

Illinois Environmental  
Protection Agency

**Total Maximum Daily Load  
Development for  
Altamont New Reservoir Watershed**

April 2004

*Draft Final Report*

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## **Parameter changes for developing TMDLs**

In May 2001, Illinois EPA entered into a contract with Camp Dresser & McKee to develop Total Maximum Daily Loads (TMDLs) for Altamont New Reservoir. In the 1998 Section 303(d) List, Altamont New Reservoir was listed as impaired for the following parameters: aldrin (sediment), copper (sediment), phosphorus, nitrogen, excessive algal growth, and chlorophyll-a. Since then, new data assessed in 2002 showed that Altamont New Reservoir is currently impaired for aldrin (sediment), copper (sediment), phosphorus, total ammonia-N, un-ionized ammonia, excessive algal growth, and chlorophyll-a.

Illinois EPA has since determined that at this time TMDLs will only be developed for those parameters with numeric water quality standards. These numeric water quality standards will serve as the target endpoints for TMDL development and provide a greater degree of clarity and certainty about the TMDL and implementation plans. As a result, this TMDL will only focus on the parameter of phosphorus, for which a numeric water quality standard exists. The un-ionized ammonia cause is being re-evaluated and Illinois EPA plans to continue monitoring for this parameter in Altamont New Reservoir.

Causes of impairment not based on numeric water quality standards will be assigned a lower priority for TMDL development. Pending development of numeric water quality standards for these parameters, as may be proposed by the Agency and adopted by the Illinois Pollution Control Board, Illinois EPA will continue to work toward improving water quality throughout the state by promoting and administering existing programs and working toward creating new methods for treating these potential causes of impairment.

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# Acronyms

°F	Fahrenheit
µg/L	micrograms per liter
ALMP	Ambient Lake Monitoring Program
BMP	best management practices
CCC	Commodity Credit Corporation
CPP	Conservation Practices Program
CRP	Conservation Reserve Program
CWA	Clean Water Act
DEM	Digital Elevation Model
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentive Program
FSA	Farm Service Agency
GIS	geographic information system
GWLF	Generalized Watershed Loading Function
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
ICLP	Illinois Clean Lakes Program
IDA	Illinois Department of Agriculture
IDNR	Illinois Department of Natural Resources
Illinois EPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
ISWS	Illinois State Water Survey
LA	Load Allocation
LC	Loading Capacity
MBI	Macroinvertebrate Biotic Index
mg/L	milligrams per liter
MOS	Margin of Safety
NASS	National Agricultural Statistics Service
NCDC	National Climate Data Center
NCSU	North Carolina State University
NRCS	National Resource Conservation Service
NWIS	National Water Inventory System
ppm	parts per million
<i>STATSGO</i>	State Soil Geographic database
<i>STORET</i>	USEPA <i>Storage and Retrieval</i> database
TMDL	Total Maximum Daily Load

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USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WHIP	Wildlife Habitat Incentives Program
WLA	Waste Load Allocation
WRP	Wetlands Reserve Program

# Executive Summary

## Altamont New Reservoir Watershed

### TMDL Fact Sheet

<b>Basin Name:</b>	Altamont New Reservoir
<b>Impaired Segment:</b>	RCJ
<b>Location:</b>	Effingham County, Illinois
<b>Size:</b>	57 acres at normal stage
<b>Primary Watershed Land Uses:</b>	Grassland, agriculture, and forest
<b>Criteria of Concern:</b>	Phosphorus
<b>Designated Uses Affected:</b>	General use
<b>Environmental Indicators:</b>	Phosphorus monitoring
<b>Major Sources:</b>	Nonpoint source loading from agricultural and internal cycling
<b>Loading Allocation:</b>	510 pounds/year total phosphorus
<b>Waste Load Allocation:</b>	Zero; No point sources
<b>Margin of Safety:</b>	Implicit through conservative modeling; Additional explicit of 5 percent

This Total Maximum Daily Load (TMDL) assessment for impaired water bodies in the Altamont New Reservoir Watershed addresses the sources of water body impairments, reductions in source loading necessary to comply with water quality standards, and the implementation of procedures to mitigate the impairment.

Primary sources of phosphorus loading to Altamont New Reservoir include internal cycling from the lake-bottom sediments and runoff from agricultural lands. Procedures outlined in the implementation plan to decrease phosphorus loading to the lake include in-lake measures as well as measures applied to the watershed to control nutrients in surface runoff and eroded sediment. In-lake mitigation practices include dredging the lake bottom and aerating the lake to eliminate internal cycling. Watershed controls include filter strips and wetlands to prevent phosphorus in surface runoff from reaching the lake, conservation tillage to decrease nutrient-rich soil erosion from agricultural fields, and development of nutrient management plans to ensure that excess phosphorus is not applied to agricultural fields.

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# **Section 1**

## **Goals and Objectives for Altamont New Reservoir Watershed (RCJ21)**

### **1.1 Total Maximum Daily Load (TMDL) Overview**

A Total Maximum Daily Load, or TMDL, is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards. TMDLs are a requirement of Section 303(d) of the Clean Water Act (CWA). To meet this requirement, the Illinois Environmental Protection Agency (Illinois EPA) must identify water bodies not meeting water quality standards and then establish TMDLs for restoration of water quality. Illinois EPA lists water bodies not meeting water quality standards every two years. This list is called the 303(d) list and water bodies on the list are then targeted for TMDL development.

In general, a TMDL is a quantitative assessment of water quality problems, contributing sources, and pollution reductions needed to attain water quality standards. The TMDL specifies the amount of pollution or other stressor that needs to be reduced to meet water quality standards, allocates pollution control or management responsibilities among sources in a watershed, and provides a scientific and policy basis for taking actions needed to restore a water body (U.S. Environmental Protection Agency [USEPA] 1998a).

Water quality standards are laws or regulations that states authorize to enhance water quality and protect public health and welfare. Water quality standards provide the foundation for accomplishing two of the principal goals of the CWA. These goals are:

- Restore and maintain the chemical, physical, and biological integrity of the nation's waters
- Where attainable, to achieve water quality that promotes protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water

Water quality standards consist of three elements:

- The designated beneficial use or uses of a water body or segment of a water body
- The water quality criteria necessary to protect the use or uses of that particular water body
- An antidegradation policy

Examples of designated uses are recreation, drinking water, and protection of aquatic life. Water quality criteria describe the quality of water that will support a designated use. Water quality criteria can be expressed as numeric limits or as a narrative

statement. Antidegradation policies are adopted so that water quality improvements are conserved, maintained, and protected.

## 1.2 TMDL Goals and Objectives for Altamont New Reservoir Watershed

The TMDL goals and objectives for the Altamont New Reservoir Watershed include developing TMDLs for all impaired water bodies within the watershed, describing all of the necessary elements of the TMDL, developing an implementation plan for each TMDL, and gaining public acceptance of the process. Following is the impaired water body segment in the Altamont New Reservoir Watershed, which is also shown in Figure 1-1:

- Altamont New Reservoir (RCJ)

The TMDL for each segment listed above will specify the following elements:

- Loading Capacity (LC) or the maximum amount of pollutant loading a water body can receive without violating water quality standards
- Waste Load Allocation (WLA) or the portion of the TMDL allocated to existing or future point sources
- Load Allocation (LA) or the portion of the TMDL allocated to existing or future nonpoint sources and natural background
- Margin of Safety (MOS) or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality

These elements are combined into the following equation:

$$\text{TMDL} = \text{LC} = \sum \text{WLA} + \sum \text{LA} + \text{MOS}$$

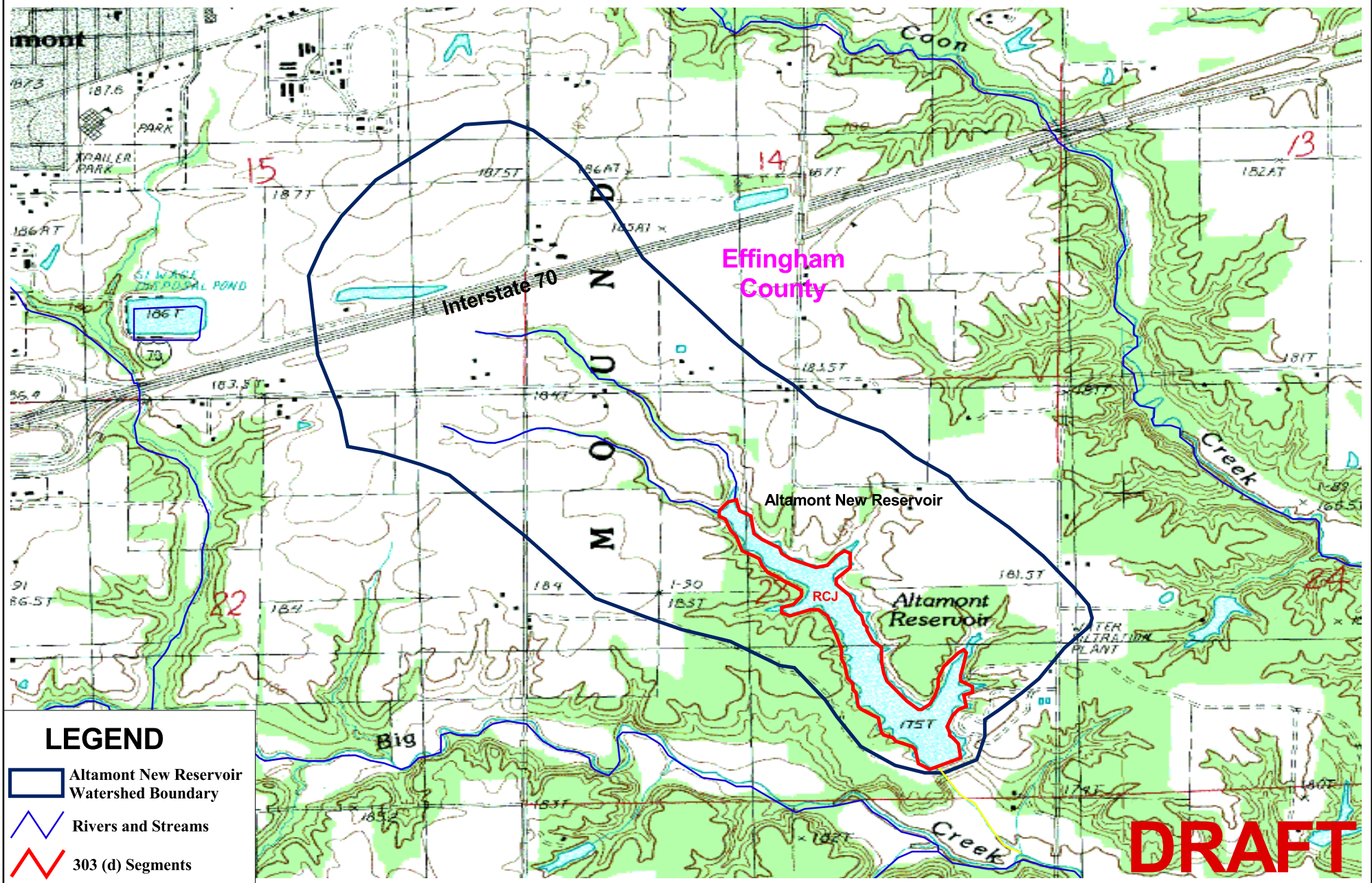
Each TMDL developed must also take into account the seasonal variability of pollutant loads so that water quality standards are met during all seasons of the year. Also, reasonable assurance that the TMDLs will be achieved is described in the implementation plan. The implementation plan for the Altamont New Reservoir Watershed describes how water quality standards will be attained. This implementation plan includes recommendations for implementing best management practices (BMP), cost estimates, institutional needs to implement BMPs and controls throughout the watershed, and timeframe for completion of implementation activities.

## 1.3 Report Overview

The remaining sections of this report contain:

- **Section 2 Altamont New Reservoir Watershed Description** provides a description of the impaired water body and general watershed characteristics.
- **Section 3 Public Participation and Involvement** discusses public participation activities that occurred throughout the TMDL development.
- **Section 4 Altamont New Reservoir Watershed Water Quality Standards** defines the water quality standards for the impaired water body. Pollution sources will also be discussed in this section.
- **Section 5 Altamont New Reservoir Watershed Data Review** provides an overview of available data for the Altamont New Reservoir Watershed.
- **Section 6 Methodologies to Complete TMDLs for the Altamont New Reservoir Watershed** discusses the models and analyses needed for TMDL development.
- **Section 7 Model Development for Altamont New Reservoir** provides an explanation of model development for Altamont New Reservoir.
- **Section 8 Total Maximum Daily Load for the Altamont New Reservoir** discusses the allowable loadings to water bodies to meet water quality standards and the reduction in existing loadings needed to meet allowable loads.
- **Section 9 Implementation Plan for Altamont New Reservoir** provides methods to reduce loadings to impaired water bodies.
- **Section 10 References** lists references used in this report.

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**Figure 1-1**  
**Little Wabash River Watershed (ILC21)**  
**Impaired Water Bodies**

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## Section 2

# Altamont New Reservoir Watershed Description

### 2.1 Altamont New Reservoir Watershed Overview

The Altamont New Reservoir Watershed originates in southwest Effingham County. The watershed encompasses an area of approximately one square mile, and is located within the U.S. Geological Survey (USGS) Little Wabash Basin (Hydrologic Unit Code [HUC] 05120114). Figure 1-1 shows the impaired lake segments within the watershed. Impaired segments are shown in red. Table 2-1 lists the water body segment, water body size, and potential causes of impairment.

**Table 2-1 Impaired Water Bodies in Altamont New Reservoir Watershed**

Water Body Segment ID	Water Body Name	Size	Potential Causes of Impairment
RCJ	Altamont New Reservoir	57 acres	Phosphorus

Land use data was obtained from the Critical Trends Assessment Land Cover Database of Illinois (Illinois Department of Natural Resources [IDNR] 1996). Land use in the watershed is predominantly agricultural followed by forest land. Farmers in the area primarily raise cash crops, such as corn, soybeans, and alfalfa.

Soils within the Altamont New Reservoir Watershed are primarily comprised of silty and loamy soils. The surface layer is made up of grayish silt loam extending about nine inches. The underlying material is a firm clay loam extending more than 60 inches. Soils are classified as well drained to somewhat poorly drained (U.S. Department of Agriculture [USDA] 1991).

The climate in the Altamont New Reservoir Watershed is typically cold in the winter and warm in the summer. In the winter, the average temperature is 39 degrees Fahrenheit (°F) and the average daily minimum temperature is 29°F according to data collected in Effingham, Illinois. Summer temperatures are typically 68°F with an average daily maximum of 80°F. Annual precipitation is 42 inches of which 24 inches, approximately 56 percent, usually falls in April to September (National Climate Data Center [NCDC] 2002).

### 2.2 Lake Segment Site Reconnaissance of the Altamont New Reservoir Watershed

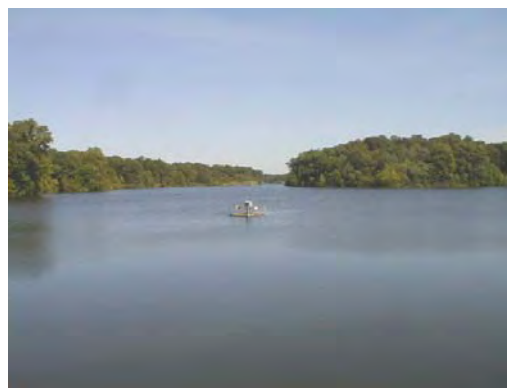
The project team conducted a site reconnaissance of the Altamont New Reservoir Watershed on June 18, 2001. This section briefly describes the lake segment and the site reconnaissance.

Table 2-1 lists the impaired stream segments in the Altamont New Reservoir Watershed. Illinois EPA has listed one lake segment as impaired based on the 1998

and 2002 303(d) list for the Altamont New Reservoir Watershed. The Altamont New Reservoir, Segment RCJ, is located on Big Creek, a tributary to the Little Wabash River, in west central Effingham County as shown in Figure 1-1. Altamont Reservoir Dam was constructed on an unnamed tributary of Big Creek in 1972. The dam is owned by the city of Altamont. The dam structure is 506 feet in length and 42 feet tall enabling it to store a maximum volume of 1,255 acre-feet, although the normal storage capacity is 950 acre-feet. The lake is used for both recreation and a local drinking water supply. A few small tributaries and direct drainage constitutes a majority of the 1.1 square miles of contributing drainage area (U.S. Army Corps of Engineers [USACE] 1999a).

Altamont New Reservoir was observed on June 18, 2001 at the southern end of the lake from the Altamont Reservoir Dam, which is located off of 500 E Road. The observed surrounding land was primarily farmland with wooded areas surrounding the lake. No residential areas were observed near the lake.

The Altamont water treatment plant has an intake in the reservoir, and the facility is located nearby. The reservoir has a volunteer sampling program, and the sign noting this was observed at the reservoir. An aerator was present in the lake. The spillway was dry at the time of the observation. Some algal growth was observed on the rocks near the shore of the reservoir. Riprap had been placed on the slope of the road over the dam for bank stabilization.



*Altamont New Reservoir, looking north-northwest at the aerator from the dam.*



## **Section 3**

### **Public Participation and Involvement**

#### **3.1 Altamont New Reservoir Watershed Public Participation and Involvement**

Public knowledge, acceptance, and follow through are necessary to implement a plan to meet recommended TMDLs. It was important to involve the public as early in the process as possible to achieve maximum cooperation and counter concerns as to the purpose of the process and the regulatory authority to implement the recommendations. A public meeting was held to discuss the Altamont New Reservoir Watershed at 6:30 p.m. on December 6, 2001 at the Effingham County Building in Effingham, Illinois. A total of 25 interested citizens including public officials and organizations other than Illinois EPA attended the public meeting.

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# **Section 4**

## **Altamont New Reservoir Watershed Water Quality Standards**

### **4.1 Illinois Water Quality Standards**

Water quality standards are developed and enforced by the state to protect the "designated uses" of the state's waterways. In the state of Illinois, setting the water quality standards is the responsibility of the Illinois Pollution Control Board (IPCB). Illinois is required to update water quality standards every three years in accordance with the CWA. The standards requiring modifications are identified and prioritized by Illinois EPA, in conjunction with USEPA. New standards are then developed or revised during the three-year period.

Illinois EPA is also responsible for developing scientifically based water quality criteria and proposing them to the IPCB for adoption into state rules and regulations. The Illinois water quality standards are established in the Illinois Administrative Rules Title 35, Environmental Protection; Subtitle C, Water Pollution; Chapter I, Pollution Control Board; Part 302, Water Quality Standards.

### **4.2 Designated Uses**

The waters of Illinois are classified by designated uses, which include: General Use, Public and Food Processing Water Supplies, Lake Michigan, and Secondary Contact and Indigenous Aquatic Life Use. The only designated uses applicable to the Altamont New Lake (Reservoir) Watershed are the General Use and Public and Food Processing Water Supplies.

#### **4.2.1 General Use**

The General Use classification provides for the protection of indigenous aquatic life, primary and secondary contact recreation (e.g., swimming or boating), and agricultural and industrial uses. The General Use is applicable to the majority of Illinois streams and lakes (Illinois EPA 2000).

#### **4.2.2 Public and Food Processing Water Supplies**

The Public and Food Processing Water Supplies classification was developed for the protection of potable water supplies and water used for food processing purposes. These waters have more stringent water quality standards and they apply at any point from which water is withdrawn for these uses (Illinois EPA 2000).

### **4.3 Illinois Water Quality Standards**

To make 303(d) listing determinations, Illinois EPA compares collected data for the water body to the available water quality standards developed by Illinois EPA for assessing water body impairment. Table 4-1 presents the water quality standards of the potential causes of impairment for TMDLs that will be developed in the Altamont New

Lake (Reservoir) Watershed. These water quality standards are further discussed in the remainder of the section.

**Table 4-1 Summary of General Use Water Quality Standards for Altamont New Reservoir Watershed**

Parameter	General Use Water Quality Standard
Phosphorous	0.05 mg/L Lakes/reservoirs >20 acres and streams entering lakes or reservoirs

### 4.3.1 Phosphorus

The General Use water quality standard for phosphorus shall not exceed 0.05 milligrams per liter (mg/L) in any lake or reservoir with a surface area of 20 acres or more, or in any stream at the point where it enters any such reservoir or lake. The General Use water quality standard for phosphorous does not apply to streams outside the point where the stream enters a lake or reservoir. At this time, the Illinois EPA has not established phosphorus water quality standards for streams that do not enter lakes or reservoirs.

