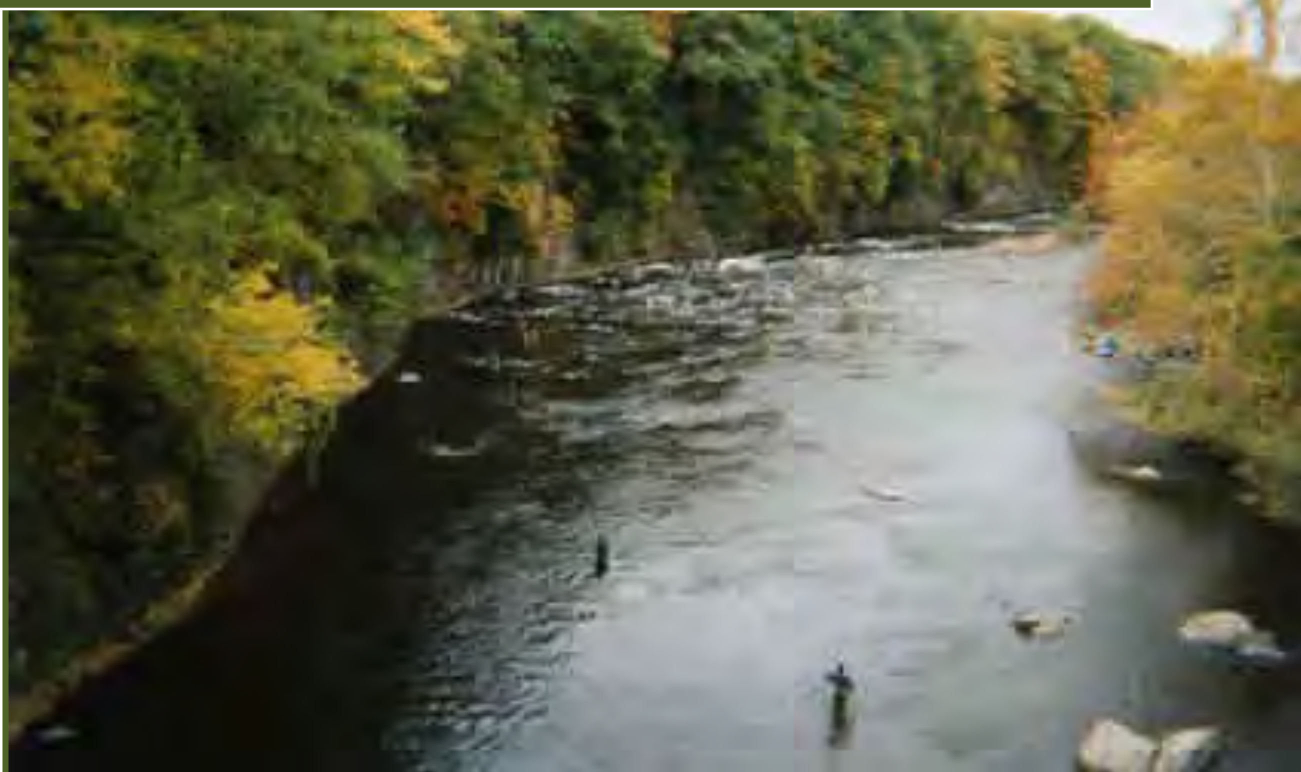
Salmon River Watershed Natural Resources Viability Analysis



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ACKNOWLEDGMENTS

This Salmon River Watershed Viability Analysis represents the collective work of numerous individuals, agencies and organizations. Several local citizens, private and government resource managers, elected officials, and scientists attended a day-long workshop to identify the conservation targets that were the objects of this analysis. The participants of that workshop are included in Appendix 1. Several others participated in expert working group sessions to help inform the viability analysis component for the matrix forest, wetlands and aquatics conservation targets. Working group participants are listed in Appendix 2. These meetings included many fair, but candid, discussions of the condition and management of the Salmon River watershed's natural resources, oftentimes with divergent points of view being expressed. It should be noted that a person's participation in the process of preparing this report does not imply their individual or institutional agreement with all or any of the findings of this report.

Funding for this project was provided by the US Fish and Wildlife Service, Wildlife Conservation and Restoration Program, and obtained through a grant proposal submitted by Tracey Tomajer, NYSDEC Watershed Coordinator. The following agencies and organizations cooperated with NYSDEC to complete this project: NY Tug Hill Commission, Tug Hill Tomorrow Land Trust, The Nature Conservancy, NY Sea Grant, Oswego County Environmental Management Council, NY Natural Heritage Program, Salmon River Fish Hatchery, SUNY-Oswego, SUNY-ESF.

The following individuals provided oversight and guidance in the development of this report:

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John Bartow and Linda Gibbs of the New York State Tug Hill Commission administered the grant and facilitated the public participation and governmental outreach. Michelle Peach also provided valuable guidance in organizing public input throughout the process. Deborah Forester, Engaging People, facilitated the public workshop to identify conservation targets.

Mapping and geographic analyses were conducted by Michelle Peach; Jennifer Harvill and Linda Gibbs, Tug Hill Commission; Michelle Henry, USGS Tunison Laboratory of Aquatic Science; and Gregg Sargis, The Nature Conservancy. James McKenna, USGS Tunison Laboratory, provided raw data, and generously conducted GAP analyses of fish communities and aquatic conditions in the watershed specifically for this project. The datasets used for completing the geographic analyses within this report are listed in Appendix 3. Several NY State DEC offices provided raw data or summaries that were used to describe current condition of various resources in the watershed -- these contributions are cited within the text of the viability analysis.

Michelle Peach, Tracey Tomajer and Linda Gibbs provided careful review and criticism of earlier, draft reports.

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1.0 INTRODUCTION

1.1 Project Scope

The objective of this Salmon River Watershed Natural Resource Viability Analysis was to synthesize information from numerous, disparate sources to develop an integrated understanding of the biodiversity and ecological condition of the Salmon River Watershed's natural resources. The study will provide an analysis of natural resource quality for the entire ~176,000-acre drainage, as opposed to the more site specific, fragmented information presently available.

The purpose of this analysis is to articulate the current "State of the Watershed" as a component of a more extensive and forthcoming Salmon River Watershed Natural Resources Assessment Report. The purpose of the eventual Natural Resource Assessment will be to build on the efforts of several ongoing initiatives (e.g., the Ontario Lakewide Management Plan; the Great Lakes Strategy 2002; the New York Comprehensive Wildlife Conservation Strategy; and several projects of the NY Natural Heritage Program, NY Department of Environmental Conservation, The Nature Conservancy, the Tug Hill Commission, the Tug Hill Tomorrow Land Trust, etc.) in order to coordinate these efforts and focus resources to attain their greatest effectiveness. The Assessment will also be available as a resource for local officials, government agencies, local landowners, and non-profit organizations to inform local land use planning efforts and individual land management decisions.

This Viability Analysis is limited in scope to the Salmon River Watershed's *natural* resources – those resources of the land, air and water, which although manipulated, exploited and enjoyed by humans, are not created by humans. It is these natural resources that past and future generations have used and will continue to use to build communities and industry. The communities, ways of life, and traditions that exist in the region have been shaped, and in many ways, limited, by the array of natural resources at our disposal. Likewise, the opportunities of those who come after us to enhance communities, maintain local traditions, and advance industry will be limited, in large part, by the quality of the natural resources they inherit.

Proper planning and resource management do not take place in a vacuum, but rather include by their nature consideration of cultural, economic and social resources. However, a thorough understanding of the quality and viability of available natural resources is necessary to help guide resource management and planning efforts to ensure that those resources continue to support cultural, economic and social values and activities for generations to come. It is the purpose of this Viability Analysis to quantify the current state of natural resources as a tool for local organizations and individuals to use in promoting wise planning for community and economic development within the Salmon River Watershed.

1.2 Administrative Background

The Salmon River Watershed Natural Resource Assessment project was initiated through funding from the US Fish and Wildlife Service and made available through the State Wildlife Grant program to the New York State Department of Environmental Conservation (NYSDEC) - Division of Fish, Wildlife and Marine Resources. The NYSDEC became the eligible recipient of State Wildlife Grants funds for New York after completing a statewide Comprehensive Wildlife Conservation Strategy in 2005. An explicit conservation priority of New York's Comprehensive Wildlife Conservation Strategy includes the improved understanding of habitat distribution and condition within the state (NYSDEC 2006a: 75). Furthermore, the Comprehensive Wildlife Conservation Strategy recognized that watersheds can serve to unify conservation efforts aimed at disparate targets, and to integrate those conservation efforts into a geographically meaningful effort that synthesizes information regarding biotic, physical and chemical interactions within geographically large and diverse ecosystems. Subsequently, the NYSDEC established two watershed planning projects in New York: the Nissequogue River on Long Island; and the Salmon River along the eastern shore of Lake Ontario.

The NYSDEC asked the New York State Tug Hill Commission to assist with the project by facilitating a collaboration of interested parties, carrying information to local communities, and administering the grant funds. Cooperators in this project include NYSDEC, The Nature Conservancy, New York Natural Heritage Program, New York Sea Grant, Tug Hill Tomorrow Land Trust, Oswego County Environmental Management Council, State University of New York at Oswego, and State University of New York College of Environmental Science and Forestry.

1.3 Planning Process

The Salmon River Watershed Natural Resource Assessment process relied heavily on the expertise of local scientists, resource managers, planners and citizens to identify important natural resource targets, assess the current condition and threats to those targets, and develop strategies to abate those threats. The process occurred in open forums and expert working groups, and has been modeled after The Nature Conservancy's widely applied framework for site conservation planning (TNC 2003), which is briefly summarized below.

Step 1: Natural Resource Target Selection. The first step in this planning process was to identify natural resource targets that would become the subjects of further natural resource planning within the watershed. Targets can be species, natural communities, or whole ecosystems, and for the purposes of this Assessment, targets were selected to represent the entire range of biodiversity within the Salmon River Watershed. Thirty-eight people participated in the day-long Natural Resource Target Selection forum, held on September 25, 2006, in Pulaski (Forester 2007; Appendix 1). The following seven conservation targets were selected at this forum and further refined by consultation with additional experts and focus group meetings around each target. These targets are more fully defined in Section 2 of this report.

- ❖ Salmon River Freshwater Estuary and Dune/Beach System
- ❖ Main Branch and Major Tributaries to Salmon River
- ❖ Headwater Streams
- ❖ Open Waters
- ❖ Non-Estuarine Freshwater Wetlands
- ❖ Matrix Forests (including open terrestrial communities)
- ❖ Gorge, Cliff and Steep Slope Communities

Step 2: Target Viability Analysis.
Viability refers to the capacity for a natural resource target to persist over time and to be resilient to occasional natural fluctuations or disturbances, and human-caused stresses. The viability analysis of the seven natural resource targets occurred over several months beginning in November 2006. The findings of this analysis are presented in Section 2 of this report. Information was gathered through published reports, unpublished data, and personal communication with local experts. Working group meetings were held for several aquatic targets (November 2006), the matrix forest communities (January 2007) and wetlands (March 2007). Appendix 2 acknowledges the contributions of those who participated in the three working groups. In addition, this viability analysis utilized information previously compiled by the New York Natural Heritage Program in the Salmon River Watershed Inventory and Land Analysis (Howard 2006), which applied Geographic Information System (GIS) analyses to identify existing and new locations of rare & endangered species, and unique communities within the basin.

The viability analyses for each of the natural resource targets consisted of a three-step procedure, and the format of Section 2 parallels this procedure.

A. Identify Key Ecological Attributes (KEAs) of each target. A KEA is an aspect of a target's biology or ecology that, if missing or altered, would lead to the loss of that target over time. As such, attributes define the target's viability or integrity (e.g. water chemistry, population size). Past exercises in viability analysis have organized KEAs into three broad categories: s**ize, condition** and **landscape context.**

Size includes measures of area or abundance of a natural resource target. For instance, if a target is a particular species of concern, then size would reflect population density or area of occupancy. For a community or ecosystem, size would simply consider area of occurrence.

Condition represents an integration of several measures of the quality of biotic and abiotic factors that influence a target or natural processes that are sustained by a target. For a species, condition might reflect reproductive success, size/behavior of individuals, or concentrations of contaminants in tissues. For communities, condition reflects species composition (e.g., occurrence of invasive species), ecological processes (altered hydrologic flow, declines in productivity), and abiotic factors (water/air quality, substrate stability).

Landscape Context considers the processes and conditions that surround a particular target which may influence the condition of the target. Context integrates pattern, connectivity, fragmentation, and patchiness of a target.

B. Establish Quantifiable Indicators of the respective attributes, and benchmarks suggestive of the viability of the attributes. Indicators must be measurable entities that are used to assess the status and trend of a key ecological attribute. Indicators need to be measurable (quantifiable), precise and practical. For example, if "water quality" is a Key Ecological Attribute, the indicators of water quality could include dissolved oxygen (mg/l), temperature (°C), or phosphate concentration (ppm).

C. Rate the Current Condition of the attributes based upon the benchmarks established for each indicator. Indicator ratings define the ranges of variation in an indicator that distinguish Very Good, Good, Fair, and Poor conditions for a KEA. The ratings are meant to provide a consistent, objective and scientific basis for assessing the status of each attribute. Even still, in many instances, quantifiable information was unavailable for several of the viability indicators within the watershed, and guidance was not readily available for ranking current condition of many indicators when they could be quantified.

Step 3: Threats and Situation Analysis. A second public workshop was held on May 4, 2007 during which participants (a) identified activities or conditions that may negatively impact each of the conservation targets; (b) developed an understanding of the causal factors influencing the level of each threat; and (c) rated the significance of each threat with respect to each target.

Step 4: Strategies. A third and final public workshop was held on June 21, 2007during which participants developed plans for moving forward on implementing conservation actions. Strategies were outlined to abate the threats identified in the previous workshop and maintain or enhance the current condition of the natural resource targets.

The final Salmon River Watershed Natural Resource Assessment Report will synthesize information from this Viability Analysis and from the subsequent Threats and Situation Analysis, and Strategies sessions.

2.0 VIABILITY ANALYSIS

This section presents the viability analysis for the seven natural resource targets in the Salmon River watershed. It is presented in seven subsections, one for each of the targets. The natural resource targets are more fully defined at the beginning of each subsection, and then an information synthesis is presented for each of several Key Ecological Attributes (KEAs). Indicators of viability for each of the KEAs are defined, and ratings of the current condition for each indicator are presented.

The natural resource targets that are the subjects of this analysis are readily segregated into aquatic and terrestrial types. While it is acknowledged in the broad context of the Salmon River ecosystem that these targets are integrated, with energy and material flowing between them and many organisms migrating among them, for organizational purposes they require independent treatment. For instance, the Salmon River freshwater estuary, Salmon River Main Stem, and headwater streams all form a continuum of the Salmon River stream system. Furthermore, this continuum is frequently punctuated by wetlands and open waters. Because many of the natural resource targets are, in fact, components of a single, interrelated continuum, they will share many similar biotic and physical characteristics, key ecological attributes and indicators of viability. Therefore, this viability analysis will be burdened by redundancy in order to provide each target with complete and thorough consideration.

2.1 Overview of Salmon River Study Area

The Salmon River Watershed is located in northern New York and is situated approximately midway between the cities of Watertown and Syracuse (Figure 1). The watershed ranges in elevation from 1,900 feet at the upper headwaters to 250 feet at the mouth of the Salmon River on eastern Lake Ontario, and drains approximately 181,000 acres. The Salmon River system is one of several that form the radial stream drainages of the Tug Hill Plateau. This landform slopes gently upward and eastward from the Ontario Lake Plain to its highest elevation (2100 ft) in the east-central portion of the region and is then terminated by an abrupt escarpment on its eastern edge at the Black River Valley.

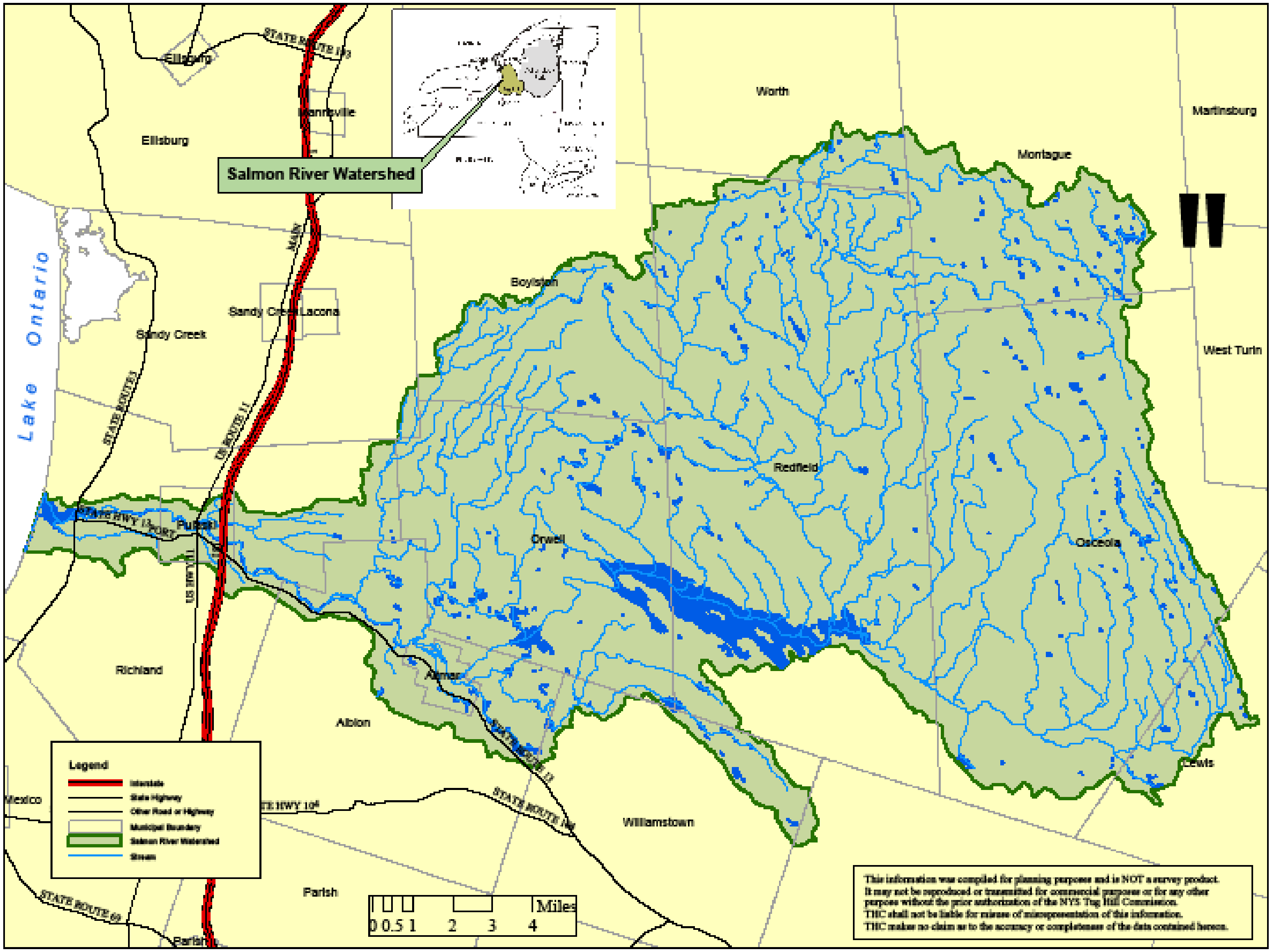


Figure 1. Salmon River Watershed Study Area.

The notable abundance of water resources (~4000 miles of streams, 117,000 acres of wetlands) within the Tug Hill region is due in large part to the high average annual precipitation that the region receives. An average of 42-50 inches of precipitation fall annually across the region (lesser amounts at lower elevations), including up to ~200 inches of average annual snowfall at highest elevations (Eschner et al. 1974). Precipitation patterns are influenced by the position of the Tug Hill on the eastern shore of Lake Ontario. Westerly air masses accumulate moisture as they pass over the lake and then as they are forced to rise over the Tug Hill they cool, which decreases moisture holding capacity. The condensing water falls as “lake effect” snow and rain. Substantially more precipitation falls over the region than can be evaporated or transpired by plants. Annual water surplus is a measure of excess precipitation (surplus = precipitation minus losses by evaporation and plant transpiration), and for the region water surplus ranges from 40” at the highest elevations to approximately 16” at Lake Ontario (Eschner et al. 1974). Consequently, an abundance of water is available during most of the year to create the extensive wetland systems, high velocity streams and eroded gulfs of the region.

The Salmon River drainage is a network of headwater stream communities (marsh headwater streams, rocky headwater streams), mid-reach and main channel stream communities, and a freshwater estuary at the river’s mouth. This stream network is punctuated with frequent occurrences of wetlands and open waters. The US Geological Service Hydrologic Unit Code (HUC) system places the Salmon River within the SE Lake Ontario Subregion (Subregion 0415) of the Great Lakes Hydrologic Region (Region 04), which represents the entire Great Lakes basin. The Salmon River System includes three 11-digit HUCs: the Lower Salmon River, Salmon River Reservoir, and the Upper Salmon River, which are the smallest hydrologic units recognized by this cataloguing system (Hunt et al. 2005). To facilitate more focused consideration on aspects of the Salmon River watershed, Howard (2006) further subdivided the watershed into fifteen sub-watersheds (Figure 2, Table 1). These smaller units will be referenced throughout this assessment.

Figure 2. Location of fifteen sub-watersheds within the Salmon River watershed (based on Howard 2006). See accompanying Table 1 for information on sub-watersheds.

Table 1. Summary of sub-watersheds within the Salmon River drainage (compiled from 2001 National Land Cover Data). "Location" references the situation of the sub-watershed above ("upper") or below ("lower") the Light House Hill Reservoir.

Code	Location	Name	Area (acres)	Sub-Watershed Towns
BBMC	Lower	Beaverdam Brook-Meadow Creek-Reservoir	17,285	Albion, Williamstown, Florence, Redfield, Orwell
BGWM	Upper	Beaver-Gillmore-Willow-McDougal	6,891	Worth, Redfield
COBR	Upper	Cold Brook	6,512	Worth, Redfield, Montague
FBTT	Upper	Fall Brook-Twomile-Threemile	9,780	Osceola
GRMM	Upper	Grindstone-Mill-Muddy	10,897	Redfield, Osceola, Montague
KESF	Upper	Keese-Smith-Finnegan	6,372	Osceola
LSRM	Lower	Lower Salmon River-Main Stem	11,197	Richland, Albion
MARI	Upper	Mad River	20,696	Worth, Redfield, Montague, Osceola
NOBR	Upper	North Branch	17,856	Boylston, Worth, Redfield
ORPE	Lower	Orwell-Pekin	12,793	Albion, Orwell, Boylston
PECK	Upper	Pennock-Coey-Kenny	19,888	Orwell, Redfield
PMLB	Upper	Prince-Mulligan-Little Baker	7,226	Redfield, Osceola
SBLB	Upper	Stony Brook-Lime Brook	4,572	Redfield, Osceola
TRBR	Lower	Trout Brook	12,866	Richland, Orwell, Boylston
UPSR	Upper	Upper Salmon River	16,098	Osceola, Lewis

The region is underlain by sedimentary limestone, shale, siltstone and sandstone bedrock that was deposited between 460 and 420 million years ago during the Middle Ordovician to Middle Silurian periods when the region was below sea level and receiving eroded materials from adjacent uplands of what is now the Adirondacks and Ontario (Leaf and Wittwer 1974). Approximately 220 million years ago the Appalachian Plateau, including the Tug Hill, was uplifted and these sedimentary deposits now form the bedrock of the Tug Hill upland (Figure 3). Around the perimeter of the plateau, a number of deeply eroded gorges (locally know as gulfs) occur at locations where high velocity streams have eroded through shale deposits. The Salmon River Gorge is one such notable gulf that occurs within the watershed. The region was further sculpted by a series of Pleistocene glaciations ending approximately 11,000-13,000 years ago. These glaciers deposited till and sorted outwash material from which a complex variety of soils with varying chemistry and drainage capabilities have formed (see Leaf and Wittwer 1974 and Cressey 1966 for more complete synthesis of geological processes shaping the region and influencing soil characteristics). In general, soils at mid- to upper elevations are predominantly stony, medium- to coarse-textured, highly acidic, and derived from glacial till of sandstone origin. Many are poorly drained. Soils at lower elevations tend to be of medium texture, with neutral or slightly acidic fragipans (dense subsurface soil layers with low permeability) (Leaf and Wittwer 1974; USDA NRCS 2008).

