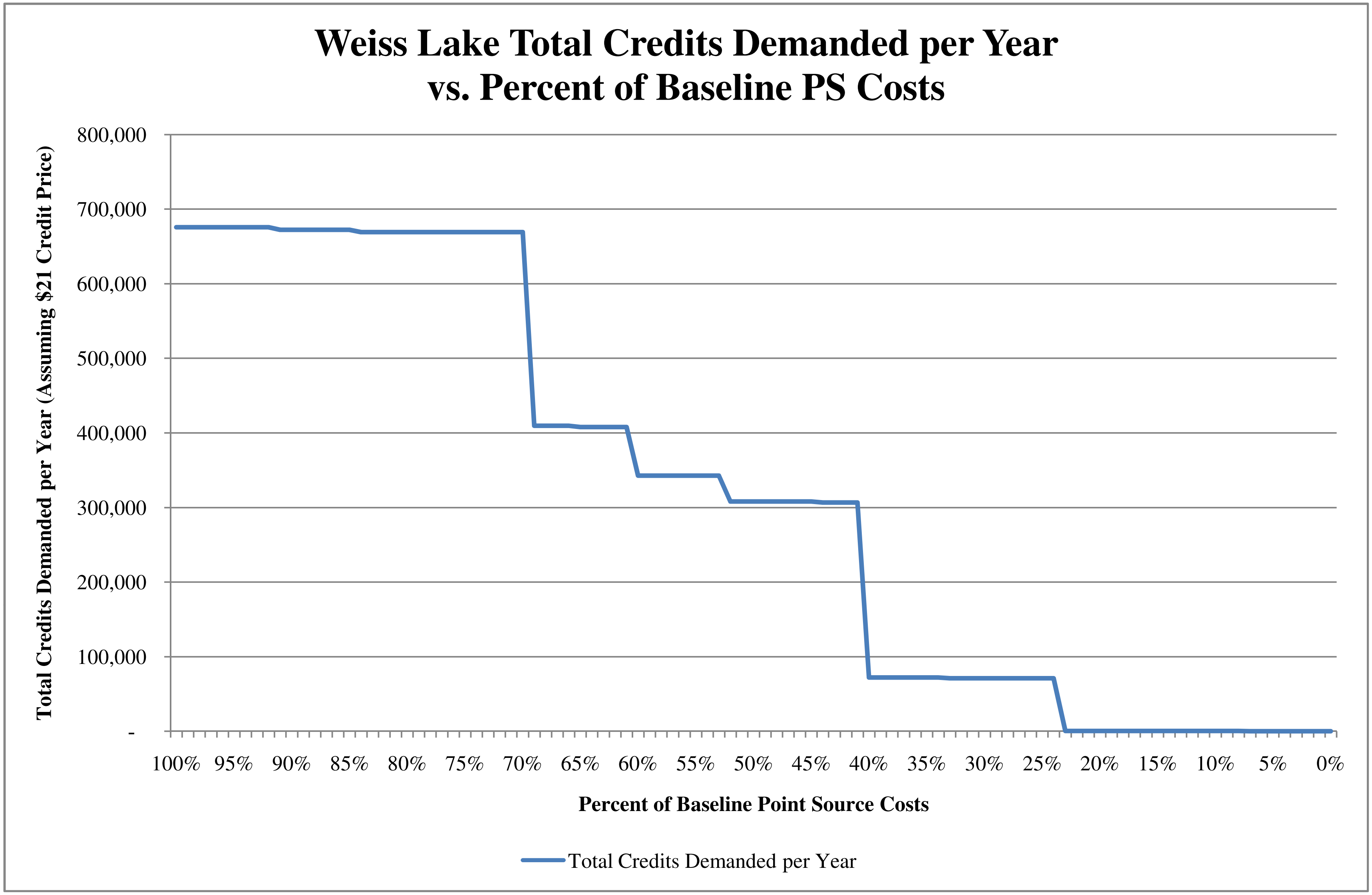

Figure C.2. Weiss Lake Credits Demanded per Year vs. Percent of Baseline Point Source Costs

APPENDIX D

NON-POINT SOURCE SENSITIVITY ANALYSIS RESULTS

Table D.1 Credit Summary - Lake Allatoona Non-Point Sources by Sub-watershed by Land Cover (NPS Scenario A.1)

Sub-watershed	Land Cover	BMP[1]	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)	Range of Credit Supply[2] Min (lbs/year)	Avg (lbs/year)	Max (lbs/year)	Range of Credit Prices[2] Min ($/credit)	Avg ($/credit)	Max ($/credit)
Acworth/Allatoona	Cropland	Cropland: Cover Crop	-	$0	-	-	-	-	-	-
Acworth/Allatoona	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	48	$176	2	22	48	$176	$2,198	$7,729
Acworth/Allatoona	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	43	$5,744	6	6	43	$5,744	$72,584	$251,691
Acworth/Allatoona	Urban (Highly)	Highly Developed: Restored Riparian Buffer	242	$12,225	69	231	311	$12,225	$46,098	$130,487
Acworth/Allatoona	Urban (Less)	Less Developed: Restored Riparian Buffer	144	$8,804	41	138	186	$8,804	$67,013	$147,657
		Total by Sub-watershed (Average)	**477**	**($6,737)**	**119**	**397**	**588**	**($6,737)**	**($46,973)**	**($134,391)**
Little/Noonday	Cropland	Cropland: Riparian Buffers (Forested)	149	$11	22	122	187	$11	$173	$430
Little/Noonday	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	1,099	$310	44	517	1,099	$310	$3,532	$13,526
Little/Noonday	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	216	$9,515	32	32	216	$9,515	$117,832	$415,744
Little/Noonday	Urban (Highly)	Highly Developed: Restored Riparian Buffer	2,966	$2,813	847	2,825	3,814	$2,813	$10,901	$29,842
Little/Noonday	Urban (Less)	Less Developed: Restored Riparian Buffer	1,324	$2,843	378	1,261	1,703	$2,843	$22,141	$49,299
		Total by Sub-watershed (Average)	**5,754**	**($3,098)**	**1,323**	**4,756**	**7,018**	**($3,098)**	**($30,916)**	**($101,768)**
Owl/Kellogg	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Owl/Kellogg	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	19	$314	1	9	19	$314	$3,377	$13,721
Owl/Kellogg	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	4	$12,562	1	1	4	$12,562	$155,527	$548,843
Owl/Kellogg	Urban (Highly)	Highly Developed: Restored Riparian Buffer	35	$2,404	10	34	45	$2,404	$20,198	$44,182
Owl/Kellogg	Urban (Less)	Less Developed: Restored Riparian Buffer	21	$29,991	6	20	27	$29,991	$113,415	$317,181
		Total by Sub-watershed (Average)	**78**	**($11,318)**	**17**	**63**	**94**	**($11,318)**	**($73,129)**	**($230,982)**
Shoal Creek	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Shoal Creek	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	1,511	$79	20	685	1,511	$79	$1,395	$3,434
Shoal Creek	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	86	$4,417	13	13	86	$4,417	$54,744	$193,016
Shoal Creek	Urban (Highly)	Highly Developed: Restored Riparian Buffer	136	$1,869	39	129	174	$1,869	$9,020	$18,730
Shoal Creek	Urban (Less)	Less Developed: Restored Riparian Buffer	117	$1,313	33	112	151	$1,313	$12,193	$29,127
		Total by Sub-watershed (Average)	**1,849**	**($1,919)**	**105**	**938**	**1,922**	**($1,919)**	**($19,338)**	**($61,077)**
Stamp/Rowland	Pasture (Litter)		-	-	-	-	-	-	-	-
Stamp/Rowland	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Stamp/Rowland	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	17	$10,748	3	3	17	$10,748	$134,284	$470,198
Stamp/Rowland	Urban (Highly)	Highly Developed: Restored Riparian Buffer	23	$7,308	7	22	30	$7,308	$40,187	$72,690
Stamp/Rowland	Urban (Less)	Less Developed: Restored Riparian Buffer	15	$8,058	4	14	19	$8,058	$80,626	$197,463
		Total by Sub-watershed (Average)	**55**	**($8,705)**	**13**	**39**	**66**	**($8,705)**	**($85,033)**	**($246,784)**
Upper Etowah	Cropland	Cropland: Riparian Buffers (Forested)	266	$165	39	216	333	$165	$2,522	$6,218
Upper Etowah	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	41,258	$43	445	18,628	41,258	$43	$1,028	$2,045
Upper Etowah	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	2,230	$1,152	327	327	2,230	$1,152	$14,571	$50,500
Upper Etowah	Urban (Highly)	Highly Developed: Restored Riparian Buffer	1,729	$1,601	494	1,647	2,224	$1,601	$8,057	$15,831
Upper Etowah	Urban (Less)	Less Developed: Restored Riparian Buffer	935	$1,890	267	890	1,202	$1,890	$18,048	$43,524
		Total by Sub-watershed (Average)	**46,418**	**($970)**	**1,572**	**21,709**	**47,247**	**($970)**	**($8,845)**	**($23,624)**
		Total for Lake Allatoona (Average)	**54,633**	**($5,054)**	**3,150**	**27,902**	**56,935**	**($5,054)**	**($40,467)**	**($122,924)**

[1] BMP represents the BMP with lowest credit price by land cover type.

[2] Range of Credit Supply and Credit Prices are for all BMPs by land cover type.

Table D.2 Credit Analysis - Lake Allatoona Litter Transfer by Sub-watershed by County (NPS Scenario A.1)

Sub-watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Acworth/Allatoona	Litter Transport from: BARTOW	29.58	$55
Acworth/Allatoona	Litter Transport from: CHEROKEE	15.15	$53
Acworth/Allatoona	Litter Transport from: COBB	-	-
Acworth/Allatoona	Litter Transport from: PAULDING	21.42	$55
	Total by Sub-watershed (Average)	**66.15**	**($54)**
Little/Noonday	Litter Transport from: CHEROKEE	665.92	$58
Little/Noonday	Litter Transport from: COBB	-	-
Little/Noonday	Litter Transport from: FORSYTH	35.71	$105
Little/Noonday	Litter Transport from: FULTON	-	-
	Total by Sub-watershed (Average)	**701.64**	**($82)**
Owl/Kellogg	Litter Transport from: CHEROKEE	46.42	$59
Owl/Kellogg	Litter Transport from: COBB	-	-
	Total by Sub-watershed (Average)	**46.42**	**($59)**
Shoal Creek	Litter Transport from: BARTOW	13.39	$16
Shoal Creek	Litter Transport from: CHEROKEE	1,573.30	$15
Shoal Creek	Litter Transport from: PICKENS	452.27	$15
	Total by Sub-watershed (Average)	**2,038.96**	**($15)**
Stamp/Rowland	Litter Transport from: BARTOW	-	-
Stamp/Rowland	Litter Transport from: CHEROKEE	-	-
	Total by Sub-watershed (Average)	**-**	**($0)**
Upper Etowah	Litter Transport from: CHEROKEE	3,906.85	$13
Upper Etowah	Litter Transport from: DAWSON	33,551.17	$15
Upper Etowah	Litter Transport from: FANNIN	35.32	$63
Upper Etowah	Litter Transport from: FORSYTH	4,200.37	$23
Upper Etowah	Litter Transport from: GILMER	1,426.62	$14
Upper Etowah	Litter Transport from: LUMPKIN	5,349.00	$20
Upper Etowah	Litter Transport from: PICKENS	16,325.44	$13
Upper Etowah	Litter Transport from: UNION	-	-
	Total by Sub-watershed (Average)	**64,795**	**($23)**
	Total for Lake Allatoona (Average)	**67,648**	**($37)**

Table D.3 Credit Summary - Lake Allatoona Non-Point Sources by Sub-watershed by Land Cover (NPS Scenario A.2)

					Range of Credit Supply[2]			Range of Credit Prices[2]		
Sub-watershed	Land Cover	BMP[1]	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)	Min (lbs/year)	Avg (lbs/year)	Max (lbs/year)	Min ($/credit)	Avg ($/credit)	Max ($/credit)
Acworth/Allatoona	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Acworth/Allatoona	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	190	$44	8	90	190	$44	$549	$1,932
Acworth/Allatoona	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	172	$1,436	25	25	172	$1,436	$18,146	$62,923
Acworth/Allatoona	Urban (Highly)	Highly Developed: Restored Riparian Buffer	969	$3,056	277	923	1,246	$3,056	$11,524	$32,622
Acworth/Allatoona	Urban (Less)	Less Developed: Restored Riparian Buffer	578	$2,201	165	550	743	$2,201	$16,753	$36,914
		Total by Sub-watershed (Average)	**1,910**	**($1,684)**	**475**	**1,588**	**2,352**	**($1,684)**	**($11,743)**	**($33,598)**
Little/Noonday	Cropland	Cropland: Riparian Buffers (Forested)	598	$3	88	486	749	$3	$43	$108
Little/Noonday	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	4,395	$77	174	2,067	4,395	$77	$883	$3,382
Little/Noonday	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	863	$2,379	127	127	863	$2,379	$29,458	$103,936
Little/Noonday	Urban (Highly)	Highly Developed: Restored Riparian Buffer	11,864	$703	3,390	11,299	15,254	$703	$2,725	$7,460
Little/Noonday	Urban (Less)	Less Developed: Restored Riparian Buffer	5,297	$711	1,513	5,045	6,811	$711	$5,535	$12,325
		Total by Sub-watershed (Average)	**23,017**	**($775)**	**5,291**	**19,024**	**28,071**	**($775)**	**($7,729)**	**($25,442)**
Owl/Kellogg	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Owl/Kellogg	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	74	$79	4	35	74	$79	$844	$3,430
Owl/Kellogg	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	15	$3,141	2	2	15	$3,141	$38,882	$137,211
Owl/Kellogg	Urban (Highly)	Highly Developed: Restored Riparian Buffer	141	$601	40	134	182	$601	$5,050	$11,046
Owl/Kellogg	Urban (Less)	Less Developed: Restored Riparian Buffer	83	$7,498	24	79	106	$7,498	$28,354	$79,295
		Total by Sub-watershed (Average)	**313**	**($2,829)**	**70**	**251**	**377**	**($2,829)**	**($18,282)**	**($57,745)**
Shoal Creek	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Shoal Creek	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	6,044	$20	81	2,739	6,044	$20	$349	$859
Shoal Creek	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	343	$1,104	50	50	343	$1,104	$13,686	$48,254
Shoal Creek	Urban (Highly)	Highly Developed: Restored Riparian Buffer	543	$467	155	517	698	$467	$2,255	$4,683
Shoal Creek	Urban (Less)	Less Developed: Restored Riparian Buffer	469	$328	134	446	603	$328	$3,048	$7,282
		Total by Sub-watershed (Average)	**7,398**	**($480)**	**420**	**3,752**	**7,687**	**($480)**	**($4,835)**	**($15,269)**
Stamp/Rowland	Pasture (Litter)		-	-	-	-	-	-	-	-
Stamp/Rowland	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Stamp/Rowland	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	69	$2,687	10	10	69	$2,687	$33,571	$117,549
Stamp/Rowland	Urban (Highly)	Highly Developed: Restored Riparian Buffer	92	$1,827	26	88	118	$1,827	$10,047	$18,172
Stamp/Rowland	Urban (Less)	Less Developed: Restored Riparian Buffer	59	$2,014	17	57	76	$2,014	$20,157	$49,366
		Total by Sub-watershed (Average)	**221**	**($2,176)**	**53**	**154**	**264**	**($2,176)**	**($21,258)**	**($61,696)**
Upper Etowah	Cropland	Cropland: Riparian Buffers (Forested)	1,064	$41	156	865	1,334	$41	$630	$1,554
Upper Etowah	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	165,031	$11	1,780	74,513	165,031	$11	$257	$511
Upper Etowah	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	8,922	$288	1,309	1,309	8,922	$288	$3,643	$12,625
Upper Etowah	Urban (Highly)	Highly Developed: Restored Riparian Buffer	6,918	$400	1,977	6,588	8,894	$400	$2,014	$3,958
Upper Etowah	Urban (Less)	Less Developed: Restored Riparian Buffer	3,739	$473	1,068	3,561	4,807	$473	$4,512	$10,881
		Total by Sub-watershed (Average)	**185,674**	**($243)**	**6,290**	**86,836**	**188,988**	**($243)**	**($2,211)**	**($5,906)**
		Total for Lake Allatoona (Average)	**218,531**	**($1,264)**	**12,599**	**111,606**	**227,739**	**($1,264)**	**($10,117)**	**($30,731)**

[1] BMP represents the BMP with lowest credit price by land cover type.