Phosphorous is listed as a cause of less than full support use attainment in lakes or reservoirs if the surface total phosphorous concentration is greater than 0.05 mg/L based on Ambient Lake Monitoring Program (ALMP) or Illinois Clean Lakes Program (ICLP) data.

### 4.3.2 Parameters without Water Quality Standards

It should be noted that although formal TMDLs will not be developed for parameters without water quality standards in the Altamont New Reservoir Watershed, many of the management measures discussed in Section 9 of this report will result in reductions of the parameters listed in the 1998 and 2002 303(d) lists that do not currently have adopted water quality standards. For example, many of the management measures that will be discussed in Section 9 address the other parameters of concern for the watershed. For total ammonia-N and un-ionized ammonia management measures that control erosion will reduce these pollutants from entering the reservoir. All management measures discussed in Section 9 will help reduced chlorophyll-a and excessive algal growth within in the reservoir as the BMPs discussed are based on controlling nutrient levels in the reservoir. For copper and aldrin, dredging of the reservoir which is discussed in Section 9 is a management measure that would address these impairments.

## 4.4 Pollutant Sources

As part of the Illinois EPA use assessment presented in the annual Illinois Water Quality Report, the causes of the pollutants resulting in a less than full support use attainment are associated with a potential source, based on data, observations, and other existing information. The following is a summary of the sources associated with the listed causes for the TMDL listed segments in this watershed. They are summarized in Table 4-2.

**Table 4-2 Summary of Potential Sources of Pollutants**

Potential Source	Cause of Impairment
<b>Agriculture</b> Nonirrigated crop production Pasture land Animal holding/management areas	Phosphorous
<b>Contaminated Sediments</b>	Phosphorous

#### 4.4.1 Agriculture

The southern Illinois area is largely agriculture land use. Rural grassland is the largest single category land use in the basin. Agricultural land uses potentially contribute nutrients and pesticides to stream and lake loadings. The amount that is contributed is a function of the soil type, slope, crop management, precipitation, total amount of cropland, and the distance to the water resource (D.B. Muir, R.L. Hite, M.M. King, M.R. Matson 1995).

Erosion of the land and streambanks carries sediment to the streams and lakes, resulting in higher levels of nutrients and pesticides. This can also be caused by livestock on pastures and feedlots. Wastes from livestock can enter streams or lakes, which can contribute a phosphorus load.

#### 4.4.2 Contaminated Sediments

Sediments are carried to streams, lakes, and reservoirs during runoff conditions and are generally deposited in streambeds or lake bottoms. Constituents contained in sediment may include metals, pesticides, and nutrients. Contaminated sediments containing metals can originate from urban areas or mining locations, while the contaminated sediments containing pesticides are typically from agricultural lands. Both agricultural lands and urban areas can contribute to the nutrient loading in the sediment.

Suspended sediments settle out to stream bottoms during periods of low flow. During periods of high flow, sediments are resuspended and carried downstream to be deposited in another location. Once the sediment reaches a lake or reservoir, the sediments are deposited and typically accumulate in these areas. The source of the contaminated sediment can therefore be located much farther upstream than the location detected.

Contaminated sediments can slowly leach contaminants to the water column, thereby being a continual source of impact to the water body. Phosphorous is commonly released from sediment into the water column especially when anoxic conditions persist.

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# Section 5

## Altamont New Reservoir Watershed Data Review

### 5.1 Existing Data Review

The following data sources were reviewed for model selection and analysis:

- Mapping data
- Topography data
- Flow data
- Precipitation data
- Temperature data
- Evaporation data
- Existing water quality data
- Land use
- Soil data
- Cropping practices
- Reservoir characteristics
- Point sources
- Dairy and animal confinement locations
- Septic systems

#### 5.1.1 Mapping Data

USGS quadrangle maps (scale 1:24,000) were collected for the watershed in paper and electronic form. These were utilized for base mapping.

#### 5.1.2 Topography Data

A Digital Elevation Model (DEM) was used to delineate watersheds in a geographic information system (GIS) for Altamont New Reservoir, Segment RCJ. A DEM is a digital representation of the landscape as a GIS-compatible grid in which each grid cell is assigned an elevation. DEMs of 90-meter resolution were downloaded from the *BASINS* database (USEPA 2002a) for watershed delineation. GIS watershed delineation defines the boundaries of a watershed by computing flow directions from elevations and locating elevation peaks on the DEM. The GIS-delineated watershed was checked against USGS 7.5-minute topographic maps to ensure agreement between the watershed boundaries and natural topographic boundaries. Figure 5-1 at the end of this section shows the location of water quality stations for the Altamont New Reservoir Watershed and the watershed boundary. Purple areas in Figure 5-1 represent features of the topographic maps that have been updated through aerial photography, but have not been field verified.

### 5.1.3 Flow Data

Analyses of the Altamont New Reservoir Watershed require an understanding of flow into Altamont New Reservoir. No gage for the tributary to Altamont New Reservoir exists, and there is no active stream gage within the impaired segment. Therefore, the drainage area ratio method, represented by the following equation, was used to estimate flows within the watersheds.

$$Q_{\text{gaged}} \left( \frac{\text{Area}_{\text{ungaged}}}{\text{Area}_{\text{gaged}}} \right) = Q_{\text{ungaged}}$$

where:  $Q_{\text{gaged}}$  = Streamflow of the gaged basin  
 $Q_{\text{ungaged}}$  = Streamflow of the ungaged basin  
 $\text{Area}_{\text{gaged}}$  = Area of the gaged basin  
 $\text{Area}_{\text{ungaged}}$  = Area of the ungaged basin

The assumption behind the equation is that the flow per unit area is equivalent in watersheds with similar characteristics. Therefore, the flow per unit area in the gaged watershed times the area of the ungaged watershed will result in a flow for the ungaged watershed.

USGS gage 05595820 (Casey Fork at Mount Vernon, Illinois) was chosen as an appropriate gage from which to compute flow into Altamont New Reservoir. Gage 05595820 captures flow from a drainage area of 77 square miles in an upstream section of the Casey Fork Watershed, which is about 50 miles southwest of the Altamont New Reservoir Watershed. Daily streamflow data for the gage were downloaded from the USGS National Water Inventory System (NWIS) for the entire period of record from October 1, 1985 to September 30, 2000 (USGS 2002a). Figure 5-2 at the end of this section shows average monthly flows over the period of record into Altamont New Reservoir calculated from the drainage area ratio method using gage 05595820.

### 5.1.4 Precipitation, Temperature, and Evaporation Data

As discussed in Section 2.1, the Altamont New Reservoir Watershed is located entirely within Effingham County as shown in Figure 5-1. Daily precipitation and temperature data for Effingham County were extracted from the NCDC database for the years of 1985 through 2001. Two months of data were missing from the Effingham County gage. Missing data were supplemented with data from a gage in neighboring Fayette County. Table 5-1 lists the station details for the Effingham County and Fayette County gages.

**Table 5-1 Historical Precipitation Data for the Altamont New Reservoir Watershed**

NCDC Gage Number	Station Location	Period of Record
2687	Effingham County (Effingham)	1901-present
8781	Fayette County (Vandalia)	1948-present



**Table 5-2 Average Monthly Precipitation in Effingham County from 1985 to 2001**

Month	Average Precipitation (inches)
January	2.7
February	2.6
March	2.8
April	4.1
May	4.8
June	4.2
July	4.8
August	2.8
September	3.0
October	3.1
November	4.5
December	2.8
<b>TOTAL</b>	<b>42.2</b>

Table 5-2 shows the average monthly precipitation of the dataset developed for Effingham County for the years 1985 to 2001. The average annual precipitation over the same period is approximately 42 inches for Effingham County.

Pan evaporation data is available through the Illinois State Water Survey (ISWS) website at nine locations across Illinois (ISWS 2002). The Carlyle station was chosen for its proximity to the 303(d)-listed water bodies and stream segments in southern Illinois and the completeness of the dataset as compared to other

stations. The Carlyle station is approximately 45 miles southwest of the Altamont New Reservoir Watershed. The average monthly pan evaporation for the years 1980 to 2001 at the Carlyle station was downloaded from the ISWS website and summed to produce an average annual pan evaporation of 44.2 inches. Actual evaporation is typically less than pan evaporation, so the average annual pan evaporation was multiplied by 0.75 to calculate an average annual evaporation of 33.2 inches (ISWS 2002).

### 5.1.5 Water Quality Data

Three historic water quality stations exist within the Altamont New Reservoir Watershed and are presented in Table 5-3. This table provides the location, station identification number, and the agency that collected the data. Location and station identification number are also shown in Figure 5-1.

**Table 5-3 Historic Water Quality Stations for Altamont New Reservoir**

Location	Station Identification Number	Data Collection Agency
Altamont Lake	RC-A09-J-1	Illinois EPA Division of Water Pollution Control
Altamont Lake	RC-A09-J-2	Illinois EPA Division of Water Pollution Control
Altamont Lake	RC-A09-J-3	Illinois EPA Division of Water Pollution Control

The impaired water body segment in the Altamont New Reservoir Watershed was presented in Section 2. For Altamont New Reservoir, segment RCJ, there are three historic water quality stations. Table 5-4 summarizes available historic water quality data since 1990 from the USEPA *Storage and Retrieval (STORET)* database associated with impairments discussed in Section 2 for the Altamont New Reservoir Watershed.

**Table 5-4 Summary of Constituents Associated with Impairments in the Altamont New Reservoir**

Sample Location and Parameter	Endpoint (mg/L)	Period of Record Examined for Samples	Number of Samples
<b>Altamont New Reservoir Segment RCJ; Sample Locations RCJ-1, RCJ-2, and RCJ-3</b>			
<b>RCJ-1</b>			
Phosphorus	0.05	4/13/90-8/22/01	51
<b>RCJ-2</b>			
Phosphorus	0.05	4/13/90-8/22/01	14
<b>RCJ-3</b>			
Phosphorus	0.05	4/13/90-8/22/01	20

### 5.1.5.1 Altamont New Reservoir Water Quality Data

There are three water quality stations in Altamont New Reservoir as shown in Figure 5-1 and listed in Table 5-3. The water quality station data for Altamont New Reservoir were downloaded from the *STORET* online database (USEPA 2002b). Data collected after 1998 were available from the Illinois EPA and were incorporated into the electronic database. The data summarized in this section include water quality data for impaired constituents in Altamont New Reservoir as well as constituents used in modeling efforts. The raw data are contained in Appendix A.

Constituents are sampled at various depths throughout Altamont New Reservoir, and compliance with water quality standards is determined by the sample at a one-foot depth from the lake surface. This section discusses the one-foot depth samples of water quality constituents used in modeling efforts for Altamont New Reservoir. The exception is chlorophyll "a," which was sampled at various depths at each water quality station and will be presented as an average over all sample depths. Modeling of the reservoir required use of phosphorus samples at all depths, which is discussed and presented in Section 7.2.3.2.

#### 5.1.5.1.1 Total Phosphorus

The average total phosphorus concentrations at one-foot depth for each year of available data from 1990 to 2001 at each monitoring site in Altamont New Reservoir are presented in Table 5-5. At station RCJ-1, samples were taken at a one-foot depth from the lake surface and at the lake bottom. Beginning in 2001, samples include a mid-depth sample at RCJ-1 because Altamont New Reservoir is a public water supply. Samples at stations RCJ-2, and RCJ-3 were only taken at a one-foot depth from the lake surface. The water quality standard for total phosphorus is less than or equal to 0.05 mg/L at a one-foot depth. The TMDL endpoint for total phosphorus in lakes is 0.05 mg/L. The raw data for all samples are contained in Appendix A.

**Table 5-5 Average Total Phosphorus Concentrations (mg/L) in Altamont New Reservoir at One-Foot Depth (Illinois EPA 2002 and USEPA 2002b)**

Year	RCJ-1	RCJ-2	RCJ-3	Lake Average
1990	0.11	0.18	0.17	0.15
1993	0.12		0.13	0.12
1995	0.08			0.08
1997	0.09			0.09
1998	0.12	0.15	0.18	0.15
2001	0.13	0.11	0.11	0.12

The annual averages for total phosphorus at all three stations and the annual lake averages are all greater than the endpoint of 0.05 mg/L. It is apparent from Table 5-5 that concentrations at all stations repeatedly violate the phosphorus standard. The raw data for all sample depths are contained in Appendix A.

Phosphorus exists in water in either a particulate phase or a dissolved phase. Particulate matter includes living and dead plankton, precipitates of phosphorus, phosphorus adsorbed to particulates, and amorphous phosphorus. The dissolved phase includes inorganic phosphorus and organic phosphorus. Phosphorus in natural waters is usually found in the form of phosphates ( $\text{PO}_4$ ). Phosphates can be in inorganic or organic form. Inorganic phosphate is phosphate that is not associated with organic material. Types of inorganic phosphate include orthophosphate and polyphosphates. Orthophosphate is sometimes referred to as "reactive phosphorus." Orthophosphate is the most stable kind of phosphate, and is the form used by plants or algae. There are several forms of phosphorus that can be measured. Total phosphorus is a measure of all the forms of phosphorus, dissolved or particulate, that are found in a sample. Soluble reactive phosphorus is a measure of orthophosphate, the filterable (soluble, inorganic) fraction of phosphorus, the form directly taken up by plant cells.

#### **5.1.5.1.2 Tributary Data**

There is no water quality data available for the unnamed tributaries to Altamont New Reservoir. Tributary water quality data along with flow information would be useful in assessing contributing loads from the watersheds to help differentiate between external loading and internal loading. External loads are those loadings from the watershed such as nonpoint source runoff and point sources. Internal loads are caused by low dissolved oxygen conditions near lake sediments, which promote re-suspension of phosphorus from the sediments into the water column. External versus internal loads will be discussed further in Section 7.3.2.

#### **5.1.6 Land Use**

The Illinois Natural Resources Geospatial Clearinghouse distributes the Critical Trends Assessment Land Cover Database of Illinois. This database represents 23 land use classes created by satellite imagery captured between 1991 and 1995. The data were published in 1996 and are distributed by county in grid format for use in GIS. The GIS-delineated watershed for Altamont New Reservoir was used to obtain the land use from the Critical Trends Assessment Land Cover grid. Table 5-6 lists the land uses

contributing to the Altamont New Reservoir Watershed as well as each land use area and percent of total area.

**Table 5-6 Critical Trends Assessment Land Uses in Altamont New Reservoir (IDNR 1996)**

Land Use	Acres	Percent of Area
Rural Grassland (pastureland, grassland, waterways, buffer strips, CRP land, etc.)	227	36%
Row Crop (corn, soybeans, and other tilled crops)	219	35%
Deciduous Forest	101	16%
Small Grains (wheat, oats, etc.)	81	13%
<b>Total</b>	<b>628</b>	<b>100%</b>

Additional land use data were obtained from the Spatial Analysis Research Center's Cropland Data Layer to supplement the Critical Trends Assessment dataset. The data were requested from the National Agricultural Statistics Service (NASS) website for the years of 1999 and 2000 (NASS 2002). The Cropland Data Layer is also derived from satellite imagery, but the land use classes for crops are more detailed than those presented in the Critical Trends Assessment dataset. The detailing of crops in the Cropland Data Layer land use classes makes it a more accurate dataset for calculation of crop-related parameters. The dataset was also used to verify the land use obtained from the Critical Trends Assessment. Table 5-7 shows the cropland use classes of the Cropland Data Layer and the Critical Trends Assessment classes to which they were applied.

**Table 5-7 Comparison of Land Use Classes in Altamont New Reservoir Watershed**

Cropland Data Layer Land Use Class	Critical Trends Assessment Land Use Class
Corn	Row Crop
Sorghum	Small Grains
Soybeans	Row Crop
Winter Wheat	Small Grains
Other Small Grains & Hay	Small Grains
Double-Cropped Winter Wheat/Soybeans	Half to Small Grains Half to Row Crops

## 5.1.7 Point Sources and Animal Confinement Operations

### 5.1.7.1 Animal Confinement Operations

The presence of a dairy farm in the watershed was discussed in a public meeting held on December 6, 2001. The location of the dairy was confirmed with aerial photographs as shown in Figure 5-3 at the end of this section. Illinois EPA has confirmed that this dairy is no longer producing milk, but the cows associated with the dairy operation are potentially still located on the property. No other point sources were identified in the Altamont New Reservoir Watershed.

## 5.1.8 Soil Data

State Soil Geographic (*STATSGO*) Database data, created by the USDA-National Resource Conservation Service (NRCS) Soil Survey Division, are aggregated soil

surveys for GIS use published for Illinois in 1994. The *STATSGO* shapefiles were downloaded by HUC from the USEPA *BASINS* website (USEPA 2002a). *STATSGO* data are presented as map units of soils in which each map unit has a unique code linking it to attribute tables listing percentages of soil types within a map unit, soil layer depths, hydrologic soil groups, and soil texture among other soil properties.

### 5.1.9 Cropping Practices

Tillage practices can be categorized as conventional till, reduced till, mulch-till, and no-till. The percentage of each tillage practice for corn, soybeans, and small grains, presented in Table 5-8, was generated by the Illinois Department of Agriculture from the 2001 County Transect Survey for Effingham County. Data specific to the Altamont New Reservoir Watershed were not available; however, the Effingham County NRCS office verified that the percentages of each tillage practice were acceptable for application to the Altamont New Reservoir Watershed as shown in Table 5-8 (NRCS 2002a).

**Table 5-8 Tillage Practices in Effingham County (Effingham County Soil & Water Conservation District 2001)**

<b>Tillage Practice</b>	<b>Corn</b>	<b>Soybeans</b>	<b>Small Grains</b>
Conventional Till	91%	48%	89%
Reduced Till	4%	18%	4%
Mulch-Till	2%	8%	0%
No-Till	3%	26%	7%

Crop rotation practices in the Altamont New Reservoir Watershed were obtained from the Effingham County NRCS office (2002a). The typical rotations in the watershed are a two-year rotation of corn and soybeans and a three-year rotation of corn, soybeans, and wheat.

### 5.1.10 Reservoir Characteristics

Reservoir characteristics were obtained from the GIS analysis, the Illinois EPA, and USEPA water quality data. The Illinois EPA reports a surface area of 57 acres, which was used to validate the surface area of 57 acres obtained from GIS analysis.

The water quality dataset described in Section 5.1.5.1 was used to determine the average depth of Altamont New Reservoir. On each date sampled for water quality constituents, the total depth at the site was measured. Table 5-9 lists the average depth calculated for each water quality site in Altamont New Reservoir for each year of available data after 1990.

**Table 5-9 Average Depths (ft) for Altamont New Reservoir (Illinois EPA 2002 and USEPA 2002a)**

Year	RCJ-1	RCJ-2	RCJ-3	Lake Average
1990	28.9	16.8	7.8	17.8
1991	27.0	15.5	6.8	16.4
1992	25.5	13.5	4.2	14.4
1993	29.2	17.9	8.4	18.5
1994	27.9	16.7	7.0	17.2
1995	28.2	16.6	6.9	17.2
1996	27.7	16.7	7.1	17.2
1997	27.5	16.3	6.9	16.9
1998	28.3	16.7	8.1	17.7
2001	28.5	15.8	8.0	17.4

Reservoir characteristics that were unavailable were flows into and out of the reservoir.

### **5.1.11 Septic Systems**

Typically, septic systems near lake waters have greater potential for impacting water quality than systems near streams due to their proximity to the water body of concern. The number of septic systems within the watershed could not be confirmed from available data sources. There were no residences observed near the reservoir during the site visit described in Section 2.2. It is anticipated that failing septic systems are a negligible source of pollutant loads in this watershed.

### **5.1.12 Aerial Photography**

Aerial photographs of the Altamont New Reservoir Watershed were obtained from the Illinois Natural Resources Geospatial Data Clearinghouse. The photographs were used to supplement the USGS quadrangle maps when locating facilities.