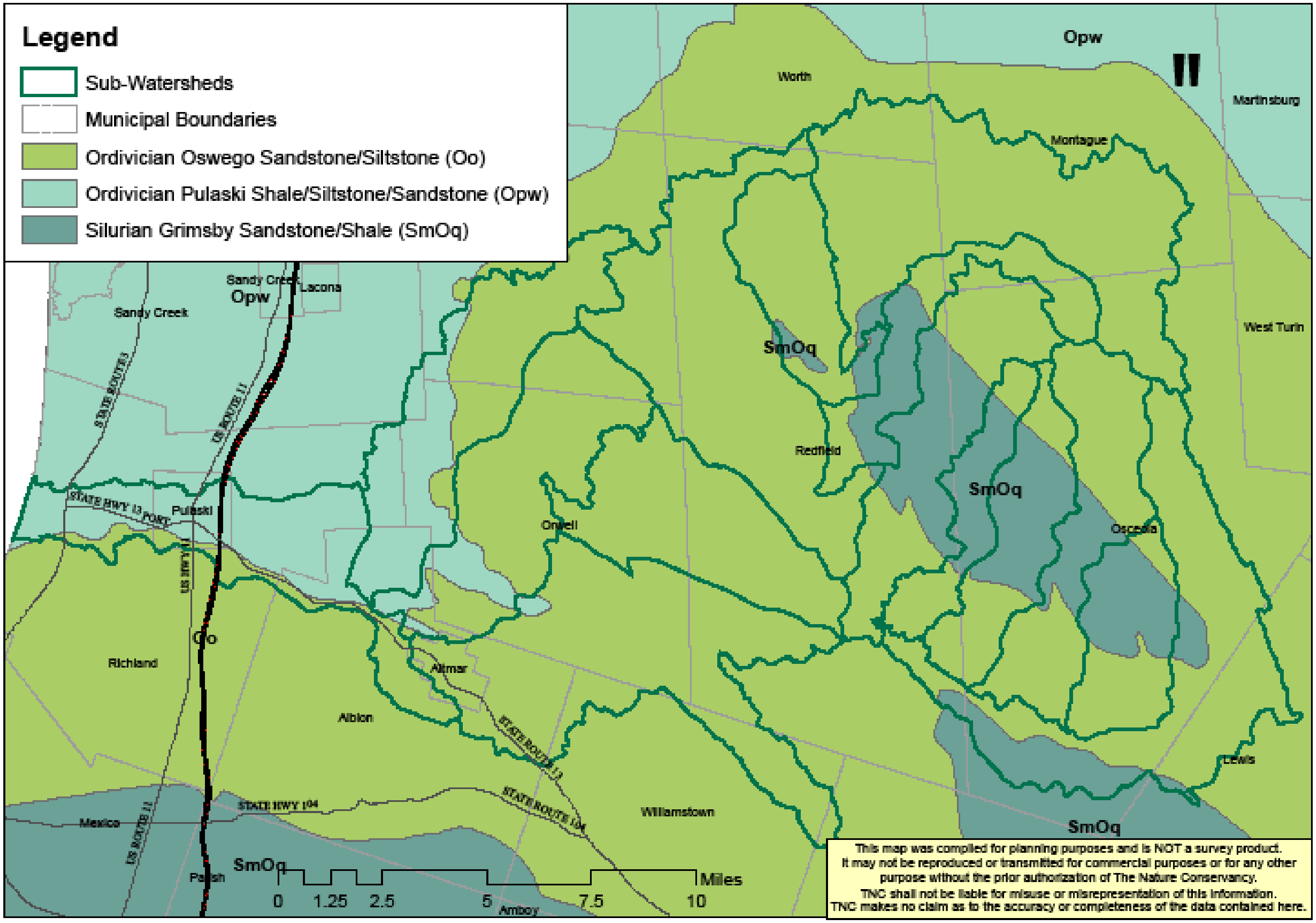


Figure 3. Bedrock geology of the Salmon River watershed.

In addition to the widespread till deposits of the region, a ~4-mile wide area of 20-30 feet-thick deposits of well-sorted glacial sand and gravel exists at mid-elevations of the watershed representing a segment of the 47-mile long Tug Hill Aquifer (Miller et al. 1989; Figure 4). Streams within the Salmon River drainage that intersect the aquifer formation lose water to the aquifer as they cross the east side and then regain water at the west side. Water discharges from the aquifer by seepage to streams, springs and wetlands along its west side; evapotranspiration; subsurface flow to adjacent deposits; and to groundwater wells (Miller et al. 1989). Private, municipal and industrial wells served ~14,500 people and pumped 6.12 Mgal/day from the aquifer in 1986 (Miller et al. 1989).

Historic and current land-use patterns have been influenced by broad geologic and hydrologic features of the region. Agriculture and larger accompanying settlements persist at lower elevations on better soils (Figure 5, Table 2). At the highest, eastern elevations, agriculture was never attempted and this area remains as intact forest. At mid-elevations subsistence agriculture was attempted and abandoned during the late 19th and early 20th centuries (Temporary State Commission on the Tug Hill 1976: 10). Many of these abandoned farmlands were incorporated into the New York State Forest system in the 1940s, and later into the New York system of Wildlife Management Areas. Consequently, state land holdings tend to be concentrated at the mid-elevations within the watershed.

The USDA Forest Service has established a hierarchical system of “ecoregional” mapping. Ecoregions represent geographic areas possessing similar types, quality and quantity of ecological resources. These ecoregions serve as a spatial framework for research, management and monitoring of ecosystems (USDA Forest Service 2004, 2005). Due to the range in elevation and location, the Salmon River watershed spans two ecoregional sections. The upper elevations of the watershed and Tug Hill form the western limit of the Northern Appalachian – Boreal Forest Ecoregion. The lower elevations of the western Tug Hill and Salmon River watershed along the Ontario Lake Plain fall within the Erie and Ontario Lake Plain Section of the Eastern Broadleaf Forest Province (Figure 6). Biological elements of the watershed’s aquatic and terrestrial systems reflect the characteristics of these broad ecoregions, and much of the watershed shows transitional elements between the two ecoregions (Figure 5).

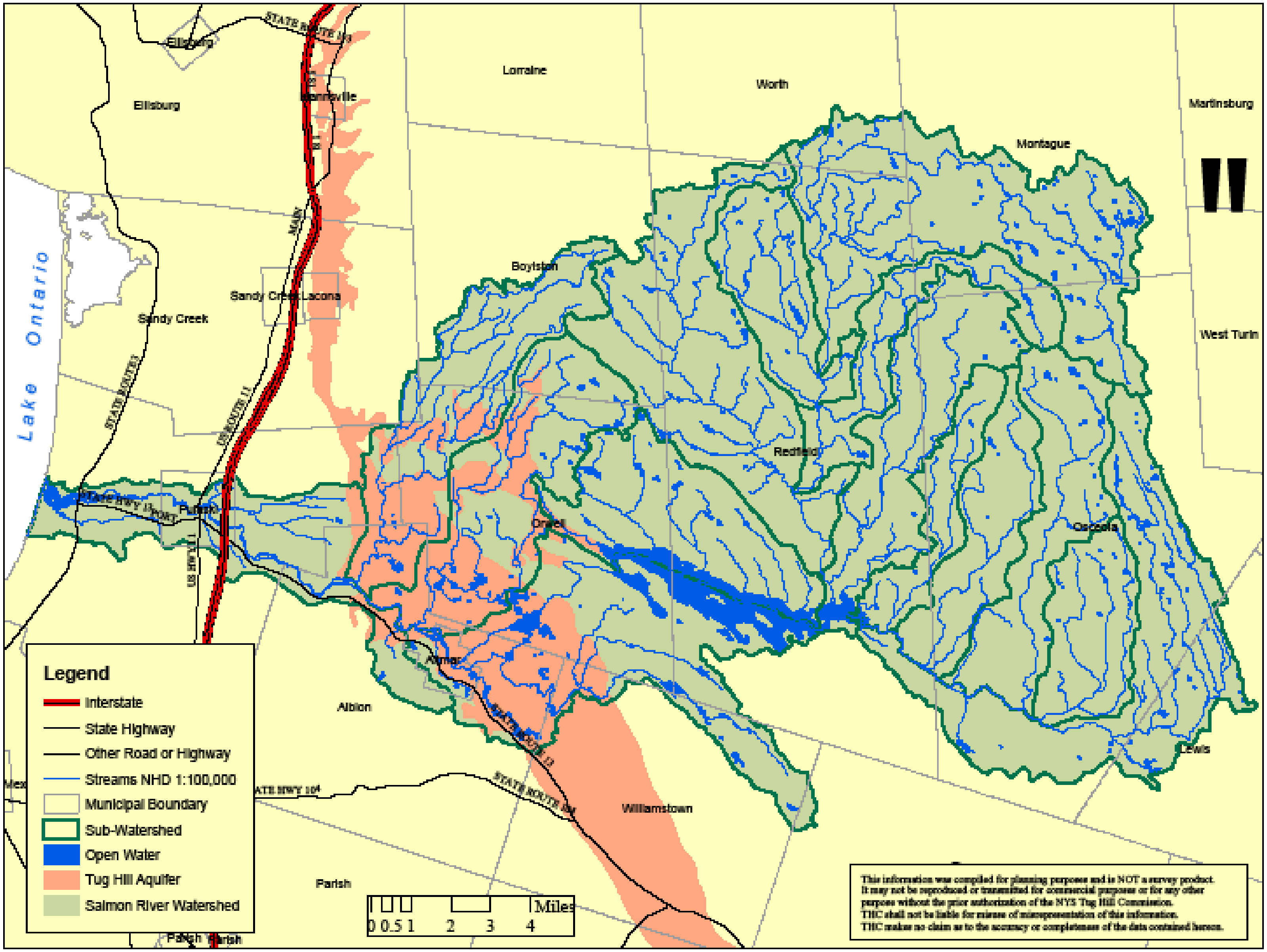


Figure 4. Location of the Tug Hill Aquifer.

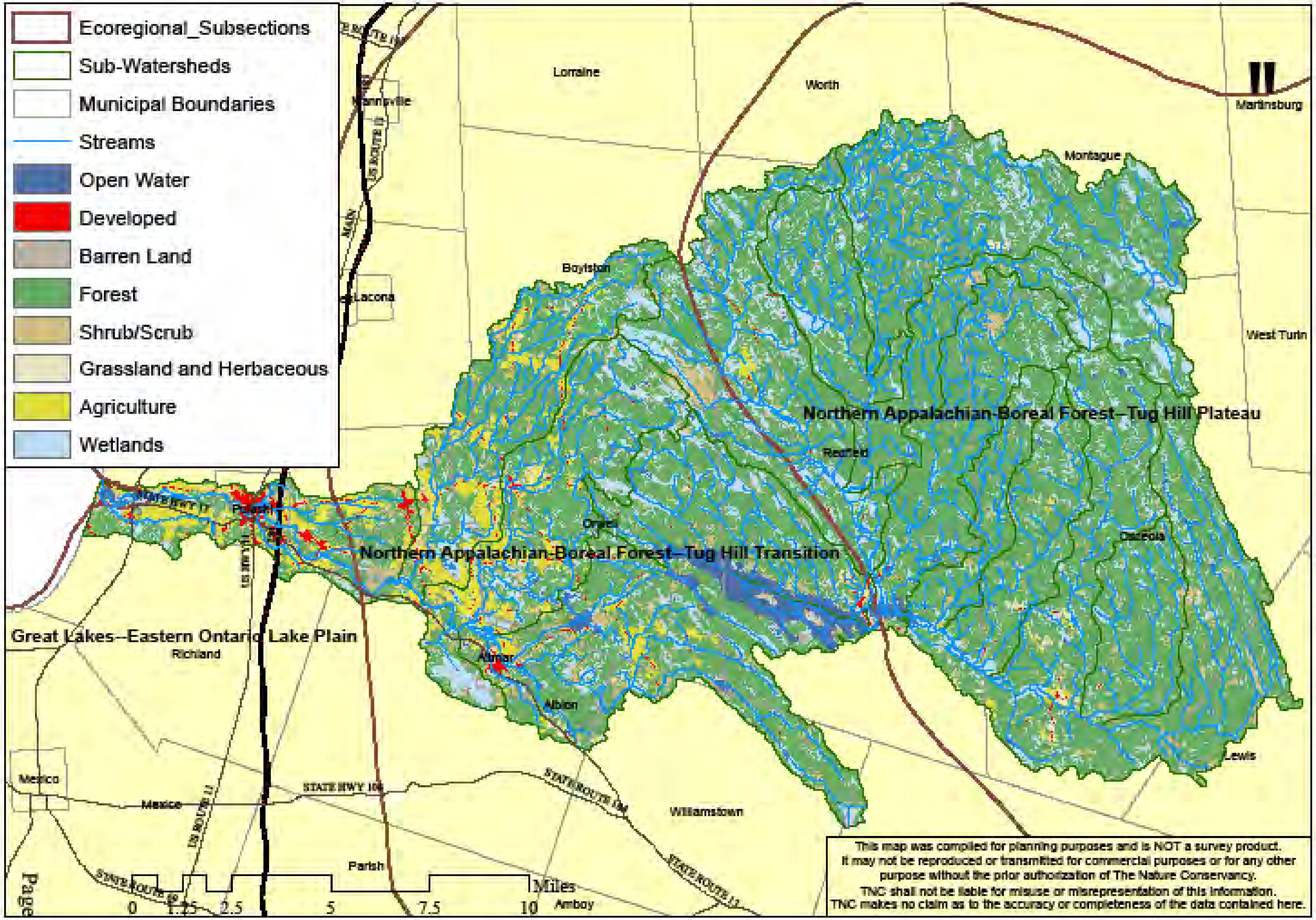


Figure 5. Land cover types and ecoregional subsections of the Salmon River watershed.

Table 2. Total acreage of land cover types by sub-watershed in the Salmon River watershed (compiled from 2001 National Land Cover Data).

				wetlands				forest			sub-watershed
	Developed	barren	agric.	woody	herbaceous	grassland	shrub	decid	conifer	mixed	total
BBMC	222	41	921	2482	212	173	1642	9624	1375	552	17285
BGWM	0	0	2	1292	79	1	100	5243	148	27	6891
COBR	0	4	0	997	36	1	194	5178	47	51	6512
FBTT	22	0	79	1506	61	159	374	7268	234	76	9780
GRMM	12	0	29	1316	31	9	346	8945	95	113	10897
KESF	1	0	1	586	10	12	279	5182	194	106	6372
LSRM	1025	38	2362	1482	126	142	1411	2990	1130	453	11197
MARI	0	2	11	4233	268	63	232	15551	77	258	20696
NOBR	50	0	181	4300	82	62	951	10903	766	562	17856
ORPE	127	0	1466	2244	95	291	902	6287	965	416	12793
PECK	1118	0	78	1614	53	80	565	5971	9870	539	19888
PMLB	14	0	28	959	12	74	284	5560	204	91	7226
SBLB	0	0	10	491	9	1	135	3844	54	28	4572
TRBR	149	0	2104	1400	71	281	1002	6783	567	510	12866
UPSR	15	4	128	1771	72	96	974	11762	869	403	16098
Watershed Totals	2755	90	7400	26673	1216	1444	9390	111092	16595	4184	180929

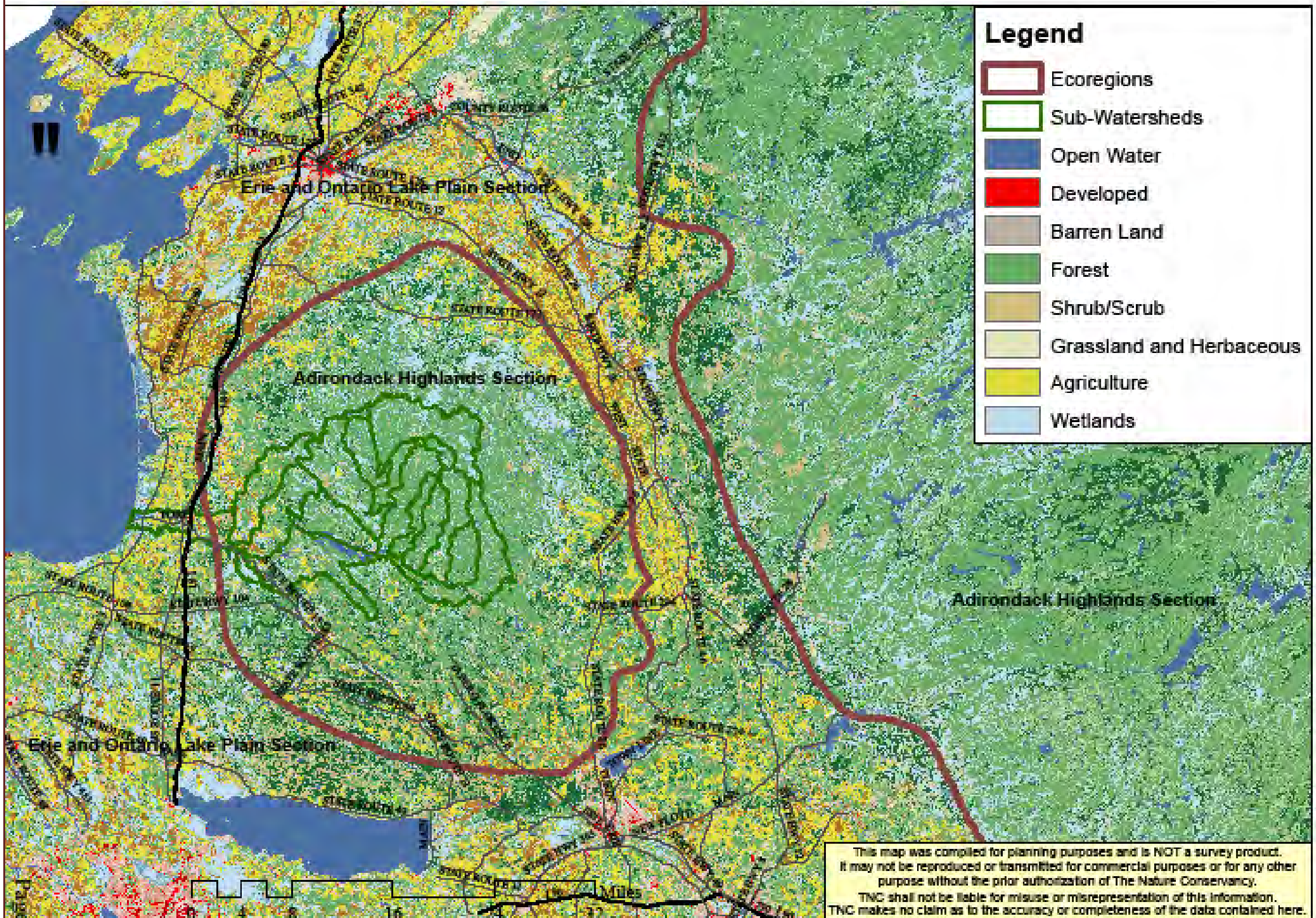


Figure 6. Ecoregional sections of northwestern New York. Inset map of New York ecoregions provided by NYSDEC.

2.2 Salmon River Freshwater Estuary

2.2.1 Salmon River Freshwater Estuary Definition

The Salmon River Freshwater Estuary is located at the mouth of the Salmon River at Port Ontario. For the purpose of this viability analysis, the ~270-acre freshwater estuary is defined as the reach of the Salmon River open waters and marshes that are bounded by the barrier dunes to the west and the last river riffle in the Salmon River, which is located approximately 1200 feet east of County Rt. 3 (Figure 7).

This system can be defined as a riverine-lacustrine estuary (*sensu* Albert 2001), which represents those sections of tributary rivers that are influenced by lake water levels. Such reaches (also referred to as "drowned river mouths") represent a transition zone from river to lake in which water level, geomorphic processes and biological interactions are controlled by fluctuations in the lake level. In the case of the Salmon River freshwater estuary, it can be further categorized as a "barred drowned river mouth" owing to the presence of a sand bar that partially isolates the river from the lake. Alternatively, it may be categorized as a Great Lakes aquatic bed (*sensu* Edinger et al. 2002:29), which represents a quiet bay protected by extreme wave action by sand bars or other barriers, and which typically support areas of aquatic macrophytes.

The freshwater estuary is a dynamic system of braided river channels and sandbars that are constantly in a state of flux from lateral erosion and sedimentation processes along with a shallow, open bay. The freshwater estuary system contains different wetland habitat types that correspond primarily with water depth, which averages approximately 3 ft, with a maximum of about 7 ft (Harman et al. 2000). These community types include the following.

- <u>Riverine</u> wetlands (~130 acres) associated with the river channels. Segments of river channel are periodically dredged to maintain a stable, navigable channel (FERC 1996).
- <u>Emergent marshes</u> (~110 acres) occur in shallow sections of the freshwater estuary, between the river channels and adjacent uplands or river bar islands. Both deep and shallow emergent marsh communities occur here.
- <u>Woody wetlands</u> (~30 acres), including shrub swamps and floodplain forests occupying higher microsites around the fringe of the freshwater estuary and on river bar islands.

The freshwater estuary is a significant habitat for migratory and resident waterfowl. The beds of emergent marsh vegetation and submergent aquatic plants provide habitat in this warm water fish concentration area. Further, it is a staging area for annual migrations of spawning salmonines on the Salmon River.

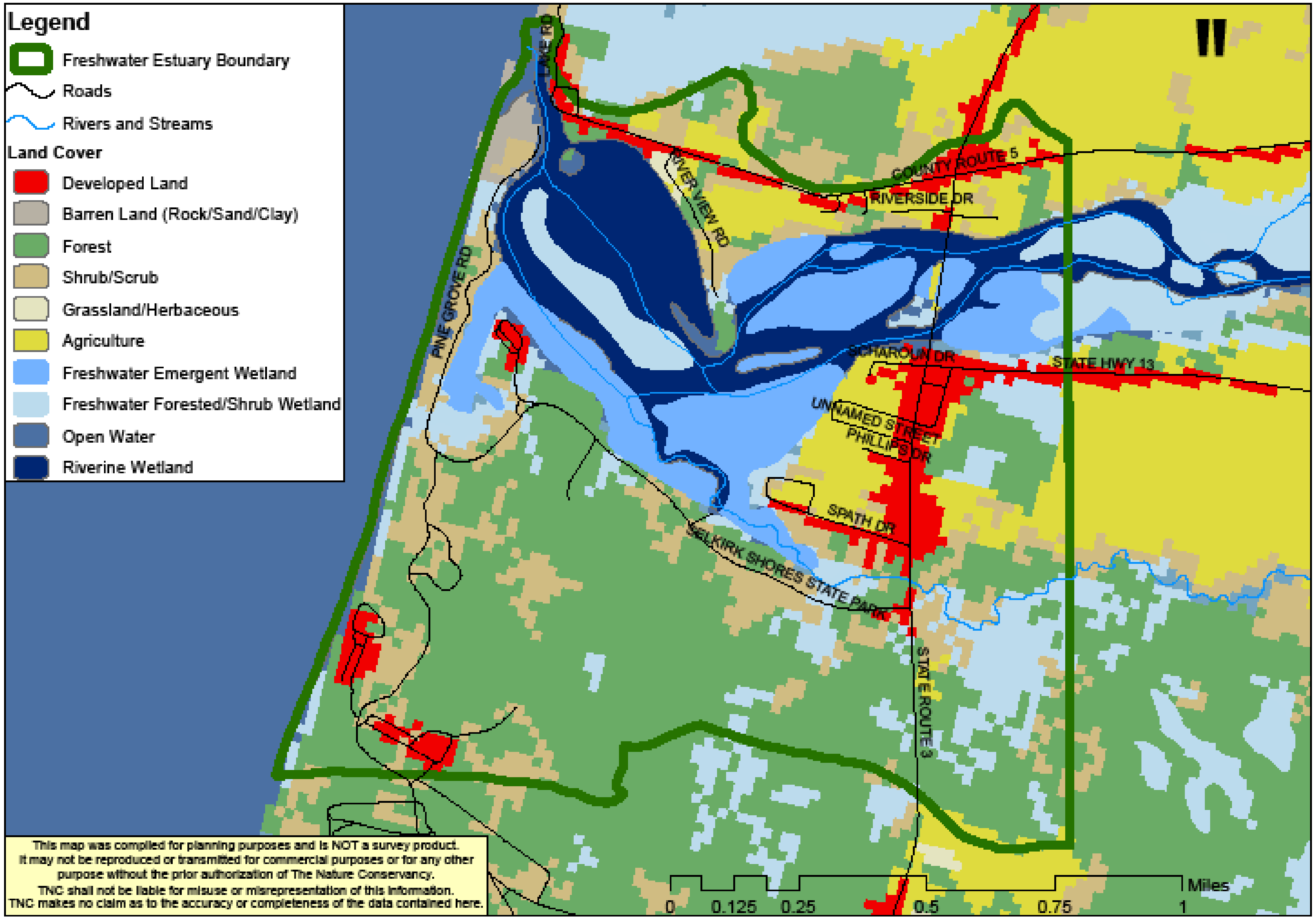


Figure 7. The Salmon River freshwater estuary and local sub-watershed.