[2] Range of Credit Supply and Credit Prices are for all BMPs by land cover type.

Table D.4.A. Credit Analysis - Lake Allatoona Litter Transfer by Sub-watershed by County (NPS Scenario A.2)

Sub-watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Acworth/Allatoona	Litter Transport from: BARTOW	118.31	$14
Acworth/Allatoona	Litter Transport from: CHEROKEE	60.60	$13
Acworth/Allatoona	Litter Transport from: COBB	-	-
Acworth/Allatoona	Litter Transport from: PAULDING	85.70	$14
	Total by Sub-watershed (Average)	**264.61**	**($14)**
Little/Noonday	Litter Transport from: CHEROKEE	2,663.70	$15
Little/Noonday	Litter Transport from: COBB	-	-
Little/Noonday	Litter Transport from: FORSYTH	142.86	$26
Little/Noonday	Litter Transport from: FULTON	-	-
	Total by Sub-watershed (Average)	**2,806.55**	**($20)**
Owl/Kellogg	Litter Transport from: CHEROKEE	185.68	$15
Owl/Kellogg	Litter Transport from: COBB	-	$0
	Total by Sub-watershed (Average)	**185.68**	**($15)**
Shoal Creek	Litter Transport from: BARTOW	53.58	$4
Shoal Creek	Litter Transport from: CHEROKEE	6,293.18	$4
Shoal Creek	Litter Transport from: PICKENS	1,809.08	$4
	Total by Sub-watershed (Average)	**8,155.85**	**($4)**
Stamp/Rowland	Litter Transport from: BARTOW	-	-
Stamp/Rowland	Litter Transport from: CHEROKEE	-	-
	Total by Sub-watershed (Average)	**-**	**($0)**
Upper Etowah	Litter Transport from: CHEROKEE	15,627.38	$3
Upper Etowah	Litter Transport from: DAWSON	134,204.68	$4
Upper Etowah	Litter Transport from: FANNIN	141.28	$16
Upper Etowah	Litter Transport from: FORSYTH	16,801.47	$6
Upper Etowah	Litter Transport from: GILMER	5,706.49	$4
Upper Etowah	Litter Transport from: LUMPKIN	21,396.02	$5
Upper Etowah	Litter Transport from: PICKENS	65,301.75	$3
Upper Etowah	Litter Transport from: UNION	-	-
	Total by Sub-watershed (Average)	**259,179**	**($06)**
	Total for Lake Allatoona (Average)	**270,592**	**($09)**

Table D.4.B. Upper Etowah Litter Producers - Credits Supplied, Average Credit Price, and Total Demand by NPS:PS Ratio

NPS:PS Ratio	Credit Supply	Avg. Credit Price	Total Demand
1:1	259,179	$6	14,344
2:1	129,590	$12	14,344
3:1	86,393	$17	14,344
4:1	64,795	$23	14,344
5:1	51,836	$29	14,344
6:1	43,197	$35	12,165
7:1	37,026	$41	12,165
8:1	32,397	$47	12,165
9:1	28,798	$52	12,165
10:1	25,918	$58	12,165
11:1	23,562	$64	12,165
12:1	21,598	$70	12,165
13:1	19,937	$76	12,165
14:1	18,513	$81	12,165
15:1	17,279	$87	12,165
16:1	16,199	$93	12,165
17:1	15,246	$99	12,165
18:1	14,399	$105	12,165
19:1	13,641	$111	12,165
20:1	12,959	$116	12,165
21:1	12,342	$122	12,165
22:1	11,781	$128	12,165
23:1	11,269	$134	12,165
24:1	10,799	$140	12,165
25:1	10,367	$145	12,165
26:1	9,968	$151	12,165
27:1	9,599	$157	-
28:1	9,256	$163	-
29:1	8,937	$169	-
30:1	8,639	$175	-

Table D.5 Credit Summary - Lake Allatoona Non-Point Sources by Sub-watershed by Land Cover (NPS Scenario B)

					Range of Credit Supply[2]			Range of Credit Prices[2]		
Sub-watershed	Land Cover	BMP[1]	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)	Min (lbs/year)	Avg (lbs/year)	Max (lbs/year)	Min ($/credit)	Avg ($/credit)	Max ($/credit)
Acworth/Allatoona	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Acworth/Allatoona	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	86	$98	3	40	86	$98	$1,221	$4,294
Acworth/Allatoona	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	78	$3,191	11	11	78	$3,191	$40,324	$139,828
Acworth/Allatoona	Urban (Highly)	Highly Developed: Restored Riparian Buffer	436	$6,792	125	415	561	$6,792	$25,610	$72,493
Acworth/Allatoona	Urban (Less)	Less Developed: Restored Riparian Buffer	260	$4,891	74	248	334	$4,891	$37,230	$82,032
		Total by Sub-watershed (Average)	**859**	**($3,743)**	**214**	**715**	**1,058**	**($3,743)**	**($26,096)**	**($74,662)**
Little/Noonday	Cropland	Cropland: Riparian Buffers (Forested)	269	$6	39	219	337	$6	$96	$239
Little/Noonday	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	1,978	$172	78	930	1,978	$172	$1,962	$7,514
Little/Noonday	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	388	$5,286	57	57	388	$5,286	$65,462	$230,969
Little/Noonday	Urban (Highly)	Highly Developed: Restored Riparian Buffer	5,339	$1,563	1,525	5,085	6,864	$1,563	$6,056	$16,579
Little/Noonday	Urban (Less)	Less Developed: Restored Riparian Buffer	2,384	$1,580	681	2,270	3,065	$1,580	$12,301	$27,388
		Total by Sub-watershed (Average)	**10,358**	**($1,721)**	**2,381**	**8,561**	**12,632**	**($1,721)**	**($17,175)**	**($56,538)**
Owl/Kellogg	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Owl/Kellogg	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	33	$174	2	16	33	$174	$1,876	$7,623
Owl/Kellogg	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	7	$6,979	1	1	7	$6,979	$86,404	$304,913
Owl/Kellogg	Urban (Highly)	Highly Developed: Restored Riparian Buffer	64	$1,336	18	61	82	$1,336	$11,221	$24,546
Owl/Kellogg	Urban (Less)	Less Developed: Restored Riparian Buffer	37	$16,662	11	35	48	$16,662	$63,008	$176,211
		Total by Sub-watershed (Average)	**141**	**($6,288)**	**31**	**113**	**170**	**($6,288)**	**($40,627)**	**($128,323)**
Shoal Creek	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Shoal Creek	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	2,720	$44	36	1,233	2,720	$44	$775	$1,908
Shoal Creek	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	154	$2,454	23	23	154	$2,454	$30,414	$107,231
Shoal Creek	Urban (Highly)	Highly Developed: Restored Riparian Buffer	244	$1,039	70	233	314	$1,039	$5,011	$10,406
Shoal Creek	Urban (Less)	Less Developed: Restored Riparian Buffer	211	$729	60	201	271	$729	$6,774	$16,182
		Total by Sub-watershed (Average)	**3,329**	**($1,066)**	**189**	**1,689**	**3,459**	**($1,066)**	**($10,743)**	**($33,932)**
Stamp/Rowland	Pasture (Litter)		-	-	-	-	-	-	-	-
Stamp/Rowland	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Stamp/Rowland	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	31	$5,971	5	5	31	$5,971	$74,602	$261,221
Stamp/Rowland	Urban (Highly)	Highly Developed: Restored Riparian Buffer	41	$4,060	12	39	53	$4,060	$22,326	$40,383
Stamp/Rowland	Urban (Less)	Less Developed: Restored Riparian Buffer	27	$4,477	8	25	34	$4,477	$44,792	$109,702
		Total by Sub-watershed (Average)	**99**	**($4,836)**	**24**	**70**	**119**	**($4,836)**	**($47,240)**	**($137,102)**
Upper Etowah	Cropland	Cropland: Riparian Buffers (Forested)	479	$91	70	389	600	$91	$1,401	$3,454
Upper Etowah	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	74,264	$24	801	33,531	74,264	$24	$571	$1,136
Upper Etowah	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	4,015	$640	589	589	4,015	$640	$8,095	$28,055
Upper Etowah	Urban (Highly)	Highly Developed: Restored Riparian Buffer	3,113	$889	889	2,965	4,003	$889	$4,476	$8,795
Upper Etowah	Urban (Less)	Less Developed: Restored Riparian Buffer	1,683	$1,050	481	1,602	2,163	$1,050	$10,027	$24,180
		Total by Sub-watershed (Average)	**83,553**	**($539)**	**2,830**	**39,076**	**85,045**	**($539)**	**($4,914)**	**($13,124)**
		Total for Lake Allatoona (Average)	**98,339**	**($2,808)**	**5,670**	**50,223**	**102,482**	**($2,808)**	**($22,481)**	**($68,291)**

[1] BMP represents the BMP with lowest credit price by land cover type.

[2] Range of Credit Supply and Credit Prices are for all BMPs by land cover type.

Table D.6. Credit Analysis - Lake Allatoona Litter Transfer by Sub-watershed by County (NPS Scenario B)

Sub-watershed	**BMP**	**Supply Credits (lbs/ year)**	**Min Credit Price (Unit Price)**
Acworth/Allatoona	Litter Transport from: BARTOW	53.24	$30
Acworth/Allatoona	Litter Transport from: CHEROKEE	27.27	$30
Acworth/Allatoona	Litter Transport from: COBB	-	-
Acworth/Allatoona	Litter Transport from: PAULDING	38.56	$30
	Total by Sub-watershed (Average)	**119.08**	**($30)**
Little/Noonday	Litter Transport from: CHEROKEE	1,198.66	$32
Little/Noonday	Litter Transport from: COBB	-	-
Little/Noonday	Litter Transport from: FORSYTH	64.29	$58
Little/Noonday	Litter Transport from: FULTON	-	-
	Total by Sub-watershed (Average)	**1,262.95**	**($45)**
Owl/Kellogg	Litter Transport from: CHEROKEE	83.56	$33
Owl/Kellogg	Litter Transport from: COBB	-	-
	Total by Sub-watershed (Average)	**83.56**	**($33)**
Shoal Creek	Litter Transport from: BARTOW	24.11	$9
Shoal Creek	Litter Transport from: CHEROKEE	2,831.93	$8
Shoal Creek	Litter Transport from: PICKENS	814.09	$8
	Total by Sub-watershed (Average)	**3,670.13**	**($9)**
Stamp/Rowland	Litter Transport from: BARTOW	-	-
Stamp/Rowland	Litter Transport from: CHEROKEE	-	-
	Total by Sub-watershed (Average)	**-**	**($0)**
Upper Etowah	Litter Transport from: CHEROKEE	7,032.32	$7
Upper Etowah	Litter Transport from: DAWSON	60,392.11	$8
Upper Etowah	Litter Transport from: FANNIN	63.58	$35
Upper Etowah	Litter Transport from: FORSYTH	7,560.66	$13
Upper Etowah	Litter Transport from: GILMER	2,567.92	$8
Upper Etowah	Litter Transport from: LUMPKIN	9,628.21	$11
Upper Etowah	Litter Transport from: PICKENS	29,385.79	$7
Upper Etowah	Litter Transport from: UNION	-	-
	Total by Sub-watershed (Average)	**116,631**	**($13)**
	Total for Lake Allatoona (Average)	**121,766**	**($21)**

Table D.7. Credit Summary - Lake Allatoona Non-Point Sources by Sub-watershed by Land Cover (NPS Scenario C)

Sub-watershed	Land Cover	BMP[1]	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)	Range of Credit Supply[2] Min (lbs/year)	Avg (lbs/year)	Max (lbs/year)	Range of Credit Prices[2] Min ($/credit)	Avg ($/credit)	Max ($/credit)
Acworth/Allatoona	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Acworth/Allatoona	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	95	$88	4	45	95	$88	$1,196	$3,880
Acworth/Allatoona	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	86	$2,876	13	13	86	$2,876	$37,029	$126,368
Acworth/Allatoona	Urban (Highly)	Highly Developed: Restored Riparian Buffer	485	$6,375	138	461	623	$6,375	$26,279	$66,656
Acworth/Allatoona	Urban (Less)	Less Developed: Restored Riparian Buffer	289	$5,199	83	275	371	$5,199	$43,318	$99,292
		Total by Sub-watershed (Average)	**955**	**($3,635)**	**238**	**794**	**1,176**	**($3,635)**	**($26,955)**	**($74,049)**
Little/Noonday	Cropland	Cropland: Riparian Buffers (Forested)	299	$6	44	243	375	$6	$87	$216
Little/Noonday	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	2,197	$155	87	1,034	2,197	$155	$1,876	$6,781
Little/Noonday	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	431	$4,762	63	63	431	$4,762	$59,685	$208,417
Little/Noonday	Urban (Highly)	Highly Developed: Restored Riparian Buffer	5,932	$1,472	1,695	5,650	7,627	$1,472	$6,259	$15,274
Little/Noonday	Urban (Less)	Less Developed: Restored Riparian Buffer	2,649	$1,688	757	2,522	3,405	$1,688	$14,350	$33,159
		Total by Sub-watershed (Average)	**11,508**	**($1,617)**	**2,646**	**9,512**	**14,036**	**($1,617)**	**($16,451)**	**($52,769)**
Owl/Kellogg	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Owl/Kellogg	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	37	$157	2	18	37	$157	$1,780	$6,878
Owl/Kellogg	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	7	$6,287	1	1	7	$6,287	$78,772	$275,137
Owl/Kellogg	Urban (Highly)	Highly Developed: Restored Riparian Buffer	71	$1,437	20	67	91	$1,437	$12,995	$29,252
Owl/Kellogg	Urban (Less)	Less Developed: Restored Riparian Buffer	41	$15,724	12	39	53	$15,724	$65,676	$162,513
		Total by Sub-watershed (Average)	**157**	**($5,901)**	**35**	**125**	**188**	**($5,901)**	**($39,806)**	**($118,445)**
Shoal Creek	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Shoal Creek	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	3,022	$39	40	1,369	3,022	$39	$774	$1,722
Shoal Creek	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	171	$2,211	25	25	171	$2,211	$27,738	$96,767
Shoal Creek	Urban (Highly)	Highly Developed: Restored Riparian Buffer	271	$1,010	78	258	349	$1,010	$5,440	$9,772
Shoal Creek	Urban (Less)	Less Developed: Restored Riparian Buffer	234	$815	67	223	301	$815	$8,047	$19,625
		Total by Sub-watershed (Average)	**3,699**	**($1,019)**	**210**	**1,876**	**3,843**	**($1,019)**	**($10,500)**	**($31,971)**
Stamp/Rowland	Pasture (Litter)		-	-	-	-	-	-	-	-
Stamp/Rowland	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Stamp/Rowland	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	35	$5,380	5	5	35	$5,380	$68,233	$235,873
Stamp/Rowland	Urban (Highly)	Highly Developed: Restored Riparian Buffer	46	$4,038	13	44	59	$4,038	$24,820	$48,612
Stamp/Rowland	Urban (Less)	Less Developed: Restored Riparian Buffer	30	$5,106	8	28	38	$5,106	$53,563	$133,118
		Total by Sub-watershed (Average)	**110**	**($4,841)**	**27**	**77**	**132**	**($4,841)**	**($48,872)**	**($139,201)**
Upper Etowah	Cropland	Cropland: Riparian Buffers (Forested)	532	$82	78	433	667	$82	$1,279	$3,121
Upper Etowah	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	82,516	$22	890	37,256	82,516	$22	$594	$1,309
Upper Etowah	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	4,461	$577	654	654	4,461	$577	$7,435	$25,356
Upper Etowah	Urban (Highly)	Highly Developed: Restored Riparian Buffer	3,459	$871	988	3,294	4,447	$871	$4,899	$9,016
Upper Etowah	Urban (Less)	Less Developed: Restored Riparian Buffer	1,869	$1,182	534	1,780	2,404	$1,182	$11,940	$29,331
		Total by Sub-watershed (Average)	**92,837**	**($547)**	**3,145**	**43,418**	**94,494**	**($547)**	**($5,229)**	**($13,627)**
		Total for Lake Allatoona (Average)	**109,266**	**($2,702)**	**6,300**	**55,803**	**113,869**	**($2,702)**	**($22,563)**	**($65,898)**

[1] BMP represents the BMP with lowest credit price by land cover type.