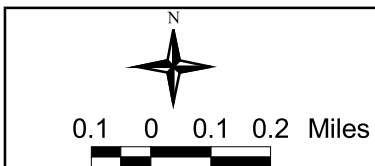
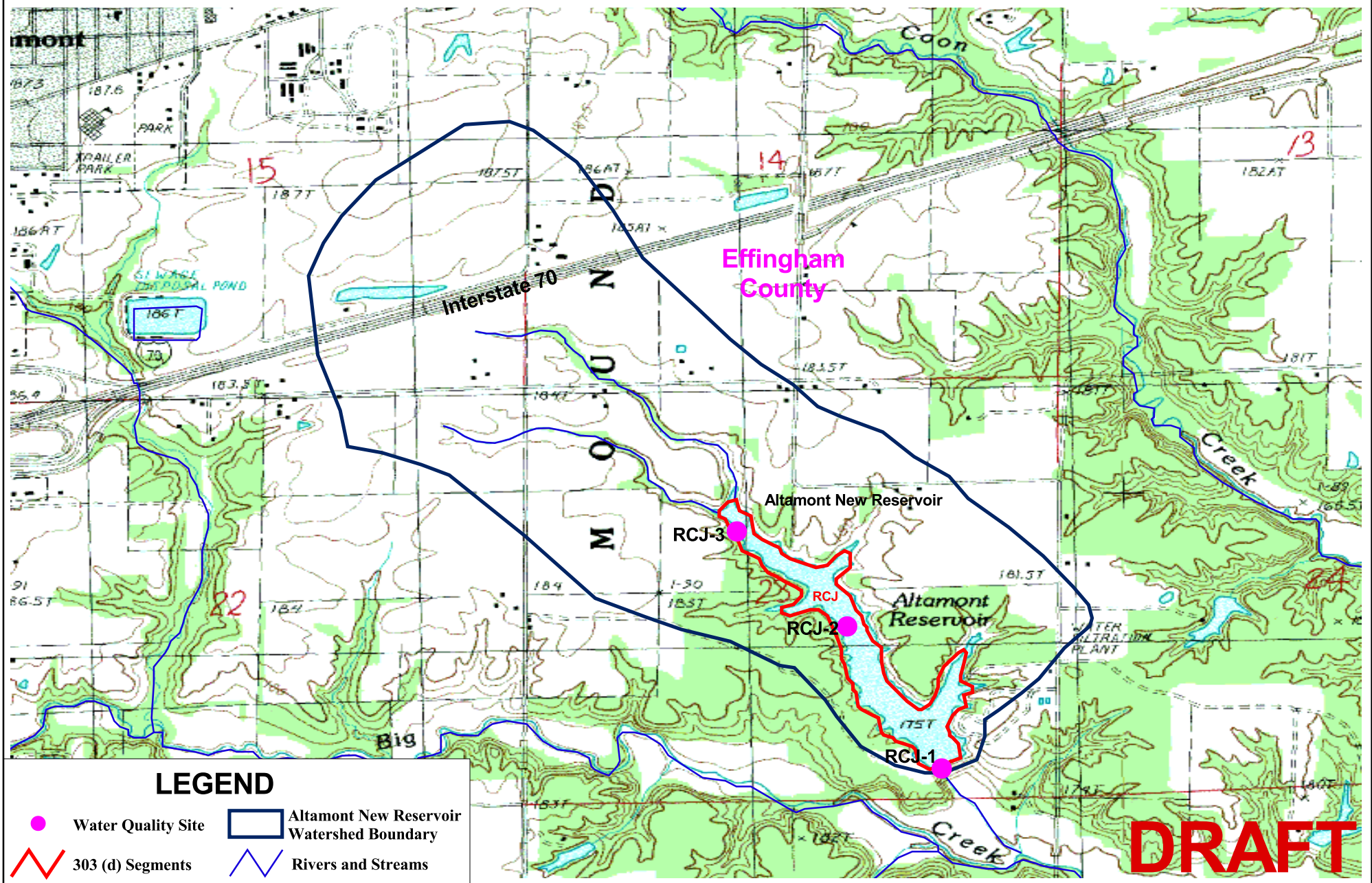
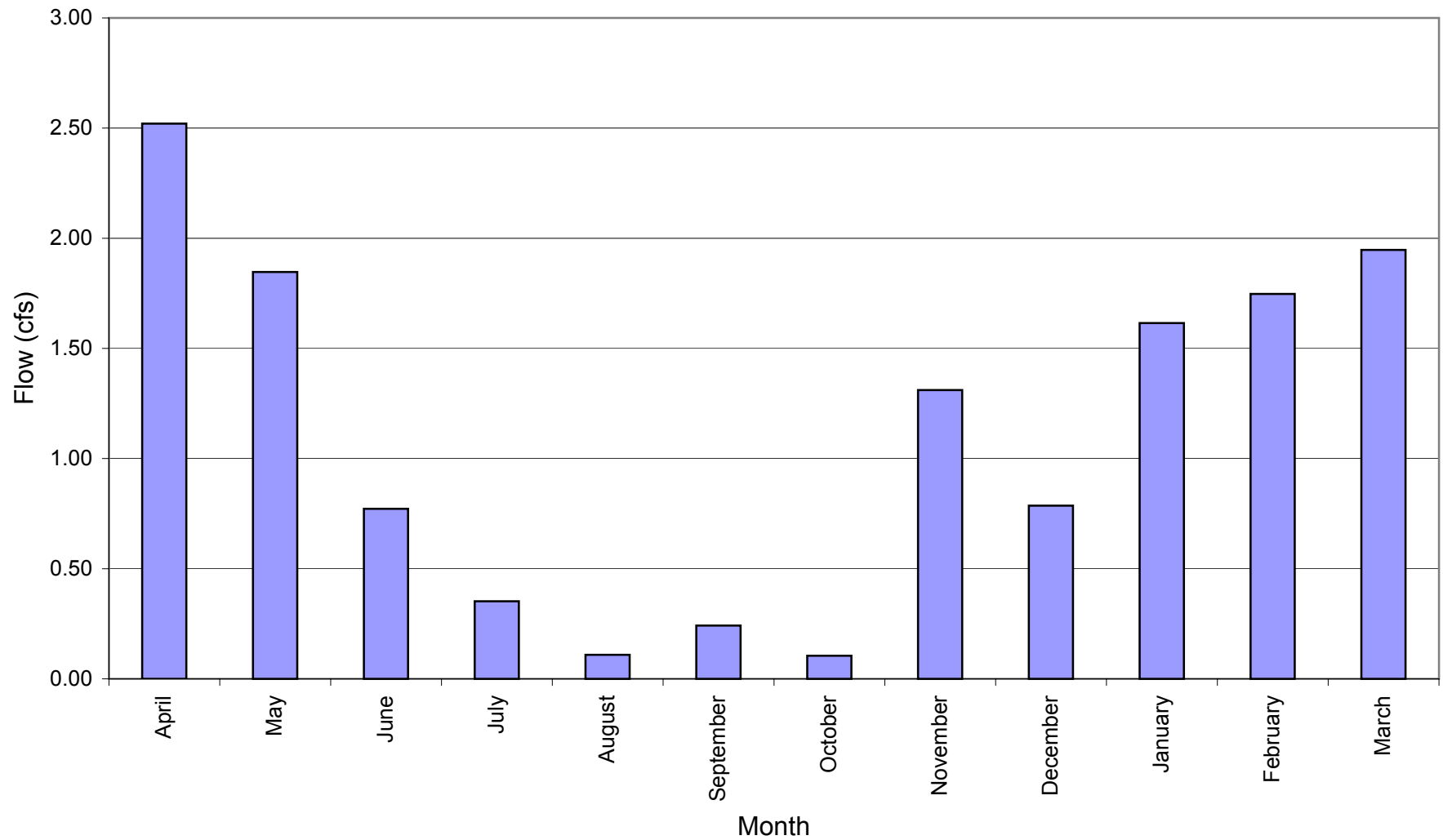


Figure 5-1  
Altamont New Reservoir Watershed and  
Historic Sampling Locations

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Figure 5-2: Estimated Streamflows in the Altamont New Reservoir  
Watershed Calculated from Gage 05595820



Period of Record  
October 1, 1985 to September 30, 2000

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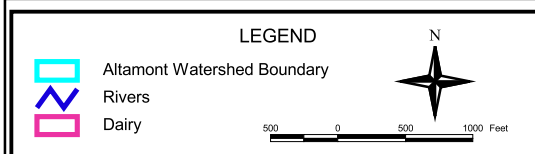


Figure 5-3  
Location of Dairy in  
Altamont New Reservoir Watershed

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# **Section 6**

## **Methodologies and Models to Complete TMDLs for the Altamont New Reservoir Watershed**

### **6.1 Set Endpoints for TMDLs**

TMDLs are used to define the total amount of pollutants that may be discharged into a particular water body within any given day based on a particular use of that water body. Developing TMDLs must, therefore, account for both present and future stream users, habitat, flow variability, and current and future point and nonpoint pollutant loadings that may impact the water body. Defining a TMDL for any particular stream segment must take into account not only the science related to physical, chemical, and biological processes that may impact water body water quality, but must also be responsive to temporal changes in the watershed and likely influences of potential solutions to water quality impairments on entities that reside in the watershed.

Stream and lake water quality standards were presented in Section 4, specifically in Table 4-1. Biological data, such as the Index of Biotic Integrity (IBI) and the Macroinvertebrate Biotic Index (MBI), are used to support 305(b) and 303(d) listing decisions; however, TMDLs were not developed specifically to meet biological endpoints for the Altamont New Reservoir Watershed. The endpoint presented in Section 4, which is a chemical endpoint of the following constituents, was targeted: phosphorus.

### **6.2 Methodologies and Models to Assess TMDL Endpoints**

Methodologies and models were utilized to assess TMDL endpoints for the Altamont New Reservoir Watershed. Model development is more data intensive than using simpler methodologies or mathematical relationships for the basis of TMDL development. In situations where only limited or qualitative data exist to characterize impairments, methodologies were used to develop TMDLs and implementation plans as appropriate.

In addition to methodologies, watershed and receiving water computer models are available for TMDL development. Most models have similar overall capabilities but operate at different time and spatial scales and were developed for varying conditions. The available models range between empirical and physically based. However, all existing watershed and receiving water computer models simplify processes and often include obviously empirical components that omit the general physical laws. They are, in reality, a representation of data.

Each model has its own set of limitations on its use, applicability, and predictive capabilities. For example, watershed models may be designed to project loads within annual, seasonal, monthly, or storm event time scales with spatial scales ranging from

large watersheds to small subbasins to individual parcels such as construction sites. With regard to time, receiving water models can be steady state, quasi-dynamic, or fully dynamic. As the level of temporal and spatial detail increases, the data requirements and level of modeling effort increase.

### **6.2.1 Watershed Models**

Watershed or loading models can be divided into categories based on complexity, operation, time step, and simulation technique. USEPA has grouped existing watershed-scale models for TMDL development into three categories based on the number of processes they incorporate and the level of detail they provide (USEPA 1997):

- Simple models
- Mid-range models
- Detailed models

Simple models primarily implement empirical relationships between physiographic characteristics of the watershed and pollutant runoff. A list of simple category models with an indication of the capabilities of each model is shown in Table 6-1. Simple models may be used to support an assessment of the relative significance of different nonpoint sources, guide decisions for management plans, and focus continuing monitoring efforts. Generally, simple models aggregate watershed physiographic data spatially at a large scale and provide pollutant loading estimates on large time scales. Although they can easily be adopted to estimate storm event loading, their accuracy decreases since they cannot capture the large fluctuations of pollutant concentrations observed over smaller time-scales.

**Table 6-1 Evaluation of Watershed Model Capabilities - Simple Models (USEPA 1997)**

Criteria		USEPA Screening <sup>1</sup>	Simple Method <sup>1</sup>	Regression Method <sup>1</sup>	SLOSS-PHOSPH <sup>2</sup>	Watershed	FHWA	WMM
Land Uses	Urban	○	●	●	—	●	○ <sup>3</sup>	●
	Rural	●	—	○	●	●	○	●
	Point Sources	—	—	—	—	○	—	○
Time Scale	Annual	●	●	●	●	●	●	●
	Single Event	○	○	○	—	—	○	—
	Continuous	—	—	—	—	—	—	—
Hydrology	Runoff	— <sup>4</sup>	●	—	—	—	○	○
	Baseflow	—	—	—	—	—	—	○
Pollutant Loading	Sediment	●	●	●	●	●	—	—
	Nutrients	●	●	●	●	●	●	●
	Others	○	●	●	—	●	●	●
Pollutant Routing	Transport	—	—	—	—	—	—	—
	Transformation	—	—	—	—	—	—	○
Model Output	Statistics	—	—	—	—	●	○	○
	Graphics	—	—	—	—	●	—	○
	Format Options	—	—	—	—	●	—	○
Input Data	Requirements	○	○	○	○	○	○	○
	Calibration	—	—	—	○	●	—	●
	Default Data	●	●	●	●	○	●	●
	User Interface	—	—	—	—	●	○	●
BMPs	Evaluation	○	○	—	○	●	●	●
	Design Criteria	—	—	—	—	—	—	—
Documentation		●	●	●	●	●	●	●

<sup>1</sup> Not a computer program

<sup>2</sup> Coupled with GIS

<sup>3</sup> Highway drainage basins

<sup>4</sup> Extended Versions recommended use of SCS-curve number method for runoff estimation

● High

● Medium

○ Low

— Not Incorporated

Mid-range models attempt a compromise between the empiricism of the simple models and complexity of detailed mechanistic models. Mid-range models are designed to estimate the importance of pollutant contributions from multiple land uses and many individual source areas in a watershed. Therefore, they require less aggregation of the watershed physiographic characteristics than the simple models. Mid-range models may be used to define large areas for pollution migration programs on a watershed basis and make qualitative evaluations of BMP alternatives. A list of models within the mid-range category and their capabilities is shown in Table 6-2.

**Table 6-2 Evaluation of Watershed Model Capabilities - Mid-Range Models (USEPA 1997)**

Criteria		SITEMAP	GWLF	P8-UCM	Auto-QI	AGNPS	SLAMM
Land Uses	Urban	●	●	●	●	—	●
	Rural	●	●	—	—	●	—
	Point Sources	◐	◐	●	—	●	●
Time Scale	Annual	—	—	—	—	—	—
	Single Event	○	—	●	—	●	—
	Continuous	●	●	●	●	—	●
Hydrology	Runoff	●	●	●	●	●	●
	Baseflow	○	●	○	○	—	○
Pollutant Loading	Sediment	—	●	●	●	●	●
	Nutrients	●	●	●	●	●	●
	Others	—	—	●	●	—	●
Pollutant Routing	Transport	○	○	○	◐	●	◐
	Transformation	—	—	—	—	—	—
Model Output	Statistics	◐	○	—	—	—	○
	Graphics	◐	◐	●	—	●	○
	Format Options	●	●	●	○	●	●
Input Data	Requirements	◐	◐	◐	◐	◐	◐
	Calibration	○	○	○	◐	○	◐
	Default Data	●	●	◐	○	◐	◐
	User Interface	●	●	●	◐	◐	●
BMPs	Evaluation	○	○	●	◐	◐	◐
	Design Criteria	—	—	●	◐	◐	○
Documentation		●	●	●	◐	●	◐

● High      ◐ Medium      ○ Low      — Not Incorporated

Detailed models use storm event or continuous simulation to predict flow and pollutant concentrations for a range of flow conditions. These models explicitly simulate the physical processes of infiltration, runoff, pollutant accumulation, instream effects, and groundwater/surface water interaction. These models are complex and were not designed with emphasis on their potential use by the typical state or local planner. Many of these models were developed for research into the fundamental land surface and instream processes that influence runoff and pollutant generation rather than to communicate information to decision makers faced with planning watershed management (USEPA 1997). Although detailed or complex models provide a comparatively high degree of realism in form and function, complexity does not come without a price of data requirements for model construction, calibration, verification, and operation. If the necessary data are not available, and many inputs must be based upon professional judgment or taken from literature, the resulting uncertainty in predicted values undermine the potential benefits from greater realism. Based on the available data for the Altamont New Reservoir Watershed, a detailed model could not



be constructed, calibrated, and verified with certainty and the watershed model selection should focus on the simple or mid-range models.

### 6.2.1.1 Watershed Model Recommendation

The watershed model recommendation for Altamont New Reservoir is the Generalized Watershed Loading Function (GWLF) model. The GWLF model was chosen for the Altamont New Reservoir TMDL based on the following criteria:

- Ease of use and Illinois EPA familiarity
- Compatible with pollutants of concern and existing data
- Provide adequate level of detail for decisionmaking

The GWLF manual estimates dissolved and total monthly phosphorus loads in streamflow from complex watersheds. Both surface runoff and groundwater sources are included, as well as nutrient loads from point sources and onsite wastewater disposal (septic) systems. In addition, the model provides monthly streamflow, soil erosion, and sediment yield values (Haith et al. 1996).

### 6.2.2 Receiving Water Quality Models

Receiving water quality models differ in many ways, but some important dimensions of discrimination include conceptual basis, input conditions, process characteristics, and output. Table 6-3 presents extremes of simplicity and complexity for each condition as a point of reference. Most receiving water quality models have some mix of simple and complex characteristics that reflect tradeoffs made in optimizing performance for a particular task.

**Table 6-3 General Receiving Water Quality Model Characteristics**

Model Characteristic	Simple Models	Complex Models
Conceptual Basis	Empirical	Mechanistic
Input Conditions	Steady State	Dynamic
Process	Conservative	Nonconservative
Output Conditions	Deterministic	Stochastic

The concept behind a receiving water quality model may reflect an effort to represent major processes individually and realistically in a formal mathematical manner (mechanistic), or it may simply be a "black-box" system (empirical) wherein the output is determined by a single equation, perhaps incorporating several input variables, but without attempting to portray constituent processes mechanistically.

In any natural system, important inputs such as flow in the river change over time. Most receiving water quality models assume that the change occurs sufficiently slowly so that the parameter (for example, flow) can be treated as a constant (steady state). A dynamic receiving water quality model, which can handle unsteady flow conditions, provides a more realistic representation of hydraulics, especially those conditions associated with short duration storm flows, than a steady state model. However, the

price of greater realism is an increase in model complexity that may be neither justified nor supportable.

The manner in which input data are processed varies greatly according to the purpose of the receiving water quality model. The simplest conditions involve conservative substances where the model need only calculate a new flow-weighted concentration when a new flow is added (conservation of mass). Such an approach is unsatisfactory for constituents such as dissolved oxygen (DO) or labile nutrients, such as nitrogen and phosphorus, which will change in concentration due to biological processes occurring in the stream.

Whereas the watershed nonpoint model's focus is the generation of flows and pollutant loads from the watershed, the receiving water models simulate the fate and transport of the pollutant in the water body. Table 6-4 presents the steady state (constant flow and loads) models applicable for this watershed. The steady state models are less complex than the dynamic models. Also, as discussed above, the dynamic models require significantly more data to develop and calibrate an accurate simulation of a water body.

**Table 6-4 Descriptive List of Model Components - Steady State Water Quality Models**

Model	Water Body Type	Parameters Simulated	Process Simulated	
			Physical	Chemical/Biological
USEPA Screening Methods	River, lake/reservoir, estuary, coastal	Water body nitrogen, phosphorus, chlorophyll "a," or chemical concentrations	Dilution, advection, dispersion	First order decay - empirical relationships between nutrient loading and eutrophication indices
EUTROMOD	Lake/reservoir	DO, nitrogen, phosphorus, chlorophyll "a"	Dilution	Empirical relationships between nutrient loading and eutrophication indices
BATHTUB	Lake/reservoir	DO, nitrogen, phosphorus, chlorophyll "a"	Dilution	Empirical relationships between nutrient loading and eutrophication indices
QUAL2E	Rivers (well mixed/shallow lakes or estuaries)	DO, CBOD, arbitrary, nonconservative substances, three conservative substances	Dilution, advection, dispersion	First order decay, DO-BOD cycle, nutrient-algal cycle
EXAMSII	Rivers	Conservative and nonconservative substances	Dilution, advection, dispersion	First order decay, process kinetics, daughter products, exposure assessment
SYMPTOX3	River/reservoir	Conservative and nonconservative substances	Dilution, advection, dispersion	First order decay, sediment exchange
STREAMDO	Rivers	DO, CBOD, and ammonium	Dilution	First order decay, BOD-DO cycle, limited algal component

### 6.2.2.1 Receiving Water Model Recommendation

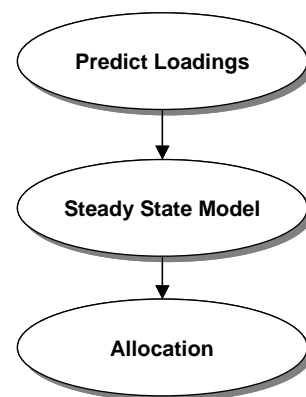
The receiving water model recommended for Altamont New Reservoir is BATHTUB, which applies a series of empirical eutrophication models to reservoirs and lakes. The program performs steady state water and nutrient balance calculations in a spatially segmented hydraulic network that accounts for advective and diffusive transport, and nutrient sedimentation. Eutrophication-related water quality conditions are predicted using empirical relationships (USEPA 1997).

