Cayuga Lake Watershed

Wetland Management

September 2001

Cayuga Lake Watershed Wetlands Management Project

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Funding for this project was provided by the United States Environmental Protection Agency Region II.

Additional resources are available by using the Cayuga Lake Watershed Restoration & Protection Plan, which is available at http://www.cayugawatershed.org.

It should be noted that the black and while version of this report is available digitally in Adobe Acrobat Reader format in color. Optimal viewing of this document, especially many of the maps, figures and tables, is in color.

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1. Objectives and Purpose of this Document

This document summarizes a technical strategy for identifying priority actions to restore riparian corridors and wetlands. Using this approach, watershed managers can rank subwatersheds in terms of the environmental benefit that can be realized by restoring and protecting these critical riparian areas. The strategy also guides selection of appropriate restoration strategy based on landscape position, dominant land use, and the water quality issues to be addressed.

Underlying the technical strategy is a functional analysis of riparian corridors and wetlands. By understanding how these important ecosystems function in moderating pollution runoff and water flux, managers can direct their efforts to subwatersheds and stream segments in need of targeted protection and restoration efforts.

The Cayuga Lake Watershed is used to illustrate the technical strategy. Development of a collaborative management plan for the Cayuga Lake Watershed began in 1998 with creation of an Intermunicipal Organization, a voluntary partnership of 31 municipalities working together to create the *Cayuga Lake Watershed Restoration and Protection Plan* (the *RPP*). The RPP identified sediment as the most significant non-point source (NPS) pollutant affecting Cayuga Lake and its tributary streams. Protection of riparian zones is one of the most effective strategies for overall reduction in sediment loading. The recommendations developed in this document have been incorporated into the *Cayuga Lake Watershed Restoration & Protection Plan* process. For a full understanding of this process see the *Cayuga Lake Watershed Restoration & Protection Plan* <http://www.cayugawatershed.org>.

2. Approach

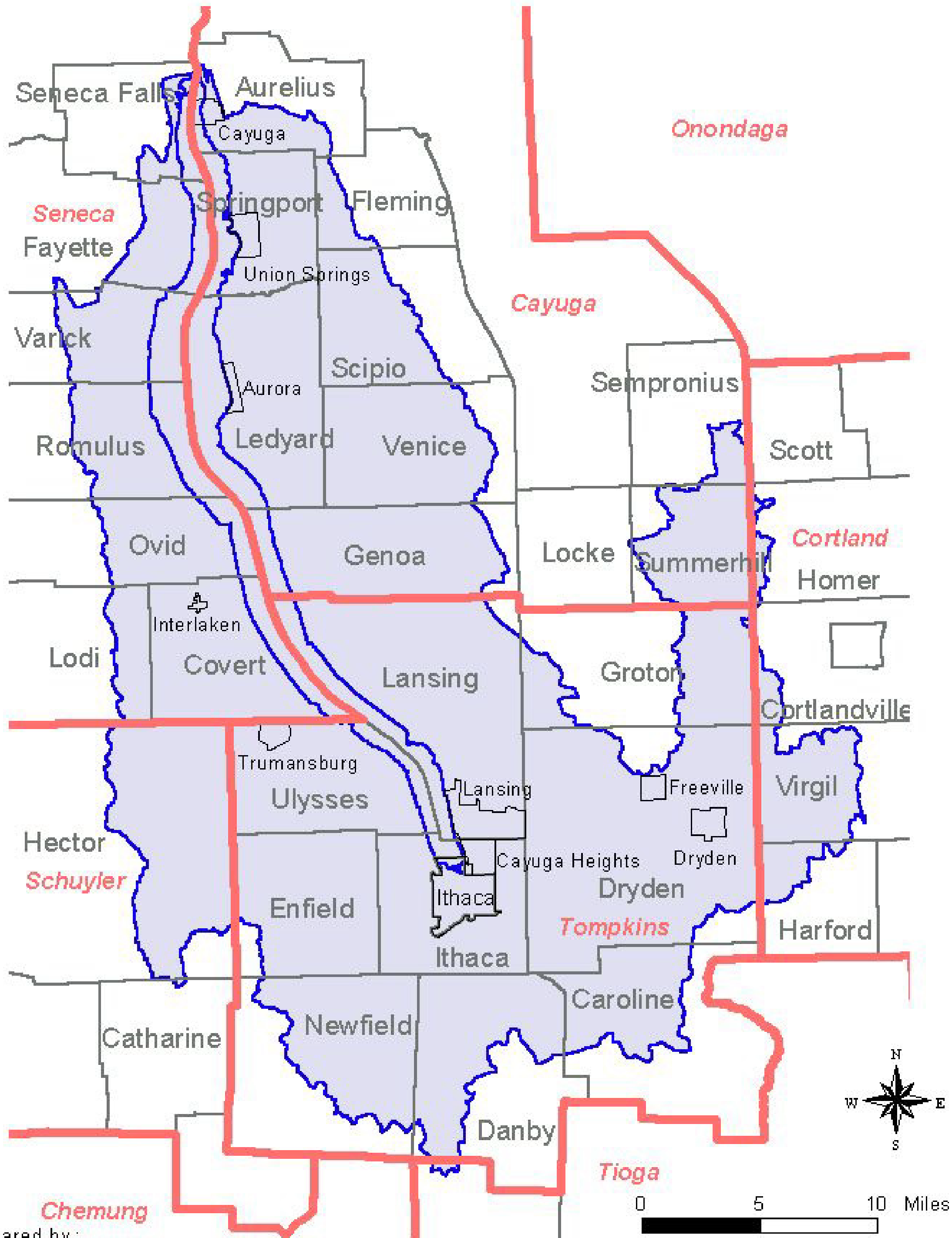
A watershed-wide approach was used to develop recommendations for specific wetlands and riparian corridors in the Cayuga watershed. As displayed in Maps 1 and 2, the Cayuga Lake Watershed extends over approximately 785 square miles of the Finger Lakes region of Central New York and encompasses 46 minor and 19 major subwatersheds. Many types of wetlands and riparian areas are found throughout the large watershed, reflecting the tremendous diversity in geology, land use, hydrology, vegetative cover, and soil types.

Recommendations for protection and restoration are based on the natural conditions (soils, slopes and drainage characteristics) coupled with the human-induced changes (land use, especially encroachment of the riparian corridor) within the subwatersheds. The objective of the management strategy is to restore and improve this ecosystem network. Their effect on water quality depends on the types of wetlands/riparian areas present and their position in the watershed. By evaluating their function, priorities for restoration efforts can be defined and management strategies targeted to needed water quality improvements.

A four-stage evaluation was utilized to develop a Wetland, Shoreline and Riparian Corridor Management strategy.

Define Existing Conditions. The first stage was to examine the existing wetland and riparian zone attributes. This stage focuses on understanding the attributes and processes

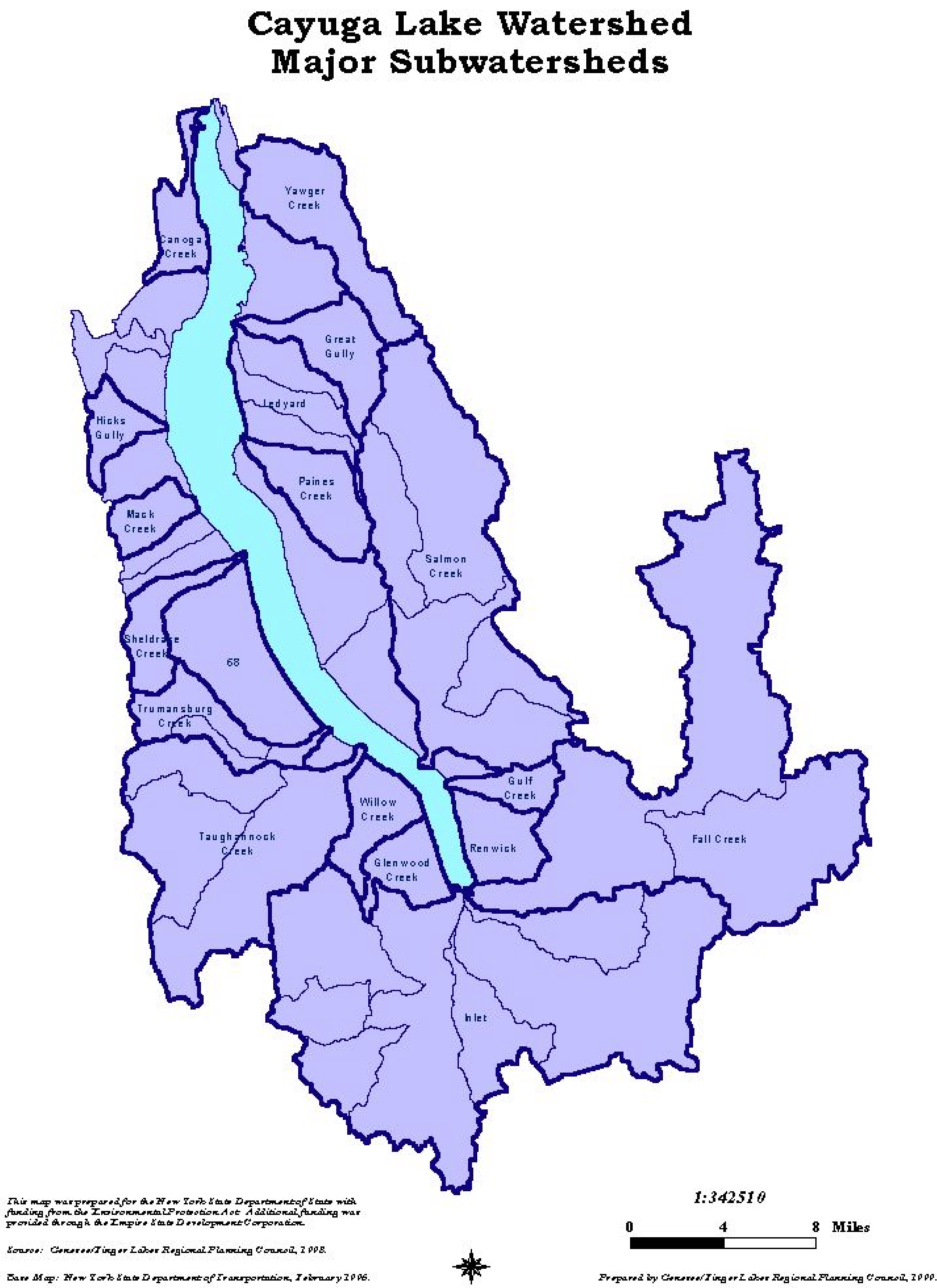
Cayuga Lake Watershed



Prepared by:
Genesee Finger/Lakes Regional Planning Council
Source:
Genesee/Finger Lakes Regional Planning Council, 1998.
Base Map:
New York State Department of Transportation, February 1996.

This map was prepared for the New York State Department of State with funding from the Environmental Protection Act. Additional funding was provided through the Empire State Development Corporation.

Map 1


Cayuga Lake Watershed
Major Subwatersheds
Yawger Creek
Canoga Creek
Great Gully
Ledyard
Hicks Gully
Paines Creek
Mack Creek
Salmon Creek
Sheldrake Creek
68
Trumansburg Creek
Gulf Creek
Willow Creek
Taughannock Creek
Fall Creek
Renwick
Glenwood Creek
Inlet
This map was prepared for the New York State Department of State with funding from the Environmental Protection Act. Additional funding was provided through the Empire State Development Corporation.
Source: Genesee/Finger Lakes Regional Planning Council, 1998.
Base Map: New York State Department of Transportation, February 1996.
1:342510
0
4
8 Miles
Prepared by Genesee/Finger Lakes Regional Planning Council, 1999.

Map 2

occurring in the riparian/wetland area of the watershed. Table 1 lists a number of attributes that may be present within wetlands and riparian corridors.

- **Complete a Functional Assessment**. The second stage of this evaluation was to categorize wetlands and riparian corridors into functional classes based on their position in the watershed and their significant attributes and processes.
- **Establish Priorities**. The third stage was to establish subwatershed priorities for restoring and protecting wetlands and riparian corridors.
- **Recommend Solutions**. The fourth stage is to establish a restoration and management strategy for those wetlands and riparian areas.

Two pilot subwatersheds, Taughannock Creek (Figure 1) and Yawger Creek (Figure Y-1), were selected to serve as prototypes for wetland and riparian area management strategies. These pilot subwatersheds are used throughout this document to illustrate wetland and riparian zone characteristics and the approach to defining priorities for restoration and protection.

Table 1. Percent (%) land-use within 150 ft. riparian corridor

	Industrial	Junkyard	Institutional	Residential	Ag Res	Ag Open	Developed Categories	Recreation	Forest	Wetland	Unknown	Undeveloped
Great Gully	0	0.13	0	1	2	78	**81.13**	0	19	0	0	19
Yawger Cr.	0.02	0	0	3	0	74	**77.02**	0	23	0	0.02	23.02
Sheldrake	0	0	0	3	1	70	**74**	0	25	0	0	25
Hicks Gully	2	0	0	4	0	68	**74**	0	27	0	0	27
Paines Cr.	0.35	0	0	3	0.38	70	**73.73**	0	26	0	0	26
Ledyard	0.05	0	0	2	1	68	**71.05**	0	29	0	0	29
68	1	0	0	4	1	64	**70**	0	30	0	0.04	30.04
Direct Drainage	2	0	0	6	1	61	**70**	0	31	0.01	0.01	31.02
Mack Creek	0.04	0	0	1	0	63	**64.04**	0	36	0	0	36
Trumansburg	0.32	0	0	5	1	57	**63.32**	0.46	37	0	0	37.46
Salmon Cr.	0.39	0.03	0	3	1	58	**62.42**	0	38	0	0	38
Canoga Creek	0	0	0	16	0.32	46	**62.32**	0.47	24	9	4	37.47
Renwick	11	0	0.08	27	0.4	23	**61.48**	1	38	0	0	39
Taughannok	0.06	0	0	3	1	50	**54.06**	0.3	46	0	0.07	46.37
Glenwood	0.31	0.42	0	9	1	41	**51.73**	0	48	0	0	48
Willow Cr.	0	0	0	0.03	1	48	**49.03**	0	51	0	0.21	51.21
Fall Creek	0.61	0	0.54	7	0.23	39	**47.38**	0.53	51	0	0	51.53
Gulf Creek	0	0.39	0	9	0	37	**46.39**	0	54	0	0	54
Inlet	2	0	0.24	8	0.07	28	**38.31**	0.06	63	0	0	63.06

Many sources of data and information are needed to complete the assessment. Site-specific field information is needed to complete site prioritization as well to prepare design of restoration projects. The following data sources related to the Cayuga Lake watershed were used in this application of the technical strategy to the Cayuga Lake Watershed.