[2] Range of Credit Supply and Credit Prices are for all BMPs by land cover type.

Table D.8. Credit Analysis - Lake Allatoona Litter Transfer by Sub-watershed by County (NPS Scenario C)

Sub-watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Acworth/Allatoona	Litter Transport from: BARTOW	59.15	$37
Acworth/Allatoona	Litter Transport from: CHEROKEE	30.30	$36
Acworth/Allatoona	Litter Transport from: COBB	-	-
Acworth/Allatoona	Litter Transport from: PAULDING	42.85	$37
	Total by Sub-watershed (Average)	**132.31**	**($37)**
Little/Noonday	Litter Transport from: CHEROKEE	1,331.85	$39
Little/Noonday	Litter Transport from: COBB	-	-
Little/Noonday	Litter Transport from: FORSYTH	71.43	$71
Little/Noonday	Litter Transport from: FULTON	-	-
	Total by Sub-watershed (Average)	**1,403.28**	**($55)**
Owl/Kellogg	Litter Transport from: CHEROKEE	92.84	$40
Owl/Kellogg	Litter Transport from: COBB	-	-
	Total by Sub-watershed (Average)	**92.84**	**($40)**
Shoal Creek	Litter Transport from: BARTOW	26.79	$11
Shoal Creek	Litter Transport from: CHEROKEE	3,146.59	$10
Shoal Creek	Litter Transport from: PICKENS	904.54	$10
	Total by Sub-watershed (Average)	**4,077.92**	**($10)**
Stamp/Rowland	Litter Transport from: BARTOW	-	-
Stamp/Rowland	Litter Transport from: CHEROKEE	-	-
	Total by Sub-watershed (Average)	**-**	**($0)**
Upper Etowah	Litter Transport from: CHEROKEE	7,813.69	$9
Upper Etowah	Litter Transport from: DAWSON	67,102.34	$10
Upper Etowah	Litter Transport from: FANNIN	70.64	$43
Upper Etowah	Litter Transport from: FORSYTH	8,400.74	$16
Upper Etowah	Litter Transport from: GILMER	2,853.24	$10
Upper Etowah	Litter Transport from: LUMPKIN	10,698.01	$14
Upper Etowah	Litter Transport from: PICKENS	32,650.88	$9
Upper Etowah	Litter Transport from: UNION	-	-
	Total by Sub-watershed (Average)	**129,590**	**($16)**
	Total for Lake Allatoona (Average)	**135,296**	**($25)**

Table D.9. Credit Summary - Lake Allatoona Non-Point Sources by Sub-watershed by Land Cover (NPS Scenario D)

					Range of Credit Supply[2]			Range of Credit Prices[2]		
Sub-watershed	**Land Cover**	**BMP[1]**	**Supply Credits (lbs/ year)**	**Min Credit Price (Unit Price)**	**Min (lbs/year)**	**Avg (lbs/year)**	**Max (lbs/year)**	**Min ($/credit)**	**Avg ($/credit)**	**Max ($/credit)**
Acworth/Allatoona	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Acworth/Allatoona	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	95	$88	4	45	95	$88	$1,002	$3,848
Acworth/Allatoona	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	86	$2,868	13	13	86	$2,868	$35,555	$125,323
Acworth/Allatoona	Urban (Highly)	Highly Developed: Restored Riparian Buffer	485	$5,850	138	461	623	$5,850	$19,819	$63,831
Acworth/Allatoona	Urban (Less)	Less Developed: Restored Riparian Buffer	289	$3,605	83	275	371	$3,605	$23,695	$48,366
		Total by Sub-watershed (Average)	**955**	**($3,103)**	**238**	**794**	**1,176**	**($3,103)**	**($20,018)**	**($60,342)**
Little/Noonday	Cropland	Cropland: Cover Crop	44	$5	44	243	375	$5	$85	$215
Little/Noonday	Pasture (Litter)	Pasture (Litter): Cover Crop	322	$136	87	1,034	2,197	$136	$1,656	$6,745
Little/Noonday	Pasture (No Litter)	Pasture (No Litter): Cover Crop	63	$4,178	63	63	431	$4,178	$58,147	$207,327
Little/Noonday	Urban (Highly)	Highly Developed: Restored Riparian Buffer	5,932	$1,341	1,695	5,650	7,627	$1,341	$4,642	$14,567
Little/Noonday	Urban (Less)	Less Developed: Restored Riparian Buffer	2,649	$1,155	757	2,522	3,405	$1,155	$7,791	$16,139
		Total by Sub-watershed (Average)	**9,010**	**($1,363)**	**2,646**	**9,512**	**14,036**	**($1,363)**	**($14,464)**	**($48,999)**
Owl/Kellogg	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Owl/Kellogg	Pasture (Litter)	Pasture (Litter): Cover Crop	5	$137	2	18	37	$137	$1,597	$6,843
Owl/Kellogg	Pasture (No Litter)	Pasture (No Litter): Cover Crop	1	$5,482	1	1	7	$5,482	$76,755	$273,706
Owl/Kellogg	Urban (Highly)	Highly Developed: Restored Riparian Buffer	71	$967	20	67	91	$967	$7,204	$16,125
Owl/Kellogg	Urban (Less)	Less Developed: Restored Riparian Buffer	41	$14,267	12	39	53	$14,267	$47,739	$154,667
		Total by Sub-watershed (Average)	**118**	**($5,213)**	**35**	**125**	**188**	**($5,213)**	**($33,324)**	**($112,835)**
Shoal Creek	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Shoal Creek	Pasture (Litter)	Pasture (Litter): Cover Crop	443	$35	40	1,369	3,022	$35	$621	$1,712
Shoal Creek	Pasture (No Litter)	Pasture (No Litter): Cover Crop	25	$1,986	25	25	171	$1,986	$27,007	$96,249
Shoal Creek	Urban (Highly)	Highly Developed: Restored Riparian Buffer	271	$859	78	258	349	$859	$3,580	$8,958
Shoal Creek	Urban (Less)	Less Developed: Restored Riparian Buffer	234	$498	67	223	301	$498	$4,146	$9,502
		Total by Sub-watershed (Average)	**974**	**($845)**	**210**	**1,876**	**3,843**	**($845)**	**($8,839)**	**($29,105)**
Stamp/Rowland	Pasture (Litter)		-	-	-	-	-	-	-	-
Stamp/Rowland	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Stamp/Rowland	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	35	$5,368	5	5	35	$5,368	$66,051	$234,325
Stamp/Rowland	Urban (Highly)	Highly Developed: Restored Riparian Buffer	46	$3,270	13	44	59	$3,270	$15,367	$33,021
Stamp/Rowland	Urban (Less)	Less Developed: Restored Riparian Buffer	30	$2,952	8	28	38	$2,952	$27,063	$64,345
		Total by Sub-watershed (Average)	**110**	**($3,863)**	**27**	**77**	**132**	**($3,863)**	**($36,160)**	**($110,564)**
Upper Etowah	Cropland	Cropland: Riparian Buffers (Forested)	532	$82	78	433	667	$82	$1,243	$3,097
Upper Etowah	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	82,516	$22	890	37,256	82,516	$22	$434	$941
Upper Etowah	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	4,461	$575	654	654	4,461	$575	$7,136	$25,144
Upper Etowah	Urban (Highly)	Highly Developed: Restored Riparian Buffer	3,459	$730	988	3,294	4,447	$730	$3,158	$7,535
Upper Etowah	Urban (Less)	Less Developed: Restored Riparian Buffer	1,869	$708	534	1,780	2,404	$708	$6,107	$14,193
		Total by Sub-watershed (Average)	**92,837**	**($423)**	**3,145**	**43,418**	**94,494**	**($423)**	**($3,616)**	**($10,182)**
		Total for Lake Allatoona (Average)	**104,004**	**($2,287)**	**6,300**	**55,803**	**113,869**	**($2,287)**	**($17,904)**	**($57,469)**

[1] BMP represents the BMP with lowest credit price by land cover type.

[2] Range of Credit Supply and Credit Prices are for all BMPs by land cover type.

Table D.10. Credit Analysis - Lake Allatoona Litter Transfer by Sub-watershed by County (NPS Scenario D)

Sub-watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Acworth/Allatoona	Litter Transport from: BARTOW	59.15	$18
Acworth/Allatoona	Litter Transport from: CHEROKEE	30.30	$17
Acworth/Allatoona	Litter Transport from: COBB	-	-
Acworth/Allatoona	Litter Transport from: PAULDING	42.85	$18
	Total by Sub-watershed (Average)	**132.31**	**($18)**
Little/Noonday	Litter Transport from: CHEROKEE	1,331.85	$19
Little/Noonday	Litter Transport from: COBB	-	-
Little/Noonday	Litter Transport from: FORSYTH	71.43	$34
Little/Noonday	Litter Transport from: FULTON	-	-
	Total by Sub-watershed (Average)	**1,403.28**	**($27)**
Owl/Kellogg	Litter Transport from: CHEROKEE	92.84	$19
Owl/Kellogg	Litter Transport from: COBB	-	-
	Total by Sub-watershed (Average)	**92.84**	**($19)**
Shoal Creek	Litter Transport from: BARTOW	26.79	$5
Shoal Creek	Litter Transport from: CHEROKEE	3,146.59	$5
Shoal Creek	Litter Transport from: PICKENS	904.54	$5
	Total by Sub-watershed (Average)	**4,077.92**	**($5)**
Stamp/Rowland	Litter Transport from: BARTOW	-	-
Stamp/Rowland	Litter Transport from: CHEROKEE	-	-
	Total by Sub-watershed (Average)	**-**	**($0)**
Upper Etowah	Litter Transport from: CHEROKEE	7,813.69	$4
Upper Etowah	Litter Transport from: DAWSON	67,102.34	$5
Upper Etowah	Litter Transport from: FANNIN	70.64	$21
Upper Etowah	Litter Transport from: FORSYTH	8,400.74	$8
Upper Etowah	Litter Transport from: GILMER	2,853.24	$5
Upper Etowah	Litter Transport from: LUMPKIN	10,698.01	$7
Upper Etowah	Litter Transport from: PICKENS	32,650.88	$4
Upper Etowah	Litter Transport from: UNION	-	-
	Total by Sub-watershed (Average)	**129,590**	**($08)**
	Total for Lake Allatoona (Average)	**135,296**	**($12)**

Table D.11. Credit Summary - Lake Allatoona Non-Point Sources by Sub-watershed by Land Cover (NPS Scenario E)

Sub-watershed	Land Cover	BMP[1]	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)	Range of Credit Supply[2] Min (lbs/year)	Avg (lbs/year)	Max (lbs/year)	Range of Credit Prices[2] Min ($/credit)	Avg ($/credit)	Max ($/credit)
Acworth/Allatoona	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Acworth/Allatoona	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	86	$98	3	40	86	$98	$1,329	$4,312
Acworth/Allatoona	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	78	$3,196	11	11	78	$3,196	$41,143	$140,409
Acworth/Allatoona	Urban (Highly)	Highly Developed: Restored Riparian Buffer	436	$7,084	125	415	561	$7,084	$29,199	$74,063
Acworth/Allatoona	Urban (Less)	Less Developed: Restored Riparian Buffer	260	$5,777	74	248	334	$5,777	$48,131	$110,324
		Total by Sub-watershed (Average)	**859**	**($4,039)**	**214**	**715**	**1,058**	**($4,039)**	**($29,950)**	**($82,277)**
Little/Noonday	Cropland	Cropland: Riparian Buffers (Forested)	269	$6	39	219	337	$6	$97	$240
Little/Noonday	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	1,978	$172	78	930	1,978	$172	$2,084	$7,534
Little/Noonday	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	388	$5,291	57	57	388	$5,291	$66,317	$231,574
Little/Noonday	Urban (Highly)	Highly Developed: Restored Riparian Buffer	5,339	$1,636	1,525	5,085	6,864	$1,636	$6,954	$16,972
Little/Noonday	Urban (Less)	Less Developed: Restored Riparian Buffer	2,384	$1,876	681	2,270	3,065	$1,876	$15,944	$36,844
		Total by Sub-watershed (Average)	**10,358**	**($1,796)**	**2,381**	**8,561**	**12,632**	**($1,796)**	**($18,279)**	**($58,633)**
Owl/Kellogg	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Owl/Kellogg	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	33	$175	2	16	33	$175	$1,978	$7,643
Owl/Kellogg	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	7	$6,985	1	1	7	$6,985	$87,525	$305,708
Owl/Kellogg	Urban (Highly)	Highly Developed: Restored Riparian Buffer	64	$1,597	18	61	82	$1,597	$14,438	$32,502
Owl/Kellogg	Urban (Less)	Less Developed: Restored Riparian Buffer	37	$17,471	11	35	48	$17,471	$72,973	$180,570
		Total by Sub-watershed (Average)	**141**	**($6,557)**	**31**	**113**	**170**	**($6,557)**	**($44,229)**	**($131,606)**
Shoal Creek	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Shoal Creek	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	2,720	$44	36	1,233	2,720	$44	$860	$1,913
Shoal Creek	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	154	$2,456	23	23	154	$2,456	$30,820	$107,519
Shoal Creek	Urban (Highly)	Highly Developed: Restored Riparian Buffer	244	$1,122	70	233	314	$1,122	$6,045	$10,858
Shoal Creek	Urban (Less)	Less Developed: Restored Riparian Buffer	211	$905	60	201	271	$905	$8,941	$21,805
		Total by Sub-watershed (Average)	**3,329**	**($1,132)**	**189**	**1,689**	**3,459**	**($1,132)**	**($11,666)**	**($35,524)**
Stamp/Rowland	Pasture (Litter)		-	-	-	-	-	-	-	-
Stamp/Rowland	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Stamp/Rowland	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	31	$5,978	5	5	31	$5,978	$75,814	$262,081
Stamp/Rowland	Urban (Highly)	Highly Developed: Restored Riparian Buffer	41	$4,487	12	39	53	$4,487	$27,578	$54,013
Stamp/Rowland	Urban (Less)	Less Developed: Restored Riparian Buffer	27	$5,673	8	25	34	$5,673	$59,515	$147,909
		Total by Sub-watershed (Average)	**99**	**($5,379)**	**24**	**70**	**119**	**($5,379)**	**($54,302)**	**($154,668)**
Upper Etowah	Cropland	Cropland: Riparian Buffers (Forested)	479	$92	70	389	600	$92	$1,421	$3,468
Upper Etowah	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	74,264	$24	801	33,531	74,264	$24	$660	$1,454
Upper Etowah	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	4,015	$641	589	589	4,015	$641	$8,261	$28,173
Upper Etowah	Urban (Highly)	Highly Developed: Restored Riparian Buffer	3,113	$968	889	2,965	4,003	$968	$5,443	$10,017
Upper Etowah	Urban (Less)	Less Developed: Restored Riparian Buffer	1,683	$1,313	481	1,602	2,163	$1,313	$13,267	$32,590
		Total by Sub-watershed (Average)	**83,553**	**($608)**	**2,830**	**39,076**	**85,045**	**($608)**	**($5,811)**	**($15,141)**
		Total for Lake Allatoona (Average)	**98,339**	**($3,003)**	**5,670**	**50,223**	**102,482**	**($3,003)**	**($25,070)**	**($73,220)**

[1] BMP represents the BMP with lowest credit price by land cover type.