### 6.2.3 Altamont New Reservoir TMDL

For Altamont New Reservoir, a TMDL for the following constituent was completed using a watershed/receiving water model combination:

#### ■ Phosphorus

The strategy for completing the watershed/receiving water model TMDL for Altamont New Reservoir is shown in Schematic 1 to the right. This strategy applies to constituents whose loads can be predicted using GWLF. This approach allows a linkage between source and endpoint resulting in an allocation to meet water quality standards. A linkage was also made between phosphorus and DO. After phosphorus loads are predicted, the BATHTUB model was used to determine the resulting phosphorus concentrations within Altamont New Reservoir. Model development is discussed further in Section 7.



Schematic 1

### 6.2.4 Calibration and Validation of Models

The results of loading and receiving water simulations are more meaningful when they are accompanied by some sort of confirmatory analysis. The capability of any model to accurately depict water quality conditions is directly related to the accuracy of input data and the level of expertise required to operate the model. It is also largely dependent on the amount of data available. Calibration involves minimization of deviation between measured field conditions and model output by adjusting parameters of the model. Data required for this step are a set of known input values along with corresponding field observation results. Validation involves the use of a second set of independent information to check the model calibration. The data used for validation should consist of field measurements of the same type as the data output from the model. Specific features such as mean values, variability, extreme values, or all predicted values may be of interest to the modeler and require testing. Models are tested based on the levels of their predictions, whether descriptive or predictive. More accuracy is required of a model designed for absolute versus relative predictions. If the model is calibrated properly, the model predictions will be acceptably close to the field predictions.

The GWLF and BATHTUB models were calibrated based on existing data. As is outlined in Section 7, the GWLF model was calibrated based on historical flow records. The calibration factors taken into account for the GWLF model were the recession constant and seepage constant. Water quality data on the tributaries to Altamont New Reservoir were not available so the GWLF model could not be calibrated to tributary nutrient loads. Nutrient loads were based on literature values for Southern Illinois. GWLF model validation was not conducted as the hydrology was calibrated based on 16 years of observed flow. Data collection activities needed to calibrate nutrient loads are outlined in Section 9 Implementation Plan. The calibration process for the BATHTUB model is also outlined in Section 7. For Altamont New Reservoir, loads from a wet, normal, and dry precipitation year were taken from GWLF and entered into the BATHTUB model, which predicted average in-lake concentrations that were in turn compared to observed lake concentrations as the basis for calibration.

### **6.2.5 Seasonal Variation**

Consideration of seasonal variation, such that water quality standards for the allocated pollutant will be met during all seasons of the year, is a requirement of a TMDL submittal. TMDLs must maintain or attain water quality standards throughout the year and consider variations in the water body's assimilative capacity caused by seasonal changes in temperature and flow (USEPA 1999). Seasonal variation is discussed in Section 9.

### **6.2.6 Allocation**

Establishing a TMDL requires the determination of the LC of each stream segment. The models or methodologies were used to establish what the LC is for each segment for each pollutant. The next step was to determine the appropriate MOS for each segment. After setting the MOS, WLA of point sources and LA from the nonpoint sources were set.

The MOS can be set explicitly as a portion of the LC or implicitly through applying conservative assumptions in data analysis and modeling approaches. Data analyses and modeling limitations were taken into account when recommending a MOS. The allocation scheme (both LA and WLA) demonstrates that water quality standards will be attained and maintained and that the load reductions are technically achievable. The allocation is the foundation for the implementation and monitoring plan. Further discussion on the allocation is presented in Section 9.

### **6.2.7 Implementation and Monitoring**

For the Altamont New Reservoir Watershed, a plan of implementation was produced to support the developed TMDL analyses. The plan of implementation has reasonable assurance of being achieved. The plan provides the framework for the identification of the actions that must be taken on point and nonpoint sources to achieve the desired TMDLs. The accomplishment of the necessary actions to reach these targets may involve substantial efforts and expenditures by a large number of parties within the

watershed. Depending upon the specific issues and their complexity in the Altamont New Reservoir Watershed, the time frame for achieving water quality standards has been developed.

The implementation plan delineates a recommended list of the sources of stressors that are contributing to the water quality impairments. The amount of the reduction needed from various sources to achieve the water quality limiting parameter was then delineated. For nonpoint sources, the use of BMPs is one way to proceed to get the desired reduction in loading. The effectiveness of various BMPs was factored into the modeling and methodologies to develop the range of options of BMPs to use. Associated with those BMPs is cost information, as available. Reductions from point sources through waste stream management, pretreatment controls, and other structural and nonstructural programs were also identified as applicable. The implementation plan for the Altamont New Reservoir Watershed is presented in Section 9.

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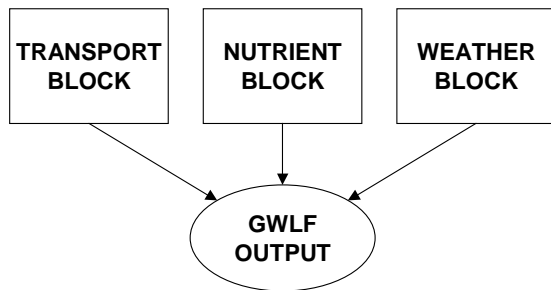
# Section 7

## Model Development for Altamont New Reservoir

### 7.1 Model Overview

The models used for the TMDL analysis of Altamont New Reservoir were GWLF and BATHTUB. These models require input from several sources including online databases, GIS-compatible data, and hard-copy data from various agencies. This section describes the existing data reviewed for model development, model inputs, and model calibration and verification.

Schematic 1 shows how the GWLF model and BATHTUB model is utilized in calculating the TMDL. The GWLF model predicts phosphorus loads from the watershed. These loads are then inputted in the BATHTUB model to assess resulting phosphorus concentrations. The GWLF model outlined in



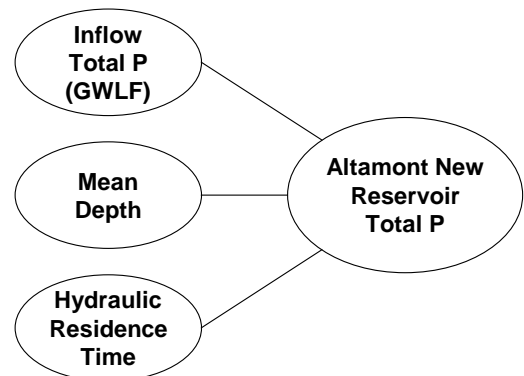
*Schematic 2  
GWLF Model.*

Schematic 2 shows how GWLF predicts phosphorus loads from the watershed. The transport block of the GWLF model uses the Universal Soil Loss Equation to determine erosion in the watershed.

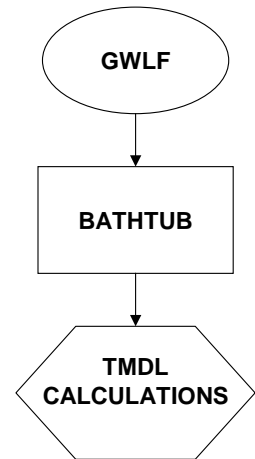
The transport block also calculates runoff based on the SCS Curve Number equation. The nutrient block allows the model user to input concentrations of phosphorus contained in the soil

and in the dissolved phase for runoff. These two blocks in conjunction with the weather block predict both solid and dissolved phosphorus loads.

Schematic 3 shows how, by using total phosphorus concentrations predicted from GWLF, the resulting in-lake total phosphorus concentrations can be predicted. The BATHTUB model uses empirical relationships between mean reservoir depth, total phosphorus inputted into the lake, and the hydraulic residence time to determine in-reservoir concentrations.



*Schematic 3  
BATHTUB Model Schematic.*



*Schematic 1  
Models used for  
Altamont New  
Reservoir TMDL  
calculation.*

## **7.2 Model Development and Inputs**

The ability of the GWLF and BATHTUB models to accurately reflect natural processes depends on the quality of the input data. The following sections describe the selection, organization, and use of existing data as input to the GWLF and BATHTUB models and outline assumptions made in the process.

### **7.2.1 Watershed Delineation**

Prior to developing input parameters for the GWLF or BATHTUB models, a watershed for Altamont New Reservoir was delineated with GIS analyses through use of the DEM as discussed in Section 5.1.2. The delineation indicates that Altamont New Reservoir captures flows from a watershed of approximately one square mile. The flow through the lake is primarily from northwest to southeast. Figure 7-1 at the end of this section shows the location of each water quality station in Altamont New Reservoir, the boundary of the GIS-delineated watershed contributing to Altamont New Reservoir used in GWLF modeling, and the outline of the lake for BATHTUB modeling purposes.

### **7.2.2 GWLF Inputs**

GWLF requires input in the form of three data files that represent watershed parameters, nutrient contributions, and weather records. Each data file will be discussed in the following sections. The input files and actual values used for each parameter are listed in Appendix B. The GWLF manual is contained in Appendix C.

DEMs of 30-meter resolution were downloaded from the USGS National Elevation Dataset for development of GWLF model parameters discussed in this section (USGS 2002b).

#### **7.2.2.1 Transport Data File**

The transport data file provides watershed parameters including land use characteristics, evapotranspiration and erosion coefficients, groundwater and streamflow characteristics, and initial soil conditions. Table 7-1 presents each transport file input parameter and its source. Those requiring further explanation are discussed in the next section.



**Table 7-1 Data Needs for GWLF Transport File (Haith et al. 1996)**

Input Parameter	Source
Land Use	Critical Trends Assessment Database, GIS
Land Use Area	GIS
Curve Number	STATSGO, GIS, Critical Trends Assessment Database, TR-55 Manual, WMM Manual
KLSCP	STATSGO, GIS, DEM, GWLF Manual pages 34 and 35, NRCS
Evapotranspiration Cover Coefficient	GWLF Manual page 29
Daylight Hours	GWLF Manual page 30
Growing Season	GWLF Manual Recommendation page 54
Erosivity Coefficient	GWLF Manual pages 32 and 37
Sediment Delivery Ratio	GIS, GWLF Manual page 33
5-day Antecedent Rain and Snow	GWLF Manual Recommendation page 37
Initial Unsaturated Storage	GWLF Manual Recommendation page 30
Initial Saturated Storage	GWLF Manual Recommendation page 37
Recession Constant	Calibrated
Seepage Constant	Calibrated
Initial Snow	GWLF Manual Recommendation page 37
Unsaturated Available Water Capacity	GWLF Manual Recommendation page 37

#### **7.2.2.1.1 Land Use**

Land use for the Altamont New Reservoir Watershed was extracted from the Critical Trends Assessment Database grid for Effingham County in GIS. Within the transport input file, each land use must be identified as urban or rural. The land uses were presented in Table 5-6.

Individually identifying each field of crops or urban community in GWLF would be time intensive, so each land use class was aggregated into one record for GIS and GWLF representation. For example, the area of each row crop field was summed to provide a single area for row crops. Additionally, the parameters for each row crop field were averaged to provide a single parameter for the row crop land use. Details of the parameter calculation are contained in the remainder of this section. GWLF computes runoff, erosion, and pollutant loads from each land use, but it does not route flow over the watershed. For example, the model does not recognize that runoff may flow from a field of corn over grassland and then into the river. The model assumes all runoff from the field of corn drains directly to the stream. Therefore, the location of each land use is irrelevant to the model allowing each land use class to be aggregated into a single record.

The GWLF model requires nutrient runoff concentrations for each land use. The rural grassland category provided in Table 5-6 represents multiple land uses such as the Conservation Reserve Program (CRP), grassland, waterways, pasture land, and buffer strips, which may have varying runoff concentrations. To provide accurate modeling in GWLF, the Effingham County NRCS office was contacted to provide more information about the rural grassland land use class. The Effingham County NRCS recommended the category be considered idle grassland as it primarily represents areas around the lake that are owned by the city of Altamont and allowed to remain idle (2002a).

Due to the detailing of crops, the Cropland Data Layer land use classes, presented in Table 5-8 were used to generate evapotranspiration cover coefficients, cropping management factors, and to verify the land use obtained from the Critical Trends Assessment. Land uses used in GWLF correspond to land uses in the Critical Trends Assessment, so calculations based on the Cropland Data Layer land use classes were typically weighted by area to match the Critical Trends Assessment classes. Details of the calculations are presented in later sections and Appendix D.

#### **7.2.2.1.2 Land Use Area**

GIS was used to summarize the area of each aggregated land use in square meters as well as acres and hectares. Area in hectares was input for each land use in the transport data file.

#### **7.2.2.1.3 Curve Number**

The curve number, a value between zero and 100, represents the ability of the land surface to infiltrate water, which decreases with increasing curve number. The curve number is assigned with consideration to hydrologic soil group and land use. The hydrologic soil group, represented by the letters A through D, denotes how well a soil drains. A well-drained, sandy soil would be classified as a type A soil, whereas clay would be classified as a type D soil. This property is identified in the *STATSGO* attribute table for each soil type.

Assigning curve numbers to a large area with multiple soil types and land uses was streamlined using the GIS *ArcView* project, CRWR-PrePro (Olivera 1998), developed at the University of Texas at Austin. This process was used to develop a curve number grid. Scripts in the project intersect shapefiles of land use and soil with the *STATSGO* attribute table to create a grid in which each cell contains a curve number based on the combination.

The transport data file requires that a single curve number be associated with each land use. To accomplish this, the curve number in each grid cell was averaged over each aggregated land use area. Details of the GIS process are provided in Appendix D.

#### **7.2.2.1.4 KLSCP**

GWLF uses the Universal Soil Loss Equation, represented by the following equation (Novotny and Olem 1994), to calculate soil erosion.

$$A = (R)(K)(LS)(C)(P)$$

where

A	=	calculated soil loss in tons/ha for a given storm or period
R	=	rainfall energy factor
K	=	soil erodibility factor
LS	=	slope-length factor
C	=	cropping management factor
P	=	supporting practice factor

The combined coefficient, KLSCP, is required as input to GWLF for each rural land use. The development of each factor will be discussed in the next sections. GWLF calculates the rainfall energy factor (R) with precipitation and a rainfall erosivity coefficient that will be discussed in Section 7.2.2.1.5.

**Soil Erodibility Factor (K).** The soil erodibility factor, K, represents potential soil erodibility. The *STATSGO* soils representation in GIS is by map unit, which incorporates multiple soil types (and K-values) in each unit, but the *STATSGO* attribute table lists the K factor for each soil type. Using this column, a weighted K factor was developed for each GIS map unit. Details of this process are provided in Appendix D.

**Topographic Factor (LS).** The topographic, or LS, factor represents the contribution to erosion from varying topography. This factor is independent of soil type, but dependent on land use and land surface elevations, requiring use of the DEM. Multiple equations and methodologies are used to calculate the LS factor and for this application we used methodology outlined in the *TMDL USLE* software package (USEPA 2001). The LS factor was calculated with a series of equations that compute intermediate values of slope steepness, runoff length, and rill to interill erosion before combining them into the LS factor. This process was also performed with GIS analyses to automate computational tasks. Details of the GIS computation are provided in Appendix D.

**Cropping Management Factor (C).** The cropping management factor, C, represents the influence of ground cover, soil condition, and management practices on erosion. The Effingham County NRCS office provided a table of C factors for various crops and tillage practices (NRCS 2002a). The table is included as Appendix E. Although the percentage of each tillage practice for corn, soybeans, and small grains in Effingham County is known, the specific locations in the watershed to which these practices are applied were unknown, so a weighted C-factor was created for these crops. In Table 7-2, the weighted C factor for corn, soybeans, and small grains and the C factor for other land uses are listed by the Cropland Data Layer land uses and areas in the Altamont New Reservoir Watershed.

**Table 7-2 Cropland Data Layer Land Uses and C Factors**

Land Use	Area (acres)	C factor
Corn	140	0.32
Soybeans	98	0.20
Winter Wheat	22	0.11
Other Small Grains & Hay	16	0.11
Double-Cropped WW/SB	47	0.09
Idle Cropland/CRP	0	0.004
Fallow/Idle Cropland	35	0.004
Pasture/Grassland/ Nonagricultural	153	0.004
Woods	122	0.003
Urban	10	–
Water	24	–
Buildings/Homes/Subdivisions	7	–
Wetlands	1	–

The identification of crops is more detailed in the Cropland Data Layer file than the Critical Trends Land Assessment file, but the latter is used for GWLF input. Therefore, the C factor associated with the Cropland Data Layer land uses was weighted by area to create a C factor for the Critical Trends Land Assessment land uses shown in Table 7-3. A more detailed description of the weighting procedure is provided in Appendix D.

**Table 7-3 Critical Trends Land Assessment Land Uses and C Factors**

Land Use	Area (acres)	C factor
Row Crop	219	0.25
Small Grains	81	0.10
Rural Grassland	227	0.004
Deciduous Forest	101	0.003

**Supporting Practice Factor (P).** The supporting practice factor, P, represents erosion control provided by various land practices such as contouring or terracing. None of these land practices are utilized in the Altamont New Reservoir Watershed, so a P factor of one was assigned to each land use.

#### **7.2.2.1.5 Erosivity Coefficient**

The erosivity coefficient varies spatially across the United States. Figure B-1 on page 32 of the GWLF manual places Altamont New Reservoir in Zone 19, which corresponds to a cool season rainfall erosivity coefficient of 0.14 and a warm season coefficient of 0.27.

#### **7.2.2.1.6 Evapotranspiration (ET) Cover Coefficient**

An ET cover coefficient for each month is required as an input parameter to GWLF representing the effects of ground cover on evapotranspiration. Ground cover changes with land use and growing season, so the computation of a single cover coefficient for each month required a series of calculations. ET cover coefficients for corn, winter wheat, sorghum, and soybeans at 10 percent increments of the growing season were obtained from GWLF Manual, page 29. These coefficients were weighted by the area of each crop in the Cropland Data Layer land use file to compute a single crop ET cover coefficient for each 10 percent increment of the growing season. The crop coefficients for each portion of the growing season were averaged to obtain a single crop coefficient for each calendar month. Monthly ET cover coefficients for pasture, woods, and urban areas were also obtained from pages 29 and 30 of the GWLF Manual. A monthly cover coefficient for water and wetlands was assumed to be 0.75. Weighting the coefficient for each land use by the Cropland Data Layer land use area created a single ET cover coefficient for each month. Details of the ET cover coefficient calculation are provided in Appendix D.

#### **7.2.2.1.7 Recession Constant**

The recession coefficient controls the falling limb of the hydrograph in GWLF. This coefficient was calibrated to USGS streamflow and is discussed in Section 7.3.1.

#### **7.2.2.1.8 Seepage Constant**

The seepage constant controls the amount of water lost from the GWLF system by deep seepage. This value was also determined by calibration and is detailed in Section 7.3.1.

#### **7.2.2.1.9 Sediment Delivery Ratio**

The sediment delivery ratio is based on watershed area. The watershed area determined by GIS was used to obtain the corresponding sediment delivery ratio from the chart on page 33 of the GWLF manual. The sediment delivery ratio for Altamont New Reservoir is 0.33 representing the annual sediment yield per annual erosion.

#### **7.2.2.2 Nutrient Data File**

The nutrient input file contains information about dissolved phosphorus and nitrogen from each rural land use, solid-phase phosphorus and nitrogen from urban runoff, solid-phase nutrient concentrations in the soil and groundwater, and any point source inputs of phosphorus or nitrogen.