- United States Fish &Wildlife Service (FWS) National Wetland Inventory Maps (NWI) (digitized where unavailable in digital format)
- New York State Department of Environmental Conservation (NYSDEC) Freshwater Wetland Maps
- NYSDEC wetland classification
- New York State's Land Use and Natural Resource (LUNR) Inventory (LUNR Classification Manual, 1971)
- Federal Emergency Management Agency (FEMA) Maps (Map 3)
- 7 ½ minute quadrangle U.S. Geological Survey Maps
- Aerial Photos (orthophotos, NYSDEC)
- Other remote sensing data (e.g., satellite imagery)
- Cayuga Lake Watershed Streambank Inventory (G/FLRPC, 2000)
- Cayuga Lake Watershed Roadbank Inventory (G/FLRPC, 2000)
- Hydrology map (NYSDEC)
- Hydrology gauging data
- Subwatersheds
- Land use (digitized from digital orthophotos, 12/00 - 2/01)
- General soil associations
- Detailed soil associations
- Tourism and recreation data
- *Cayuga Lake Preliminary Watershed Characterization* (G/FLRPC, 2000)

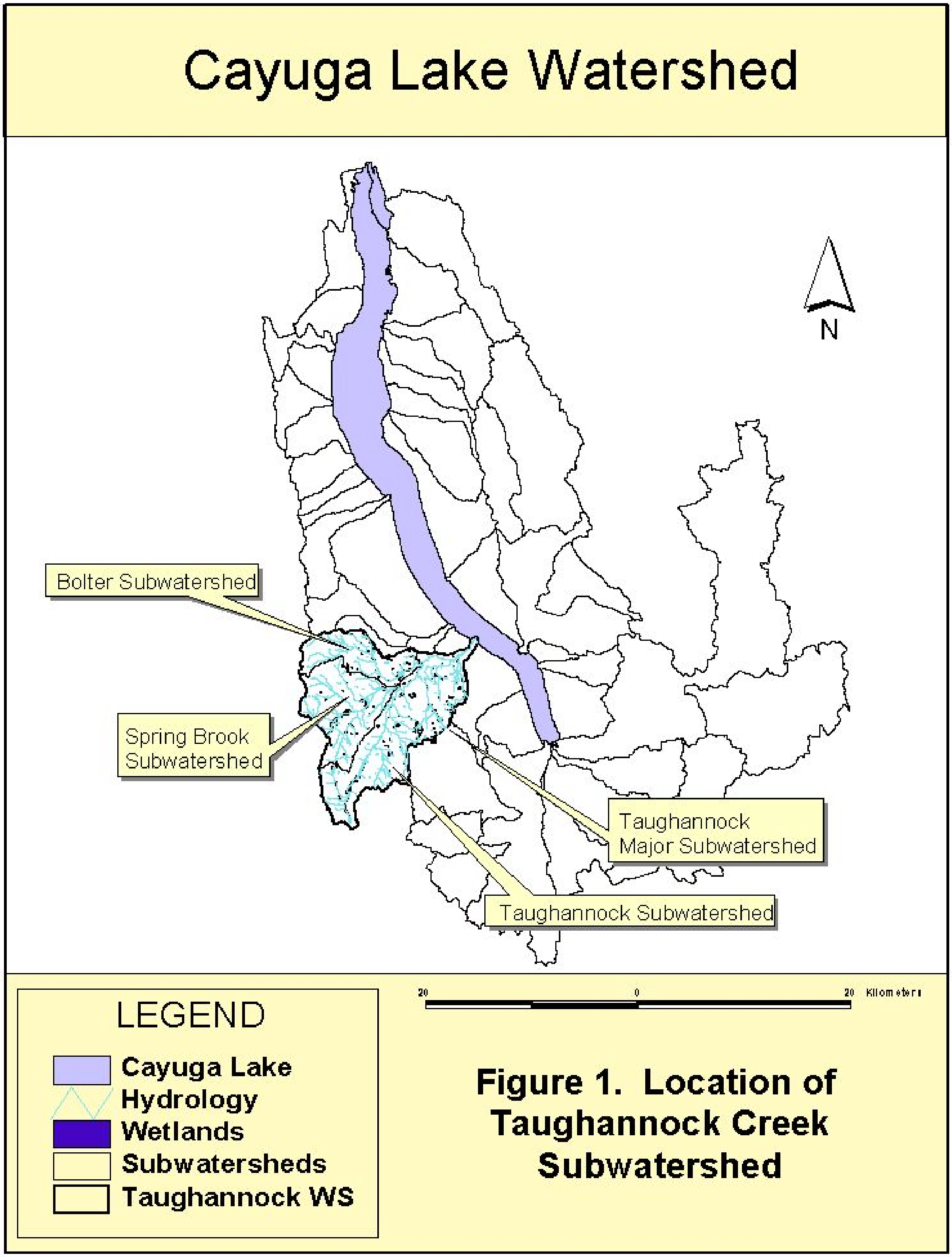


Figure 1. Location of Taughannock Creek Subwatershed

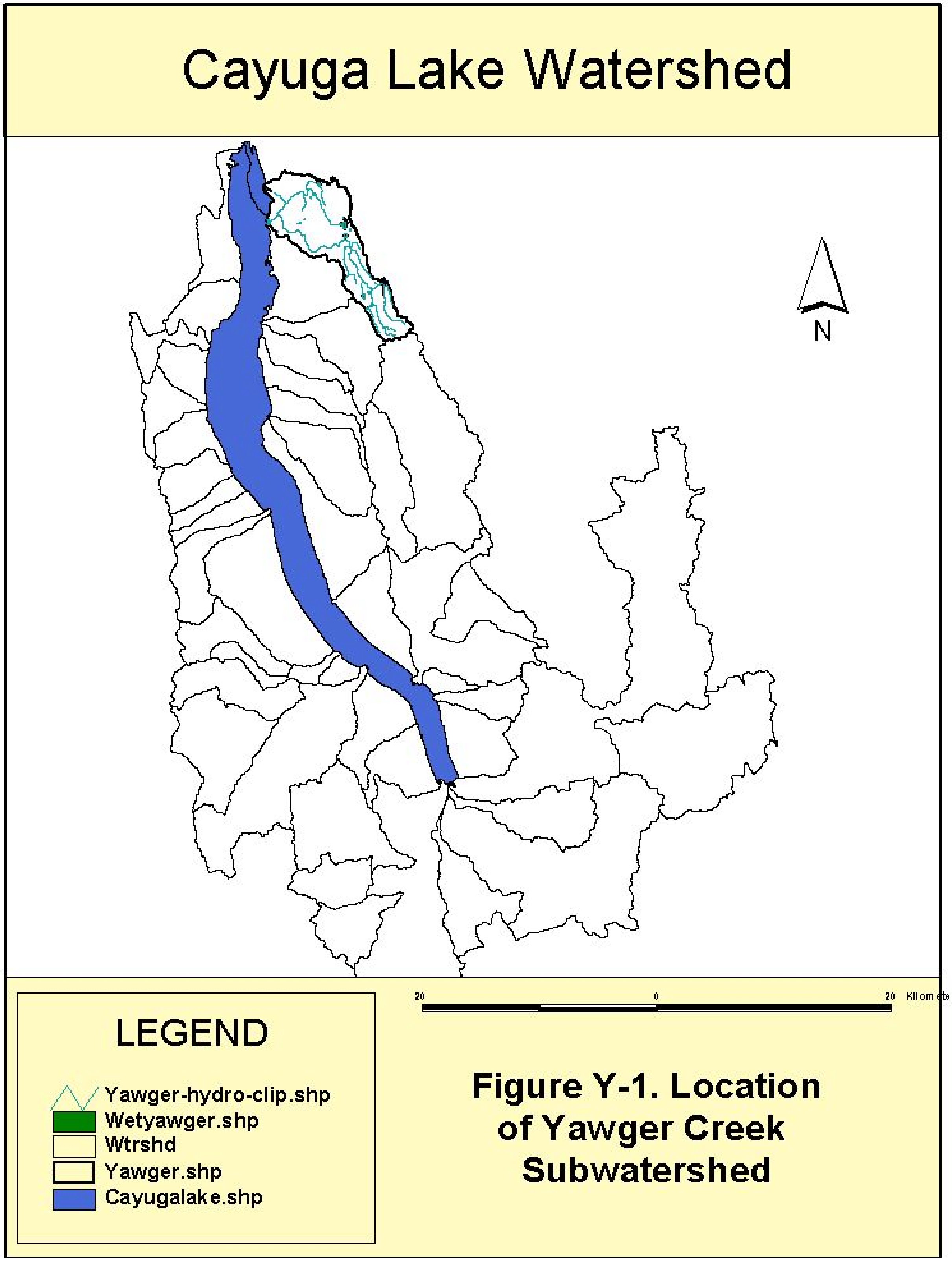
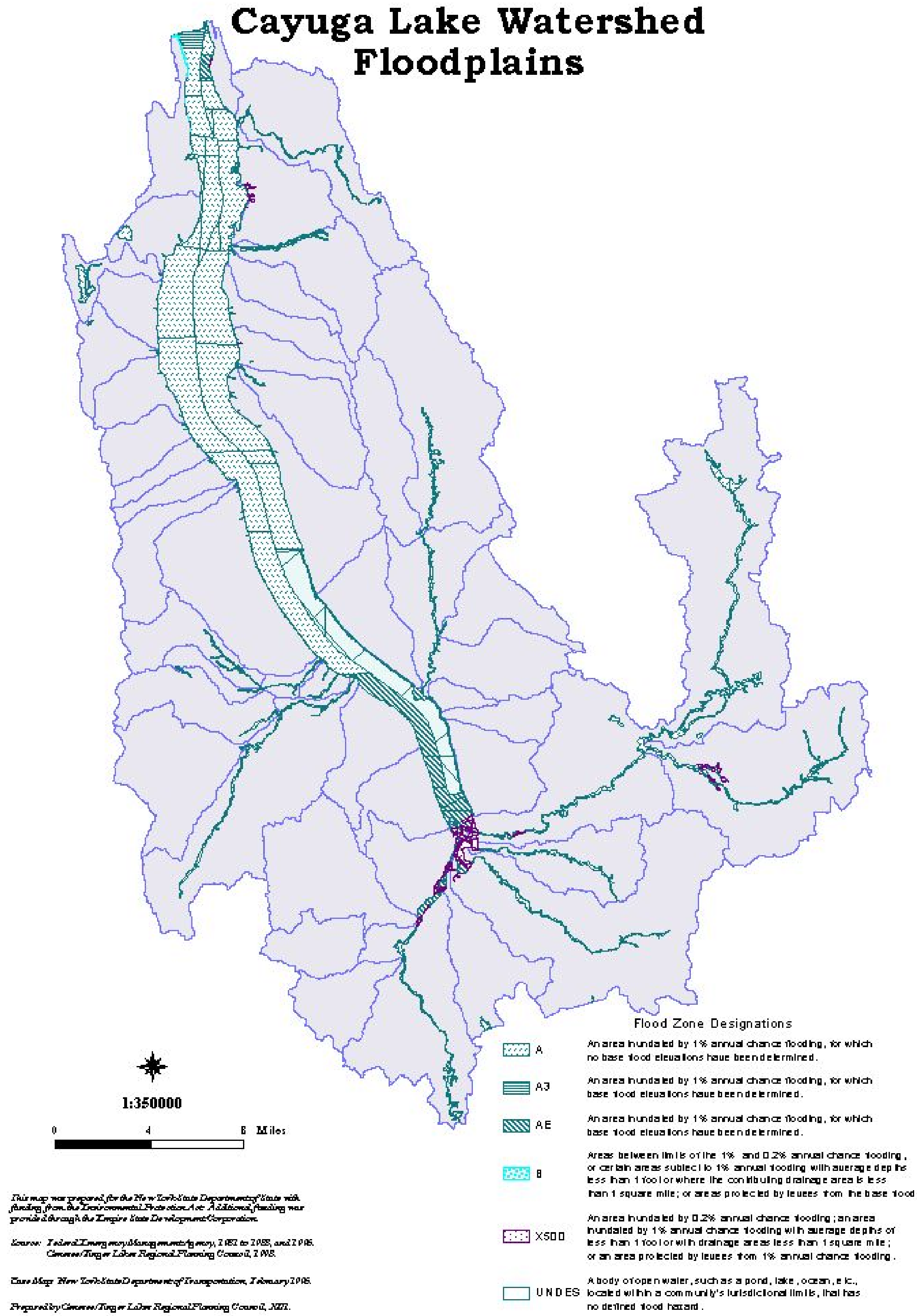


Figure Y-1. Location of Yawger Creek Subwatershed



Cayuga Lake Watershed
Floodplains
1:350000
0
4
8
Miles
Flood Zone Designations
A
An area inundated by 1% annual chance flooding, for which no base flood elevations have been determined.
A3
An area inundated by 1% annual chance flooding, for which base flood elevations have been determined.
AE
An area inundated by 1% annual chance flooding, for which base flood elevations have been determined.
B
Areas between limits of the 1% and 0.2% annual chance flooding, or certain areas subject to 1% annual flooding with average depths less than 1 foot or where the contributing drainage area is less than 1 square mile; or areas protected by levees from the base flood.
X500
An area inundated by 0.2% annual chance flooding; an area inundated by 1% annual chance flooding with average depths of less than 1 foot or with drainage areas less than 1 square mile; or an area protected by levees from 1% annual chance flooding.
UNDES
A body of open water, such as a pond, lake, ocean, etc., located within a community's jurisdictional limits, that has no defined flood hazard.

Map 3

3. Technical Strategy Stage 1: Define Existing Conditions

3.1 Wetlands

Wetlands are defined both in terms of natural resources and by their regulatory status. From a natural resource perspective, wetlands are ecosystems that depend on constant or recurrent shallow inundation or saturation at or near the surface. Wetlands include swamps, marshes, fens, and bogs. The characteristics and functions of a given wetland are determined by climate, hydrology, and substrate, as well as by its position and dominance in the landscape. While wetlands have a vast range of features, they share some specific structural and functional characteristics such as water, substrate, and biota as well as nutrient cycling, water balance, and production of organic compounds.

Wetlands functions are the physical, chemical, and biological processes that characterize wetland ecosystems, such as flooding, denitrification, and provision of habitat and support to wildlife. Wetlands have been shown to have the ability to significantly improve water quality (Kelly and Harwell, 1985, Nixon and Lee, 1988). This is particularly true of wetlands associated with stream corridors. Wetlands are a critical component of these riparian corridors. Wetland vegetation can keep stream channels intact by both slowing runoff and by evenly distributing its energy. Wetland vegetation can also regulate stream temperature by providing streamside shading.

Wetlands are defined and regulated by both New York State Department of Environmental Conservation (NYSDEC) and the U.S. Army Corps of Engineers (ACOE). Both agencies hold jurisdiction over the wetlands in the Cayuga Lake watershed. The ACOE, in accordance with Section 404 of the Clean Water Act, regulates the filling of "waters of the United States." This includes streams, lakes, impoundments, intermittent drainage ways, and associated wetlands. The ACOE defines wetlands as "Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."

At the state level, wetlands and watercourses are regulated by the NYSDEC in accordance with the Article 24 *Freshwater Wetlands* and Title 23 of Article 71 of the Environmental Conservation Law. NYSDEC defines wetlands as: "Lands and submerged lands commonly known as swamps, sloughs, bogs, and flats which support wetland vegetation. Wetland vegetation is categorized into wetland trees, wetland shrubs, and wet meadow vegetation that... 'depend on permanent or seasonal flooding [wetland hydrology] or sufficiently water-logged soils [hydric soils] to give them a competitive advantage over other [vegetation].'

3.1.1 Watershed-Wide Characterization of Wetlands

The Cayuga Lake Watershed contains approximately 6,575 acres of New York State Department of Conservation regulated wetlands or about 1% of the total watershed area. These state designated wetlands, 12.5 acres in size by definition, often coinciding with the U.S. Fish and Wildlife National Wetlands Inventory (NWI) designated wetlands. There are many more wetlands under this threshold that are not regulated. The large wetlands (> 12.5 acres) are regulated at both the Federal level (by the Army Corps of Engineers) and the State level (by NYSDEC). These agencies require a 100 feet buffer around regulated wetlands.

As indicated on Map 4, Cayuga Lake Watershed Wetlands, the large NYSDEC-designated freshwater wetlands are generally evenly distributed from the north to the south within the watershed with slightly more located toward the south end. In the east-west direction, the wetlands are clustered along the edges of the watershed away from the lake.

The largest wetland areas, which are mainly forested, are located on the upper portions of the watershed away from the lake shoreline. This is consistent with the steep topography along both sides of the watershed. There is a large wetland area in the northwestern edge of the watershed, in the upper reaches of the Red Creek watershed. At the north end of the lake is the Montezuma National Wildlife Refuge, a very large (6,820-acre) wildlife refuge.

Smaller wetlands are scattered throughout the upper watershed area. These smaller wetland areas, which have a high diversity of cover types, tend to be clustered in the outer edges of the watershed. They are more evenly distributed in the east-west direction than the larger wetlands. Other than those associated with the very large streams and those located at the south and north ends of the lake, very few wetlands are found adjacent to the lake's shoreline.

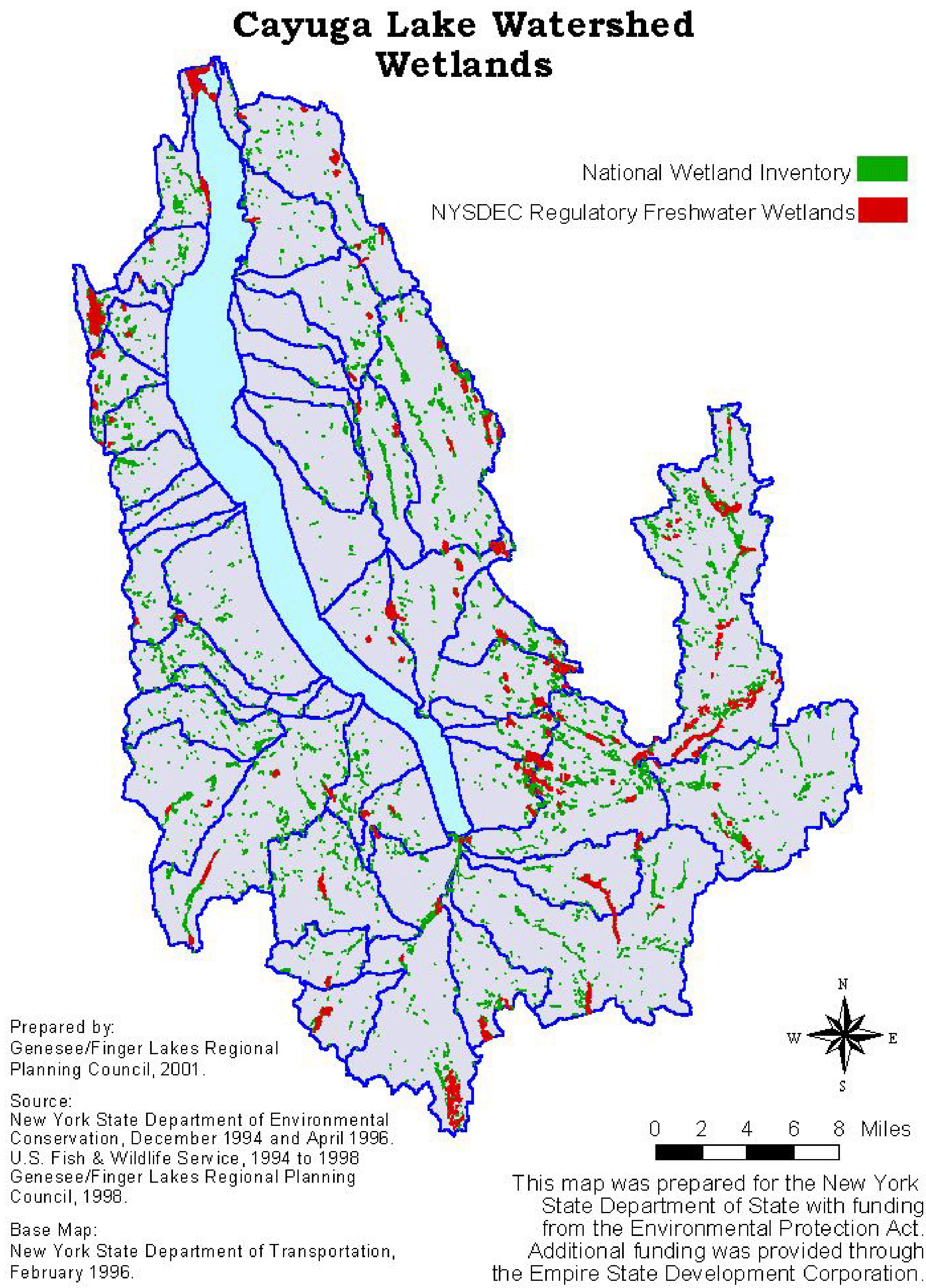
A number of wetland types are found throughout the watershed. The Fish and Wildlife service has mapped wetland cover types throughout the United States and documented these wetlands on the National Wetland Inventory Maps as displayed on Map 4.