In addition, the Salmon River freshwater estuary represents the southern extreme of the unique 17-mile long Great Lakes barrier beach/dune system along the eastern shore of Lake Ontario. This barrier dune system, with associated ponds, marshes and fens, represents the most extensive freshwater sand dune formation in New York and is of global ecological significance. This system begins at Selkirk at the south and continues northward to include Deer Creek Marsh, Lakeview Marsh, and North and South Sandy ponds, and provides habitat for a number of rare plant and animal species.

2.2.2 Salmon River Freshwater Estuary Viability

2.2.2.1. KEA: SIZE – Freshwater Estuary Area

Indicator – Freshwater Estuary Area (ac): The area of open water and wetlands within the freshwater estuary is a direct measure of it size.

Current Condition - Good: Total wetland area of the system is approximately 271 acres, consisting of ~132 acres of open water, 27 acres of forested/shrub wetland, and 112 acres of emergent wetland. The aerial extent of the freshwater estuary and proportions of wetland types will vary depending on lake water levels and in-system sediment transport dynamics. Lake Ontario water levels are currently maintained between 74.5-75.0 m. It is likely that estuarine wetlands were filled in the past prior to federal and state wetland regulations in order to develop along the shores. However, activities that would further reduce habitat beyond current conditions are unlikely due to NYSDEC and US Army Corps of Engineers regulations.

2.2.2.2. KEA: CONDITION – Plant Communities

The marsh communities within the freshwater estuary provide substrate, cover and food for a variety of birds, fish, mammals and invertebrates, and stabilize river bottom substrate. Two different marsh communities occur in the freshwater estuary (Edinger et al. 2002, Howard 2006).

- Shallow emergent marshes are meadow communities that occur on mineral or organic soils that are seasonally flooded. Water depths range from 0.5 to 3 feet during flooding, but surface water levels usually drop and the substrate is typically exposed during late summer.
- Deep emergent marshes occur on mineral soils or fine-grained organic soils that are flooded but not subject to erosive wave action. Water depths range from 0.5 to 6.5 feet, and water levels fluctuate seasonally, but soils rarely dry.

Indicator – Total Macrophyte Cover: Indicators of macrophyte abundance and community composition include total percent cover or biomass of plants. Abundance of resident fish communities, invertebrate communities and breeding birds are directly related to habitat availability. The state-protected marsh birds that breed in the freshwater estuary nest, hunt and forage in macrophyte beds.

No information is available on the natural range of variation in aquatic vegetation of the freshwater estuary that would serve as a quantitative baseline for estimating viability.

<u>Current Condition – Good:</u> Table 3 summarizes the available quantitative descriptions of the emergent marsh communities of the freshwater estuary. Harman et al. (2000) mapped beds of emergent macrophytes. They reported that macrophytes occurred in a patchy distribution across the freshwater estuary and that, in their judgment, total coverage was good. They further concluded that, given the mesotrophic status (moderate nutrient availability) of the system, vegetation removal was not necessary except in a few areas. Howard (2006) estimated over 90% cover of macrophytes in patches of shallow and deep emergent marsh vegetation. McKenna (unpublished data) randomly sampled vegetation at 35 stations in the freshwater estuary and found total percent cover averaged 35% and ranged from 0 to 100%.

Table 3. Community composition of macrophytes in the Salmon River freshwater estuary. Data are percent cover estimates from Harman et al. (2000) who sampled along transects within macrophyte patches at varying depths (reported data are minimums of cover classes); and Howard (2006) who estimated cover on subjectively located releves in deep and shallow emergent marsh communities. Species noted as present but with inconsequential cover are denoted with a diamond (♦). Exotic invasive species are indicated with an asterisk.

		Harman			Howard	
Common name	Scientific name	0.5 m	1 m	2 m	Deep	shallow
swamp loosestrife	*Decodon verticillatus*					5
	Phalaris arundinaceae					21
Sedges	*Carex* spp.	5			♦	
	C stricta					6
	C. lacustris					5
Rice cutgrass	*Leersia oryzoides*					13
bluejoint grass	*Calamagrostis canadensis*					14
Joe-pye weed	*Eupatorium maculatum*					5
common boneset	*Eupatorium perfoliatum*					5
	Peltandra virginica					5
Pickerelweed	*Pontederia cordata*	5			25	
Broadleaf arrowhead	*Sagittaria latifolia*	50				18
Cattail	*Typha* sp.	5			70	
*purple loosestrife	*Lythrum salicaria*	5			♦	♦
bullhead lily	*Nuphar variegatum*	25			♦	
Am. white water lily	*Nymphaea odorata*	5			♦	
coon's tail	*Ceratophyllum demersum*		1			
Canadian waterweed	*Elodea Canadensis*	5	25			
*Eurasian milfoil	*Myriophyllum spicatum*		1			
wild celery	*Vallisneria Americana*	25	50	50		
Bladderwort	*Utricularia vulgaris*		1			
*curly pondweed[1]	*Potamogeton crispus*	1				
Richardson pondweed	*P. richardsonii*	1	1			
nodding waternymph	*Najas flexilis*	5				
green arrow arum	*Peltandra virginica*				5	
Broadfruit bur-reed	*Sparganium eurycarpum*				♦	
*European frog-bit	*Hydrocharis morsus-ranae*				♦	♦
Total Invasives		6	1	0	<1	<1
TOTAL		~100	~75	~50	~100	~95

[1] *P. crispus*: was most abundant in several areas during spring sample.

Indicator – Invasive Plant Species Frequency and Abundance: Invasive species are those nonnative organisms whose introduction to an ecosystem causes or is likely to cause economic or environmental harm (New York State Invasive Species Task Force 2005). Many invasive plant species are competitive or weedy plants that are able to displace others, thereby reducing diversity of other plants and organisms that rely on a diverse assemblage of plants. Given the boating activity within the freshwater estuary and level of establishment by invasive macrophytes within the Great Lakes, potential exists for invasives to reduce diversity and ecosystem functions of the freshwater estuary's macrophyte beds.

Table 4 presents the criteria used to rank community viability in relation to the dominance of invasive species.

Table 4. Generalized criteria (modified from Drake et al., 2003) for ranking community viability in relation to the frequency of occurrence (proportion of observations in which an invasive species is present) and dominance (relative density, cover, biomass) of invasive species, pests and pathogens (ISPPs) within natural communities.

	Excellent	Good	Fair	Poor
Frequency	ISPPs not present in study area	ISPPs present on <5% of sites/plots	ISPPs present on 5-25% of sites/plots	ISPPs present on >25% of sites/plots
Abundance	ISPPs not present in study area	ISPPs comprise <5% density, cover or basal area	ISPPs comprise 5-25% of density, cover or basal area	ISPPs comprise >25% of density, cover or basal area

<u>Current Condition – Good to Fair</u>: Table 3 reports percent cover of component macrophyte species in the freshwater estuary. Harman et al. (2000) reported that several potentially invasive species are present within the system (purple loosestrife, Eurasian milfoil, curly pondweed), but that total cover of these species was low (ranging from 1-6%) and, given the relatively low nutrient levels in the freshwater estuary, these species were not expected to develop into problematic weeds and this location. Howard (2006) noted the presence of Eurasian milfoil, purple loosestrife and Euopean frog-bit, but cover never reached 1% in their sample. Eurasian milfoil occurred in 17% of McKenna's random samples. Using the Drake et al. (2003) guidelines for frequency, community composition with respect to invasive occurrences would be rated "fair" (up to 17% frequency of occurrence of milfoil in random samples). However, if guidelines for cover are applied, the freshwater estuary would be rated "good" given that invasive species typically account for less than 5% of the total estimated macrophyte cover.

2.2.2.3. KEA – CONDITION - Fish Communities

The Salmon River freshwater estuary is a warm water fishery that supports a variety of game fish species and forage species for several shore birds. Furthermore, it serves as a concentration area for migratory salmonines during annual spawning runs. Fish communities are assembled from populations in both the river and Lake Ontario. Maintenance of a diverse and productive fishery is vital for the viability of the system.

Indicator – Fish Community Diversity (Richness): Species richness is an important indicator of ecosystem health in that it reflects the potential complexity of food webs and often increases a community's capacity to prevent the establishment of invasive species. Greater fish richness provides for more diverse consumption of food types, thereby controlling population growth of a wide variety of plants, algae and invertebrates. In turn, diverse forage fish support a greater variety of bird, fish and mammal predators.

There are no quantitative accounts of historic species richness of the freshwater estuary upon which to base a viability ranking. However more recent surveys exist that can provide a baseline for future monitoring.

<u>Current condition – Good:</u> Two recent, unpublished and ongoing surveys of the freshwater estuary fish communities have together recorded 44 species between 1996 and 2003 (Table 5). A 1977 survey collected 43 fish species near the river's mouth (FERC 1996). By comparison, fish species richness in the summers of 2001-2002 in nearby protected embayments of southeastern Lake Ontario (Blind Sodus, Little Sodus, Floodwood, North Sandy Pond, Colwell) ranged from 20-43 (Meixler et al. 2005). Comparing data among these surveys requires caution since different sampling methods, intensities and timing were employed. Regional fisheries managers believe the freshwater estuary possesses a good level of species richness.

Indicator – Index of Biotic Integrity: An index of biotic integrity (IBI) was developed by Carlson et al. (2006) to describe the overall condition of fish community composition in 35 bays along the eastern and southern shores of Lake Ontario. The IBI synthesizes data describing thirteen metrics including species richness and composition, tolerance and sensitivity, feeding guilds, reproductive guilds, and abundance of native species. Bays obtaining IBI scores greater than 38 were ranked in "good" condition and those scoring less than 33 were ranked as "poor."

<u>Current Condition – Good:</u> The Salmon River Freshwater Estuary received the highest IBI score (41) of all 35 bays sampled along Lake Ontario.

Table 5. Relative density (percent of total catch) of fish species in samples from the Salmon River freshwater estuary. Data are from J.McKenna (unpublished, 1996-2003 sampling with combination of bottom and surface trawls, and large (1.5") and small (1/8") seines) and NYSDEC Rare and Endangered species survey 9/97. Sample methodology and intensity vary between the data sources.

	-------------J. McKenna-------------				NYSDEC R&E Survey
	Fall N=8	Spring n=7	Summer N=8	Avg. all seasons	Fall 1997
avg. total catch	**170**	**48**	**81**	**99**	**969**
shiner, golden	11.2	6.0	3.1	6.6	25.8
perch, yellow	6.1	35.3	19.0	20.1	22.2
pumpkinseed	5.3	6.0	14.4	8.6	20.6
shiner, bridled	8.6	0.3	0	3.0	8.2
minnow, bluntnose	37.5	11.7	1.8	17.0	6.2
bass, largemouth	0.2	0	2.2	0.8	5.5
bass, rock	5.1	3.6	4.8	4.5	1.8
darter, tessellated	2.2	20.7	13.5	12.1	1.6
crappie, black	0.2	0	0.8	0.3	1.0
bluegill	5.2	0.3	2.8	2.8	1.0
killfish, banded	0	0	0.2	0.1	1.0
minnow, fathead	0	0	0	0	1.0
alewife	0	1.5	0	0.5	0
bass, smallmouth	2.2	0	10.5	4.2	0.0
Bowfin	0	0.6	0	0.2	0.5
bullhead, brown	2.2	6.6	9.7	6.2	0.9
bullhead, yellow	0	0	0.3	0.1	0
carp, common	0	0	0	0	0.1
chubsucker, creek	<0.1	0	0	<0.1	0
chubsucker sp.	<0.1	0	0	<0.1	0
dace, blacknose	0.7	0	0	0.2	0
eel, American	0	0	0.2	0.1	0
lamprey	0	0	0	0	0.1
minnow sp.	0	1.2	0.5	0.6	0
minnow, cutlip	3.6	0.3	0	1.3	0.1
minnow, eastern silvery	0.7	1.8	0	0.8	0
Moxostoma sp.	0	0	1.1	0.4	0
mudminnow, central	0	0.3	1.4	0.6	0
Notropis sp.	0	0	2.2	0.7	0
perch, log	0	0.6	0	0.2	0

Table 5, continued

	J. McKenna				NYSDEC R&E Survey
	Fall N=8	Spring n=7	Summer N=8	Avg. all seasons	Fall 1997
pickerel, chain	1.1	0.6	5.6	2.4	0
pickerel, grass	0	0	0	0	0.3
pike, northern	0.4	0.6	0.2	0.4	0.8
redhorse, shorthead	0	0	0	0	0.3
redhorse, silver	0	0.9	0	0.3	0
salmon, Chinook	0.4	0.3	0	0.2	0
shiner, blacknose	0.2	0	3.4	1.2	0
shiner, common	6.3	0	0.2	2.2	0
shiner, emerald	<0.1	0	1.6	0.5	0
shiner, spottail	0	0.6	0.2	0.2	0.4
sucker, hognose	0	0	0	0	0.1
sucker sp.	0	0	0.2	0.1	0
sucker, white	0.4	0.3	0.5	0.4	0.1
sunfish sp.	0	0	0.2	0.1	0

Indicator – Invasive Species Densities: NYSDEC fisheries managers considered the sea lamprey (*Petromyzon marinus*) to be the most invasive species in the lower Salmon River and its freshwater estuary. Lampreys are parasitic and attach themselves to other fish with their suction-disk mouths and feed on the host fish's bodily fluids. Introduction of sea lampreys to the Great Lakes has caused declines in lake trout and whitefish populations. They spawn in tributary streams.

Common carp (*Cyprinus carpio*) is another potentially invasive fish species inhabiting the estuary. Carp are native to Eurasia, and inhabit slow-moving and standing freshwaters and brackish estuaries. They feed on invertebrates and aquatic vegetation. During feeding activities they uproot aquatic plants, thereby causing siltation that can disturb nursery areas of native fishes, and inhibit the ability of sight-oriented predatory fish (e.g., bass, sunfish) to forage (USGS 2006). Carp are present in several tributaries of the Great Lakes.

Current Condition – Lampreys, Good: Lampreys are present but not abundant in the freshwater estuary. They comprised only 0.1% of the fish collected during a NYSDEC sample for Rare and Endangered species in 1997 (Table 5). Based on ranking criteria for invasive species (Table 4), the condition of the freshwater estuary relative to lamprey densities is good. The freshwater estuary is included in the Great Lakes Fisheries Commission lamprey treatment program and is treated on a 4-yr cycle (D. Bishop, NYSDEC personal communication; for additional information see also http://www.glfc.org/lampcon.php).

Current Condition – Common Carp, Good: Carp are present but not abundant in the estuary. They comprised only 0.1% of the fish collected during a NYSDEC sample for Rare and Endangered species in 1997 (Table 5). Local fisheries managers do not believe carp currently present a threat to the Salmon River fishery.

2.2.2.4. KEA – CONDITION - Populations of Rare and Endangered Species. Several wildlife species of concern are known to occur within the freshwater estuary. These include:

- black tern (*Chidonias niger*), status endangered
- least bittern (*Ixobrychus exilis*), status threatened
- pied-billed grebe (*Podilymbus podiceps*), status threatened
- sedge wren (*Cistothorus platensis*), status threatened

A fifth species, the lake sturgeon (*Acipenser fulvescens*), is believed to be extirpated from the freshwater estuary, and the system represents a potential site for restoration.

Indicator – Numbers of Black Tern Breeding Pairs: These insectivorous birds are known to nest within the freshwater estuary. They tend to nest in a colonial fashion, often with clusters of up to 11-50 nests in the same area of marsh. Nests are usually placed 11-50 m apart but can range from 1 to 600 m. Territories are defended to about 2 m from the nest. Nests are small collections of aquatic vegetation usually built on floating substrates of matted or decaying marsh vegetation, or on other features that provide a platform (US Fish and Wildlife Service 2007).

No quantitative determination of carrying capacity for nesting pairs has been proposed for this species at this location.

Current Condition – Fair: The New York Natural Heritage program rated this occurrence as fair (Howard 2006). That report indicated the number of nesting pairs (unspecified) has been lower than in recent years, but habitat availability is still excellent. Lower rating for the ranking is due to heavy development and use by boaters that may possibly lead to harassment of nesting pairs.

Indicator – Numbers of Pied-billed Grebe Breeding Pairs: This species breeds on seasonal or permanent ponds or bays with dense stands of emergent vegetation. It feeds on fish in open waters and among aquatic vegetation. It constructs its nest on floating vegetation (Cornell Lab of Ornithology 2007).

No quantitative determination of carrying capacity for nesting pairs has been proposed for this species at this location.

Current Condition - Good to Fair: The NY Natural Heritage Program reported one to two pairs in 2001 with at least four pairs encountered in 2005 (Howard 2006). Habitat of emergent vegetation is abundant with nearby open bay and channels.

Indicator – Numbers of Least Bittern Breeding Pairs: This species requires marshes with tall, emergent vegetation for both foraging and nesting purposes. It feeds on small fish and insects within emergent marshes and constructs nests made of plant materials in dense, tall vegetation (Cornell Lab of Ornithology 2007).

No quantitative determination of carrying capacity for nesting pairs has been proposed for this species at this location.

Current Condition – Good to Fair: The NY Natural Heritage Program reported at least two pairs of least bitterns were present at the site in 2005 (Howard 2006). The area of suitable habitat (emergent marsh, with open channel and bay) is large.

Indicator – Numbers of Sedge Wren Breeding Pairs: This species inhabits margins of wetlands dominated by grasses and sedges, and other damp grassland habitats. This species has experienced a noticeable decline in the northeastern United States and the Great Lakes region (Patuxent Wildlife Research Center 2005).

Current Condition – Unranked: The species has been observed in the freshwater estuary. No quantitative information exists regarding its abundance in the system.

Indicator – Numbers of Lake Sturgeon: This species is one of New York's largest freshwater fish, and can occasionally grow to more than seven feet in length. It is listed as threatened in all states where it occurs due to over exploitation for caviar and flesh, construction of dams that eliminate spawning and nursery areas, and habitat degradation from to pollution and channelization. Lake sturgeon spawn in clean, large cobbles along rocky shores of islands and in rapids in streams, and feed on invertebrates, small fish and algae that occur along river bottoms. In New York, sturgeon have been collected in the St. Lawerence, Niagara, Oswegatchie and Grasse Rivers, and in Lake Ontario, Erie, Champlain, and Cayuga (NYSDEC 2008). The NYSDEC is currently assessing restoration potential for this species in several waterways where it is known to occur (Zollweg et al. 2003, NYSDEC 2008) and some fisheries managers believe the Salmon River Freshwater Estuary has excellent potential to support a reintroduction effort (D. Carlson, NYSDEC, personal communication).

Current Condition – Poor: This species is not known to occur in the freshwater estuary.

2.2.2.5. KEA: CONDITION – Hydrology

Water level within the freshwater estuary determines the aerial extent and distribution of available wildlife and fisheries habitat. Due to the geomorphology of this drowned river mouth, the water levels within the freshwater estuary are influenced primarily by lake levels. However, the presence of the sandbar/dunes across the mouth of the embayment limits water circulation with the freshwater estuary. Therefore water chemistry is determined largely by surface water discharge by the Salmon River and locally by small tributary streams (Mud Creek), as well as possible groundwater discharge.

Indicator: Surface Water Level Variation: Variability in water level probably served as an historic periodic disturbance that regulated plant community composition and local biodiversity. Water fluctuations would flood or dry out patches of emergent plants and permit for the shifting of sand and gravel bars by the river. These changes would reduce the extent and density of dominant, competitive plants and open exposed substrate for colonization by less dominant species, thus maintaining wetland community types within the freshwater estuary in a constant state of flux.

Stabilization of water levels within Lake Ontario began in the late 1950s (Figure 8) to provide for unhindered shipping traffic through the St. Lawrence River. This stabilization in water levels using the current regulatory plan (1958-D with Deviations) has reduced variation in plant community types in coastal marsh communities along the lake, which in turn reduces potential breeding and feeding grounds for marsh-dwelling birds and fish. Greater variation in water levels leads to a greater variety of marsh communities, which in turn provides more productive habitat for animals. Since regulation of water levels began in the late 1950s, there has been an estimated 50% reduction in meadow marsh and emergent-floating vegetation, and a concomitant 29% increase in cattail-dominated emergent marsh areas within the Lake Ontario and St. Lawrence wetlands (ILOSLR Study Board 2006).

<u>Current Condition – Fair to Poor:</u> No specific information exists regarding the influence of water level fluctuations on the distribution and integrity of wetland communities within the Salmon River freshwater estuary. Guidance from ISOSLR (2006) suggests that ecological integrity of this and other similar embayments along Lake Ontario would benefit from greater fluctuations in lake water levels.

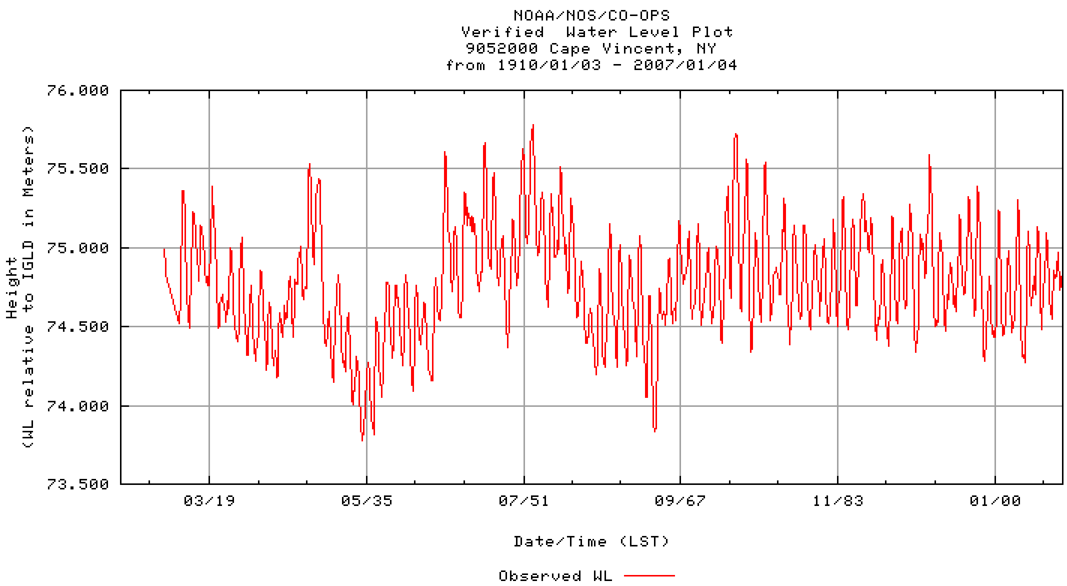


Figure 8. Historic water levels in Lake Ontario gauged at Cape Vincent, New York. Source: National Oceanic & Atmospheric Administration, Center for Operational Oceanographic Products and Services <http://www.great-lakes.net/envt/water/levels/levels-cur/ontwlc.html>.

