Appendix A: Upper Salem River Phase I Report

WATERSHED RESTORATION PLAN FOR THE UPPER SALEM RIVER WATERSHED: PHASE I

Final Report submitted to the Cumberland Salem Soil Conservation District
April 19, 2006

Rutgers Grant No. 4-24861

Rutgers Cooperative Research & Extension Water Resources Program
Prepared by Dr. Christopher C. Obropta, Ph.D., P.E. and Katie Buckley

In conjunction with:
The Cumberland Salem Conservation District
Rutgers Cooperative Research & Extension of Salem County

TABLE OF CONTENTS

FIGURES

TABLES

I. Introduction

A. Project Background

In 1987, the Clean Water Act established the section 319 Nonpoint Source Management Program (319(h)) which authorizes the U.S. Environmental Protection Agency (USEPA) to direct grant programs to distribute monies to states, territories, and tribes to improve the management of nonpoint source (NPS) pollution. New Jersey receives these funds because of the development of the Nonpoint Source Assessment Report produced by the State and the current Nonpoint Source Management Program. New Jersey is authorized to use these funds to implement projects and programs that will result in a reduction of NPS pollution (NJDEP, 2005a).

In June 2004, the New Jersey Department of Environmental Protection (NJDEP) provided the Cumberland-Salem Soil Conservation District, the Rutgers Cooperative Research & Extension (RCRE) Water Resources Program and RCRE of Salem County with funding to prepare Phase I of a Watershed Restoration Plan for the Upper Salem River Watershed. The Borough of Woodstown, Pilesgrove Township, and Upper Pittsgrove Township also participated and provided support for this effort. According to the NJDEP Division of Watershed Management, a Watershed Restoration Plan is a watershed-based plan designed to determine the necessary course of action to restore impaired waters. The plan must identify specific measures that will achieve the pollutant load reductions necessary to achieve water quality criteria (NJDEP, 2005b).

B. Project Goals

The overall goal of this project is to restore the water quality to the headwaters of the Salem River and Memorial Lake by reducing phosphorus and fecal coliform loading throughout the watershed. Phase I of this project is the initial step in the development of a comprehensive Watershed Restoration Plan that when implemented will achieve Total Maximum Daily Loads (TMDLs) reductions that are required to meet water quality standards for fecal coliform and phosphorus for these waterbodies.

C. Existing Regulations Guiding this Project

TMDLs have been defined by the NJDEP as the following:

"TMDLs represent the assimilative or carrying capacity of the receiving water, taking into consideration point and nonpoint sources of pollution, natural background, and surface water withdrawals (NJDEP, 2005c)*."*

The NJDEP has defined a protocol that involves comparing measured water quality data to the New Jersey Surface Water Quality Standards (N.J.A.C. 7:9B) to determine which waterways are impaired and require the development of a TMDL. Through the TMDL process, the necessary reductions of the pollutant or pollutants are calculated so that the designated uses can be met. As defined by the USEPA, "designated uses are the desirable uses that the water quality should support (USEPA, 2001)." The TMDL document contains several components including problem statement, numeric target, source analysis, loading capacity estimate, allocations, and implementation elements.

Although the TMDL identifies implementation elements, these implementation plans are typically very general and lack the detail needed to ensure that the necessary pollutant load reductions will be achieved to bring the waterway into compliance with State water quality standards. The Watershed Restoration Plan is intended to serve as a more detailed implementation plan for the TMDL. There are nine minimum requirements of a Watershed Restoration Plan, which are listed below:

a. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan and to achieve any other watershed goals identified in the watershed-based plan, as discussed in item (b) below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed.
b. An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above.
c. A description of the nonpoint source (NPS) management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map and description) of the critical areas in which those measures will be needed to implement this plan.
d. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan. Possible sources of funding include Section 319(h) Programs, the New Jersey Environmental Infrastructure Trust, U.S. Department of Agriculture's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.
e. An information/education component that will be used to enhance public understanding of the project and encourage the public's early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.
f. A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.
g. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS TMDL has been established, whether the NPS TMDL needs to be revised.
i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above (NJDEP, 2005b).

Phase I of this Watershed Restoration Plan includes a characterization of the watershed area through the use of Geographic Information Systems (GIS), development of a Quality Assurance Project Plan (QAPP), and an assessment of the Watershed Characterization. Phase II will build upon the foundation developed in Phase I to fully complete, at a minimum, the nine requirements outlined above.

II. Upper Salem River Watershed GIS Characterization

A. Watershed Background

New Jersey is divided into 20 watershed management areas. The Salem River Watershed lies within Watershed Management Area (WMA) 17, as show in Figure 1. WMA 17 encompasses Atlantic, Cumberland, Gloucester, and Salem Counties, all or portions of 38 municipalities, and 885 square miles of New Jersey. The largest rivers of WMA 17 include the Cohansey River, the Maurice River, and the Salem River.

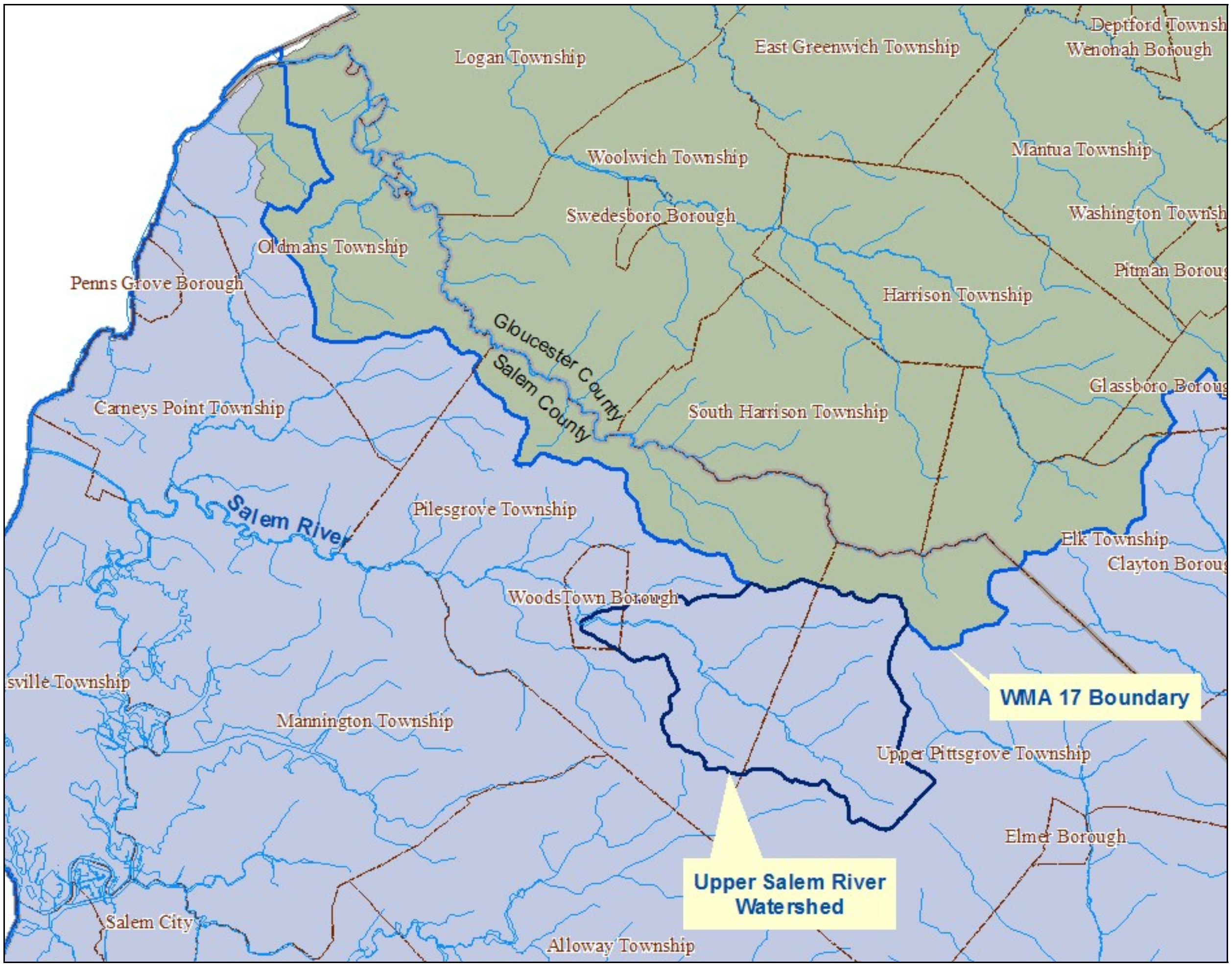


Figure 1: Location of the Salem River Watershed

The Salem River begins in Upper Pittsgrove Township and runs through Salem County to Pennsville Township where it discharges to the Delaware River. The entire Salem River Watershed is more than 110 square miles. The headwaters of this major river system have been designated as a priority waterbody for protection and restoration by the NJDEP. The Upper Salem River Watershed, for this project, has been determined as the drainage basin concluding at the United States Geological Survey (USGS) gaging station below Memorial Lake, 01482500 (see Figure 2). This basin is approximately 15 square miles in size and includes Upper Pittsgrove Township, Pilesgrove Township, and Woodstown Borough. The project watershed includes 20 miles of river. The entire drainage area lies within Salem County, New Jersey.

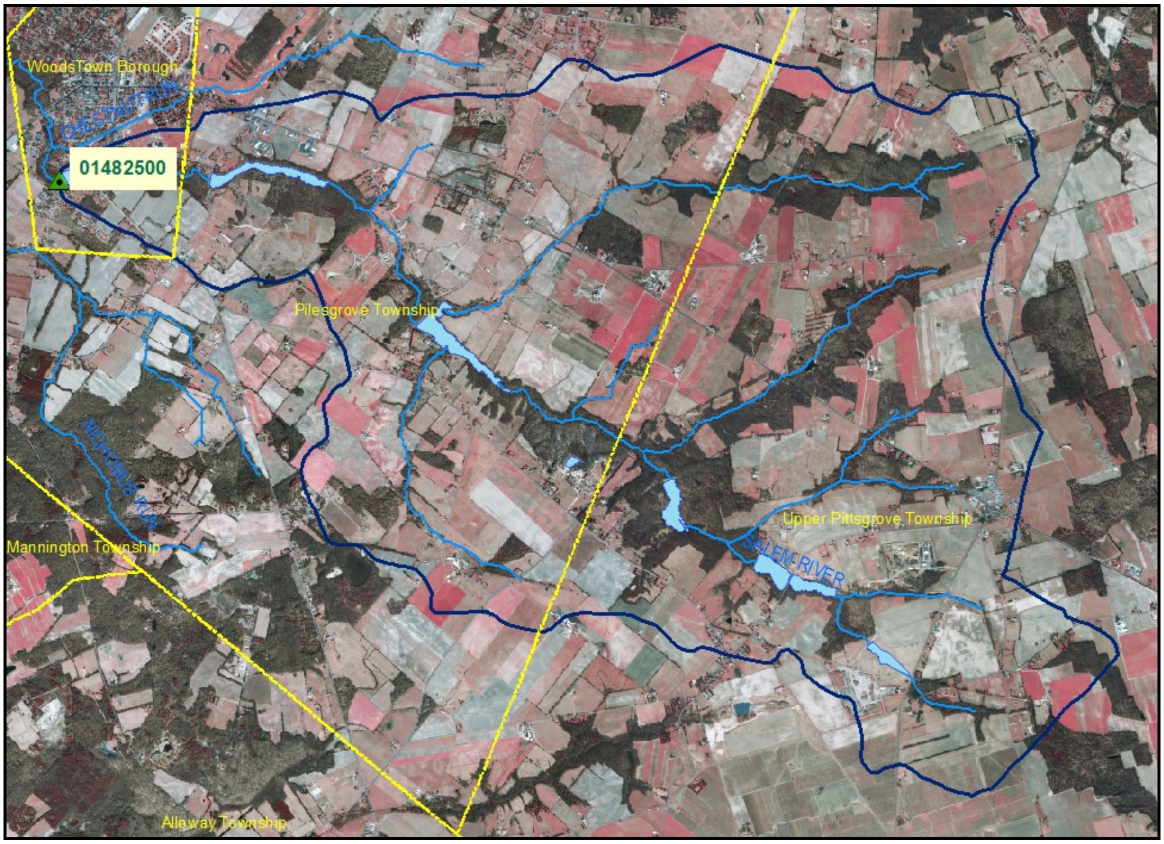


Figure 2: Upper Salem River Watershed Boundary

The highest elevations within the watershed are along the Salem County – Gloucester County boundary at approximately 150 feet above sea level. The average change in stream elevation from the headwaters to discharge to the mainstem Salem River is estimated as 53 feet.

B. Land Use/Land Cover

Land within the Upper Salem River Watershed has a variety of uses, according to NJDEP 1995 aerial orthophotography (NJDEP, 2001b). Agriculture land uses dominate this drainage basin, composing 68% of land use in the watershed (see Table 1). Remaining land uses include forest, wetland, urban areas and open water. Barren land, though an extremely small amount of the total watershed area, includes lands characterized by thin soil, sand, or rocks, and a lack of vegetative cover in a non-urban setting. If present, vegetation is dispersed through the area and not contiguous. Examples of barren land include natural areas such as beaches and rock faces; barren land may also include mining operations, landfill sites, and other types of disposal areas (Anderson *et al*., 2001).

Table 1: 1995/97 Land Use Data

1995 Land Use Type	Area (acres)	Area (square miles)	Land Use as a Percentage of the Watershed (%)
AGRICULTURE	*6,250.84*	*9.77*	*68%*
BARREN LAND	8.26	0.01	~0%
FOREST	991.61	1.55	11%
URBAN	819.88	1.30	9%
WATER	130.87	0.20	1%
WETLANDS	973.91	1.52	11%
TOTAL	9,175.36	14.35	100%

Based on 1995 land use classifications, more information can be gained by evaluating the several subcategories of land use as detailed in Table 2. Of the 68% of the land use which is agriculture in the watershed, 95% of this land use is cropland and pastureland, specifically nine square miles. Cropland and pastureland have been defined by the NJDEP as agricultural lands managed for the production of row and field crops and for cattle, sheep, and horse grazing. This land use category may also include lands left fallow or planted with soil improvement grasses and legumes. Land use category "Other Agriculture" includes experimental fields, horse farms, and isolated dikes and access roads (Anderson *et al*., 1976). The extent of agricultural land use types is displayed in Figure 3.

In the 1995 land use assessment, the NJDEP has included cropland/pastureland as one category. Additionally, this is true for orchards/nurseries/vineyards. Since 95% of agriculture falls under this "cropland/pastureland" designation, the project partners have begun to characterize agricultural land use as either cropland or pastureland. Aerial orthophotography taken in 2002 will be used, along with on-the-ground surveys, to identify the specific agricultural type. This data will enable the project partners to more appropriately evaluate and recommend best management practices (BMPs) for the watershed. This data layer will be made available to the NJDEP as a product of this Watershed Restoration effort.

Table 2: 1995/97 Land Use/Land Cover Type

1995 Land Use Type	1995 Land Use	Area (acres)	Land Use as a Percentage of the Watershed (%)
AGRICULTURE	CONFINED FEEDING OPERATIONS	9.70	0.10
AGRICULTURE	*CROPLAND AND PASTURELAND*	*5,895.38*	*63.15*
AGRICULTURE	ORCHARDS/VINEYARDS/NURSERIES/HORTICULTURAL AREAS	88.26	0.95
AGRICULTURE	OTHER AGRICULTURE	257.50	2.76
BARREN LAND	TRANSITIONAL AREAS	8.26	0.09
FOREST	CONIFEROUS BRUSH/SHRUBLAND	24.69	0.26
FOREST	CONIFEROUS FOREST (>50% CROWN CLOSURE)	4.43	0.05
FOREST	DECIDUOUS BRUSH/SHRUBLAND	16.39	0.18
FOREST	*DECIDUOUS FOREST (>50% CROWN CLOSURE)*	*804.55*	*8.62*
FOREST	DECIDUOUS FOREST (10-50% CROWN CLOSURE)	62.62	0.67
FOREST	MIXED DECIDUOUS/CONIFEROUS BRUSH/SHRUBLAND	62.95	0.67
FOREST	MIXED FOREST (>50% CONIFEROUS WITH >50% CROWN CLOSURE)	6.98	0.07
FOREST	MIXED FOREST (>50% CONIFEROUS WITH 10%-50% CROWN CLOSURE)	2.46	0.03
FOREST	MIXED FOREST (>50% DECIDUOUS WITH 10-50% CROWN CLOSURE)	6.54	0.07
FOREST	OLD FIELD (< 25% BRUSH COVERED)	160.23	1.72
URBAN	ATHLETIC FIELDS (SCHOOLS)	25.32	0.27
URBAN	COMMERCIAL/SERVICES	62.17	0.67
URBAN	INDUSTRIAL	74.00	0.79
URBAN	OTHER URBAN OR BUILT-UP LAND	73.85	0.79
URBAN	RECREATIONAL LAND	60.00	0.64
URBAN	RESIDENTIAL, HIGH DENSITY, MULTIPLE DWELLING	3.20	0.03
URBAN	*RESIDENTIAL, RURAL, SINGLE UNIT*	*398.31*	*4.27*
URBAN	RESIDENTIAL, SINGLE UNIT, LOW DENSITY	86.17	0.92
URBAN	RESIDENTIAL, SINGLE UNIT, MEDIUM DENSITY	19.59	0.21
URBAN	TRANSPORTATION/COMMUNICATIONS/UTILITIES	17.28	0.19

Table 2 Continued

1995 Land Use Type	1995 Land Use	Area (acres)	Land Use as a Percentage of the Watershed (%)
WATER	*ARTIFICIAL LAKES*	*127.05*	*1.36*
WATER	NATURAL LAKES	1.67	0.02
WATER	STREAMS AND CANALS	2.15	0.02
WETLANDS	AGRICULTURAL WETLANDS (MODIFIED)	278.80	2.99
WETLANDS	CONIFEROUS WOODED WETLANDS	1.02	0.01
WETLANDS	DECIDUOUS SCRUB/SHRUB WETLANDS	59.35	0.64
WETLANDS	*DECIDUOUS WOODED WETLANDS*	*575.02*	*6.16*
WETLANDS	DISTURBED WETLANDS (MODIFIED)	12.47	0.13
WETLANDS	FORMER AGRICULTURAL WETLAND (BECOMING SHRUBBY, NOT BUILT-UP)	4.99	0.05
WETLANDS	HERBACEOUS WETLANDS	17.18	0.18
WETLANDS	MANAGED WETLAND IN MAINTAINED LAWN GREENSPACE	6.96	0.07
WETLANDS	MIXED FORESTED WETLANDS (CONIFEROUS DOM.)	1.16	0.01
WETLANDS	MIXED FORESTED WETLANDS (DECIDUOUS DOM.)	13.72	0.15
WETLANDS	MIXED SCRUB/SHRUB WETLANDS (CONIFEROUS DOM.)	1.62	0.02
WETLANDS	WETLAND RIGHTS-OF-WAY (MODIFIED)	1.63	0.02
	TOTAL	**9,335.59**	**100.00**

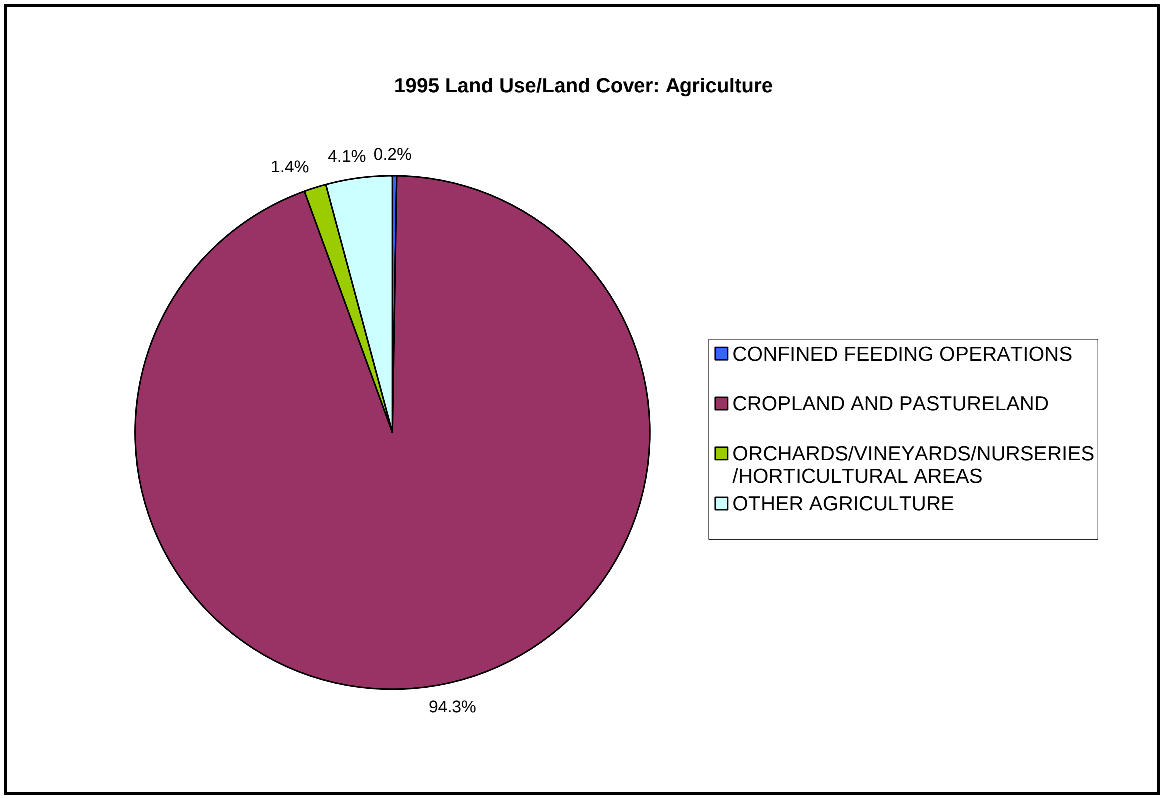


Figure 3: Distribution of Agricultural Land Uses in the Upper Salem River Watershed

C. Projected Land Uses within the Watershed

A build out analysis is a useful land planning tool, which uses zoning data to evaluate the impact of future land use. The build out analysis was completed using ArcGIS. Zoning data were obtained from the municipalities of the watershed. The municipal boundaries and the existing land use/land cover were obtained from NJDEP's GIS 1995/97 database. These data sets were merged into an ArcGIS file so that data could easily be manipulated to account for build out conditions.

The build out analysis only considers developable lands or increased density in lands that are already developed. Lands that have been defined as "environmentally constrained" were not considered developable and therefore were eliminated from the build out analysis. The NJDEP has defined environmentally constrained areas as the following:

> *"Environmentally constrained area" means the following areas where the physical alteration of the land is in some way restricted, either through regulation, easement, deed restriction or ownership such as: wetlands, floodplains, threatened and endangered species sites or designated habitats, and parks and preserves* (N.J.A.C. 7:8-1.2).

As per this definition, 33% of the watershed is constrained. Sixty-seven percent (9.7 square miles) will undergo a change in land use given the data that was used in this build out analysis. As much as possible, additional data including local park space and farmland preservation was collected and used for this analysis.

Any parcels of land that were identified as developable were changed to the most intensive land use for the particular zone where the developable parcel was located. For example, if a parcel of land was currently forested but located in Zone AR-1 (residential zone – single unit residential), the land was converted to rural, single unit residential (NJDEP Land Use Code 1140). Also, if a parcel is already developed at a higher density than the zoning ordinances allow, the build out analysis assumes that the parcel of land will remain at that more intense land use. For example, some areas zoned for AR-1 were already developed in a manner that was determined to be commercial by the NJDEP who developed the land use data set. This area, then, remained commercial (NJDEP Land Use Code 1200) and was an exception within that municipal zone.

Table 3 describes how the areas that were found to be "unconstrained" are anticipated to be developed given the zoning data and preserved land information. As described in the table, there is a large loss of cropland/pastureland and deciduous forest where there is a projected growth of residential areas and commercial services. In terms of "Other Agriculture (NJDEP Land Use Code 2400)," there existed many areas where the zoning information was more general than the available land use type as identified by the NJDEP. Therefore, for areas zoned for agriculture, if the land was existing agriculture, the land use was projected to continue on as that land use. However, if the area zoned for agriculture was of a different land use, such as forest, then "Other Agriculture" was used rather than assuming a specific type of agriculture.