The most important wetland communities in the Cayuga Lake watershed are described as follows:

a. *Palustrine Forested, Broad-leaved Deciduous, Seasonally Flooded/Saturated Areas (PFOIE).* PFOIE wetlands make up the largest area of wetlands within the watershed. They are located throughout the watershed, particularly in higher elevations. They consist of overstory trees, such as red maple, black ash and elm, a dense shrub layer, and a sparse understory.

b. *Palustrine Shrub-scrub, Broad-leaved Deciduous, Semi-Permanently Flooded Areas (PSSIF).* These wetlands are present throughout the watershed, although they make up a smaller percentage of the total wetland area. They contain some trees but are dominated by shrubs, such as red-stemmed dogwood and northern arrow-wood, with a variety of herbaceous plants and grasses in the herbaceous layer. These are seasonally flooded areas that maintain standing water in very wet years. In most years, they become ephemeral pools and dry up by the end of the year. Sedges, grasses, broad-leafed cattail, and common arrowhead dominate the wetter portions of these wetlands.

c. *Palustrine Emergent (PEM).* These are freshwater marshes dominated by persistent and non-persistent grasses, rushes, sedges, forbs, and other herbaceous or grass-like plants. Many of the nuisance species are found in these marshes including cattails, water willow (*Decodon verticillatus*), woolgrass, common reed, and purple loosestrife. Other plants often found in the semipermanently flooded areas include pickerelweed, arrowheads,


Cayuga Lake Watershed
Wetlands
National Wetland Inventory
NYSDEC Regulatory Freshwater Wetlands
Prepared by:
Genesee/Finger Lakes Regional
Planning Council, 2001.
Source:
New York State Department of Environmental
Conservation, December 1994 and April 1996.
U.S. Fish & Wildlife Service, 1994 to 1998
Genesee/Finger Lakes Regional Planning
Council, 1998.
Base Map:
New York State Department of Transportation,
February 1996.
N
W
E
S
0 2 4 6 8 Miles
This map was prepared for the New York
State Department of State with funding
from the Environmental Protection Act.
Additional funding was provided through
the Empire State Development Corporation.
Map 4

burrheads, cattails, and soft-stemmed bulrush. Seasonally flooded areas include the cattails, tussock sedge, bluejoint, sweet flag, smartweeds, bulrushes, purple loosestrife, and arrow arum. Sweetflag often forms almost pure stands in depressions of wet pastures.

d. *Open Water Excavated Wetlands (POWZh)*. There are a few open water wetlands within the watershed. Many of these are likely farm ponds created for a variety of purposes. These tend to be hydrologically isolated and fed by a variety of sources.

3.2 Riparian Corridors

The riparian corridor is defined as lands along, adjacent to, or contiguous with perennially and intermittently flowing rivers and streams, and the shores of lakes and reservoirs with stable water levels. Riparian areas form a transition between permanently saturated wetlands and upland areas. The vegetative community and physical characteristics of riparian corridors are strongly influenced by the hydrologic regime: the presence of permanent surface or subsurface water inundation.

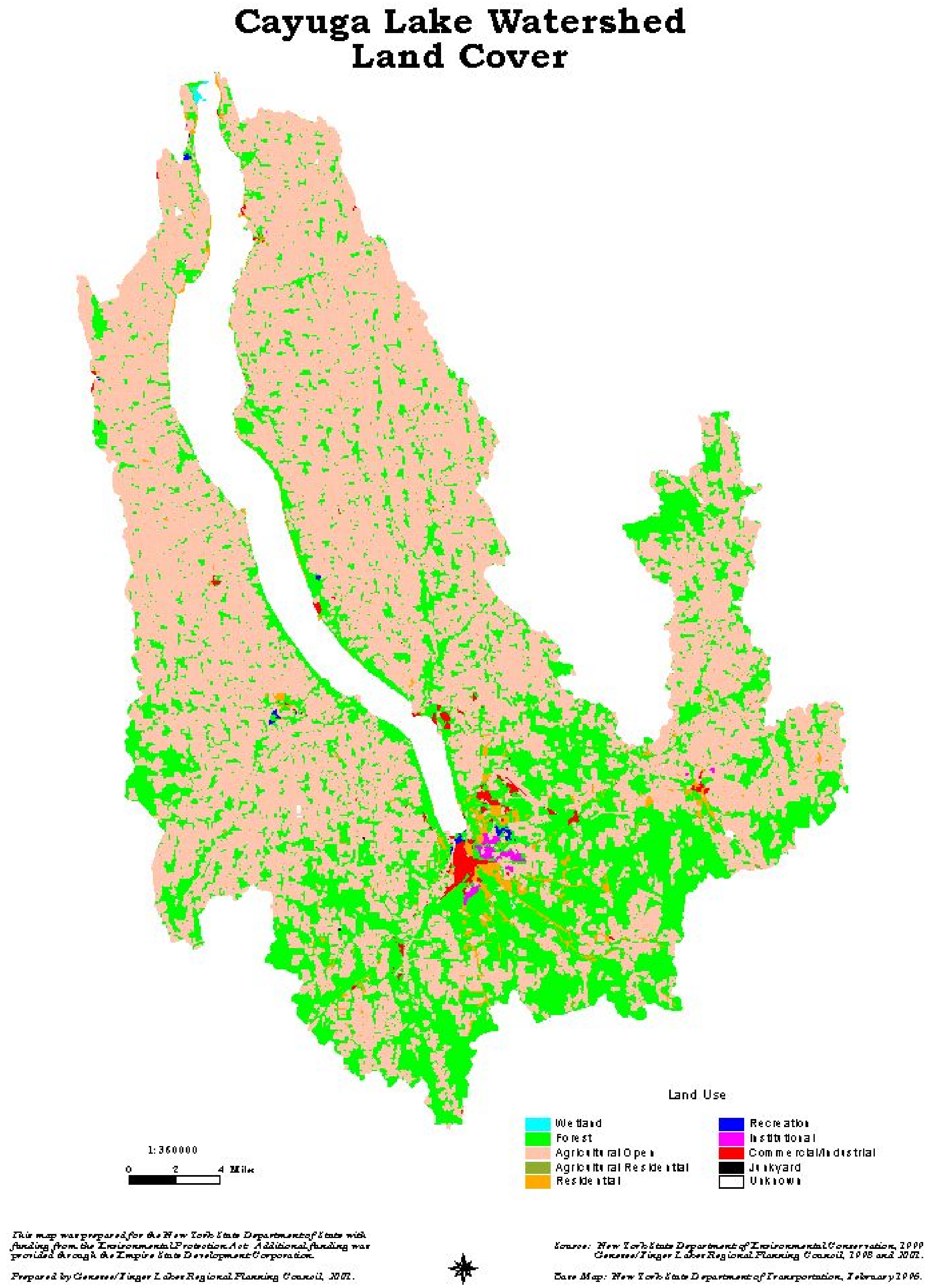
Like wetlands, riparian corridors play an important role in water quality, channel stability, erosion control and habitat for wildlife. In addition, they have values more directly related to humans such as aesthetic, recreational and resource values. The focus of the technical strategy was on protecting or restoring the major functions of riparian corridors that relate directly or indirectly to water quality. These functions include hydrologic regulation, filtration of sediment and dissolved nutrients, stabilization of stream structure, and regulation of water temperature.

3.2.1 Watershed-Wide Characterization of Riparian Corridors

Higher order creeks tend to occur in lowlands and are affected by upland land use practices. Examination of the land use patterns indicates that stream corridors in these areas are largely modified by agriculture or development. Alterations to the riparian zone and wetlands as a result of land use changes within the Cayuga Lake Watershed are variable. Additional site-specific data are needed to document these conditions for each stream segment.

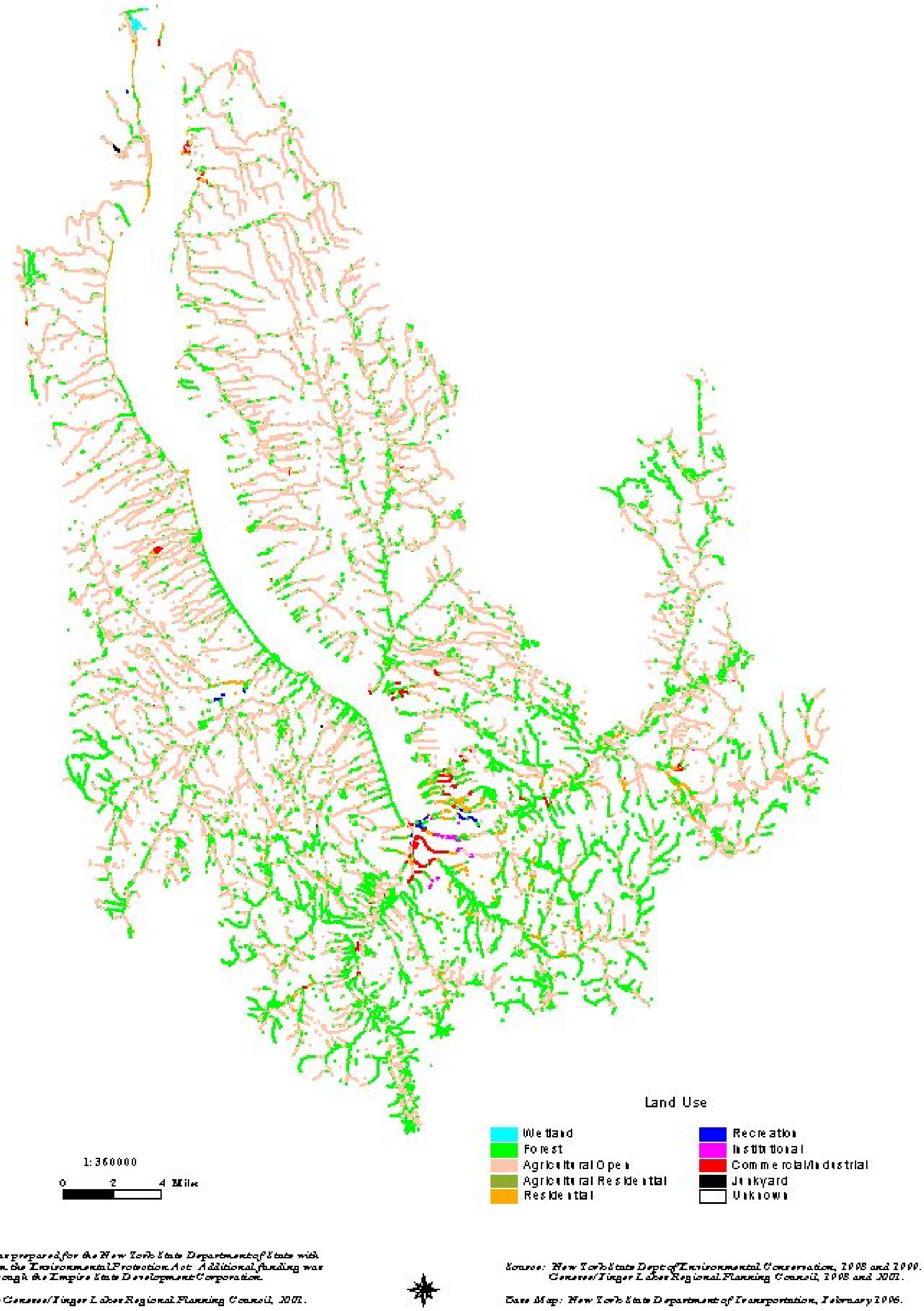
Map 5, Land Cover in the Cayuga Lake Watershed shows the land use cover throughout the watershed based on digital aerial photography. An analysis of land uses within 150 feet of the centerline of each stream was carried out based on detailed photo interpretation of aerial photographs. A map of Land Use in the Riparian Corridor (Map 6), and Table 1 and Figure 2 indicate the percent of each land use.

Stream networks are integrally linked to a more extensive network of roadside ditches that need to be considered in riparian restoration efforts. Although functioning only during storm events and spring runoff, there is evidence that this network of ditches within the Cayuga Lake Watershed significantly increases the total volume of discharge and degrades the quality of water entering into their connecting creeks (Schneider 1999). In addition there is evidence from the Roadbank Inventory (G/FLRPC, 2000) that the roadbanks themselves show signs of significant erosion and are a major source of sediment. This, in combination with the road ditch network, indicates a significant problem that directly affects wetlands, riparian corridors and ultimately, Cayuga Lake.


Cayuga Lake Watershed
Land Cover
Land Use
Wetland
Forest
Agricultural Open
Agricultural Residential
Residential
Recreation
Institutional
Commercial/Industrial
Junkyard
Unknown
1:360000
0
2
4 Miles
This map was prepared for the New York State Department of State with funding from the Environmental Protection Act. Additional funding was provided through the Empire State Development Corporation.

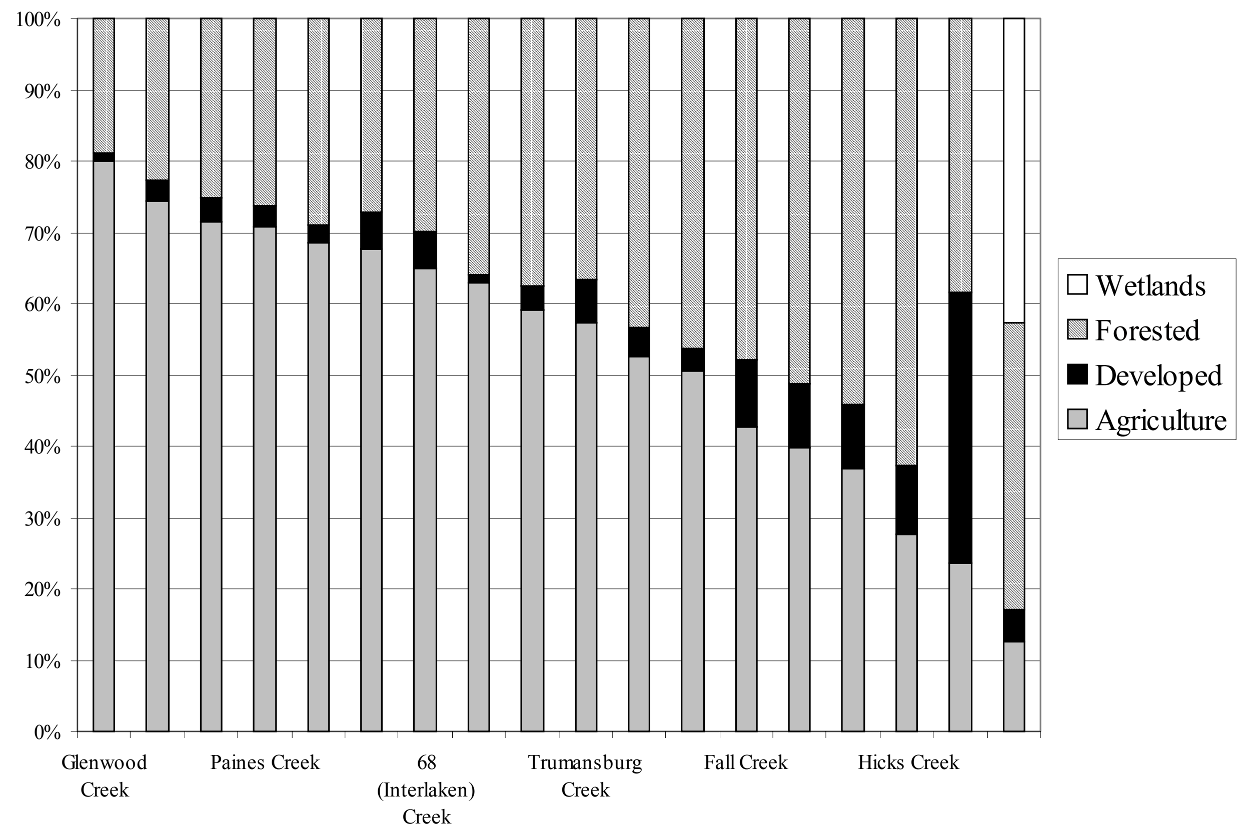
Map 5

Cayuga Lake Watershed
Land Use in the Riparian Corridor



Map 6

Figure 2. Percent of Major Cayuga Lake Subwatershed Riparian Zones by Land Use



4. Technical Strategy Stage 2: Functional Assessment

This stage of the technical strategy evaluates the functional role played by the wetland and riparian corridors for each subwatershed. Wetland functions are the physical, chemical, and biological processes that characterize wetland ecosystems. Examples of wetland functions include: storage and attenuation of flood flows; nutrient trapping and removal through mechanisms including denitrification; trapping and removal of pathogens, metals, and organic compounds; provision of habitat for organisms; and support of aquatic life. The value of a wetland is a measure of its importance to society, which could include aesthetics, open space, and recreation.