All solid-phase nutrient concentrations from runoff for Altamont New Reservoir were obtained from the GWLF manual. Figure B-4 (page 39 of Appendix C) was utilized for determining solid-phase phosphorus concentrations in the soil. A mid-range value of 0.07-percent phosphate was selected and then converted to 700 parts per million (ppm) using the relationship  $0.1 \text{ percent} = 1,000 \text{ ppm}$ . Phosphate is composed of 44-percent phosphorus, so the 700-ppm phosphate was multiplied by 0.44 to obtain a value of 308-ppm phosphorus in the sediment. This solid-phase phosphorus concentration was multiplied by the recommended enrichment ratio of 2.0 and therefore a total solid-phase concentration of 616 ppm was utilized for modeling purposes. The enrichment ratio represents the ratio of phosphorus in the eroded soil to that in the non-eroded soil. Specific soil phosphorus data is not available, so the GWLF manual recommended enrichment ratio of 2.0 was used. Dissolved phosphorus concentrations in the runoff from each agricultural land use were obtained from page 41 of the GWLF manual with the exception of the rural grassland land use and concentrations from the dairy. The rural grassland dissolved phosphorus concentration was estimated from the dissolved phosphorus concentration for pasture. The idle grassland is assumed to have less animals, and therefore animal waste, than pasture land, so the concentration was reduced for the rural grassland land use class. The selection of dissolved phosphorus concentrations will be confirmed in Section 7.3.1. The concentration from the dairy was obtained from USEPA, which provides a range of 5 to 500 mg/L for dairy barnyards (2000). The concentration used to model the dairy was 123.75 mg/L, which was determined through calibration analyses discussed in Section 7.3.2.

**Table 7-4 Dissolved Phosphorus Concentrations in Runoff from the Altamont New Reservoir Watershed**

Land Use	Dissolved Phosphorus (mg/L)
Row Crop	0.26
Small Grains	0.3
Rural Grasslands	0.15
Deciduous Forest	0.009
Dairy Farm	123.75

Table 7-4 lists the land uses in the Altamont New Reservoir Watershed and associated runoff phosphorus concentrations used in the GWLF model. It should be noted that although the majority of dissolved phosphorus concentrations in Table 7-4 exceed the endpoint of

0.05 mg/L of total phosphorus, once the surface runoff reaches Altamont New Reservoir or its tributaries, it mixes with water already in the stream or lake and the concentration decreases. Therefore, it cannot be concluded without analysis that constituents with dissolved concentrations above the endpoint for total phosphorus are responsible for water quality impairments.

The GWLF manual suggests nutrient concentrations in groundwater based on the percentage of agricultural versus forestlands. These percentages were calculated from the land use areas in the watershed, and the appropriate groundwater concentrations were selected from the GWLF manual, page 41. The Altamont New Reservoir watershed is 48-percent agricultural lands, which corresponds to a phosphorus concentration of 0.067 mg/L in the groundwater.

### 7.2.2.3 Weather Data File

The weather data file is a text file of daily precipitation and temperature and was compiled from weather data presented in Section 5.1.4. An excerpt of the weather data file is recorded in Appendix B. The precipitation data are used in GWLF to determine runoff, erosion, and evapotranspiration, and temperature data are used to compute potential evaporation and snowmelt.

### 7.2.3 BATHTUB Inputs

BATHTUB has three primary input interfaces: global, reservoir segment(s), and watershed inputs. The individual inputs for each of these interfaces are described in the following sections and the data input screens are provided in Appendix B.

**Table 7-5 Annual Precipitation in Effingham County**

Year	Precipitation (inches)
1986	38
1987	34
1988	36
1989	46
1990	44
1991	47
1992	38
1993	59
1994	46
1995	40
1996	41
1997	37
1998	48
1999	43
2000	54
2001	36
<b>Annual Average</b>	<b>42</b>

Multiple simulations of the BATHTUB model were run to investigate variations in total phosphorus concentrations in a wet, normal, and dry year of precipitation to bracket conditions for calibration. The first step in choosing the wet, normal, and dry years was to calculate average annual precipitation. BATHTUB models lake concentrations based on a water year (October to September), so the precipitation data presented in Section 5.1.4 were averaged to coincide with the water year. Table 7-5 shows these annual and average annual precipitation values in Effingham County. Each water year was then classified as wet, dry, or normal based on a comparison to the average water year precipitation of 42 inches. Another consideration in selecting the years for simulation was determining which years coincided with the collection dates of in-lake total phosphorus concentrations at the water quality

stations within recent years. With these criteria, the wet, normal, and dry years were chosen as 1993, 1998, and 2001, respectively, for Altamont New Reservoir based Table 7-5.

### 7.2.3.1 Global Inputs

Global inputs represent atmospheric contributions of precipitation, evaporation, and atmospheric phosphorus. Precipitation was discussed in the previous section and is shown in Table 7-5 for the model years 1993, 1998, and 2001. An average annual evaporation was determined from pan evaporation data as discussed in Section 5.1.4. The default atmospheric phosphorus deposition rate suggested in the BATHTUB model was used in absence of site-specific data, which is a value of 30 kg/km<sup>2</sup>-yr (USACE 1999b).

### 7.2.3.2 Reservoir Segment Inputs

The data included as segment inputs represents reservoir characteristics in BATHTUB. These data were used in BATHTUB simulations and for calibration targets. The calibration targets are observed water quality data summarized in Section 5.1.5.1.

Altamont New Reservoir was modeled as a single segment in BATHTUB because it is a small reservoir. To represent the average reservoir characteristics, an average annual value of total phosphorus was calculated for the entire reservoir for input of observed data. The averages of total phosphorus sampled at one-foot depth were presented in Table 5-5; however, the BATHTUB model calculates an average lake concentration. Therefore, total phosphorus samples at all depths were averaged to provide targets for the BATHTUB model. Table 7-6 shows the average annual total phosphorus concentrations for all sample depths at each station in the Altamont New Reservoir. As mentioned in Section 5.1.5.1.1, station RCJ-1 had samples taken at one-foot depth from the surface and at the lake bottom whereas stations RJC-2 and RJC-3 were only

sampled at one-foot depth. The raw data for all sample depths are contained in Appendix A.

**Table 7-6 Average Total Phosphorus Concentrations in Altamont New Reservoir (mg/L) over All Depths**

Year	RCJ-1	RCJ-2	RCJ-3	Lake Average
1993	0.12		0.13	0.12
1998	0.14	0.15	0.18	0.15
2001	0.14	0.11	0.11	0.12

Other segment inputs include lake depth, lake length, and depth to the metalimnion. The lake depth was represented by the averaged data from the water quality stations shown in Table 5-9. The lake length was determined in GIS, and the depth to the metalimnion was estimated from a chart of temperature versus depth. The charts are presented in Appendix F.

### 7.2.3.3 Tributary Inputs

Tributary inputs to BATHTUB are drainage area, flow, and total phosphorus (dissolved and solid-phase) loading. The drainage area of each tributary is equivalent to the basin or subbasin it represents, which was determined with GIS analyses. For the Altamont New Reservoir Watershed, the single basin modeled in GWLF represents the tributary input. Loadings were calculated with the monthly flow and total phosphorus concentrations obtained from GWLF output. The monthly values were summed over the water year for input to BATHTUB. To obtain flow in units of volume per time, the depth of flow was multiplied by the drainage area and divided by one year. To obtain phosphorus concentrations, the nutrient mass was divided by the volume of flow.

## 7.3 Model Calibration and Verification

The GWLF model was calibrated prior to BATHTUB calibration. The GWLF model for the Altamont New Reservoir Watershed was calibrated to flow data, as tributary phosphorus concentrations were not available. Nutrient concentrations entered into the GWLF model were calibrated based on response occurring in the BATHTUB model. Therefore, the nutrient block of the GWLF model and the BATHTUB model were calibrated together to reach agreement with observed data in Altamont New Reservoir.

### 7.3.1 GWLF Calibration

The GWLF model must run from April to March to coincide with the soil erosion cycle. GWLF does not retain erodible sediment between model years, so the model year must begin after the previous year's sediment has been washed off. The model assumes that the soil erosion cycle begins with spring runoff events in April and that erodible soil for the year has been washed off by the end of winter for the cycle to begin again the following April. GWLF generates monthly outputs including precipitation, flow, runoff and nutrient mass per watershed, and annual outputs including precipitation, flow, runoff, and nutrient mass per land use. These outputs are part of the input for the BATHTUB model.



In-stream nutrient data was not available for model calibration, so GWLF was only calibrated to flow. The monthly average flow output from GWLF was compared to the monthly average streamflow calculated from USGS gage 05595820 with the drainage area ratio method presented in Section 5.1.3. The model flow was calibrated visually through the recession constant and seepage constant. Visual calibration is a subjective approach to model calibration in which the modeler varies inputs to determine the parameter combination that looks like the best fit to the observed data (Chapra 1997). According to the GWLF manual, an acceptable range for the recession constant is 0.01 to 0.2. No range suggestions are provided for the seepage constant. Figure 7-2 (at the end of this section) shows the comparison between the two flows for Altamont New Reservoir. The GWLF model for Altamont New Reservoir was visually calibrated with a resulting recession constant of 0.1 and a seepage constant of 0.05. Once calibrated, the model output data could properly be included as BATHTUB inputs. The GWLF model was not validated as flow was calibrated by visually comparing 17 years of observed flow.

Although in-stream nutrient concentrations are not available for the tributaries to Altamont New Reservoir, Clean Lakes Studies have been conducted by Illinois EPA on various Illinois lake watersheds, which do provide in-stream nutrient data for lake tributaries including dissolved and total phosphorus. The dissolved and total phosphorus concentrations predicted by GWLF for tributaries to the Altamont New Reservoir were compared to the measured dissolved and total phosphorus concentrations from tributaries to lakes observed in the Clean Lakes studies as shown in Figure 7-3. The concentrations within the Altamont New Reservoir Watershed are within the ranges of those in the other lake watersheds shown in Figure 7-3.

Table 7-7 shows the comparison between dissolved and total phosphorus in watersheds from Clean Lakes Studies and in the Altamont New Reservoir Watershed.

**Table 7-7 Percentage of Dissolved Phosphorus to Total Phosphorus Concentrations in Clean Lake Study Watersheds and the Altamont New Reservoir Watershed**

<b>Watershed</b>	<b>Site</b>	<b>Mean Dissolved Phosphorus (mg/L)</b>	<b>Mean Total Phosphorus (mg/L)</b>	<b>Dissolved/Total Phosphorus</b>
<b>Nashville City</b>	ROO 02	0.68	0.89	0.76
<b>Paradise</b>	RCG 02	0.06	0.07	0.87
<b>Raccoon</b>	RA 02	0.30	0.46	0.66
	RA 03	0.21	0.29	0.71
	RA 04	0.46	0.63	0.73
	RA 05	0.07	0.22	0.30
<b>Lake Lou Yeager</b>	A	0.06	0.13	0.46
	B	0.15	0.16	0.92
	C	0.05	0.25	0.20
	D	0.13	0.17	0.78
	E	0.06	0.12	0.46
	F	0.17	0.20	0.87
	G	0.33	0.41	0.79
	H	0.33	0.35	0.93
	I	0.13	0.14	0.96
<b>Altamont New Reservoir</b>	1	0.19	0.32	0.61

The ratio of dissolved to total phosphorus in the Altamont New Reservoir Watershed are within the ranges of the Clean Lake Study watersheds.

A study of baseline loadings of total and dissolved phosphorus was conducted on Illinois watersheds. The study developed median concentrations of dissolved and total phosphorus concentrations and the ratio of dissolved to total phosphorus at water quality stations across Illinois over the period from October 1980 through September 1996. Concentrations of dissolved and total phosphorus modeled in the Altamont New Reservoir Watershed are within the range of concentrations provided in the study. The study also provides a spatial representation of mean total phosphorus concentrations across Illinois (Short 1999). The concentrations of total phosphorus modeled in the Altamont New Reservoir Watershed are consistent with those seen in the spatial representation for watersheds.

### 7.3.2 BATHTUB Comparison with Observed Data

The BATHTUB model's response to changes in the GWLF nutrient block were compared to known in-lake concentrations of total phosphorus and chlorophyll "a" for each year of simulation. These known concentrations were presented in Tables 5-4 and 5-5. The BATHTUB manual defines the limits of total phosphorus calibration factors as 0.5 and 2.0. The calibration factor accounts for sedimentation rates, and the limits were determined by error analysis calculations performed on test data sets (USACE 1999b). The calibration limits for chlorophyll "a" are not defined in the BATHTUB manual.

Because independent measurements of internal nutrient loading are not available, these values were estimated based on varying concentration from the inactive dairy located within the watershed and total phosphorus concentration in the soil as shown in Table 7-8 (at the end of this section). The internal loads were entered into the BATHTUB model so that agreement between the observed and estimated in-lake values matched. To establish at what levels the appropriate dairy dissolved phosphorus concentration and soil total phosphorus concentration occur, the calibration factors that would need to be applied for each scenario outlined were calculated as presented in Table 7-8.

The GWLF model was set at a total phosphorus soil concentration of 616 ppm and the dairy dissolved phosphorus concentration of 123.75 mg/L based on comparison with observed data in the BATHTUB model. As part of the comparison process, the watershed was also modeled with a total phosphorus soil concentration of 792 ppm to perform a sensitivity analysis on soil phosphorus. Increasing the total soil phosphorus concentration shows little impact on the estimated in-lake concentrations (Table 7-8). The calibration factor range for total phosphorus modeling in BATHTUB is 0.5 to 2 and use of the 616-ppm total phosphorus in the soil falls within this accepted range. Table 7-8 also shows what calibration factors for chlorophyll "a" would be required so that estimated concentrations would match observed concentrations. The columns labeled *target* in Table 7-8 represent the average observed in-lake concentrations. The results of the modeling sensitivity analyses are contained in Appendix G.

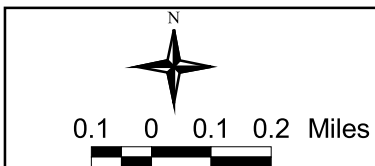
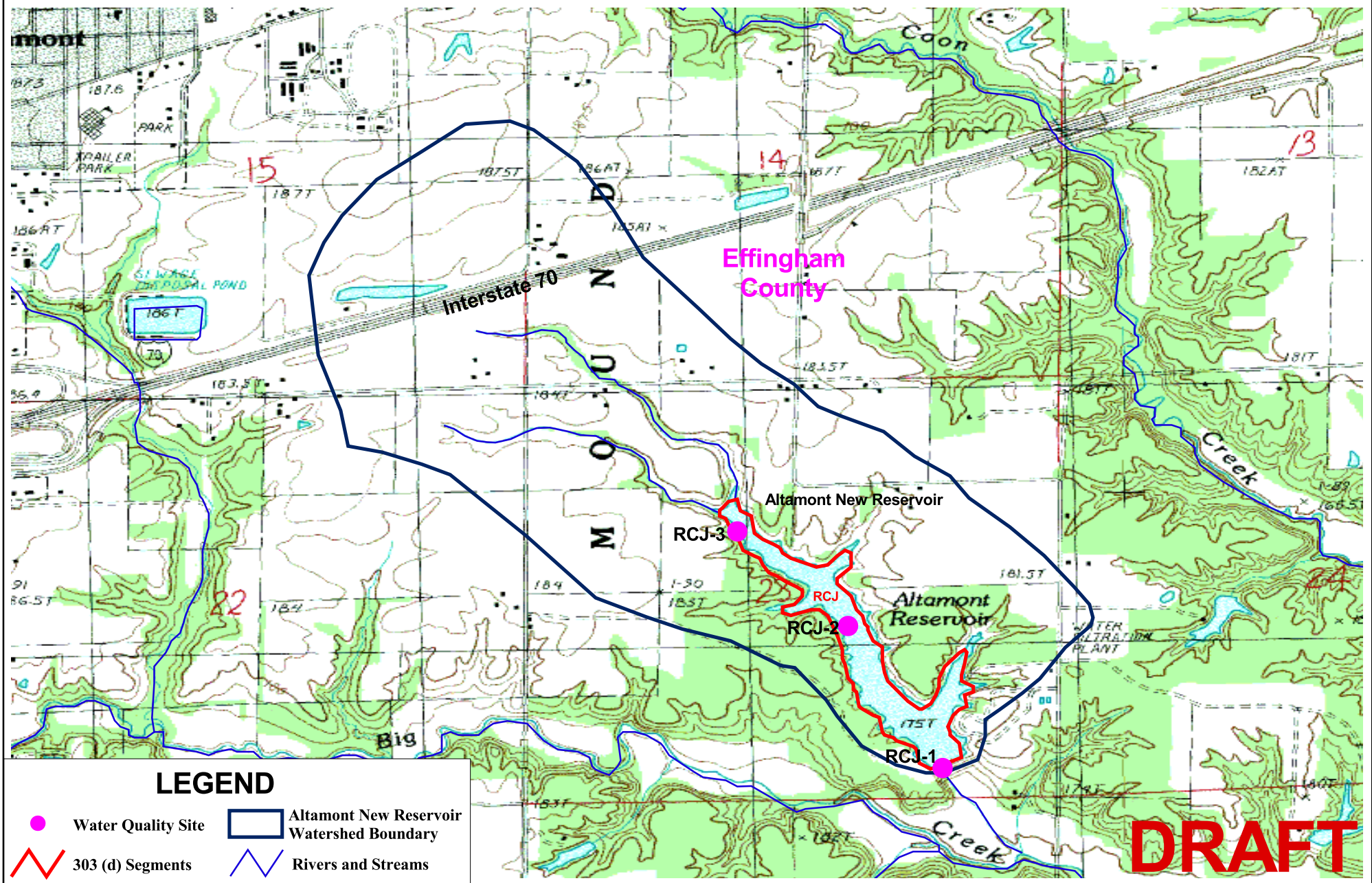
A robust calibration and validation of Altamont New Reservoir could not be completed because the following information was not available: observed nutrient concentrations in tributaries to the lake, site-specific data on internal cycling rates, reservoir outflow rates, and nutrient concentrations in reservoir releases. The analysis presented in Table 7-8 is therefore considered a preliminary calibration. However, BATHTUB modeling results indicate a fair estimate between predicted and observed values for the years modeled based on error statistics calculated by the BATHTUB model and should be sufficient for estimating load reductions required in the watershed and from internal cycling within the reservoir. BATHTUB calculates three measures of error on each output concentration. If the absolute value of the error statistic is less than 2.0, the modeled output concentration is within the 95 percent confidence interval for that constituent (USACE 1999b). A robust calibration and validation of Altamont New Reservoir will be possible if data collection activities outlined in the future monitoring in Section 9 are implemented.

The preliminary calibration is considered sufficient to make "planning level" decisions regarding load reductions within the watershed required to meet water quality standards. As more data become available and BMPs are implemented within the watershed, the calibration can be supplemented and resulting impacts of improvements within the watershed can be quantified.

Based on modeling results it appears that internal cycling is occurring in Altamont New Reservoir in 1993, 1998, and 2001. The BATHTUB manual notes that internal cycling can be significant in shallow prairie reservoirs and provides Lake Ashtabula (approximately 42 feet deep) as an example (USACE 1999b and 2003). Table 5-10 notes a depth of approximately 17 feet for Altamont New Reservoir, which places it in the category of shallow reservoir. Literature sources suggest that internal loading for deeper, more stratified lakes could be in the range of 10 to 30 percent of total loadings and that values for shallower reservoirs could be much higher (Wetzel 1983). Estimates of internal cycling are also included in Table 7-8.

Because the modeling of Altamont New Reservoir changes based on annual loadings and climatic conditions, a validation of the model could not be completed. The model was calibrated for three climatic conditions, which will be the basis for the TMDL analysis presented in Section 8. The preliminary calibrated model was used to estimate the amount of load reductions needed from the watershed and internal loads to meet water quality standards.