Table 3: Change in Land Use from 1995 to Build Out Using Zoning Data (Unconstrained Lands Only)

LAND USE TYPE	LAND USE ID	LAND USE LABEL	EXISTING AREA (ACRES)	BUILD OUT AREA (ACRES)	CHANGE IN LAND USE (ACRES)	TOTAL CHANGE IN LAND USE TYPE (ACRES)
AGRICULTURE	1800	OTHER AGRICULTURE	0.00	154.48	154.48	
	2100	CROPLAND AND PASTURELAND	4,344.60	3,578.47	-766.13	
	2200	ORCHARDS/VINEYARDS/NURSERIES/HORTICULTURAL AREAS	84.56	80.43	-4.13	
	2300	CONFINED FEEDING OPERATIONS	7.45	7.45	0.00	
	2400	OTHER AGRICULTURE (Unspecified agriculture from zoning.)	206.07	469.44	263.37	***-352.40***
BARREN LAND	7500	TRANSITIONAL AREAS	6.33	0.00	-6.33	***-6.33***
FOREST	4110	DECIDUOUS FOREST (10-50% CROWN CLOSURE)	47.84	0.60	-47.24	
	4120	DECIDUOUS FOREST (>50% CROWN CLOSURE)	520.68	0.49	-520.19	
	4220	CONIFEROUS FOREST (>50% CROWN CLOSURE)	4.19	0.00	-4.19	
	4311	MIXED FOREST (>50% CONIFEROUS WITH 10%-50% CROWN CLOSURE)	2.23	0.00	-2.23	
	4312	MIXED FOREST (>50% CONIFEROUS WITH >50% CROWN CLOSURE)	5.64	0.00	-5.64	
	4321	MIXED FOREST (>50% DECIDUOUS WITH 10-50% CROWN CLOSURE)	6.52	0.00	-6.52	
	4410	OLD FIELD (< 25% BRUSH COVERED)	133.04	0.00	-133.04	
	4420	DECIDUOUS BRUSH/SHRUBLAND	7.42	0.00	-7.42	
	4430	CONIFEROUS BRUSH/SHRUBLAND	21.38	0.00	-21.38	
	4440	MIXED DECIDUOUS/CONIFEROUS BRUSH/SHRUBLAND	33.73	0.00	-33.73	***-781.58***
URBAN	1110	RESIDENTIAL, HIGH DENSITY, MULTIPLE DWELLING	3.20	97.44	94.24	
	1120	RESIDENTIAL, SINGLE UNIT, MEDIUM DENSITY	16.51	64.43	47.92	
	1130	RESIDENTIAL, SINGLE UNIT, LOW DENSITY	73.84	46.80	-27.05	
	1140	RESIDENTIAL, RURAL, SINGLE UNIT	358.63	1,028.41	669.78	
	1200	COMMERCIAL/SERVICES	57.01	269.29	212.28	

Table 3 Continued

LAND USE TYPE	LAND USE ID	LAND USE LABEL	EXISTING AREA (ACRES)	BUILD OUT AREA (ACRES)	CHANGE IN LAND USE (ACRES)	TOTAL CHANGE IN LAND USE TYPE (ACRES)
URBAN	1300	INDUSTRIAL	69.43	69.43	0.00	
	1400	TRANSPORTATION/COMMUNICATIONS/UTILITIES	15.28	0.08	-15.20	
	1700	OTHER URBAN OR BUILT-UP LAND	65.84	46.11	-19.73	
	1800	RECREATIONAL LAND	50.27	230.43	180.16	
	1804	ATHLETIC FIELDS (SCHOOLS)	25.21	23.13	-2.09	***1,140.32***
WATER	5200	NATURAL LAKES	0.32	0.32	0.00	
	5300	ARTIFICIAL LAKES	14.19	14.19	0.00	***0.00***

D. Characterization of the Soils within the Watershed

The U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) maintains an inventory of soil series descriptions and locations for the entire nation. Soils information for the watershed was extracted from the NRCS Official Soil Series Description database located at http://soils.usda.gov/technical/classification/osd/index.html. The soils queried were chosen according to the GIS layers produced by the NRCS on a county-wide basis; this dataset is often referred to as SSURGO data, Soil Survey Geographic data. The Salem SSURGO data was produced in 2002 and used for this characterization. Table 4 lists the soils, soil properties, and approximate percent of coverage within the Upper Salem River Watershed.

Table 4: Soils of the Upper Salem River Watershed

Map Unit Symbol	Soil Characteristics	Area (acres)	Percent of Watershed
AdkB	Adelphia sandy loam, 2 to 5 percent slopes	5.95	0.06
AhmB	Alloway sandy loam, 2 to 5 percent slopes	10.96	0.12
AhpB	Alloway loam, 2 to 5 percent slopes	347.71	3.72
AhpC	Alloway loam, 5 to 10 percent slopes	33.92	0.36
AhrA	Alloway silt loam, 0 to 2 percent slopes	40.82	0.44
AhrB	Alloway silt loam, 2 to 5 percent slopes	406.65	4.36
AugB	Aura sandy loam, 2 to 5 percent slopes	124.64	1.34
AugC	Aura sandy loam, 5 to 10 percent slopes	53.73	0.58
AuhC	Aura gravelly sandy loam, 5 to 10 percent slopes	13.92	0.15
AupB	Aura loam, 2 to 5 percent slopes	202.79	2.17
ChsAt	Chicone silt loam, 0 to 1 percent slopes, frequently flooded	742.91	7.96
ChtA	Chillum silt loam, 0 to 2 percent slopes	22.75	0.24
ChtB	Chillum silt loam, 2 to 5 percent slopes	2,560.27	27.42
DoeB	Downer sandy loam, 2 to 5 percent slopes	46.52	0.50
EveC	Evesboro sand, 5 to 10 percent slopes	12.61	0.14
FodB	Fort Mott loamy sand, 0 to 5 percent slopes	1.85	0.02
GabB	Galestown sand, 0 to 5 percent slopes	52.54	0.56
HboA	Hammonton sandy loam, 0 to 2 percent slopes	12.58	0.13
MakAt	Manahawkin muck, 0 to 1 percent slopes, frequently flooded	33.81	0.36
MbrB	Matapeake silt loam, 2 to 5 percent slopes	62.90	0.67
MbrC	Matapeake silt loam, 5 to 10 percent slopes	282.76	3.03
MbuA	Mattapex silt loam, 0 to 2 percent slopes	282.91	3.03
MbuB	Mattapex silt loam, 2 to 5 percent slopes	1,214.16	13.01
MbxB	Mattapex-Urban land complex, 0 to 5 percent slopes	2.24	0.02
MutA	Muttontown sandy loam, 0 to 2 percent slopes	104.65	1.12
OTKA	Othello and Fallsington soils, 0 to 2 percent slopes	1,386.08	14.85
OTMA	Othello, Fallsington, and Trussum soils, 0 to 2 percent slopes	127.63	1.37
PEEAR	Pedricktown, Askecksy, and Mullica soils, 0 to 2 percent slopes	33.73	0.36
PHG	Pits, sand and gravel	2.26	0.02

Map Unit Symbol	Soil Characteristics	Area (acres)	Percent of Watershed
SacB	Sassafras sandy loam, 2 to 5 percent slopes	572.25	6.13
SacC	Sassafras sandy loam, 5 to 10 percent slopes	224.24	2.40
Water	Water	125.67	1.35
WoeA	Woodstown sandy loam, 0 to 2 percent slopes	187.21	2.01
	Total Acres	9,335.58	100.00
	Total Square Miles	14.59	

Throughout the Upper Salem River Watershed, the soils are gently sloping complexes of silt loam, sandy loam, and loam. The upper limit of the water table of the region varies monthly, but can be expected to range from 0.0 feet (at surface) to more than 6.0 feet below the surface. The depth to water table and the restricted permeability of the soils limit uses of the soils in the watershed. For instance, according to N.J.A.C. 7:9 Subchapter 10, almost 60% of the soils in the watershed are “very limited” for onsite wastewater disposal treatment due to depth to zone of saturation. Also, 55% of the watershed is limited for building dwellings with basements. In addition, almost 50% of the watershed’s soils are described as hydric. The hydric soils of the watershed follow the river system and exist in the natural floodplain. Specific site conditions may differ from this soil survey information. Appendix A includes maps that spatially describe soil limitations in the watershed.

E. Flooding Conditions in the Watershed

Sources of Floodplain Information

There are several sources of floodplain information. The NJDEP Floodplain Management Office maintains information on available studies that have delineated floodplains specific to a watershed or municipality boundary. This list is limited according to where work has been completed and is not a full account of floodplain information across the state. A second source of data is available from the Federal Emergency Management Agency (FEMA). FEMA produces floodplain maps to identify floodplains and risks of developing within certain areas of the floodplain. Unfortunately, these FEMA panels are old and a Map Modernization effort is being made to update the floodplain information to reflect new development and natural changes in the environment. New maps will also incorporate edited data and new or improved technologies that have located flood hazard areas. Currently, these floodplain maps do not include the highest potential accuracy given available technologies, but are a legal document which are often relied upon by many municipalities for floodplain ordinances and so forth. Finally, the State of New Jersey, in 1995, produced a GIS data set of “floodprone areas.” The areas are delineated by risk of flooding: 1) moderate potential for flooding and 2) high potential for flooding. This data set is not as reliable as the FEMA data; for that reason, it was not used for this project.

<u>*The Upper Salem River Watershed Floodplain*</u>

Contacts were made with the NJDEP Floodplain Management Office. According to conversations with that office in November of 2005, no floodplain mapping is available through the office for this watershed. Since most of the data that are collected by the NJDEP Floodplain Management Office is associated with new development, it was expected that little data would be available from this source.

The next data to consider is from FEMA. The existing data show areas that are predicted to be inundated during the 100-year storm; this is shown in Figure 4 and mapped in Appendix B. The majority of flooded areas include the forested buffer along stream reaches. There are very few residential and commercial areas that exist in the 100-year floodplain based on the FEMA data and an analysis of 2002 aerial imagery.

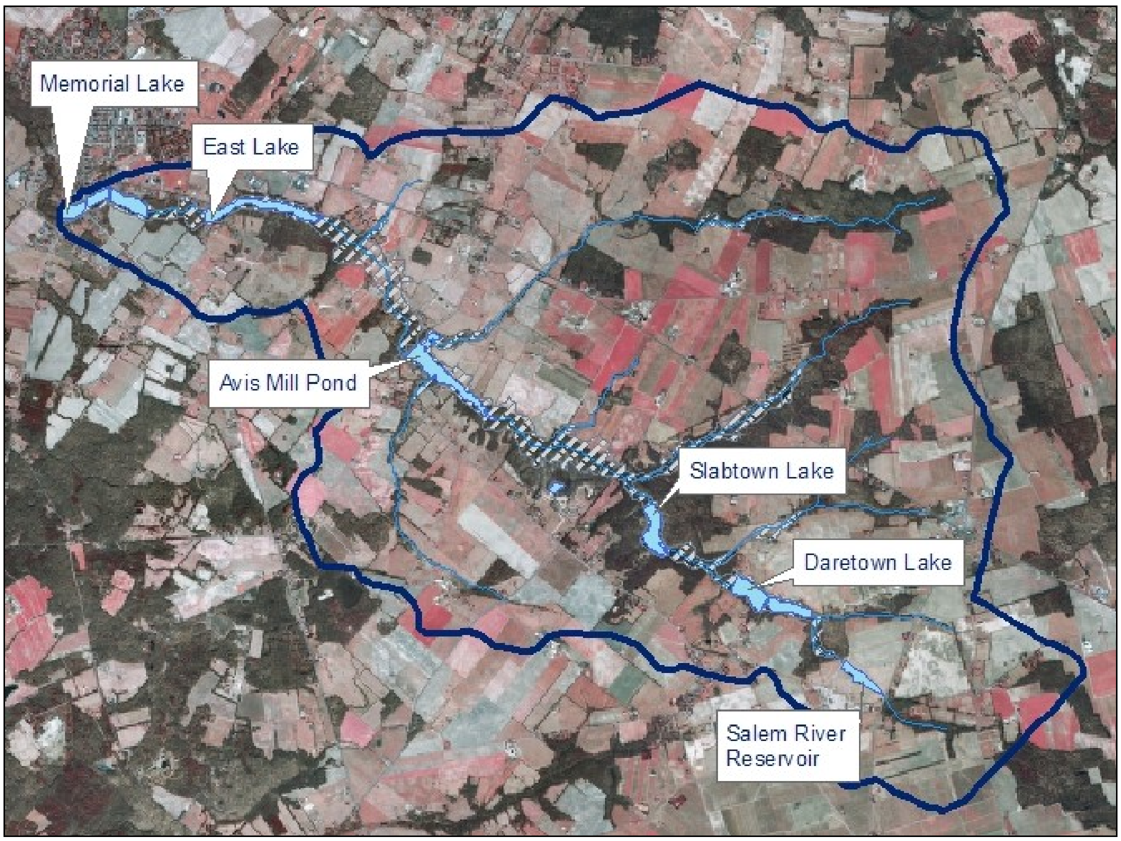


Figure 4: Areas Inundated by 100-Year Storm

Some road crossings are also included within the 100-year flood zone as predicted by FEMA; this list has been modified to incorporate personal history of the area. The roads likely to be flooded by the 100-year storm include the following:

- Daretown Road, Upper Pittsgrove Township,
- Fox's Mill Road, Upper Pittsgrove Township,
- Slabtown Road, Upper Pittsgrove, Township,

- Fox Road, Pilesgrove Township, and
- East Lake Road, Pilesgrove Township.

F. Groundwater Recharge and Wellhead Protection

1. Groundwater Recharge

Groundwater recharge is defined as that water that can penetrate the ground and will reach the groundwater table not considering the underlying geology. The methodology that is employed to calculate the potential recharge of a system is taken from the New Jersey Geological Survey report GSR-32, "A Method of Evaluating Ground-Water-Recharge Areas in New Jersey" (Charles *et al*., 1993).

GIS coverage of the groundwater recharge data was assembled by the New Jersey Geological Survey and can be found with the Upper Salem River Watershed boundary in Appendix A.

The recharge coverages were generated by overlaying the soil, land use/land cover (LULC) and the municipality coverages. The values that represent the ability of the ground to recharge precipitation were determined through the use of the following equation:

groundwater recharge = (recharge factor x climate factor) - recharge constant.

The recharge factor and recharge constant are established through the examination of the LU/LC and the soils series. The climate factor is governed by the location of the municipality and is a ratio of precipitation to potential evapotranspiration (French, 2003).

The highest ranking groundwater recharge area in the Upper Salem River Watershed exists in Pilesgrove Township along Avis Mill Road. This area of approximately 50 acres recharges 13 – 15 inches of rain per year and is depicted in Figure 5 using NJDEP 2002 aerial orthophotography.

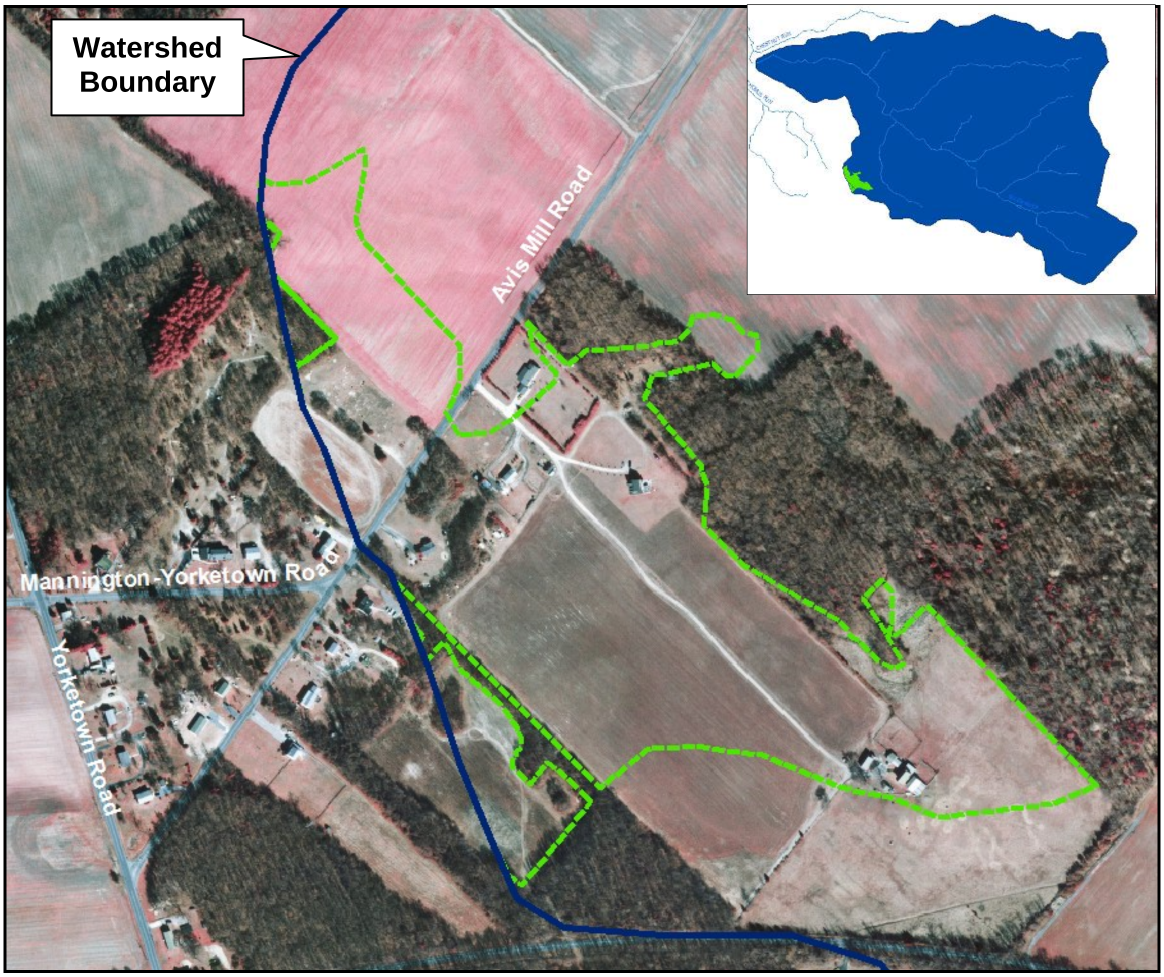


Figure 5: Area of Highest Groundwater Recharge in the Upper Salem River Watershed

The majority of other lands within the watershed will recharge 9 – 12 inches per year. By further examining the recharge estimates and acreage within the watershed, it is calculated that the Upper Salem River Watershed recharges at a minimum 1.6 billion gallons of rainwater each year, assuming 45 inches of rainfall per year. The full extent of groundwater recharge throughout the drainage area is featured in Appendix A.

2. Wellhead Protection

A Well Head Protection Area (WHPA) in New Jersey is an area calculated around a Public Community Water Supply Well in the State that delineates the horizontal extent of groundwater that is drawn by that well pumping at a specific known rate over a two-, five-, and twelve-year period of time for confined wells. The delineation is performed by a qualified hydrologist by using several approved methods put forth in the open-file report published by the New Jersey Geological Survey (Spayd and Johnson, 2003). The Well Head Protection Area Map can be found in Appendix A.

Two public community water supply wells exist within the watershed. Both are owned by Woodstown Borough Water Department. These wells are Tier 1, meaning that there is a 2-year travel time before the groundwater reaches the well.

There are many other wells within the watershed. These wells are privately owned and are critical to the agricultural resources within the watershed. According to agricultural water use certifications, there are 42 groundwater irrigation wells used by the agricultural community within the watershed. Several of these wells may be distributed on one property. These certified wells each have the capability of pumping 100,000 gallons per day; the wells may not use the full extent of this certification.

G. Environmentally Constrained and Environmentally Critical Areas

The definition of "Environmentally Constrained" and "Environmentally Critical" areas are contained in N.J.A.C. 7:8-1.2. Environmentally constrained areas, as mentioned above, refer to areas where the physical alteration of the land is in some way restricted, such as through regulation, easement or deed restriction. These could include floodplains, threatened and endangered species sites and parks and preserves, among others. An environmentally critical area is defined as an area that is of significant environmental value, such as stream corridors, large areas of contiguous open space, or groundwater recharge areas.

Environmentally constrained areas of the Upper Salem River Watershed are depicted in Appendix A. A wetland buffer of twenty-five feet was prepared to denote the constrained area related to a wetland, as per the Freshwater Wetland regulations (N.J.A.C. 7:7A). To define areas where threatened or endangered species have been sighted, the New Jersey Landscape Project data was used. The Landscape Project ranks areas of the State based on suitable habitat for a threatened or endangered species and occurrences of threatened and endangered species. Suitable habitats and critical habitats are defined by a protocol developed by the NJDEP, which is available online at http://www.state.nj.us/dep/fgw/ensp/landscape. Areas that had recorded occurrences of at least one threatened or endangered species (Ranks 3-5) in the watershed were included as constrained areas. These priority areas included Critical Forest Wetland Habitat and Critical Emergent Wetland Habitat. No habitat-specific areas exist within this drainage area which would represent habitat specific for peregrine falcon or the wood turtle. Farmland preservation areas, local park information, and county park data was acquired through the Rutgers University Center for Remote Sensing and Spatial Analysis (CRSSA). Approximately 28% of the watershed is environmentally constrained, mostly due to farmland preservation areas and buffered tributaries of the Salem River.

Appendix A also includes a map of the Environmentally Critical Areas of the watershed. To represent the locations that are of significant environmental value, several GIS layers were evaluated. For the large areas of contiguous open space or upland forest, the critical habitat layer was used. In this layer, the NJDEP located all contiguous forest that intersected major road ways. Please note these data are from 1995 and may not represent newer development. Stream corridors are represented by a fifty foot buffer around the streams, using Stream Encroachment Regulations and the Flood Hazard Area Control Act for FW2, or fresh waters.

III.Upper Salem River Watershed Visual Assessment

A. Stream Visual Assessment Protocol (SVAP) Data Collection

Stream Visual Assessment Protocol (SVAP) is just the first step in a hierarchy of methods used to characterize watershed health. After a baseline visual assessment, it is important to further document watershed characteristics and assess the health of a system through biological and chemical means. The SVAP process is an inexpensive method of beginning to collect data within a project area. The process, however, can be labor-intensive and is created for use with those familiar with the watershed. Training was provided to all participants in the visual assessment process. The SVAP was used as the first step in assessing the Upper Salem River Watershed health.

The assessments for this project were completed from May through August of 2005. Seventy-three reaches were assessed within this 15 square-mile watershed. A reach, for this project's purposes, was defined as a stretch of stream that had similar characteristics throughout and no clear change in conditions or obstructions in flow pattern. For instance, a reach of similar characteristics may be determined to end at the nearby overpass, where flow is channelized and thus, the bridge structure alters the conditions of the streambank and streambed. Based on stream reach lengths and river miles, almost 70% of all stream reaches were covered during this assessment. The total stream miles do not include those reaches where access was limited.

The SVAP ranks stream conditions for several stream and riparian elements using a quantitative scoring system for elements that often may be considered qualitative. The scores are ranked from worst (1) to best (10) for the majority of parameters. The numeric system allows for easy organization, data sorting, and an average can be calculated for overall score. Listed below are the elements scored in the Upper Salem River Watershed assessment process and a short description of each element:

- Channel Condition: evaluates anthropogenic impacts on the stream channel and the potential for the stream to recover from these impacts.
- Hydrologic Alteration: rates the frequency that the stream accesses the floodplain. This category is best scored with the landowner or someone familiar with flooding conditions at this location. Where a landowner was not present, this category was left blank.
- Riparian Zone: rates not only the width of the riparian buffer relative to channel width, but also the diversity and extent of natural vegetation within the buffer.

- Bank Stability: recognizes the importance of stable stream channel versus one that is eroding, downcutting, or undercut.
- Water Appearance: determines whether the stream is clear, turbid, or pea-green. This category is scored only after a stream has settled after a precipitation event.
- Nutrient Enrichment: evaluates not only the clarity and color of the water, but also the amount of algae on substrate within the stream. This category should be scored as if it is under sunny, warm conditions (but can be performed during any season).
- Instream Fish Cover: numerically rates the habitat opportunities for fish to survive within the stream. Instream fish cover includes overhanging vegetation, logs, undercut banks, pools, and riffles.
- Invertebrate Habitat: numerically rates habitat opportunities for macroinvertebrates. Types of invertebrate habitat include fine woody debris, submerged logs, cobble, boulders, course gravel, undercut banks, and leaf packs.
- Manure Presence: this category rates the potential and presence of manure at the reach. The potential includes the presence of a manure storage facility within the floodplain.
- Riffle Embeddedness: measures the inundation of stream substrate with sediment by evaluating the percentage of the rock/cobble/gravel covered in sand and silt within the streambed. This category should not be scored unless riffles are present. Riffles are referred to as agitated areas of stream flow where a stream is passing over rocks (usually downstream from pools) (USDA, 1998).

Using the categories listed above and a scoring range as indicated in the USDA Stream Visual Assessment Protocol, a score is given for each parameter and averaged to yield an overall score. The following range and description is used:

< 6.0	Poor
6.1-7.4	Fair
7.5-8.9	Good
>9.0	Excellent

Using the SVAP, impaired reaches of stream are rated as to their degree of degradation in regards to bank erosion, water appearance, health and presence of riparian buffer, and so on. The stream reach is also photo-documented and given a location with a global positioning system (GPS). The original SVAP has been adapted to include more anthropogenic influences, such as the inclusion of identification and assessment of pipes and ditches. Pipes and ditches that may be altering stream condition and quality are included as an important feature to this assessment process. The appearance of flow, erosion of ditch lining, or potential for a pipe to be flowing during dry weather (illicit connection) is included in the data collection.

Across the watershed, the majority of the categories above have been scored. Hydrologic alteration was difficult to score without the aid of the landowner; therefore, this category was often not rated. Overall, the Upper Salem River Watershed received a "good" rating of a 7.2. This average score is not weighted by stream length.

IV. Results of the Visual Assessment Process

A. SVAP Results

As described in Table B-1 of Appendix B, bank stability is a serious concern in many areas of the Upper Salem River Watershed with a score that is well below the rating of "poor." Channel modification, describing signs of past stream alteration and recovery, is often thought to be related to streambank stability since oftentimes streambank modification requires the removal of vegetation and trees which provide the stream with structure. However, the 73 assessed locations showed no linear relationship of bank stability versus channel modification. In analyzing 72 locations for a relationship between bank stability and water appearance, there was a strong correlation of $r^2 = 0.80$.

Even more significant, however, the visual assessment process resulted in a positive correlation between bank stability and nutrient enrichment (similar reasoning behind assessment score as water appearance). In a regression analysis that evaluated multiple SVAP categories and their individual relationship to nutrient enrichment, it was found that bank stability is highly correlated to nutrient enrichment ($r^2 = 0.93$). According to this analysis, it was also found that SVAP observations of riparian zone and bank stability were not linearly related ($r^2 = 0.38$). These last two statements demonstrate some very important points. Eroding banks may be contributing nutrient-adsorbed particles to the stream, resulting in nutrient-rich, green waters. Finally, for an area with highly erodible soils, riparian zone protection may not be enough to control stream bank erosion.

Manure presence is not a category scored unless signs of manure are located at the site or there exist signs of animal access to stream, including deer or livestock tracks. Where manure is present, the SVAP score can range between a 3 or 1 depending on the extent of manure and the location within the floodplain. A manure presence score of 5 is given to areas where livestock has access to the riparian zone or there are signs of tracks of wildlife or livestock (USDA, 1998). Knowing the wildlife and species within the watershed and the habitats of these species, one can assume the type of animal that would be present and perhaps identify some controls. Therefore, based on the combination of scores for manure presence and canopy cover, watershed managers could ascertain the source or possibility of pathogen source that exists within the reaches where this data is available. For instance, in the areas where canopy cover was consistently rated a 10 and manure presence was rated 5, deer or other wildlife could be an assumed source of fecal contamination within that stream reach. This was the case for 40 of 73 assessments. For the Upper Salem River Watershed, all instances where manure presence was scored less than 5, canopy cover was scored "poor." These two categories enable watershed managers to determine the type of fecal contamination that may be occurring within the watershed and target these specific areas for restoration efforts including streambank plantings (to deter resident Canada geese) or livestock fencing (to keep livestock from entering the stream). An example of such a location is depicted in Figure 6.