Riparian corridors also provide these functions. In addition, they are important in stabilizing shorelines and sediments. The water quality related functions are most important in the context of the Cayuga Lake watershed and the goals of the *RPP*. It is important to recognize the linkage between the hydrologic functions of flood flow storage and desynchronization of peak flows in protecting downstream water quality.

Most functional analyses require intensive site-specific data and analysis. For illustrating the approach in this technical strategy, function was inferred from the NWI cover types and geomorphic position within the watershed.

4.1 Wetland and Riparian Function and Stream Order

It is the combination of landscape position and wetland cover type that determines the water quality functions provided by wetlands within the watershed. Water that flows from the outside rim of the watershed first encounters headwater wetlands associated with small streams (Figure 3 and Y2). Headwater recharging wetlands are frequently source waters for these creeks. As water flows into higher order streams (second-fourth), most of the water contacts wetlands only during periods of flooding or when it enters areas where flow has been reduced, such as impoundments or larger palustrine (forested) wetlands. Many of the streams and rivers in the Cayuga Lake watershed are dominated by first and second order, steeply sloping creeks. It is only on the larger stream systems (such as Taughannock) that third and fourth order streams are developed. In these larger streams natural topographic depressions dominate the subwatersheds as a result of the glacial parent material. Examination of the topography of the Taughannock subwatershed shows that the stream flows from one depression to the next, forming a sequence of wetland systems along the riparian corridor. As water moves into higher order streams the percentage of total flow that passes through (or contacts) the wetland system decreases.

As a general rule the amount of nutrients that can be processed (or renovated) by a wetland is directly proportional to the amount of flow that is going through that wetland. Within these subwatersheds maximum contact occurs in areas associated with smaller streams, in areas where stream flow is constricted and in areas were water flows through wetlands. Wetland areas with maximum contact are noted on the Figures. Healthy vegetated streamsides, or riparian zones, improve water quality by filtering contaminants from groundwater, trapping suspended sediments, and retarding floodwaters.

4.2 Wetland and Riparian Function and Landscape Position

While the physical, biological, and chemical characteristics of riparian areas and wetlands largely determine how they function, the impact of the riparian corridor on water quality depends on its geomorphic position within the watershed. Vegetated riparian corridors, including wetlands, that are located upstream of first order streams serve important water quality functions. They are particularly important because of their sediment trapping capacity and ability to remove nitrogen, particularly nitrate, from groundwater. Sediment retention is primarily a physical phenomenon. The ability to remove nitrate seems to be related to the presence of waterlogged soils, high organic matter inputs, and relatively elevated concentrations of nitrate in ground water; these conditions promote denitrification (Whigham, et. al., 1988).

These functions are characteristic of riparian areas (Johnson and McCormick, 1979). Riparian vegetation has been shown to be particularly important in agricultural landscapes (Schlosser and Karr, 1981), which comprises the majority of the Cayuga Lake watershed. Downstream from first order streams, nutrients and sediments contact riparian wetlands either during flooding

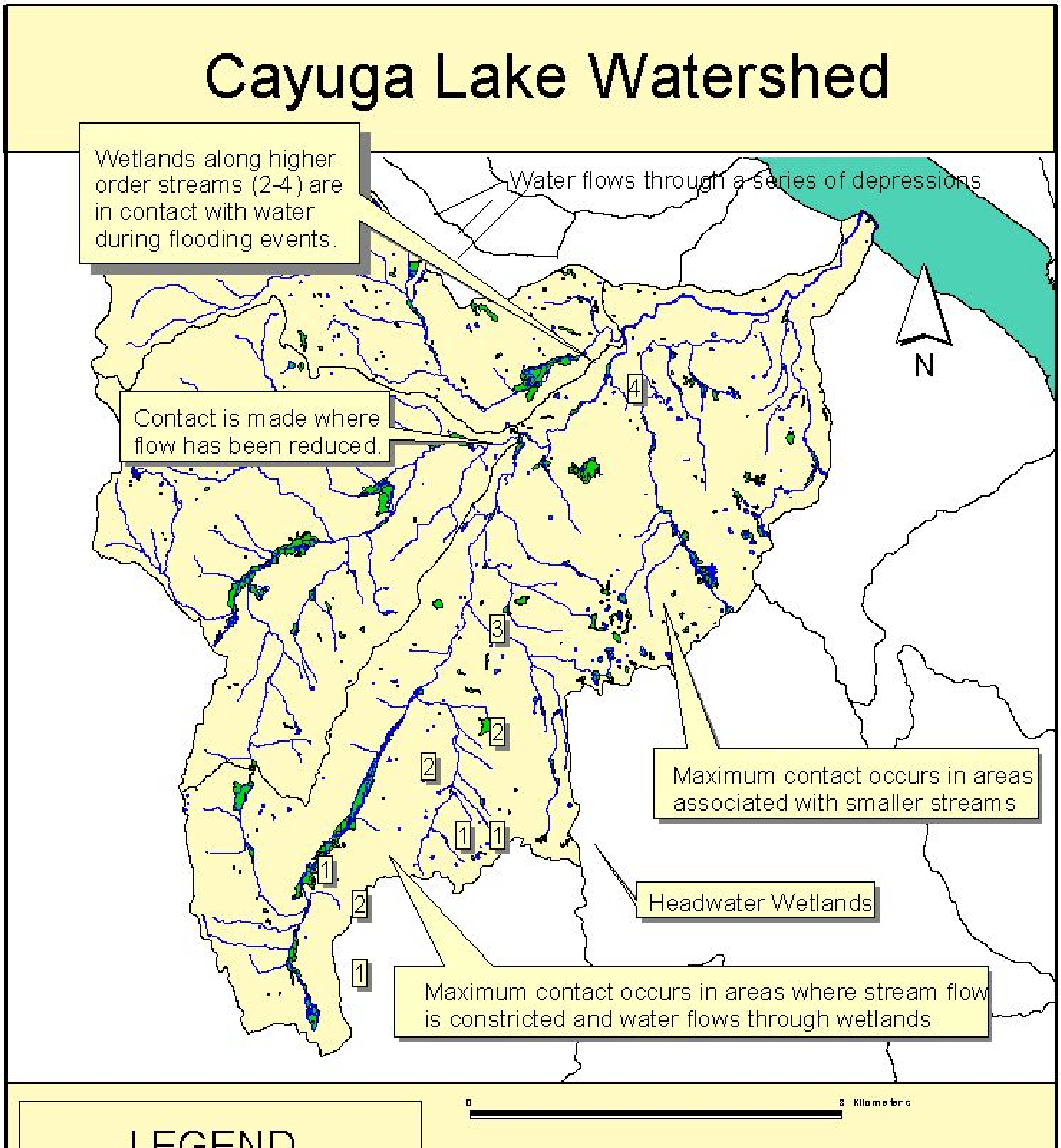


Figure 3. Watershed Position and Water Quality Functions Within the Taughannock Creek Subwatershed

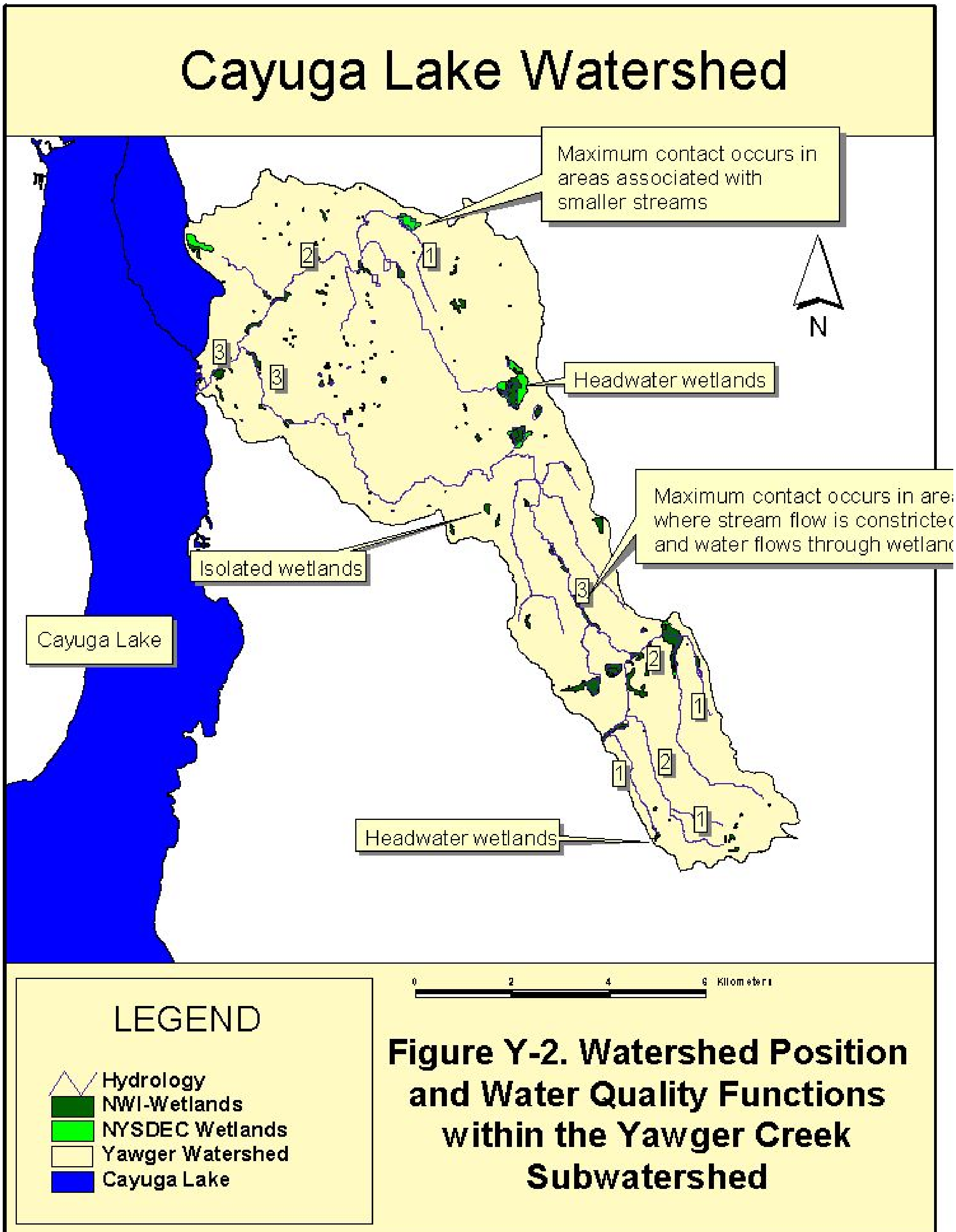


Figure Y-2. Watershed Position and Water Quality Functions within the Yawger Creek Subwatershed

events or when flow is directed to low areas in the landscape, or when the flow is altered to create impounded conditions.

Among first and second order streams, impoundments can have major impacts on water quality. Small impoundments (natural or created) are very effective in reducing downstream movement of carbon (by about 88%) and nitrogen, partly due to decreased flow rates and the presence of wetland vegetation. Palustrine wetlands have been shown to improve water quality and are sinks for nitrogen and phosphorus (Davis and others, 1981). In addition, they seem to be able to retain more nutrients as inputs increase. Riverine wetlands are effective in retaining phosphorus during flooding. These wetlands tend to have contact with stream water only during periodic flooding. During low flows only small amounts of phosphorus are removed by these wetlands. If less than 50% of the floodplain is inundated, between 10% and 17% of total phosphorus is retained. If more than 50% of the floodplain is inundated, between 46% and 69% of the phosphorus is retained (Yarbo et. al, 1984). This phosphorus retention is related to the riverine wetland's capacity for trapping and retaining sediments.

Because of the steep nature of the Cayuga watershed, wetlands tend to be located in the headwaters of streams, serving more as baseflow stream augmentation than flood reduction. The few wetlands in the lower portion of the landscape provide flooding attenuation.

4.3 Wetland and Riparian Function and Cover Type

As described in Technical Strategy Stage 1: Define Existing Conditions the wetland community of Cayuga Lake watershed tend to be dominated by a few types. The functions of these major wetland cover types are summarized as follow.

- *Palustrine Forested, Broad-leaved Deciduous, Seasonally Flooded/Saturated Areas (PFOIE).* The principal function and value associated with these palustrine wetlands is wildlife habitat, particularly for breeding and migration, and sediment stabilization. Their position would also indicate they serve a water quality function by trapping sediments and absorbing nutrients before the sediments reach the surface water drainage network and ultimately Cayuga Lake. The actual effectiveness of these wetlands in fulfilling these functions, however, would need to be assessed based on specific site conditions.

- *Palustrine Shrub-scrub, Broad-leaved Deciduous, Semi-Permanently Flooded Areas (PSSIF).* The PSSIF wetlands tend to be relatively diverse and perform several functions. The prime functions are flood-flow alteration and provision of habitat. Detention occurs in small ponded areas throughout the wetland and in adjacent wetlands having well-saturated hydric soils.

- *Open Water Excavated Wetlands (POWZh).* The primary functions provided by these ponds are habitat value, surface runoff collection and discharge, flood-flow alteration, and sediment retention.

The distribution and type of wetlands in Taughannock and Yawger subwatersheds and the general functions they provide are illustrated in Figures 4, Y3 and 5. The headwater wetlands in the Taughannock subwatershed are largely undisturbed, indicating that the headwater corridor is