[2] Range of Credit Supply and Credit Prices are for all BMPs by land cover type.

Table D.12. Credit Analysis - Lake Allatoona Litter Transfer by Sub-watershed by County (NPS Scenario E)

Sub-watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Acworth/Allatoona	Litter Transport from: BARTOW	53.24	$41
Acworth/Allatoona	Litter Transport from: CHEROKEE	27.27	$40
Acworth/Allatoona	Litter Transport from: COBB	-	-
Acworth/Allatoona	Litter Transport from: PAULDING	38.56	$41
	Total by Sub-watershed (Average)	**119.08**	**($41)**
Little/Noonday	Litter Transport from: CHEROKEE	1,198.66	$44
Little/Noonday	Litter Transport from: COBB	-	-
Little/Noonday	Litter Transport from: FORSYTH	64.29	$79
Little/Noonday	Litter Transport from: FULTON	-	-
	Total by Sub-watershed (Average)	**1,262.95**	**($61)**
Owl/Kellogg	Litter Transport from: CHEROKEE	83.56	$44
Owl/Kellogg	Litter Transport from: COBB	-	-
	Total by Sub-watershed (Average)	**83.56**	**($44)**
Shoal Creek	Litter Transport from: BARTOW	24.11	$12
Shoal Creek	Litter Transport from: CHEROKEE	2,831.93	$11
Shoal Creek	Litter Transport from: PICKENS	814.09	$11
	Total by Sub-watershed (Average)	**3,670.13**	**($11)**
Stamp/Rowland	Litter Transport from: BARTOW	-	-
Stamp/Rowland	Litter Transport from: CHEROKEE	-	-
	Total by Sub-watershed (Average)	**-**	**($0)**
Upper Etowah	Litter Transport from: CHEROKEE	7,032.32	$10
Upper Etowah	Litter Transport from: DAWSON	60,392.11	$11
Upper Etowah	Litter Transport from: FANNIN	63.58	$48
Upper Etowah	Litter Transport from: FORSYTH	7,560.66	$18
Upper Etowah	Litter Transport from: GILMER	2,567.92	$11
Upper Etowah	Litter Transport from: LUMPKIN	9,628.21	$15
Upper Etowah	Litter Transport from: PICKENS	29,385.79	$10
Upper Etowah	Litter Transport from: UNION	-	-
	Total by Sub-watershed (Average)	**116,631**	**($17)**
	Total for Lake Allatoona (Average)	**121,766**	**($28)**

Table D.13. Credit Summary - Lake Allatoona Non-Point Sources by Sub-watershed by Land Cover (NPS Scenario F)

Sub-watershed	Land Cover	BMP[1]	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)	Range of Credit Supply[2] Min (lbs/year)	Avg (lbs/year)	Max (lbs/year)	Range of Credit Prices[2] Min ($/credit)	Avg ($/credit)	Max ($/credit)
Acworth/Allatoona	Cropland		-	-	-	-	-	-	-	-
Acworth/Allatoona	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	95	$0	4	45	95	$0	$277	$1,035
Acworth/Allatoona	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	86	$12	13	13	86	$12	$2,105	$6,160
Acworth/Allatoona	Urban (Highly)	Highly Developed: Restored Riparian Buffer	485	$750	138	461	623	$750	$9,029	$23,952
Acworth/Allatoona	Urban (Highly)	Less Developed: Filter Strip	289	$1,765	83	275	371	$1,765	$7,480	$19,234
		Total by Sub-watershed (Average)	**955**	**($632)**	**238**	**794**	**1,176**	**($632)**	**($4,723)**	**($12,595)**
Little/Noonday	Cropland	Cropland: Riparian Buffers (Forested)	299	$0	44	243	375	$0	$2	$8
Little/Noonday	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	2,197	$0	87	1,034	2,197	$0	$314	$1,181
Little/Noonday	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	431	$12	63	63	431	$12	$2,197	$6,428
Little/Noonday	Urban (Highly)	Highly Developed: Restored Riparian Buffer	5,932	$188	1,695	5,650	7,627	$188	$2,260	$5,994
Little/Noonday	Urban (Highly)	Less Developed: Filter Strip	2,649	$590	757	2,522	3,405	$590	$2,500	$6,428
		Total by Sub-watershed (Average)	**11,508**	**($158)**	**2,646**	**9,512**	**14,036**	**($158)**	**($1,454)**	**($4,008)**
Owl/Kellogg	Cropland		-	-	-	-	-	-	-	-
Owl/Kellogg	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	37	$0	2	18	37	$0	$262	$947
Owl/Kellogg	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	7	$16	1	1	7	$16	$2,882	$8,434
Owl/Kellogg	Urban (Highly)	Highly Developed: Restored Riparian Buffer	71	$672	20	67	91	$672	$8,093	$21,469
Owl/Kellogg	Urban (Highly)	Less Developed: Filter Strip	41	$1,613	12	39	53	$1,613	$6,837	$17,582
		Total by Sub-watershed (Average)	**157**	**($576)**	**35**	**125**	**188**	**($576)**	**($4,519)**	**($12,108)**
Shoal Creek	Cropland		-	-	-	-	-	-	-	-
Shoal Creek	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	3,022	$0	40	1,369	3,022	$0	$218	$912
Shoal Creek	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	171	$6	25	25	171	$6	$1,044	$3,055
Shoal Creek	Urban (Highly)	Highly Developed: Restored Riparian Buffer	271	$216	78	258	349	$216	$2,601	$6,898
Shoal Creek	Urban (Highly)	Less Developed: Filter Strip	234	$351	67	223	301	$351	$1,487	$3,823
		Total by Sub-watershed (Average)	**3,699**	**($143)**	**210**	**1,876**	**3,843**	**($143)**	**($1,337)**	**($3,672)**
Stamp/Rowland	Pasture (Litter)		-	-	-	-	-	-	-	-
Stamp/Rowland	Cropland		-	-	-	-	-	-	-	-
Stamp/Rowland	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	35	$18	5	5	35	$18	$3,117	$9,120
Stamp/Rowland	Urban (Highly)	Highly Developed: Restored Riparian Buffer	46	$1,097	13	44	59	$1,097	$13,212	$35,048
Stamp/Rowland	Urban (Highly)	Less Developed: Filter Strip	30	$2,383	8	28	38	$2,383	$10,101	$25,975
		Total by Sub-watershed (Average)	**110**	**($1,166)**	**27**	**77**	**132**	**($1,166)**	**($8,810)**	**($23,381)**
Upper Etowah	Cropland	Cropland: Riparian Buffers (Forested)	532	$0	78	433	667	$0	$52	$179
Upper Etowah	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	82,516	$0	890	37,256	82,516	$0	$229	$970
Upper Etowah	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	4,461	$2	654	654	4,461	$2	$427	$1,250
Upper Etowah	Urban (Highly)	Highly Developed: Restored Riparian Buffer	3,459	$202	988	3,294	4,447	$202	$2,433	$6,454
Upper Etowah	Urban (Highly)	Less Developed: Filter Strip	1,869	$525	534	1,780	2,404	$525	$2,223	$5,718
		Total by Sub-watershed (Average)	**92,837**	**($146)**	**3,145**	**43,418**	**94,494**	**($146)**	**($1,073)**	**($2,914)**
		Total for Lake Allatoona (Average)	**109,266**	**($417)**	**6,300**	**55,803**	**113,869**	**($417)**	**($3,255)**	**($8,730)**

[1] BMP represents the BMP with lowest credit price by land cover type.

[2] Range of Credit Supply and Credit Prices are for all BMPs by land cover type.

Table D.14. Credit Summary - Lake Allatoona Non-Point Sources by Sub-watershed by Land Cover (NPS Scenario G)

					Range of Credit Supply[2]			Range of Credit Prices[2]		
Sub-watershed	**Land Cover**	**BMP[1]**	**Supply Credits (lbs/ year)**	**Min Credit Price (Unit Price)**	**Min (lbs/year)**	**Avg (lbs/year)**	**Max (lbs/year)**	**Min ($/credit)**	**Avg ($/credit)**	**Max ($/credit)**
Acworth/Allatoona	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Acworth/Allatoona	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	71	$118	4	34	71	$118	$1,347	$5,152
Acworth/Allatoona	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	86	$2,872	13	13	86	$2,872	$36,292	$125,845
Acworth/Allatoona	Urban (Highly)	Highly Developed: Restored Riparian Buffer	491	$6,026	140	468	632	$6,026	$22,723	$64,320
Acworth/Allatoona	Urban (Less)	Less Developed: Restored Riparian Buffer	293	$4,340	84	279	377	$4,340	$33,033	$72,784
		Total by Sub-watershed (Average)	**942**	**($3,339)**	**241**	**794**	**1,166**	**($3,339)**	**($23,349)**	**($67,026)**
Little/Noonday	Cropland	Cropland: Riparian Buffers (Forested)	299	$6	44	243	375	$6	$86	$215
Little/Noonday	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	1,648	$206	87	789	1,648	$206	$2,192	$9,017
Little/Noonday	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	431	$4,758	63	63	431	$4,758	$58,916	$207,872
Little/Noonday	Urban (Highly)	Highly Developed: Restored Riparian Buffer	6,109	$1,366	1,746	5,818	7,855	$1,366	$5,292	$14,488
Little/Noonday	Urban (Less)	Less Developed: Restored Riparian Buffer	2,728	$1,380	779	2,598	3,507	$1,380	$10,749	$23,934
		Total by Sub-watershed (Average)	**11,215**	**($1,543)**	**2,719**	**9,512**	**13,816**	**($1,543)**	**($15,447)**	**($51,105)**
Owl/Kellogg	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Owl/Kellogg	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	28	$209	2	14	28	$209	$2,121	$9,147
Owl/Kellogg	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	7	$6,281	1	1	7	$6,281	$77,764	$274,422
Owl/Kellogg	Urban (Highly)	Highly Developed: Restored Riparian Buffer	73	$1,157	21	70	94	$1,157	$9,722	$21,266
Owl/Kellogg	Urban (Less)	Less Developed: Restored Riparian Buffer	43	$14,435	12	41	55	$14,435	$54,590	$152,668
		Total by Sub-watershed (Average)	**152**	**($5,521)**	**36**	**125**	**185**	**($5,521)**	**($36,049)**	**($114,376)**
Shoal Creek	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Shoal Creek	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	2,266	$52	40	1,034	2,266	$52	$806	$2,289
Shoal Creek	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	171	$2,209	25	25	171	$2,209	$27,372	$96,508
Shoal Creek	Urban (Highly)	Highly Developed: Restored Riparian Buffer	460	$551	132	439	592	$551	$2,657	$5,518
Shoal Creek	Urban (Less)	Less Developed: Restored Riparian Buffer	398	$387	114	379	511	$387	$3,592	$8,581
		Total by Sub-watershed (Average)	**3,296**	**($800)**	**311**	**1,876**	**3,541**	**($800)**	**($8,607)**	**($28,224)**
Stamp/Rowland	Pasture (Litter)	0	-	-	-	-	-	-	-	-
Stamp/Rowland	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Stamp/Rowland	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	35	$5,374	5	5	35	$5,374	$67,142	$235,099
Stamp/Rowland	Urban (Highly)	Highly Developed: Restored Riparian Buffer	46	$3,654	13	44	59	$3,654	$20,094	$36,345
Stamp/Rowland	Urban (Less)	Less Developed: Restored Riparian Buffer	30	$4,029	8	28	38	$4,029	$40,313	$98,732
		Total by Sub-watershed (Average)	**110**	**($4,352)**	**27**	**77**	**132**	**($4,352)**	**($42,516)**	**($123,392)**
Upper Etowah	Cropland	Cropland: Riparian Buffers (Forested)	532	$82	78	433	667	$82	$1,261	$3,109
Upper Etowah	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	61,887	$29	890	28,088	61,887	$29	$574	$1,260
Upper Etowah	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	4,461	$576	654	654	4,461	$576	$7,286	$25,250
Upper Etowah	Urban (Highly)	Highly Developed: Restored Riparian Buffer	9,708	$285	2,774	9,246	12,482	$285	$1,435	$2,820
Upper Etowah	Urban (Less)	Less Developed: Restored Riparian Buffer	5,247	$337	1,499	4,997	6,746	$337	$3,215	$7,754
		Total by Sub-watershed (Average)	**81,835**	**($262)**	**5,895**	**43,418**	**86,242**	**($262)**	**($2,754)**	**($8,039)**
		Total for Lake Allatoona (Average)	**97,550**	**($2,429)**	**9,229**	**55,803**	**105,083**	**($2,429)**	**($19,623)**	**($60,176)**

[1] BMP represents the BMP with lowest credit price by land cover type.

[2] Range of Credit Supply and Credit Prices are for all BMPs by land cover type.

Table D.15. Credit Analysis - Lake Allatoona Litter Transfer by Sub-watershed by County (NPS Scenario G)

Sub-watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Acworth/Allatoona	Litter Transport from: BARTOW	44.37	$37
Acworth/Allatoona	Litter Transport from: CHEROKEE	22.73	$35
Acworth/Allatoona	Litter Transport from: COBB	-	-
Acworth/Allatoona	Litter Transport from: PAULDING	32.14	$37
	Total by Sub-watershed (Average)	**99.23**	**($36)**
Little/Noonday	Litter Transport from: CHEROKEE	998.89	$39
Little/Noonday	Litter Transport from: COBB	-	-
Little/Noonday	Litter Transport from: FORSYTH	53.57	$70
Little/Noonday	Litter Transport from: FULTON	-	-
	Total by Sub-watershed (Average)	**1,052.46**	**($54)**
Owl/Kellogg	Litter Transport from: CHEROKEE	69.63	$39
Owl/Kellogg	Litter Transport from: COBB	-	-
	Total by Sub-watershed (Average)	**69.63**	**($39)**
Shoal Creek	Litter Transport from: BARTOW	20.09	$10
Shoal Creek	Litter Transport from: CHEROKEE	2,359.94	$10
Shoal Creek	Litter Transport from: PICKENS	678.41	$10
	Total by Sub-watershed (Average)	**3,058.44**	**($10)**
Stamp/Rowland	Litter Transport from: BARTOW	-	-
Stamp/Rowland	Litter Transport from: CHEROKEE	-	-
	Total by Sub-watershed (Average)	**-**	**($0)**
Upper Etowah	Litter Transport from: CHEROKEE	5,860.27	$9
Upper Etowah	Litter Transport from: DAWSON	50,326.76	$10
Upper Etowah	Litter Transport from: FANNIN	52.98	$42
Upper Etowah	Litter Transport from: FORSYTH	6,300.55	$16
Upper Etowah	Litter Transport from: GILMER	2,139.93	$10
Upper Etowah	Litter Transport from: LUMPKIN	8,023.51	$14
Upper Etowah	Litter Transport from: PICKENS	24,488.16	$9
Upper Etowah	Litter Transport from: UNION	-	-
	Total by Sub-watershed (Average)	**97,192**	**($16)**
	Total for Lake Allatoona (Average)	**101,472**	**($25)**

Table D.16. Credit Summary - Lake Allatoona Non-Point Sources by Sub-watershed by Land Cover (NPS Scenario H)