Indicator – Salmon River Baseflow: Water levels of the freshwater estuary equilibrate with Lake Ontario levels, but water chemistry, temperature and circulation within the freshwater estuary are influenced greatly by flow from the Salmon River since the barrier dunes isolate the embayment from wave action on the lake. During summer periods of low flow, it is possible that environmental conditions within the freshwater estuary (e.g., temperature, dissolved oxygen) may become suboptimal for many organisms. Although measuring temperature and dissolved oxygen is more direct in assessing condition within the freshwater estuary, river baseflow is the hydrologic process that may be most important for controlling these factors. Baseflow conditions of the Salmon River at its mouth are regulated in large part by discharge from the hydropower reservoirs.

The licensing agreement (NERC 1996) for the hydropower plants require that continuous baseflow be maintained from the reservoirs under the following schedule:

January 1 – April 30	285 cfs
May 1 through August 31	185 cfs
September 1 through December 31	335 cfs.

This baseflow schedule represents a compromise between needs to maximize electricity generation and provide habitat that sustains a diverse river ecosystem. Importantly, the schedule sustains a minimum of 185 cfs of baseflow during the critical, dry summer months. This summer baseflow criterion was produced through several iterations of computer models that generated estimates of aquatic habitat availability and quality for all life stages of several indicator fish species under different baseflow release schedules.

Current Condition-Good: Baseflow input to the freshwater estuary by the Salmon River is maintained at a minimum of 185 cfs as determined by regulated discharge from the hydroelectric dams (Figure 9). This artificial flow schedule maintains high-volume river discharge into the freshwater estuary during the critical summer months at greater frequencies than historic flows without the influence of the upstream dams.

Indicator – Groundwater Discharge: Groundwater discharge into the freshwater estuary would influence freshwater estuary temperature and water quality and potentially help to maintain summer baseflow conditions.

Current Condition - Unranked: There is currently no information available regarding the volume and quality of any groundwater discharge into the freshwater estuary, and whether such discharge is consequential to freshwater estuary viability.

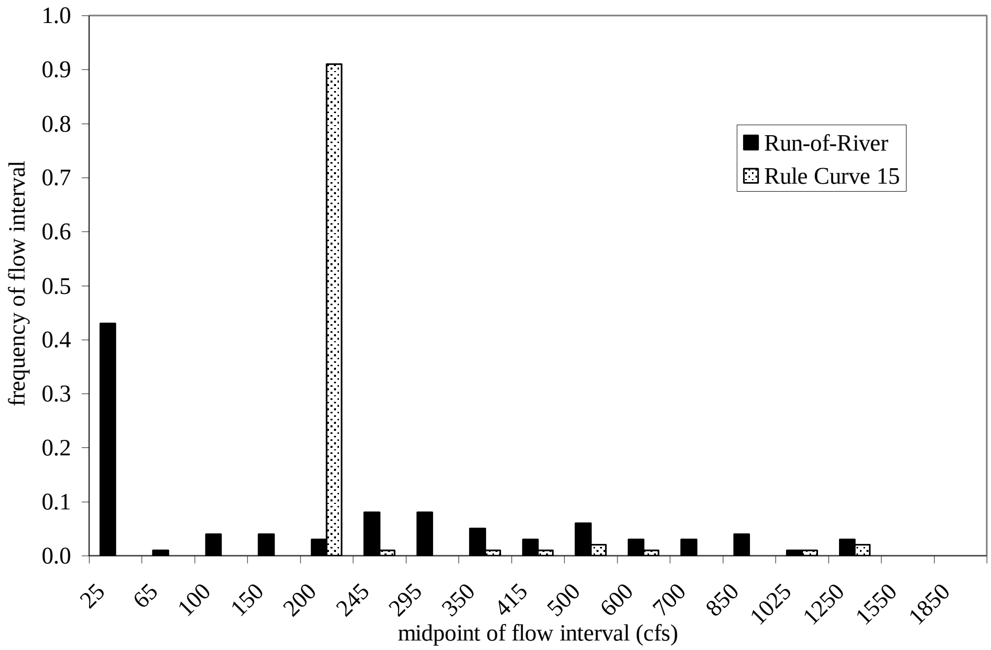


Figure 9. August flow distribution for different regulated flow regimes in the Salmon River . Run-of-river represents natural flow regimes. Rule Curve 15 maintains 200 cfs minimum baseflow during summer months (Sourc: F. Verdoliva, NYSDEC Altmar.)

2.2.2.6. KEA – CONDITION: Water Quality

Indicator - Percent Natural Vegetation in 100-ft Shoreline Buffer: Vegetated buffers along waterways are important for maintaining several aspects of water quality and habitat viability. Vegetation sequesters nutrients, stabilizes soils thereby reducing erosion, delivers organic material to be used as aquatic energy sources, and provides shade to moderate water temperatures. Available guidance suggests that 100-ft-wide vegetated buffers are typically effective at maintaining water quality and shading stream environments (Klapproth and Johnson 2000, Baird and Wetmore 2006).

Table 6 summarizes ranking criteria for assessing potential water quality condition as it may be influenced by land use within the freshwater estuary buffer zone.

Table 6. Ranking criteria for percent land-cover as natural vegetation in upland buffers adjacent to freshwater bodies (rivers/streams, open waters, wetlands).

	poor	fair	good
Percent of upland areas directly adjacent to water edge that is in some form of natural cover type (types other than roads, developed, agriculture, barren).	<75%	75-90%	>90%

Current Condition – Fair: An analysis of the land-cover types (National Land Cover Database 2001) within a 100-ft buffer established at the edge of the freshwater estuary (Figure 10) reveals that developed, agricultural and barren land uses comprise 8%, 9% and 4%, respectively, of the buffer area (total 21%). The balance (79%) is in some form of natural cover type (forest, scrub/shrub, grassland, wetland). The freshwater estuary is well buffered along its south shore adjacent to Selkirk Shores State Park. Development and agriculture occur along the north and southeast shores of the freshwater estuary. The land-cover on the barrier dune was mapped as scrub-shrub, but substantial development of seasonal homes exists there.

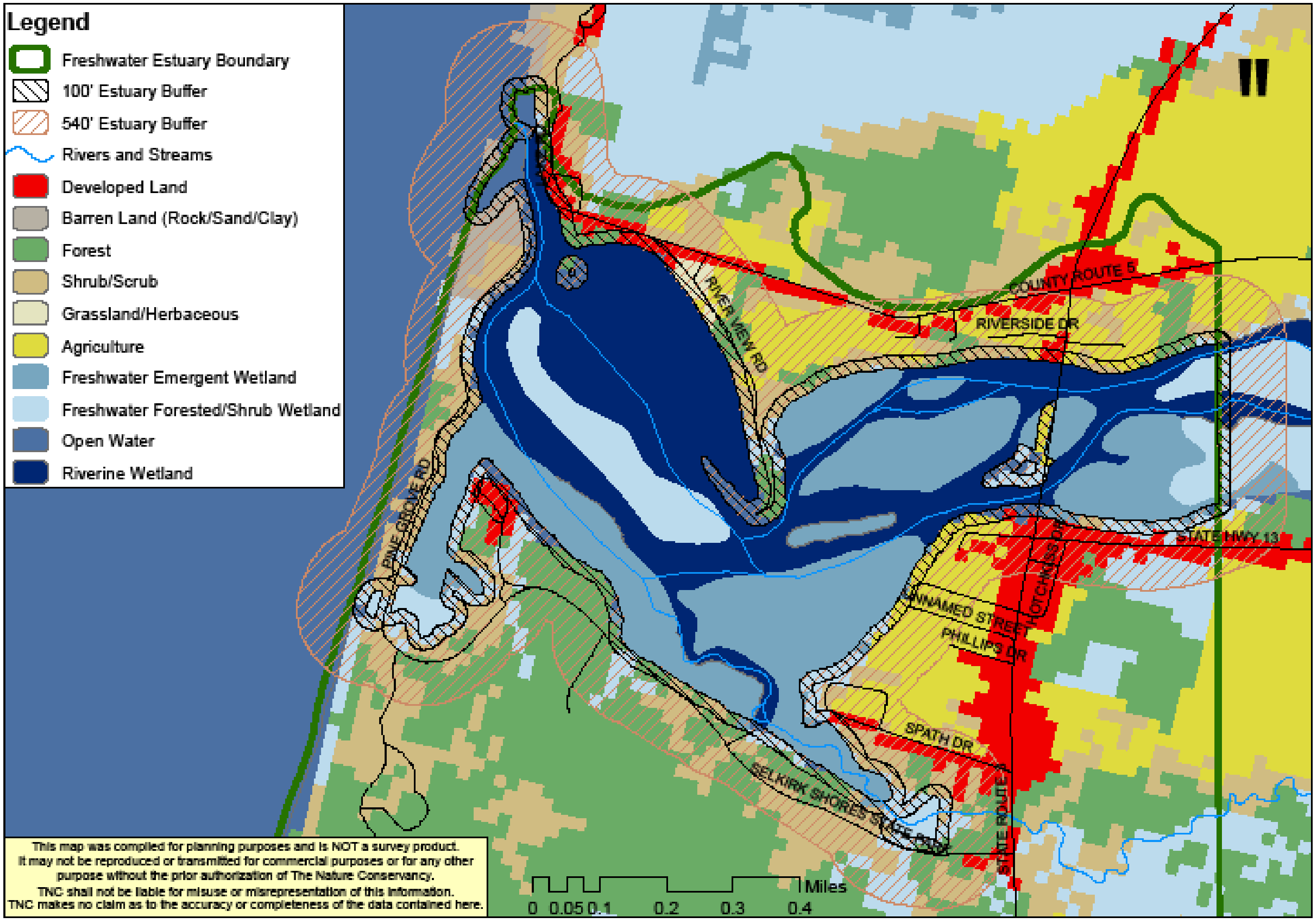


Figure 10. Analysis of land cover-types in 100- and 540-ft-wide buffers of the Salmon River freshwater estuary. Data are from the National Land Cover Database (2001).

Indicator: Phosphorus (P) Concentrations: Phosphorus is a naturally occurring mineral nutrient that is frequently the single-most important limiting resource for biological productivity in freshwater systems. It typically occurs in freshwaters in low concentrations owing to its low solubility. High P concentrations in water bodies are normally due to human activities (septic waste disposal, agricultural waste and fertilizer runoff), and typically result in high rates of productivity by algae and plants (eutrophication). The benthic (bottom) zones of eutrophic water bodies often become depleted in oxygen when large amounts of organic matter accumulate and undergo bacterial decomposition. Oxygen depletion, in turn, results in mortality of fish and other aquatic invertebrates.

No national standards have been set for phosphorus compounds in surface waters, but the USEPA has issued guidelines suggesting that to reduce eutrophication, total phosphates in streams entering lakes or reservoirs should not exceed 0.05 mg/L (Mueller and Helsel 1996).

<u>Current Condition – Good:</u> No data were available to specifically quantify phosphate concentrations in the water column of the freshwater estuary. However, Harman et al. (2000) subjectively describe the freshwater estuary as a mesotrophic system, suggesting low to only moderate concentrations of elemental nutrients.

Indicator – Carlson Trophic State Index: The Carlson TSI index (USEPA 2007a) synthesizes related data associated with indicators of trophic condition: chlorophyll *a* concentration (an indirect, but practical, measure of algal biomass); total phosphorus concentration (important limiting nutrient in freshwater systems); and Secchi disk transparency (depth to which one can see into the water). TSI is calculated separately for each respective measurement:

TSI = 60 – 14.41 ln Secchi disk (meters)
TSI = 9.81 ln Chlorophyll *a* (ug/L) + 30.6
TSI = 14.42 ln Total Phosphorus (ug/L) + 4.15

Ranges of TSI values can be assigned trophic state classifications:
TSI < 40: oligotrophic (low productivity)
TSI 40-50: mesotrophic (moderate productivity)
TSI >50: eutrophic (high productivity).

For instance TSI based upon concentration of P=0.5 mg/L (maximum suggested P concentration by Mueller and Helsel 1996) yields a TSI=61=eutrophic.

<u>Current Condition – Unranked:</u> No data are available for Secchi disk, chlorophyll *a* or total P in the freshwater estuary.

Indicator: Summertime Water Temperature: Temperature is an important regulator of partial pressure (solubility) of gases, particularly oxygen, in water. Cold water can maintain higher concentrations of oxygen than warm water. Furthermore, cellular respiration rates tend to increase with temperature, so rates of biotic activities increase. Importantly, bacterial decay of organic material increases, leading to more rapid oxygen depletion under warm conditions. The freshwater estuary naturally experiences diurnal fluctuations in temperature – warming by day and cooling by night – especially during the summer months and in the shallower reaches with slow water velocity. Because the freshwater estuary is isolated from Lake Ontario, wave action is minimized and mixing of the water column is limited. The freshwater estuary is classified as a "warm water fishery" and therefore will naturally not support certain fish requiring colder water temperatures. Even still, baseflow from the Salmon River is important for regulating water temperatures during the summer. Maximum temperature thresholds, at which many aquatic organisms begin to experience adverse physiological effects, must be considered by both temperature and duration.

Optimal temperature ranges for common warm water fish species (Michigan DNR 2007) inhabiting the freshwater estuary are:

80-82 ºF for largemouth bass;
68-70 ºF for smallmouth bass;
66-70 ºF for yellow perch.

Current Condition – Good: Limited available data (Table 7) suggest summertime high water temperatures in the freshwater estuary fall within the range of tolerance for common warm water fish species. No summer fish kills associated with lethal temperatures in the freshwater estuary have been reported.

Table 7. Summary of seasonal water quality parameters in the Salmon River freshwater estuary. Data are average temperatures taken during 1- to 2-day long sampling activities over the years reported. Average temperatures for the sampling activities are organized by season. (Source: J. McKenna, unpublished data).

	Temp. ºF	Dissolved Oxygen (mg/L)	pH
Autumn ('95,'96,'97)	68.4	10.1	8.1
Spring ('96,'97,'98,'99)	54.3	11.6	7.2
Summer ('96,'97)	72.9	8.8	7.5

Indicator – Sediment Load/Turbidity: Excessive sedimentation by silt within the slow reaches of the Salmon River can have substantial negative consequences. Siltation can smother spawning beds of several resident fish species. Silt load in the water column leads to greater absorption of light, thereby increasing water temperature.

Current Condition - Unranked: No information was obtained with which to rank this indicator for the freshwater estuary.

2.2.2.7. KEA – CONDITION: Pathogens

Several pathogens of concern to wildlife, fisheries and human health occur in or near the watershed. Table 8 presents ranking criteria used to assess current condition of pathogen occurrences in fish and wildlife populations.

Table 8. Ranking criteria for pathogen occurrences in freshwater bodies (rivers/streams, open waters, wetlands).

	Good	Fair	Poor
Percent of population within or in the vicinity of the Salmon River freshwater estuary that displays disease symptoms.	0 %	1-5%	>5%

Indicator – Type E Botulism Occurrence: Botulism is a disease caused by a neurotoxin that is produced by a bacterium and that leads to paralysis. The disease is spread by consumption of infected meat and has been known to affect fish-eating shore birds in the Great Lakes since 1999 (NYSDEC 2006b).

Current Condition – Fair: In autumn, 2006, an outbreak of Type E Botulism occurred in gulls, grebes and loons along the southern and eastern shores of Lake Ontario. This was the first occurrence in Lake Ontario (NYSDEC 2006b). No birds within the freshwater estuary were known to have been infected.

There are six viral and bacterial pathogens that are being monitored by NYSDEC for the salmonine fishery management (A. Noyes, NYSDEC Aquatic Pathologist, personal communication).

Indicator – Bacterial Kidney Disease Occurrence: BKD is caused by a gram-positive bacterium (*Renebacterium salmoninarum*) that survives in and causes extensive tissue damage to kidneys (Grayson et al. 2002). The disease is widespread in the Upper Great Lakes, with symptoms occurring in ~30-40% of Coho, Chinook, and Steelhead salmon there. The disease is spread by spawning fish migrating back into the river from Lake Ontario.

Current Condition - Fair: The bacterium has occurred sporadically in the Salmon River fishery but has not been detected since 2003.

Indicator – Furnunculosis Occurrence: Furnunculosis is a bacterial disease caused by *Aeromonas salmonicida.* The bacterium causes severe blood poisoning and acute mortality. Fish affected with pathogen may swim erratically, become sluggish and stop feeding. The disease is common throughout North America and the Great Lakes. (For more information see http://www.lsc.usgs.gov/FHB/leaflets/FHB66.pdf)

Current Condition - Good: The pathogen has recently been detected in approximately 5-10% of fish in the Salmon River, but no disease symptoms have been observed.

Indicator – Infectious Pancreatic Necrosis (IPN) Occurrence: IPN is a viral disease that infects all ages and varieties of salmonines and is transmitted vertically (adults to eggs), or horizontally (consumption of infected dead fish or by fish excretions in the water). Infected fish may have swollen stomachs, swim in spiral manners, be inactive and produce white fecal casts. (For additional information see http://www.mass.gov/czm/wpfshlth.htm, http://www.disease-watch.com/documents/CD/index/html/fv035ipn.htm)

Current Condition - Good: This disease was present in the Salmon River fishery in the 1950's and 1960's but has not been detected recently. It continues to be monitored.

Indicator – Yersinia ruckeri Occurrence: This bacterium is the causative agent of enteric redmouth (ERM), referring to symptomatic red mouths of infected fish. ERM most often infects rainbow trout, but it also affects several other salmonids. Infected fish are often found at the top of the water, isolated from other fish, and they may stop eating. The bacterium is common in Appalachian and mid-Atlantic fisheries as well as in the western Great Lakes. (For more information see http://www.mass.gov/czm/wpfshlth.htm.)

Current Condition - Fair: It is present but not common in the Salmon River.

Indicator – Viral Hemorrhagic Septicemia (VHS): The IV-B strain of this virus was detected in Nova Scotia in the 1990s. Current evidence suggests this is probably an Atlantic strain of the virus that is just now being spread into the Great Lakes. This particular strain does not target salmonines as the other strains do (I, II and IV on salmonids in Europe and Asia; and IV-A in the Pacific Northwest), but rather walleye, perch, minnows and gobies. Infected fish exhibit dark color, pale gills, sluggishness and erratic swimming. (For more information see http://www.mass.gov/czm/wpfshlth.htm, http://www.dec.state.ny.us/website/dfwmr/fish/vhsv.html.)

Current Condition - Good: The virus has not yet been detected in the Salmon River.

2.2.2.8. KEA-CONDITION: Toxins

Several known toxins are of concern within the freshwater estuary, some of which reach levels to warrant health advisories.

Indicator – Game Fish Tissue Mercury Concentration: Mercury (Hg) is a naturally occurring element that has increased in abundance due to a number of human activities. Important sources of mercury into the air and water include utilities, municipal wastewater plants, and incinerators. Toxic effects include reduced reproductive success, hormonal changes and motor skill impairment (Driscoll et al. 2007). Mercury bioaccumulates through food chains and can reach levels in carnivorous fish that are hazardous to human health. It is believed that the source of mercury in the lower Salmon River is primarily from migrating salmonines returning from Lake Ontario. However, some mercury is also deposited via wet and dry deposition in the upper watershed.

The current New York State threshold for issuing specific fish consumption advisories is the USDA standard of 1 ppm. In 2001 the USEPA set the human health standards for mercury at 0.3 ppm (=300 ng/g), but USDA, rather than EPA has enforcement capacity for human food. The source of data for this viability analysis (NYSDOH 2006) indicates those water bodies where fish exceed the USDA standard, and no data are provided that report actual tissue concentrations. Piscivorous (fish-consuming) wildlife are at high risk of adverse effects from mercury if they consume forage fish with mercury tissue concentrations >77 ng/g or higher trophic-level fish with mercury tissue concentrations >300 ng/g (USEPA 1997; Loukmas et al. 2006).

Current Condition - Fair: Elevated mercury levels are known to occur in fish in the lower Salmon River, but currently there are no fish consumption advisories for mercury in game fish taken from the lower Salmon River (NYSDOH 2006). No information is available on mercury concentrations on forage fish in the watershed.

Indicator – Game Fish and Snapping Turtle Tissue PCB Concentration: PCBs are a class of organochlorides that are persistent and bioaccumulate in aquatic food chains.

Toxicity to humans include carcinogenicity, reproductive and developmental toxicity, neurotoxicity, and acute toxicity.

Two potential rating criteria were obtained for this indicator. The first rating criterion follows NY State Department of Health standards. Another indicator is a measure of contaminant levels in snapping turtle eggs (Table 9), which have been shown to be highly correlated with contaminant concentrations in liver and adipose (fat) tissue (Pagano et al. 1999). Turtles accumulate persistent contaminants in their tissues from food and water taken directly from the wetland systems they inhabit, so their contamination levels directly reflect those of their immediate environments.

Table 9. Indicator ratings for PCB and Mirex concentrations (mg/kg) in snapping turtle eggs (data are from Pagano et al. 1999). Threshold values applied here for indicator ratings are based upon empirical measurements taken in perceived uncontaminated and contaminated (USEPA Superfund sites and NY State Hazardous waste sites) environments. These values do no reflect thresholds for adverse impacts to the animals.

	Good	Fair	Poor
PCB (mg/kg)	0	≤ 2	>2
Mirex (mg/kg)	0	≤0.2	>0.2

Current Condition (Fish Advisory Indicator)- Poor: There is currently a DOH fish consumption advisory for PCBs in smallmouth bass taken from the Salmon River from the mouth to the Reservoir (NYSDOH 2006).

Current Condition (Snapping Turtle Egg Indicator) – Fair: There are no data available for snapping turtle PCB concentrations in the watershed. However, Pagano et al. (1999) reported snapping turtle egg concentrations to be 1.5 mg/kg at the nearby Rice Creek Biological Station in Oswego County.

Indicator – Mink Jaw Lesions: The occurrence of cancerous lesions in the jaws of mink appears to serve as a sensitive indicator to PCB exposure (Haynes et al. 2007). That study further concluded that mink living and feeding near the shore of Lake Ontario, were exposed to bioaccumulative compounds (e.g., PCBs) in concentrations sufficient to cause lesions (40 parts per billion).

Current Condition - Poor: There are no data available reporting the occurrence of cancerous lesions in mink for the Salmon River watershed. However, based upon the work of Beckett and Haynes (2007) in the Rochester Embayment, mink feeding within the Lake Ontario system appear to be exposed to sufficiently high PCB concentrations to induce growth of lesions in jaw tissue and this exposure is apparently from food sources exposed to contaminated water in Lake Ontario rather than within the Rochester Embayment watershed.

Indicator – Game Fish and Snapping Turtle Tissue Mirex Concentration: Mirex, which was banned in the US since the 1970s, is an organochloride that was used as an insecticide and flame retardant in a number of materials. It is persistent and bioaccumulates in aquatic food webs. Toxicity to humans includes carcinogenicity, reproductive and developmental toxicity, neurotoxicity, and acute toxicity (NYSDOH 2006, PAN Database 2007).

As with PCBs this indicator will be ranked using two criteria: issuance of fish consumption advisories by NYDOH and concentrations in snapping turtle eggs.

<u>Current Condition (Fish Advisory Indicator) - Poor</u>: There is currently a NYSDOH fish consumption advisory for Mirex in smallmouth bass taken from the Salmon River from the mouth to the Reservoir (NYSDOH 2006).

<u>Current Condition (Snapping Turtle Egg Indicator) – Fair:</u> There are no data available for snapping turtle Mirex concentrations in the watershed. However, Pagano et al. (1999) reported Mirex concentrations in snapping turtle eggs to be 0.04 kg/mg at the nearby Rice Creek Biological Station in Oswego County.

2.2.2.9. KEA-LANDSCAPE CONTEXT

The condition of the freshwater estuary is influenced by factors outside the actual limit of the wetlands, such as fragmenting landscape features and land uses that may affect water quality within the freshwater estuary or influence its use or accessibility by wildlife. The local landscape surrounding the freshwater estuary is defined by projecting its eastern boundary (last riffle of the Salmon River) northward and southward to the intersection of the Salmon River watershed boundary (Figure 7).