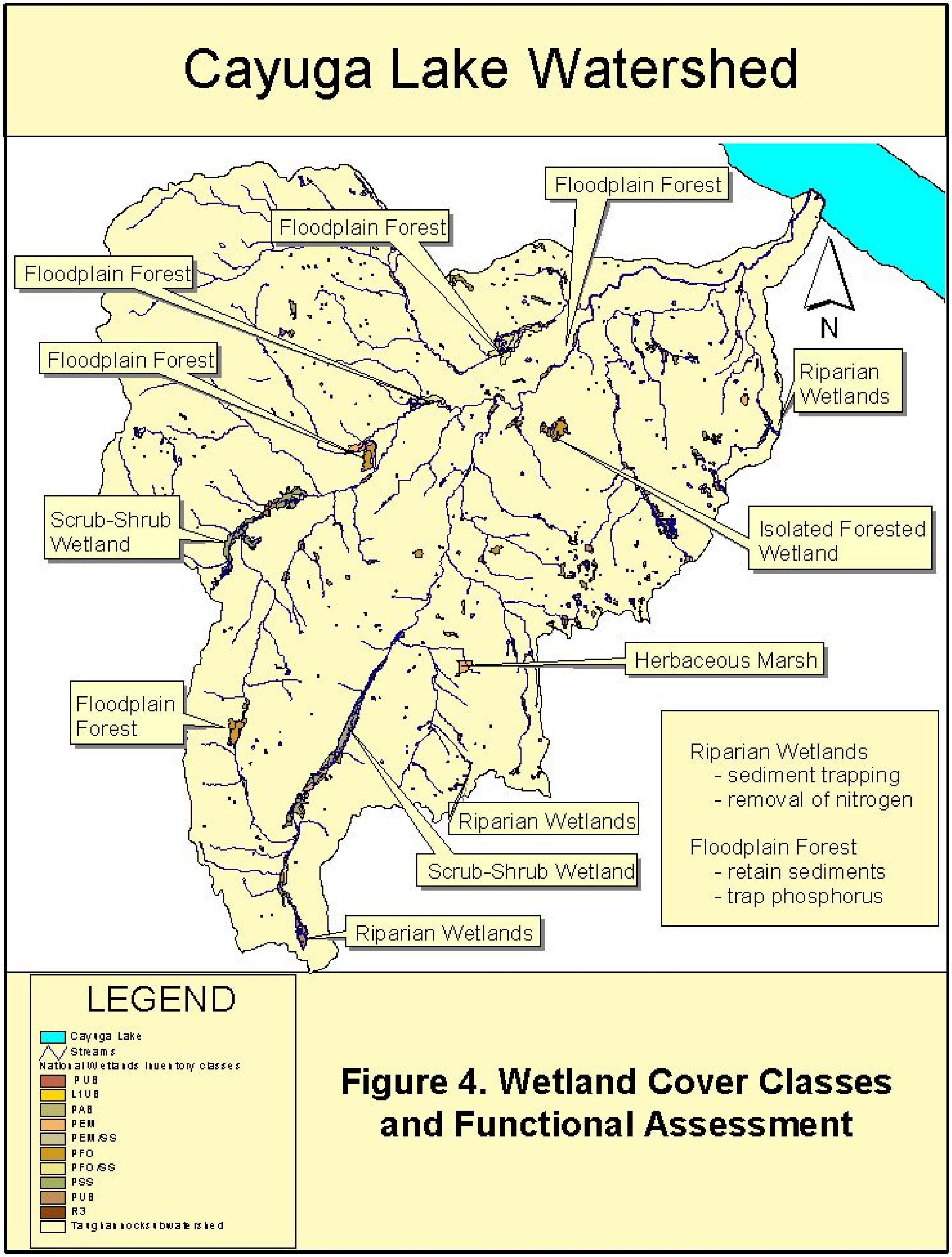


Figure 4. Wetland Cover Classes and Functional Assessment

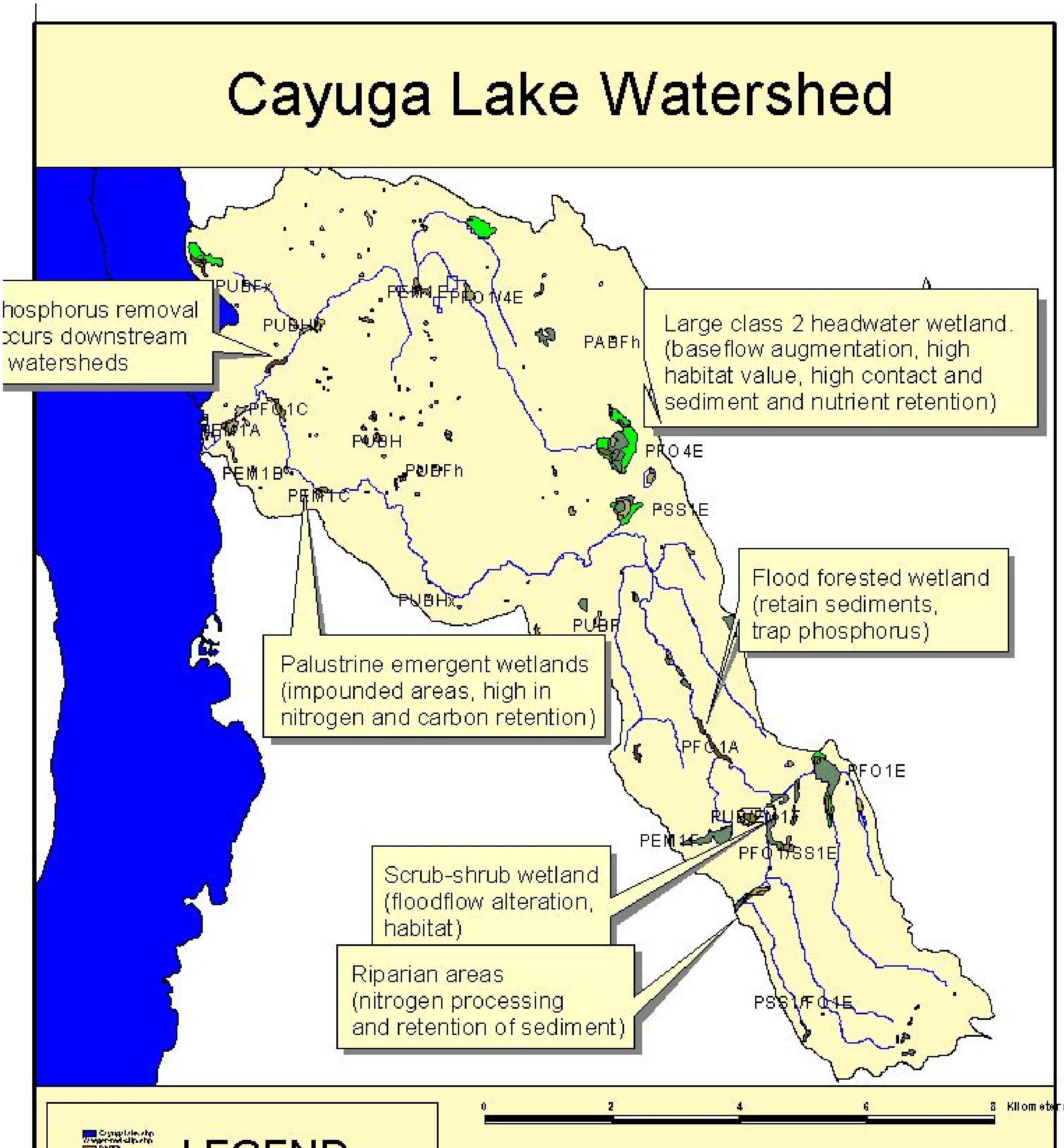


Figure Y-3. Wetland Cover Classes and Functional Assessment

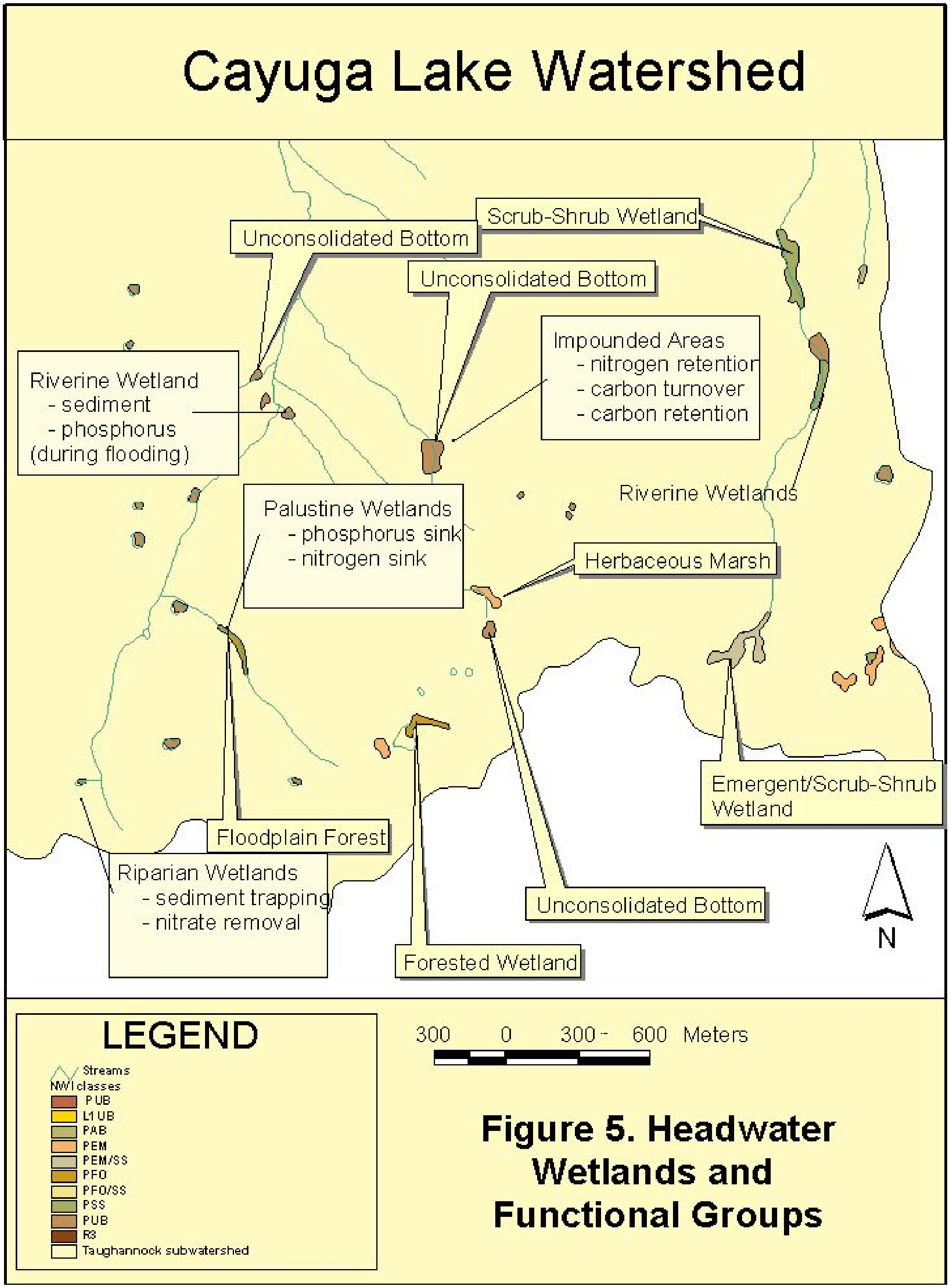


Figure 5. Headwater Wetlands and Functional Groups

functioning to provide habitat to the stream community, filter pollutants from the terrestrial ecosystem, and retard storm flows.

4.4 Additional Field Investigations to Assess Function

Additional detail of how the riparian areas and wetlands are functioning under current conditions can be gleaned from a targeted field investigation. While outside of the scope of this Technical Strategy, a trained field scientist can assess structural features such as vegetation, landform, and large woody debris and assign the condition of the riparian corridor/wetland to one of four categories:

- *Properly functioning*
- *Functional - At Risk* - wetland area is in functional condition but an existing soil, water, or vegetation attribute makes it susceptible to degradation.
- *Nonfunctional* – wetland areas that clearly do not provide adequate vegetation, landform, or large woody debris to dissipate stream energy.
- *Unknown* – wetland areas that lack sufficient information to make an evaluation.

5.0 Technical Strategy Stage 3: Establish Priorities.

5.1 Streambank Assessment within the Cayuga Lake Watershed

As part of the *Preliminary Watershed Characterization* phase of the *Cayuga Lake Watershed RPP*, the Genesee/Finger Lakes Regional Planning Council led an intensive field effort to inventory streambanks and roadbank conditions. This effort has produced invaluable site-specific information regarding the extent of erosion and conditions of the riparian corridor throughout the 785 square mile watershed.

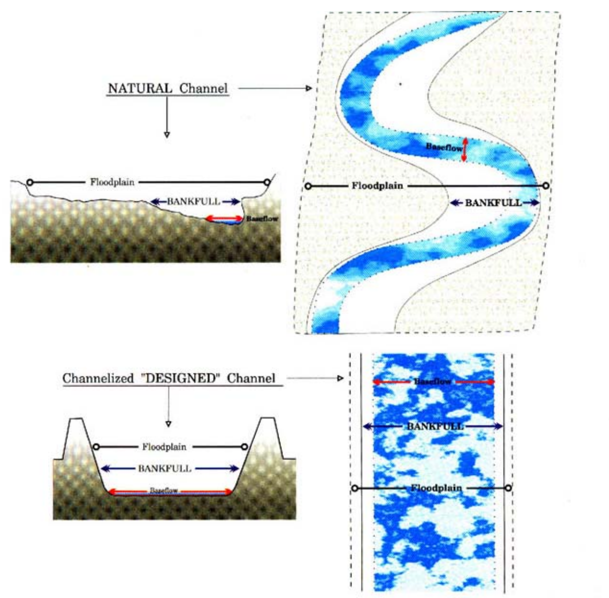


Figure 6

According to the streambank inventory, a number of streams within the watershed have been channelized, banks straightened with rock walls or railroad ties and major sections of streams altered. Figure 6 illustrates a natural stream vs. a channelized one. Floodplains are often cut off from the stream channel and, as in the illustration, adjacent levees are constructed to contain flood flows within one large channel. The objective is to allow areas of the floodplain to be developed commercially without the risk of flooding. The effect of this is that the previous flood stage is now associated with storms of less magnitude. In effect, the flood stage is elevated and the flood hazard has increased. As flows increase, the ability of the stream to erode and transport sediment increases as well. Downstream issues are thus both the quantity and the quality of the water.

Results of the streambank inventory for Cayuga Lake watershed are displayed in Map 7. This approach provides a defensible mechanism for ranking riparian corridors by subwatershed.

- **Minor** erosion was found along the western and eastern subwatersheds north of the Taughannock Creek and Salmon Creek subwatersheds. The direct drainage basins on the southern end of the lake showed very few signs of erosion.
- **Appreciable** erosion problems were found in the northeastern subwatershed of Yawger, Great Gully and Lavanna Area subwatersheds. Spring Brook also ranked as "appreciable".
- **Low end of severe** erosion was found in Taughannock and Bolter subwatersheds. The major Salmon Creek subwatershed (Salmon, Little Salmon, and Big Salmon Creeks) also had severe erosion problems (G/FLRPC, 2000).
- **Severe** erosion was found in the large subwatersheds in the southern end of the basin such as Fall, Virgil, and Sixmile Creeks.
- **Very Severe** erosion was documented along the Cayuga Inlet.

5.2 Priorities for Wetland Restoration and Protection

Priorities for restoring and creating wetland areas can be assigned on a subwatershed basis based on the present extent of Class 1 and 2 wetlands (most valuable coupled with the relative magnitude of nutrient and sediment export to Cayuga Lake.

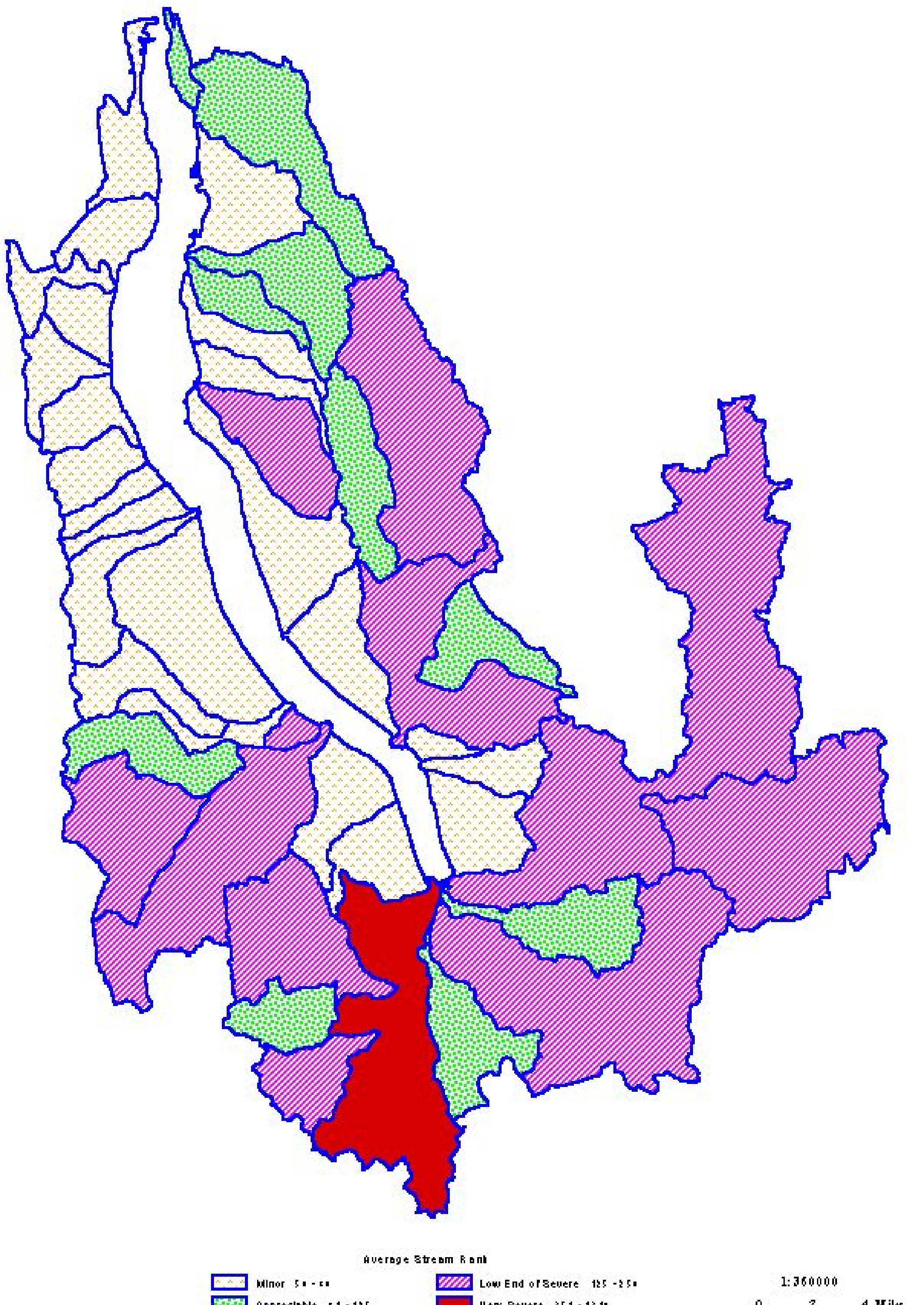
Using this approach, priorities for protection, restoration, and creation may be compared for the subwatersheds as follows:

Amount of Existing High Quality Wetlands	Relative Loading of Nutrients and Sediment to Lake	Recommended Strategy
High	Low	Wetland Preservation
High	Moderate to High	Wetland Restoration
Low	High	Wetland Creation

This approach is illustrated for the Cayuga Lake watershed in the tables and figures that follow.