Sub-watershed	Land Cover	BMP[1]	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)	Range of Credit Supply[2] Min (lbs/year)	Avg (lbs/year)	Max (lbs/year)	Range of Credit Prices[2] Min ($/credit)	Avg ($/credit)	Max ($/credit)
Acworth/Allatoona	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Acworth/Allatoona	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	64	$131	3	31	64	$131	$1,609	$5,749
Acworth/Allatoona	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	78	$3,196	11	11	78	$3,196	$41,143	$140,409
Acworth/Allatoona	Urban (Highly)	Highly Developed: Restored Riparian Buffer	442	$6,983	126	421	569	$6,983	$28,786	$73,015
Acworth/Allatoona	Urban (Less)	Less Developed: Restored Riparian Buffer	264	$5,695	75	251	339	$5,695	$47,450	$108,763
		Total by Sub-watershed (Average)	**848**	**($4,001)**	**217**	**715**	**1,050**	**($4,001)**	**($29,747)**	**($81,984)**
Little/Noonday	Cropland	Cropland: Riparian Buffers (Forested)	269	$6	39	219	337	$6	$97	$240
Little/Noonday	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	1,483	$230	78	711	1,483	$230	$2,564	$10,046
Little/Noonday	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	388	$5,291	57	57	388	$5,291	$66,317	$231,574
Little/Noonday	Urban (Highly)	Highly Developed: Restored Riparian Buffer	5,498	$1,588	1,571	5,237	7,069	$1,588	$6,752	$16,479
Little/Noonday	Urban (Less)	Less Developed: Restored Riparian Buffer	2,455	$1,821	701	2,338	3,156	$1,821	$15,482	$35,775
		Total by Sub-watershed (Average)	**10,094**	**($1,787)**	**2,447**	**8,561**	**12,434**	**($1,787)**	**($18,242)**	**($58,823)**
Owl/Kellogg	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Owl/Kellogg	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	25	$233	2	12	25	$233	$2,464	$10,190
Owl/Kellogg	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	7	$6,985	1	1	7	$6,985	$87,525	$305,708
Owl/Kellogg	Urban (Highly)	Highly Developed: Restored Riparian Buffer	66	$1,537	19	63	85	$1,537	$13,899	$31,288
Owl/Kellogg	Urban (Less)	Less Developed: Restored Riparian Buffer	39	$16,819	11	37	50	$16,819	$70,248	$173,827
		Total by Sub-watershed (Average)	**136**	**($6,394)**	**33**	**113**	**166**	**($6,394)**	**($43,534)**	**($130,253)**
Shoal Creek	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Shoal Creek	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	2,040	$58	36	930	2,040	$58	$982	$2,551
Shoal Creek	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	154	$2,456	23	23	154	$2,456	$30,820	$107,519
Shoal Creek	Urban (Highly)	Highly Developed: Restored Riparian Buffer	414	$661	118	395	533	$661	$3,562	$6,398
Shoal Creek	Urban (Less)	Less Developed: Restored Riparian Buffer	358	$533	102	341	460	$533	$5,268	$12,848
		Total by Sub-watershed (Average)	**2,966**	**($927)**	**280**	**1,689**	**3,187**	**($927)**	**($10,158)**	**($32,329)**
Stamp/Rowland	Pasture (Litter)		-	-	-	-	-	-	-	-
Stamp/Rowland	Cropland	Cropland: Cover Crop	-	-	-	-	-	-	-	-
Stamp/Rowland	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	31	$5,978	5	5	31	$5,978	$75,814	$262,081
Stamp/Rowland	Urban (Highly)	Highly Developed: Restored Riparian Buffer	41	$4,487	12	39	53	$4,487	$27,578	$54,013
Stamp/Rowland	Urban (Less)	Less Developed: Restored Riparian Buffer	27	$5,673	8	25	34	$5,673	$59,515	$147,909
		Total by Sub-watershed (Average)	**99**	**($5,379)**	**24**	**70**	**119**	**($5,379)**	**($54,302)**	**($154,668)**
Upper Etowah	Cropland	Cropland: Riparian Buffers (Forested)	479	$92	70	389	600	$92	$1,421	$3,468
Upper Etowah	Pasture (Litter)	Pasture (Litter): Riparian Buffers (Forested)	55,698	$32	801	25,279	55,698	$32	$729	$1,454
Upper Etowah	Pasture (No Litter)	Pasture (No Litter): Riparian Buffers (Forested)	4,015	$641	589	589	4,015	$641	$8,261	$28,173
Upper Etowah	Urban (Highly)	Highly Developed: Restored Riparian Buffer	8,737	$345	2,496	8,321	11,234	$345	$1,939	$3,569
Upper Etowah	Urban (Less)	Less Developed: Restored Riparian Buffer	4,722	$468	1,349	4,497	6,072	$468	$4,727	$11,612
		Total by Sub-watershed (Average)	**73,651**	**($316)**	**5,306**	**39,076**	**77,618**	**($316)**	**($3,416)**	**($9,655)**
		Total for Lake Allatoona (Average)	**87,795**	**($2,878)**	**8,306**	**50,223**	**94,574**	**($2,878)**	**($24,198)**	**($71,386)**

[1] BMP represents the BMP with lowest credit price by land cover type.

[2] Range of Credit Supply and Credit Prices are for all BMPs by land cover type.

Table D.17. Credit Analysis - Lake Allatoona Litter Transfer by Sub-watershed by County (NPS Scenario H)

Sub-watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Acworth/Allatoona	Litter Transport from: BARTOW	44.37	$37
Acworth/Allatoona	Litter Transport from: CHEROKEE	22.73	$35
Acworth/Allatoona	Litter Transport from: COBB	-	-
Acworth/Allatoona	Litter Transport from: PAULDING	32.14	$37
	Total by Sub-watershed (Average)	**99.23**	**($36)**
Little/Noonday	Litter Transport from: CHEROKEE	998.89	$39
Little/Noonday	Litter Transport from: COBB	-	-
Little/Noonday	Litter Transport from: FORSYTH	53.57	$70
Little/Noonday	Litter Transport from: FULTON	-	-
	Total by Sub-watershed (Average)	**1,052.46**	**($54)**
Owl/Kellogg	Litter Transport from: CHEROKEE	69.63	$39
Owl/Kellogg	Litter Transport from: COBB	-	-
	Total by Sub-watershed (Average)	**69.63**	**($39)**
Shoal Creek	Litter Transport from: BARTOW	20.09	$10
Shoal Creek	Litter Transport from: CHEROKEE	2,359.94	$10
Shoal Creek	Litter Transport from: PICKENS	678.41	$10
	Total by Sub-watershed (Average)	**3,058.44**	**($10)**
Stamp/Rowland	Litter Transport from: BARTOW	-	-
Stamp/Rowland	Litter Transport from: CHEROKEE	-	-
	Total by Sub-watershed (Average)	**-**	**($0)**
Upper Etowah	Litter Transport from: CHEROKEE	5,860.27	$9
Upper Etowah	Litter Transport from: DAWSON	50,326.76	$10
Upper Etowah	Litter Transport from: FANNIN	52.98	$42
Upper Etowah	Litter Transport from: FORSYTH	6,300.55	$16
Upper Etowah	Litter Transport from: GILMER	2,139.93	$10
Upper Etowah	Litter Transport from: LUMPKIN	8,023.51	$14
Upper Etowah	Litter Transport from: PICKENS	24,488.16	$9
Upper Etowah	Litter Transport from: UNION	-	-
	Total by Sub-watershed (Average)	**97,192**	**($16)**
	Total for Lake Allatoona (Average)	**101,472**	**($25)**

Table D.18. Credit Analysis - Weiss Lake Litter Transfer by Sub-watershed by County (NPS Scenario A.1)

Market	Watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Weiss-Alabama				
	Upper Coosa, AL	Litter Transport from: CALHOUN, AL	552,649	$180
	Upper Coosa, AL	Litter Transport from: CHEROKEE, AL	6,654,144	$180
	Upper Coosa, AL	Litter Transport from: CLEBURNE, AL	1,846,062	$41
	Upper Coosa, AL	Litter Transport from: DE KALB, AL	9,644,376	$41
	Upper Coosa, AL	Litter Transport from: ETOWAH, AL	54,672	$41
		Total by Weiss Market (Average)	**18,751,903**	**($97)**
Weiss-Georgia				
	Conasauga, GA	Litter Transport from: CATOOSA	3	$38
	Conasauga, GA	Litter Transport from: FANNIN	336	$137
	Conasauga, GA	Litter Transport from: GILMER	313	$31
	Conasauga, GA	Litter Transport from: GORDON	1,573	$72
	Conasauga, GA	Litter Transport from: MURRAY	9,596	$47
	Conasauga, GA	Litter Transport from: WALKER	195	$47
	Conasauga, GA	Litter Transport from: WHITFIELD	12,032	$47
	Coosawattee	Litter Transport from: BARTOW	3,025	$29
	Coosawattee	Litter Transport from: CHEROKEE	299	$28
	Coosawattee	Litter Transport from: DAWSON	88	$33
	Coosawattee	Litter Transport from: FANNIN	75	$137
	Coosawattee	Litter Transport from: GILMER	39,370	$31
	Coosawattee	Litter Transport from: GORDON	19,925	$72
	Coosawattee	Litter Transport from: MURRAY	1,847	$47
	Coosawattee	Litter Transport from: PICKENS	7,380	$28
	Oostanaula	Litter Transport from: BARTOW	1,390	$29
	Oostanaula	Litter Transport from: CHATTOOGA	-	-
	Oostanaula	Litter Transport from: FLOYD	3,595	$223
	Oostanaula	Litter Transport from: GORDON	17,750	$72
	Oostanaula	Litter Transport from: WALKER	3,779	$47
	Oostanaula	Litter Transport from: WHITFIELD	473	$47
	Lower Etowah	Litter Transport from: BARTOW	10,972	$29
	Lower Etowah	Litter Transport from: COBB	-	-
	Lower Etowah	Litter Transport from: FLOYD	2,625	$223
	Lower Etowah	Litter Transport from: HARALSON	3	$137
	Lower Etowah	Litter Transport from: PAULDING	2,182	$29
	Lower Etowah	Litter Transport from: POLK, GA	3,555	$180
	Upper Coosa, GA	Litter Transport from: CHATTOOGA	-	-
	Upper Coosa, GA	Litter Transport from: DADE	158	$47
	Upper Coosa, GA	Litter Transport from: FLOYD	3,961	$223
	Upper Coosa, GA	Litter Transport from: HARALSON	255	$137
	Upper Coosa, GA	Litter Transport from: POLK, GA	4,399	$180
	Upper Coosa, GA	Litter Transport from: WALKER	6,695	$47
		Total by Weiss Market (Average)	**157,851**	**($83)**
Weiss-Tennessee				
	Conasauga, TN	Litter Transport from: BRADLEY, TN	4,096,458	$47
	Conasauga, TN	Litter Transport from: POLK, TN	302,049	$77
		Total by Weiss Market (Average)	**4,398,506**	**($84)**
		Total from All Weiss Markets (Average)	**23,308,260**	**($85)**

Table D.19.A. Credit Analysis - Weiss Lake Litter Transfer by Sub-watershed by County (NPS Scenario A.2)

Market	Watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Weiss-Alabama				
	Upper Coosa, AL	Litter Transport from: CALHOUN, AL	2,210,594	$45
	Upper Coosa, AL	Litter Transport from: CHEROKEE, AL	26,616,577	$45
	Upper Coosa, AL	Litter Transport from: CLEBURNE, AL	7,384,249	$10
	Upper Coosa, AL	Litter Transport from: DE KALB, AL	38,577,502	$10
	Upper Coosa, AL	Litter Transport from: ETOWAH, AL	218,688	$10
		Total by Weiss Market (Average)	**75,007,610**	**($24)**
Weiss-Georgia				
	Conasauga, GA	Litter Transport from: CATOOSA	12	$10
	Conasauga, GA	Litter Transport from: FANNIN	1,344	$34
	Conasauga, GA	Litter Transport from: GILMER	1,252	$8
	Conasauga, GA	Litter Transport from: GORDON	6,291	$18
	Conasauga, GA	Litter Transport from: MURRAY	38,385	$12
	Conasauga, GA	Litter Transport from: WALKER	779	$12
	Conasauga, GA	Litter Transport from: WHITFIELD	48,129	$12
	Coosawattee	Litter Transport from: BARTOW	12,102	$7
	Coosawattee	Litter Transport from: CHEROKEE	1,197	$7
	Coosawattee	Litter Transport from: DAWSON	353	$8
	Coosawattee	Litter Transport from: FANNIN	301	$34
	Coosawattee	Litter Transport from: GILMER	157,479	$8
	Coosawattee	Litter Transport from: GORDON	79,701	$18
	Coosawattee	Litter Transport from: MURRAY	7,389	$12
	Coosawattee	Litter Transport from: PICKENS	29,521	$7
	Oostanaula	Litter Transport from: BARTOW	5,562	$7
	Oostanaula	Litter Transport from: CHATTOOGA	-	-
	Oostanaula	Litter Transport from: FLOYD	14,379	$56
	Oostanaula	Litter Transport from: GORDON	71,000	$18
	Oostanaula	Litter Transport from: WALKER	15,114	$12
	Oostanaula	Litter Transport from: WHITFIELD	1,891	$12
	Lower Etowah	Litter Transport from: BARTOW	43,890	$7
	Lower Etowah	Litter Transport from: COBB	-	-
	Lower Etowah	Litter Transport from: FLOYD	10,499	$56
	Lower Etowah	Litter Transport from: HARALSON	13	$34
	Lower Etowah	Litter Transport from: PAULDING	8,729	$7
	Lower Etowah	Litter Transport from: POLK, GA	14,218	$45
	Upper Coosa, GA	Litter Transport from: CHATTOOGA	-	-
	Upper Coosa, GA	Litter Transport from: DADE	631	$12
	Upper Coosa, GA	Litter Transport from: FLOYD	15,846	$56
	Upper Coosa, GA	Litter Transport from: HARALSON	1,022	$34
	Upper Coosa, GA	Litter Transport from: POLK, GA	17,596	$45
	Upper Coosa, GA	Litter Transport from: WALKER	26,782	$12
		Total by Weiss Market (Average)	**631,406**	**($21)**
Weiss-Tennessee				
	Conasauga, TN	Litter Transport from: BRADLEY, TN	16,385,831	$12
	Conasauga, TN	Litter Transport from: POLK, TN	1,208,194	$19
		Total by Weiss Market (Average)	**17,594,025**	**($21)**
		Total from All Weiss Markets (Average)	**93,233,041**	**($21)**

Table D.19.B. Alabama Litter Producers (Cleburne, De Kalb, Etowah) - Supply of Credits, Average Credit Price, and Total Demand by NPS:PS Ratio

NPS:PS Ratio	Credit Supply	Avg. Credit Price	Total Demand
1:1	46,180,439	$10	684,059
2:1	23,090,220	$21	675,842
3:1	15,393,480	$31	409,629
4:1	11,545,110	$41	308,003
5:1	9,236,088	$51	90,105
6:1	7,696,740	$62	71,959
7:1	6,597,206	$72	70,897
8:1	5,772,555	$82	70,897
9:1	5,131,160	$92	192
10:1	4,618,044	$103	192
11:1	4,198,222	$113	192
12:1	3,848,370	$123	192
13:1	3,552,341	$133	192
14:1	3,298,603	$144	192
15:1	3,078,696	$154	192
16:1	2,886,277	$164	192
17:1	2,716,496	$174	192
18:1	2,565,580	$185	192
19:1	2,430,549	$195	192
20:1	2,309,022	$205	192
21:1	2,199,069	$215	192
22:1	2,099,111	$226	192
23:1	2,007,845	$236	192
24:1	1,924,185	$246	192
25:1	1,847,218	$256	192
26:1	1,776,171	$267	192
27:1	1,710,387	$277	-
28:1	1,649,301	$287	-
29:1	1,592,429	$297	-
30:1	1,539,348	$308	-