Figure 6: Example Reach of Low Manure Presence Score and Low Canopy Cover Score

B. SVAP Scores and Land Use

1. Subwatershed Scale

Of the 21 subwatersheds, of which 14 were assessed, there is no statistically significant correlation between land use and overall SVAP site average scores (see Figure 7). Where other researchers have found percent forested area within a catch basin to be a substantial indicator of watershed quality (Potter *et al.*, 1993), this assessment process has revealed an r^2 equal to 0.51 in a univariate linear model with overall site average score for physical quality. Percent wetlands within the subwatershed area were found to be only somewhat correlated to overall site average score ($r^2 = 0.48$).

A multivariate linear regression was performed using SPSS for Windows (Version 14.0), a statistical software package. The analysis showed that overall site average scores could not be statistically correlated to land use on a subwatershed scale. A regression analysis was used to determine that water appearance scores were correlated with land uses (commercial, agricultural, and urban) at $r^2 = 0.50$.

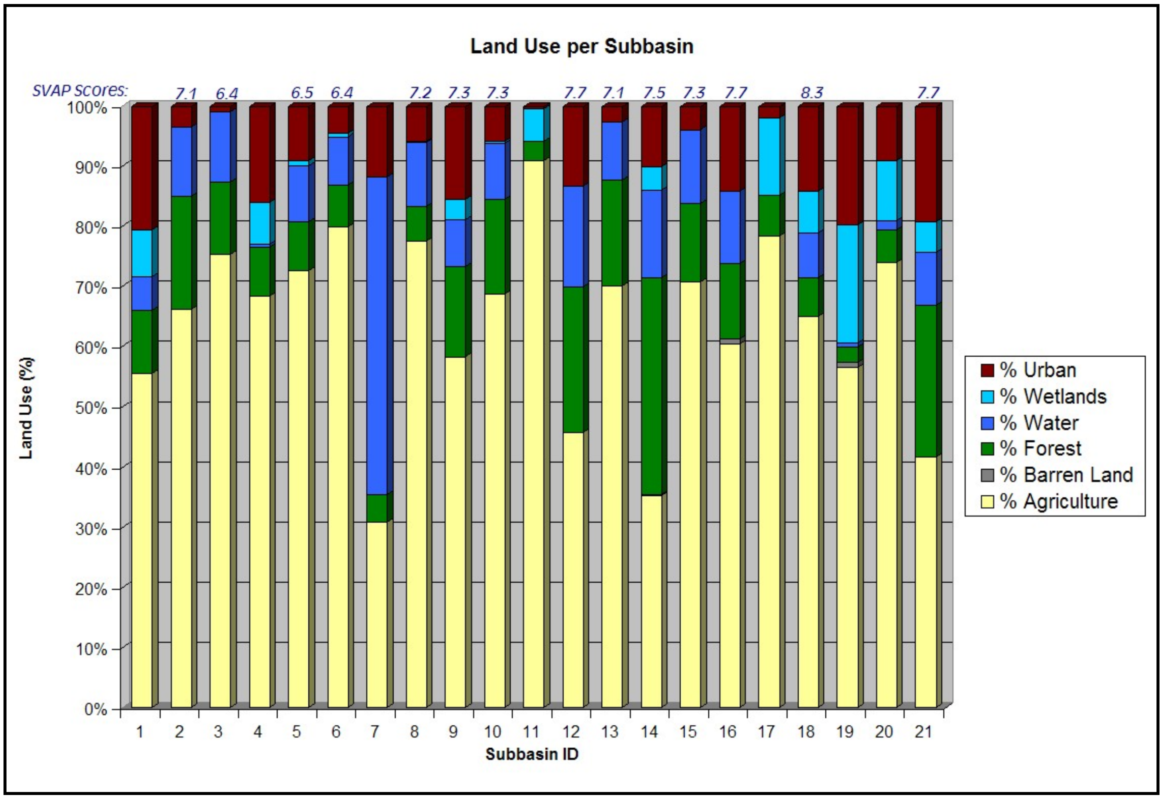


Figure 7: Land Use per Subbasin and Overall SVAP Site Average Score

2. Land Use Adjacent to Reach

The lack of strong correlation (greater than 95%) between watershed land use and SVAP scores raises the question of scales. If land use relationships are to be defined, perhaps it is not on a subwatershed level, but within the riparian corridor. All 73 SVAP locations have a designated land use at the reach being assessed. This question of scale is similar to that asked by Potter *et al.* (2004). In evaluating NPS pollution risk in North Carolina watersheds, a group of researchers evaluated landscape characteristics at multiple scales (i.e., the entire watershed and the riparian zone) along both sides of the stream. Potter's research found that the percent of forest cover at the watershed scale and in the riparian zone were both highly correlated with tolerant aquatic invertebrates and water quality degradation ($r^2 = 0.776$). The amount of development was found to be a statistically significant predictor of macroinvertebrate tolerance of water quality degradation; whereas, at a riparian scale, the amount of development was not (Potter *et al*., 2004).

For this SVAP analysis the active land use, as determined by 1995 NJDEP aerial photography, has been associated with each stream reach.
Table 5 evaluates land use at the assessment reach and the overall score. In general, land use adjacent to the stream reach being assessed is an important factor in stream health.

Table 5: Immediate Land Use Classification and Mean SVAP Score

1995 Land Use	Count	Mean SVAP Score
Agriculture	5	6.8
Forest	12	7.0
Wetlands	55	7.3

When land use is described in more detail, the number of sites per land use decreases, though more information may be extracted from this type of data output. A comparison of means across overall SVAP average site scores and their adjacent detailed land use is described in Table 6. This table describes some interesting findings of this SVAP effort in the Upper Salem River Watershed. In evaluating a reduced set of parameters, the analysis demonstrates the following:

- Assessments performed in modified agricultural wetlands dominate the lowest means across SVAP categories and hold the lowest overall site average at 6.14.
- Cropland and pastureland have "fair" riparian corridors (average left and right bank, 7.50), whereas, forested areas with 10-50% crown closure show a lack of native, diverse riparian zones. This low score within the thinner forested area is most likely a result of score deductions due to the presence of invasive species.
- Water appearance is lowest not along cropland and pastureland, but in the managed wetland areas in maintained lawn and greenspace (5.00).
- Cropland and pastureland did show the lowest score for channel modification, which may indicate a lack of recovery from any in-stream modifications. In this very agricultural watershed, it is not surprising that modifications to the stream have been found in this assessment due to historical practices of damming streams for irrigation ditches. A lack of recovery shows that little effort may be in place to restore the streams to their "natural" condition, or that drainage ditches or tile drains continue to prohibit streambank recovery. Old fields, where brush has returned to 25% of the land area, have demonstrated this recovery by a higher score of 6.55.
- The overall highest score is at stream reaches within deciduous scrub/shrub wetlands at 7.50, a rating of "good." The next two highest scores include mixed forested wetlands and deciduous wooded wetlands. This showing of high scores within wetland land uses stresses the importance of wetlands in this watershed in preserving the health of the stream.

Table 6: Adjacent Land Use and SVAP Score Evaluation

LULC at stream reach		Channel Modification	Riparian Zone-left	Riparian Zone-right	Bank Stability-left	Bank Stability-right	Water Appearance	Nutrient Enrichment	Canopy Cover	Site Average
AGRICULTURAL WETLANDS (MODIFIED)	Mean	5.67	4.00	3.67	4.00	4.33	6.33	6.67	Incor-rect data	6.14
	N	3	3	3	3	3	3	3		3
	Std. Deviation	1.15	3.46	3.79	2.65	2.08	1.15	.58		.91
CROPLAND AND PASTURELAND	Mean	4.60	7.20	7.80	4.60	4.20	6.40	6.20	10.00	6.79
	N	5	5	5	5	5	5	5	5	5
	Std. Deviation	2.70	1.92	1.10	.89	.45	.89	.45	.00	.56
DECIDUOUS BRUSH/ SHRUBLAND	Mean	5.00	5.00	8.00	3.00	2.00	6.00	7.00	7.00	6.25
	N	1	1	1	1	1	1	1	1	1
	Std. Deviation	.	.	.	.	.	.	.	.	.
DECIDUOUS FOREST (>50% CROWN CLOSURE)	Mean	5.86	6.86	7.00	4.43	4.43	6.43	6.71	9.57	7.02
	N	7	7	7	7	7	7	7	7	7
	Std. Deviation	3.13	2.79	1.91	2.51	2.76	1.13	.95	1.13	1.12
DECIDUOUS FOREST (10-50% CROWN CLOSURE)	Mean	5.00	3.00	2.00	3.00	1.00	7.00	7.00	10.00	6.63
	N	1	1	1	1	1	1	1	1	1
	Std. Deviation	.	.	.	.	.	.	.	.	.
DECIDUOUS SCRUB/SHRUB WETLANDS	Mean	6.00	8.00	8.00	7.00	7.00	8.00	8.00	10.00	7.50
	N	1	1	1	1	1	1	1	1	1
	Std. Deviation	.	.	.	.	.	.	.	.	.
DECIDUOUS WOODED WETLANDS	Mean	6.94	7.81	7.71	4.92	4.35	6.63	6.44	9.29	7.41
	N	48	48	48	48	48	48	48	48	48
	Std. Deviation	2.23	1.04	1.66	2.35	2.36	1.00	.90	1.77	.63
MANAGED WETLAND IN MAINTAINED LAWN GREENSPACE	Mean	6.00	4.00	9.00	1.00	6.00	5.00	6.00	10.00	7.18
	N	1	1	1	1	1	1	1	1	1
	Std. Deviation	.	.	.	.	.	.	.	.	.
MIXED FORESTED WETLANDS (DECIDUOUS DOM.)	Mean	7.00	8.50	9.00	5.50	5.50	8.00	7.50	8.50	7.48
	N	2	2	2	2	2	2	2	2	2
	Std. Deviation	2.83	.71	.00	.71	3.54	.00	.71	2.12	2.83
OLD FIELD (< 25% BRUSH COVERED)	Mean	6.33	8.33	8.00	4.33	5.67	6.33	6.67	9.00	7.13
	N	3	3	3	3	3	3	3	3	3
	Std. Deviation	.58	.58	1.00	2.31	1.53	.58	.58	1.73	.15
Total	Mean	6.55	7.42	7.49	4.78	4.48	6.59	6.51	8.85	7.24
	N	73	73	73	73	73	73	73	73	73
	Std. Deviation	2.29	1.78	1.96	2.28	2.32	1.00	.87	2.56	.72

V. Assessment of the Watershed Characterization

A. Conclusions based on Stream Visual Assessment Scores

In this assessment covering 70% of stream miles, the reliability of a stream visual assessment process has been tested. This visual assessment process is a first step in characterizing watershed health. This protocol provides a cost-effective tool to help stakeholders identify problem areas within their local watershed.

Based on observations from this analysis, there are several changes that could refine the SVAP for improved use in New Jersey. First and foremost, riparian corridor is a valued parameter in this protocol as this field enables managers to associate areas with improved filtering of runoff. Bioassimilation within the riparian zone is an effective method in the prevention of the impact of pollutants from agriculture land uses. Riparian corridors can influence storage capacity, aquifer recharge, primary and secondary productivity, and the dilution, modification, incorporation of concentration of pollutants before entering the river system (Osborne and Kovacic, 1993). For New Jersey streams, the riparian score analysis in SVAP may be overshadowed by the measure of invasive species within the floodplain. The riparian zone score is not solely based on width of riparian zone versus active channel width, but also should include the presence of abundant and diverse native species within the riparian zone, consisting of herbaceous plants, understory, and overstory (USDA, 1998). Unless the invasive species is similar to the native species, this protocol purposefully excludes these plants as being a beneficial part of the riparian zone. Invasive plants, by definition, can be native or nonnative, but will out-compete surrounding vegetation and lead to a decrease in biodiversity among other environmental, ecological, and hydrogeomorphological factors. An invasive species that was often cited during field work was Japanese Knotweed, *Fallopia japonica*. Knotweed, whether Japanese, Himalayan, giant, or other hybrid, is a creeping perennial that spreads quickly to form dense clusters that shade other low-growing species and preclude natural revegetation of a normally diverse native species assemblage (USACE, 2006). As the biodiversity of the riparian corridor changes with an invasion of an exotic species, so do the hydrogeomorphical properties of the floodplain. The true nature of the hydrogeomorphological change will be a function of what native species the Knotweed is replacing (Tickner *et al.*, 2001). The Knotweed could lessen the bank stability provided by deep-rooted, diverse species but that has not been well-documented. However, defining a separate parameter to estimate the density of invasive species within the floodplain may improve the effectiveness of rating the riparian zone.

Bank stability is also a critical factor in stream corridor management, and from this analysis, bank stability is understood to be a streambank component that needs improvement and further consideration for management. The relationships defined concerning streambank stability, water appearance, and nutrient enrichment may be clues to sources of nutrients in the Upper Salem River Watershed. The surface water quality sampling that will be conducted in Phase II of this project may reveal more information as to the relationship between streambank erosion and nutrient enrichment and water appearance. Sediment loading and deposition are one of the most serious water quality problems throughout the world (Osborne and Kovacic, 1993). Management of sediment-bound nutrients in surface runoff and perhaps in the streambanks may make an improvement for the nutrient enrichment and water appearance scores over the long-term.

Additionally, this visual assessment data should be related to indices of biological integrity (IBI) when this information is collected during Phase II of the Upper Salem River Watershed Restoration Plan. There may be relationships that can be identified between the impact of humans on land use, observed stream degradation, and biological integrity. Associations have been made between human activities, in-stream stressors, and change in biological communities, as demonstrated by many researchers (Yuan and Norton, 2004).

Finally, statistical analyses are needed to better identify a relationship between SVAP scores and land use/land cover. Only a multivariate linear regression analysis was completed for this portion of the work. Further analysis may include weighting parameters, log linear statistics, and multiple response scenarios.

B. Existing and Potential Water Quality Pollutants and Sources of Pollutants

1. The Integrated Report

Background

One goal of watershed management is to ensure that the existing water quality meets all water quality standards and criteria. Under the Federal Clean Water Act (CWA), Section 303(d) and 305(b), each state is mandated to identify impaired waters where designated uses of the waterway are not supported by the water quality. Pursuant to the CWA, the N.J.A.C. 7:9B Surface Water Quality Standards set the required water quality for each waterbody according to its designated use. The NJDEP then compares measured water quality data to the standards to determine which waterways are impaired and require the development of a TMDL. Through the TMDL process, the necessary reductions of the pollutant or pollutants will be calculated so that the designated uses can be met.

Pursuant to the CWA, the NJDEP summarized water quality in the State in its biennial report entitled “New Jersey’s Water Quality Inventory Report” or 305(b) report. The State also prepared a list of impaired waterbodies to meet 303(d) requirements; this report was entitled “Identification and Setting of Priorities for 303(d) requirements under Section 303(d)(1)(A) of the Federal Clean Water Act” and was most recently submitted in 1998.

In 2002, the USEPA recommended that each state produce an integrated list combining both 305(b) and 303(d). The resulting report for New Jersey is known as the *New Jersey 2004 Integrated Water Quality Monitoring and Assessment Report* (Integrated Report). This report summarizes the Integrated List as it pertains to use classifications set for the waterbodies of New Jersey. The Integrated List is comprised of unique Sublists 1 through 5 and adds a priority recommendation to each impaired reach. Waterbodies are placed on Sublists based on NJDEP’s results when they compare observed water quality data to water quality standards. The various Sublists are as follows:

Sublist 1 suggests that the waterbody is meeting water quality standards.

Sublist 2 states that a waterbody is attaining some of the designated uses, and no use is threatened. Furthermore, Sublist 2 suggests that data are insufficient to declare if other uses are being met.

Sublist 3 maintains a list of waterbodies where there exists a lack of data or information to support an attainment determination.

Sublist 4 lists waterbodies where use attainment is threatened and/or a waterbody is impaired; however, a TMDL will not be required to restore the waterbody to meet its use designation.

Sublist 4a includes waterbodies that have a TMDL developed and approved by the USEPA, that when implemented, will result in the waterbody reaching its designated use.

Sublist 4b establishes that the impaired reach will require pollutant control measurements taken by local, state, or federal authorities that will result in full attainment of designated use.

Sublist 4c states that the impairment is not caused by a pollutant, but is due to factors such as instream channel condition and so forth. It is recommended by the USEPA that this list be a guideline for water quality management actions that will address the cause of impairment.

Sublist 5 clearly states that the water quality standard is not being attained and requires a TMDL (NJDEP, 2003a).

This report also includes a schedule of TMDLs and other actions to be undertaken in the following two-year period, a list of waterbodies delisted in 2004, and a Comparison Document which summarizes changes between the 2002 and 2004 Sublists.

In assembling the Integrated List, the NJDEP reviews all existing and available data as required. The NJDEP is committed to using only data with acceptable quality assurance to develop the Integrated Report (NJDEP, 2003a). Further information regarding the quality assurance needed for data inclusion in the Integrated Report can be found in the General Data Requirements section of *Integrated Water Quality Monitoring and Assessment Methods.*

The Integrated List and the Salem River

In the Upper Salem River Watershed, there has been a limited amount of chemical monitoring data available for inclusion in the Integrated List. However, two active biomonitoring stations exist. These biomonitoring stations are two of approximately 800 stations monitored by the NJDEP's Bureau of Freshwater & Biological Monitoring known as the Ambient Biomonitoring Network (AMNET) (NJDEP, 1996). Data collected from these monitoring locations are used to evaluate streams for biological impairment as indicated by New Jersey Impairment Score (NJIS). The two sites within the Upper Salem River Watershed were monitored in 1995 and in 2000.

Table 7 lists these two AMNET locations and their assessment results. Assessment results can be defined as non-impaired, moderately impaired, and severely impaired.

> **Non-impaired** is defined by a benthic community comparable to other undisturbed streams within the region. The community is characterized by maximum taxa richness, balanced taxa groups, and good representation of intolerant individuals.
>
> **Moderately impaired** describes a macroinvertebrate community whose richness has been reduced, in particular, pollutant-intolerant species. There may also be a reduced community balance and numbers of pollutant-intolerant taxa.
>
> **Severely impaired** refers to a benthic community dramatically different from those in less impaired situations; macroinvertebrates are dominated by a few taxa with many individuals and only pollutant-tolerant individuals are present (NJDEP, 1996).

Table 7: AMNET Locations in the Upper Salem River Watershed

Site ID	Station Name	1995 Results	2000 Results
AN0690	Salem River, Commissioner's Road (Route 581), Upper Pittsgrove Township, Salem County, Alloway Quad	Moderately Impaired	Moderately Impaired
AN0691	Salem River, Mill Street (Outlet of Memorial Lake), Woodstown, Salem County, Woodstown Quad	Severely Impaired	Moderately Impaired

(NJDEP, 1996 and NJDEP, 2001a)

AMNET Station AN0690, according to NJDEP protocol, can be classified as non-attainment, which will designate this site on Sublist 5. Though moderately impaired, this station is an inclusive sample, meaning it was collected between April and November and meets the protocol for a non-attainment determination.

The location of the Salem River AMNET Station AN0691 below Memorial Lake will necessitate further data collection as per NJDEP protocol, which states that moderately impaired sites immediately below lakes and wetlands are to be classified as "further assessment required" and placed on Sublist 3 (NJDEP, 2003a).

Starting with the second round of sampling under the AMNET program, habitat assessments were conducted in conjunction with the biological assessments. The first round of sampling under the AMNET program did not include habitat assessments. The habitat assessment, which was designed to provide a measure of habitat quality, involves a visual based technique for assessing stream habitat structure. The findings from the habitat assessment are used to interpret survey results and identify obvious constraints on the attainable biological potential within the study area. The habitat assessment is designed to provide an estimate of habitat quality based upon qualitative estimates of selected habitat attributes. The assessment involves the numerical scoring of ten habitat parameters to evaluate instream substrate, channel morphology, bank structural features, and riparian vegetation. Each parameter is scored and summed to produce a total score which is assigned a habitat quality category of optimal, sub-optimal, marginal, or poor. Sites with optimal/excellent habitat conditions have total scores ranging from 160 to 200; sites with suboptimal/good habitat conditions have total scores ranging from 110 to 159; sites with marginal/fair habitat conditions have total scores ranging from 60 to 109, and sites with poor habitat conditions have total scores less than 60. AN0690, in 2000, was rated as having an optimal habitat (score of 163) and AN0691 had suboptimal conditions (score of 147) (NJDEP, 2003a).

As discussed previously, a waterbody must meet water quality standards that are based on the designated use of that waterbody. Similar to a stream, a lake may also be characterized according to the designated uses including aquatic life, recreational (human health and aesthetic quality), drinking water supply, shellfish harvesting, lake trophic status, fish consumption, industrial water supply, and agricultural water supply. For both lakes and streams, each designated use has a specific assessment method and criteria determining the non-attainment, insufficient data, and full attainment status. In the Upper Salem River Watershed, all streams are classified as FW2-NT/SE1. “FW-2” is a general classification for fresh waters that are not FW1, those waters set aside for their posterity due to aesthetic value, exceptional recreational significance, exceptional water supply significance, exceptional fisheries, or unique ecological significance. “NT” refers to the waterway being nontrout. Finally, “SE1” is a general surface water classification applied to saline waters (waters having salinities greater than 3.5 parts per million at mean high tide) or estuaries. The FW2-NT/SE1 combination of two classifications denotes a waterway in which there may be a saltwater/freshwater interface (NJDEP, 2003b). As for the lakes of the watershed, these waterbodies are not individually identified in N.J.A.C. 7:9B and are greater than five acres in size. According to regulation, these waterbodies are FW2-NT. Appendix A includes a map of waterbodies and their surface water quality classification information. Table 8 includes the surface water quality standard for both fecal coliform and total phosphorus for FW2-NT waters, according to N.J.A.C. 7:9B.

Table 8: New Jersey Surface Water Quality Standards

Substance	**Criteria**
Total phosphorus (mg/L)	[FW2] Lakes: Phosphorus as total P shall not exceed 0.05 in any lake, pond, or reservoir, or in a tributary at the point where it enters such bodies of water, except where watershed or site-specific criteria are developed pursuant to N.J.A.C. 7:9B-1.5(g) 3.
	[FW2]

	Streams: Except as necessary to satisfy the more stringent criteria in accordance with "Lakes" (above) or where watershed or site-specific criteria are developed pursuant to N.J.A.C. 7:9B-1.5(g) 3, phosphorus as total P shall not exceed 0.1 in any stream, unless it can be demonstrated that total P is not a limiting nutrient and will not otherwise render the waters unsuitable for the designated uses.
Fecal Coliform (Counts of colonies/100 mL)	[FW2] Shall not exceed geometric average of 200/100 mL, nor should more than 10% of the total samples taken during any 30-day period exceed 400/100 mL.

Table 9 has been derived from the Integrated Report. This table defines both lakes and streams of the watershed that are monitored and have been included in the NJDEP 2004 Integrated List of Impaired Waterbodies.

Table 9: 2004 Integrated List of Impaired Waterbodies in the Upper Salem River Watershed

Sublist	Station Name/ Waterbody	Site ID	Parameters	Data Source
1	Salem River at Woodstown	01482500	Temperature, pH, Dissolved Oxygen, Nitrate, Dissolved Solids, Total Suspended Solids, Unionized Ammonia	NJDEP/USGS Data
3	Salem River at Mill Street in Woodstown	AN0691	Benthic Macroinvertebrates	NJDEP AMNET
4	Memorial Lake	Memorial Lake	Phosphorus	NJDEP Clean Lakes, NJDEP Fish Tissue Monitoring
4	Salem River at Woodstown	01482500	Fecal Coliform	NJDEP/USGS Data
5	4 Seasons Campground Pond	Four Seasons	Fecal Coliform	Salem County Health Department
5	Memorial Lake	Memorial Lake	Fish-Mercury	NJDEP Clean Lakes, NJDEP Fish Tissue Monitoring
5	Salem River at Newkirk Station Rd in Upper Pittsgrove	*AN0690A	Benthic Macroinvertebrates	NJDEP AMNET

5	Salem River, Commissioner's Road (Route 581), Upper Pittsgrove Township	ANO690	Benthic Macroinvertebrates	NJDEP AMNET
5	Salem River at Woodstown	01482500	Phosphorus	NJDEP/USGS Data

** AN0690A was listed in the NJDEP 2004 Integrated Report rather than AN0690. Using the NJDEP Integrated List GIS data sets and reports and maps available from the NJDEP Bureau of Freshwater & Biological Monitoring, no further information is available for an AN0690A AMNET Station located at Newkirk Station Road in Upper Pittsgrove.*

As stated earlier in this section, Sublist 5 waterbodies are not meeting water quality standards, and a TMDL is necessary to determine pollutant removal needed for standards to be met. Appendix A spatially describes the surface water classifications and existing water quality monitoring stations in the watershed.

TMDLs in the Upper Salem River Watershed

The USGS gaging station 01482500, Salem River at Woodstown, is on sublist 4 and has an approved TMDL for fecal coliform. The TMDL will require an 84% reduction of fecal coliform loads in the watershed on 17.9 miles of stream. As per the TMDL document, sources may include uncontrolled runoff from dairy farms, horse farms, poultry farms, and large Canada geese populations at Avis Mill Pond and Memorial Lake (referred to in the TMDL as Woodstown Lake). Additionally, the TMDL document states that septic systems, or onsite wastewater treatment systems (OWTS), which exist throughout the watershed may also be a source of fecal pollution. Other than Woodstown Borough, the remaining municipalities of the watershed rely on OWTS for wastewater treatment. The TMDL recommends fecal coliform sampling throughout the watershed to narrow the scope of impairment (NJDEP, 2003c).

As for phosphorus, the TMDL addressing this impairment is not yet complete. According to the schedule for TMDL development and the Memorandum of Agreement between the NJDEP and the USEPA, there is no specific date for the development of this mandate (NJDEP, 2003a).

2. Point Source and Nonpoint Source Pollution in the Watershed

In the Upper Salem River Watershed, as in other watersheds, the quality of the water is affected by both point and nonpoint sources. Point sources are regulated by the NJDEP and must meet stringent water quality standards. Point sources include wastewater treatment plants and municipal separate storm sewer systems (MS4s), which are both regulated through the New Jersey Pollutant Discharge Elimination System

(NJPDES) permit program. Nonpoint sources are typically considered stormwater runoff from agricultural or natural lands, septic system discharges, and atmospheric deposition. The effect of point source and nonpoint source pollution on water quality is vital to developing a comprehensive watershed restoration plan.