As a means of setting restoration priorities, each major subwatershed was analyzed for the loading of total phosphorus (TP) (Table 2; Figure 7) ; unit areal loading of TP (Table 3) ; area of NYSDEC wetland (by class) within the subwatershed Table 4 ; and the percent total area of wetland (NWI wetlands) (Table 5) within the watershed. Figure 8 compares both DEC and NWI

Cayuga Lake Watershed
Streambank Inventory By Subwatershed



This map was prepared for the New York State Department of State with funding from the Environmental Protection Act. Additional funding was provided through the Empire State Development Corporation.

Source: Genesee/Finger Lakes Regional Planning Council, 1998 and 2000.
Base Map: New York State Department of Transportation, February 1996.
Prepared by Genesee/Finger Lakes Regional Planning Council, 2000.

Map 7

Table 2. Total Annual TP Loading

Sub-watershed	kg/year	%
Salmon Creek	7918.99	33.5%
Sheldrake Creek	6906.73	29.2%
Cayuga Inlet	2919.52	12.3%
Taughannok Creek	2128.87	9.0%
Great Gully	758.03	3.2%
Yawger Creek	679.50	2.9%
Paines Creek	554.22	2.3%
Fall Creek	522.41	2.2%
Trumansburg Creek	368.68	1.6%
Mack Creek	190.89	0.8%
Hicks Creek	180.58	0.8%
Ledyard Creek	153.87	0.7%
Gulf Creek	96.89	0.4%
Willow Creek	85.48	0.4%
Canoga Creek	82.17	0.3%
68 (Interlacken) Creek	67.16	0.3%
Glenwood Creek	22.31	0.1%
Renwick Creek	19.04	0.1%

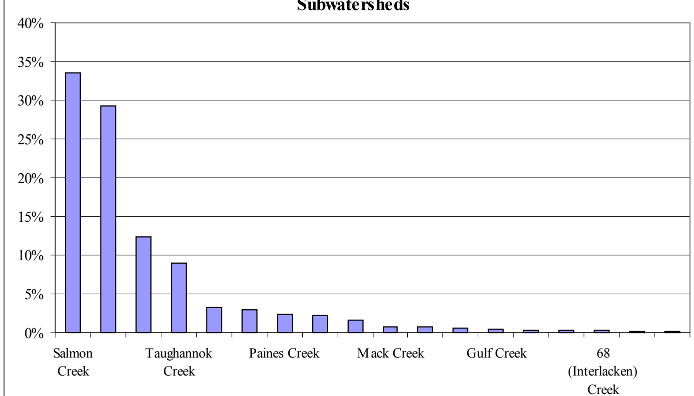
Table 3. Areal Loading

Sub-watershed	kg/year	kg/ha/year
Sheldrake Creek	6906.73	2.64
Salmon Creek	7918.99	0.33
Great Gully	758.03	0.20
Paines Creek	554.22	0.14
Taughannok Creek	2128.87	0.12
Yawger Creek	679.50	0.11
Hicks Creek	180.58	0.10
Mack Creek	190.89	0.10
Trumansburg Creek	368.68	0.10
Cayuga Inlet	2919.52	0.07
Gulf Creek	96.89	0.06
Canoga Creek	82.17	0.03
Willow Creek	85.48	0.03
Ledyard Creek	153.87	0.03
Fall Creek	522.41	0.02
68 (Interlaken) Creek	67.16	0.01
Glenwood Creek	22.31	0.01
Renwick Creek	19.04	0.01

wetlands for each subwatershed. Table 6 shows the final ranking of each category. Watersheds were prioritized as follows:

These subwatersheds were ranked from 1 to 18 based on wetland data and plotted in decreasing order in Figure 8. This ranking was combined for each category and the final score assigned. The highest-ranking subwatersheds are those that should be targeted first for wetland restoration. These are subwatersheds with the highest loadings and least area in wetlands. They could benefit the most from a program of wetland creation designed to control non-point source pollution. The middle group of subwatersheds exhibits a medium to high loading of TP but a

Figure 7. Percent of Annual Total TP Loading from Major Cayuga Lake Subwatersheds



relatively high percentage of the land area is classified as wetlands. This group of subwatersheds would be targeted mostly for wetland restoration. The lowest priority group of subwatersheds has the lowest loadings and the highest percentage of wetlands. These subwatersheds appear to be in the highest functioning condition and would therefore benefit from a wetland preservation policy.

Table 4. Area of NWI Wetlands per Subwatershed

Subwatershed	Area (ha)	NWI Wetland Area (ha)	Percent NWI Wetland
Renwick Creek	324	147.09	45%
Canoga Creek	829	247.50	30%
68 (Interlaken) Creek	510	62.62	12%
Glenwood Creek	505	58.03	11%
Fall Creek	33111	3444.29	10%
Hicks Creek	1349	130.50	10%
Willow Creek	862	82.79	10%
Salmon Creek	23165	2177.92	9%
Gulf Creek	1608	94.19	6%
Mack Creek	1424	64.36	5%
Yawger Creek	3664	154.68	4%
Trumansburg Creek	3572	132.80	4%
Taughannock Creek	17224	555.26	3%
Ledyard Creek	1536	49.32	3%
Sheldrake Creek	2142	66.02	3%
Cayuga Inlet	40979	1179.35	3%
Great Gully	4064	99.20	2%
Paines Creek	3942	54.90	1%

Cayuga Inlet, Taughannock, Salmon, Paines, Great Gully, and Sheldrake would be candidates for wetland creation. Hicks, Fall, Trumansburg, Ledyard, Mack, and Yawger Creeks are candidates for wetland restoration. Renwick, Canoga, Glenwood, Gulf, Tributary 68, and Willow Brook would be targeted for wetland preservation.

5.3 Priorities for Riparian Corridor Restoration

A similar matrix approach can be adopted for use in defining subwatershed priorities for riparian corridors.

Percent of Riparian Corridor developed	Percent of Riparian Corridor in Agricultural Land Use	Restoration Strategy
Low	Low	Preservation
Moderate	Moderate	Restoration
High	High	Stream and Riparian Corridor Reconfiguration

This approach was applied to the Cayuga Lake watershed. Land use within a 150-ft corridor of each stream was analyzed to assign each subwatershed to an action of preservation, restoration, or reconfiguration. These data are summarized in Table 7.

The percentage of land use class within the riparian zone is the best measure of condition within these areas. Table 8 combines land uses (shown in Table 7) within each riparian zone to show the percentage of developed areas within a 150 feet buffer area. Subwatersheds with over 70% development are assigned to a "high" category, from 70% to 54% to "medium", and below 53% to "low". Watersheds with the highest percent of developed area should be given the highest priority for riparian zone restoration.

Table 5. Percent total wetlands areas to total subwatershed area

Subwatershed	Total area (ha)	Percent total wetland area per class			
		1	2	3	4
Canoga	2387.9	6.7	na	na	na
Direct Drainage	22388.8	na	na	na	na
Fall	33507.4	0.4	1.5	0.1	0.09
Glenwood	2487.7	na	0.8	0.03	na
Great Gully	3861.9	na	0.2	0.4	na
Gulf	1598.2	2.7	0.9	na	1.7
Hicks	1812	na	0.5	1.7	na
Inlet	41229	1	0.3	0.03	na
Interlaken	6727.2	na	na	na	na
Ledyard	5224.8	na	na	0.04	na
Mack	1922.9	na	na	na	na
Paines	3851.8	na	na	0.2	na
Renwick	2946.3	1.2	1	na	na
Salmon	23860.6	na	0.8	1	na
Sheldrake	2620.9	na	0.3	na	na
Taughannok	17539.2	na	0.3	0.09	0.07
Trumansburg	3749.8	na	0.3	na	na
Willow	2893	na	0.2	na	na
Yawger	6313.2	na	1	0.3	na

Figure 8. Percent of Major Cayuga Lake Subwatersheds Made up of NWI Wetlands

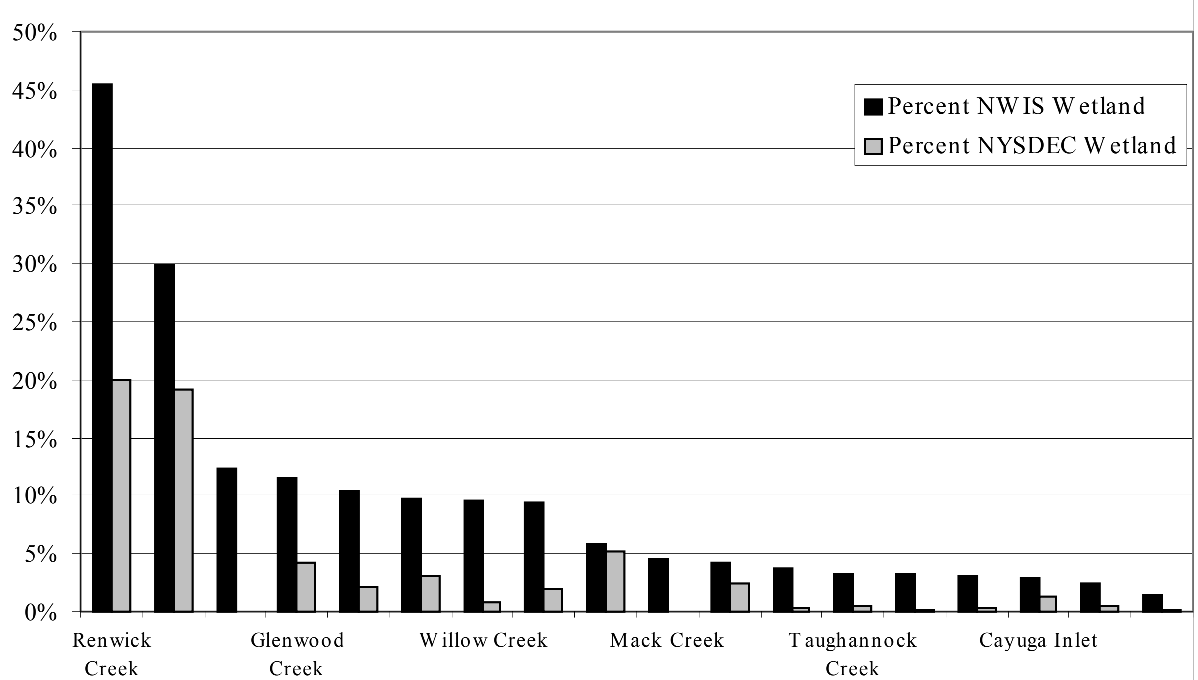


Table 6. Subwatershed wetland priorities

Rank	Loading (TP) Percentage of Annual Total TP Loading (sorted low to high)	Rank	Aerial L (kg/ha/yr) (sorted low to high)	Rank	Wetland Quality Percentage of Class wetland from 1 to 3 (sorted from high to low)	Rank	Percent of Watershed in NWI Wetlands (sorted from high to low)	**Cumulative Rank**		**Wetland Strategy**
3	68 (Interlaken) Creek	6	68 (Interlaken)	13	68 (Interlacken)	3	68 (Interlaken)	7	Renwick	Wetland Preservation
4	Canoga Creek	4	Canoga Creek	1	Canoga Creek	2	Canoga Creek	11	Canoga Creek	
16	Cayuga Inlet	3	Cayuga Inlet	4	Cayuga Inlet	16	Cayuga Inlet	14	Glenwood Creek	
11	Fall Creek	9	Fall Creek	5	Fall Creek	5	Fall Creek	19	Gulf Creek	
2	Glenwood Creek	1	Glenwood Creek	7	Glenwood	4	Glenwood Creek	25	68 (Interlaken)	
14	Great Gully	8	Great Gully	10	Great Gully	17	Great Gully	26	Willow Creek	
6	Gulf Creek	2	Gulf Creek	2	Gulf Creek	9	Gulf Creek	28	Hicks Creek	Wetland Restoration
8	Hicks Creek	6	Hicks Creek	8	Hicks Creek	6	Hicks Creek	30	Fall Creek	
7	Ledyard Creek	4	Ledyard Creek	12	Ledyard Creek	14	Ledyard Creek	35	Trumansburg Creek	
9	Mack Creek	6	Mack Creek	13	Mack Creel	10	Mack Creek	37	Ledyard Creek	
12	Paines Creek	7	Paines Creek	11	Paines Creel	18	Paines Creek	38	Mack Creek	
1	Renwick Creek	2	Renwick Creek	3	Renwick Creek	1	Renwick	38	Yawger Creek	
18	Salmon Creek	11	Salmon Creek	7	Salmon Creek	8	Salmon Creek	39	Cayuga Inlet	Wetland Creation
17	Sheldrake Creek	10	Sheldrake Creek	9	Sheldrake Creek	15	Sheldrake Creek	42	Taughanock Creek	
15	Taughanock Creek	5	Taughannok Creek	9	Taughanock Creek	13	Taughanock Creek	44	Salmon Creek	
10	Trumansburg Creek	4	Trumansburg Creek	9	Trumansburg Creek	12	Trumansburg Creek	48	Paines Creek	
5	Willow Creek	4	Willow Creek	10	Willow Creek	7	Willow Creek	49	Great Gully	
13	Yawger Creek	8	Yawger Creek	6	Yawger Creek	11	Yawger Creek	51	Sheldrake Creek	

Table 7. Percent (%) land-use within 150 ft. riparian corridor

	Industrial	Junkyard	Institutional	Residential	Urban Categories	Ag Res	Ag Open	Ag Categories	Recreation	Forest	Wetland	Unknown	Undeveloped
Canoga Creek	0	0	0	16	16	0.32	46	46.32	0.47	24	9	4	37.47
Sheldrake	0	0	0	3	3	1	70	71	0	25	0	0	25
Willow Cr.	0	0	0	0.03	0.03	1	48	49	0	51	0	0.21	51.21
Great Gully	0	0.13	0	1	1.13	2	78	80	0	19	0	0	19
Gulf Creek	0	0.39	0	9	9.39	0	37	37	0	54	0	0	54
Yawger Cr.	0.02	0	0	3	3.02	0	74	74	0	23	0	0.02	23.02
Mack Creek	0.04	0	0	1	1.04	0	63	63	0	36	0	0	36
Ledyard	0.05	0	0	2	2.05	1	68	69	0	29	0	0	29
Taughannok	0.06	0	0	3	3.06	1	50	51	0.3	46	0	0.07	46.37
Glenwood	0.31	0.42	0	9	9.73	1	41	42	0	48	0	0	48
Trumansburg	0.32	0	0	5	5.32	1	57	58	0.46	37	0	0	37.46
Paines Cr.	0.35	0	0	3	3.35	0.38	70	70.38	0	26	0	0	26
Salmon Cr.	0.39	0.03	0	3	3.42	1	58	59	0	38	0	0	38
Fall Creek	0.44	0	0.38	5	5.82	28	28	56	0.38	37	0	0	37.38
68	1	0	0	5	6	1	63	64	0	30	0	0.04	30.04
Direct Drainage	2	0	0	6	8	1	61	62	0	31	0.01	0.01	31.02
Hicks Gully	2	0	0	4	6	0	68	68	0	27	0	0	27
Inlet	2	0	0.24	8	10.24	0.07	28	28.07	0.06	63	0	0	63.06
Renwick	11	0	0.08	27	38.08	0.4	23	23.4	1	38	0	0	39

6. Technical Strategy Stage 4: Recommend Solutions

As a final stage in the strategy, various institutional and technical measures are identified. The size of the Cayuga Lake watershed makes recommending institutional measures a complex task. The overall goals of the restoration and protection strategy must be articulated and shared with stakeholders. For example, the RPP lists the following objectives for the riparian and wetland areas within the Cayuga Lake watershed:

- Preserve existing wetlands and restore degraded wetlands within the watershed
- Restore degraded streams to a natural condition for the purposes of reducing streambank erosion and restoring aquatic habitat.

- Develop and maintain streamside vegetation corridors for the purposes of reducing streambank erosion, trapping sediments and nutrients, and providing shading and cool water during the summer.
- Construct and/or restore wetlands for natural water treatment and moderation of flood flows.
- Protect a full range of wetlands and riparian functions by preventing development activity in hydrologically sensitive areas.

Example strategies for preservation, restoration, creation of wetlands, and stream reconfiguration are discussed for wetlands and the riparian corridor. Examples of controls and Best Management Practices (BMPs) are provided that transcend these categories. Throughout this section, there are cross-references to the Cayuga Lake Watershed RPP, where additional strategies are presented.

6.1. Preservation of Wetlands and Riparian Corridors

Actions that protect wetland and riparian ecosystems by discouraging encroachment within a buffer area can are the first line of defense to degradation of the ecological functions. This can be achieved through education or a regulatory framework. An important element of this strategy is to encourage proper management of upstream watershed activities such as agriculture, forestry, and urban development.

Non-government groups that purchase wetlands for conservation purposes, such as The Nature Conservancy, the Trust for Public Land, and local land trusts, are playing an increasingly important role in protecting water quality. For a listing of current and recommended wetland and riparian preservation education activities see the *Cayuga Lake Watershed Restoration & Protection Plan*.