Table D.20. Credit Analysis - Weiss Lake Litter Transfer by Sub-watershed by County (NPS Scenario B)

Market	Watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Weiss-Alabama				
	Upper Coosa, AL	Litter Transport from: CALHOUN, AL	994,767	$100
	Upper Coosa, AL	Litter Transport from: CHEROKEE, AL	11,977,460	$100
	Upper Coosa, AL	Litter Transport from: CLEBURNE, AL	3,322,912	$23
	Upper Coosa, AL	Litter Transport from: DE KALB, AL	17,359,876	$23
	Upper Coosa, AL	Litter Transport from: ETOWAH, AL	98,410	$23
		Total by Weiss Market (Average)	**33,753,425**	**($54)**
Weiss-Georgia				
	Conasauga, GA	Litter Transport from: CATOOSA	5	$21
	Conasauga, GA	Litter Transport from: FANNIN	605	$76
	Conasauga, GA	Litter Transport from: GILMER	564	$17
	Conasauga, GA	Litter Transport from: GORDON	2,831	$40
	Conasauga, GA	Litter Transport from: MURRAY	17,273	$26
	Conasauga, GA	Litter Transport from: WALKER	351	$26
	Conasauga, GA	Litter Transport from: WHITFIELD	21,658	$26
	Coosawattee	Litter Transport from: BARTOW	5,446	$16
	Coosawattee	Litter Transport from: CHEROKEE	539	$16
	Coosawattee	Litter Transport from: DAWSON	159	$18
	Coosawattee	Litter Transport from: FANNIN	136	$76
	Coosawattee	Litter Transport from: GILMER	70,866	$17
	Coosawattee	Litter Transport from: GORDON	35,866	$40
	Coosawattee	Litter Transport from: MURRAY	3,325	$26
	Coosawattee	Litter Transport from: PICKENS	13,284	$16
	Oostanaula	Litter Transport from: BARTOW	2,503	$16
	Oostanaula	Litter Transport from: CHATTOOGA	-	-
	Oostanaula	Litter Transport from: FLOYD	6,471	$124
	Oostanaula	Litter Transport from: GORDON	31,950	$40
	Oostanaula	Litter Transport from: WALKER	6,801	$26
	Oostanaula	Litter Transport from: WHITFIELD	851	$26
	Lower Etowah	Litter Transport from: BARTOW	19,750	$16
	Lower Etowah	Litter Transport from: COBB	-	-
	Lower Etowah	Litter Transport from: FLOYD	4,725	$124
	Lower Etowah	Litter Transport from: HARALSON	6	$76
	Lower Etowah	Litter Transport from: PAULDING	3,928	$16
	Lower Etowah	Litter Transport from: POLK, GA	6,398	$100
	Upper Coosa, GA	Litter Transport from: CHATTOOGA	-	-
	Upper Coosa, GA	Litter Transport from: DADE	284	$26
	Upper Coosa, GA	Litter Transport from: FLOYD	7,131	$124
	Upper Coosa, GA	Litter Transport from: HARALSON	460	$76
	Upper Coosa, GA	Litter Transport from: POLK, GA	7,918	$100
	Upper Coosa, GA	Litter Transport from: WALKER	12,052	$26
		Total by Weiss Market (Average)	**284,133**	**($46)**
Weiss-Tennessee				
	Conasauga, TN	Litter Transport from: BRADLEY, TN	7,373,624	$26
	Conasauga, TN	Litter Transport from: POLK, TN	543,687	$43
		Total by Weiss Market (Average)	**7,917,311**	**($47)**
		Total from All Weiss Markets (Average)	**41,954,869**	**($47)**

Table D.21. Credit Analysis - Weiss Lake Litter Transfer by Sub-watershed by County (NPS Scenario C)

Market	Watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Weiss-Alabama				
	Upper Coosa, AL	Litter Transport from: CALHOUN, AL	1,105,297	$122
	Upper Coosa, AL	Litter Transport from: CHEROKEE, AL	13,308,289	$122
	Upper Coosa, AL	Litter Transport from: CLEBURNE, AL	3,692,124	$28
	Upper Coosa, AL	Litter Transport from: DE KALB, AL	19,288,751	$28
	Upper Coosa, AL	Litter Transport from: ETOWAH, AL	109,344	$28
		Total by Weiss Market (Average)	**37,503,805**	**($65)**
Weiss-Georgia				
	Conasauga, GA	Litter Transport from: CATOOSA	6	$26
	Conasauga, GA	Litter Transport from: FANNIN	672	$93
	Conasauga, GA	Litter Transport from: GILMER	626	$21
	Conasauga, GA	Litter Transport from: GORDON	3,145	$48
	Conasauga, GA	Litter Transport from: MURRAY	19,192	$32
	Conasauga, GA	Litter Transport from: WALKER	390	$32
	Conasauga, GA	Litter Transport from: WHITFIELD	24,064	$32
	Coosawattee	Litter Transport from: BARTOW	6,051	$20
	Coosawattee	Litter Transport from: CHEROKEE	599	$19
	Coosawattee	Litter Transport from: DAWSON	177	$22
	Coosawattee	Litter Transport from: FANNIN	151	$93
	Coosawattee	Litter Transport from: GILMER	78,740	$21
	Coosawattee	Litter Transport from: GORDON	39,851	$48
	Coosawattee	Litter Transport from: MURRAY	3,694	$32
	Coosawattee	Litter Transport from: PICKENS	14,760	$19
	Oostanaula	Litter Transport from: BARTOW	2,781	$20
	Oostanaula	Litter Transport from: CHATTOOGA	-	-
	Oostanaula	Litter Transport from: FLOYD	7,190	$150
	Oostanaula	Litter Transport from: GORDON	35,500	$48
	Oostanaula	Litter Transport from: WALKER	7,557	$32
	Oostanaula	Litter Transport from: WHITFIELD	945	$32
	Lower Etowah	Litter Transport from: BARTOW	21,945	$20
	Lower Etowah	Litter Transport from: COBB	-	-
	Lower Etowah	Litter Transport from: FLOYD	5,250	$150
	Lower Etowah	Litter Transport from: HARALSON	6	$93
	Lower Etowah	Litter Transport from: PAULDING	4,365	$20
	Lower Etowah	Litter Transport from: POLK, GA	7,109	$122
	Upper Coosa, GA	Litter Transport from: CHATTOOGA	-	-
	Upper Coosa, GA	Litter Transport from: DADE	315	$32
	Upper Coosa, GA	Litter Transport from: FLOYD	7,923	$150
	Upper Coosa, GA	Litter Transport from: HARALSON	511	$93
	Upper Coosa, GA	Litter Transport from: POLK, GA	8,798	$122
	Upper Coosa, GA	Litter Transport from: WALKER	13,391	$32
		Total by Weiss Market (Average)	**315,703**	**($56)**
Weiss-Tennessee				
	Conasauga, TN	Litter Transport from: BRADLEY, TN	8,192,915	$32
	Conasauga, TN	Litter Transport from: POLK, TN	604,097	$52
		Total by Weiss Market (Average)	**8,797,012**	**($57)**
		Total from All Weiss Markets (Average)	**46,616,521**	**($57)**

Table D.22. Credit Analysis - Weiss Lake Litter Transfer by Sub-watershed by County (NPS Scenario D)

Market	Watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Weiss-Alabama				
	Upper Coosa, AL	Litter Transport from: CALHOUN, AL	1,105,297	$59
	Upper Coosa, AL	Litter Transport from: CHEROKEE, AL	13,308,289	$59
	Upper Coosa, AL	Litter Transport from: CLEBURNE, AL	3,692,124	$13
	Upper Coosa, AL	Litter Transport from: DE KALB, AL	19,288,751	$13
	Upper Coosa, AL	Litter Transport from: ETOWAH, AL	109,344	$13
		Total by Weiss Market (Average)	**37,503,805**	**($31)**
Weiss-Georgia				
	Conasauga, GA	Litter Transport from: CATOOSA	6	$12
	Conasauga, GA	Litter Transport from: FANNIN	672	$45
	Conasauga, GA	Litter Transport from: GILMER	626	$10
	Conasauga, GA	Litter Transport from: GORDON	3,145	$23
	Conasauga, GA	Litter Transport from: MURRAY	19,192	$15
	Conasauga, GA	Litter Transport from: WALKER	390	$15
	Conasauga, GA	Litter Transport from: WHITFIELD	24,064	$15
	Coosawattee	Litter Transport from: BARTOW	6,051	$10
	Coosawattee	Litter Transport from: CHEROKEE	599	$9
	Coosawattee	Litter Transport from: DAWSON	177	$11
	Coosawattee	Litter Transport from: FANNIN	151	$45
	Coosawattee	Litter Transport from: GILMER	78,740	$10
	Coosawattee	Litter Transport from: GORDON	39,851	$23
	Coosawattee	Litter Transport from: MURRAY	3,694	$15
	Coosawattee	Litter Transport from: PICKENS	14,760	$9
	Oostanaula	Litter Transport from: BARTOW	2,781	$10
	Oostanaula	Litter Transport from: CHATTOOGA	-	-
	Oostanaula	Litter Transport from: FLOYD	7,190	$72
	Oostanaula	Litter Transport from: GORDON	35,500	$23
	Oostanaula	Litter Transport from: WALKER	7,557	$15
	Oostanaula	Litter Transport from: WHITFIELD	945	$15
	Lower Etowah	Litter Transport from: BARTOW	21,945	$10
	Lower Etowah	Litter Transport from: COBB	-	-
	Lower Etowah	Litter Transport from: FLOYD	5,250	$72
	Lower Etowah	Litter Transport from: HARALSON	6	$45
	Lower Etowah	Litter Transport from: PAULDING	4,365	$10
	Lower Etowah	Litter Transport from: POLK, GA	7,109	$59
	Upper Coosa, GA	Litter Transport from: CHATTOOGA	-	-
	Upper Coosa, GA	Litter Transport from: DADE	315	$15
	Upper Coosa, GA	Litter Transport from: FLOYD	7,923	$72
	Upper Coosa, GA	Litter Transport from: HARALSON	511	$45
	Upper Coosa, GA	Litter Transport from: POLK, GA	8,798	$59
	Upper Coosa, GA	Litter Transport from: WALKER	13,391	$15
		Total by Weiss Market (Average)	**315,703**	**($27)**
Weiss-Tennessee				
	Conasauga, TN	Litter Transport from: BRADLEY, TN	8,192,915	$15
	Conasauga, TN	Litter Transport from: POLK, TN	604,097	$25
		Total by Weiss Market (Average)	**8,797,012**	**($27)**
		Total from All Weiss Markets (Average)	**46,616,521**	**($27)**

Table D.23. Credit Analysis - Weiss Lake Litter Transfer by Sub-watershed by County (NPS Scenario E)

Market	Watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Weiss-Alabama				
	Upper Coosa, AL	Litter Transport from: CALHOUN, AL	994,767	$135
	Upper Coosa, AL	Litter Transport from: CHEROKEE, AL	11,977,460	$135
	Upper Coosa, AL	Litter Transport from: CLEBURNE, AL	3,322,912	$31
	Upper Coosa, AL	Litter Transport from: DE KALB, AL	17,359,876	$31
	Upper Coosa, AL	Litter Transport from: ETOWAH, AL	98,410	$31
		Total by Weiss Market (Average)	**33,753,425**	**($72)**
Weiss-Georgia				
	Conasauga, GA	Litter Transport from: CATOOSA	5	$29
	Conasauga, GA	Litter Transport from: FANNIN	605	$103
	Conasauga, GA	Litter Transport from: GILMER	564	$24
	Conasauga, GA	Litter Transport from: GORDON	2,831	$54
	Conasauga, GA	Litter Transport from: MURRAY	17,273	$35
	Conasauga, GA	Litter Transport from: WALKER	351	$35
	Conasauga, GA	Litter Transport from: WHITFIELD	21,658	$35
	Coosawattee	Litter Transport from: BARTOW	5,446	$22
	Coosawattee	Litter Transport from: CHEROKEE	539	$21
	Coosawattee	Litter Transport from: DAWSON	159	$24
	Coosawattee	Litter Transport from: FANNIN	136	$103
	Coosawattee	Litter Transport from: GILMER	70,866	$24
	Coosawattee	Litter Transport from: GORDON	35,866	$54
	Coosawattee	Litter Transport from: MURRAY	3,325	$35
	Coosawattee	Litter Transport from: PICKENS	13,284	$21
	Oostanaula	Litter Transport from: BARTOW	2,503	$22
	Oostanaula	Litter Transport from: CHATTOOGA	-	-
	Oostanaula	Litter Transport from: FLOYD	6,471	$167
	Oostanaula	Litter Transport from: GORDON	31,950	$54
	Oostanaula	Litter Transport from: WALKER	6,801	$35
	Oostanaula	Litter Transport from: WHITFIELD	851	$35
	Lower Etowah	Litter Transport from: BARTOW	19,750	$22
	Lower Etowah	Litter Transport from: COBB	-	-
	Lower Etowah	Litter Transport from: FLOYD	4,725	$167
	Lower Etowah	Litter Transport from: HARALSON	6	$103
	Lower Etowah	Litter Transport from: PAULDING	3,928	$22
	Lower Etowah	Litter Transport from: POLK, GA	6,398	$135
	Upper Coosa, GA	Litter Transport from: CHATTOOGA	-	-
	Upper Coosa, GA	Litter Transport from: DADE	284	$35
	Upper Coosa, GA	Litter Transport from: FLOYD	7,131	$167
	Upper Coosa, GA	Litter Transport from: HARALSON	460	$103
	Upper Coosa, GA	Litter Transport from: POLK, GA	7,918	$135
	Upper Coosa, GA	Litter Transport from: WALKER	12,052	$35
		Total by Weiss Market (Average)	**284,133**	**($62)**
Weiss-Tennessee				
	Conasauga, TN	Litter Transport from: BRADLEY, TN	7,373,624	$35
	Conasauga, TN	Litter Transport from: POLK, TN	543,687	$58
		Total by Weiss Market (Average)	**7,917,311**	**($63)**
		Total from All Weiss Markets (Average)	**41,954,869**	**($63)**

Table D.24. Credit Analysis - Weiss Lake Litter Transfer by Sub-watershed by County (NPS Scenario I)