Indicator – Percent of Land in Natural Vegetation in Local Sub-watershed: Percent of a landscape in natural vegetation indicates capacity for habitat and migration corridors for wildlife species that utilize the freshwater estuary for certain aspects of their life histories, and for ecosystem functions such as nutrient sequestration and sediment control.

Table 10 presents criteria for ranking landscape viability based upon the amount of natural vegetation land cover-types.

Table 10. Criteria for ranking landscapes based upon percent of land cover-types as natural vegetation.

	poor	fair	good
Percent of land base in some form of natural cover-type (types other than roads, developed, agriculture, barren).	<75%	75-90%	>90%

Current Condition – Poor to Fair: Analysis of the National Land Cover Database (2001) indicates that 75% of the land cover in the local sub-watershed is "natural cover types" (i.e., wetland, forest, scrub/shrub, grassland, Figure 7). A cursory ground-truth of the NLCD (2001) data indicates that the barrier dunes forming the western limit of the freshwater estuary are comprised of wooded, but developed lots. This area, however, is classified as a natural cover type (shrub/scrub) by the NLCD data. The majority of natural cover within the freshwater estuary's sub-watershed is provided by Selkirk Shores State Park.

Indicator – Percent Natural Cover in 540-ft Shoreline Buffer: Naturally-vegetated buffers provide opportunities for wildlife species to simultaneously utilize upland and wetland habitats within their home ranges, to migrate along water features, and to disperse from wetlands into adjacent upland communities. For instance, amphibians are known to travel 1000-1800 ft, and up to 4500 ft between breeding grounds and hibernation areas (Hels and Buchwald 2001; Gibbs and Shriver 2005). Semlitsch (1998) found adults of six salamander species at an average of approximately 375 ft distance from the edge of aquatic habitats, and suggested that a buffer of ~540 ft from wetlands would capture 95% of the individuals within populations of those species.

Current Condition – Poor: An analysis of the land-cover types (National Land Cover Database 2001) within a 540-ft buffer established at the edge of the freshwater estuary reveals that developed, agricultural and barren land uses comprise 11%, 19% and 3%, respectively, of the buffer area (Figure 10). The balance (67%) is in some form of natural cover-type (forest, scrub/shrub, grassland, wetland). Therefore, the the 540-ft buffer around the freshwater estuary is ranked as "Poor" based upon criteria presented in Table 6.

Indicator – Percent of 540-ft Freshwater Estuary Buffer Isolated by Roads: Road crossings are isolating features that limit the movement of many wildlife species. For instance roads are known to be a significant source of mortality to amphibians and reptiles (Hels and Buchwald 2001; Gibbs and Shriver 2005), especially those that breed in aquatic habitats and must cross roads to travel between hibernation and breeding sites.

Table 11 presents the criteria used to rank current condition of total road intercepts within the freshwater the estuary buffer zone.

Table 11. Criteria for ranking the amount of road intercepts within the 540-ft buffer of the Salmon River freshwater estuary.

	Poor	Fair	Good
Percent of total perimeter formed by a 540-ft buffer around the freshwater estuary that is intercepted by a road.	>25%	10-25%	<10%

Current Condition – Poor: An analysis of land-cover type data (National Land Cover Database 2001) indicated that the freshwater estuary is completely surrounded and isolated by paved roads (Figure 10). Seventy-nine percent of the area falling within a 540-ft buffer around the freshwater estuary has a road passing through it.

Indicator – Percent Natural Vegetation in 100-ft Buffers of Local First Order Streams: Apart from the main branch of the Salmon River, one mapped first-order stream feeds the freshwater estuary (Mud Creek). This stream may have localized influences on water quality and habitat within the freshwater estuary. Vegetated buffers of ~100 ft widths can provide effective nutrient and sediment controls. Ranking criteria presented in Table 6 were used to assess current condition associated with land use within a 100-ft buffer along Mud Creek.

Current Condition - Poor: The Mud Creek watershed has high agricultural use, and the buffer along the length of the creek contains less than 75% natural cover (see headwaters buffer analysis, Section 2.4.2.2, Figure 26).

2.2.3 Dune Community Viability

2.2.3.1 KEA – Size

Indicator – Dune Area (ac): The area of dunes is a direct measure of their extent.

Current Condition – Good: Total dune area at the mouth of the Salmon River to the extension of the freshwater estuary's southern shore is approximately 33 acres. These dunes are contiguous with the larger dune system extending northward from the mouth of the Salmon River. The aerial extent of existing dunes within the system does not appear to be reduced by interruptions of natural dune building processes. A recent study (Woodrow et al. 2002) analyzed sediment transport processes along the eastern Ontario lake shore with the purpose of determining, in part, the extent to which the jetty and Salmon River influence long-shore sediment transport and dune building processes. The study determined that the Salmon River does not contribute sediments to the beach/dunes and that the jetty system does not inhibit long-shore transport along this section of the Ontario lakeshore. Material for the dunes was deposited when the lake levels were higher during deglaciation. The area of dunes that was lost through construction of cottages is not known.

2.2.3.2 KEA – Condition – Dune Plant Community

The barrier dunes at the mouth of the Salmon River represent the southern extent of a 17-mile long Great Lakes dune system. These communities occur in New York only along the eastern shore of Lake Ontario and have a NY Natural Heritage Program ranking of S1S2, meaning they are rare within the state (Edinger et al. 2002). Community composition varies depending on stability of a particular dune and distance from the lake. Unstable dunes occur in closer proximity to the lake and are dominated by beachgrass (*Ammophila breviligulata*) and wormwood (*Artemisia campestris* var. *caudata*). Other species with low percent cover include cottonwood (*Populus deltoides*), heartleaf sand dune willow (*Salix cordata*), sand dropseed (*Sporobolus cryptandrus*), beach-pea (*Lathyrus japonicus* var. *glaber*), and dune grape (*Vitis riparia*). With time and stability, shrub and vine communities establish that are dominated by poison ivy (*Toxicodendron radicans*), dune grape (*Vitis riparia*), and cottonwood (*Populus deltoides*), with lower abundances of red osier dogwood (*Cornus sericea*), silky dogwood (*C. amomum*), sand cherry (*Prunus pumila*), sand-dune willow (*Salix cordata*), and bittersweet (*Celastrus scandens*), along with several herbaceous species. With further stabilization and time, open forest communities establish that are dominated by red oak (*Quercus rubra*) and red maple (*Acer rubrum*). Other characteristic species of the forested dunes include sugar maple (*Acer saccharum*), striped maple (*Acer pensylvanicum*), shad bush (*Amelanchier* spp.), American beech (*Fagus grandifolia*), black cherry (*Prunus serotina*), chokecherry (*Prunus virginiana*), blackberry (*Rubus allegheniensis*), red raspberry (*Rubus idaeus*), nannyberry (*Viburnum lentago*), arrowwood (*V. recognitum*), wild sarsparilla (*Aralia nudicaulis*), and wreath goldenrod (*Solidago caesia*).

Rare plant species known to occur on the dunes at the Salmon River freshwater estuary are Champlain beachgrass (*Ammophila champlainensis*), low sand-cherry (*Prunus pumila var. pumila*) and sand dune willow (*Salix cordata*).

Indicator – Total Vegetation Cover: Due to erosion from wind and wave action, front dunes are often unstable and, therefore, plant establishment is critical for eventual stabilization and maintenance of the dune formations. In high use areas, pedestrian and off-road vehicle traffic promote destabilization.

Bonanno (1992) reported average total ground cover, under high and low use, on foredunes and secondary dunes within the eastern Lake Ontario dune system. Total cover under low use averaged ~40-60% on foredunes and 80% on secondary dunes. Under high use, cover averaged 20% on foredunes and 30% on secondary dunes.

Current Condition - Unranked: No data are available on vegetation cover of dunes at the Salmon River freshwater estuary.

Indicator – Rare Species Population Densities/Cover: Long-term trends in densities/cover of Champlain beachgrass, low sand-cherry and sand dune willow should be monitored.

There is currently no guidance on expected population sizes of these species at this location with which to make a quantitative viability ranking

Current Condition – Fair to Poor: NY Natural Heritage Program (Howard 2006) has ranked the condition for both the sand-cherry and dune willow as Fair to Poor. The sand-cherry population was estimated at 500 stems in five groups that were widely distributed within an active residential development. The population of dune willow is located at the edge of the marsh amongst *Phragmites* and purple loosestrife (*Lythrum salicaria*) along the base of a degraded dune.

Indicator – Dominance by Invasive Species: Table 4 provides guidance for ranking the abundance of invasive species based upon their relative cover or frequencies.

Current Condition -Unranked: No information is available on the distribution and abundance of invasive species in this dune complex. Potential for invasives is high given the degree of development and public use of the area.

2.2.4 Salmon River Freshwater Estuary and Dunes
Viability Summary

Notes on Guidance for Current Condition:		
	"NG"	No guidance was obtained to rank this indicator
	"SGR"	Subjective guidance and/or ranking based on professional opinion
	"ND"	No data are available with which to rank this indicator

Estuary	Exellent	Good	Fair	Poor	Current Condition	Notes on Guidance for Current Condition
KEA-Size						
Ind. - Estuary area (acre)					Good	SG; ranking based on current area
KEA-Condition -Estuary Plant Community						
Ind. - Total macrophyte cover					Good	SGR; Harman et al. (2000)
Ind. - Invasive plant frequency (% of plots)	0	<5	5-25	>25	Fair	Drake et al. (2003)
Ind. - Invasive plant cover (avg % cover)	0	<5	5-25	>25	Good	Drake et al. (2003)
KEA - Condition - Fish Community						
Ind.- Fish species richness (# species in samples)					Good	SGR, local fisheries managers
Ind. – Index of Biotic Integrity		>38	33-37	<33	Good	Carlson et al. (2006)
Ind.- Invasive fish species relative densities (sea lamprey)	0	<5	5-25	>25	Good	Drake et al. (2003)
Ind.-Invasive fish species relative densities (common carp)					Good	
KEA-Condition-Rare & Endangered Species						
Ind. – No. black tern breeding pairs					Fair	SGR, Howard (2006)
Ind. - No. pied-billed grebe breeding pairs					Good-Fair	SGR, Howard (2006)
Ind. - No. least bittern breeding pairs					Good-Fair	SGR, Howard (2006)
Ind. – No .sedge wren breeding pairs					Unranked	ND
Ind. – No. lake sturgeon		Present		absent	Poor	SGR

	Exellent	Good	Fair	Poor	Current Condition	Notes on Guidance for Current Condition
KEA-Condition-Hydrology						
Ind. - Lake Ontario surface water level variation (m)		74.0-75.5		74.5-75.0	Fair-Poor	ISOSLR (2006)
Ind. - Freq. Salmon River summertime baseflow <25 cfs		<40%		>40%	Good	FERC license agreement (1996)
Ind. – groundwater discharge					Unranked	NG, ND
KEA-Condition-Water Quality						
Ind. - % of 100-ft buffer in natural cover types		>90	75-90	<75	Fair	SGR, Klapproth & Johnson (2000), Baird & Wetmore (2006)
Ind. - total dissolved phosphorus concentration (mg/L)		<0.05		>0.05	Good	Mueller and Helsel (1996); SGR, Harman et al (2000)
Ind. - Carlson Trophic Status (unitless)		<50		>50	Unranked	US EPA (2007); ND
Ind. - summertime water temperature (°F)		68-80		>82	Good	Michigan DNR (2007)
Ind. – sediment load / turbidity					Unranked	NG, ND
KEA-Condition-Pathogens						
Ind.– Type E Botulism occurrence (% of population w/ symptoms)		0	1-5	>5	Fair	SGR, local fisheries managers
Ind. – Bacterial Kidney Disease occurrence		0	1-5	>5	Fair	SGR, local fisheries managers
Ind. – Furnunculosis occurrence		0	1-5	>5	Good	SGR, local fisheries managers
Ind. – Infectious Pancreatic Necrosis occurrence		0	1-5	>5	Good	SGR, local fisheries managers
Ind. – Yersinia ruckeri occurrence		0	1-5	>5	Fair	SGR, local fisheries managers
Ind. – Viral Haemorrhagic Septicaemia occurrence		0	1-5	>5	Good	SGR, local fisheries managers

	Exellent	Good	Fair	Poor	Current Condition	Notes on Guidance for Current Condition
KEA-Condition-Toxins						
Ind.– Game fish mercury concentration (ppm)		0	0-1	>1	Fair	NY State Dept. Health (2006)
Ind.– Game fish PCB concentration (ppm)					Poor	NY State Dept. Health (2006)
Ind.– Snapping turtle egg PCB concentration (ppm)		0	0-2	>2	Fair	SGR; Pagano et al. (1999)
Ind.- Game fish Mirex concentrations (ppm)					Poor	NY State Dept. Health (2006)
Ind.- PCB-induced mink jaw lesions (ppb)		0	<40	>40	Poor	Haynes et al. (2007)
Ind.- Snapping turtle egg Mirex concentrations (ppm)		0	0-0.2	>0.2	Fair	SGR; Pagano et al. (1999)
KEA-Landscape Context						
Ind. - Natural land cover of local watershed (%)		>90	90-75	<75	Fair-Poor	SGR
Ind. – Natural land cover in 540-ft buffer (%)		>90	90-75	<75	Poor	SGR
Ind. – Amount of 540-ft freshwater estuary buffer isolated by roads (%)		<10	10-25	>25	Poor	SGR
Ind. – Natural vegetation in 100-ft buffers along local first order streams (%)		>90	90-75	<75	Poor	SGR

Dunes

	Exellent	Good	Fair	Poor	Current Condition	Notes on Guidance for Current Condition
KEA-Size						
Ind. - Dune area (acre)					~33-Good	SGR; based on current estimated area
KEA-Condition -Dune Plant Community						
Ind. - Total vegetation cover (%)		40-80		<30	Unranked	Bonanno (1992); ND
Ind. - Rare species cover (%)						
Champlain beach grass					Unranked	NG; ND
Low sand-cherry					Fair-Poor	SGR, Howard (2006)
Sand dune willow					Fair-Poor	SGR, Howard (2006)
Ind. - Invasive plant frequency (% of plots)	0	<5	5-25	>25	Unranked	Drake et al. (2003); ND
Ind. - Invasive plant cover (avg % cover)	0	<5	5-25	>25	Unranked	Drake et al. 2003; ND

2.3 Main Branch Salmon River & Major Tributaries

2.3.1 Main Salmon River & Major Tributaries Target Definition

The main branch/major tributaries target reflects the definition of "confined rivers" (*sensu* Edinger et al. 2002). These waters represent fast flowing sections of relatively large streams having moderate to gentle gradients. These streams are characterized by well-defined segments of riffles, pools and runs that occur within confined valleys. Stream velocity is great enough to cause lateral erosion, thereby creating braids, bars and channel islands; and to create coarse-rocky to sandy substrates. Biotic energy is typically generated within the streams. Confined rivers have high water clarity and are well oxygenated.

Howard (2006) generated an element distribution model for confined rivers within the Salmon River watershed, and this model roughly matches the occurrence of 3rd-order and higher streams (mapped at 1:100,000 scale). For simplicity, this target has been mapped as 3rd-order and higher streams (Figure 11) to distinguish it from the headwaters target (1st- and 2nd-order streams).

The Salmon River Falls represents a natural migration barrier within this drainage system. Currently the hydroelectric dam at the Light House Hill Reservoir (just below the falls) functions as the first barrier to migration upstream of the freshwater estuary along the main branch of the Salmon River. Consequently the fish communities differ markedly above and below the Light House Hill Reservoir/Salmon River Falls reach. Furthermore, land uses within the watershed differ along a line roughly delineated by the Oswego Sandstone escarpment, at which the Salmon River Falls form. Agriculture and urban development are more prevalent west of the escarpment/falls, while more intact, primary and secondary forests exist east of and above the escarpment. Since there are natural differences in the biotic communities and prevailing land uses (and concomitant stresses to the biotic communities) above and below the Reservoir/Falls, the sub-watersheds within the drainage have been divided into "lower" and "upper" sub-watersheds (Table 1). Specifically, the "lower" sub-watersheds are Beaverdam Brook-Meadow Creek-Reservoir, Lower Salmon River-Main Stem, Orwell-Pekin and Trout Brook. The remaining eleven are the "upper" sub-watersheds. Several indicators presented in this and subsequent sections have received separate treatment for the upper and lower portions of the watershed.

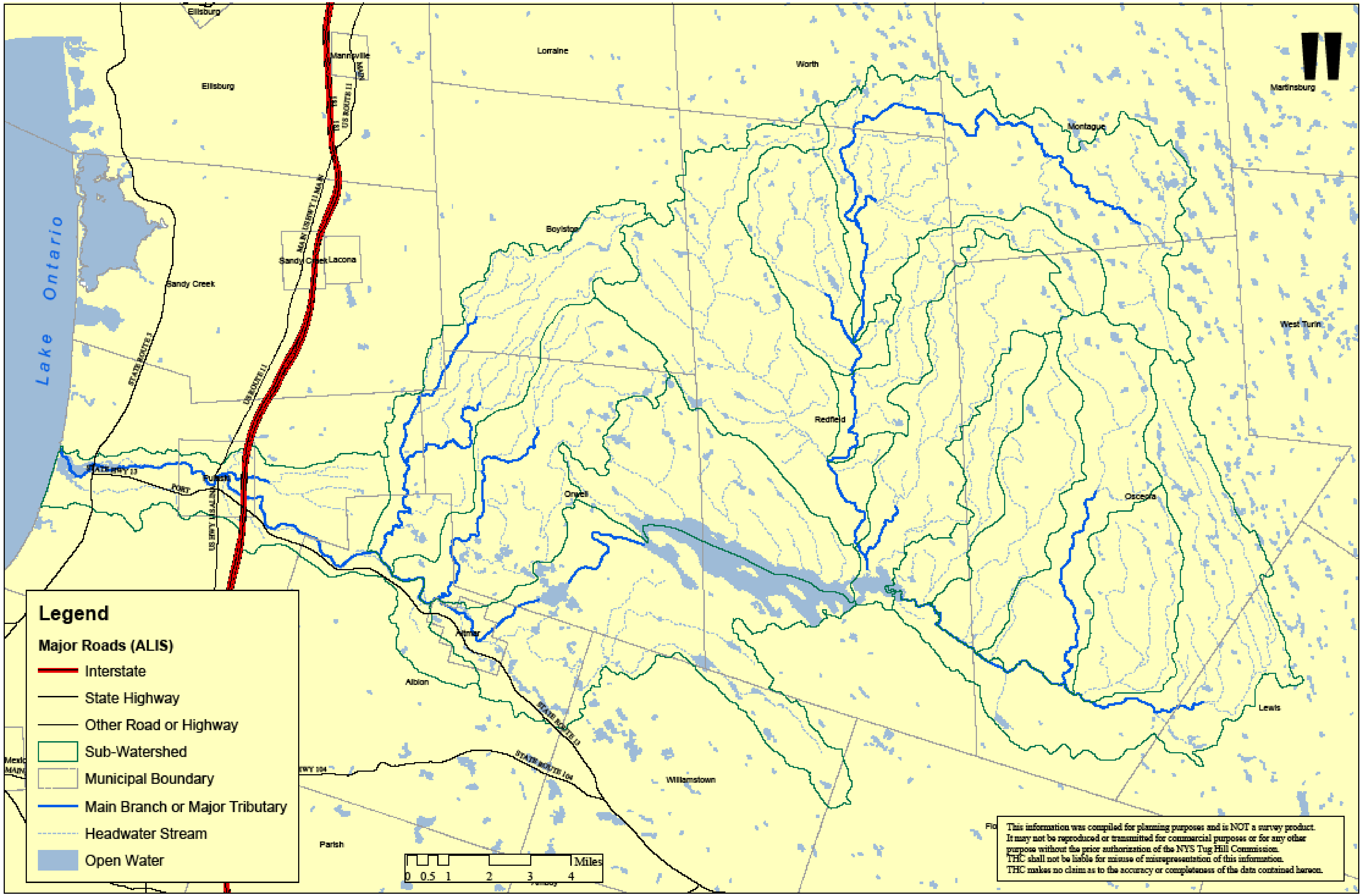


Figure 11. The Main Branch of the Salmon River and its major tributaries.

2.3.2. Main Branch / Major Tributaries Target Viability

2.3.2.1. KEA - AREA

The total area of in-stream habitat is a function of stream flow, and maintaining adequate baseflow during dry summer conditions provides greater within-channel habitat for aquatic organisms. As flow decreases, elevated areas of the channel will dry up, forcing fish and other aquatic organisms to move to remaining available submerged habitat.

The Tug Hill Aquifer (Figure 4) is a potentially important factor regulating summertime baseflow in the Trout Brook, Orwell-Pekin, and Lower Salmon River –Main Stem sub-watersheds. This aquifer is one of the largest and most productive groundwater reserves in New York. Although the aquifer is known to recharge cool, mineral enriched water to spring-fed headwaters and stream channels during baseflow periods in late summer (Miller et al. 1989), the extent to which it controls surface water flow and quality is not known. This water source is potentially very important to maintaining summertime flows in the Trout Brook and Orwell-Pekin sub-watersheds since the baseflows of these two largest tributaries in the lower watershed are not regulated by the Lighthouse Hill Reservoir.

Indicator – Volume Flow (cubic feet per second – cfs): Water flow in the lower reaches of the Salmon River is regulated by the Federal Energy Regulatory Commission (FERC) in accordance with the Salmon River Hydroelectric Project licensing agreement (FERC 1996). This license requires that continuous baseflow be maintained from the reservoirs under the following schedule:

January 1 – April 30	285 cfs
May 1 through August 31	185 cfs
September 1 through December 31	335 cfs.

<u>Current Condition - Good</u>: The flow schedule outlined in the FERC licensing agreement represents a compromise among several interests, and appears to provide adequate baseflow to maintain critical habitat in the Salmon River at different times of the year (Figure 12). The volumes were intended to maintain sufficient cover during dry summer months, provide necessary flow to sustain salmon spawning runs in the autumn and to cover and protect eggs during the winter. Under average historic flow levels, the Salmon River would experience summertime flows less <200 cfs approximately 50% of the time, and flows <25 cfs 40% of the time (Figure 9). With current regulation, summer flows do not drop below 185 cfs. The average baseflow in the regulated lower Salmon River is greater than in Sandy Creek, which can experience very low flow during the summer (Hallock 2003). No information is available to assess baseflow levels in the major tributaries of the lower watershed. It is believed that flow within streams of the upper subwatersheds do not vary from natural regimes.

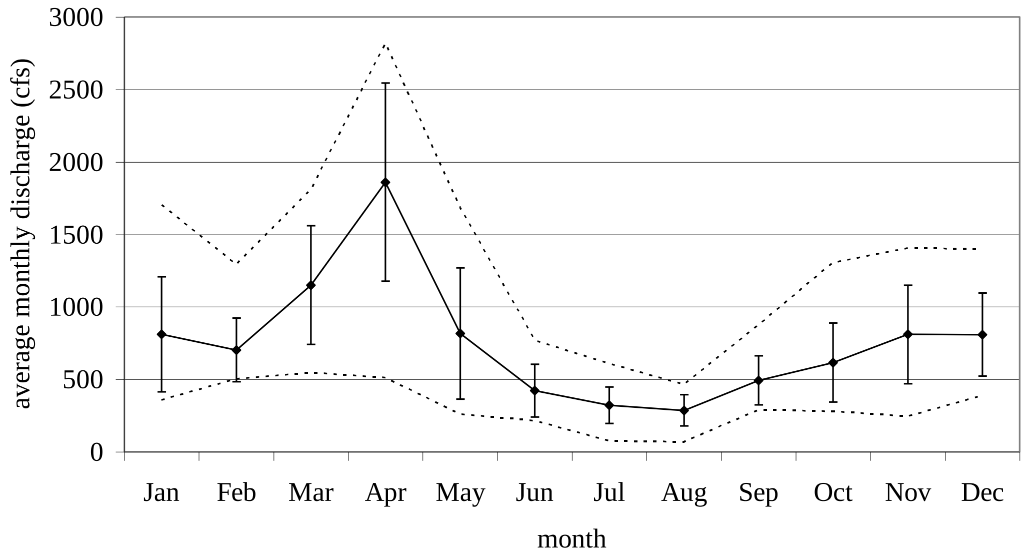


Figure 12. Average (1 std dev), maximum and minimum monthly discharges of the Salmon River at USGS Pineville station for the period December 1992 to September 2005. (Source: http://cfpub.epa.gov/surf/huc.cfm?huc_code=04140102.)