Table 8. Percent (%) developed area landuse within 150 ft. riparian corridor

	Developed Categories	ENCROACHMENT RANK	Undeveloped Categories
Great Gully	81.1	H	19.0
Yawger Cr.	77.0	H	23.0
Sheldrake	74.0	H	25.0
Hicks Gully	74.0	H	27.0
Paines Cr.	73.7	H	26.0
Ledyard	71.1	H	29.0
68	70.0	H	30.0
Direct Drainage	70.0	H	31.0
Mack Creek	64.0	M	36.0
Trumansburg	63.3	M	37.5
Salmon Cr.	62.4	M	38.0
Canoga Creek	62.3	M	37.5
Fall Creek	61.8	M	37.4
Renwick	61.5	M	39.0
Taughannok	54.1	M	46.4
Glenwood	51.7	L	48.0
Willow Cr.	49.0	L	51.2
Gulf Creek	46.4	L	54.0
Inlet	38.3	L	63.1

6.2 Restoration of Degraded Wetlands and Riparian Corridors

This non-regulatory strategy promotes restoration of degraded wetlands and riparian zones. Restoration can involve the community. Based on the analysis presented in Stage 3, restoration should target those areas with the greatest potential for adverse impacts on downstream receiving waters.

The primary goal of restoration is to enhance aquatic habitat and ecological functions that have been lost or degraded as development and other land uses have encroached on buffer zones or into the wetlands themselves. Restoration activities should re-create a full range of preexisting wetland functions. That means re-planting degraded wetlands with native plant species and, depending on the location and degree of degradation, using structural devices to control water flows. Restoration projects factor in ecological principles, such as habitat diversity and connections between different aquatic and riparian habitat types, which distinguishes these kinds of projects from wetlands that are constructed for pretreatment. Table 9 provides examples of potential riparian, streambank, in-stream and upland restoration techniques.

Table 9. Examples of Riparian, Streambank, Wetland, Instream and Upland Restoration Techniques.

Restoration Category	Description
Streambank Treatment	**Streambank planting.** A common problem encountered (particularly in urban streams) is that the riparian stream buffer zone has been cleared. Streambank and floodplain replanting are excellent community projects that can effectively re-vegetate riparian areas within a matter of a few years. Through volunteer tree planting programs this can be accomplished at a fairly low cost. (see below)
	Brush mattresses or brush bundles. Combination of live stakes, live fascines, and branch cuttings installed to cover and physically protect streambanks, eventually to sprout and establish numerous individual parts.
	Coconut fiber roll. Cylindrical structures composed of coconut husk fibers bound together with twine woven from coconut material to protect slopes from erosion while trapping sediment that encourages plant growth within the fiber roll.
	Dormant post planting. Planting of cottonwood, willow poplar, or other species embedded vertically into streambanks to increase channel roughness, reduce flow velocities near the slope face, and trap sediment.
	Vegetated gabions. Wire-mesh, rectangular baskets filled with small to medium size rock and soil and laced together to form a structural toe or sidewall. Live branch cuttings are placed on each consecutive layer between the rock filled baskets to take root, consolidate the structure, and bind it to the slope.
	Joint plantings. Live stakes tamped into joints or openings between rock that has previously been installed on a slope or while rock is being placed on the slope face.
	Live cribwalls. Hollow, box-like interlocking arrangements of untreated log or timber members filled above baseflow with alternate layer of soil material and live branch cuttings that root and gradually take over the structural functions of the wood members.
	Live stakes. Live wood cuttings that are tamped into the soil to root, grow and create a living root mat that stabilizes the soil by reinforcing and binding soil particles together, and by extracting excess soil moisture. This can include willow wattles.
	Live fascines. Dormant branch cuttings bound together into long sausage-like, cylindrical bundles and placed in shallow trenches on slopes to reduce erosion and shallow sliding.
	Vegetated geogrids. Alternating layers of live branch cuttings and compacted soil with natural or synthetic geotextile materials wrapped around each soil lift to rebuild and vegetate eroded streambanks.
Riparian	**Livestock exclusion or management.** Constructing fences and gates in riparian corridor to control access of grazing livestock and other agricultural practices.
	Riparian forest buffers. Re-establishing vegetation in the riparian corridor with native species best suited to current hydrologic and soil conditions (e.g. forested riparian buffers).
	Water diversion control. Controlling the timing, location, and extent of water diversion from streams and controlling irrigation return flows to stream channel.
	Wetland Restoration. (see below)

Wetland	**Excavation** of upland adjacent to wetland.
	Revegetation (see bank relocation)
	Large scale excavation and reshaping of the wetland, stream and floodplain and subsequent revegetation
	Dike and excavation to enlarge size and change cover type.
	Selected grading of mining or other spoil banks.
	Creation of nesting islands and nesting structure construction.
	Flooding areas through alteration in hydrology (e.g., diversion, diking, water direction baffles, etc.)
	Levee damming channel to make reservoir or other type of impoundment.
	Water control including periodic draw-downs or pumping stations. Water level control would include the use of ditches or structures such as stop log devices, dikes with screw gates, and culverts.
	Shallow dam to create shallow water reservoir.
	Repair of damaged or abandoned dikes or dams.
Instream	**Instream techniques** are applied directly in the stream channel. Many streams have lost or have a degraded stream habitat structure. This includes loss of pools, riffles, and clean spawning areas. There are a host of habitat improvement techniques that have been developed by stream biologists such as: (see below)
	Boulder clusters: Large boulders are placed strategically in the stream channel to increase structural complexity, including eddies and small pools.
	Log drop structures. The drop log consists of a log placed across the stream, with a V notch cut into the middle to direct flow. This is an example of one of many structures that alter flow conditions to create small drops and pools. Characteristics of the structures (i.e., height of the drop and width of the log) are carefully designed to prevent the obstruction of fish migration.
	Log, root wad, and boulder revetment. Boulders and logs with root masses attached, placed in and on streambanks to provide streambank erosion control, trap sediment, and improve habitat diversity.
	Rip-rap. A blanket of appropriately sized stones extending from the toe of the slope to a height needed for long term durability. This can be vegetated.
	Lunker Structure. Cells constructed of heavy wooden planks and blocks that are imbedded into the toe of the streambanks at channel bed level to provide covered compartments for fish shelter, habitat, and prevention of streambank erosion.
	Identification and removal of fish barriers. Streams often develop barriers to anadromous and resident fish migration.
Channel reconstruction	Stream meander restoration
	Maintenance of hydraulic connection

Uplands	**Upland reforestation.** Using native tree species, upland reforestation can counter the impacts of landuse changes within the watershed.
	Agricultural and grazing BMP's. Erosion and sediment control (e.g., filter strips, grassed waterways, and conservation tillage); confined animal facility management (e.g., sediment basins); grazing management (e.g., livestock exclusion, alternative drinking locations, and stream crossings.
	Forest BMP's. Streamside management areas that contain canopy species to control temperature and increase bank stability; road decommissioning; erosion control (e.g., grass seeding, hydro-mulch, installation of road drainage structures, such as water bars, dips, or ditches).
	Urban BMP's. Retention devices (e.g., infiltration basins, trenches, dry wells, and porous pavements); vegetative controls (e.g., basin landscaping, filter strips, grassed swales, and wetlands); source controls (e.g., education regarding the inappropriate discharges to storm drains and proper disposal of potential contaminants); erosion control (e.g., construction site management and controls); land use planning (e.g., limiting direct connection of impervious areas to water bodies); sewage overflow controls; urban stormwater retrofits.
Water Management	**Sediment basins**. Barriers, often employed in conjunction with excavated pools, constructed across a drainage way, or off-stream, and connected to the stream by a flow diversion channel to trap and store waterborne sediment and debris.
	Water level controls. Managing water levels within the channel and adjoining riparian zone to control aquatic plants and restore desired functions, including aquatic habitat.

6.3 Wetland Creation And Other Engineered Systems, including BMPs

The third strategy promotes the use of constructed wetlands or engineered treatment systems for recreating ecosystem functions. Despite regulations protecting wetlands, it is likely that the Cayuga Lake watershed has lost and will continue to lose large areas of freshwater wetlands to development. Some of this wetland loss results from direct filling; other loss results from inadequate provisions for stormwater management. It is therefore critical to create new stormwater wetland areas rather than direct additional stormwater into existing wetlands. While these wetlands are preserved, their functions and values are degraded by excessive sediment and nutrient inputs.

Constructed wetlands and vegetated filter strips are especially effective at removing suspended solids and sediment before runoff reaches natural wetlands. Constructed wetlands are engineered complexes of water, plants, and animal life that simulate naturally occurring wetlands. Sediment removal rates greater than 90% can be achieved under optimal conditions. Vegetated filter strips are swaths of land planted with grasses and trees to intercept sheet runoff before the runoff reaches wetlands or other receiving waters. Sediment removal rates can exceed 70%.

Stream restoration can be a mosaic of in-stream, riparian, and upland techniques, including Best Management Practices (BMPs), to be used in combination to eliminate or reduce the impact of stressors (both chemical and non-chemical) on aquatic ecosystems. A multiple level restoration and creation can often be the most effective means of improving water quality for the entire subwatershed (see Figure 9 and Y5) & Figure 10 and Y6) for an example of a multi-level control strategy for the Taughannock and Yawger Creek Subwatersheds.

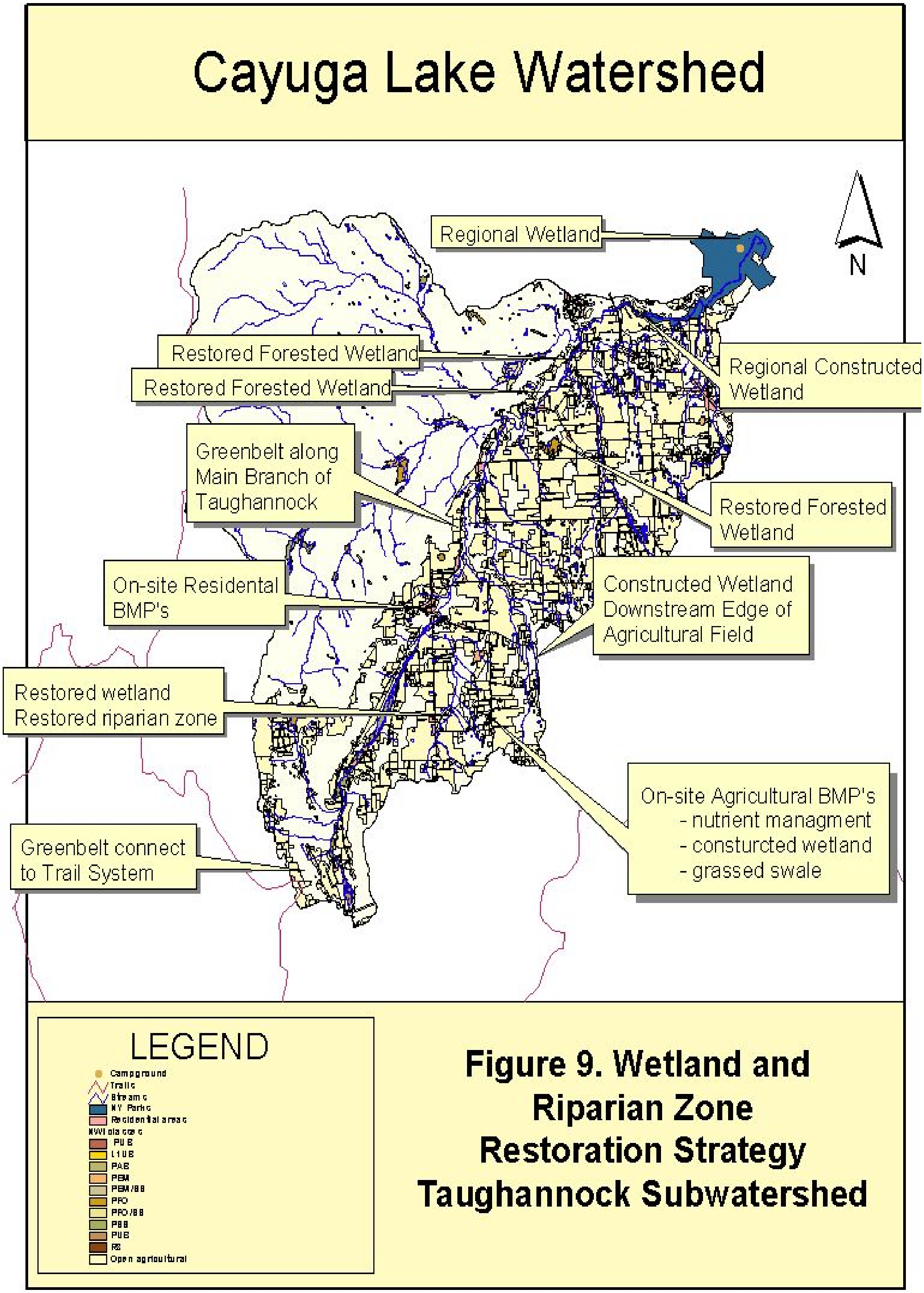


Figure 9. Wetland and Riparian Zone Restoration Strategy Taughannock Subwatershed