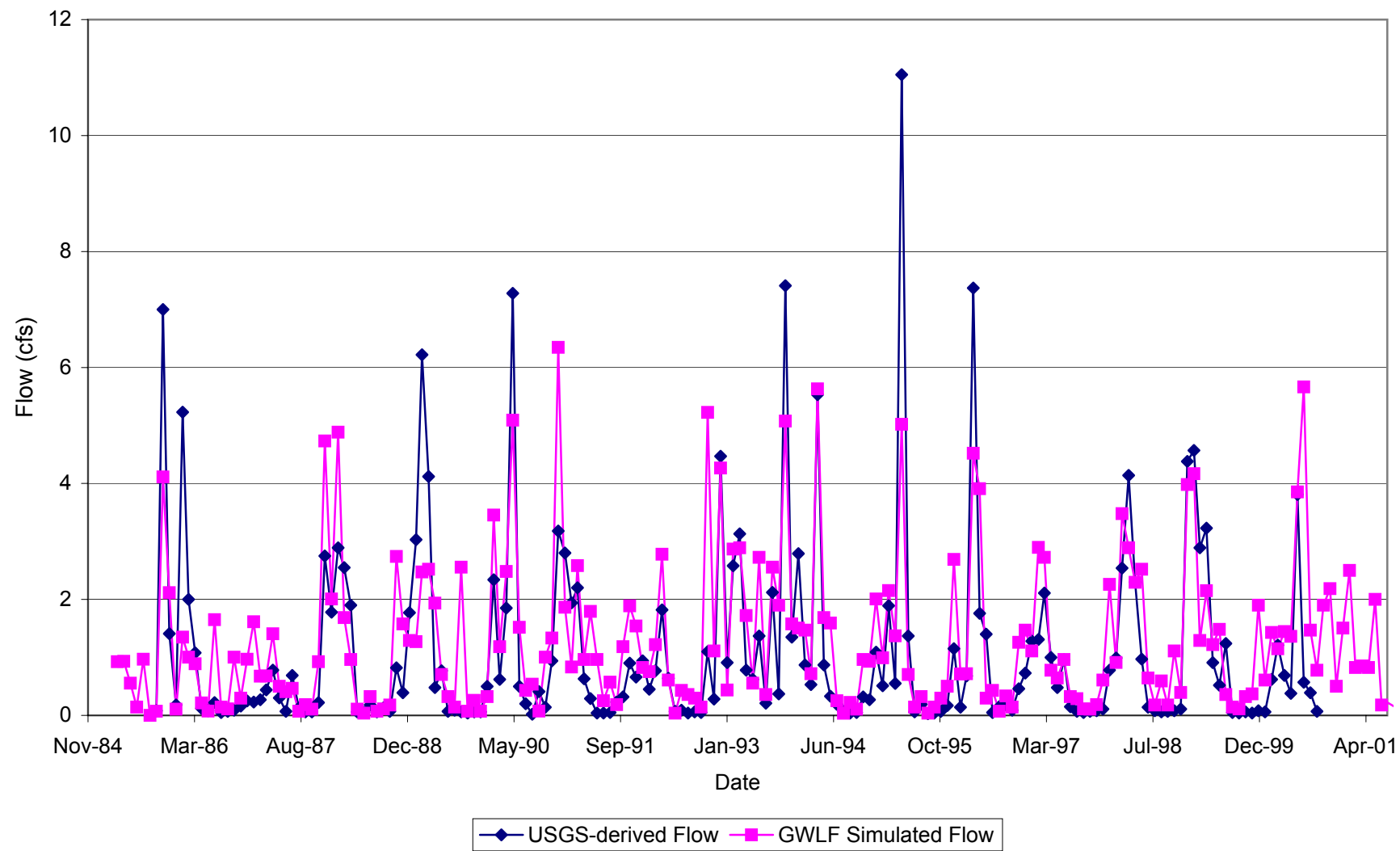
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**Figure 7-1**  
**Altamont New Reservoir Watershed and**  
**Historic Sampling Locations**

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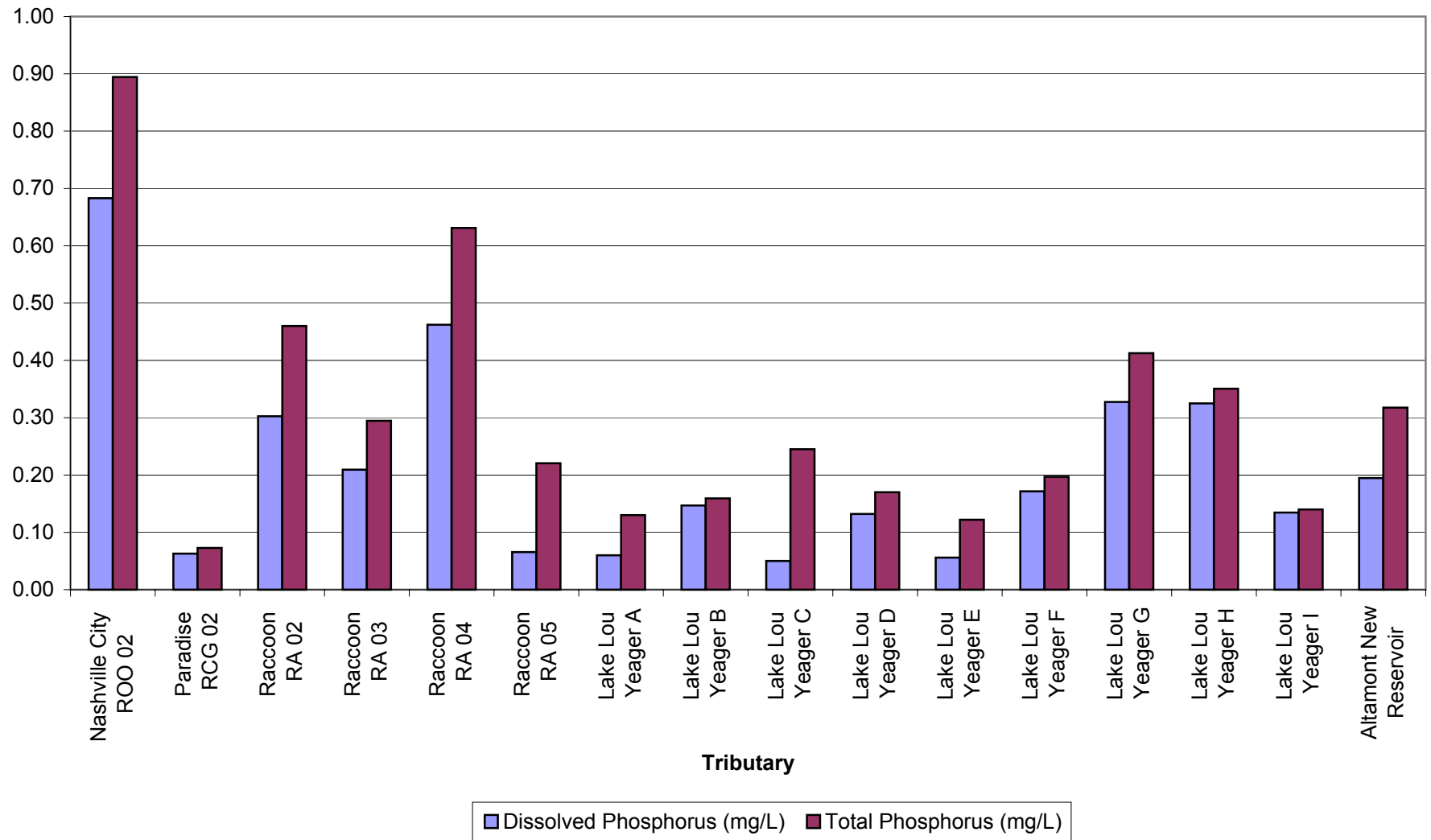
Figure 7-2: Altamont New Reservoir Inflows  
Monthly Flow Comparison



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**Figure 7-3: Dissolved and Total Phosphorus Concentrations Measured in Clean Lake Study Tributaries and Estimated for Tributaries to Altamont New Reservoir**



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Table 7-8 Altamont New Reservoir Calibration Sensitivity Analysis

				Dairy Dissolved Phosphorus 5 mg/L					Dairy Dissolved Phosphorus 82.5 mg/L				
Year	In-Lake Target Total Phosphorus (mg/L)	In-Lake Target Chlorophyll "a" (µg/L)		In-Lake Estimated Total Phosphorus (mg/L)	% of Total Loads from Internal Loading Required to Meet Target	Phosphorus Calibration Factor	In-Lake Estimated Chlorophyll "a" (µg/L)	Chlorophyll "a" Calibration Factor	In-Lake Estimated Total Phosphorus (mg/L)	% of Total Loads from Internal Loading Required to Meet Target	Phosphorus Calibration Factor	In-Lake Estimated Chlorophyll "a" (µg/L)	Chlorophyll "a" Calibration Factor
1993	0.12	61	Soil Total Phosphorus 616 ppm	0.05	81%	2.5	17.9	3.4	0.07	63%	1.7	22.1	2.8
1998	0.15	61		0.03	94%	4.7	13.0	4.7	0.03	94%	4.7	13.0	4.7
2001	0.13	22		0.04	88%	3.5	10.4	2.1	0.04	88%	3.5	10.4	2.1
1993	0.12	61	Soil Total Phosphorus 792 ppm	0.06	74%	2.1	19.7	3.1	0.07	63%	1.7	22.1	2.8
1998	0.15	61		0.03	94%	4.7	13.0	4.7	0.05	88%	3.2	17.5	3.5
2001	0.13	22		0.04	88%	3.5	10.4	2.1	0.05	77%	2.4	13.6	1.6

Table 7-8 Altamont New Reservoir Calibration Sensitivity Analysis (continued)

				Dairy Dissolved Phosphorus 123.75 mg/L					Dairy Dissolved P 247.25 mg/L				
Year	In-Lake Target Total Phosphorus (mg/L)	In-Lake Target Chlorophyll "a" (µg/L)		In-Lake Estimated Total Phosphorus (mg/L)	% of Total Loads from Internal Loading Required to Meet Target	Phosphorus Calibration Factor	In-Lake Estimated Chlorophyll "a" (µg/L)	Chlorophyll "a" Calibration Factor	In-Lake Estimated Total Phosphorus (mg/L)	% of Total Loads from Internal Loading Required to Meet Target	Phosphorus Calibration Factor	In-Lake Estimated Chlorophyll "a" (µg/L)	Chlorophyll "a" Calibration Factor
1993	0.12	61	Soil Total Phosphorus 616 ppm	0.09	49%	1.4	23.7	2.6	0.10	37%	1.3	24.8	2.5
1998	0.15	61		0.07	77%	2.2	21.8	2.8	0.09	66%	1.7	24.1	2.5
2001	0.13	22		0.05	77	2.4	13.6	1.6	0.07	66%	1.9	15.5	1.4
1993	0.12	61	Soil Total Phosphorus 792 ppm	0.09	49%	1.4	23.7	2.6	0.10	31%	1.2	25.2	2.4
1998	0.15	61		0.07	77	2.2	21.8	2.8	0.09	66%	1.7	24.1	2.5
2001	0.13	22		0.05	77	2.4	21.3	1.0	0.09	40%	1.4	17.5	1.2

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# Section 8

## Total Maximum Daily Load for Altamont New Reservoir

### 8.1 TMDL Endpoints for Altamont New Reservoir

The desired in-lake water quality concentration for total phosphorus is less than or equal to 0.05 mg/L. Table 5-5 in Section 5 summarized the average total phosphorus concentrations sampled in the Altamont New Reservoir Watershed. As noted in Section 5.1.5.1.1, all observed in-lake total phosphorus averages have exceeded the target. The total phosphorus target is set to prevent eutrophic conditions in the Altamont New Reservoir and maintain aquatic life. Phosphorus is a concern as nuisance plant growth and algal concentrations in many freshwater lakes are enhanced by the availability of phosphorus. Additionally, excess phosphorus can cause large DO fluctuations.

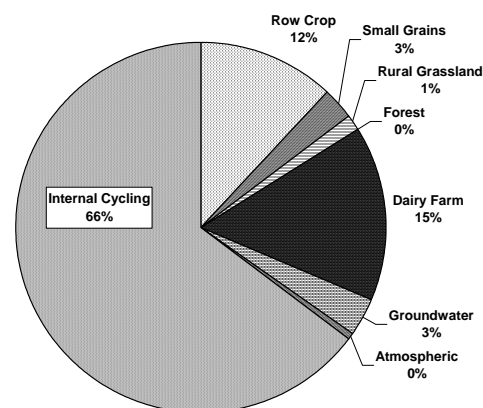
### 8.2 Pollutant Sources and Linkages

Pollutant sources and their linkages to Altamont New Reservoir were established through the GWLF and BATHTUB modeling techniques described in Section 7. Pollutant sources of phosphorus include nonpoint source runoff from agriculture and an inactive dairy. Atmospheric deposition and internal cycling are also potential sources of loads. The predicted phosphorus loads from GWLF modeling and their sources are presented in Table 8-1. The mean loads presented in Table 8-1 will be used in the overall TMDL calculation for the amount of reductions that need to occur in the Altamont New Reservoir Watershed.

**Table 8-1 Modeled Total Phosphorus Load by Source**

Land Use	1993 (wet)		1998 (normal)		2001 (dry)		Mean	
	lb/yr	percent	lb/yr	percent	lb/yr	percent	lb/yr	percent
Row Crop	570	17%	322	8%	244	11%	379	12%
Small Grains	136	4%	68	2%	70	3%	91	3%
Rural Grassland	54	2%	34	1%	35	2%	41	1%
Forest	0	0%	0	0%	0	0%	0	0%
Dairy Farm	841	24%	356	9%	261	12%	486	15%
Groundwater	163	5%	102	3%	52	2%	106	3%
Atmospheric	15	0%	15	0%	15	1%	15	0%
Internal Cycling	1,675	48%	2,977	77%	1,488	69%	2,047	66%
<b>TOTAL</b>	<b>3,454</b>	<b>100%</b>	<b>3,874</b>	<b>100%</b>	<b>2,165</b>	<b>100%</b>	<b>3,164</b>	<b>100%</b>

The majority of the predicted phosphorus load is from internal cycling and agricultural nonpoint sources as shown in the pie chart to the right. The loads represented in Table 8-1 and the pie chart were entered into the BATHTUB model as explained in Section 7 to determine resulting in-lake total phosphorus concentration in mg/L. As explained in Section 7, these loads result in in-lake concentrations that exceed the total phosphorus target of 0.05 mg/L. The TMDL explained throughout the remainder of this section will examine how much both the external and internal loads need to be reduced in order to meet the total phosphorus water quality standard of 0.05 mg/L in the Altamont New Reservoir.



### 8.3 Allocation

As explained in Section 1, the TMDL for the Altamont New Reservoir will address the following equation:

$$\text{TMDL} = \text{LC} = \Sigma \text{WLA} + \Sigma \text{LA} + \text{MOS}$$

- where
- LC = Maximum amount of pollutant loading a water body can receive without violating water quality standards
  - WLA = The portion of the TMDL allocated to existing or future point sources
  - LA = Portion of the TMDL allocated to existing or future nonpoint sources and natural background
  - MOS = An accounting of uncertainty about the relationship between pollutant loads and receiving water quality

Each of these elements will be discussed in this section as well as consideration of seasonal variation in the TMDL calculation.

#### 8.3.1 Loading Capacity

The LC of Altamont New Reservoir is the pounds per year of total phosphorus that can be allowed as input to the lake and still meet the water quality standard of 0.05-mg/L total phosphorus. The allowable phosphorus loads that can be generated in the watershed and still maintain water quality standards was determined with the models that were set up and calibrated as discussed in Section 7. To accomplish this, the loads presented in Table 8-1 were reduced by a percentage and entered into the BATHTUB model until the water quality standard of 0.05-mg/L total phosphorus was met in Altamont New Reservoir. Table 8-2 shows the allowable phosphorus loading determined for 1993, 1998, and 2001 by reducing modeled inputs to Altamont New

Reservoir through GWLF and BATHTUB. The output files to BATHTUB showing the results of the load reductions for 1993, 1998, and 2001 are contained in Appendix H. The allowable pounds per year resulting from the modeling show the effects of varying climatic conditions observed during these years. Therefore, an average value of these years was set as the target loading to meet the in-lake water quality standards of 0.05 mg/L.

**Table 8-2 Allowable Total Phosphorus Load by Model Year for Altamont New Reservoir**

Model Year	Phosphorus (lb/yr)
1993	694
1998	507
2001	408
Mean	536

### 8.3.2 Seasonal Variation

A season is represented by changes in weather; for example, a season can be classified as warm or cold as well as wet or dry. Seasonal variation is represented in the Altamont New Reservoir TMDL as conditions were modeled on an annual basis and by taking 15 years of daily precipitation data when calculating run-off through the GWLF model. This takes into account the seasonal effects the reservoir will undergo during a given year. Since the various pollutant sources are expected to contribute loadings in different quantities during different time periods (e.g., atmospheric deposition year round, spring run-off loads), the loadings for this TMDL will focus on average annual loadings rather than specifying different loadings by season. In addition, three data sets (wet, dry, average) were examined to assess the effects of varying precipitation on loading to the reservoir and resulting in-lake concentrations.

### 8.3.3 Margin of Safety

The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loadings) or a combination of both. The MOS for the Altamont New Reservoir TMDL should be based on a combination of both. Model inputs were selected from the GWLF manual when site-specific data were unavailable. These default input values are assumed to be conservative, which implicitly includes a MOS in the modeling effort. Because the default input values are not site-specific, they are assumed more conservative and therefore a MOS can be implicitly assumed. Default input values include:

- Sediment delivery ratio – using literature value is assumed conservative as cropping practices have changed within Illinois since ratio was developed in 1975
- Soil phosphorus concentration – phosphorus concentrations in the soil were not available therefore literature values were assumed conservative as the mid-point of the range of suggested literature range was used as a starting point for analyses

In addition, averaging of a normal and dry year is assumed to be conservative and part of the implicit MOS.

Due to uncertainty with nutrient model inputs as explained in Section 7.3, an explicit MOS of 5 percent is also recommended. Due to unknowns regarding estimated versus actual measurements of loadings to the lake, an explicit MOS is included. The 5 percent MOS is appropriate based upon the generally good agreement between the GWLF loading model and observed flows, and in the BATHTUB water quality model and observed values in Altamont New Reservoir (Section 7.3). Since these models reasonably reflect the conditions in the watershed, a 5 percent MOS is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. The MOS can be reviewed in the future as new data is developed.

### 8.3.4 Waste Load Allocation

There are no point sources in the watershed; therefore, no WLA (WLA = 0 pounds) is recommended at this time.

### 8.3.5 Load Allocation and TMDL Summary

Table 8-3 shows a summary of the TMDL for Altamont New Reservoir. On average, a total reduction of 84 percent of total phosphorus loads to Altamont New Reservoir would result in compliance with the water quality standard of 0.05 mg/L total phosphorus.

**Table 8-3 TMDL Summary for Total Phosphorus in Altamont New Reservoir**

LC (lb/yr)	WLA (lb/yr)	LA (lb/yr)	MOS (lb/yr)	Reduction Needed (lb/yr)	Reduction Needed (percent)
537	0	510	27	2,654	84%

Table 8-4 shows the respective reductions needed from internal cycling, atmospheric loads, and nonpoint sources in the watershed to meet the TMDL. The reduction of atmospheric loads is zero because atmospheric contributions cannot be controlled by watershed management measures. The percent reduction from internal cycling is estimated as 90 percent based on attainable reductions from management measures that will be discussed in Section 9. An approximate 74 percent reduction of nonpoint sources from the watershed in addition to the reduction of internal cycling would be necessary to meet the load allocation presented in Table 8-3. Methods to meet these targets will be outlined in Section 9.

**Table 8-4 Sources for Total Phosphorus Reductions**

Source	Current Load (lb/yr)	Load Reduction (lb/yr)	Percent Reduction
Atmospheric	15	0	0
Internal Cycling	2,047	1,842	90%
Nonpoint Sources	1,103	812	74%



# **Section 9**

## **Implementation Plan for Altamont New Reservoir**

### **9.1 Implementation Actions and Management Measures**

Phosphorus loads in the Altamont Reservoir Watershed originate from external and internal sources. From modeling estimates, internal phosphorus cycling from sediments accounts for approximately 66 percent of the loading to Altamont New Reservoir. External loads from nonpoint source runoff from agricultural crops, a non-operational dairy facility, and rural grassland potentially account for 15 percent, 15 percent, and 1 percent, respectively, of the loading. The remainder of the loading is attributed to groundwater (3 percent). To achieve the 84 percent reduction of phosphorus established in Section 8 (Table 8-3), management measures must address nonpoint source loading through sediment and surface runoff controls and internal nutrient cycling through in-lake management. Phosphorus sorbs readily to soil particles and controlling sediment load into the reservoir helps control phosphorus loadings.

Implementation actions, management measures, or BMPs are used to control the generation or distribution of pollutants. BMPs are either structural, such as wetlands, sediment basins, fencing, or filter strips; or managerial, such as conservation tillage, nutrient management plans, or crop rotation. Both types require good management to be effective in reducing pollutant loading to water resources (Osmond et al. 1995).