2.3.2.2 KEA: CONDITION - Water Quality

A number of indicators reflect the ecologically important physical and chemical conditions of the river. The river, along with its tributaries Trout Brook, Orwell Brook and Beaverdam Brook, and with the exception of the freshwater estuary, is classified by NYSDEC as Class C(t) -- a designation for fishing, recreational use, and fish propagation and survival (FERC 1996).

Indicator - Percent Natural Cover in 100-ft Wide Stream Reach Buffer: Vegetated buffers along waterways are important for maintaining several aspects of water quality and habitat viability. Vegetation sequesters nutrients; stabilizes soils, thereby reducing erosion; delivers organic material to be used as aquatic energy sources; and provides shade to moderate water temperatures. Available guidance suggests that 100-ft-wide vegetated buffers are typically effective at maintaining water quality and shading stream environments (Klapproth and Johnson 2000, Baird and Wetmore 2006).

Criteria used for ranking current condition of the watershed with regard to natural land cover-types within 100 ft-wide buffers are provided in Table 6.

Current Condition: Upper watershed, Good; Lower watershed, Fair: A stream buffer analysis was conducted by constructing 100-ft wide buffers along each edge of mapped stream segments (mapped at 1:100,000 scale) to calculate the percent unnatural cover (developed, roads, crops and hayfield, barren) occurring within the buffers. The analysis was conducted by stream reach (between mapped stream confluences) and presented by cover classes defined in Table 6. This analysis (Figure 13) reveals that the vast majority of stream reaches within the watershed are well-buffered by natural vegetation. No stream reaches in the watershed were ranked as "poor" with regard to natural vegetation in the 100-ft buffer. All streams within the upper sub-watersheds achieved "good" rankings (>90% natural cover). Four stream reaches, all occurring in the lower sub-watersheds (Beaver Dam Brook-Meadow Creek-Reservoir, Lower Salmon River-Main Stem, Trout Brook, Orwell-Pekin) were ranked as "fair" (75-90% natural cover).

Indicator – Embeddedness: Embeddedness describes the degree to which fine sediments surround coarse substrates in a streambed. This measurement has been used to assess fish spawning and macroinvertebrate habitat. Increased embeddedness is caused by excessive levels of siltation, and therefore it is often used as a measure of water quality. Embeddedness is a widely used substrate measurement, but its applicability is limited by the non-standardized methods applied to quantify it, and by the lack of published guidance for applying it (Sylte and Fischenich 2002).

No available guidance was obtained with which to rank this indicator. Few measurements have been made of this parameter within the watershed; these are provided for reference.

<u>Current Condition – Unranked:</u> Bode et al. (1997) reported 32 ± 11 (average ± 1 SD) embeddedness values for the main branch of the Salmon River above the freshwater estuary.

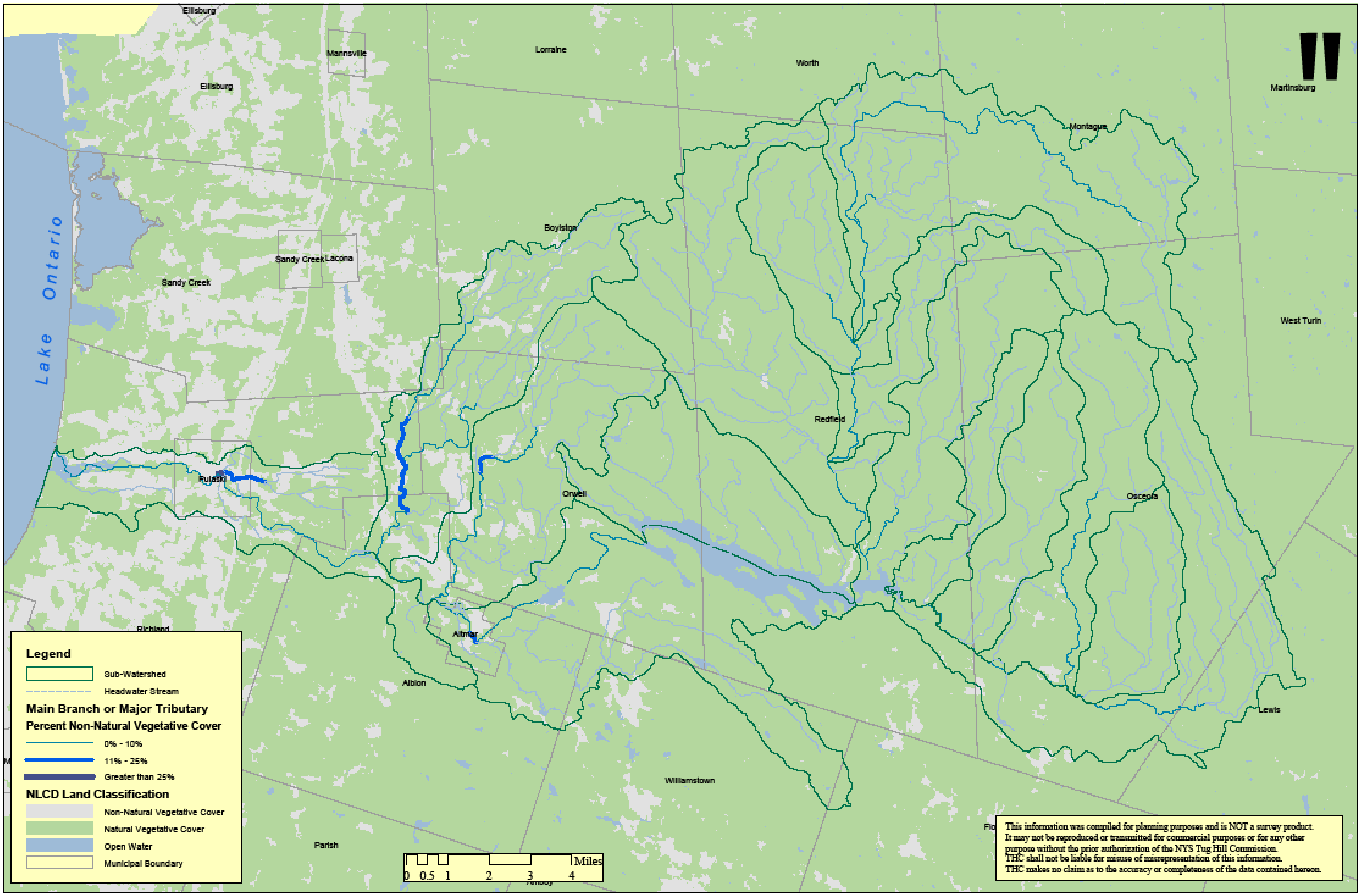


Figure 13. Analysis of land-cover types in 100-ft buffers of the Main Branch of Salmon River and its major tributaries. Data are from the National Land Cover Database (2001).

Indicator - Summertime High Temperatures: Temperature is an important regulator of partial pressure (solubility) of gases, particularly oxygen, in water. Colder water can hold higher concentrations of dissolved oxygen than warmer water. Maximum temperature thresholds, at which many aquatic organisms begin to experience adverse physiological effects, must account for both temperature and duration. Increased temperatures also are known to predispose fish to effects of various pathogens (A. Noyes, NYSDEC Pathologist, personal communication). Many salmonines are intolerant of temperatures greater than 70°F (21°C).

Due to lack of complete canopy cover, mid-reach streams such as the Salmon River and its major tributaries naturally experience diurnal fluctuations in temperature – warming by day and cooling by night – especially during the summer months. Temperature is influenced by a number of factors that act cumulatively at any particular location; these include:

- water flow and depth: the amount of water flowing over solid substrate reduces warming of that substrate;
- riparian cover: shade provided by overhanging trees and shrubs reduces warming;
- groundwater input: groundwater recharge through springs helps to maintain low temperatures of surface waters;
- discharge from impoundments: standing water in the reservoirs will heat up during the summer. Shallow water in lakes (epiplimnion) heats faster than deep water (hypolimnion). The depth from which water is discharged from impoundments, therefore influences downstream water temperature. Water released from the dams on the Salmon River is drawn from upper layers of the reservoirs, resulting in higher water temperatures below the dams than above them.

<u>Current Condition – Lower sub-watersheds, Good/Fair; Upper sub-watersheds, Good:</u> Several studies have reported temperatures at various locations within the Salmon River main stem and its major tributaries over a variety of time frames. These studies are summarized in Table 12.

Table 12. Summary of summertime water temperatures in the Salmon River watershed. Values (°F) are averages and maxima (in parentheses).

		------------------Location----------------			
Source	Sample period	Lower Salmon	E Branch Salmon	N Branch Salmon	Mad River
Hallock 2003	Summer 2000	68 (79)	59 (68)		
Bode et al. 1996	August 1996	70 (72)			
NYSDEC unpublished	Repeated July/ August samples			61(65)	67(75)
Everitt 2006	July 2005	68 (71)			

Summer temperatures are generally cooler in the upper reaches of the Salmon River compared to the lower Salmon River. In all years for which data were obtained, summertime temperatures in the lower Salmon River surpassed tolerance thresholds for salmonids (70 °F) for at least one day. No information is available to describe the duration of time for which temperatures surpass tolerance thresholds.

A GAP analysis was performed for this study (J. McKenna, unpublished data) to predict mid-summer water temperature within respective reaches of the watershed. This analysis (Figure 14) reveals that most of the higher-order stream reaches in the watershed are predicted to reach 70-73 °F, even in upper sub-watersheds. Lower order streams are predicted to be generally cooler in upper sub-watersheds, compared to lower sub-watersheds (particularly the Trout Brook and Orwell-Pekin sub-watersheds).

No data were obtained to assess the degree to which groundwater discharge moderates temperatures within the watershed.

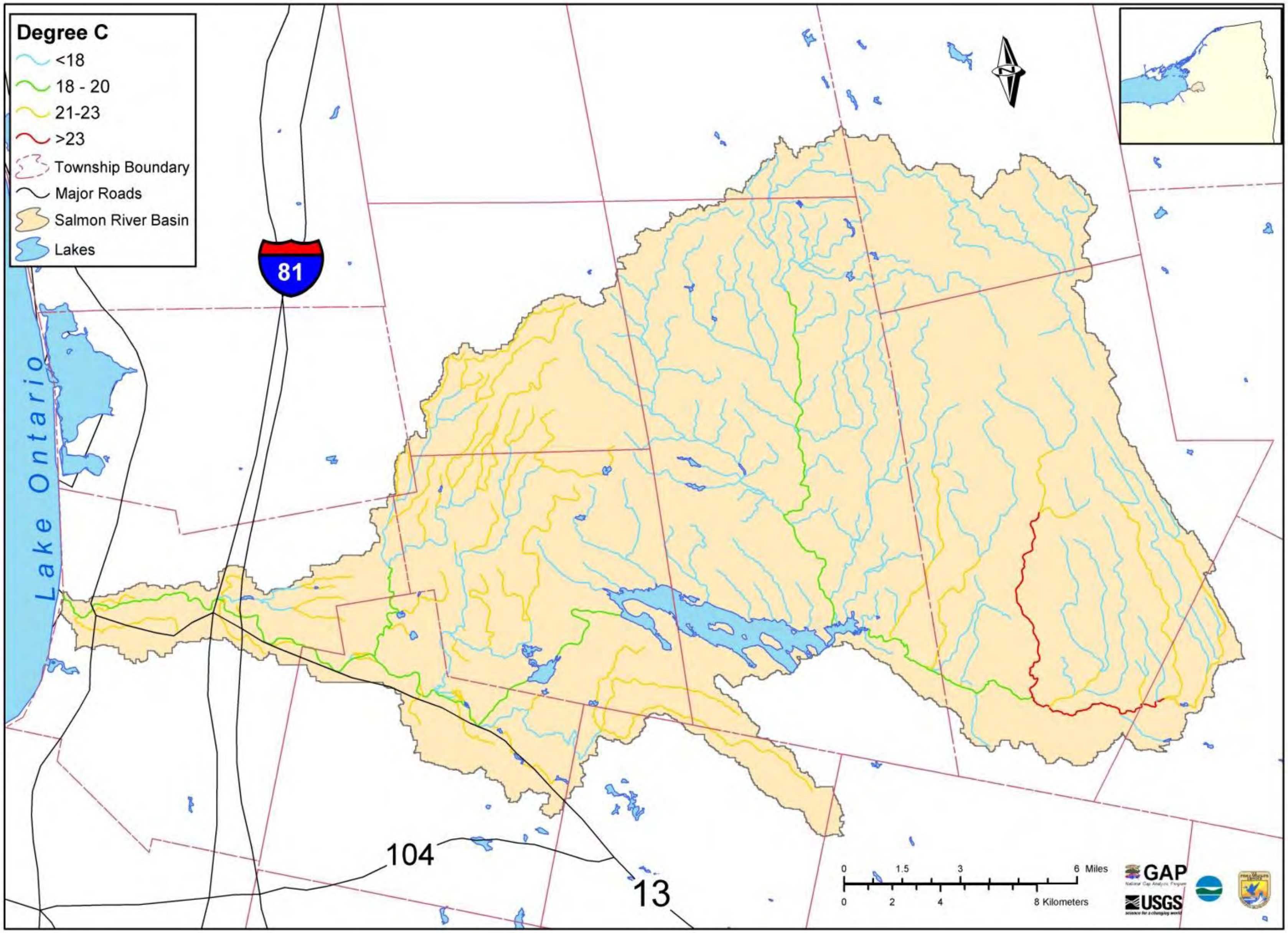


Figure 14. Predicted summer temperatures for the Salmon River watershed (J. McKenna, unpublished).

Indicator: pH: Acidity is a measure of hydrogen ion (H^+) concentration of a solution, and is frequently reported on the pH scale. The higher the concentration of H^+, the more "acidic" a solution is said to be (corresponding to low pH values). Hydrogen ions are chemically active and are readily exchanged from soils and sediments with other positively charged ions (cations) such as calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+), sodium (Na^+) and other naturally occurring metals. Acidified waters typically impact aquatic biota by increasing the solubility of aluminum (Al^{n+}) to toxic levels. Surface waters with pH <6.0 or having Al^{n+} concentrations > 2 μmol/L place aquatic biota at risk (Driscoll et al. 2001). In the absence of continuous monitoring, measuring pH and Al^{n+} during spring high flows and summer base flows provide information on the potential range of conditions. Acidification events are most likely during spring snowmelt when water has limited time to be buffered by soils and bedrock.

Table 13 presents viability rankings for surface water pH.

<u>Current Condition – Good:</u> Faigenbaum (1940) reported pH of the Salmon River at Pulaski in June 1939 was 8.6. Hallock (2003) provides the most comprehensive, seasonal reporting of pH in high order streams throughout the watershed. Springtime pH values ranged from 6-7 in 2000, while under summer baseflow conditions, pH values ranged from 7-8 (Figure 15). Summertime pH values reported by NYSDEC (unpublished) and Bode et al. (1997) are consistent with those of Hallock. Average pH of the river from 1989-1990 was 7.1 (Kozuchowski et al. 1994). NYSDEC Division of Water indicates no water bodies in the Salmon River drainage are impaired by acidification (NYSDEC 2006c).

Indicator – Total Alkalinity: Alkalinity refers to the ability of water to neutralize acids or resist changes in pH, and is a measure of the concentrations of three ions (carbonates (CO_3), bicarbonates (HCO_3), and hydroxides (OH)) expressed as mg/L $CaCO_3$.

Table 13 presents viability rankings for alkalinity, based upon susceptibility of waters of given alkalinity to further acidification.

<u>Current Condition - Good:</u> Hallock (2003) provides seasonal variation in total alkalinity for the high-order streams in the watershed. In early March, 2000, alkalinity measures were <60 mg/L for all sampled river segments (Figure 15). Alkalinity increased during summer baseflow periods that year. Orwell and Trout Brooks attained alkalinity values >100 mg/L. Summertime values of total alkalinity for the Mad River and N. Branch Salmon River were 67 and 61 mg/L (averaged over 1-3 years of sampling; source - R. Klindt), which are consistent with Hallock.

Table 13. Criteria for ranking surface water quality for total alkalinity (mg/L $CaCO_3$) and pH (Driscoll et al. 2001; Stoddard et al. 2003; Schreiber 2007). Indicator rankings for this assessment are indicated above the data columns. Summaries of critical pH thresholds for various aquatic organisms are provided in the second part of the table.

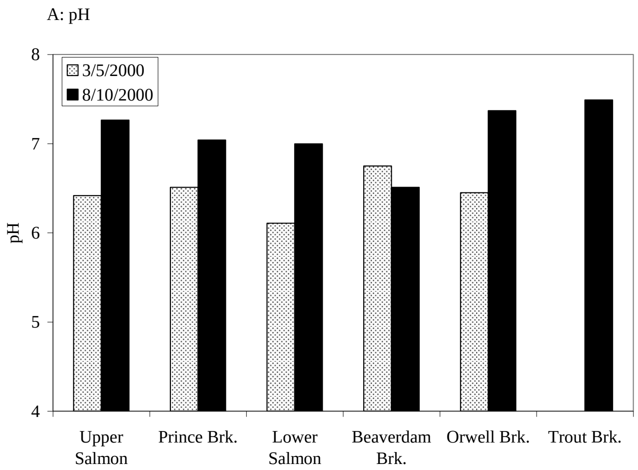
	Poor	Fair	Good	Excellent
Alkalinity	<0	0-2.5	2.5-100	>100
pH	<5	5.0-6.5	6.5-8.5	6.5-8.5
	Acidified	Sensitive	Not Sensitive	Well Buffered

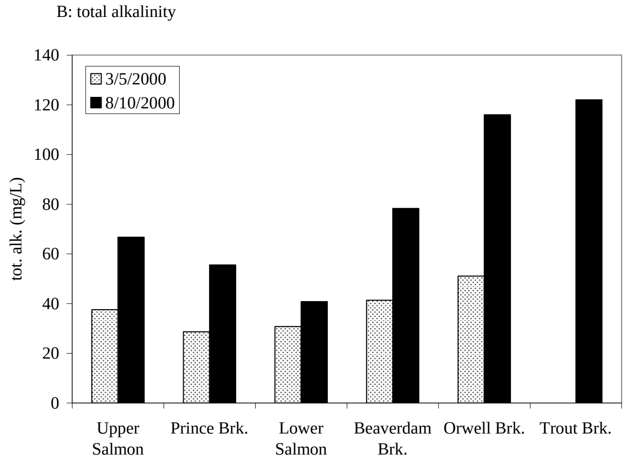
Critical minimum pH tolerance thresholds for some common aquatic organisms (USEPA 2007b; Driscoll et al. 2003a).

snails	6.0
stoneflies, mayflies, crayfish, minnows, dace	5.5
trout, walleye, bass, salamanders	5.0
perch	4.5
frogs	4.0

Indicator: Dissolved Oxygen (mg/L): Cold water fish such as trout and salmon generally require dissolved oxygen concentrations > 6 mg/L (Kozuchowski et al 1994).

Current Condition - Good: Hallock (2003) reported that dissolved oxygen concentrations in the Salmon River and its major tributaries never dropped below 8 mg/L during spring peak or summer baseflow periods in 2000 (Figure 15). Bode et al. (1997) reported dissolved oxygen concentrations ranging from 7.7-9.2 mg/L in August 1996. Kozuchowski et al. (1994) reported DO concentrations at River Mile 6 (County Rt. 2A) on the Salmon River ranged between 8 and 14 mg/L in 1989-1990, with the exception of one date (5/22/90) when DO dropped to 0 mg/L. That study suggested that DO levels at Pulaski appear to have improved since 1939 (7.7 mg/L, Faigenbaum 1940).





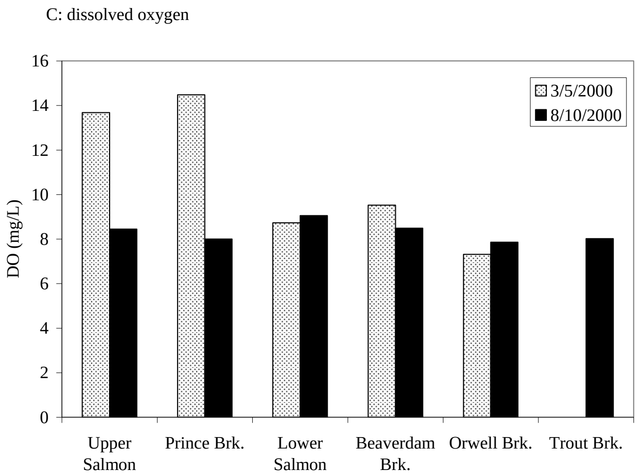


Figure 15. Water chemistry summaries for the Main Branch of the Salmon River and select major tributaries. Data are A- pH; B-Total Alkalinity; C-Dissolved Oxygen. Source: Hallock 2003.

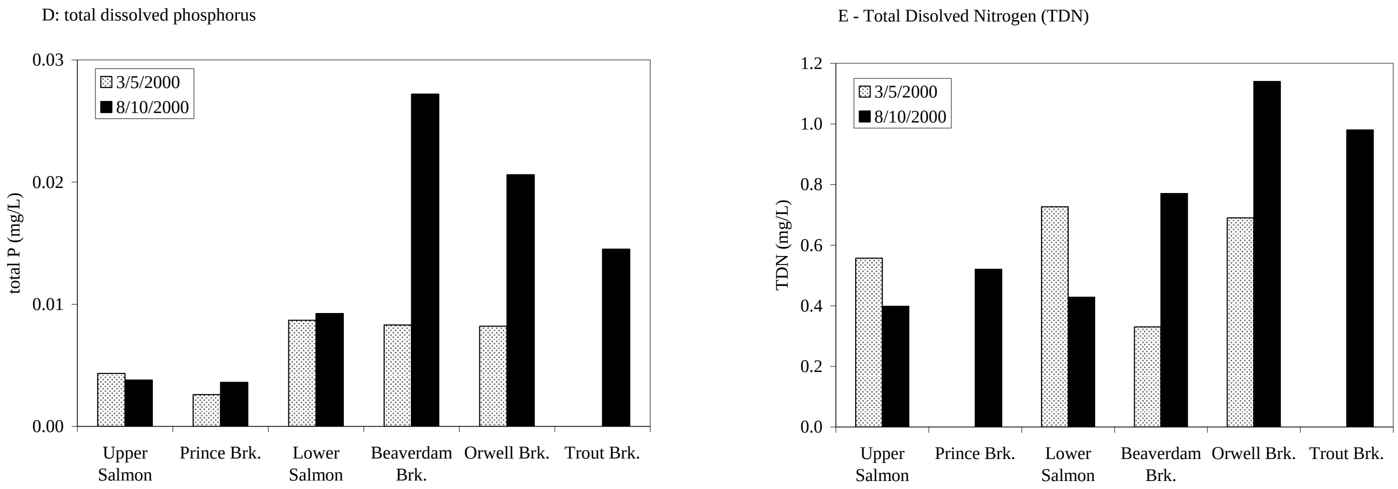


Figure 15, continued. D- Phosphorus; E-Total Dissolved Nitrogen

Indicator: Phosphorus Concentration: Phosphorus is a naturally occurring mineral nutrient that is frequently the single-most important limiting resource for biological productivity in freshwater systems. It naturally occurs in freshwaters in low concentrations (< 0.01 mg/L) owing to its low solubility. High P concentrations in water bodies are normally due to human activities (septic waste disposal, agricultural waste and fertilizer runoff), and typically result in high rates of productivity by algae and plants (eutrophication). The benthic (bottom) zones of eutrophic water bodies often become depleted in oxygen when large amounts of organic matter accumulate and undergo bacterial decomposition. Oxygen depletion, in turn, results in mortality of fish and other aquatic invertebrates.