Aerial Load Analysis

In quantifying the types and volume of pollutants that relate to land use, an Aerial Load Analysis was conducted on the Upper Salem River Watershed using the Soil and Water Assessment Tool (SWAT) hydrological modeling software to delineate the watershed into 21 subwatersheds that represent areas draining to significant tributaries or significant reaches of the stream. These 21 subwatersheds have been combined to form 13 subwatersheds so that resulting analyses based on these areas can be both more meaningful and more manageable. The 10-meter digital elevation grid produced by the NJDEP for each watershed was used to guide this process (NJDEP, 1992). Figure 8 represents the subwatershed delineation used for the purpose of aerial loading evaluations. The original subwatersheds are named 1-21, whereas the combined subwatersheds are represented alphabetically, A through P (no I or O subwatershed).

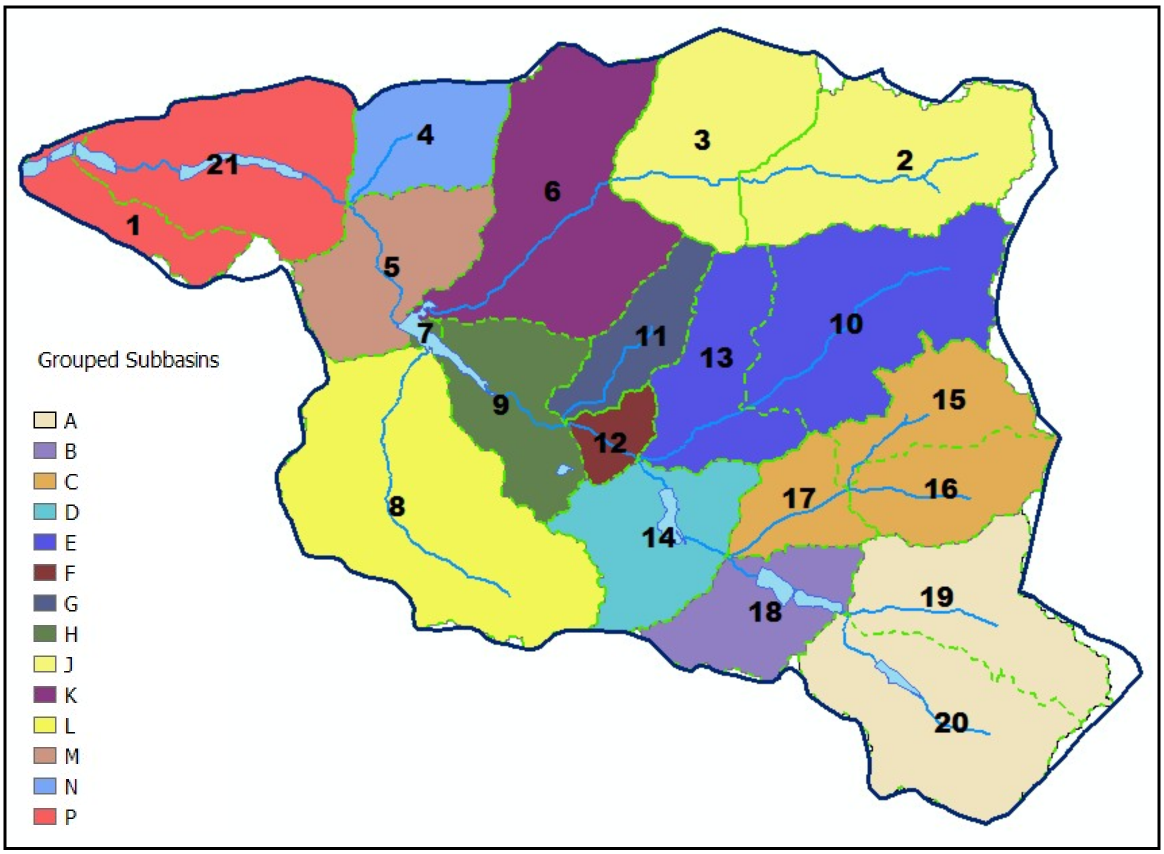


Figure 8: Subwatershed Delineations of the Upper Salem River Watershed

The Aerial Load Analysis was based on aerial pollutant export loading coefficients, UL_c. These coefficients were used to estimate pollutant loads for various land uses within the Upper Salem River Watershed. The aerial pollutant export loading coefficient for each pollutant and each land use are shown in Appendix C. These values were compiled from the New Jersey Stormwater Best Management Practices Manual and from current literature sources (NJDEP, 2004). The parameters that were evaluated as a part of this process are as follows: total phosphorus (TP), total nitrogen (TN), total suspended solids (TSS), ammonia nitrogen (NH_3-N), lead, zinc, copper, cadmium, biochemical (biological) oxygen demand (BOD), chemical oxygen demand (COD), and nitrite plus nitrate ($NO_2 + NO_3$). The land use maps for each subwatershed are from the 1995/97 NJDEP GIS layer. Annual pollutant loads for each subwatershed were then calculated using the loading equation:

$$\textbf{Load} = \textbf{UL}_{\textbf{c}} \times \textbf{Area.}$$

Load is in units of pounds of pollutant per year (lbs/yr); UL_c is in units of pounds per acre per year (lbs/acre/yr) for each specific land use. *Area* is quantified in acres for each specific land use. The loading equation provides an approximation for annual pollutant loads from nonpoint sources and MS4s on a subwatershed basis. This allows for the comparison of pollutant loading between subwatersheds and provides a method by which to prioritize subwatersheds for improvements and/or preservation. Table 10 presents estimated pollutant loads from land use within each subwatershed. The subwatershed areas have been ranked according to highest expected loads. Using this strategy for prioritizing subwatershed areas, it is found that Subwatershed A has the highest loading rate for nutrients and TSS.

Table 10: Pollutant Loads Calculated According to 1995/97 Land Use for Each Subwatershed

Sub-watershed	TP	TN	TSS	NH3-N	LEAD	ZINC	COPPER	CADMIUM	BOD	COD	NO2+ NO3
	lbs/year	*lbs/year*	*lbs/year*	*lbs/year*	*lbs/year*	*lbs/year*	*lbs/year*	*lbs/year*	*lbs/year*	*lbs/year*	*lbs/year*
A	1,257.07	10,362.27	275,299.50	50.94	217.87	225.79	127.01	0.26	17,709.07	7,550.90	200.16
B	353.89	2,903.14	79,187.79	18.44	54.13	47.89	30.21	0.03	5,151.32	3,196.95	56.65
C	833.78	6,860.86	188,245.08	38.86	83.11	83.84	47.29	0.04	11,682.77	11,239.95	113.77
D	249.80	2,479.15	58,408.80	28.15	65.02	47.73	37.85	0.04	5,619.80	4,105.12	125.34
E	1,056.27	8,781.76	246,368.83	3.18	71.79	84.05	39.74	0.00	14,954.66	797.19	94.43
F	75.47	695.97	16,904.14	16.96	35.43	22.26	17.79	0.02	1,765.24	1,865.40	46.96
G	274.47	2,153.82	63,618.89	0.02	15.25	19.14	6.35	0.00	3,414.67	37.77	5.77
H	358.56	3,112.81	78,658.81	87.01	178.57	110.10	86.68	0.12	7,867.62	9,378.57	208.87
J	1,144.10	9,513.63	268,234.11	0.54	68.52	85.32	36.36	0.00	16,148.08	628.51	96.97
K	909.51	7,214.77	210,025.18	1.11	57.35	68.38	27.91	0.00	11,604.19	224.65	31.86
L	1,170.48	9,334.59	268,825.32	16.41	98.58	101.77	49.40	0.02	15,435.90	2,144.37	75.23
M	447.20	3,593.90	102,196.09	13.27	53.04	47.30	26.94	0.02	6,207.79	1,451.01	45.61
N	310.88	2,508.27	69,405.45	16.46	46.67	39.29	25.71	0.02	4,407.99	2,789.57	43.85
P	730.20	6,684.32	152,235.97	178.87	277.79	191.52	157.04	0.21	15,202.36	34,643.15	438.30
Total (lbs/year)	9,171.67	76,199.25	2,077,613.95	470.23	1,323.12	1,174.37	716.29	0.79	137,171.46	80,053.13	1,583.78
Total (tons/year)	4.59	38.10	1,038.81	0.24	0.66	0.59	0.36	0.00	68.59	40.03	0.79

Subwatershed H, however, has the highest loading rate for many of the parameters analyzed (see Table 11). This is due to the land use of Subwatershed H, which is a mix of 57% agriculture and 15% urban, mostly rural residential. Also Avis Mill Pond is within subwatershed H, which makes this subwatershed area a potential priority for improved management; water quality data collection in Phase II of this work will aid in defining these priorities.

Subwatershed G has the highest loading rate of TP, TN, and TSS. Agriculture comprises more than 90% of this subwatershed, which is more heavily weighted in terms of loading rate for these parameters.

Table 11: Pollutant Loading Rates Calculated for Each Subwatershed

Sub-watershed	Area	TP	TN	TSS	NH3-N	LEAD	ZINC	COPPER	CADMIUM	BOD	COD	NO2+ NO3
	acres	*lbs/acre/ year*	*lbs/acre/ year*	*lbs/acre/ year*	*lbs/acre/ year*	*lbs/acre/ year*	*lbs/acre/ year*	*lbs/acre/ year*	*lbs/acre/ year*	*lbs/acre/ year*	*lbs/acre/ year*	*lbs/acre/year*
A	1108	1.13	9.35	248.47	0.05	0.20	0.20	0.11	0.00	15.98	6.81	0.18
B	340	1.04	8.54	232.91	0.05	0.16	0.14	0.09	0.00	15.15	9.40	0.17
C	793	1.05	8.65	237.38	0.05	0.10	0.11	0.06	0.00	14.73	14.17	0.14
D	418	0.60	5.93	139.73	0.07	0.16	0.11	0.09	0.00	13.44	9.82	0.30
E	1103	0.96	7.96	223.36	0.00	0.07	0.08	0.04	0.00	13.56	0.72	0.09
F	100	0.75	6.96	169.04	0.17	0.35	0.22	0.18	0.00	17.65	18.65	0.47
G	229	1.20	9.41	277.81	0.00	0.07	0.08	0.03	0.00	14.91	0.16	0.03
H	390	0.92	7.98	201.69	0.22	0.46	0.28	0.22	0.00	20.17	24.05	0.54
J	1186	0.96	8.02	226.17	0.00	0.06	0.07	0.03	0.00	13.62	0.53	0.08
K	804	1.13	8.97	261.23	0.00	0.07	0.09	0.03	0.00	14.43	0.28	0.04
L	1047	1.12	8.92	256.76	0.02	0.09	0.10	0.05	0.00	14.74	2.05	0.07
M	414	1.08	8.68	246.85	0.03	0.13	0.11	0.07	0.00	14.99	3.50	0.11
N	291	1.07	8.62	238.51	0.06	0.16	0.14	0.09	0.00	15.15	9.59	0.15
P	858	0.85	7.79	177.43	0.21	0.32	0.22	0.18	0.00	17.72	40.38	0.51

Failing Onsite Wastewater Treatment Systems (OWTS)

Since nearly all of the businesses and residences within the watershed have onsite wastewater treatment systems (OWTS), potential OWTS impacts including fecal coliform and nutrient loading are a concern. A typical OWTS consists of a septic tank and a leaching field. The septic tank portion is designed to collect, breakdown, and retain solid matter while passing the partially treated wastewater to the drainage field, where additional filtration occurs. Table 12 shows the typical effluent characteristics for a properly functioning OWTS. The "very limited" suitability of soil for OWTS within the watershed causes concern with the potential for failing OWTS contributing fecal coliforms and nutrients to the watershed. The Salem County Health Department currently regulates the siting and installation of OWTS; however, the long-term maintenance of these systems is typically the responsibility of the homeowner and are often neglected, which can sometimes lead to a failing system.

Table 12: Characteristics of OWTS Effluent

Constituent	Unit	Tchobanoglous and Burton (1991)	Canter and Knox (1985)
TSS	mg/L	50-90	75
BOD_5	mg/L	140-200	140
Total Nitrogen	mg/L	25-60	40
Total Phosphorus	mg/L	10-30	15
Total Coliform	Counts /100ml	10,000 – 10,000,000	--

Table 13 demonstrates the typical characteristics of untreated residential wastewater, which can enter a watershed from a failing OWTS.

Table 13: Characteristics of Untreated Residential Wastewater

Constituent	**Unit**	**Canter and Knox (1985)**	**Tchobanoglous and Burton (1991)**	**Burks and Minnis (1994)**
TSS	mg/L	250	436	220
BOD_5	mg/L	300	392	250
Total Nitrogen	mg/L	38	57	40
Total Phosphorus	mg/L	25	19	12
Total Coliform	Colonies /100ml	--	100,000,000	100,000,000

Resident Canada Geese Populations

As described in the TMDL, resident Canada geese populations at Avis Mill Pond and Memorial Lake are a potential source of fecal coliform in the watershed (NJDEP, 2003c). Populations of Canada geese have also been noted at Daretown Lake and at numerous other irrigation ponds throughout the watershed. Canada geese (*Branta canadensis*) are attracted to the excellent habitat that the suburban community provides. Almost year-round forage is provided by the well-kept landscape, golf courses, corporate centers, city parks, and recreational fields that often contain ponds or lakes, which provide safe nesting areas. Additionally, the farms throughout the watershed provide additional forage for the Canada geese population. Furthermore, the lack of traditional prey such as foxes and coyotes results in unchecked population growth. Large flocks of resident Canada geese leave behind large amounts of fecal matter that impair local water quality (Gosser *et al.*, 1997).

Wildlife of the Watershed

As part of Phase II of this Salem River Watershed Restoration Plan, a map of potential pollutant sources will be produced. This will include temporal habitat areas of snow geese, along with wild turkey and white-tailed deer population trends in the watershed.

3. Existing Water Quality Data

Water quality data is available at three locations in the watershed. These monitoring sites include the following:

- Salem County Health Department Lake sampling station at Turtle Pond, Four Seasons Campground, Township of Pilesgrove;
- USGS 01482455 Salem River at Route 77 near Pole Tavern Road, Upper Pittsgrove Township;
- USGS 01482500 Salem River at Woodstown, Woodstown Borough.

A summary of water quality data as it relates to the Upper Salem River Watershed Restoration Plan is provided in Table 14.

Table 14: Water Quality Data Availability and Summary Statistics

Summary of Salem Water Quality Monitoring Results			
Water Quality Stations		**Fecal Coliform**	**Total Phosphorus**
		MPN/100mL	*mg/L*
Four Seasons Campground	Number of Samples	74	No Data
Sampled in the summer months of 2001-2006	Minimum Result	5	No Data
	Maximum Result	2980	No Data
	Average Result	131	No Data
	Not Meeting Standard	12%	No Data
USGS 01482455 Route 77 Pole Tavern	Number of Samples	No Data	8
Sampled infrequently 2002-2004	Minimum Result	No Data	0.005
	Maximum Result	No Data	0.218
	Average Result	No Data	0.078
	Not Meeting Standard	No Data	25%
USGS 01482500 Salem Woodstown	Number of Samples	40	41
Sampled several times a year to several times a month from 1967 – 2004; this data summary only includes 1995-2004.	Minimum Result	20	0.035
	Maximum Result	16000	0.4
	Average Result	1043	0.181
	Not Meeting Standard	58%	83%
MPN = Most Probable Number			

Since 1974, the NJDEP has administered the Cooperative Coastal Monitoring Program (CCMP). The CCMP assesses recreational beach water quality, with the help and participation of local environmental health agencies. Under the CCMP, the Salem County Department of Health has been monitoring the Four Seasons Campground bathing beach in Pilesgrove Township. The bathing beach is in the center of the campground, which maintains summer and year-round residents in approximately 200 trailer homes. Fecal coliform data collected at this pond shows dramatic improvements in fecal coliform counts over the past two years. During the summer months of 2005 and 2006, there were no exceedences of the water quality standard for this waterbody.

The USGS gaging station at Woodstown Borough (01482500) provides the longest spanning timeframe of water quality information in the drainage area. Though data is available dating back to 1967, only results from 1995 to 2004 have been included in this analysis, relating a more current and realistic picture of the watershed. According to data collected from 1995 through 2004, the Salem River regularly exceeded the water quality standard for fecal coliform in the spring and summer months. In 1995 and 1996, fecal coliform monitoring results were highest in the month of November. Insufficient data from other years limits the conclusions that can be drawn in regards to high fecal coliform inputs to the watershed during the fall season. Correlation of rainfall events and fecal coliform monitoring results may indicate a source of this pollutant. Precipitation data is available through the National Climatic Data Center, which hosts archived climate data maintained by the National Ocean and Atmospheric Association (NOAA). The weather station at Woodstown (ID 289910) was mostly used in this evaluation, but was supplemented by weather observations at Millville Municipal Airport (ID 285581) and Mount Holly (ID 285866) when needed. In evaluating the relationship between rainfall and fecal coliform monitoring results, it is evident that precipitation events as low as 0.25″ of rain may lead to elevated fecal coliform counts instream. Rainfall events culminating in 0.8″ over two to three days prior to sampling will always result in high fecal coliform counts, based on the precipitation data and water quality data available for this assessment. With increasing volumes of precipitation, there is no direct effect on counts of fecal coliform. According to available data, fecal coliform results are above the designated water quality standard of 200 colonies/100mL during periods of dry weather, also.

Phosphorus data is also available at the USGS gaging station at Woodstown Borough (01482500) and USGS gaging station at Pole Tavern Road (01482455). Though no TMDL has yet been developed for total phosphorus for this watershed, this parameter is currently listed as impaired for this river system; a TMDL and a percent reduction of loads from all land uses can be anticipated for the near future. Figure 9 displays the fluctuation in total phosphorus concentrations over the seasons from years 1995 to 2004. Total phosphorus concentrations are clearly highest in the spring and summer, with the exception of one very high monitoring result in October 1995. Compared to the surface water quality standard, however, total phosphorus almost always exceeds the criterion, independent of season. Comparing monitoring results to rainfall amounts yields a similar scenario. At 0.5″ of rain or greater over a 36 hour timeframe, total phosphorus always exceeds the water quality standard (15 occasions within the dataset). However, the water quality standard is also exceeded during dry weather.

On only one occasion the USGS gaging station at Pole Tavern Road was sampled in the same week as the USGS gaging station at Woodstown. Total phosphorus at the downstream station at Woodstown was measured in August 2004 as 0.194 mg/L. The following day total phosphorus was measured as 0.218 mg/L at the upstream station at Pole Tavern Road. More than likely, the five lakes and numerous drainage ponds between these two stations act as sinks for phosphorus, where nutrients are taken up by plants, increasing biomass within these ecosystems. Further collection of same-day water quality data will help explain how nutrients and bacteria cycle through this watershed.

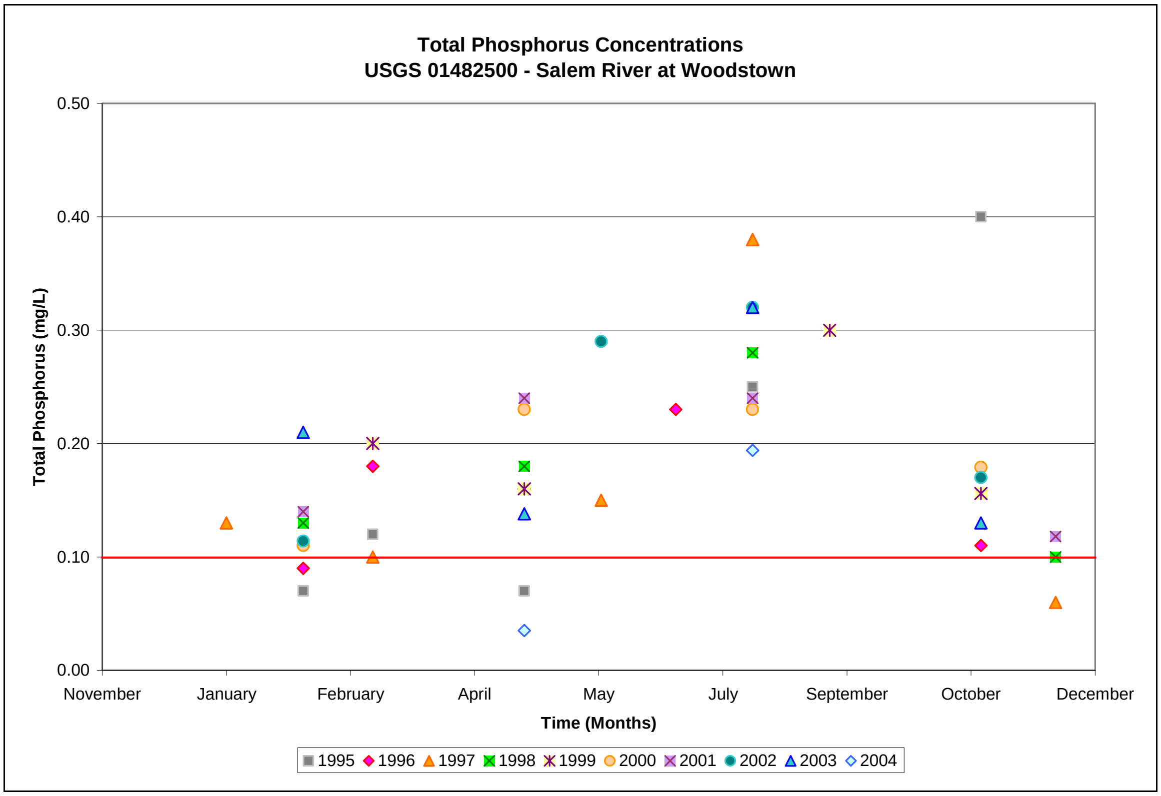


Figure 9: Seasonal Evaluation of Total Phosphorus from 1995-2004

C. Designated Uses that May be Affected by Pollutants

The numerous lakes of the watershed are important not only for their aesthetic value, but they provide recreational opportunities for the community. Within the aquatic ecosystem, microorganisms are abundantly present, and for the most part, beneficial. The small subsets of microorganisms that are disease-causing are referred to as pathogens. Of the designated water uses listed in the CWA, pathogenic contamination is of the utmost consideration in waters used for recreation, public water supply, protection and propagation of aquatic life, and aquifer protection. Excessive amounts of fecal bacteria indicate an increased risk of pathogen-induced illness to humans. Pathogen-contaminated recreational waters may result in gastrointestinal, respiratory, eye, ear, nose, throat, and skin diseases (USEPA, 2001).

Nutrient overenrichment may also limit the value of these lakes as a recreational resource to the community. Excessive phosphorus in surface waters will encourage algae growth and plant production. As seasons change and these plants die away, the degradation of organic matter will consume oxygen. If nutrient overenrichment has lead to excessive algae growth, enough oxygen may be consumed during decay to promote anoxic conditions in the lake. This process starves fish communities of oxygen and leads to fish kills. Along with the loss of dissolved oxygen, excessive rates of nutrient input will also cause an increase in turbidity, decrease in species diversity, and unpleasant taste and odors. These conditions describe lake eutrophication, or the rapid aging of a lake towards high nutrient content and high algae and macrophyte productivity. Figure 10 depicts abundant plant growth and green water appearance, results of excessive nutrient inputs.

Figure 10: Avis Mill Pond in June 2004

The lakes of the watershed are not used for potable water supplies. Instead, the majority of residents within this watershed receive their household water supply from the Kirkwood-Cohansey Bedrock Aquifer. This aquifer system is composed of sand and gravel with lenses of silt and clay. Typically, water is fresh, acidic, highly corrosive, and low in dissolved solids (Barringer *et al.*, 1993). Aquifer protection is of utmost importance for drinking water supply protection.

D. Significant Existing and Potential Pollutants and Their Sources

1. Prioritization Strategy & Ranking of Pollutants

An aerial loading analysis was performed for the watershed. Based upon this analysis, subwatersheds were ranked and prioritized. To further prioritize subwatersheds, water quality data will be collected at ten sampling locations throughout the watershed as part of Phase II of this project. These sites will be sampled during both dry and wet weather conditions for nutrients and pathogens. Flow monitoring will also be a component of each sampling effort so that pollutant loading can be better understood in the watershed. The QAPP that will guide this sampling effort will be delivered to the NJDEP for approval as part of Phase II of this work. Approval will be acquired prior to the commencement of water quality sampling.

E. Environmental Regulations Governing Pollutant Sources Identified in the Upper Salem River Watershed

Although specific sources of pollutants can not be confirmed without water quality monitoring data, there are regulations that mandate control of pollutants that may impact surface waters either directly or through NPS runoff.

New Jersey Stormwater Regulations

With point discharges of effluent strictly regulated, it has become apparent that addressing water quality criteria would require mitigating nonpoint source pollution that is brought into our waterways via stormwater runoff. In an effort to address the mounting concerns regarding impaired waterways and safe drinking water in New Jersey, new stormwater management and permitting rules were adopted in 2004.

The first set of the new rules is directed toward new development and provides the foundation in which to develop municipal and regional stormwater management plans. These regulations directly affect the requirements of several state issued permits, such as the freshwater wetlands and stream encroachment permits. The second set of rules requires municipalities, large public complexes such as hospitals, and highway systems to obtain NJPDES permits for their MS4s. These permits require the municipality or large public complex to develop, implement, and enforce a stormwater program that protects water quality from these discharges.

According to Section 7:8-2.2 of the Stormwater Management rules, the goals of stormwater management planning include reducing flood damage, minimizing any increase in stormwater runoff from any new development, reducing soil erosion from any development or construction project and protecting public safety through proper design and operation of stormwater management basins. Provisions also address the need to maintain groundwater recharge. For new development, a goal of preserving 100 percent of the average annual groundwater recharge has been set.

One highly significant aspect of the rules is the requirement of a 300 foot buffer around all Category 1 (C1) bodies of water. In the effort to protect critical drinking water, designation as a C1 status gains the highest water quality protection afforded in the state. The buffer would also be required on certain tributaries to C1 classified water bodies. It is expected that over 6,000 miles of streams will be covered by this provision to protect New Jersey's most sensitive waters.

Municipalities will need to adopt a municipal stormwater management plan as an integral part of its master plan and official map by either the deadline established in a NJPDES permit for a municipal separate storm sewer system or by the next reexamination of the master plan (N.J.A.C. 7:8-4.3). Compliance with these rules is expected to reduce the percentage of New Jersey waterways that are currently classified as impaired, as well as protect our drinking water resources.