It is generally more effective to install a combination of BMPs or a BMP system. A BMP system is a combination of two or more individual BMPs that are used to control a pollutant from the same critical source. In other words, if the watershed has more than one identified pollutant, but the transport mechanism is the same, then a BMP system that establishes controls for the transport mechanism can be employed. (Osmond et al. 1995).

Implementation actions and management measures are described for each nonpoint source in the watershed. Nonpoint sources include cropland and a non-operational dairy facility. The final source is internal phosphorus cycled from lake sediments.

#### **9.1.1 Nonpoint Source Phosphorus Management**

The sources of nonpoint source pollution in the Altamont New Reservoir TMDL are divided between a non-operational dairy farm and agricultural cropland. BMPs evaluated that could be utilized to treat these nonpoint sources are:

- Wetlands
- Filter strips
- Conservation tillage practices
- Nutrient management

Total and dissolved phosphorus originating from dairy operations can be treated with a combination of a wetland and grass filter strip. Total phosphorus originating from cropland is most efficiently treated with no-till or conservation tillage practices. Wetlands located upstream of the reservoir provide further reductions in total and dissolved phosphorus in runoff from croplands. Nutrient management focuses on source control of nonpoint source contributions to Altamont New Reservoir.

#### **9.1.1.1 Wetlands**

The use of wetlands as a structural control is most applicable to nutrient reduction from agricultural lands and an inactive dairy facility in Altamont New Reservoir Watershed. Therefore this section focuses on the use of wetlands to treat runoff from a dairy and agricultural lands. Wetlands are assumed to be an effective BMP because they:

- Prevent floods by temporarily storing water, allowing the water to evaporate, or percolate into the ground
- Improve water quality through natural pollution control such as plant nutrient uptake
- Filter sediment
- Slow overland flow of water thereby reducing soil erosion (USDA 1996)

To treat loads from the inactive dairy, a wetland could be constructed between the dairy and the reservoir. Treatment of phosphorus from livestock waste could be accomplished through a combination of wetlands and filter strips. Wetland design is critical to establishing a properly functioning and effective pollution control structure. Critical elements in wetland design are substrate composition, water budget, solids removal from wastewater, size determination, and physical characteristics such as shape, slope, and embankments. An overview of wetland design guidelines is presented in the Ohio State University Fact Sheet: Using Constructed Wetlands for Removing Contaminants from Livestock Wastewater (Simeral 1998).

While constructed wetlands have been demonstrated to effectively reduce nitrogen and sediment, literature shows mixed results for phosphorus removal. Studies have shown that artificial wetlands designed and constructed specifically to remove pollutants from surface water runoff have removal rates for suspended solids of greater than 90 percent, for total phosphorus of 0 to 90 percent, and for nitrogen species from 10 to 75 percent (Johnson, Evans, and Bass 1996; Moore 1993; USEPA 1993; Kovosic et al. 2000). In some cases, wetlands can be sources of phosphorus. Over the long term, it is generally thought that wetlands are neither sources nor sinks of phosphorus (Kovosic et al. 2000).

Efficiency of pollutant removal in wetlands can be addressed in the design and maintenance of the constructed wetland. Location, hydraulic retention time and space requirements should be considered in design. To maintain removal efficiency, sheet

flow should be maintained and substrate should be monitored to assess whether the wetland is operating optimally. Sediment or vegetation removal may be necessary if the wetland removal efficiency is lessened over a period of time (USEPA 1993; NCSU 1994).

Guidelines for wetland design suggest a wetland to watershed ratio of 0.6 percent for nutrient and sediment removal from agricultural runoff. Table 10-3 outlines estimated wetland areas for each subbasin based on these recommendations. A wetland system to treat agricultural runoff from the 640-acre Altamont New Reservoir Watershed would need to be approximately 3.8 acres based on these recommendations (Denison and Tilton 1993).

#### **9.1.1.2 Filter Strips**

Filter strips can be used as a structural control to reduce pollutant loads, including nutrients and sediment, to Altamont New Reservoir Watershed. Filter strips implemented along stream segments slow and filter nutrients and sediment out of runoff and provide bank stabilization decreasing erosion and deposition. Additionally, filter strips mitigate nutrient loads to lakes. The following paragraphs focus on the implementation of filter strips in the Altamont New Reservoir Watershed. Finally, design criteria and size selection of filter strips are detailed.

Grass and riparian buffer strips filter out nutrients and organic matter associated with sediment loads to a water body. Reduction of nutrient concentrations, specifically phosphorus, in Altamont New Reservoir will reduce the amount of algal growth in the lake system, which can cause depletion of DO when algae expire and cause more significant diurnal fluctuations from photosynthesis. Filter strips reduce nutrient and sediment loads to lakes by establishing ground depressions and roughness that settles sediment out of runoff and providing vegetation to filter nutrients out of overland flow. As much as 75 percent of sediment and 45 percent of total phosphorus can be removed from runoff by a grass filter strip (North Carolina State University [NCSU] 2000). In addition, filter strips should be harvested periodically so that removal rate efficiencies over extended periods of time remain high (USEPA 1993).

Filter strip widths for the Altamont New Reservoir TMDL were estimated based on the slope. According to the NRCS Planning and Design Manual, the majority of sediment is removed in the first 25 percent of the width (NRCS 1994). Table 9-1 outlines the guidance for filter strip flow length by slope (NRCS 1999). Based on this guidance, two filter strips were examined for the basin. Based on slope, the southern tributary would need a filter strip with 72 feet on each side of the tributary for a length of 902 feet. The northern tributary would need a filter strip that encompassed 108 feet on each side of the tributary for a length of 1,017 feet.

**Table 9-1 Filter Strip Flow Lengths Based on Land Slope**

<b>Percent Slope</b>	<b>0.5%</b>	<b>1.0%</b>	<b>2.0%</b>	<b>3.0%</b>	<b>4.0%</b>	<b>5.0% or greater</b>
<b>Minimum</b>	36	54	72	90	108	117
<b>Maximum</b>	72	108	144	180	216	234

The filter strip lengths and widths presented above are used to calculate an approximation of BMP costs in Section 9.2.2.7 and should only be used as a guideline for watershed planning. It is recommended that landowners evaluate their land near streams and lakes and create or extend filter strips according to the NRCS guidance presented in Table 9-1. Programs available to fund the construction of these buffer strips are discussed in Section 9.2.

### **9.1.1.3 Conservation Tillage Practices**

For the Altamont New Reservoir Watershed, conservation tillage practices could help reduce nutrient loads in the lake. Nonpoint source runoff from 300 acres of row crops and small grain agriculture were estimated to contribute 15 percent of the total phosphorus load to Altamont New Reservoir. Total phosphorus loading from cropland is controlled through management BMPs, such as conservation tillage. Conservation tillage maintains at least 30 percent of the soil surface covered by residue after planting. Crop residuals or living vegetation cover on the soil surface protect against soil detachment from water and wind erosion. Conservation tillage practices can remove 45 percent of the dissolved and total phosphorus from runoff and 75 percent of the sediment (NCSU 2000); however, filter strips are less effective at removing dissolved phosphorus only. Additionally, studies have found 93 percent less erosion occurred from no-till acreage compared to acreage subject to moldboard plowing (NCSU 2000). Various methods of conservation tillage are presently utilized in the Altamont New Reservoir Watershed as were shown in Table 5-8. To achieve the reductions needed, erosion control through conservation tillage could reduce phosphorus loads. The watershed's modeled erosion rate from row crop and small grains averages two tons/acre/year. To achieve a 38 percent reduction in phosphorus load, the erosion rate for the watershed would need to be reduced to 1.2 tons/acre/year. Similarly, the C-factors for corn, soybeans, and small grains would need to be reduced from 0.32, 0.20, and 0.11 to 0.20, 0.12, and 0.07, respectively.

### **9.1.1.4 Nutrient Management**

Nutrient management could result in reduced phosphorus and nitrogen loads to Altamont New Reservoir. Crop management of nitrogen and phosphorus can be accomplished through Nutrient Management Plans, which focus on increasing the efficiency with which applied nutrients are used by crops, thereby reducing the amount available to be transported to both surface and groundwater. In the past, nutrient management focused on application rates designed to meet crop nitrogen requirements but avoid groundwater quality problems created by excess nitrogen leaching. This results in buildup of soil phosphorus above amounts sufficient for optimal crop yields. Illinois, along with most Midwestern states, demonstrates high soil test phosphorus in greater than 50 percent of soil samples analyzed (Sharpley et al. 1999).

The overall goal of phosphorus reduction from agriculture should increase the efficiency of phosphorus use by balancing phosphorus inputs in feed and fertilizer with intakes of crops and animal produce as well as managing the level of phosphorus in the soil. Reducing phosphorus loss in agricultural runoff may be brought about by source and transport control measures, such as filter strips or grassed waterways. The Nutrient Management Plans account for all inputs and outputs of phosphorus to determine reductions. Elements of a Nutrient Management Plan include:

- Plan Summary
- Manure summary, including annual manure generation, use, and export
- Nutrient application rates by field and crop
- Summary of excess manure utilization procedures
- Implementation schedule
- Manure management and stormwater BMPs

Bray-1 soil data tested during the period of 1991 through 2001 on cropland located in the Altamont New Reservoir watershed indicate an average soil phosphorus of 44 ppm and 88 ppm (lb/acre) (Hirschi 2002). The Bray-1 test measures the amount of phosphorus available for plant uptake. This Bray P1 test exceeds the level of 70 lb/acre recommended by Illinois NRCS practice standard 590, the University of Illinois Agronomy Handbook, and Illinois Department of Agriculture nutrient management practice guidelines. This guidance recommends that no additional phosphorus be applied until further soil tests are conducted (University of Illinois 2004).

### **9.1.2 In-Lake Phosphorus**

Internal cycling of phosphorus contributes approximately 65 percent of the phosphorus load to Altamont New Reservoir Watershed. Reduction of phosphorus from in-lake cycling through management strategies is necessary for attainment of the TMDL load allocation. Internal phosphorus loading occurs when the water above the sediments become anoxic causing the reduction of iron phosphate, which releases phosphate from the sediment in a form that is available for plant uptake. The addition of bioavailable phosphorus in the water column stimulates more plant growth and die-off, which perpetuates the anoxic conditions and enhances the reduction of iron and the subsequent phosphate release from ferric phosphate into the water.

Control of internal phosphorus cycling must limit release of phosphorus from the sediments either through lake oxygen concentration or sediment management. If the water column never becomes anaerobic, the ferric phosphate will not be reduced to bioavailable phosphorus. Aeration, which simulates lake mixing and keeps oxygen conditions from being depleted in the epilimnion, can be very effective at preventing re-release of bound phosphorus. Reduction of internal phosphorus cycling from this measure is typically determined based on site-specific studies.

Phosphorus release from the sediment is greatest from recently deposited layers. Dredging about one meter of recently deposited phosphorus-rich sediment can remove approximately 80 to 90 percent of the internally loaded phosphorus without the

addition of potentially toxic compounds to the reservoir; although, it is more costly than other management options (NRCS 1992).

### 9.1.3 Implementation Actions and Management Measures Summary

To meet the reductions outlined in Section 8 for Altamont New Reservoir, 84 percent of the phosphorus loaded from nonpoint source pollution and 90 percent of the phosphorus from internal loads would need to be reduced in order to meet the TMDL target of a total phosphorus concentration less than 0.05 mg/L. The GWLF model was used to model the following practices to estimate achievable reductions in total phosphorus:

- Filter strips
- Conservation tillage
- Nutrient management (reduction of total phosphorus in sediment by 20 percent)

The modeling effort showed that filter strips do not provide much total phosphorus reduction, most likely due to routing constraints of the GWLF model as discussed in

**Table 9-2 Summary of Total Phosphorus Load Reductions**

Management Measure	Potential Percent Reduction
Nutrient Management	17%
Conservation Tillage Practices	38%
Filter Strips*	22%
Wetland*	5%

\* Literature value utilized for estimation

lower bound of the literature value for wetlands was used due to studies that have shown the long-term effectiveness of phosphorus removal in wetlands is negligible.

A combination of implementing these external load reduction practices coupled with the available treatments for internal loads would allow the Altamont New Reservoir Watershed to meet its total goal of reducing phosphorus loads. Section 9.2 outlines planning level costs and programs available to help with cost-sharing so that this goal can be achieved.

## 9.2 Reasonable Assurance

Reasonable assurance means that a demonstration is given that nonpoint source reductions in this watershed will be implemented. It should be noted that all programs discussed in this section are voluntary. The discussion in Section 9.1 provided a means for obtaining the reductions necessary. The remainder of this section discusses an estimate of costs to the watershed for implementing these practices and programs available to assist with funding.

### **9.2.1 Available Programs for Phosphorus TMDL**

Approximately 84 percent of the Altamont New Reservoir Watershed is classified as rural grassland (pasture land, CRP, waterways, buffers strips, etc.), row crop, and small grains land. There are several voluntary conservation programs established through the 2002 U.S. Farm Bill, which encourage landowners to implement resource-conserving practices for water quality and erosion control purposes. These programs would apply to crop fields and rural grasslands that are presently used as pasture land. Each program is discussed separately in the following paragraphs.

#### **9.2.1.1 Illinois Department of Agriculture and Illinois EPA Nutrient Management Plan Project**

The Illinois Department of Agriculture (IDA) and Illinois EPA are presently co-sponsoring a cropland Nutrient Management Plan project in watersheds that have or are developing a TMDL. Under this project, 300 acres of cropland have been targeted in the Altamont New Reservoir watershed. This voluntary project will supply incentive payments to producers to have Nutrient Management Plans developed and implemented. Additionally, if sediments or phosphorus has been identified as a cause for impairment in the watershed, then traditional erosion control practices will be eligible for cost-share assistance through the Nutrient Management Plan project as well.

#### **9.2.1.2 Clean Water Act Section 319 Grants**

Section 319 was added to the CWA to establish a national program to address nonpoint sources of water pollution. Through this program, each state is allocated section 319 funds on an annual basis according to a national allocation formula based on the total annual appropriation for the section 319 grant program. The total award consists of two categories of funding; incremental funds and base funds. A state is eligible to receive EPA 319(h) grants upon USEPA's approval of the state's Nonpoint Source Assessment Report and Nonpoint Source Management Program. States may reallocate funds through subawards (e.g., contracts, subgrants) to both public and private entities, including local governments, tribal authorities, cities, counties, regional development centers, local school systems, colleges and universities, local nonprofit organizations, state agencies, federal agencies, watershed groups, for-profit groups, and individuals. Subawards to individuals are limited to demonstration projects (USEPA 2003, 2002).

USEPA designates incremental funds, a 100-million award, for the restoration of impaired water through the development and implementation of watershed-based plans and TMDLs for impaired waters. Base funds, funds other than incremental funds, are used to provide staffing and support to manage and implement the state Nonpoint Source Management Program. Section 319 funding can be used to implement activities which improve water quality, such as filter strips, streambank stabilization, etc. (USEPA 2003, 2002).

### **9.2.1.3 Conservation Reserve Program (CRP)**

This voluntary program encourages landowners to plant long-term resource-conserving cover to improve soils, water, and wildlife resources. CRP is the USDA's single largest environmental improvement program and one of its most productive and cost-efficient. It is administered through the Farm Service Agency (FSA) by USDA's Commodity Credit Corporation (CCC). The program was initially established in the Food Security Act of 1985. The duration of the contracts under CRP range from 10 to 15 years.

Eligible land must be one of the following:

1. Cropland that is planted or considered planted to an agricultural commodity two of the five most recent crop years (including field margins). Must be physically and legally capable of being planted in a normal manner to an agricultural commodity.
2. Certain marginal pastureland enrolled in the Water Bank Program.

The CCC bases rental rates on the relative productivity of soils within each county and the average of the past three years of local dryland cash rent or cash-rent equivalent. The maximum rental rate is calculated in advance of enrollment. Producers may offer land at the maximum rate or at a lower rental rate to increase likelihood of offer acceptance. In addition, the CCC provides cost-share assistance for up to 50 percent of the participant's costs in establishing approved conservation practices. CCC also encourages restoration of wetlands by offering a one-time incentive payment equal to 25 percent of the costs incurred. This incentive is in addition to the 50 percent cost share provided to establish cover (USDA 1999).

Finally, CCC offers additional financial incentives of up to 20 percent of the annual payment for certain continuous sign-up practices. Continuous sign-up provides management flexibility to farmers and ranchers to implement certain high-priority conservation practices on eligible land. The land must be determined by NRCS to be eligible and suitable for any of the following practices:

- Riparian buffers
- Filter strips
- Grass waterways
- Shelter belts
- Field windbreaks
- Living snow fences
- Contour grass strips
- Salt tolerant vegetation
- Shallow water areas for wildlife
- Eligible acreage within an USEPA-designated wellhead protection area (FSA 1997)

### **9.2.1.4 Wetlands Reserve Program (WRP)**

The Wetlands Reserve Program (WRP) is a voluntary program that provides technical and financial assistance to eligible landowners to restore, enhance, and protect



wetlands. The goal of WRP is to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program. At least 70 percent of each project area will be restored to the original natural condition, to the extent practicable. The remaining 30 percent of each area may be restored to other than natural conditions. Landowners have the option of enrolling eligible lands through permanent easements, 30-year easements, or restoration cost-share agreements. The program is offered on a continuous sign-up basis and is available nationwide. WRP offers landowners an opportunity to establish, at minimal cost, long-term conservation and wildlife habitat enhancement practices and protection. It is administered through the NRCS (2002b).

The 2002 Farm Bill reauthorized the program through 2007, increasing the acreage enrollment cap to 2,275,000 acres with an annual enrollment of 250,000 acres per calendar year. The program is limited by the acreage cap and not by program funding. The program offers three enrollment options: permanent easements, 30-year conservation easements, and 10-year restoration cost-share agreements. Since the program began in 1985, the average cost per acre is \$1,100 in restorative costs and the average project size is 177 acres. The costs for each enrollment option follow in Table 9-3 (USDA 1996).

**Table 9-3 Costs for Enrollment Options of WRP Program**

Option	Permanent Easement	30-year Easement	Restoration Agreement
Payment for Easement	100% Agricultural Value	75% Agricultural Value	NA
Payment Options	1. Lump Sum	1. Lump Sum if less than \$50,000	NA
Restoration Payments	100% Restoration Cost Reimbursements	75% Restoration Cost Reimbursements	75% Restoration Cost Reimbursements

### 9.2.1.5 Environmental Quality Incentive Program (EQIP)

The Environmental Quality Incentive Program (EQIP) is a voluntary USDA conservation program for farmers and private landowners engaged in livestock or agricultural production who are faced with serious threats to soil, water, and related natural resources. It provides technical, financial, and educational assistance primarily in designated "priority areas." Priority areas are defined as watershed regions, or areas of special environmental sensitivity that have significant soil, water, or natural resource related concerns. The program goal is to maximize environmental benefits per dollar expended and provides "(1) flexible technical and financial assistance to farmers and ranchers that face the most serious natural resource problems; (2) assistance to farmers and ranchers in complying with federal, state, and tribal environmental laws, and encourage environmental enhancement; (3) assistance to farmers and ranchers in making beneficial, cost-effective changes to measures needed to conserve and improve natural resources; and (4) for the consolidation and simplification of the conservation planning process." As of 2001, 379,000 acres have been protected in Illinois using EQIP (NRCS 2002e; NRCS 2002f).

Landowners, with the assistance of a local NRCS or other service provider, are responsible for development of a site-specific conservation plan, which addresses the primary natural resource concerns of the priority area. Conservation practices include but are not limited to erosion control, filter strips, buffers, and grassed waterways. If the plan is approved by NRCS, a five- to 10-year contract that provides cost-share and incentive payments is developed.

Cost-share assistance may pay landowners up to 75 percent of the costs of conservation practices, such as grassed waterways, filter strips, manure management, capping abandoned wells, and other practices important to improving and maintaining the health of natural resources in the area. Total incentive and cost-share payments are limited to \$10,000 per person per year and \$50,000 over the life of the contract.

#### **9.2.1.6 Conservation Practices Program**

The Conservation Practices Program (CPP) is a 10-year program. The practices consist of waterways, water and sediment control basins (WASCOBS), pasture/hayland establishment, critical area, terrace system, no-till system, diversions, and grade stabilization structures. The CPP is state funded through the Department of Agriculture. There is a project cap of \$5,000 per landowner and costs per acre vary significantly from project to project.