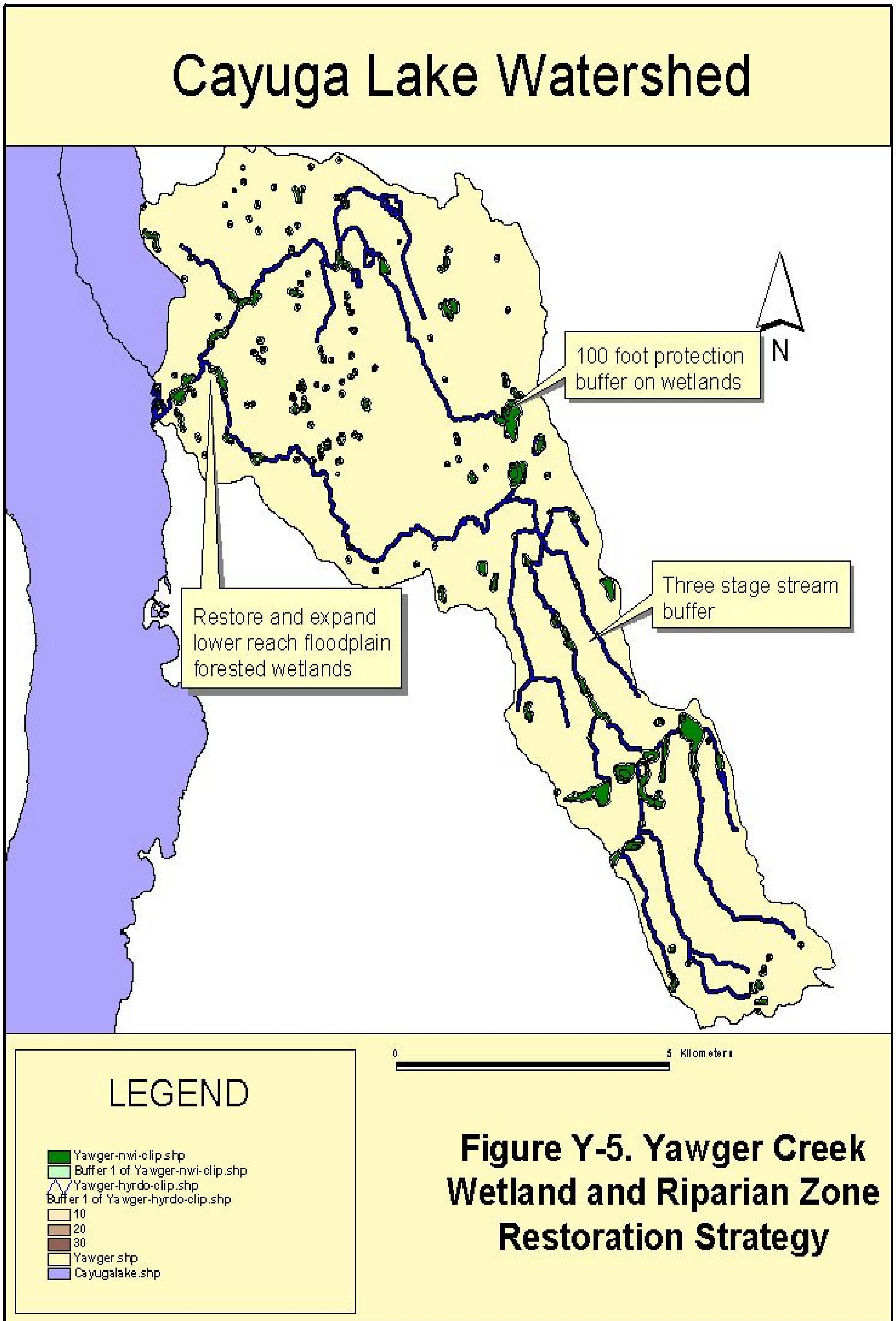


Figure Y-5. Yawger Creek Wetland and Riparian Zone Restoration Strategy

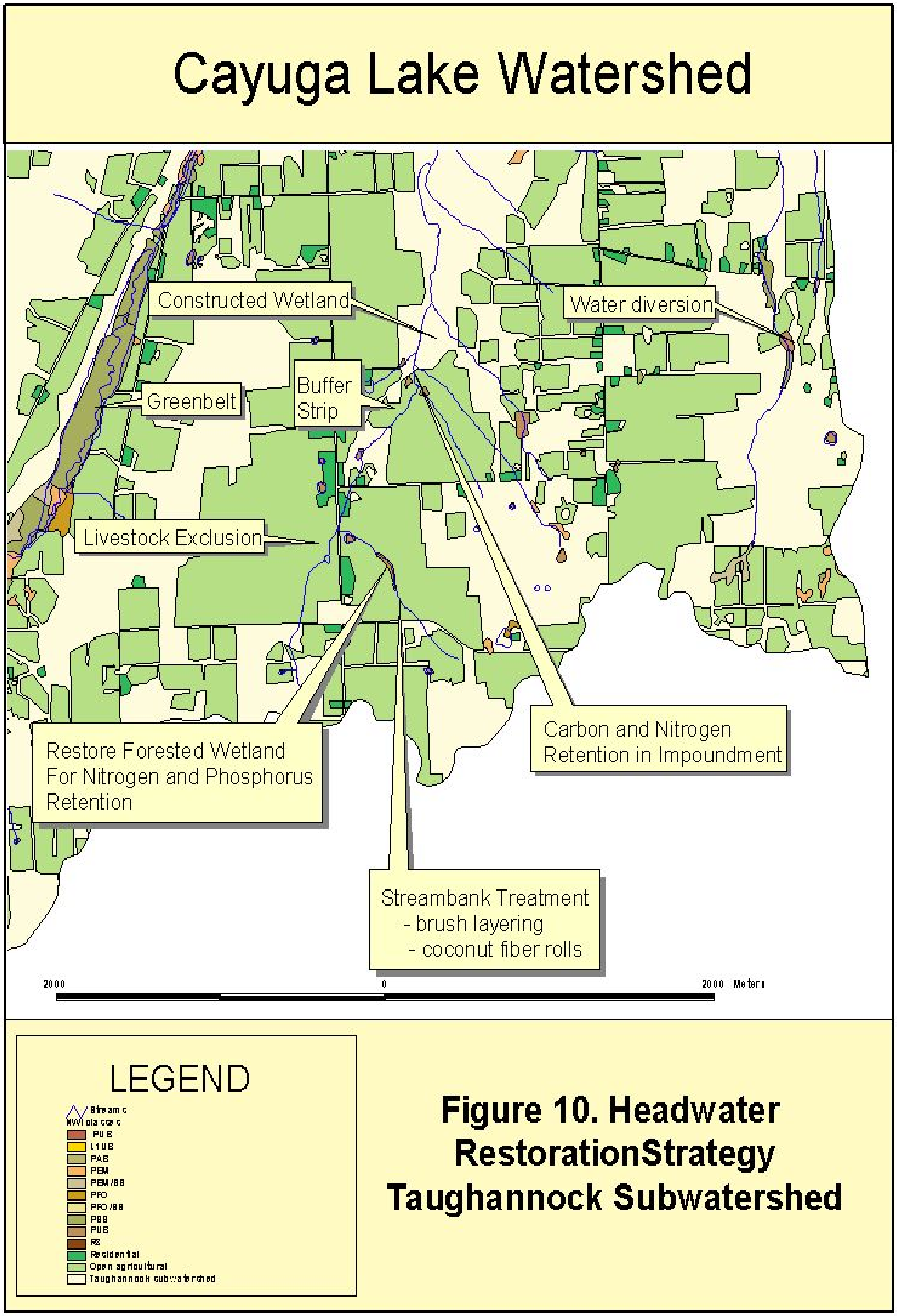


Figure 10. Headwater RestorationStrategy Taughannock Subwatershed

Cayuga Lake Watershed

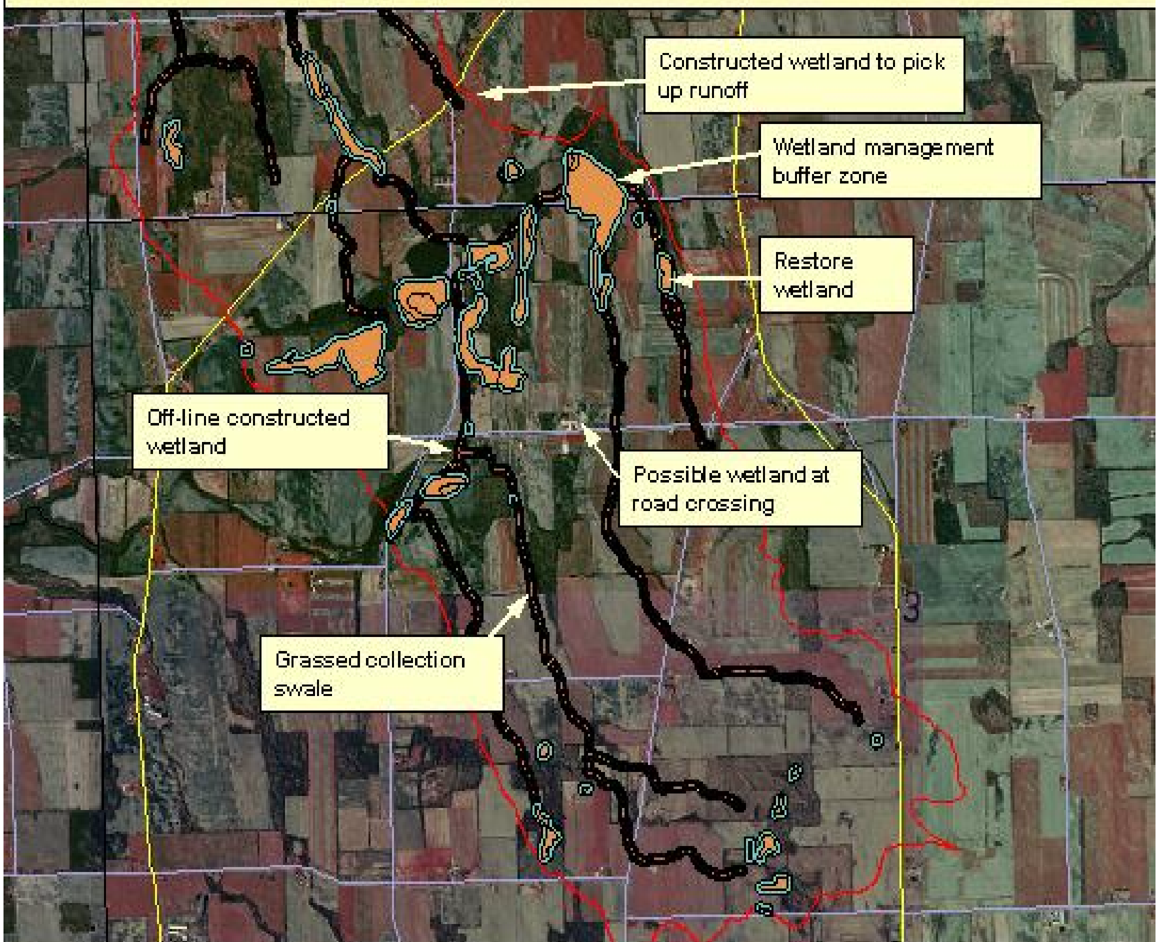


Figure 6. Yawger Creek Headwater Restoration Strategy

There are four levels of controls as follows:

(1) On-site Best Management Practices (BMPs)

These are BMPs that are implemented on a residential development or on a farm. They include bioretention and stormwater catch basins in developments, and nutrient management, grassed swales, and/or land application on farms. These BMPs are usually located in upper watershed areas and are easy to implement. They offer flexibility in choosing sites for facilities; storage unit designs, such as detention basins, can be standardized and guidance documents developed. However, since they are spread out, inspection and monitoring are difficult and maintenance and operation costs are high. Example of source controls include:

Bioretention. Bioretention is a method of managing stormwater runoff with a combination of small topographic depressions, conditioned soil, and native plants. They are designed to capture sheet flow from impervious surfaces and will be typically limited to small drainage areas of up to one acre (Engineering Technologies, 1993). The surface of the planting soil is depressed to allow for ponding of the runoff. The runoff is infiltrated through a surface organic layer of mulch and/or ground cover to the planting soil. The runoff is stored in the planting soil where it is discharged over a period of days to the *in-situ* material underlying the bioretention area. Once the infiltration capacity of the sand is exceeded, stormwater is discharged at the surface of the planting soil. This will capture the first flush, which contains the majority of pollutants, sediments, and thermal impacts.

If possible, the bioretention areas should be designed as off-line treatment areas. These areas are planted with trees tolerant to both wet and dry conditions and serve to additionally provide habitat, shade, and recreational values.

Grassed Swales. Designed to renovate stormwater during transport (overland flow modification), this category includes grassed swales, grassed swale with check dams, and meander swales. Grassed swales primarily use biofiltration and limited infiltration to remove pollutants. They need to be designed to maintain flow below the height of the vegetation up to certain design flow. They must be designed and constructed to maintain an even flow and keep velocities below a threshold that would cause erosion. Pollution removal rates are variable (Schueler, 1992) but seem to be effective in the removal of metals and suspended solids, with less long-term effectiveness for nutrients (Debo, 1995).

(2) Edge of site Controls

These are second order BMPs that are situated at the outside edge of the site (such as farm field) to provide treatment of combined runoff before it reaches a permanent tributary. This would include constructed wetland/pond system strategically located or a linear buffer strip or greenway located along the creek and its tributaries.

Constructed Wetlands. Constructed wetlands operate well both in the modification of water quantity and quality. Both natural and constructed wetlands do well in the reduction of runoff peaks and the increase in baseflow. The position in the landscape will determine the degree of each contribution. At the same time, they can be low-cost and effective in reducing contaminated runoff. Even small wetlands can remove significant amounts of pollutants and bacteria from waters moving through them if they are designed correctly. Constructed wetland/wet pond systems can remove from 50-95 percent of total suspended solids and between 20-90 percent of total phosphorous (Schueler, 1992). They are flexible in terms of their sizing and location. They can handle various types of pollutants under many circumstances and can be used as a source control or a downstream control.

Constructed wetlands can serve as both quantity and quality controls. They take advantage of natural biological processes that occur in natural wetland systems including sedimentation, nutrient removal, flood storage, and chemical transformation and removal. Nutrients are trapped and converted into plant tissues at relatively high rates.

(3) Wetland Controls strategically located along permanent streams.

These are third order pollution control sites strategically located to provide the best functional use along a stream. These would include restored wetlands along the creek and/or a linear buffer strip or greenway located along the creek and its tributaries.

Restored wetland. Restored wetlands along stream sections offer a unique opportunity for a cost effective means of improving both flooding and water quality problems along with adding recreational, educational, and aesthetic functions.

Greenways and filter strips. Green corridors along streams provide many ecological functions and human values. These include the protection of water resources, conservation of soil, expansion of recreational areas, provision of wildlife habitat, and preservation of biological diversity.

Greenways, if they are positioned between areas of non-point source pollution and receiving water bodies, serve as very effective filter for pollutants. They can be vegetated with grass, shrubs, or forest. Pollutant removal efficiency varies with the density of vegetation, flatness of the surface, the permeability of the soil, and evenness of the flow. As greenways increase in size the removal efficiency increases as well. On average, a 100-feet forested greenway filter strip will remove 80-100 percent of total suspended solids, 40-60 percent of total phosphorus, 40-60 percent of total nitrogen, and 80-100 percent of metals in inflowing runoff.

(4) *Fourth order controls, such as regional wetlands and or detention ponds.*

Fourth order controls provide final water quality refinement along with maximum flood reduction for the larger storms. These are almost always downstream controls (such as regional stormwater facilities) and are usually less costly to construct, maintain, and operate than many smaller ones that would add up to an equal size. However, they require more land and public opposition may complicate site selection.

6.4 Regulatory Controls

Finally, adoption and enforcement of local regulations that restrict activities in wetlands, buffer areas, and the riparian corridor are part of effective strategies. Regulatory controls are discussed in the Cayuga Watershed RPP. Municipalities have varying degrees of protection of wetlands and riparian corridors in their local laws. Sediment and erosion control ordinances during land disturbance should reflect the importance of the riparian corridor (see Model Stormwater & Erosion Control Local Law in *Cayuga Lake Watershed RPP*)

On a technical level, the riparian corridor must be wide enough to adequately function to slow runoff velocity and filter sediment. Adoption of comprehensive and integrated set of environmental restrictions to govern the development process can be critical to maintaining the integrity of stream corridors and wetlands. Figure 11 illustrates a recommended riparian zone system that could be established along streambanks (From USDA, 1991).

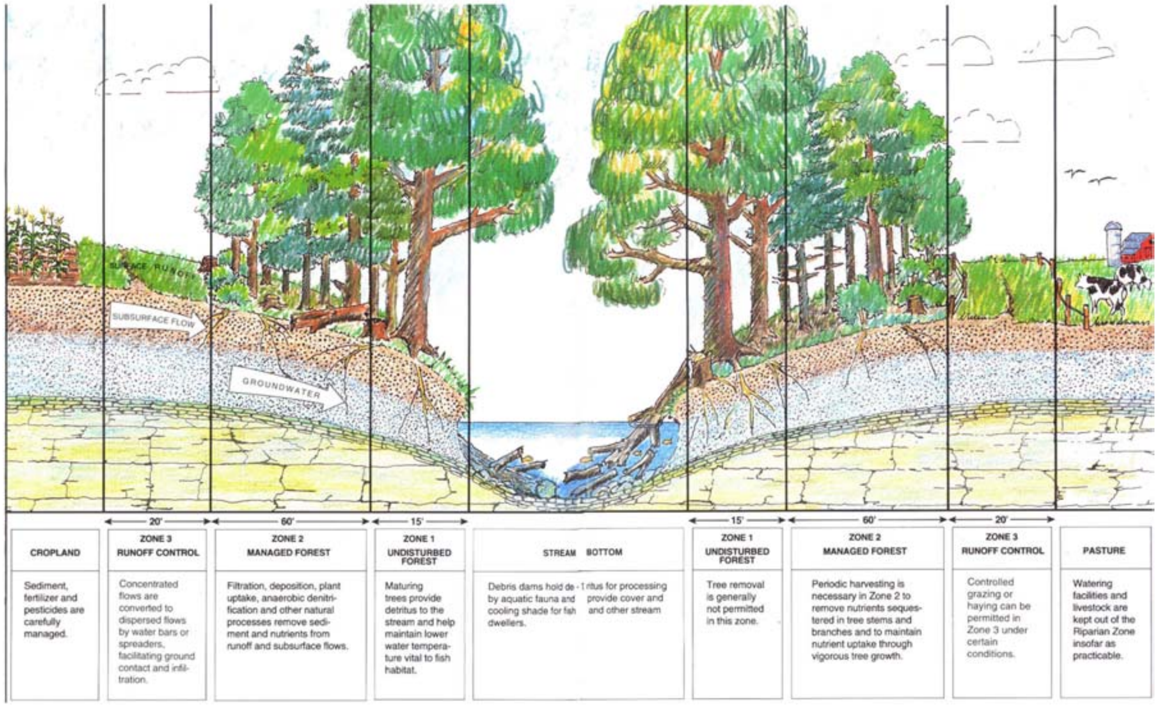
Stream buffer requirements. This provision would not allow development within a variable width buffer strip of ephemeral and perennial stream channels. Recommended minimum widths are 50 feet for low order headwater streams but expands to as much as 200 feet in larger streams. This stream buffer could include floodplains, steep slopes, wetlands, and open space areas to form a contiguous system along stream corridors.

Floodplain restriction. No development is allowed within the boundaries of the post-development 100-year floodplain.

Non-tidal wetland protection. No development is permitted within non-tidal wetland areas and a perimeter buffer area (25 to 50 feet).

Riparian tree cover requirements. Any riparian tree cover (which should be entirely contained within the stream buffer system) must be maintained or reforested (if no cover currently exists). Tree areas outside of the corridor should be tied to the corridor to establish wildlife routes.

Waterway disturbance permit. Any stream crossings from roads or utilities should be reviewed and least-impact crossings be implemented.



SURFACE RUNOFF
SUBSURFACE FLOW
GROUNDWATER
20'
60'
15'
15'
60'
20'
CROPLAND
Sediment, fertilizer and pesticides are carefully managed.
ZONE 3 RUNOFF CONTROL
Concentrated flows are converted to dispersed flows by water bars or spreaders, facilitating ground contact and infiltration.
ZONE 2 MANAGED FOREST
Filtration, deposition, plant uptake, anaerobic denitrification and other natural processes remove sediment and nutrients from runoff and subsurface flows.
ZONE 1 UNDISTURBED FOREST
Maturing trees provide detritus to the stream and help maintain lower water temperature vital to fish habitat.
STREAM BOTTOM
Debris dams hold de - 1 ritus for processing by aquatic fauna and provide cover and cooling shade for fish and other stream dwellers.
ZONE 1 UNDISTURBED FOREST
Tree removal is generally not permitted in this zone.
ZONE 2 MANAGED FOREST
Periodic harvesting is necessary in Zone 2 to remove nutrients sequestered in tree stems and branches and to maintain nutrient uptake through vigorous tree growth.
ZONE 3 RUNOFF CONTROL
Controlled grazing or haying can be permitted in Zone 3 under certain conditions.
PASTURE
Watering facilities and livestock are kept out of the Riparian Zone insofar as practicable.

Figure 11