Soil Erosion & Sediment Control Act

The Soil Erosion and Sediment Control Act became effective January 1, 1976 to protect the land, water, air, and other environmental resources of the state from stormwater runoff, and nonpoint source pollution from sediment. Rapid shifts in land use, from agricultural and rural to nonagricultural and urbanizing uses, construction of housing developments, industrial and commercial developments, and other land disturbing activities accelerated the process of soil erosion and sedimentation of the waterbodies of New Jersey. The Soil Erosion and Sediment Control Act strengthened the erosion and sediment control regulating bodies and established a statewide comprehensive and coordinated erosion and sediment control program to reduce storm water runoff and to reduce nonpoint source pollution from sediment (State of New Jersey, 1999).

From 1990 to 2000, the number of single family homes within Salem County has increased from 24,694 to 26,158, an increase of 1,464 single family homes. New residential growth was greater in 2000 then in any other year over the last decade. According to the 2000 Salem County Smart Growth Plan, the overall population of Salem County has remained unchanged. However, Pilesgrove and Pittsgrove Townships have experienced population increases of 10 percent and 20 percent, respectively (Ron Rukenstein and Associates, 2004). The Soil Erosion and Sediment Control Act has helped to decrease the impact of construction activities that have occurred in this watershed and across the State.

Standards for Individual Subsurface Sewage Disposal Systems

In New Jersey, OWTS are regulated under the N.J.A.C. 7:9A. The N.J.A.C. 7:9A regulations help to reduce pollution of New Jersey's water bodies by preventing the improper location, design, construction, installation, alteration, and operation and maintenance of individual subsurface sewage disposal systems (NJDEP, 1999). Since almost 60% of the watershed is "very limited" for OWTS, onsite sewage disposal is clearly a potential source of fecal coliform. To gain a more realistic understanding of this potential issue, the Cumberland Salem Conservation District met with the Salem County Health Department in the fall of 2005. It is the policy of the Health Department to oversee soil and site evaluations prior to permitting of OWTS in the County (Bell, 2005).

Upcoming Regulations for Animal Feed Operations

The New Jersey Aquaculture Development Act authorized the New Jersey Department of Agriculture (NJDA) to develop and adopt a comprehensive animal waste management program that provides for the proper disposal of animal waste, which includes the criteria and standards for the composting, handling, storage, processing, and utilization of animal waste. Authority was also given to develop compliance provisions with penalties and the assessment of fees to cover administrative costs. Since 1997, the NJDA has been crafting Animal Feed Operation (AFO) Regulations for the State. The AFO Regulations are expected to be available by the Fall of 2006 for comments. During the developing stages of this legislature, RCRE has worked with the NJDA and other agricultural representatives to develop this regulation so that it is not burdensome to the producer. A Memorandum of Agreement between the NJDA and the NJDEP identifies the NJDA as the lead agency in implementing manure management measures for AFOs and the NJDEP as the lead agency for implementing manure management measure for concentrated animal feed operations (CAFOs). The NJDEP's CAFO permitting program went into effect in March 2003.

The main objective of the AFO Regulations is to reduce nutrient pollution to local waterbodies and encourage sufficient nutrient application when needed. The regulations will require Nutrient Management Plans for small to medium farms that have more than seven animal units (or 8,000 pounds of animals). Farms with approximately 300 animal units will be required to have a Comprehensive Nutrient Management Plan developed by the NRCS. The goal of this regulation is also to encourage self-certified plans as allowed for by animal density. At one animal per acre, the farmer can create their own Nutrient Management Plan through a user-friendly software program. At densities greater than one animal per acre, the plan will require some oversight or agency agreement. The end result of this regulation is improved nutrient controls onsite; pathogen control may be an indirect benefit of this regulation (Westendorf, 2006).

F. Estimated Loadings from Sites within the Watershed

As demonstrated previously in this document, an aerial loading analysis can be an effective method to estimate pollutant loading from land uses contributing to a drainage area. The aerial load analysis is strictly for calculating loads from NPS pollution and MS4s based upon literature values of aerial loading coefficients. As discussed above, subwatershed G has the highest total phosphorus loading rate of 1.20 lbs/acre/year. This loading rate is high due to the high value that represents the loading rate of total phosphorus from agricultural land (refer to Appendix C). High total phosphorus runoff coming from this watershed would directly impact the Salem River and Avis Mill Pond. Results from the water quality monitoring program will be used to verify the results of the aerial loading analysis and used to determine management priorities for this basin.

The TMDL for fecal coliform produced by the NJDEP does not use an aerial loading analysis to predict fecal coliform loads from land use. Within the TMDL, a geometric mean of fecal coliform data from water years 1994-2002 was used to develop a percent reduction that would satisfy the designated water quality criterion. This percent reduction applies to all land uses within the watershed. As for available loading values, different species will have a varying amount of fecal concentrations that may contribute to stream degradation, if poorly managed. An aerial loading rate can be estimated based on research values for certain land use types. For instance, the USEPA has established fecal coliform concentrations listed in Table 15 (USEPA, 2001).

Table 15: Summary of Source-Specific Fecal Coliform Concentrations According to Land Use

Source	Concentration
Background	1.5×10^1 -4.5×10^5 MPN/100 mL
Urban runoff	$9.6 \times 10^2 – 4.3 \times 10^6$ organisms/100 mL
Grazed pasture runoff	$1.2 \times 10^2 – 1.3 \times 10^6$ organisms/100 mL
Feedlot runoff	$1.35 \times 10^6 – 2.4 \times 10^8$ organisms/100 mL
Cropland runoff	$1.2 \times 10^1 – 1.43 \times 10^4$ organisms/100 mL

Pathogen loading rates may also be source-specific in regards to species type and therefore, the USEPA has established fecal coliform concentrations in this manner. For instance, the USEPA reports a value of 1.0×10^{11} organisms/day of fecal coliform for each beef or dairy cow. It is also estimated that geese contribute 4.9×10^{10} organisms/day of fecal coliform per goose (USEPA, 2001).

Loads can be estimated based on several scenarios. Point source pathogen loads are typically easier to estimate since they are relatively constant in time. For NPS loads, the loads are usually divided between urban and rural due to their different load generation processes. Urban loads will typically gather on and wash off of impervious surfaces in stormwater or result from leaks in the sanitary sewer systems. In rural settings, runoff is more diffuse. The USEPA recommends more site-specific analysis rather than generic loading functions when evaluating rural NPS pathogen loads (USEPA, 2001). However, approaches such as estimating loads based on number of cows within a watershed is impractical due to the current management strategies that work to protect the stream from fecal pollution. Based on personal communication with landowners, the project partners have estimated the types of management practices currently used by the agricultural community to prevent offsite pollution. The effectiveness of these strategies will be considered during the analysis of water quality data in Phase II of this Upper Salem River Watershed Restoration Plan.

VI. REFERENCES

Anderson, James R., E.E. Hardy, J.T. Roach, and R.E. Witmer. 1976. A Land Use and Land Cover Classification System for Use with Remote Sensor Data, USGS Professional Paper 964, Washington, D.C.

Barringer, J. L., Kisj, G. R., and Velnich, A. J. 1993. Corrosiveness of ground water in the Kirkwood-Cohansey aquifer system of the New Jersey Coastal Plain: U.S. Geological Survey Water-Resources Investigations Report 90-4180, 79 p.

Bell, Kimberly. 2005. Personal communication with Michael Bonham, Cumberland Soil Conservation District, on October 19, 2005. City of Salem, New Jersey.

Burks, Bennette Day and Mary Margaret Minnis. 1994. *Onsite Wastewater Treatment Systems*. Hogarth House, Ltd, Madison, WI.

Canter, Larry and Robert Knox. 1985. *Septic Tank System Effects on Ground Water Quality*. Lewis Publishers, Inc. ASTM.

Charles, E.G., Behroozi, Cyrus, Schooley, Jack, and Hoffman, J.L. 1993. A method for evaluating ground-water-recharge areas in New Jersey: N.J., Geological Survey Report GSR-32, Trenton, 95p.

Durga Rao, K.H.V. and D. Satish Kumar. 2004. Spatial Decision Support System for Watershed Management. *Water Resources Management* 18: 407 – 423.

French, Mark. 2003. New Jersey Geologic Survey DGS02-3: Ground-Water Recharge for New Jersey, Project Overview, http://www.nj.gov/dep/njgs/geodata/dgs02-3/readme.htm.

Gosser, Allen L., M. R. Conover, and T. A. Messmer. 1997. Managing problems caused by urban Canada geese. Berryman Institute Publication 13, Utah State University, Logan, 8pp.

Jensen Mark E., K. Reynolds, J. Andreasen, and I.A. Goodman. 2000. A Knowledge-Based Approach to the Assessment of Watershed Condition. *Environmental Monitoring and Assessment* 64: 271 – 283.

New Jersey Department of Environmental Protection (NJDEP). 1992. 10-Meter Digital Elevation Grid for WMA 17. Trenton, NJ.

New Jersey Department of Environmental Protection (NJDEP) Bureau of Freshwater and Biological Monitoring. 1996. *Ambient Biomonitoring Network Lower Delaware Drainage Basin 1995-96 Benthic Macroinvertebrate Data.* Trenton, NJ.

New Jersey Department of Environmental Protection (NJDEP). 1999. Standards for Individual Subsurface Sewage Disposal Systems, New Jersey Administrative Code 7:9A. Trenton, NJ.

New Jersey Department of Environmental Protection (NJDEP) Bureau of Freshwater and Biological Monitoring. 2001a. *Ambient Biomonitoring Network Lower Delaware Drainage Basin 2000-01 Benthic Macroinvertebrate Data.* Trenton, NJ.

New Jersey Department of Environmental Protection Office of Information Resources Management. 2001b. NJDEP 1995/97 Land use/Land cover Update, Maurice, Salem and Cohansey Watershed Management Area 17, WMA-17.

New Jersey Department of Environmental Protection. 2003a. Integrated Water Quality Monitoring and Assessment Methods, Trenton, NJ.

New Jersey Department of Environmental Protection. 2003b. Surface Water Quality Standards N.J.A.C. 7:9B. Trenton, NJ.

New Jersey Department of Environmental Protection. 2003c. Total Maximum Daily Loads for Fecal Coliform to Address 27 Streams in the Lower Delaware Water Region, Trenton, N.J.

New Jersey Department of Environmental Protection (NJDEP). 2004. NJ Stormwater Best Management Practices Manual. Trenton, NJ.

New Jersey Department of Environmental Protection Division of Watershed Management. 2005a. Nonpoint Source Pollution, http://www.nj.gov/dep/watershedmgt/nps_program.htm. Last updated September 2, 2005.

New Jersey Department of Environmental Protection Division of Watershed Management Statewide Nonpoint Source Program. 2005b. Request for Proposals SFY 2006 Section 319(h) for Nonpoint Source Pollution Control, Trenton, NJ.

New Jersey Department of Environmental Protection Division of Watershed Management. 2005c. Total Maximum Daily Loads, http://www.nj.gov/dep/watershed mgt/tmdl.htm. Last updated August 16, 2005.

Spayd, Steven E., and S.W. Johnson. 2003. Guidelines for Delineation of Well Head Protection Areas in New Jersey, New Jersey Department of Environmental Protection, New Jersey Geological Survey, Trenton, NJ.

Osborne, Lewis L. and D.A. Kovacic. 1993. Riparian vegetated buffer strips in water-quality restoration and stream management. *Freshwater Biology* Vol. 29: 243-285.

Potter, Kevin M., F.W. Cubbage, G.B. Glank, and R.H. Schaberg. 2004. A Watershed-Scale Model for Predicting Nonpoint Pollution Risk in North Carolina. *Environmental Management* Vol. 34, No. 1: 62-74.

Ron Rukenstein and Associates. 2004. Delaware River and I-295/NJ Turnpike Planned Growth Corridor Smart Growth Plan. Titusville, NJ.

Suter, Glenn W., S.B. Norton, and S.M. Cormier. 2002. A Methodology for Inferring the Causes of Impairments in Aquatic Ecosystems. *Environmental Toxicology and Chemistry* Vol. 21 No. 6: 1101-1111.

Tchobanoglous, G. and Burton, F.L. 1991. *Wastewater Engineering: Treatment Disposal, Reuse. Metcalf & Eddy, 3rd edition.* McGraw-Hill, Inc., New York, NY.

Tickner, David P., P. G. Angold, A. M. Gurnell, and J. O. Mountford. 2001. Riparian plant invasions: hydrogeomorphological control and ecological impacts. *Progress in Physical Geography* Vol. 25 No. 1: 22-52.

United States Army Corps of Engineers (USACE). 2006. Invasive Species – An Evolving Policy. www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=REG&agename=Invasive%20Species. Last updated February 8, 2006.

United States Department of Agriculture (USDA). 1998. *Stream Visual Assessment Protocol*. Washington, D.C.

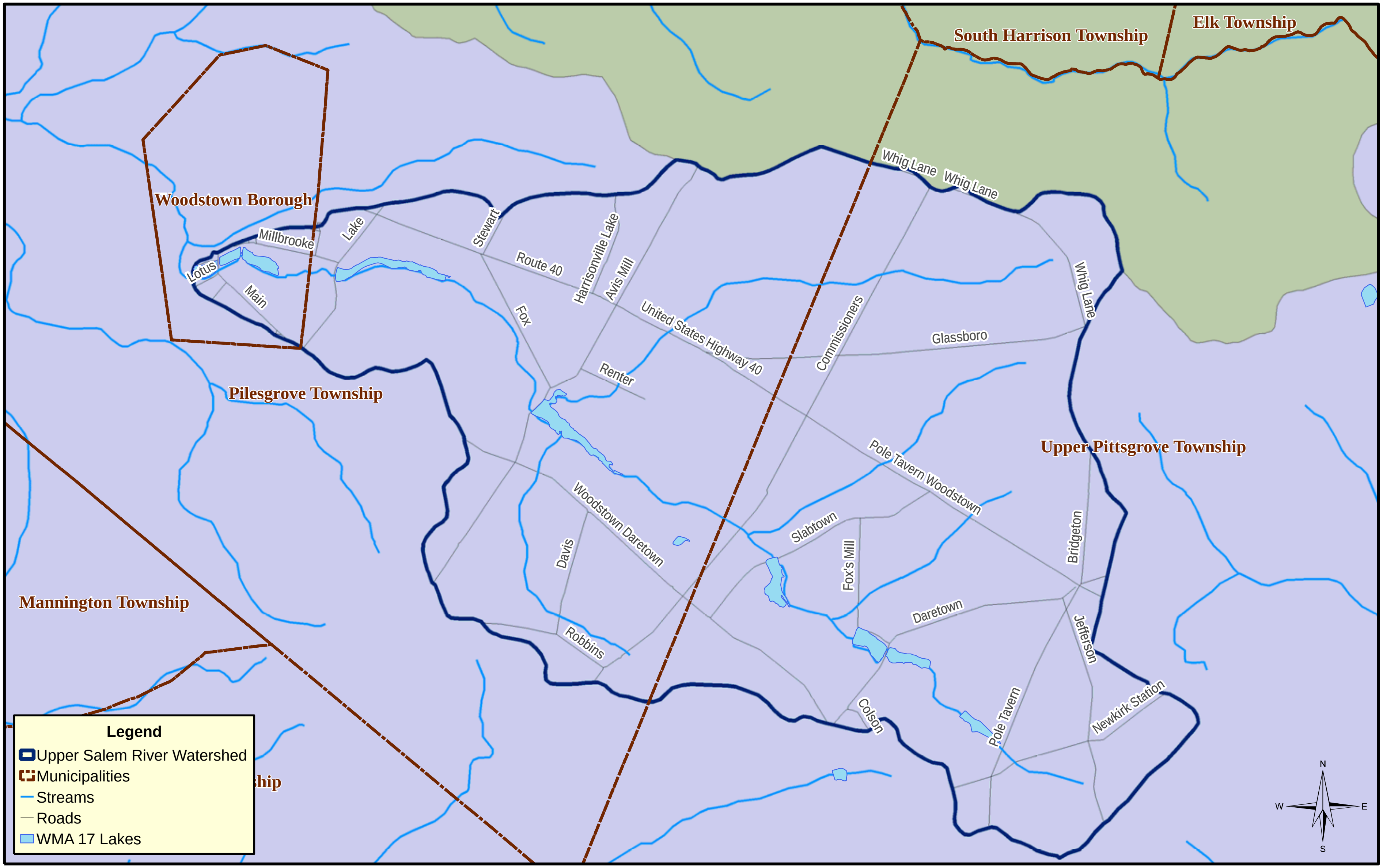
United States Environmental Protection Agency (USEPA). 2001. *Protocol for Developing Pathogen TMDLs First Edition*. Washington, D.C.

Ward, A.D. 1995. Surface runoff and subsurface drainage. Environmental Hydrology. CRC Press LLC, Boca Raton, FL: 133-175.

Westendorf, Michael. 2006. Personal communication with Katie Buckley, Rutgers Cooperative Research & Extension, on March 29, 2006. New Brunswick, New Jersey.

Yuan, L.L. and S.B. Norton. 2004. Assessing the Relative Severity of Stressors at a Watershed Scale. *Environmental Monitoring and Assessment* 98: 323-349.

APPENDIX A: Maps



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

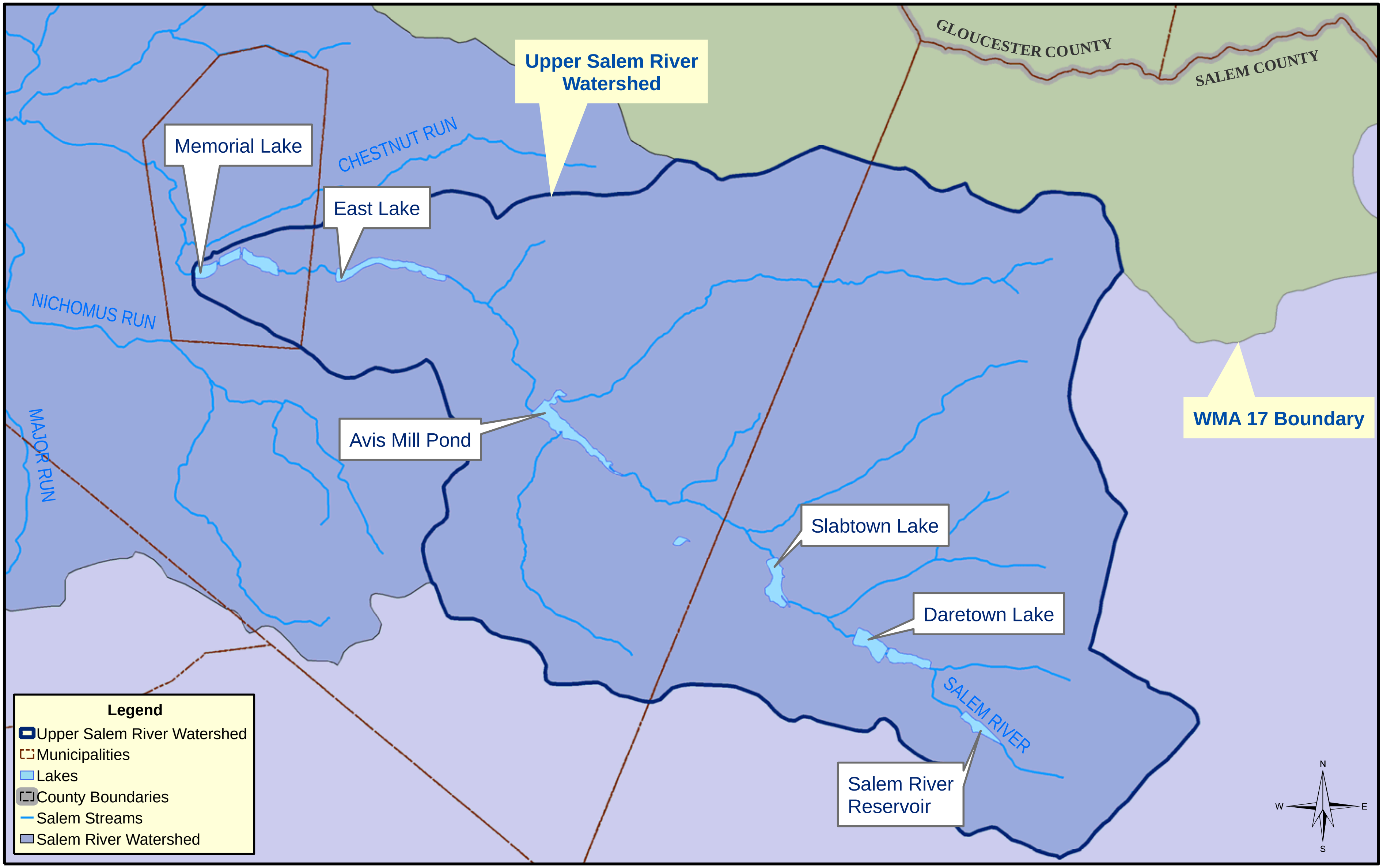
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 1: WATERSHED MAP

Data Source: NJDEP 1996 GIS Data

1" = 4,500 feet

0 2,300 4,600 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

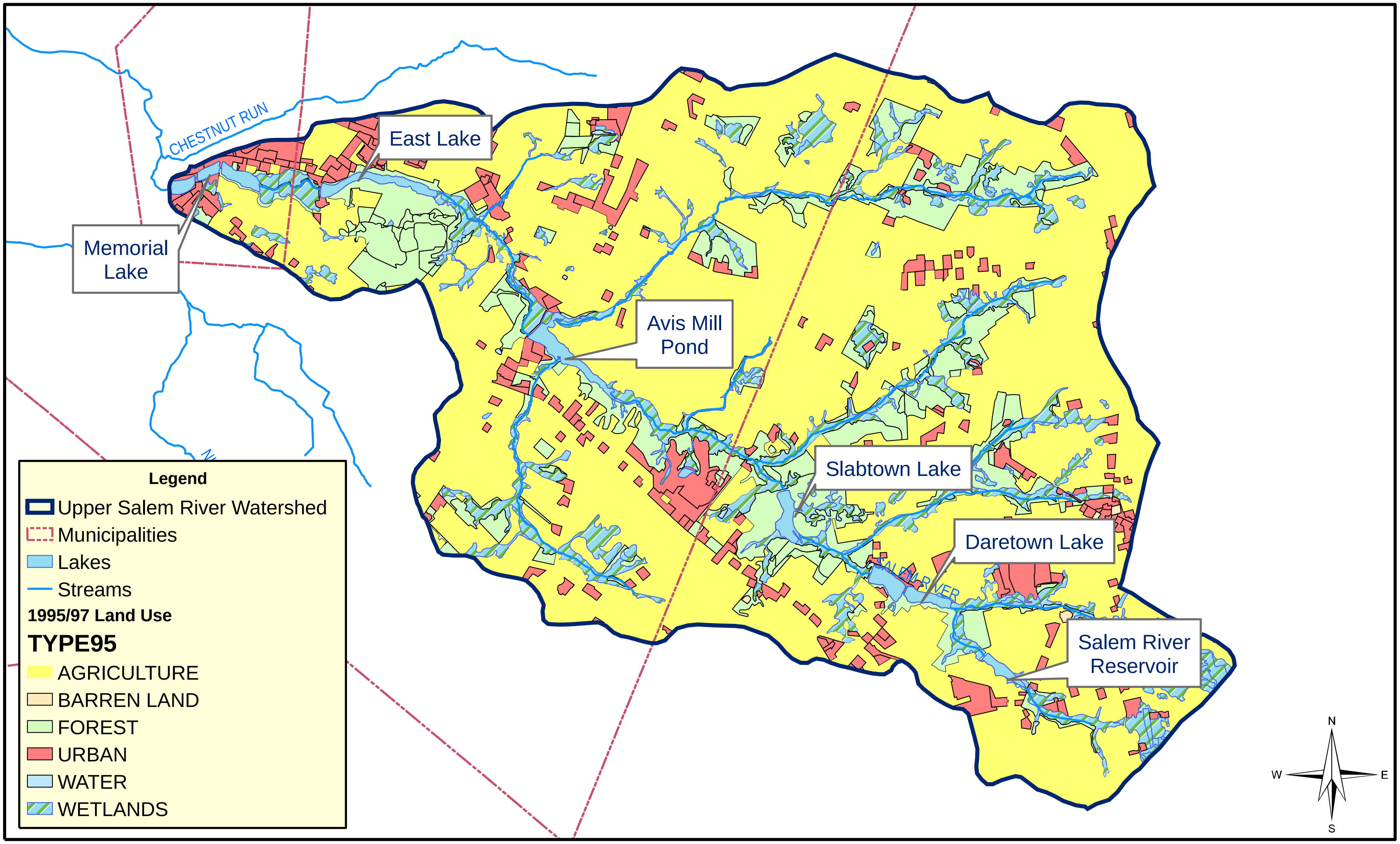
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 2: SURFACE WATERBODIES

Data Source: NJDEP 1996 GIS Data

1" = 4,500 feet

0 2,350 4,700 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

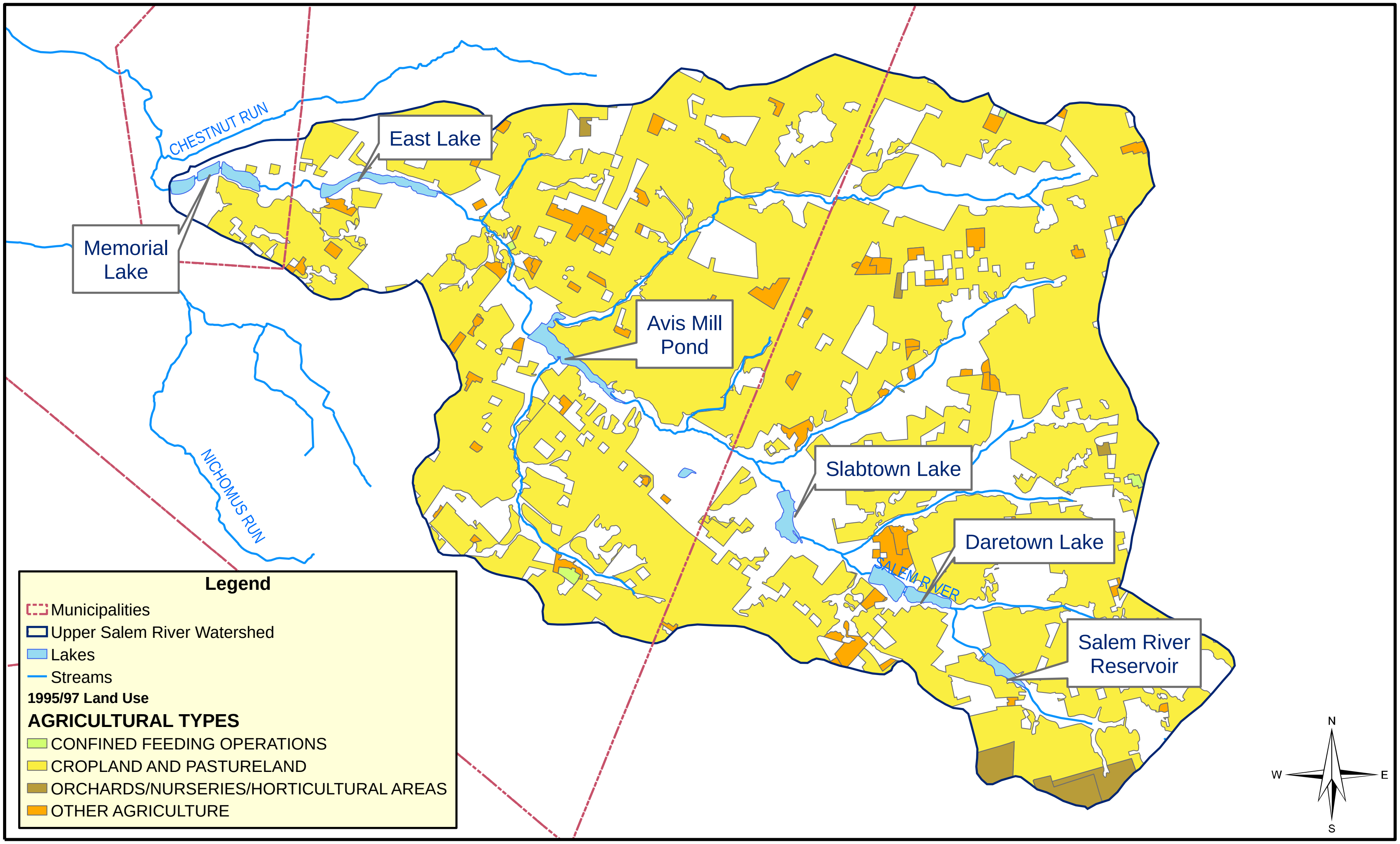
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 3: 1995/97 LAND USE/LAND COVER