No national standards have been set for phosphorus compounds in surface waters, but the USEPA has issued guidelines suggesting that to reduce eutrophication, total phosphates in streams not discharging directly to lakes or reservoirs should be less than 0.10 mg/L (Mueller and Helsel 1996).

<u>Current Condition – Upper sub-watersheds, Good; lower sub-watersheds, Fair:</u> Hallock (2003) reported seasonal variation in total dissolved phosphorus for the high-order streams in the watershed (Figure 15). Segments of the upper watershed and the Main Branch of the lower watershed consistently have low P concentrations (<0.01 mg/L). Summertime P concentrations in Orwell and Trout Brooks are elevated, but not above the USEPA guideline of 0.1 mg/L.

Indicator – Nitrogen Concentrations: Nitrogen (N) is a naturally-occurring, essential, nutrient, but it is naturally available in low supplies. Human activities such as the use of nitrogen fertilizers and burning of fossil fuels have increased the availability of N in terrestrial and aquatic systems. Nitrogen loads in excess of natural levels have been shown to alter aquatic and terrestrial plant communities and reduce biodiversity. When N exceeds biological demands of terrestrial organisms, it is usually leached from the soil in the soluble form of nitrate (NO_3^-) (Vitousek et al. 1997). In unpolluted forested landscapes, total dissolved N (TDN) in streams is usually less than 0.35 mg/L, while TDN may frequently reach 0.7-2.1 mg/L in streams draining agricultural landscapes. In extremely high concentrations (>10 mg/L), nitrogen, as NO_3^-, can have adverse human health effects (Driscoll et al. 2003).

<u>Current Condition - Fair</u>: Hallock (2003) provides seasonal variation in total dissolved nitrogen (TDN) for high-order streams in the watershed for 2000 (Figure 15). Stream water N concentrations in upper sub-watersheds and in the lower Main Branch of the Salmon River exhibit a seasonal effect for TDN (higher concentrations in spring) that probably reflects pollution inputs with the melting snowpack, and concentrations remain above the anticipated levels for unpolluted forest landscapes. The lower sub-watersheds (Beaverdam, Orwell-Pekin and Trout Brooks) exhibit higher TDN concentrations during summer baseflow than during spring snowmelt. Agriculture may be the source of N in these subwatersheds. Even still, N concentrations remain well below USEPA drinking water standards.

2.3.2.3 KEA – CONDITION – Macroinvertebrate Communities

Macroinvertebrates are important components of stream ecosystems. Many serve as primary consumers of plant (algal) and detrital biomass, and therefore serve as the lower links of aquatic food chains that eventually support predatory fish, birds and mammals. Macroinvertebrate communities can be used as monitors of water quality and overall ecosystem health. Some invertebrates are intolerant of water conditions having low oxygen concentration and high organic content – these indicators of good water quality include mayflies, stoneflies, caddisflies, and many water beetles. Other invertebrates are able to tolerate low oxygen concentrations, and/or feed on bacteria that grow on suspended organic matter (such as that associated with sewage and agricultural wastes). These indicators of poor water quality include various midges (fly larvae), bloodworms, aquatic earthworms, leeches, sowbugs, and some black fly larvae. Many species of mayflies, stoneflies and caddisflies are "shredders" that feed upon small particles of plant material suspended in the water column. Other species are filter feeders that consume single-celled algae. Large populations of such filter feeders can indicate eutrophic (excessive nutrient concentrations) conditions that support high levels of algal and plant production (Bode et al. 1997).

Indicators – Indices of Biotic Integrity: A combination of indices have been used in past efforts to assess biotic integrity and water quality of stream systems (e.g., Bode et al. 1997).

Richness is the total number of species (or discernible taxa) found in a sample. Richness is influenced by sample effort (the greater the sampling effort, the greater the likelihood of finding additional species) and therefore is typically standardized to number of species per 100-specimen collection. In New York, >26 species suggests non-impacted waters of excellent quality; 19-26, slightly impacted; 11-18, moderately impacted; and <11 species indicates severely impacted systems of poor water quality.

EPT Value is the percentage of individuals in a sample that are species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). These groups are considered indicators of high water quality. Expected ranges for streams in New York are: >10%, non-impacted; 6-10, slightly impacted; 2-5, moderately impacted; and <2, severely impacted.

Hilsenhoff Biotic Index measures overall tolerance of an invertebrate sample for organic pollution and low oxygen concentration. It is a weighted average that is found by multiplying the number of individuals of each species by that species' tolerance rating (following Bode et al., 1996 for New York), summing the products, and dividing by the total number of individuals in the sample. Tolerance values range from 0 (intolerant) to 10 (tolerant). Biotic index values of 0-4.50 indicate non-impacted, high-quality water; 4.51-6.50, slightly impacted; 6.51-8.50, moderately impacted; and 8.51-10.0, severely impacted.

Percent Model Affinity measures the similarity of a sample to a model, non-impacted community made up of 40% Ephemeroptera, 5% Plecoptera, 10% Trichoptera, 10% Coleoptera, 20% Chironomidae, 5% Oligochaeta and 10% others (Novak and Bode 1992). If a sample community is >65% similar to this model composition, it is considered non-impacted; 50-64% similar, slightly impacted; 35-49% similar, moderately impacted; and <35% similar, severely impacted.

Current Condition - Good: Bode et al. (1997) reported that macroinvertebrate communities at all sites along a 25-mile reach of the Salmon River from below Pulaski to above the Redfield Reservoir were diverse and well-balanced (Figure 16). Two sites, directly below the Lighthouse Hill Reservoir, showed evidence of nutrient enrichment and it was believed this was an effect of the reservoir. However, invertebrate communities still indicated excellent water quality. Hallock (2003) also detected an effect of the reservoirs on the abundance and diversity of some functional groups of aquatic invertebrates, and suggested that the dams are inhibiting the movement of organic debris required by shredding organisms; and that high and maintained summer discharges may be removing some types of invertebrates from the substrate and flushing them through the system.

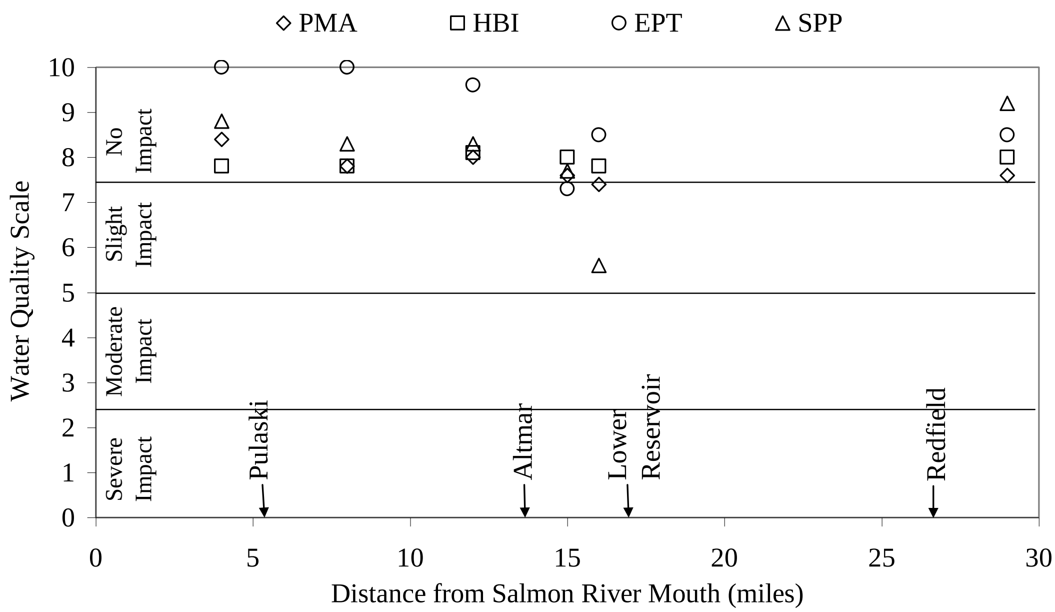


Figure 16. Profile of index values for Salmon River biotic assessment (Bode et al. 1997). Values for species richness (SPP), EPT richness (EPT), Hilsenhoff Biotic Index (HBI), and percent model affinity (PMA) have been normalized to a 0-10 scale.

2.3.2.4 KEA: CONDITION – Fish Communities

Historic Context

The Salmon River was purportedly among the most productive native salmon-producing tributaries to Lake Ontario prior to the late 19th century, but abuses occurring in both the lake and within the watershed greatly altered the fishery resource of the river prior to the 1900s. Lake Ontario originally supported two top predatory fish species; the Atlantic salmon (*Salmo salar*) and the lake trout (*Salvelinus namaycush*). A number of factors led to the collapse of these species' populations, including over-fishing, loss or alteration of spawning habitat within the tributaries (for migratory Atlantic salmon), and inhibition of spawning migrations by dam construction. For instance, on the Salmon River, the fishery showed a record of decline between 1810 and 1900, and especially following the 1837 construction of a dam just west of Pulaski (New York Conservation Department 1939). Another factor causing the decline of Atlantic salmon was the introduction of alewife (*Alosa pseudoharengus*) to Lake Ontario. Alewives are rich in the enzyme thiaminase, which breaks down thiamine; when Atlantic salmon feed on this species they experience thiamine deficiencies, which result in reproductive failure of developing embryos. The eventual loss of predatory fish in the Great Lakes led to an overpopulation of alewives and rainbow smelt (*Osmerus mordax*), and in order to reestablish predatory control in Lake Ontario, Pacific salmon (Chinook, *Oncorhynchus tshawytscha*; coho salmon, *Oncorhynchus kisutch*) were stocked in the late 1960s and early 1970s (see Coughlin 2004 and Everitt 2006 for reviews).

The Pacific salmonines have shown excellent growth and reproductive capacity in some tributaries of the Great Lakes, including the Salmon River. By the early 1980s, natural reproduction of Pacific salmonines was documented in the Salmon River system (Johnson 1978; Johnson and Ringler 1981), and within a decade this system was estimated to be the leading Lake Ontario tributary for naturally spawned salmon (Wildridge 1990).

Excellent juvenile habitat and barrier-free spawning routes within the Salmon River watershed would permit reintroduction of Atlantic salmon. Based on a recent analysis using introduced rainbow trout (*Oncorhynchus mykiss*), which has similar habitat requirements as Atlantic salmon, as a surrogate, abundant spawning and juvenile habitat exist for Atlantic Salmon within the watershed (McKenna and Johnson 2005). Furthermore, some experimental evidence indicates that Atlantic salmon are more competitive than rainbow trout under slightly warmer water temperatures (>20 °C), while rainbow trout are more competitive in slightly colder waters. Therefore, potential may exist for co-occurrence of these species within the watershed (Coughlin 2004). However, the continued presence of alewife within the Great Lakes system would likely continue to limit the ability of Atlantic salmon to establish a self-sustaining population.

Although NYSDEC frequently samples river sections within the watershed to obtain data on target game species, widespread sampling that yields accurate and complete descriptions of the watershed's fish assemblages (richness, abundance, spatial distributions) is lacking. Recently efforts have been made to predict habitat condition, along with accompanying fish community composition (McKenna et al. 2006) within the Great Lakes and their major tributaries. This methodology was tested on the Genesee River drainage (McKenna et al. 2006) and analyses were recently applied to the Salmon River for the purpose of this viability analysis (McKenna, unpublished data). The results of these analyses are presented below for illustration purposes. No guidance other than professional opinions of fisheries managers is currently available to interpret these results.

Indicator – Species Richness:

Current Condition – Unranked: Local fisheries managers and research scientists believe that species richness within the watershed is very good. However, no guidance is available with which to objectively rank this indicator for the watershed. Available data from several recent sampling efforts have been compiled in Table 14. Most of these samples are not exhaustive for determining species richness, and different methods were applied to different tributaries. Therefore, data are not readily comparable among the reaches described. These data are provided for baseline information. Forty-two species have been sampled from the lower reaches of the Salmon River. Available data account for only 8 and 12 species in Orwell and Trout Brooks, respectively. In the upper portions of the watershed, 20, 17 and 13 species have been sampled from the Mad River system, North Branch of the Salmon River, and upper Salmon River, respectively.

Modeled estimates of species richness are presented in Figure 17. This analysis predicts greatest species richness (>78 species in some reaches) in the lowest reaches of the Main Branch, with generally decreasing trends in richness toward the headwaters of the various sub-watersheds.

Table 14. Fish community data for the Salmon River and its major tributaries. Data are species' relative densities (percents of total sample catch) for respective river reaches. Methodology varied by reach (see notes) so data may not be directly comparable among reaches.

	Orwell Brook[1]	Trout Brook[1]	Lower Salmon River[3A]	Lower Salmon River[4B]	Lower Salmon River[6C]			N.Br. Mad River[2]	Mad River[2]	N.Br. Salmon River[2]	Upper Salmon River[5]	Upper Salmon River[2]
Sample date	9/97	9/97	6/93 10/93 11/93 9/96	7/90 8/99	spring	summer	autumn	8/99	7/97 8/93	7/92	6/95	7/95
Total fish in samples	794	661	1208	908	75	49	77	295	728	2845	76	406
bass, largemouth	0	0	0.83	0	0.26	0.80	0	0	0	0	0	0.25
bass, rock	0	0	4.97	2.97	1.02	0	1.29	0	0	0.56	0	1.23
bass, smallmouth	0.13	0.15	3.39	2.75	0.75	0	0.65	0	0	0	0	0
Bluegill	0	0	0	0	0.46	0	0.65	0	0	0	0	0
bullhead, brown	0	0	0	0.33	1.33	0	4.18	0	0	0.60	0	0
carp, common	0	0	0.58	0	0	0	0	0	0	0	0	0
chubsucker, creek	0	0	0	0	0.54	0	1.73	0	0	0	0	0
chubsucker sp.	0	0	0	0	0	0	0.42	0	0	0	0	0
chub, creek	0	0	0	0.55	0	0	0	13.90	10.30	13.60	2.63	0.49
dace, eastern blacknose	37.78	26.48	0	0.77	0.04	0	0	27.12	61.81	46.57	7.89	29.56
dace, longnose	0	1.06	0	8.59	0	0	0	5.08	5.49	2.39	5.26	13.55
dace, redside	0	0	0	0	0	0	0	20.34	6.87	0.53	0	0
darter, fantail	12.59	26.48	0	44.38	4.51	0	0	0	1.37	6.15	7.89	19.70
darter, rainbow	0	0	0	0	0	0	0	0	0	7.03	0	0
darter, tessellated	0	0	6.21	0.11	3.74	25.19	3.98	0	0	0.42	0	0
Fallfish	0	1.51	3.06	6.17	31.59	10.00	5.46	0	0	0	0	0
minnow sp.	0	0	0	0	0	0	1.82	0	0	0	0	0
minnow, bluntnose	0	0	41.39	2.20	3.62	0.80	10.52	0	0	0	0	0.49
minnow, cutlip	0	7.56	0.83	19.49	3.84	0	0.42	2.71	2.20	11.25	0	0
minnow, fathead	0	0	0	0	0	0	6.45	0	0	0	0	0

Table 14, continued

	Orwell Brook[1]	Trout Brook[1]	Lower Salmon River[3A]	Lower Salmon River[4B]	Lower Salmon River[6C] spring	summer	autumn	N.Br. Mad River[2]	Mad River[2]	N.Br. Salmon River[2]	Upper Salmon River[5]	Upper Salmon River[2]
mudminnow, central	0	0	0	0	0.38	0	5.77	0	0	0	0	0
perch, log	0	0	0	0.22	0	0	0.29	0	0	0	0	0
perch, yellow	0	0	9.52	0	0.42	0	7.33	0	0	0	0	0
pickerel, chain	0	0	0	0	2.25	0	2.20	0	0	0	0	0
pike, northern	0	0	2.32	0	0	0	0	0	0	0	0	0
pumpkinseed	0	0	0.83	0.22	2.81	0	0.60	1.02	0	0.14	0	0
redhorse, silver	0	0	5.38	0	0	0	0	0	0	0	0	0
salmon, Atlantic	0	0.30	0	1.65	0	0	0	0	0	0	0	0
salmon, chinook	0.13	6.05	0.25	3.52	0	22.76	7.94	0	0	0	0	0
salmon, coho	0.25	0.30	0.33	0.44	0	0	0.96	0	0	0	0	0
sculpin, mottled	0	0	0	0	0	0	0	0	0.14	0	0	30.79
sculpin, slimy	0	0	0	0	0	0	0	0	0	0.91	7.89	0
shiner, bridle	0	0	0	0	0	0	0	0	0	0.35	0	0
shiner, blacknose	0	0	0	0	0	0	0	8.47	0	0	0	0
shiner, common	0	0.91	0	0.77	18.62	26.38	13.41	20.34	4.12	6.75	0	0
shiner, golden	0	0	2.07	0	1.65	0	22.11	0	0	0	0	0
shiner, spottail	0	0	0	0	0	0	0	0	3.43	0	0	0
shiner, notropis sp.	0	0	0	0	0	1.60	0	0	0	0	0	0
stickleback, brook	0	0	0	0.11	0	0	0	0	0	0	0	0
Stonecat	0	0	0	0.55	0	0	0	0	0	0	0	0
Stoneroller, central	0	0	0	0.11	0	0	0	0	0	0	0	0
sucker, northern hog	0	0	0	2.53	0	0	0	0	0	0	0	0
sucker, hognose	0	0	2.15	0	1.02	11.67	0	0	0	0	0	0
sucker, white	0	0	4.14	0.66	4.40	0.80	1.41	0	0	1.97	0	2.46
sucker sp	0	0	0	0	0	0	0.42	0	0	0	0	0
sunfish	0	0	0	0	9.62	0	0	0	0	0	0	0
trout, brook	0.13	0	0	0	7.14	0	0	1.02	4.26	0.67	68.42	0

Table 14, continued

	Orwell Brook[1]	Trout Brook[1]	Lower Salmon River[3A]	Lower Salmon River[4B]	Lower Salmon River[6C] spring	Lower Salmon River[6C] summer	Lower Salmon River[6C] autumn	N.Br. Mad River[2]	Mad River[2]	N.Br. Salmon River[2]	Upper Salmon River[5]	Upper Salmon River[2]
trout, brown	0.50	0.76	1.41	0	0	0	0	0	0	0.11	0	0.49
trout, lake	0	0	0.41	0	0	0	0	0	0	0	0	0
trout, rainbow	48.49	28.44	9.93	0.88	0	0	0	0	0	0	0	0.99

Sample Methods: 1-NYDEC, Population estimate; 2-NYDEC, CROTS survey; 3-NYDEC, STMP collection; 4-NYDEC, other; 5-NYDEC, General Biological & CROTS; 6- J. McKenna sampled in repeated years over three seasons using a combination of large(1.5") and small seines (1/8").

Lower River Sample Reaches: A-immediately above Salmon River estuary; B above estuary to Lower Reservoir; C above estuary to Pineville

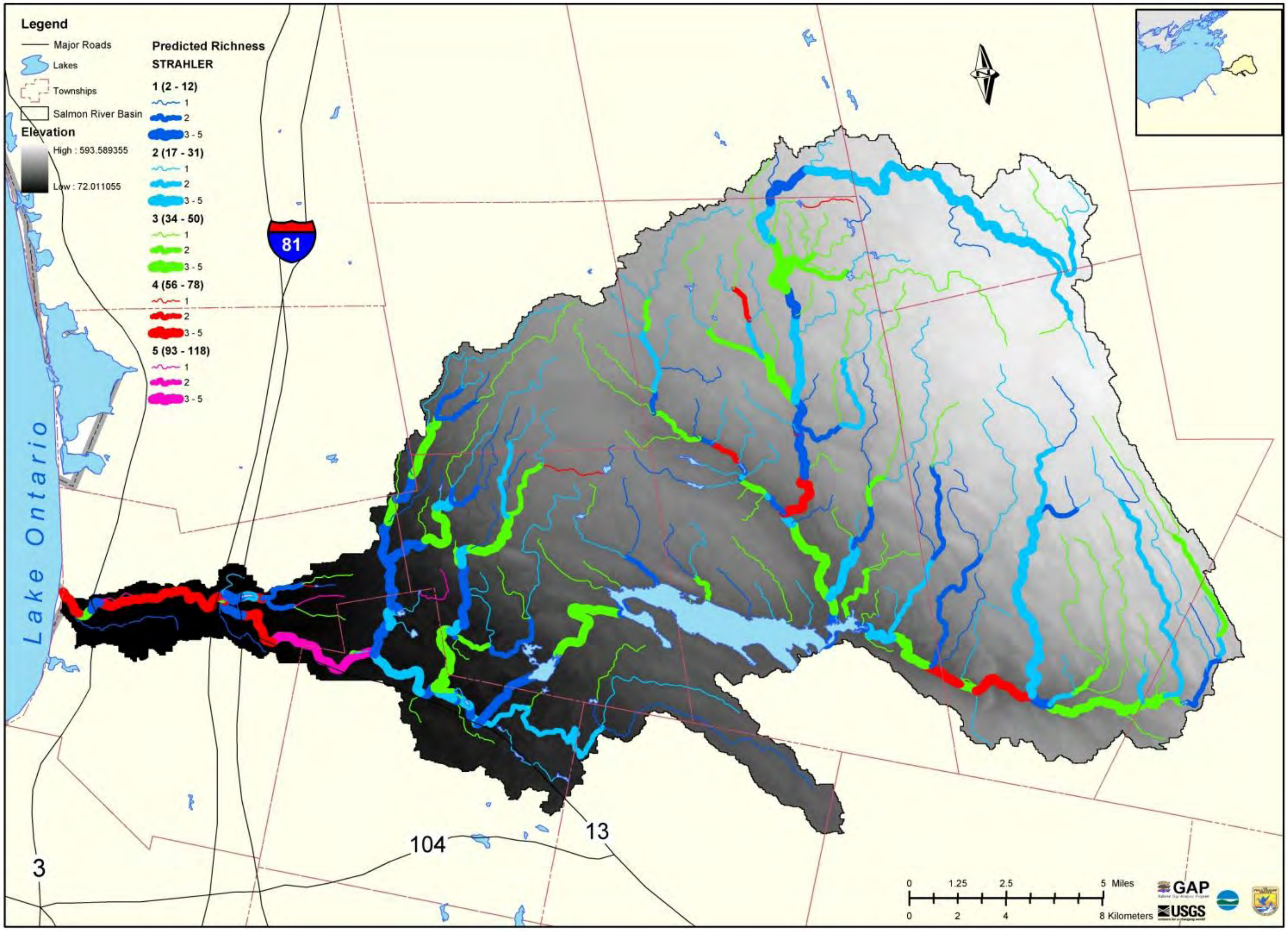


Figure 17. Predicted fish species richness in the Salmon River Watershed. Stream reaches are plotted by Strahler order: 1st and 2nd order streams are headwater streams (thin lines); 3rd-5th order streams are the Main Branch and major tributaries (thick lines). Richness (#species) categories are indicated by color (Source: J. McKenna).

Indicator – Fish Species Distributions:

<u>Current Condition – Common Species – white sucker and blacknose dace:</u> Several common species such as white suckers (*Catostomus commersonii*) and blacknose dace (*Rhinichthys atratulus*) are widely distributed across the watershed (Figures 18 and 19).

<u>Current Condition – Uncommon Species – fantail darter and mottled sculpin:</u> Cutlip minnow (*Exoglossum maxillingua*) and mottled sculpins (*Cottus bairdi*) are widely distributed, but occur in low densities across the watershed (Figure 20).

<u>Current Condition – Exotic Species – common carp:</u> Common carp (*Cyprinus carpio*) are native to Asia and their escape in North America has led to degradation of several water bodies. Carp have been observed in the lower watershed, and this GAP analysis reveals that suitable habitat exists throughout the watershed, although this model predicts densities would remain low if they are introduced or eventually migrate throughout the watershed (Figure 21).