Market	Watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Weiss-Alabama				
	Upper Coosa, AL	Litter Transport from: CALHOUN, AL	450,398	$221
	Upper Coosa, AL	Litter Transport from: CHEROKEE, AL	5,423,001	$221
	Upper Coosa, AL	Litter Transport from: CLEBURNE, AL	1,504,505	$50
	Upper Coosa, AL	Litter Transport from: DE KALB, AL	7,859,982	$50
	Upper Coosa, AL	Litter Transport from: ETOWAH, AL	44,557	$50
		Total by Weiss Market (Average)	**15,282,443**	**($119)**
Weiss-Georgia				
	Conasauga, GA	Litter Transport from: CATOOSA	2	$47
	Conasauga, GA	Litter Transport from: FANNIN	274	$169
	Conasauga, GA	Litter Transport from: GILMER	255	$39
	Conasauga, GA	Litter Transport from: GORDON	1,282	$88
	Conasauga, GA	Litter Transport from: MURRAY	7,821	$58
	Conasauga, GA	Litter Transport from: WALKER	159	$58
	Conasauga, GA	Litter Transport from: WHITFIELD	9,806	$58
	Coosawattee	Litter Transport from: BARTOW	2,466	$36
	Coosawattee	Litter Transport from: CHEROKEE	244	$35
	Coosawattee	Litter Transport from: DAWSON	72	$40
	Coosawattee	Litter Transport from: FANNIN	61	$169
	Coosawattee	Litter Transport from: GILMER	32,086	$39
	Coosawattee	Litter Transport from: GORDON	16,239	$88
	Coosawattee	Litter Transport from: MURRAY	1,505	$58
	Coosawattee	Litter Transport from: PICKENS	6,015	$34
	Oostanaula	Litter Transport from: BARTOW	1,133	$36
	Oostanaula	Litter Transport from: CHATTOOGA	-	-
	Oostanaula	Litter Transport from: FLOYD	2,930	$273
	Oostanaula	Litter Transport from: GORDON	14,466	$88
	Oostanaula	Litter Transport from: WALKER	3,079	$58
	Oostanaula	Litter Transport from: WHITFIELD	385	$58
	Lower Etowah	Litter Transport from: BARTOW	8,942	$36
	Lower Etowah	Litter Transport from: COBB	-	-
	Lower Etowah	Litter Transport from: FLOYD	2,139	$273
	Lower Etowah	Litter Transport from: HARALSON	3	$169
	Lower Etowah	Litter Transport from: PAULDING	1,779	$36
	Lower Etowah	Litter Transport from: POLK, GA	2,897	$221
	Upper Coosa, GA	Litter Transport from: CHATTOOGA	-	-
	Upper Coosa, GA	Litter Transport from: DADE	128	$58
	Upper Coosa, GA	Litter Transport from: FLOYD	3,229	$273
	Upper Coosa, GA	Litter Transport from: HARALSON	208	$169
	Upper Coosa, GA	Litter Transport from: POLK, GA	3,585	$221
	Upper Coosa, GA	Litter Transport from: WALKER	5,457	$58
		Total by Weiss Market (Average)	**128,646**	**($101)**
Weiss-Tennessee				
	Conasauga, TN	Litter Transport from: BRADLEY, TN	3,338,535	$58
	Conasauga, TN	Litter Transport from: POLK, TN	246,164	$95
		Total by Weiss Market (Average)	**3,584,699**	**($103)**
		Total from All Weiss Markets (Average)	**18,995,788**	**($104)**

Table D.25. Credit Analysis - Weiss Lake Litter Transfer by Sub-watershed by County (NPS Scenario J)

Market	Watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Weiss-Alabama				
	Upper Coosa, AL	Litter Transport from: CALHOUN, AL	2,173,726	$46
	Upper Coosa, AL	Litter Transport from: CHEROKEE, AL	26,172,665	$46
	Upper Coosa, AL	Litter Transport from: CLEBURNE, AL	7,261,094	$10
	Upper Coosa, AL	Litter Transport from: DE KALB, AL	37,934,105	$10
	Upper Coosa, AL	Litter Transport from: ETOWAH, AL	215,041	$10
		Total by Weiss Market (Average)	**73,756,630**	**($25)**
Weiss-Georgia				
	Conasauga, GA	Litter Transport from: CATOOSA	12	$10
	Conasauga, GA	Litter Transport from: FANNIN	1,321	$35
	Conasauga, GA	Litter Transport from: GILMER	1,231	$8
	Conasauga, GA	Litter Transport from: GORDON	6,186	$18
	Conasauga, GA	Litter Transport from: MURRAY	37,745	$12
	Conasauga, GA	Litter Transport from: WALKER	766	$12
	Conasauga, GA	Litter Transport from: WHITFIELD	47,326	$12
	Coosawattee	Litter Transport from: BARTOW	11,900	$7
	Coosawattee	Litter Transport from: CHEROKEE	1,177	$7
	Coosawattee	Litter Transport from: DAWSON	347	$8
	Coosawattee	Litter Transport from: FANNIN	296	$35
	Coosawattee	Litter Transport from: GILMER	154,853	$8
	Coosawattee	Litter Transport from: GORDON	78,372	$18
	Coosawattee	Litter Transport from: MURRAY	7,266	$12
	Coosawattee	Litter Transport from: PICKENS	29,028	$7
	Oostanaula	Litter Transport from: BARTOW	5,469	$7
	Oostanaula	Litter Transport from: CHATTOOGA	-	-
	Oostanaula	Litter Transport from: FLOYD	14,139	$57
	Oostanaula	Litter Transport from: GORDON	69,816	$18
	Oostanaula	Litter Transport from: WALKER	14,862	$12
	Oostanaula	Litter Transport from: WHITFIELD	1,859	$12
	Lower Etowah	Litter Transport from: BARTOW	43,158	$7
	Lower Etowah	Litter Transport from: COBB	-	-
	Lower Etowah	Litter Transport from: FLOYD	10,324	$57
	Lower Etowah	Litter Transport from: HARALSON	13	$35
	Lower Etowah	Litter Transport from: PAULDING	8,584	$7
	Lower Etowah	Litter Transport from: POLK, GA	13,981	$46
	Upper Coosa, GA	Litter Transport from: CHATTOOGA	-	-
	Upper Coosa, GA	Litter Transport from: DADE	620	$12
	Upper Coosa, GA	Litter Transport from: FLOYD	15,582	$57
	Upper Coosa, GA	Litter Transport from: HARALSON	1,005	$35
	Upper Coosa, GA	Litter Transport from: POLK, GA	17,303	$46
	Upper Coosa, GA	Litter Transport from: WALKER	26,335	$12
		Total by Weiss Market (Average)	**620,875**	**($21)**
Weiss-Tennessee				
	Conasauga, TN	Litter Transport from: BRADLEY, TN	16,112,547	$12
	Conasauga, TN	Litter Transport from: POLK, TN	1,188,044	$20
		Total by Weiss Market (Average)	**17,300,591**	**($21)**
		Total from All Weiss Markets (Average)	**91,678,096**	**($21)**

Table D.26. Credit Analysis - Weiss Lake Litter Transfer by Sub-watershed by County (NPS Scenario K)

Market	Watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Weiss-Alabama				
	Upper Coosa, AL	Litter Transport from: CALHOUN, AL	640,229	$155
	Upper Coosa, AL	Litter Transport from: CHEROKEE, AL	7,708,655	$155
	Upper Coosa, AL	Litter Transport from: CLEBURNE, AL	2,138,615	$35
	Upper Coosa, AL	Litter Transport from: DE KALB, AL	11,172,761	$35
	Upper Coosa, AL	Litter Transport from: ETOWAH, AL	63,336	$35
		Total by Weiss Market (Average)	**21,723,596**	**($83)**
Weiss-Georgia				
	Conasauga, GA	Litter Transport from: CATOOSA	3	$33
	Conasauga, GA	Litter Transport from: FANNIN	389	$119
	Conasauga, GA	Litter Transport from: GILMER	363	$27
	Conasauga, GA	Litter Transport from: GORDON	1,822	$62
	Conasauga, GA	Litter Transport from: MURRAY	11,117	$41
	Conasauga, GA	Litter Transport from: WALKER	226	$41
	Conasauga, GA	Litter Transport from: WHITFIELD	13,939	$41
	Coosawattee	Litter Transport from: BARTOW	3,505	$25
	Coosawattee	Litter Transport from: CHEROKEE	347	$24
	Coosawattee	Litter Transport from: DAWSON	102	$28
	Coosawattee	Litter Transport from: FANNIN	87	$119
	Coosawattee	Litter Transport from: GILMER	45,609	$27
	Coosawattee	Litter Transport from: GORDON	23,083	$62
	Coosawattee	Litter Transport from: MURRAY	2,140	$41
	Coosawattee	Litter Transport from: PICKENS	8,550	$24
	Oostanaula	Litter Transport from: BARTOW	1,611	$25
	Oostanaula	Litter Transport from: CHATTOOGA	-	-
	Oostanaula	Litter Transport from: FLOYD	4,164	$192
	Oostanaula	Litter Transport from: GORDON	20,563	$62
	Oostanaula	Litter Transport from: WALKER	4,377	$41
	Oostanaula	Litter Transport from: WHITFIELD	548	$41
	Lower Etowah	Litter Transport from: BARTOW	12,711	$25
	Lower Etowah	Litter Transport from: COBB	-	-
	Lower Etowah	Litter Transport from: FLOYD	3,041	$192
	Lower Etowah	Litter Transport from: HARALSON	4	$119
	Lower Etowah	Litter Transport from: PAULDING	2,528	$25
	Lower Etowah	Litter Transport from: POLK, GA	4,118	$155
	Upper Coosa, GA	Litter Transport from: CHATTOOGA	-	-
	Upper Coosa, GA	Litter Transport from: DADE	183	$41
	Upper Coosa, GA	Litter Transport from: FLOYD	4,589	$192
	Upper Coosa, GA	Litter Transport from: HARALSON	296	$119
	Upper Coosa, GA	Litter Transport from: POLK, GA	5,096	$155
	Upper Coosa, GA	Litter Transport from: WALKER	7,756	$41
		Total by Weiss Market (Average)	**182,867**	**($71)**
Weiss-Tennessee				
	Conasauga, TN	Litter Transport from: BRADLEY, TN	4,745,641	$41
	Conasauga, TN	Litter Transport from: POLK, TN	349,915	$67
		Total by Weiss Market (Average)	**5,095,556**	**($73)**
		Total from All Weiss Markets (Average)	**27,002,019**	**($73)**

Table D.27. Credit Analysis - Weiss Lake Litter Transfer by Sub-watershed by County (NPS Scenario L)

Market	Watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Weiss-Alabama				
	Upper Coosa, AL	Litter Transport from: CALHOUN, AL	1,303,929	$76
	Upper Coosa, AL	Litter Transport from: CHEROKEE, AL	15,699,908	$76
	Upper Coosa, AL	Litter Transport from: CLEBURNE, AL	4,355,632	$17
	Upper Coosa, AL	Litter Transport from: DE KALB, AL	22,755,113	$17
	Upper Coosa, AL	Litter Transport from: ETOWAH, AL	128,994	$17
		Total by Weiss Market (Average)	**44,243,577**	**($41)**
Weiss-Georgia				
	Conasauga, GA	Litter Transport from: CATOOSA	7	$16
	Conasauga, GA	Litter Transport from: FANNIN	792	$58
	Conasauga, GA	Litter Transport from: GILMER	739	$13
	Conasauga, GA	Litter Transport from: GORDON	3,711	$30
	Conasauga, GA	Litter Transport from: MURRAY	22,641	$20
	Conasauga, GA	Litter Transport from: WALKER	460	$20
	Conasauga, GA	Litter Transport from: WHITFIELD	28,389	$20
	Coosawattee	Litter Transport from: BARTOW	7,138	$12
	Coosawattee	Litter Transport from: CHEROKEE	706	$12
	Coosawattee	Litter Transport from: DAWSON	208	$14
	Coosawattee	Litter Transport from: FANNIN	178	$58
	Coosawattee	Litter Transport from: GILMER	92,890	$13
	Coosawattee	Litter Transport from: GORDON	47,012	$30
	Coosawattee	Litter Transport from: MURRAY	4,358	$20
	Coosawattee	Litter Transport from: PICKENS	17,413	$12
	Oostanaula	Litter Transport from: BARTOW	3,281	$12
	Oostanaula	Litter Transport from: CHATTOOGA	-	-
	Oostanaula	Litter Transport from: FLOYD	8,482	$94
	Oostanaula	Litter Transport from: GORDON	41,880	$30
	Oostanaula	Litter Transport from: WALKER	8,915	$20
	Oostanaula	Litter Transport from: WHITFIELD	1,115	$20
	Lower Etowah	Litter Transport from: BARTOW	25,889	$12
	Lower Etowah	Litter Transport from: COBB	-	-
	Lower Etowah	Litter Transport from: FLOYD	6,193	$94
	Lower Etowah	Litter Transport from: HARALSON	8	$58
	Lower Etowah	Litter Transport from: PAULDING	5,149	$12
	Lower Etowah	Litter Transport from: POLK, GA	8,387	$76
	Upper Coosa, GA	Litter Transport from: CHATTOOGA	-	-
	Upper Coosa, GA	Litter Transport from: DADE	372	$20
	Upper Coosa, GA	Litter Transport from: FLOYD	9,347	$94
	Upper Coosa, GA	Litter Transport from: HARALSON	603	$58
	Upper Coosa, GA	Litter Transport from: POLK, GA	10,379	$76
	Upper Coosa, GA	Litter Transport from: WALKER	15,797	$20
		Total by Weiss Market (Average)	**372,438**	**($35)**
Weiss-Tennessee				
	Conasauga, TN	Litter Transport from: BRADLEY, TN	9,665,256	$20
	Conasauga, TN	Litter Transport from: POLK, TN	712,659	$33
		Total by Weiss Market (Average)	**10,377,915**	**($36)**
		Total from All Weiss Markets (Average)	**54,993,929**	**($36)**

Table D.28. Credit Analysis - Weiss Lake Litter Transfer by Sub-watershed by County (NPS Scenario M)

Market	Watershed	BMP	Supply Credits (lbs/ year)	Min Credit Price (Unit Price)
Weiss-Alabama				
	Upper Coosa, AL	Litter Transport from: CALHOUN, AL	260,887	$381
	Upper Coosa, AL	Litter Transport from: CHEROKEE, AL	3,141,203	$381
	Upper Coosa, AL	Litter Transport from: CLEBURNE, AL	871,465	$87
	Upper Coosa, AL	Litter Transport from: DE KALB, AL	4,552,793	$87
	Upper Coosa, AL	Litter Transport from: ETOWAH, AL	25,809	$87
		Total by Weiss Market (Average)	**8,852,158**	**($205)**
Weiss-Georgia				
	Conasauga, GA	Litter Transport from: CATOOSA	1	$81
	Conasauga, GA	Litter Transport from: FANNIN	159	$291
	Conasauga, GA	Litter Transport from: GILMER	148	$66
	Conasauga, GA	Litter Transport from: GORDON	742	$152
	Conasauga, GA	Litter Transport from: MURRAY	4,530	$100
	Conasauga, GA	Litter Transport from: WALKER	92	$100
	Conasauga, GA	Litter Transport from: WHITFIELD	5,680	$100
	Coosawattee	Litter Transport from: BARTOW	1,428	$62
	Coosawattee	Litter Transport from: CHEROKEE	141	$60
	Coosawattee	Litter Transport from: DAWSON	42	$69
	Coosawattee	Litter Transport from: FANNIN	36	$291
	Coosawattee	Litter Transport from: GILMER	18,585	$66
	Coosawattee	Litter Transport from: GORDON	9,406	$152
	Coosawattee	Litter Transport from: MURRAY	872	$100
	Coosawattee	Litter Transport from: PICKENS	3,484	$59
	Oostanaula	Litter Transport from: BARTOW	656	$62
	Oostanaula	Litter Transport from: CHATTOOGA	-	-
	Oostanaula	Litter Transport from: FLOYD	1,697	$471
	Oostanaula	Litter Transport from: GORDON	8,379	$152
	Oostanaula	Litter Transport from: WALKER	1,784	$100
	Oostanaula	Litter Transport from: WHITFIELD	223	$100
	Lower Etowah	Litter Transport from: BARTOW	5,180	$62
	Lower Etowah	Litter Transport from: COBB	-	-
	Lower Etowah	Litter Transport from: FLOYD	1,239	$471
	Lower Etowah	Litter Transport from: HARALSON	2	$291
	Lower Etowah	Litter Transport from: PAULDING	1,030	$62
	Lower Etowah	Litter Transport from: POLK, GA	1,678	$381
	Upper Coosa, GA	Litter Transport from: CHATTOOGA	-	-
	Upper Coosa, GA	Litter Transport from: DADE	74	$100
	Upper Coosa, GA	Litter Transport from: FLOYD	1,870	$471
	Upper Coosa, GA	Litter Transport from: HARALSON	121	$291
	Upper Coosa, GA	Litter Transport from: POLK, GA	2,077	$381
	Upper Coosa, GA	Litter Transport from: WALKER	3,161	$100
		Total by Weiss Market (Average)	**74,517**	**($175)**
Weiss-Tennessee				
	Conasauga, TN	Litter Transport from: BRADLEY, TN	1,933,803	$100
	Conasauga, TN	Litter Transport from: POLK, TN	142,587	$164
		Total by Weiss Market (Average)	**2,076,391**	**($178)**
		Total from All Weiss Markets (Average)	**11,003,065**	**($179)**