Data Source: NJDEP 1996 GIS Data; NJDEP 1995/97 Land Use/ Land Cover

1 inch = 4,500 feet

0 2,250 4,500 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

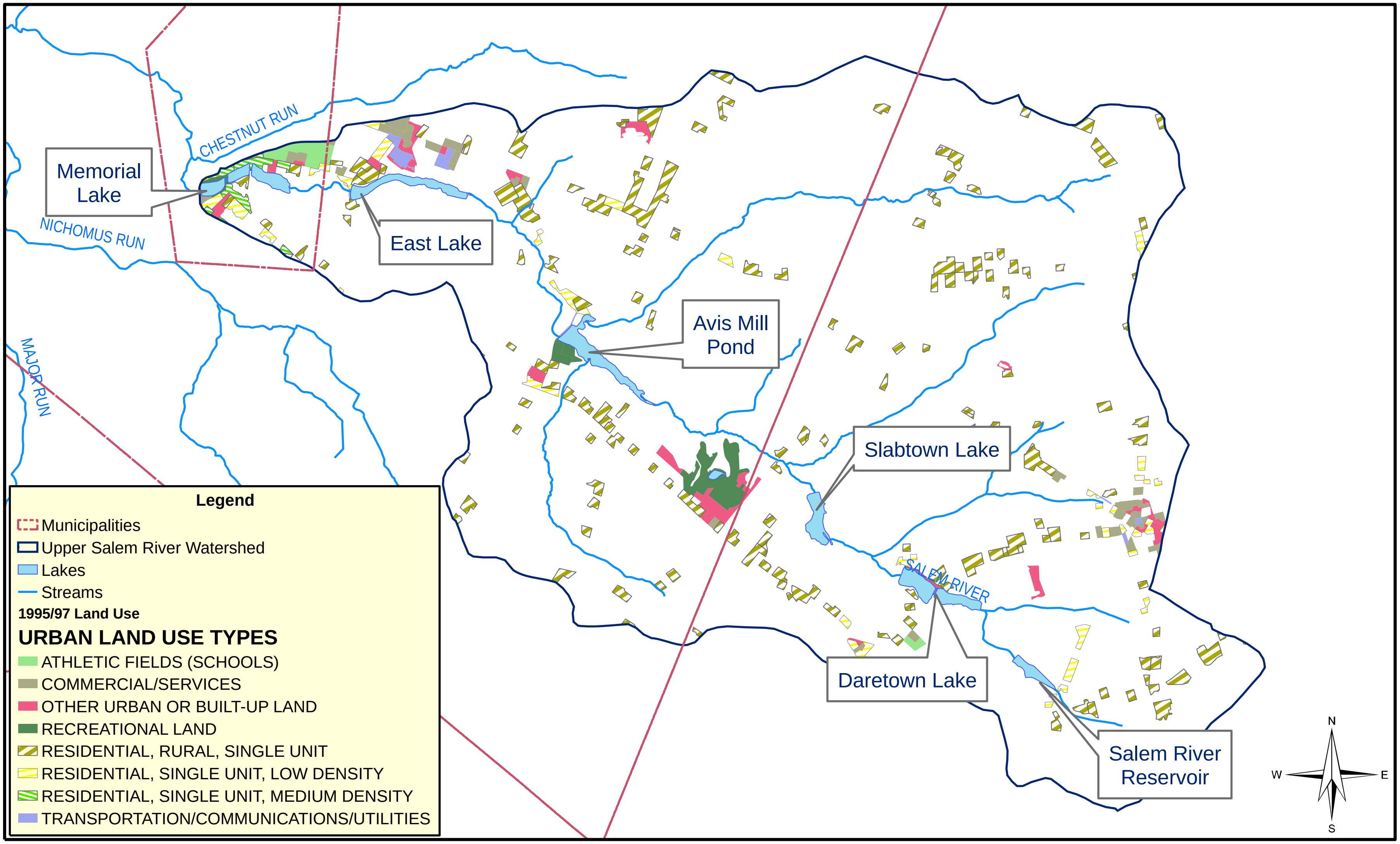
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 3a: 1995/97 AGRICULTURAL LAND USE

Data Source: NJDEP 1996 GIS Data; NJDEP 1995/97 Land Use/ Land Cover Data

1 inch = 4,500 feet

0 2,250 4,500 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

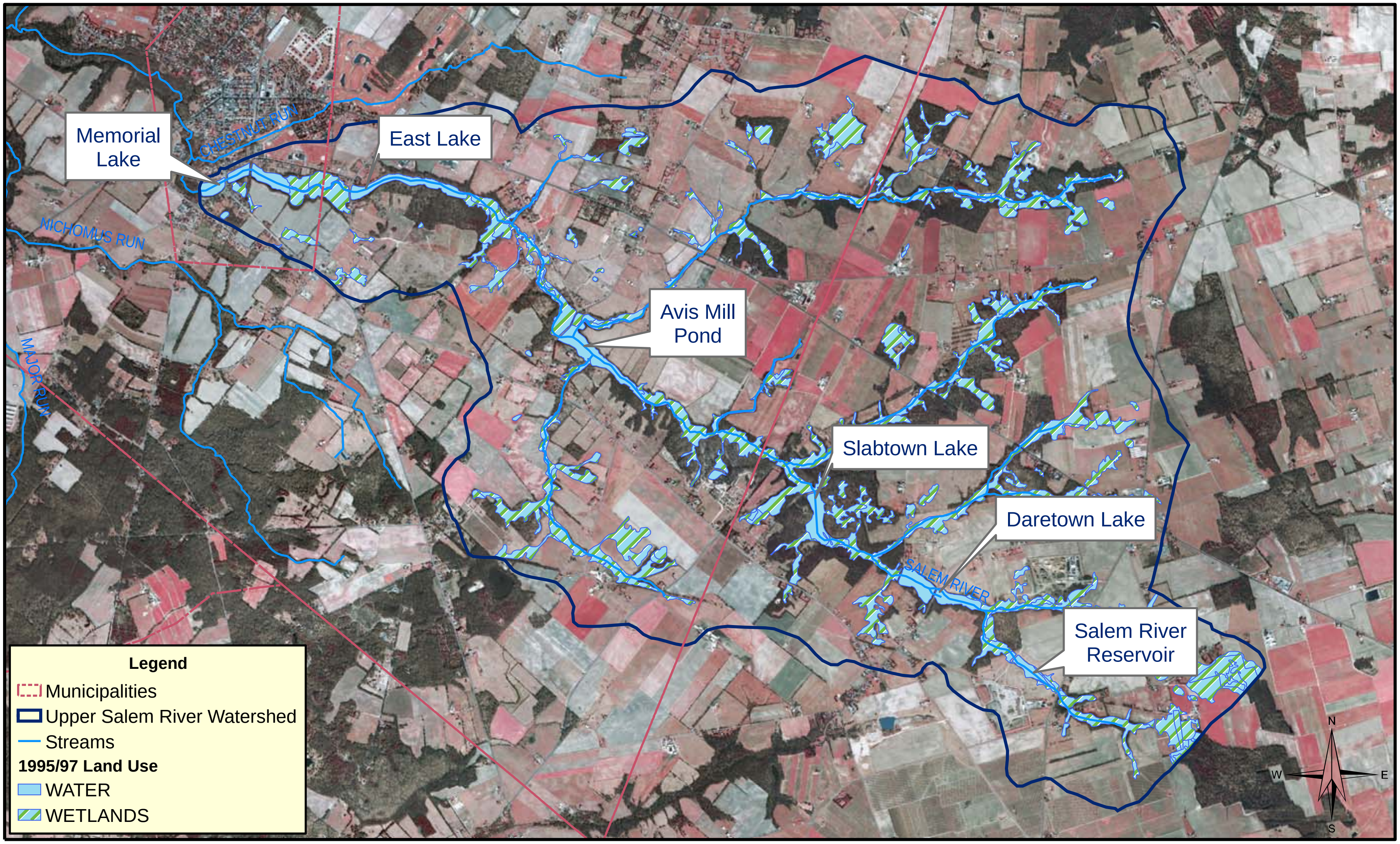
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 3b: 1995/97 URBAN LAND USES

Data Source: NJDEP 1996 GIS Data; NJDEP 1995/97 Land Use/ Land Cover Data

1 inch = 4,500 feet

0 2,250 4,500 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

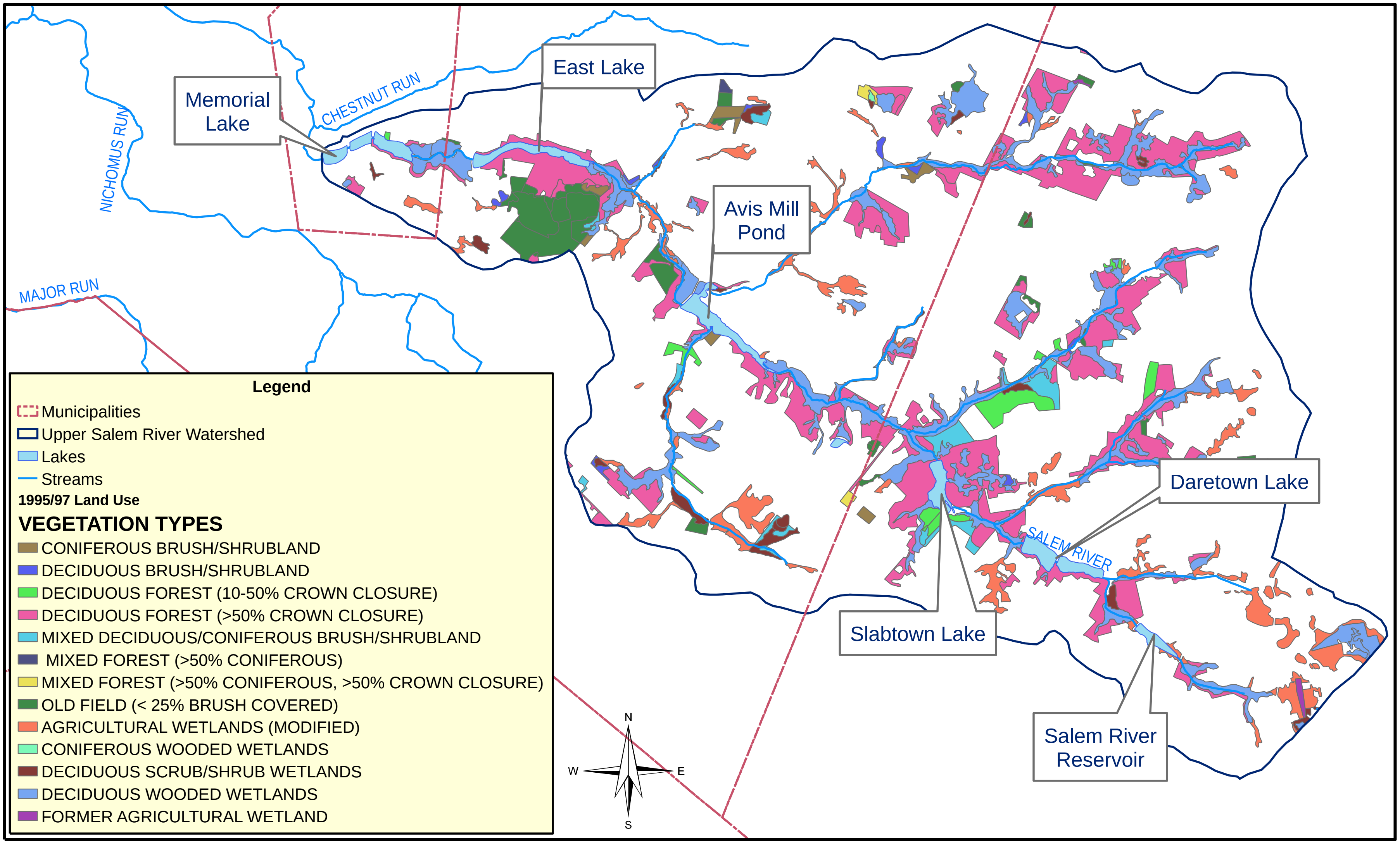
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 4: WETLANDS MAP

Data Source: NJDEP 1996 GIS Data; NJDEP 1995/97 Land Use/ Land Cover Data

1 inch = 4,500 feet

0 2,250 4,500 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

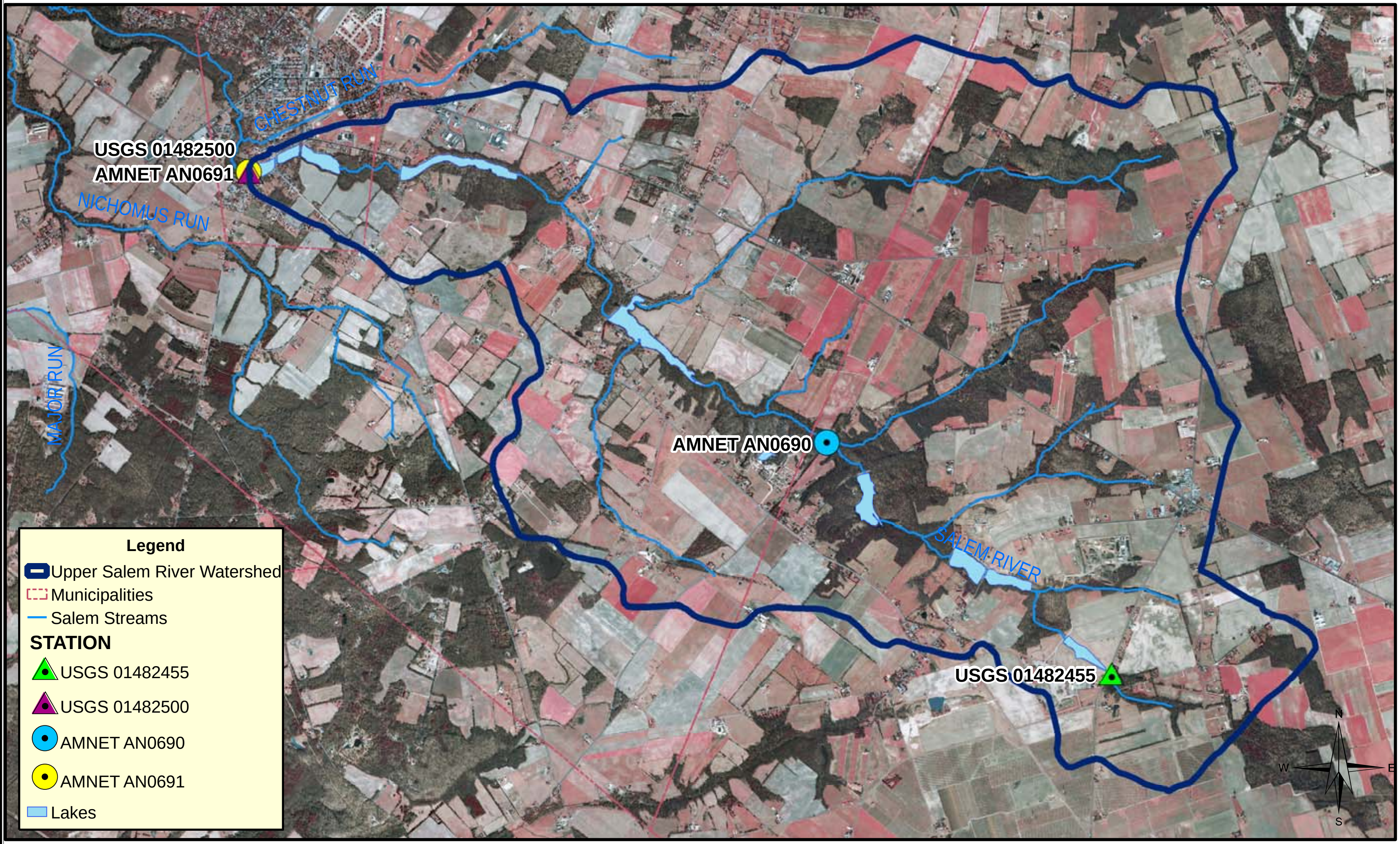
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 4a: VEGETATION TYPES

Data Source: NJDEP 1996 GIS Data; NJDEP 1995/97 Land Use/ Land Cover Data

1 inch = 4,500 feet

0 2,250 4,500 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

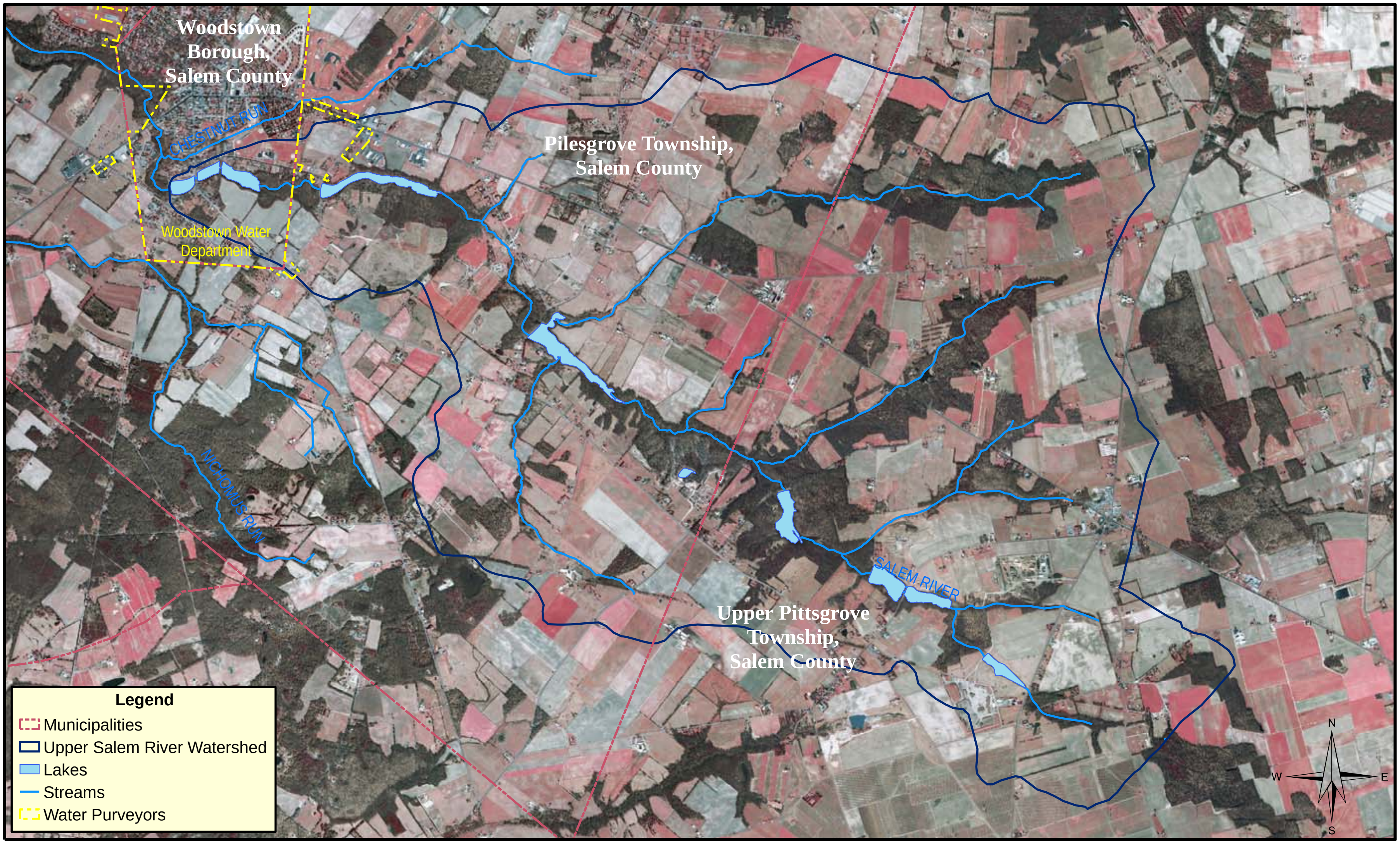
Date Produced: April 2006

UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 5: EXISTING WATER QUALITY STATIONS

Data Source: NJDEP 1996 GIS Data; NJDEP 2002 Aerial Orthophotos: NJDEP 2004 Integrated Report Data; USEPA STORET Modernized Database

1 inch = 4,500 feet
0 2,250 4,500
Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

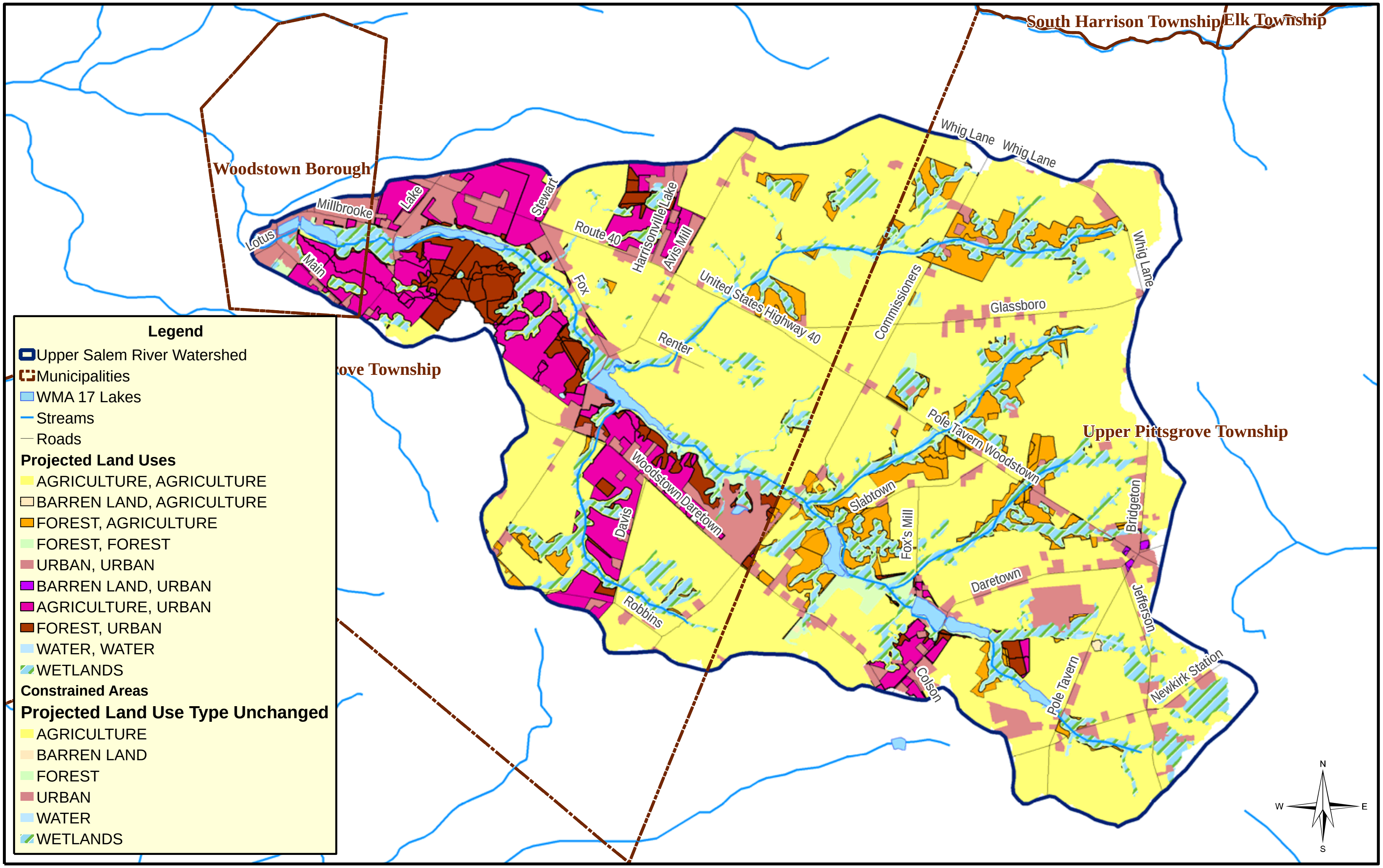
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 6: AGENCIES RESPONSIBLE FOR IMPLEMENTING WATERSHED MANAGEMENT

Data Source: NJDEP 1996 GIS Data; NJDEP 2002 Aerial Orthophotos; NJDEP 1998 Water Purveyors Data