#### **9.2.1.7 Wildlife Habitat Incentives Program (WHIP)**

The Wildlife Habitat Incentives Program (WHIP) is a voluntary program that encourages the creation of high quality wildlife habitat of national, state, tribal, or local significance. WHIP is administered through NRCS, which provides technical and financial assistance to landowners for development of upland, riparian, and aquatic habitat areas on their property. NRCS works with the participant to develop a wildlife habitat development plan, which becomes the basis of the cost-share agreement between NRCS and the participant. Most contracts are five to 10 years in duration, depending upon the practices to be installed. However, longer term contracts of 15 years or greater may also be funded. Under the agreement:

- The landowner agrees to maintain the cost-shared practices and allow NRCS or its agent access to monitor its effectiveness.
- NRCS agrees to provide technical assistance and pay up to 75 percent of the cost of installing the wildlife habitat practices. Additional financial or technical assistance may be available through cooperating partners (NRCS 2002d).

The FSA administers the CRP. NRCS administers the EQIP, WRP, and WHIP. Local NRCS and FSA contact information in Effingham County are listed in Table 9-4 below.

**Table 9-4 Local NRCS and FSA Contact Information**

Contact	Address	Phone
<b>Local NRCS Office</b>		
Bart Pals	2301 Hoffman Drive Effingham, Illinois 62401	(217) 347-7107, x 3
<b>Local FSA Office</b>		
Effingham Service Center	2301 Hoffman Drive Effingham, Illinois 62401	(217) 347-7107, x 2

## 9.2.2 Cost Estimates of BMPs

Cost estimates for different BMPs and individual practice prices such as filter strip installation are detailed in the following sections. Table 9-5 outlines the cost of implementation measures per acre. Finally, an estimate of the total order of magnitude costs for implementation measures in the Altamont New Reservoir Watershed are presented in Section 9.2.2.7 and Table 9-6.

### 9.2.2.1 Wetland

The price to establish a wetland is very site-specific. In general, the cost to restore hydrology with a six-inch to two-foot berm is \$4 to \$5/linear foot. A water control structure, if required, would cost approximately \$500 to \$1,000. Finally, tree planting using bare root stock is \$435/acre. This equates to an average cost of \$1,250/acre to construct a wetland in Effingham County.

### 9.2.2.2 Filter Strips and Riparian Buffers

Effingham County NRCS estimates an average cost per acre to install and maintain a grass filter strip with a 15-year life span at \$120/acre. This price quote accounts for seeding, fertilization, and labor. A riparian buffer strip established with bare root stock has a life span of 15-years and an installation cost of \$435/acre. The cost is based on utilization of professional contractors at a plant cost of \$0.35/seedlings and labor of \$0.65/acre and an average number of trees per acre of 435.

### 9.2.2.3 Nutrient Management Plan - NRCS

Generally, agricultural land in Effingham County is comprised of livestock and cropland. The Nutrient Management Program in Effingham County consists of soil testing and site-specific recommendations for manure and fertilizer application based on determined credits and realistic crop yields. The service averages \$10/acre.

### 9.2.2.4 Nutrient Management Plan - IDA and Illinois EPA

The costs associated with development of Nutrient Management Plans co-sponsored by the IDA and the Illinois EPA are estimated as \$5/acre paid to the producer and \$2/acre for a third party vendor who develops the plans. The total plan development cost is estimated at \$7/acre.

### 9.2.2.5 Conservation Tillage

Conservation tillage is assumed to include tillage practices that preserve at least 30 percent residue cover of the soil after crops are planted. Net costs for conservation

tillage often approach zero or are negative due to savings in labor and energy. The installation cost for conservation tillage is \$17/acre and the average annual cost for maintaining conservation tillage is \$17.35/acre/year (NCSU 2000).

### 9.2.2.6 Internal Cycling

Controls of internal phosphorus cycling in lakes are costly. Dredging is typically the most expensive management practice averaging \$8,000/acre; however, the practice is 80 to 90 percent effective at nutrient removal and will last for at least 50 years. Altamont currently has an aeration system installed in the reservoir for drinking water treatment purposes. The aeration system, consisting of a floating dock equipped with a fan to mix the water column, costs approximately \$12,000 for material and installation (Whitton 2002). The system keeps approximately half of the lake area (25 acres) destratified throughout the year. Maintenance costs are approximately 5 percent of the installation costs. Operating costs to run the pump are estimated as \$36/day for approximately 180 days/year, which totals about \$6,000/year in operating costs (Cortell 2002; Geney 2002).

### 9.2.2.7 Planning Level Cost Estimates for Implementation Measures

Cost estimates for different implementation actions are presented in Table 9-5. The column labeled *Program or Sponsor* lists the financial assistance program or sponsor available for various BMPs. The programs represented in the table are the WRP, CRP, and the IDA.

**Table 9-5 Cost Estimate of Various BMP Measures in Effingham County**

Source	Program or Sponsor	BMP	Life Span	Installation Mean \$/acre	Maintenance \$/ac/yr
Nonpoint	WRP	Wetland	10	\$1,250.00	\$125.00
	CRP	Grass Filter Strips	15	\$120.00	\$8.00
	CRP	Riparian Buffer	15	\$400.00	\$26.67
	CRP	Grassed Waterways	10	\$1,800.00	\$180.00
	NRCS	Nutrient Management Plan		\$10.00	
	IDA and Illinois EPA	Nutrient Management Plan		\$7.00	
	CRP	Conservation Tillage	1	\$17.00	\$17.35
Internal Cycling	319	Dredging	50	\$8,000.00	\$160.00
	319	Aeration	20	\$480.00	\$24.00

The total order of magnitude capital costs for implementation measures in the watershed were estimated to be \$499,500. The total cost is calculated as the number of acres over which a BMP or structural measure is applied by the cost per acre. Table 9-6 summarizes the number of acres each BMP is applied to in the basin and the corresponding cost. The acreages reported in Table 9-6 are a preliminary estimate in order to provide an overall understanding of cost of implementation in the watershed. The total only represents capital costs and annual maintenance costs. These do not represent the total costs of operating the measure over its life cycle.

**Table 9-6 Cost Estimate of Implementation Measures in the Altamont New Reservoir Watershed**

BMP	Treated Acres	Capital Costs		Maintenance Costs	
		Mean \$/acre	Watershed \$	\$/ac/yr	Watershed \$/yr
Wetland	3.8	\$1,250.00	\$5,000.00	\$125.00	\$500.00
Grass Filter Strips	8	\$120.00	\$1,000.00	\$8.00	\$100.00
Nutrient Management Plan	300	\$7.00	\$2,000.00		
Conservation Tillage	230	\$17.00	\$4,000.00	\$17.35	\$4,000.00
Aeration	57	\$480.00	\$27,000.00	\$24.00	\$11,500.00
Dredging *	57	\$8,000.00	\$456,000.00	\$160.00	\$9,000.00
<b>Total</b>			<b>\$495,000.00</b>		<b>\$25,100.00</b>

\* One time cost

## 9.3 Monitoring Plan

The purpose of the monitoring plan for Altamont New Reservoir is to assess the overall implementation of management actions outlined in this section. This can be accomplished by conducting the following monitoring programs:

- Track implementation of management measures in the watershed
- Estimate effectiveness of management measures
- Continue ambient monitoring of Altamont New Reservoir
- Tributary monitoring

Tracking the implementation of management measures can be used to address the following goals (USEPA 2000):

- Determine the extent to which management measures and practices have been implemented compared to action needed to meet TMDL endpoints
- Establish a baseline from which decisions can be made regarding the need for additional incentives for implementation efforts
- Measure the extent of voluntary implementation efforts
- Support work-load and costing analysis for assistance or regulatory programs
- Determine the extent to which management measures are properly maintained and operated

Estimating the effectiveness of the BMPs implemented in the watershed could be completed by monitoring before and after the BMP is incorporated into the watershed. Additional monitoring could be conducted on specific structural systems such as a constructed wetland. Inflow and outflow measurements could be conducted to determine site-specific removal efficiency. If aeration is used to control internal loading, site-specific data would be needed to assess the effectiveness of this management measure.

Illinois EPA monitors Altamont New Reservoir from April through October approximately every three years. Continuation of this monitoring will assess in-lake water quality as improvements in the watershed are completed. This data will also be used to assess whether water quality standards in the reservoir are being attained.

Tributary monitoring is needed to better assess the contribution of internal loading to the Altamont New Reservoir. By having further knowledge on actual contributions from external loads, a better estimate of internal loads could occur. Along with this tributary monitoring, a stage discharge relationship could be developed with the reservoir spillway so that flows into the reservoir could be paired with tributary water quality data to determine total phosphorus load from the watershed. Data on the different forms of phosphorus (dissolved, total, or orthophosphate) would also be beneficial to better assess reservoir response to phosphorus loading. In addition, a better assessment of the inactive dairy is needed and confirmation of its contribution of phosphorus loadings to the reservoir is needed prior to specific improvements being implemented near that facility.

## **9.4 Implementation Time Line**

Implementing the actions outlined in this section for the Altamont New Reservoir Watershed should occur in phases and assessing effectiveness of the management actions as improvements are made. It is assumed that it may take up to five years to secure funding for actions needed in the watershed and five to seven years after funding to implement the measures. Once improvements are implemented, it may take the Altamont New reservoir 10 years or more to reach its water quality standard target of 0.05 mg/L (Wetzel 1983). If internal loads are not effectively controlled, this time frame could be even greater as the reservoir will take time to "flush" out the phosphorus bound to bottom sediments as reductions in external loads take place. In summary, to meet water quality standards in the Altamont New Reservoir may take up to 20 years to complete.

# Section 10

## References

Bass, K.L. 2000. Evaluation of a Small In-Stream Constructed Wetland in North Carolina's Coastal Plain. North Carolina State University: Thesis.

[http://www.bae.ncsu.edu/research/evans\\_web/etd/klbass.pdf](http://www.bae.ncsu.edu/research/evans_web/etd/klbass.pdf)

Cortell, J. 2002. Personal communication regarding Marine Biochemists aeration systems. [www.marinebiochemists.com](http://www.marinebiochemists.com).

Chapra, S.C. 1997. *Surface Water-Quality Modeling*. McGraw-Hill. New York.

Denison, D. and D. Tilton. 1993. Rouge River National Wet Weather Demonstration Program: Technical Memorandum. Rouge River Project: RPO-NPS-TM-12.01. August.

EC SWCD (Effingham County Soil and Water Conservation District). 2001. 2001 *County Transect Summary Reports*. Illinois Department of Agriculture.

FSA (Farm Service Agency). 1997. *Conservation Reserve Program: Continuous Sign-Up for High Priority Conservation Practices*. USDA. February.

Geney, R. 2002. Personal communication regarding GES aeration systems. [www.airation.com](http://www.airation.com).

Haith et al. 1996. GWLF: Generalized Watershed Loading Functions. Department of Agricultural and Biological Engineering. Cornell University. Ithaca, New York.

Hirschi, M.C. 2002. Personal e-mail regarding Altamont phosphorus data. February.

IDNR (Illinois Department of Natural Resources). 1996: Illinois Clearinghouse: Natural History Data. Download: Critical Trends Assessment Land Cover Database. <http://www.isgs.uiuc.edu/nsdihome/webdocs/st-naths.html>.

Illinois EPA (Illinois Environmental Protection Agency) 2002. Monitoring Water Quality Data Sheets.

\_\_\_\_\_. 2000. *Annual Illinois Water Quality Report, 2000*. IEPA/BOW/00-005

IPCB (Illinois Pollution Control Board). 1999. *Illinois Administrative Rules, Title 35: Environmental Protection; Part 302: Water Quality Standards*.

ISWS (Illinois State Water Survey). 2000. Pan Evaporation in Illinois. Download: Pan Evaporation in Illinois. [http://www.sws.uiuc.edu/atmos/statecli/Pan\\_Evap/PanEvap.htm](http://www.sws.uiuc.edu/atmos/statecli/Pan_Evap/PanEvap.htm).

- Johnson, R., R. Evans, and K. Bass. 1996. Constructed Wetlands Demonstration Project for NPS Pollution Control. North Carolina Department of Natural Resources: Division of Water Quality. <http://h2o.enr.state.nc.us/nps/edenton96.pdf>
- Kovosic, D.A., M.B. David, L.E. Gentry, K.M. Starks, and R.A. Cooke. 2000. Effectiveness of constructed wetlands in reducing N and P export from agricultural tile drainage. *J. Environmental Quality*. 29:1262-1274.
- Moore, J.A. 1993. Using Constructed Wetlands to Improve Water Quality. Oregon State University Extension Service, EC1408: June. <http://eesc.orst.edu/agcomwebfile/edmat/ec1408.pdf>
- Muir, D.B., M.M. King, M.R. Matson, G.L. Minton, S.P. Shasteen, M.D. Bundren, R.L. Hite, and L.J. Pitcher. 1997. An Intensive Survey of the Big Muddy River Basin – Summer 1995.
- NASS (National Agricultural Statistics Service). 2002. USDA-NASS-RDD Spatial Analysis Research Section. <http://www.nass.usda.gov/research/Cropland/SARS1a.htm>.
- NCDC (National Climatic Data Center). 2002. Weather stations.
- NCSU (North Carolina State University) Water Quality Group. 2000. National Management Measures to Control Nonpoint Source Pollution from Agriculture. United States Environmental Protection Agency: Contract #68-C99-249.
- \_\_\_\_\_. 1994. Functions of Wetlands (Processes). WATERSHEDSS. NCSU Water Quality Group. August.
- Novotny and Olem. 1994. *Water Quality: Prevention, Identification, and Management of Diffuse Pollution*. Van Nostrand Reinhold. New York.
- NRC (National Research Council). 1992. "Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy." *National Academy of Sciences*. Washington, D.C.
- NRCS (Natural Resources Conservation Service). 2002a. Personal Communication with Bart Pals of Effingham County NRCS.
- \_\_\_\_\_. 2002b. Farm Bill 2002: Wetlands Reserve Program Fact Sheet. <http://www.nrcs.usda.gov/programs/farmbill/2002/pdf/WRPFct.pdf>. May.
- \_\_\_\_\_. 2002c. Farm Bill 2002: Conservation of Private Grazing Land Program Fact Sheet. <http://www.nrcs.usda.gov/programs/farmbill/2002/pdf/CPGLFct.pdf>. May.
- \_\_\_\_\_. 2002d. Farm Bill 2002: Wildlife Habitat Incentives Program Fact Sheet. <http://www.nrcs.usda.gov/programs/farmbill/2002/pdf/WHIPFct.pdf>. May.
- \_\_\_\_\_. 2002e. The Environmental Quality Incentives Program. USDA. April.



\_\_\_\_\_. 2002f. 2001 Environmental Quality Incentives Program: Illinois Summary. <http://www.nrcs.usda.gov/programs/eqip/2001summaries/ILEQIP%20doc.pdf>. USDA. January.

\_\_\_\_\_. 1999. Filter Strip Conservation Practice Standard. National Resources Conservation Service: Code 393. May. <http://www.il.nrcs.usda.gov/resources/fotg/section4/393/393.pdf>

\_\_\_\_\_. 1994. Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater. Natural Resources Conservation Service (formerly Soil Conservation Service), U.S. Department of Agriculture, Washington, DC. <http://www.abe.msstate.edu/Tools/csd/p-dm/>

Olivera, Francisco et al. 1998. CRWR-PrePro: An ArcView Preprocessor for Hydrologic, Hydraulic and Environmental Modeling. Download: ArcView Project Prepro3a.apr. <http://www.ce.utexas.edu/prof/olivera/prepro/prepro.htm>.

Osmond, D.L., J. Spooner, and D.E. Line. 1995. Systems of Best Management Practices for Controlling Agricultural Nonpoint Source Pollution: The Rural Clean Water Program Experience. North Carolina State University Water Quality Control Group: brochure 6. March.

Sharpley, A.N., T. Daniel, T. Sims, J. Lemunyon, R. Stevens, and R. Parry. 1999. Agricultural Phosphorus and Eutrophication. United States Department of Agriculture: ARS-149. July. <http://www.ars.usda.gov/is/np/Phos&Eutro/phos%26eutro.pdf>

Short, Matthew B. 1999. Baseline Loadings of Nitrogen, Phosphorus, and Sediments from Illinois Watersheds: October 1980-September 1996. Illinois Environmental Protection Agency. Bureau of Water. Division of Water Pollution Control. Surface Water Selection. Central Monitoring Unit.

Simeral, K.D. 1998. Using Constructed Wetlands for Removing Contaminants from Livestock Wastewater. Ohio State University Fact Sheet. <http://ohioline.osu.edu/a-fact/0005.html>. May.

Tomkins, S. 1994. Section 319 Success Stories, Volume III: Lake Pittsfield Project. USEPA. [www.epa.gov/owow/nps/Section319III/IL.htm](http://www.epa.gov/owow/nps/Section319III/IL.htm).

USACE (U.S. Army Corps of Engineers). 2003. Lake Astabula/Baldhill Dam Brochure. <http://www.mvp.usace.army.mil/docs/rec/ashtabula.pdf>

\_\_\_\_\_. 1999a. National Inventory of Dams. Download: Reservoir Characteristics. <http://crunch.tec.army.mil/nid/webpages/nid.cfm>.

\_\_\_\_\_. 1999b. Simplified Procedures for Eutrophication Assessment and Prediction: User Manual. William Walker. Instruction Report W-96-2. Waterways Experiment Station. USACE Headquarters.

USDA (United States Department of Agriculture). 1999. Farm Service Agency Online: Conservation Reserve Program Fact Sheet. <http://www.fsa.usda.gov/pas/publications/facts/html/crp99.htm>. October.

\_\_\_\_\_. 1996. Restoring Wetlands with the Wetland Reserve Program. <http://www.il.nrcs.usda.gov/resources/farmbill/inahgeh.htm>.

\_\_\_\_\_. 1991. Soil Survey of Effingham County, Illinois. Washington D.C.

USEPA (U.S. Environmental Protection Agency). 2003. Applying for and Administering CWA Section 319 Grants: A Guide for State Nonpoint Source Agencies. State-EPA NPS Partnership. March. <http://www.epa.gov/owow/nps/319/319stateguide-revised.pdf>

USEPA. 2002a. *BASINS - Better Assessment Science Integrating Point and Nonpoint Sources*. Download: BASINS Data. <http://www.epa.gov/OST/BASINS/>.

\_\_\_\_\_. 2002b. *STORET – Storage and Retrieval*. Download: Water Quality Data. <http://www.epa.gov/storet/>.

\_\_\_\_\_. 2002c. Supplemental Guidelines for the Award of Section 319 Nonpoint Source Grants to States and Territories in FY 2003. EPA. August. <http://www.epa.gov/owow/nps/Section319/319guide03.html>

\_\_\_\_\_. 2001. *EPA Exposure Assessment Models: TMDL USLE*. Download: TMDL USLE Model and User's Manual. <http://www.epa.gov/ceampubl/swater/usle/index.htm>.

\_\_\_\_\_. 2000. *National Management Measures to Control Nonpoint Source Pollution from Agriculture*. Office of Water. USEPA Contract #68-C99-249.

\_\_\_\_\_. 1998. *Report of the Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program*. EPA/100/R/98/006. Office of Administrator. July.

\_\_\_\_\_. 1997. *Compendium of Tools for Watershed Assessment and TMDL Development*. Office of Water. EPA/841/B/97/006.

\_\_\_\_\_. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters: Management Measures for Wetlands, Riparian Areas, and Vegetated Treatment Systems. EPA 840-B-92-002. January. <http://www.epa.gov/nps/MMGI/Chapter7/ch7-2c.html>

USGS (U.S. Geological Survey). 2002a. Daily Streamflow. Download: Daily Flows for Stream Gage 05595820. <http://waterdata.usgs.gov/nwis>.

\_\_\_\_\_. 2002b. Seamless Data Distribution System. Download: National Elevation Dataset. <http://edcnts14.cr.usgs.gov/Website/seamless.htm>.

University of Illinois. 2004. Agronomy Handbook.  
<http://www.ag.uiuc.edu/iah/pdf/agronomy%20HB/11chapter.pdf>

Wetzel, R.G. 1983. Limnology. Saunders College Publishing. Orlando, Florida. pp. 289-297.

Whitton, K. 2002. Personal communication.

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