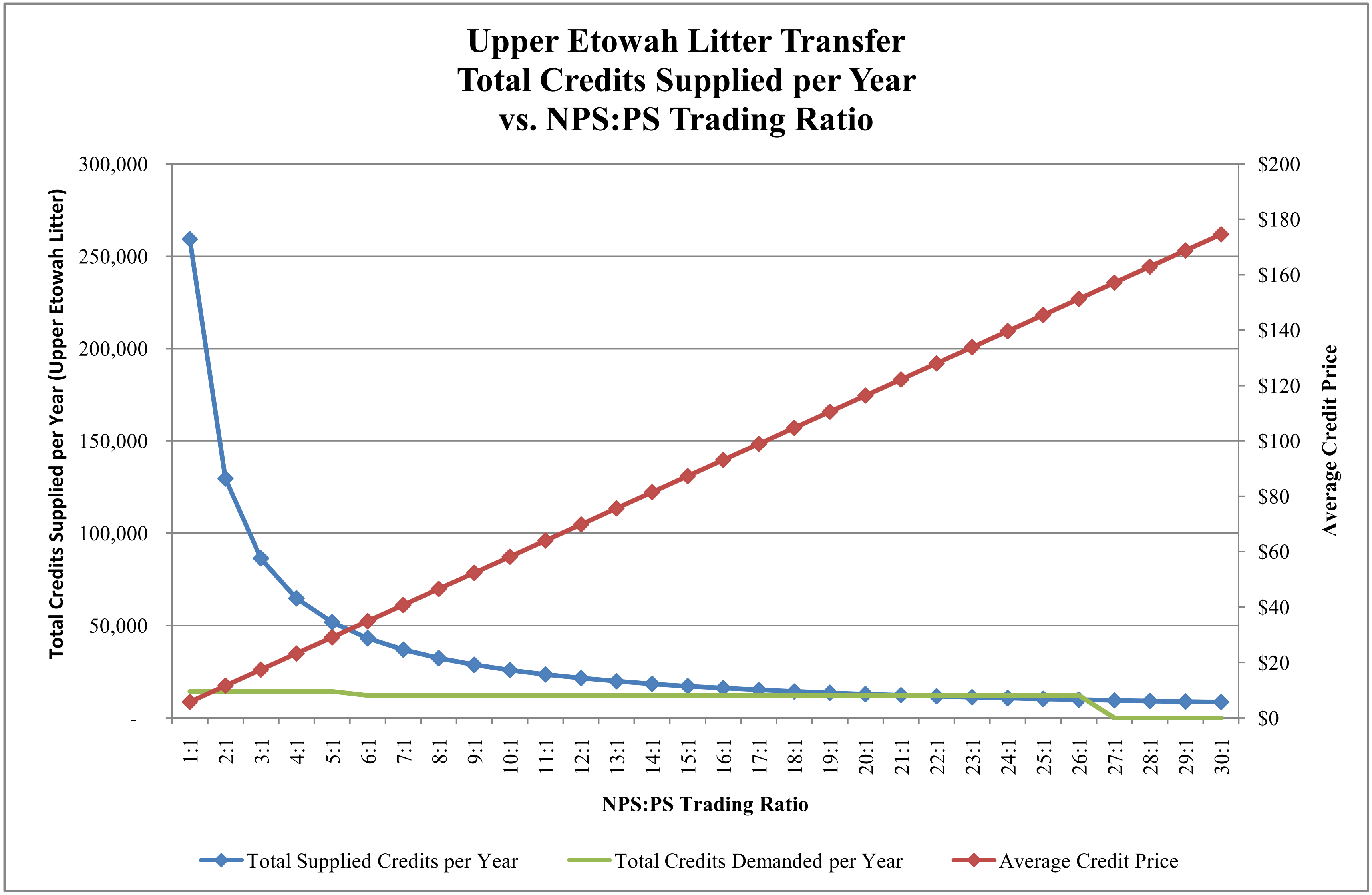

Figure D.1. Upper Etowah Litter Transfer: Total Credits Supplied per Year vs. NPS:PS Trading Ratio

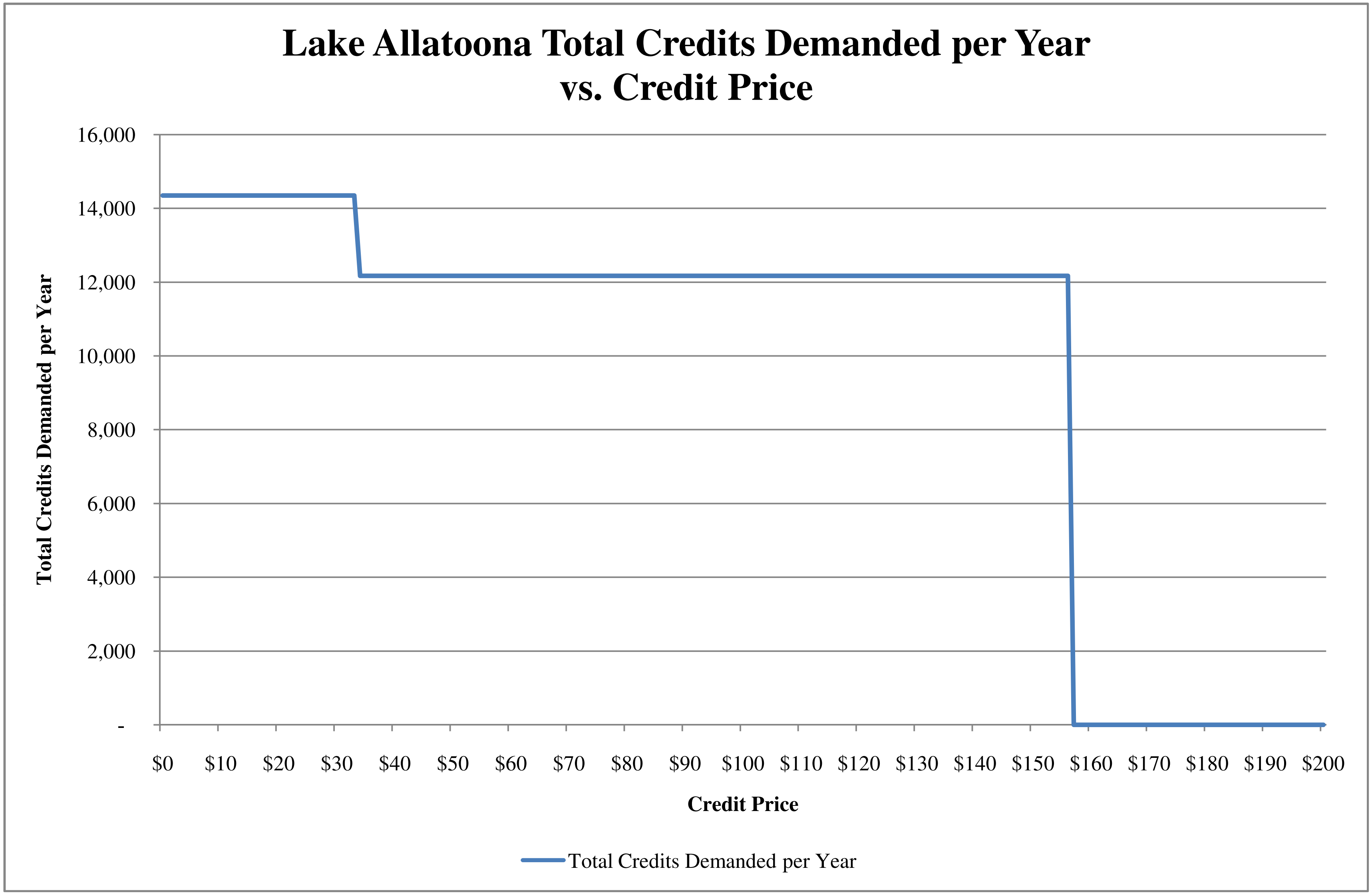

Figure D.2. Lake Allatoona Total Credits Demanded per Year vs. Credit Price

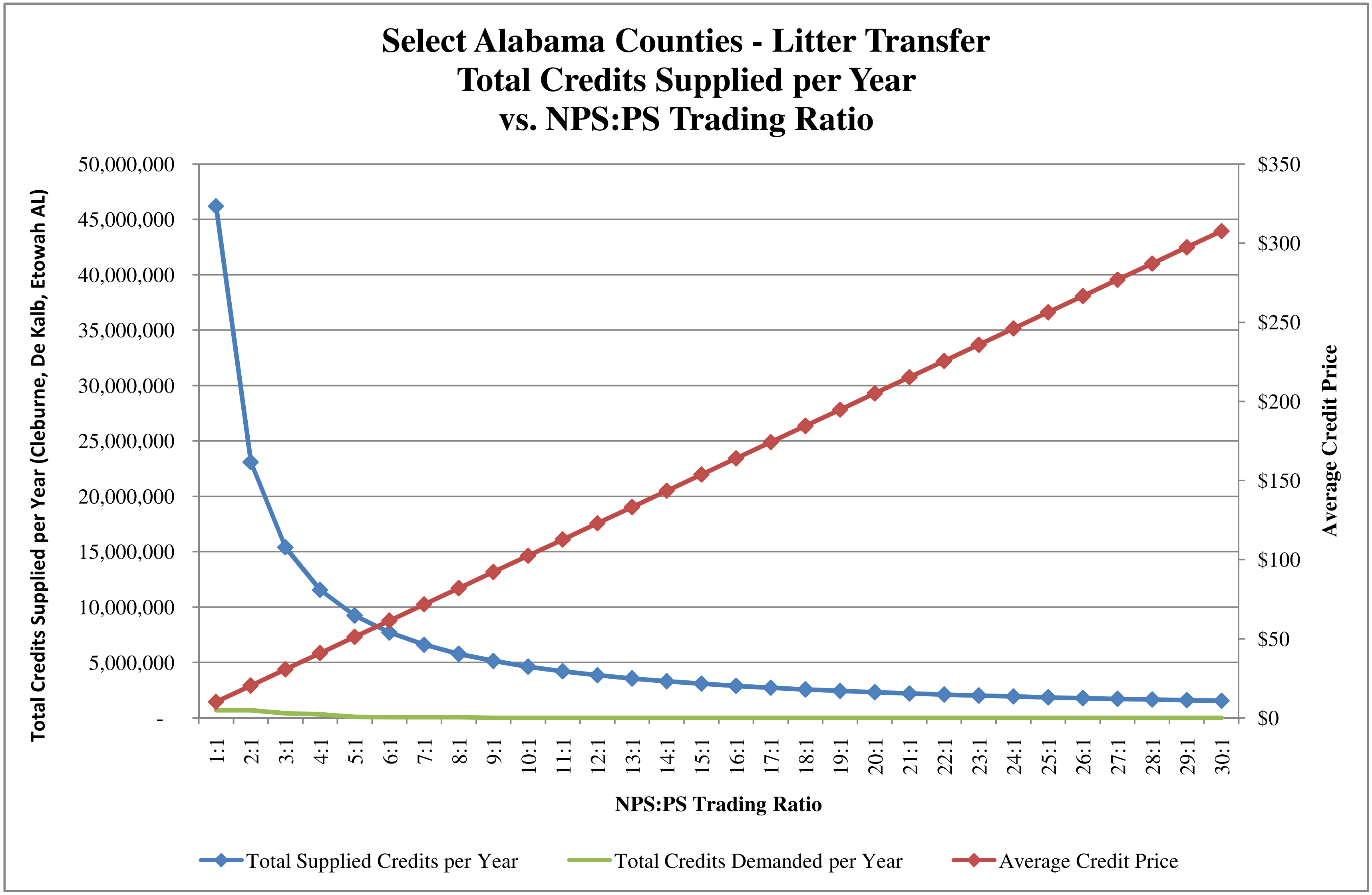

Figure D.3. Select Alabama Counties - Litter Transfer Total Credits Supplied per Year vs. NPS:PS Trading Ratio

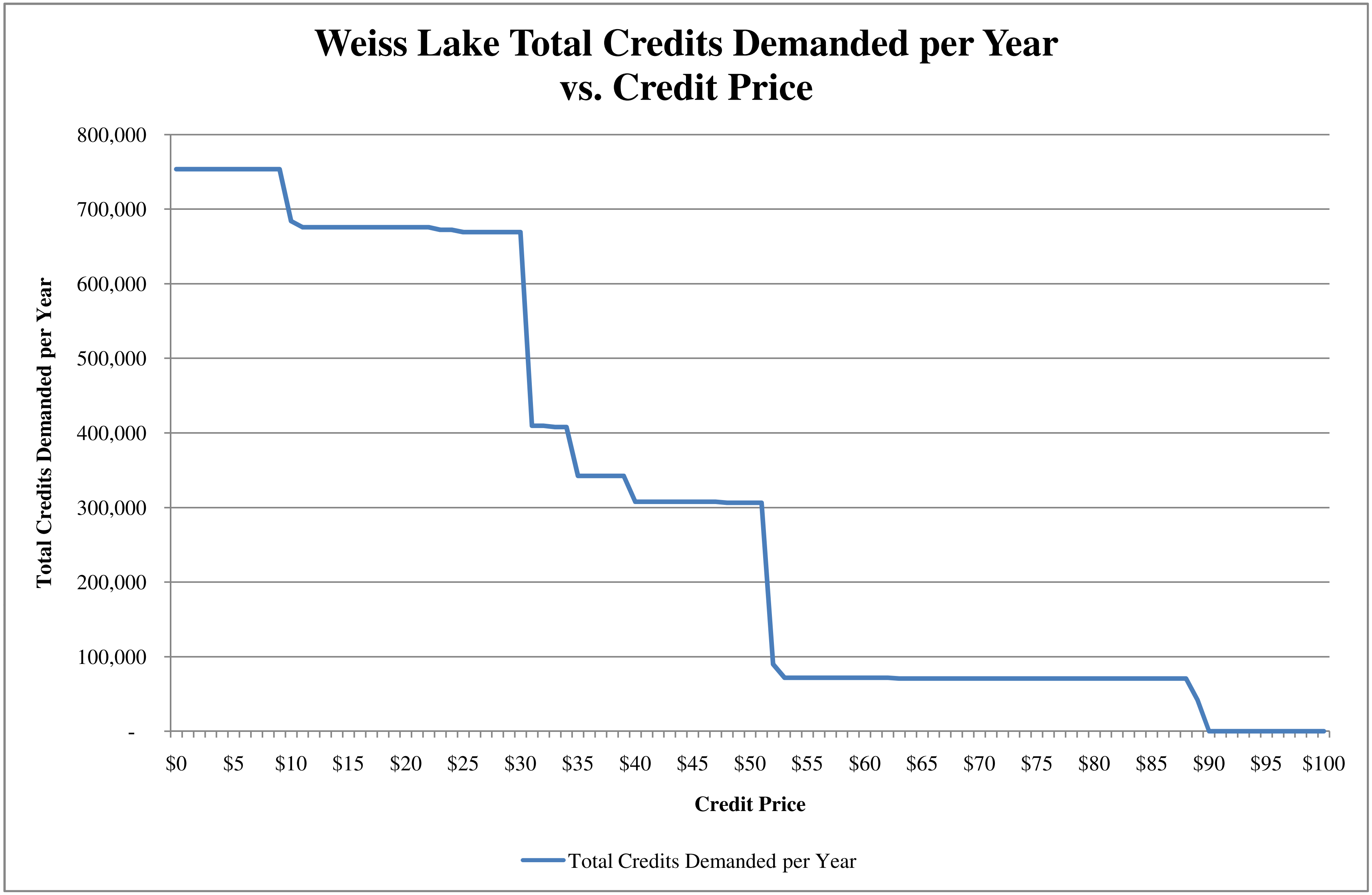

Figure D.4. Weiss Lake Total Credits Demanded per Year vs. Credit Price