1 inch = 4,500 feet

0 2,300 4,600 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

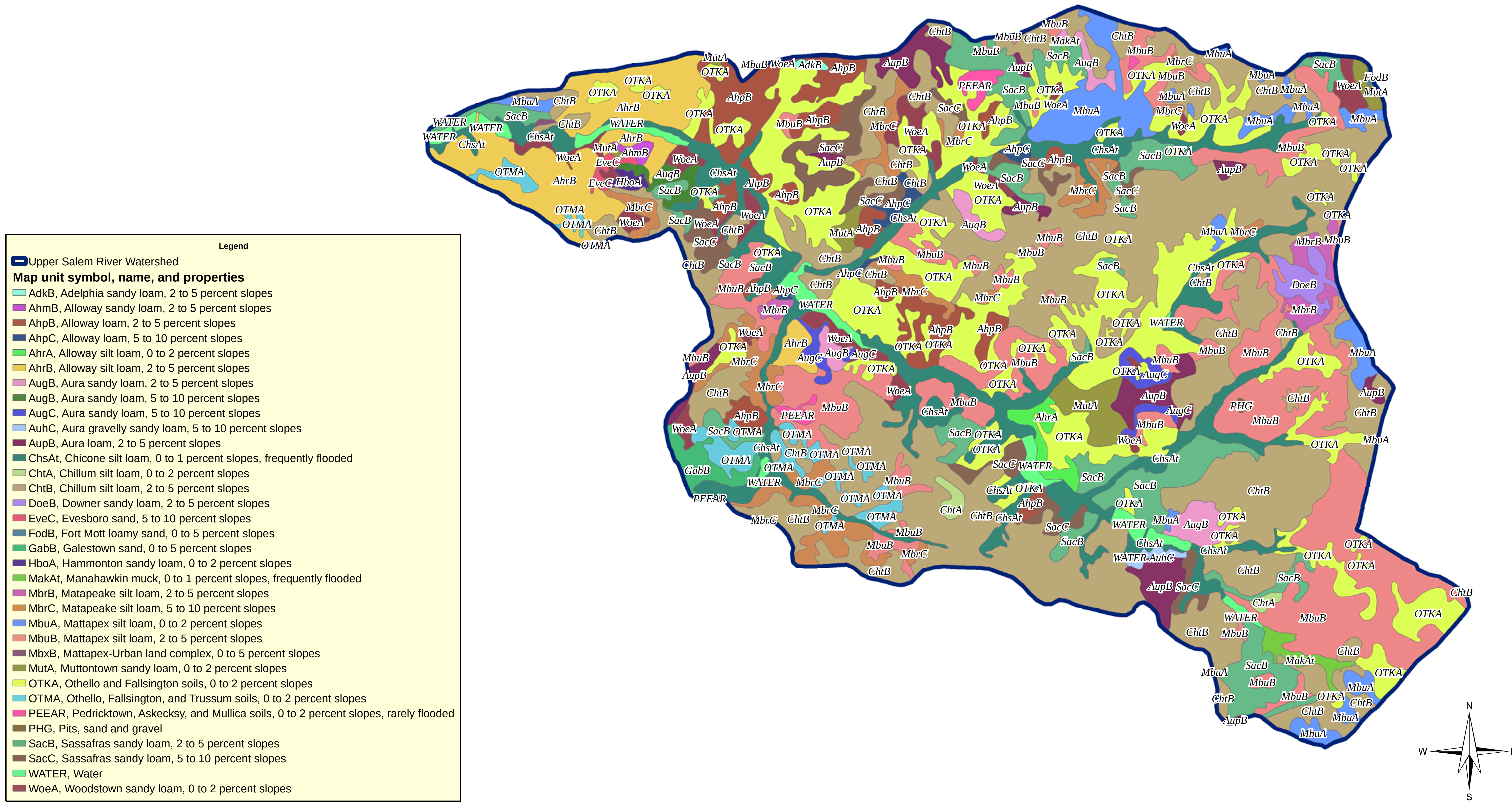
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 7: PROJECTED LAND USES

Data Source: NJDEP 1996 GIS Data; Municipal Zoning Data; 2000 Tiger Roads; NJDEP 1995/97 LU/LC; CRSSA 2001 Local Open Space; CRSSA 2002 Farmland Preservation; NJDEP 2002 Digital Orthophotography

0 2,350 4,700 Feet

1" = 4,500 feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

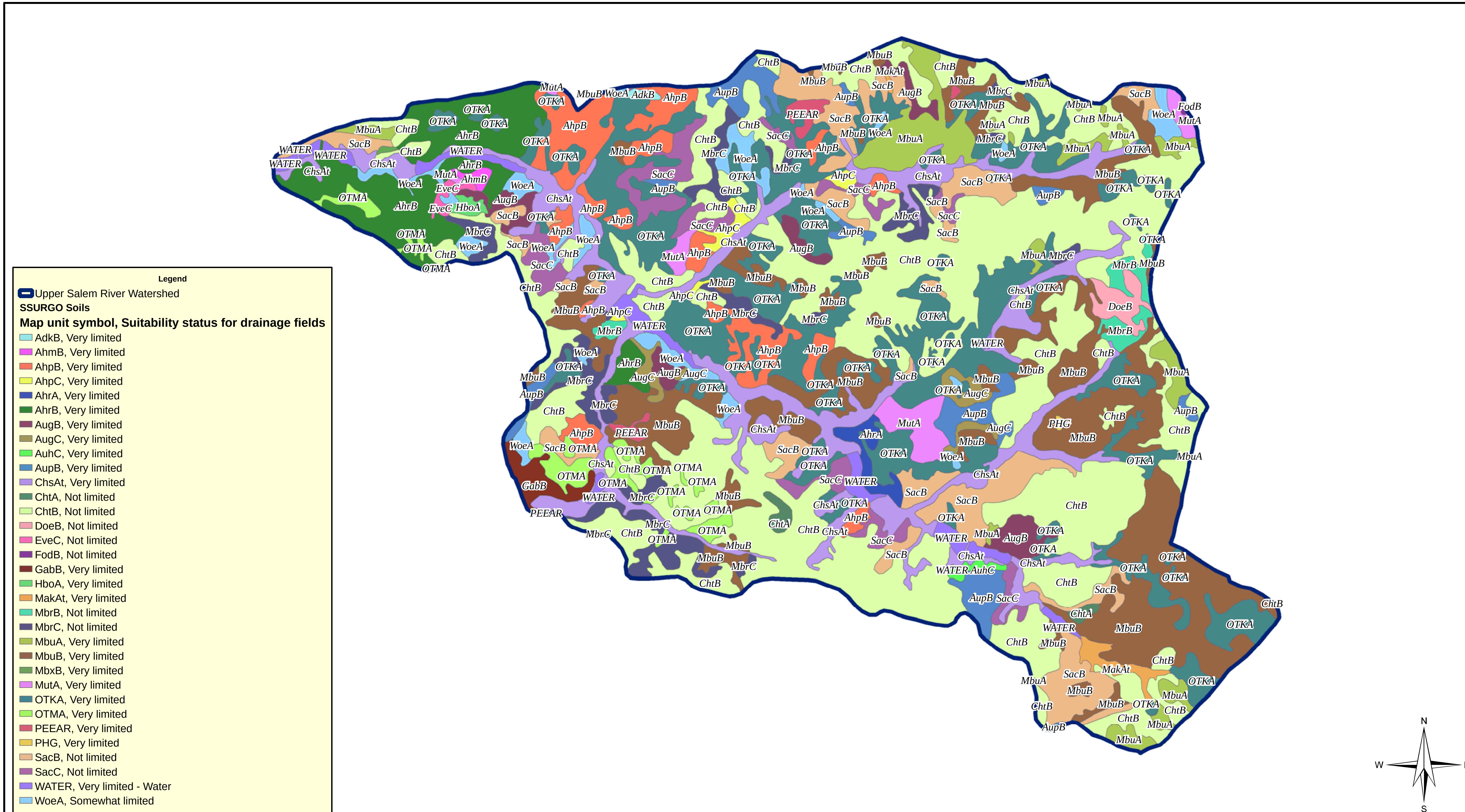
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 8: SOILS DATA

Data Source: NJDEP 1996 GIS Data; NRCS SSURGO
Data for Salem County, NJ

1 inch = 3,000 feet

0 3,000 6,000 12,000 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

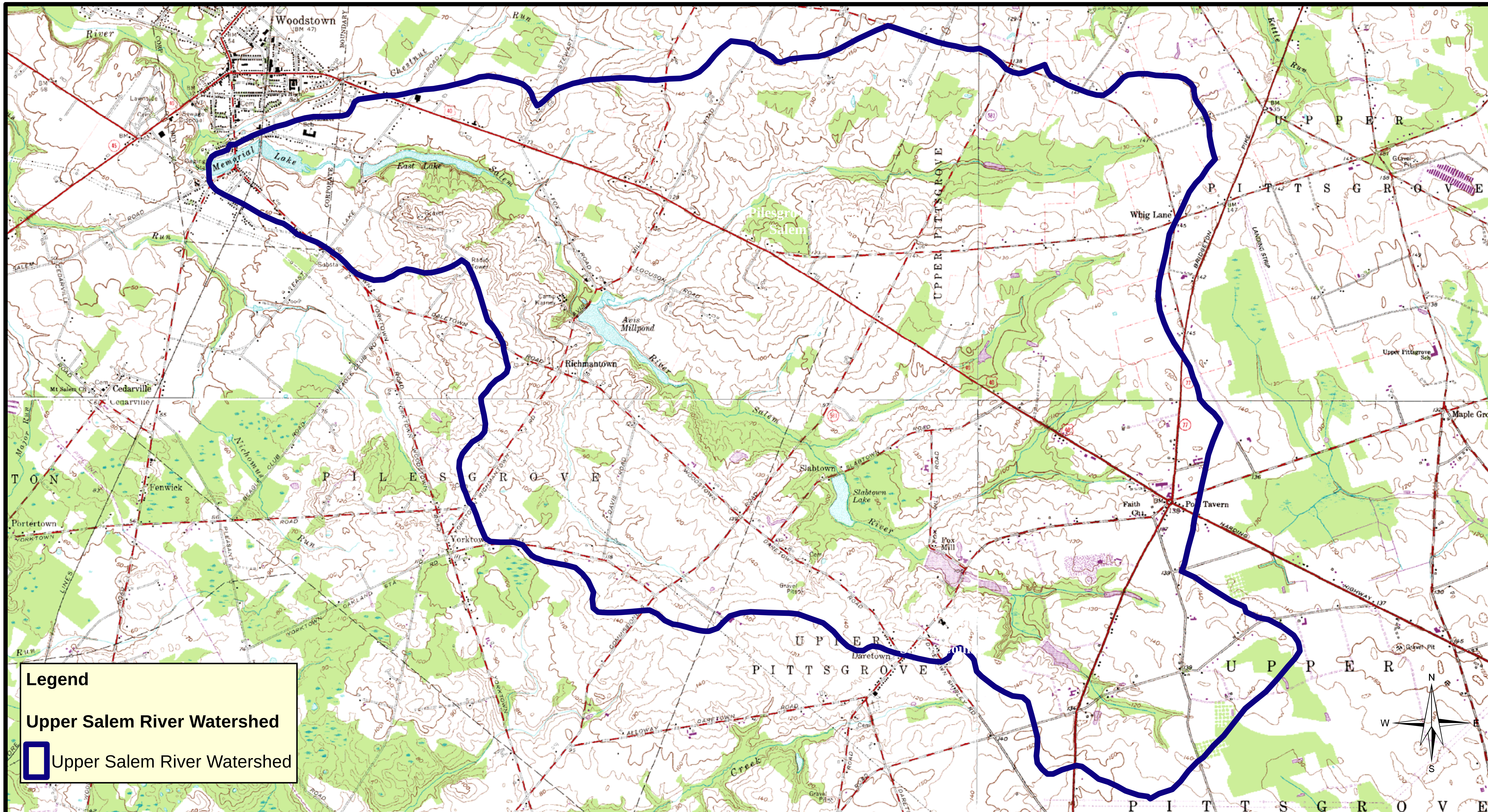
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 8a: SOIL LIMITATIONS FOR ONSITE WASTEWATER TREATMENT SYSTEMS

Data Source: NJDEP 1996 GIS Data; NRCS SSURGO Data for Salem County, NJ

1 inch = 3,000 feet

0 3,000 6,000 12,000 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

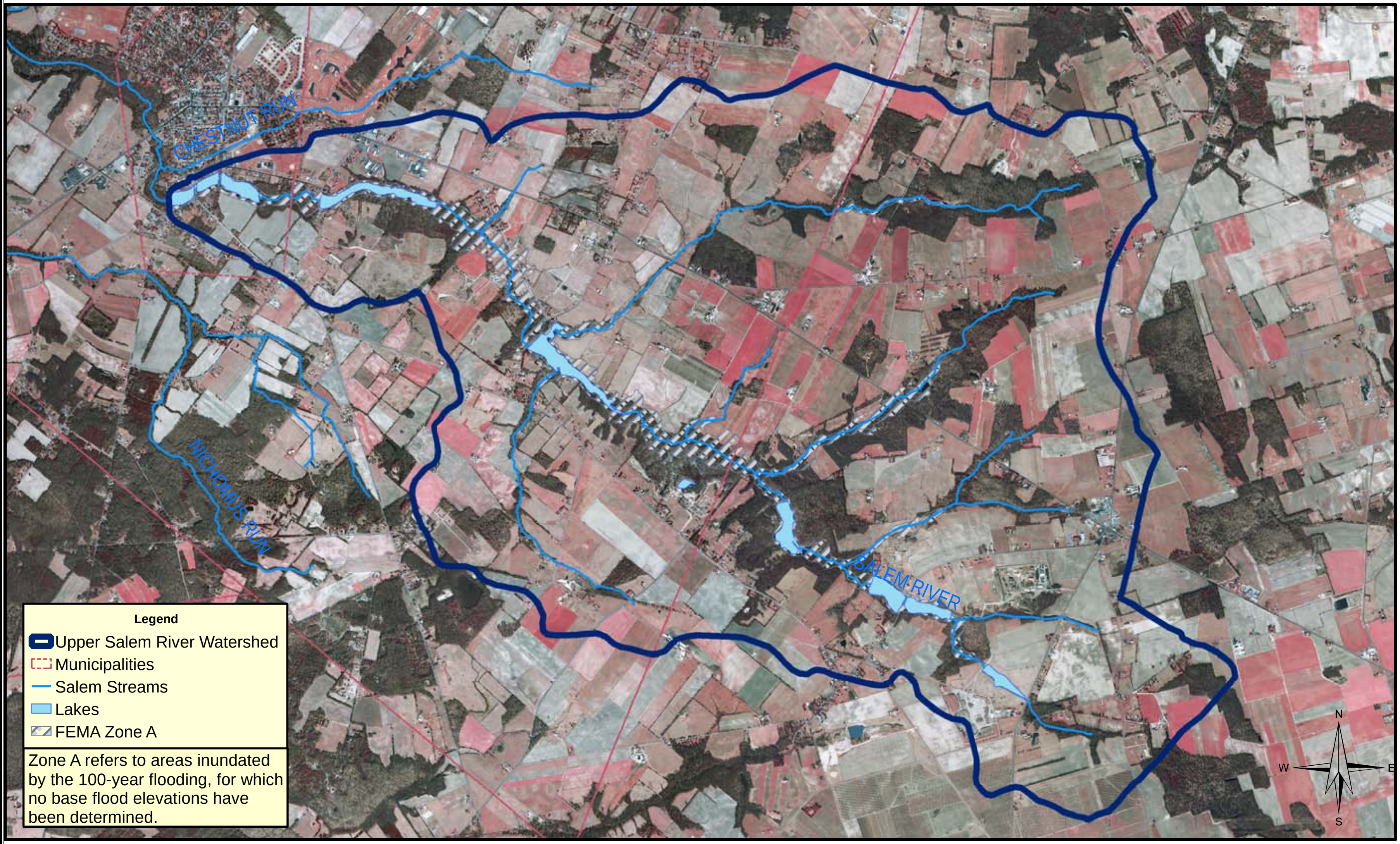
UPPER SALEM RIVER WATERSHED
RESTORATION PLAN

FIGURE 9: US GEOLOGICAL SURVEY
7.5' TOPOGRAPHIC QUANDRANGLE

Data Source: USGS 7.5' Topographic Quadrangles; NJDEP 1996 GIS Data CD-Rom

1 inch = 3,000 feet

0 1,500 3,000 6,000 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

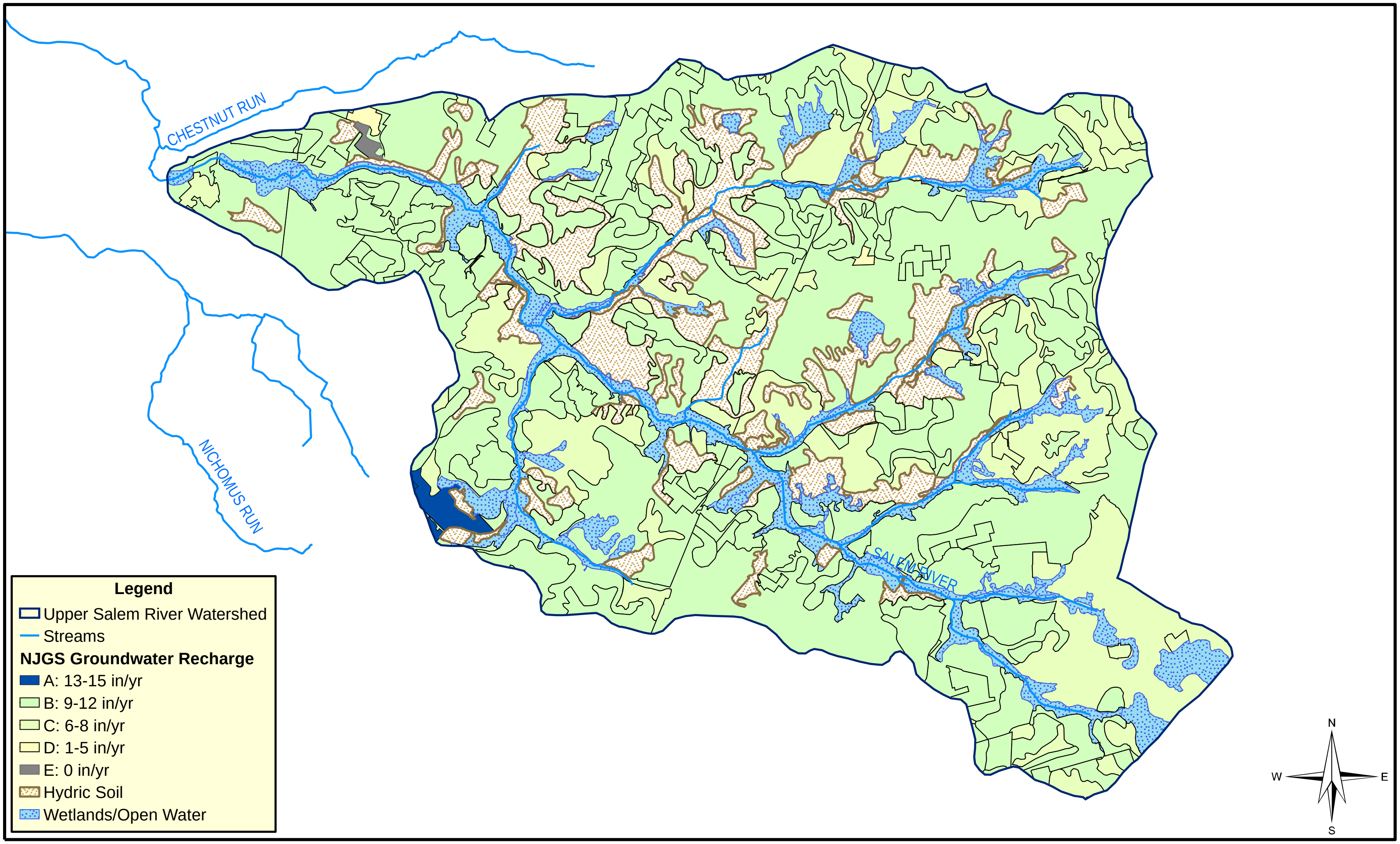
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 10: FEMA FLOOD MAP

Data Source: NJDEP 1996 GIS Data; NJDEP 2002 Aerial Orthophotos: FEMA Q3 Flood Data, Disc 18, 1996

1 inch = 4,500 feet

0 2,250 4,500 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

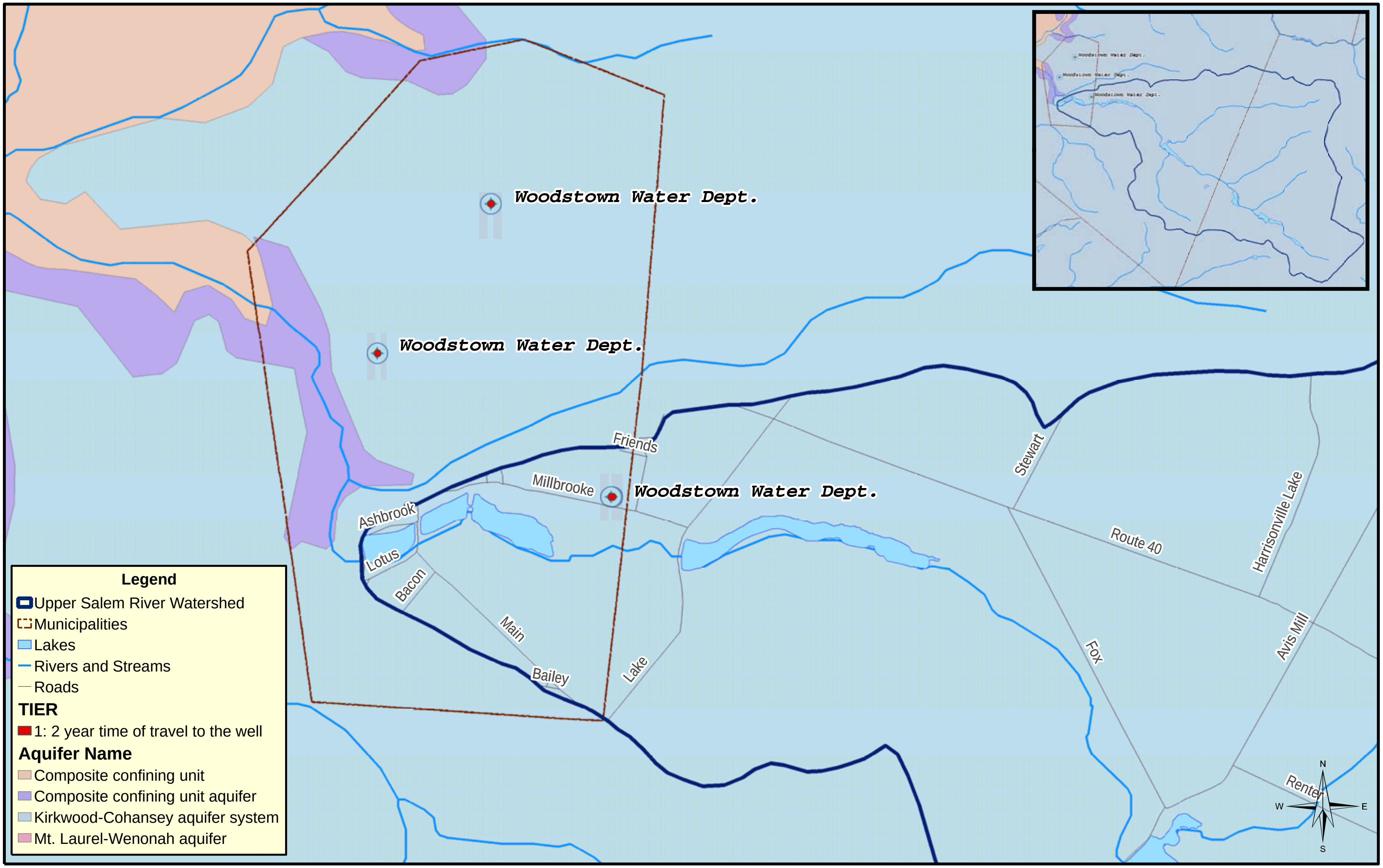
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 11: NJ GEOLOGICAL SURVEY GROUNDWATER RECHARGE

Data Source: NJDEP 1996 GIS Data; NJGS 2004 WMA17 Groundwater Recharge Data

1 inch = 4,500 feet

0 2,250 4,500 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

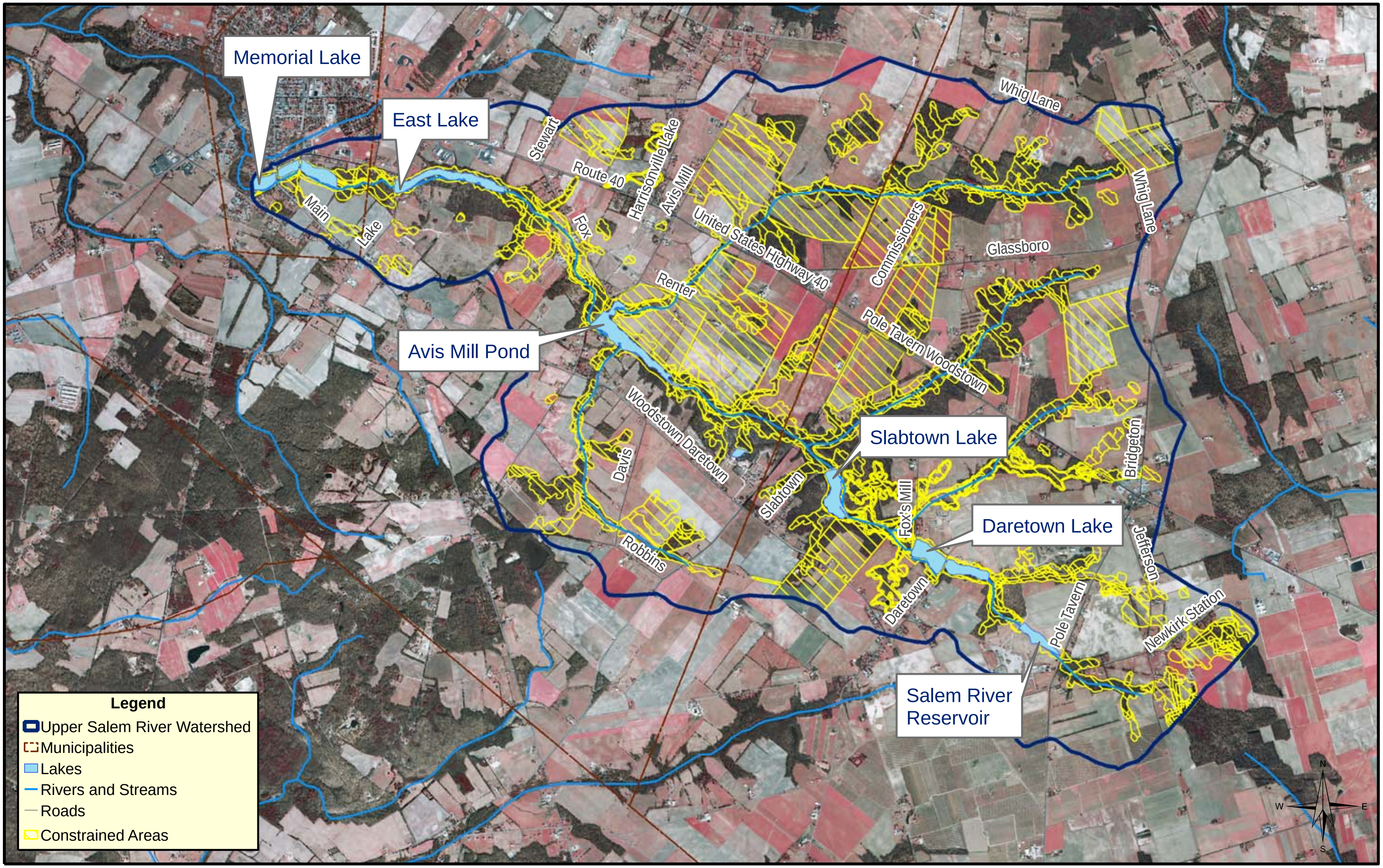
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 12: WELLHEAD PROTECTION AREAS

Data Source: NJDEP 1996 GIS Data Municipal Zoning Data; NJGS 2002 Well-head Protection Areas, Salem County, NJ

1" = 2,000 feet

0 1,050 2,100 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

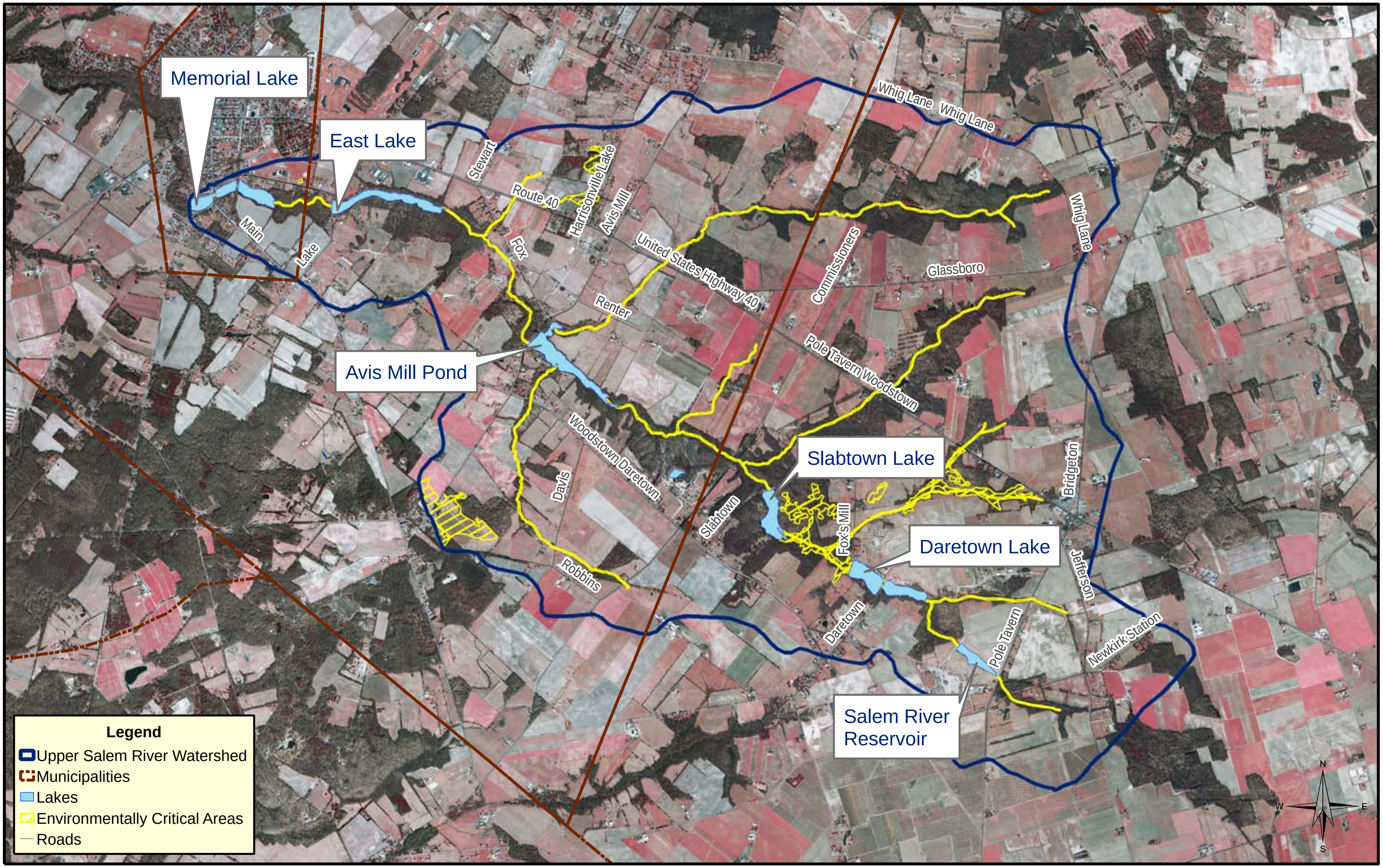
UPPER SALEM RIVER WATERSHED
RESTORATION PLAN

FIGURE 13: ENVIRONMENTALLY CONSTRAINED AREAS

Data Source: NJDEP 1996 GIS Data; 2000 Tiger Roads; NJDEP 1995/97 LU/LC; CRSSA 2001 Local Open Space; CRSSA 2002 Farmland Preservation; NJDEP 2002 Digital Orthophotography

1" = 4,500 feet

0 2,300 4,600 Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

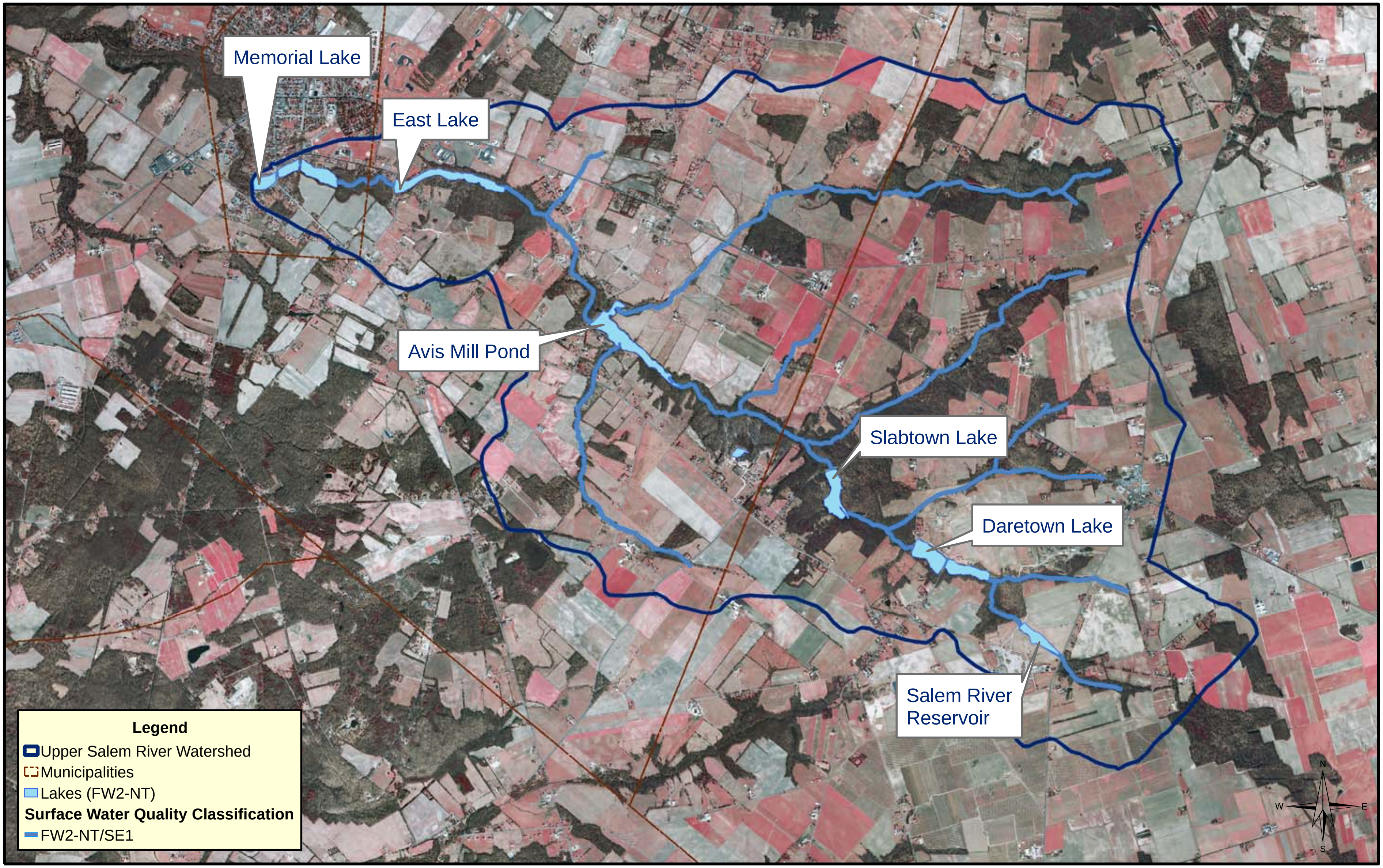
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 14: ENVIRONMENTALLY CRITICAL AREAS

Data Source: NJDEP 1996 GIS Data; NJGS 2004 Groundwater Recharge, Watershed Rank A; NJDEP Stream Corridor (with 25' buffer); NJDEP 2001 Landscape Project; NJGS 2002 Wellhead Protection Areas; NJDEP 2002 Digital Orthophotography

0 2,350 4,700 Feet

1" = 4,500 feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

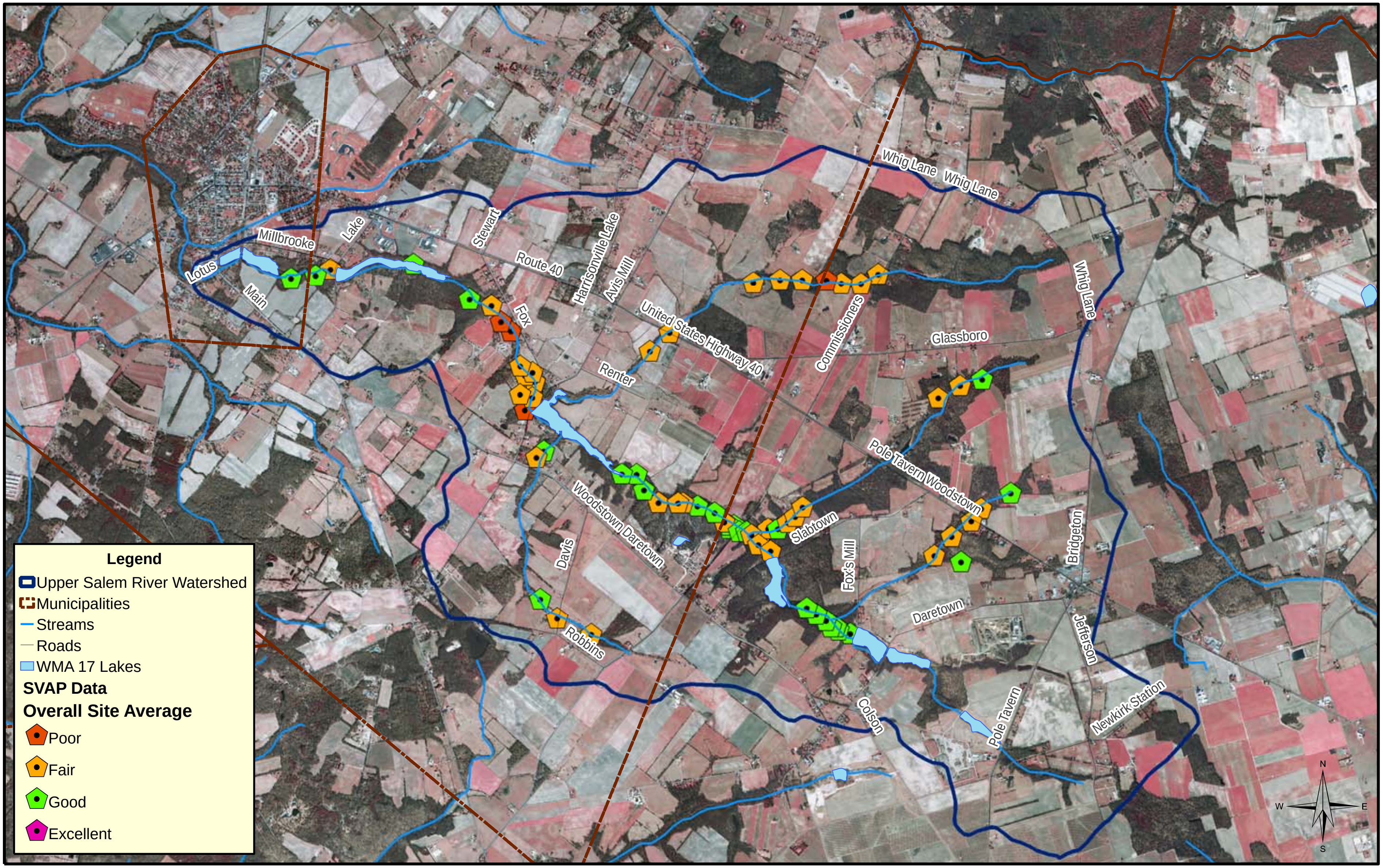
UPPER SALEM RIVER WATERSHED RESTORATION PLAN

FIGURE 15: SURFACE WATER QUALITY CLASSIFICATIONS

Data Source: NJDEP 1996 GIS Data; NJDEP 2005 Surface Water Quality Standards

1" = 4,500 feet

0 2,300 4,600
Feet



Rutgers Cooperative Research & Extension
Water Resources Program
Department of Environmental Science
14 College Farm Road
New Brunswick, New Jersey 08901
www.water.rutgers.edu

Date Produced: April 2006

UPPER SALEM RIVER WATERSHED
RESTORATION PLAN

FIGURE 16: STREAM VISUAL ASSESSMENT LOCATIONS AND RATING

Data Source: NJDEP 1996 GIS Data; SVAP Data collected during the Spring/ Summer 2006

1" = 4,500 feet

0 2,300 4,600 Feet

APPENDIX B: SVAP Methods and Analysis

I. Methods for Developing Relationships

A. Developing a Spatial Relationship Using ArcGIS

The use of GIS yields the potential to evaluate data within a spatial framework. Many industries and government agencies have recognized the use of GIS as critical in planning and site management. Specifically, watershed management has grown as an important planning tool and approach due to the efficiency and capabilities of GIS. As stated by Durga Rao and Kumar (2004), the basic principle of watershed management is to utilize the land according to its capability and to remember the needs of the land so that it is a sustainable place for people living within the area. When land is being used beyond its capabilities, adverse effects occur, including the depletion of groundwater sources and soil degradation in the form of erosion (Durga Rao and Kumar, 2004).

Numerous studies have shown that to be effective, ecosystem assessments must evaluate the local anthropogenic impacts, past and present, within a catchment-wide scale (Jensen *et al.*, 2000). The 15 square-mile watershed was divided into 21 subwatershed areas based on 10-meter digital elevation models (DEMs) made available by the NJDEP Office of Information Technology (see Figure B-1). A DEM is the array of digital numbers representing the elevations of the terrain with respect to a known or assumed datum. In addition to topography, DEMs can be used to generate slope, aspect, and hillshade (Durga Rao and Kumar, 2004). Within ArcGIS, SWAT (Soil and Water Assessment Tool) was used to delineate the larger watershed to manageable subwatershed areas. The watershed was divided according to the tributaries discharging to the Upper Salem River and the catchments that drain to each tributary.

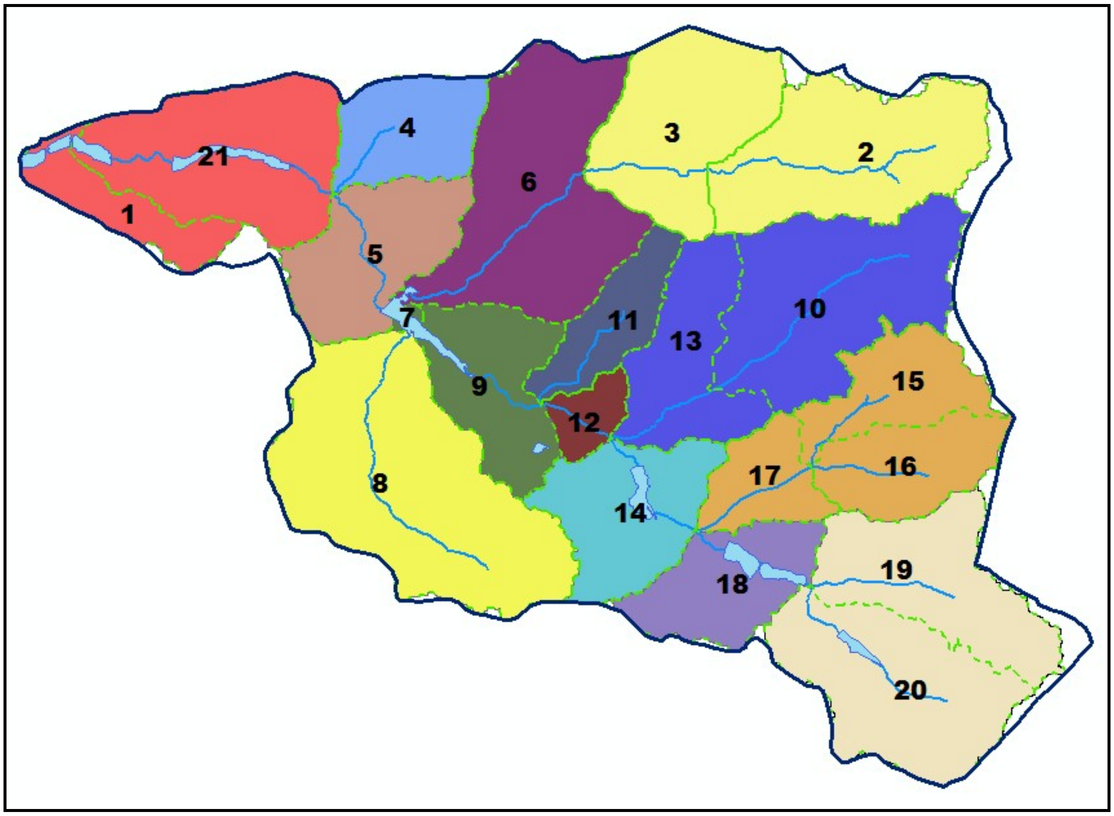


Figure B-1: 21 Subwatershed Areas Used in Analysis

Data including land use types and characteristics, imperviousness, and floodplain data was intersected with each subwatershed area and joined to each SVAP point within each subwatershed. Then, each of the 21 subwatershed areas could be given a percent land use, percent imperviousness, total acres of impervious, elevation, slope, and mean score across all SVAP parameters for analysis. Figure B-2 depicts the subwatersheds that were assessed and the average overall score applied to each subwatershed. Due to access issues and other reasons, not all subwatersheds were able to be visually assessed (14 of 21 subwatersheds). For instance, subwatershed 1 does not have any lengths of stream reach; therefore, no visual assessments were performed. Developing the relationships between SVAP parameters and land use changes is important so as to define the causation between the stream degradation occurring. A cause must always precede its effect. This analysis is similar to that what has been outlined by Suter *et al*. (2002), where Suter states that, "the stressor identification process provides input to environmental managers who may consider regulating a source, remediating contamination, or restoring ecosystem structure."

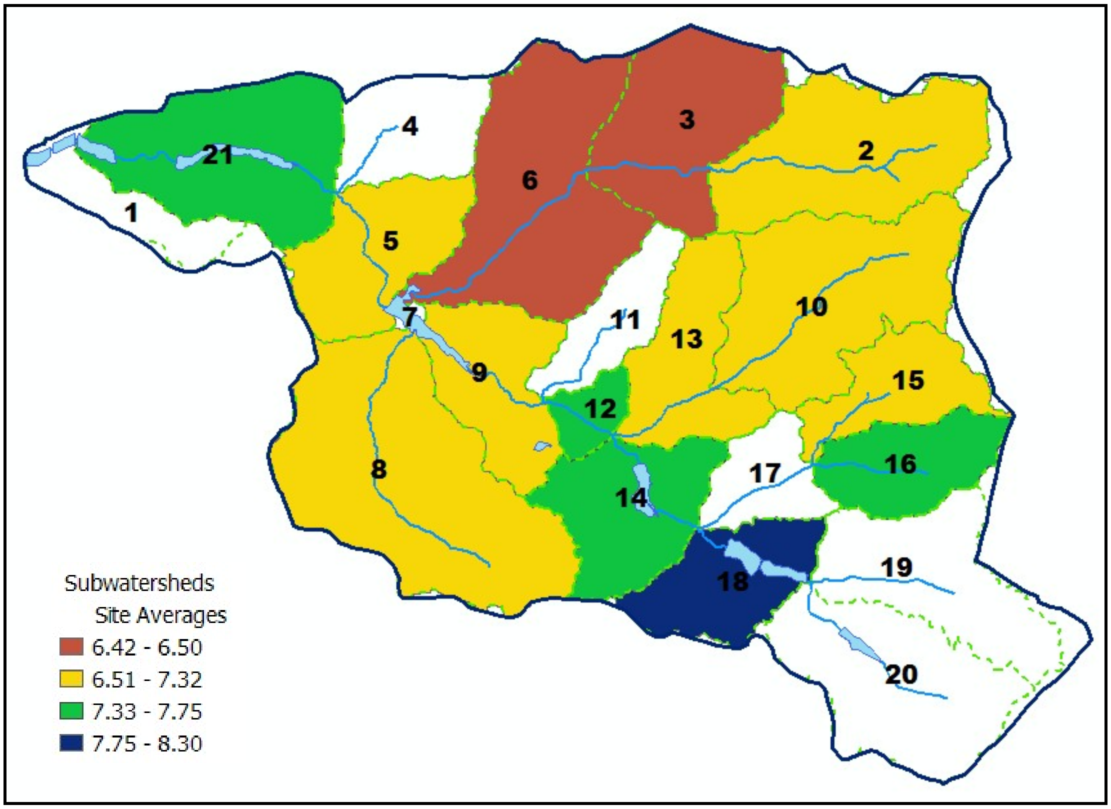


Figure B-2: 21 Subwatersheds Displayed by Overall SVAP Score

B. Identifying SVAP and Land Use Relationships Using SPSS

Data analysis was completed in SPSS so that relationships between individual SVAP scores and all SVAP scores, elevation changes, and land uses within the subwatersheds could be better understood. The first product within SPSS developed descriptive statistics for the SVAP parameters, as depicted in Table B-1. The SPSS program was used in a manner that demonstrated if SVAP scores could be predicted based on land use/land cover, riparian land use/land cover, and elevation. In other studies completed by Potter *et al*. (2004), parameters including watershed scale and watershed shape were found to be good predictors of instream macroinvertebrate health. Watershed shape is a dimensionless measure of watershed elongation, defined as

$$W_s = A/l^2$$

where A equals the area of the watershed and l is the length of the watershed, measured from the outlet to the farthest point parallel to the mainstem river channel. Higher values indicate greater roundness to the watershed shape (Potter *et al*., 2004). More round watersheds produce more concentrated runoff that reaches the mouth of the watershed more quickly, and therefore, with more explosive power (Ward, 1995).

Table B-1: SVAP Descriptive Statistics

	Count	Minimum	Maximum	Mean	Std. Deviation
Riparian Zone-left	73	1.00	10.00	7.42	1.78
Riparian Zone-right	73	1.00	9.00	7.49	1.96
Channel Modification	73	2.00	10.00	6.55	2.29
Bank Stability-left	73	1.00	9.00	4.78	2.28
Bank Stability-Right	73	1.00	9.00	4.48	2.32
Water Appearance	73	5.00	9.00	6.59	1.00
Nutrient Enrichment	73	5.00	9.00	6.51	.87
Fish Barrier	73	5.00	10.00	9.03	1.07
Instream Fish Cover	73	5.00	10.00	7.99	1.26
Pools	73	6.00	10.00	8.16	1.03
Invertebrate Cover	73	5.00	10.00	8.47	1.20
Canopy Cover	73	1.00	10.00	8.85	2.56
Left Average	73	5.36	8.55	7.26	.73
Right Average	73	5.42	8.64	7.23	.73
Site Average	73	5.45	8.59	7.24	.72

APPENDIX C: Aerial Loading Coefficients

Table C-1:Aerial Loading Coefficients Associated with Land Use

NPS Loading Coefficients											
	TP	**TN**	**TSS**	**NH3-N**	**LEAD**	**ZINC**	**COPPER**	**CADMIUM**	**BOD**	**COD**	**NO2+ NO3**
Land Use Type	lbs/acre/yr	lbs/acre/yr	lbs/acre/yr	lbs/acre/yr	lbs/acre/yr	lbs/acre/yr	lbs/acre/yr	lbs/acre/yr	lbs/acre/yr	lbs/acre/yr	lbs/acre/yr
High/Med Residential	1.4	15	140	0.65	0.2965	0.335	0.453	N/A	25.6	152.6	1.7
Low/Rural Residential	0.6	5	100	0.02	0.217	0.172	0.19	N/A	N/A	N/A	0.1
Commercial	2.1	22	200	1.9	0.955	0.873	0.784	0.002	42.1	662.6	3.1
Industrial	1.5	16	200	0.2	1.409	1.598	0.93	0.003	31.4	N/A	1.3
Mixed Urban	1	10	120	1.75	3.215	1.743	1.529	0.0025	67.2	184.8	3.55
Agriculture	1.3	10	300	N/A	0.071	0.089	0.027	N/A	15.45	N/A	N/A
Forest, Water, Wetlands	0.1	3	40	N/A	0.009	0.018	0.027	N/A	9.2	2	0.3
Barren Land	0.5	5	60	N/A	N/A	0.002	N/A	N/A	3.1	N/A	N/A
N/A: Data not available from sources used.											