<u>Current Condition – Game Species – brown and brook trout:</u> Brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) are two common game species that are both stocked and naturally reproducing within the watershed. Brown trout are an introduced species that have been widely stocked in North America, and which have similar habitat requirements as the native brook trout. However, brown trout can tolerate warmer temperatures and are therefore capable of inhabiting larger streams. In the presence of brown trout, brook trout tend to retreat to colder, headwater streams. The GAP analysis shows they are both common throughout the watershed, and that brown trout are generally predicted to occur in greater numbers, especially in the lower sub-watersheds (Figure 22).

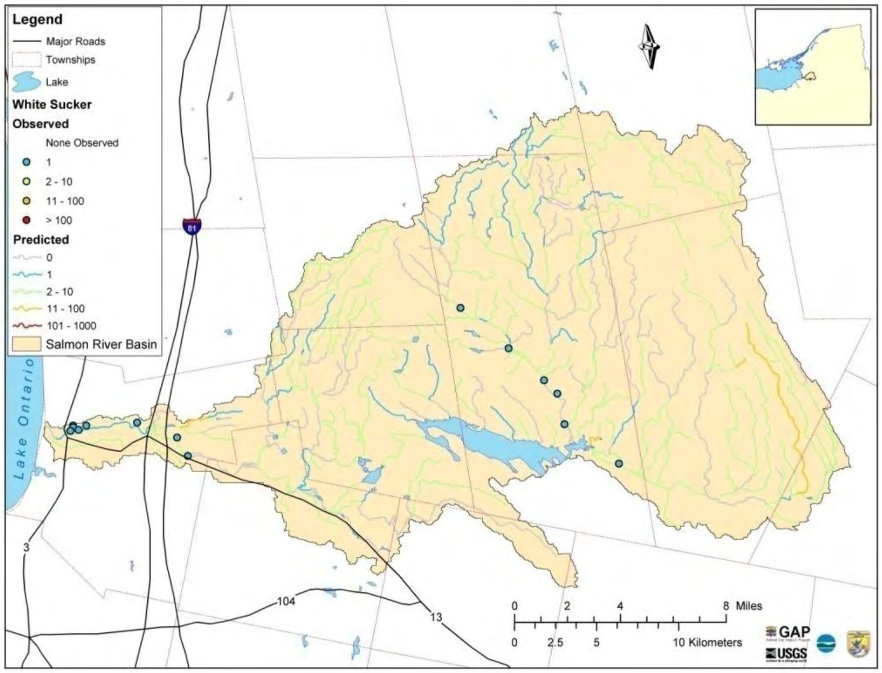


Figure 18. Observed and predicted distribution of white suckers, a common species in the Salmon River watershed.

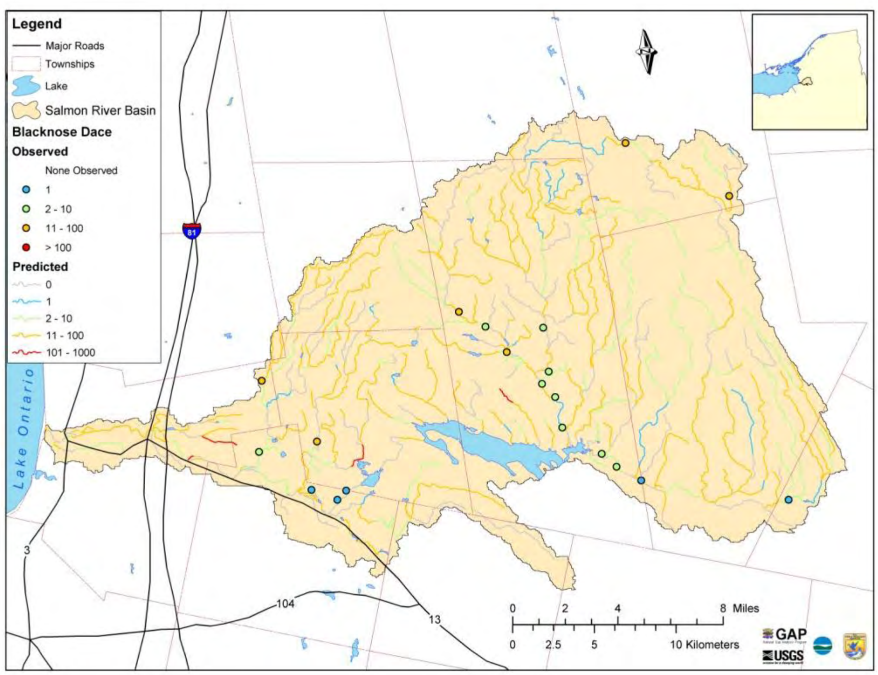


Figure 19. Observed and predicted distribution of blacknose dace, a common species in the Salmon River watershed.

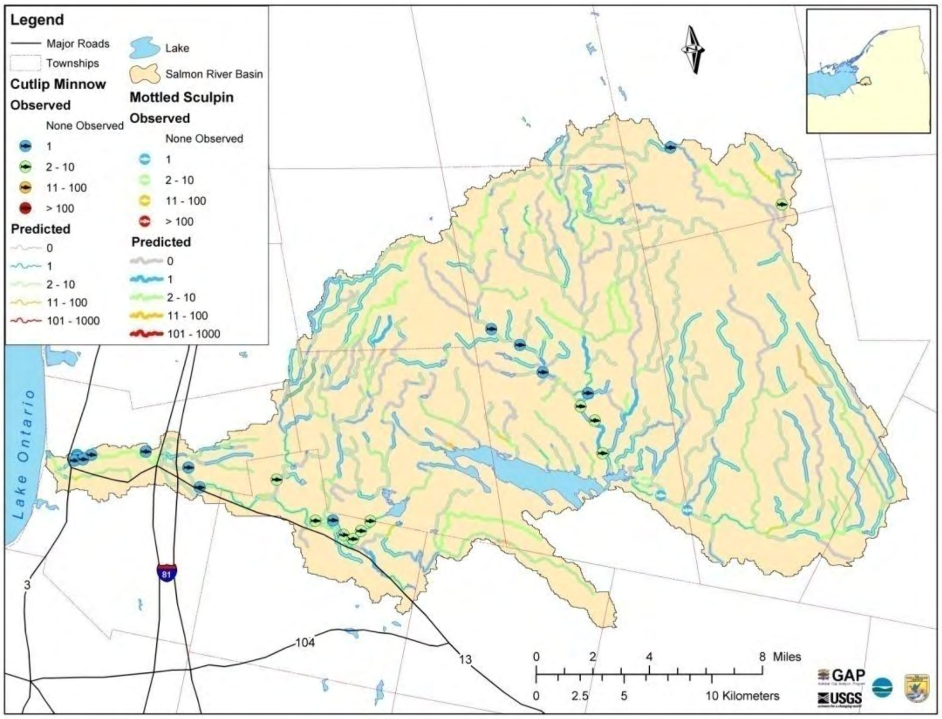


Figure 20. Observed and predicted distribution of cutlip minnow and mottled sculpin, two uncommon species in the Salmon River watershed.

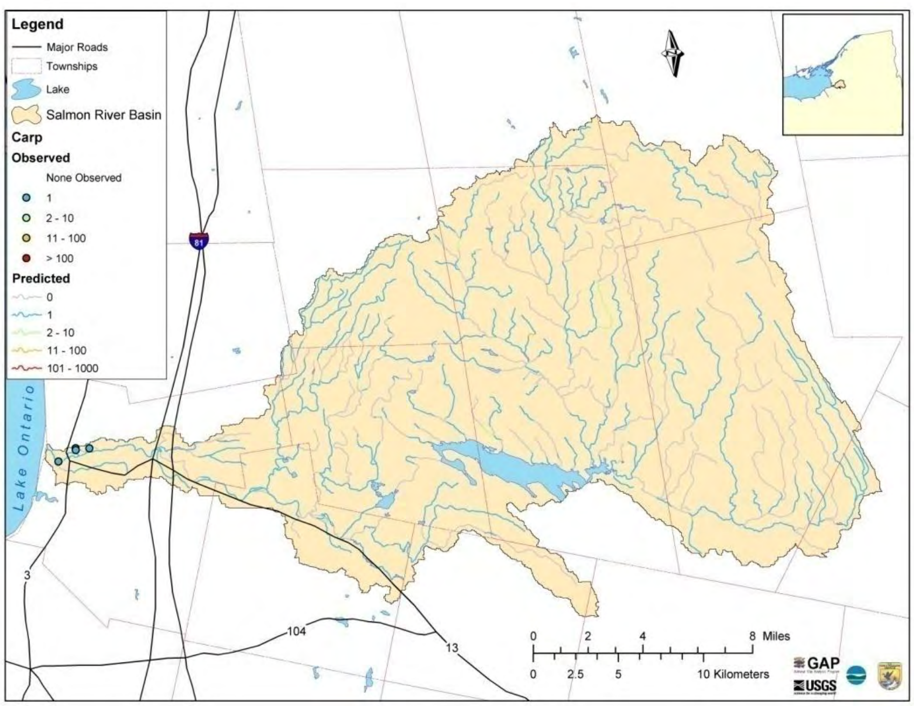


Figure 21. Observed and predicted distribution of common carp, an exotic species that occurs within the Salmon River watershed.

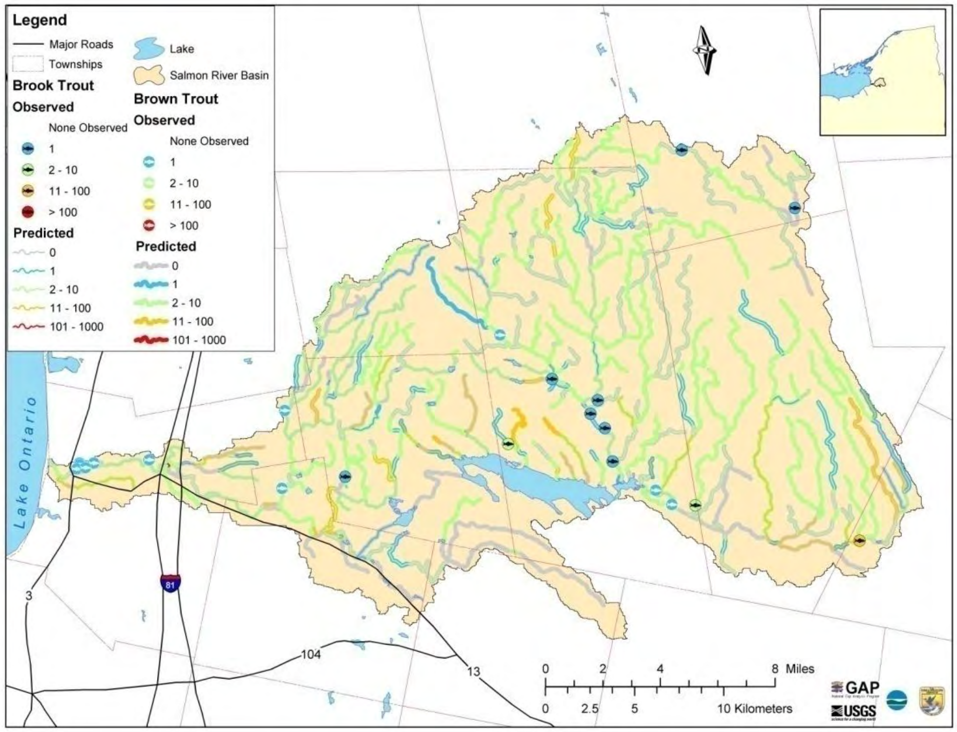


Figure 22. Observed and predicted distribution of brown trout and brook trout, two common game species of the Salmon River watershed.

Indicators of Natural Salmonine Reproduction: The level of natural salmonine production within the watershed is an integrative indicator of the number of returning adults from Lake Ontario that are available to reproduce, spawning habitat availability, and juvenile habitat and food availability. Information available for ranking these indicators in the watershed exists only for certain life history segments of Chinook salmon and rainbow trout.

Indicator – Salmonine Spawning Habitat (Proportion of Available Area): The capacity for the watershed (below the Lighthouse Hill dam) to sustain self-reproducing populations of salmonines is related, in part, to available spawning habitat along the stream beds during spawning. Chinook salmon have specific requirements for substrate size in which to create redds (nests), as well as for water depth and velocity during spawning.

<u>Current Condition - Good</u>: Everitt (2006) estimated approximately 1,900 and 2,900 redds within the lower Salmon River in 2004 and 2005. Of the total river area available (199 hectares), 15% had suitable combinations of spawning substrate, water depth and water velocity.

Indicator – Adult Escapement and Egg Production Estimate (#/yr): Adults contributing to the naturally reproducing population are those that able to survive spawning runs, and escape anglers and hatchery harvest operations.

<u>Current Condition - Good</u>: Everitt (2006) estimated the returning populations Chinook salmon into the Salmon River during 2004 and 2005 to be 48,300 and 61,900. Of these, approximately 24,400 (± 2,800, 95% CI) and 26,000 (± 3,900) were harvested by anglers in 2004 and 2005; and 10,100 and 8,100 were harvested at the hatchery in 2004 and 2005. Accounting for natural mortality during the run, an estimated 5,900 (± 2,900, 95% CI) and 11,100 (± 2,600) adults escaped the 2004 and 2005 runs and were available for natural spawning. Average egg production was approximately 5,300 and 5,000 eggs/individual female in 2004 and 2005. The total estimated number of eggs deposited by females was approximately 14.6 million (±7.1 million) in 2004 and 41.4 million (± 9.8 million) in 2005. Assuming that if only 1% of the fertilized eggs successfully yield a smolt that returns to the lake (414,000 in 2005 and 146,000 in 2004), this level of natural reproduction is comparable to that of the hatchery (~300,000).

Indicator – Salmonine Juvenile Recruitment: Estimations of juvenile recruitment have been made only for rainbow trout.

<u>Current Condition – Good:</u> Rainbow trout utilize mid-reach stream sections of the Orwell and Trout Brook systems for spawning. A recent study of natural reproduction in these streams, along with Sandy Creek, estimated 2,000-4,000 "year 0" rainbow trout per kilometer of stream, and 450-900 "yr 1+" per kilometer of stream (McKenna and Johnson 2005). Wildridge (1990) classified Orwell Brook, Trout Brook and Little Sandy Creek as the only excellent salmonine producing

streams in the Lake Ontario basin (31 total). Another study reported wide annual variation in relative abundance of naturally reproducing Chinook and coho salmon within Orwell and Trout Brooks, and Little Sandy Creek (Kennen et al. 1994).

2.3.2.5 KEA – CONDITION – Toxins

A number of environmental pollutants and toxins are capable of impairing ecological integrity of freshwaters. Toxins of current concern within the Salmon River watershed are mercury, PCBs and Mirex.

Indicator – Game Fish Tissue Mercury Concentration: Section 2.2.2.8 presents background on toxic effects, sources of contamination and viability ranking criteria for mercury.

Current Condition – Lower sub-watersheds - Fair: Elevated mercury levels are known to occur in fish in the lower Salmon River, but currently there are no fish consumption advisories for mercury in fish taken from the lower Salmon River (NYSDOH 2006).

Current Condition – Upper sub-watersheds – Unranked: In 2006 the NYSDEC listed the Salmon River Reservoir as a Section 303(d) Impaired Water due to mercury contamination in some fish (NYSDOH 2006). It is likely that the mercury source for the reservoir is internal loading from sediments due to water fluctuations. Therefore conditions within the reservoir should not be extrapolated beyond the reservoir. No other information exists with which to rank this indicator for upper sub-watersheds.

Indicator – Game Fish Tissue PCB Concentration: Section 2.2.2.8 presents background on toxic effects, sources of contamination and viability ranking criteria for PCBs in the watershed.

Current Condition – Lower sub-watersheds - Poor: There is currently an NYSDOH fish consumption advisory for PCBs in smallmouth bass taken from the Salmon River from the mouth to the Reservoir (NYSDOH 2006).

Current Condition – Upper sub-watersheds – Unranked: There are currently no fish consumption advisories for sport fish above the Redfield Reservoir, but no data are available that provide an actual indication of contaminant concentrations in fish inhabiting these waters.

Indicator - Indicator – Mink Jaw Lesions: Section 2.2.2.8 presents background on ranking criteria for PCBs based upon occurrence of cancerous lesions in mink jaws.

Current Condition – Lower sub-watersheds – Poor: There are no data available reporting the occurrence of cancerous lesions in mink for the Salmon River watershed. However, based upon the work of Beckett and Haynes (2007) in the Rochester Embayment, mink feeding within the Lake Ontario system appear to be exposed to sufficiently high PCB concentrations to induce growth of lesions in jaw tissue and this exposure is apparently from food sources exposed to contaminated water in Lake Ontario.

<u>Current Condition – Upper sub-watersheds – Unranked:</u> No data are available that suggest exposure of mink to PCB concentrations sufficiently high to cause cancerous lesions in waterways where prey species are isolated from Lake Ontario.

Indicator – Game Fish Tissue Mirex Concentration: Section 2.2.2.8 presents background on toxic effects, sources of contamination and viability ranking criteria for Mirex in the watershed.

<u>Current Condition – Lower subwatersheds - Poor</u>: There is currently a NYSDOH fish consumption advisory for Mirex in smallmouth bass taken from the Salmon River from the mouth to the Reservoir (NYSDOH 2006). Although no guidance exists for ranking Mirex concentrations in forage fish, samples of longnose dace, cutlip minnow and fantail darter in the lower Salmon River averaged 0.008, 0.014 and 0.019 ppm wet weight, respectively in 1988 (L. Skinner, NYSDEC, unpublished data).

<u>Current Condition – Upper subwatersheds – Good:</u> Mirex concentrations were below detection limits in forage fish above the Redfield Reservoir in 1988 (L. Skinner, NYSDEC, unpublished data).

Indicator – Permitted Point Source Discharges: There are currently four facilities with National Pollution Discharge Elimination System (NPDES) water discharge or USEPA Toxic Release Inventory (TRI) discharge permits in the watershed (Figure 23). Information on permits and release reporting for these facilities can be obtained from the USEPA website http://cfpub.epa.gov/surf/huc.cfm?huc_code=04140102. Indicator rankings are based here on available information regarding permit compliance histories.

	Good	Fair	Poor
Number of violations w/in last 5 years	0	1	>1

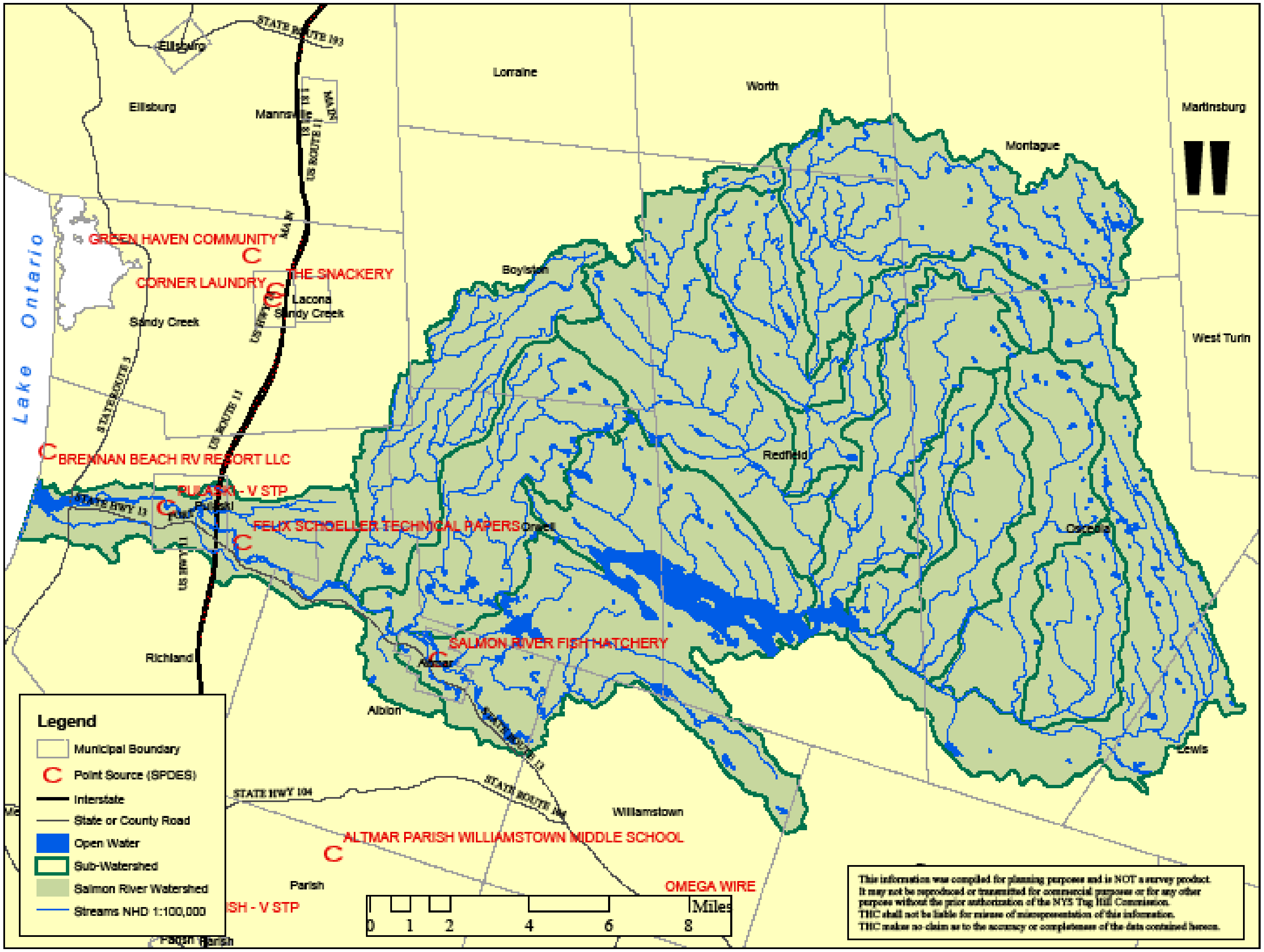


Figure 23. Location of facilities with National Pollution Discharge Elimination System (NPDES) or USEPA Toxic Release Inventory (TRI) discharge permits in the Salmon River watershed.

Current Condition - Felix Schoeller Technical Papers, Pulaski – Good: Total aggregate toxic releases from this facility have declined from 976,580 lb in 1987 to 380 lb in 2005 (the last year for which reporting is available). The only permitted toxic release from this facility in 2005 was 380 lb of N-butyl alcohol. The facility also has an NPDES permit (NY0000515) to discharge wastewater and must comply with permitted parameters for the following pollutants: temperature, turbidity, biological oxygen demand (BOD), pH, total suspended and settleable solids, phosphorus, and aluminum. The facility has not been out of compliance with discharge schedules since 1991.

Current Condition - Pulaski Sewage Treatment Plant, Pulaski – Fair: This facility has an NPDES permit (NY0020257) for discharge of wastewater and must comply with permitted parameters for the following pollutants: temperature, BOD, pH, total suspended solids, settleable solids, phosphorus, chlorine, and fecal coliform. The last violation of NPDES permit requirements for this facility was December 2002.

Current Condition - Pulaski Ford and Mercury, Pulaski: This facility has an NPDES permit (NYU700534) for discharge of wastewater. No permit documents were found through the USEPA web database for this facility.

Current Condition - New York State Fish Hatchery, Altmar - Fair: This facility has an NPDES permit (NY0109053) for discharge of wastewater and must comply with permitted parameters for the following pollutants: hydrogen peroxide, terramycin, formalin, diquat product, chloramine, chloride, pH, BOD, temperature, suspended and settleable solids, ammonia, phosphorus, potassium permanganate. The last violation of NPDES permit requirements for this facility was May 2004.

2.3.2.6 KEA: CONDITION-Pathogens

Several pathogens of concern to fisheries and human health exist in or near the watershed that are monitored for health and fisheries management. There are six viral and bacterial pathogens that are being monitored by NYSDEC for the salmonine fishery management (A. Noyes, NYSDEC Aquatic Pathologist, personal communication). Guidance for pathogen indicator rankings is provided in Table 8.

Indicator – Bacterial Kidney Disease Occurrence: BKD is caused by a gram-positive bacterium (*Renebacterium salmoninarum*) that survives in and causes extensive tissue damage to kidneys (Grayson et al. 2002). The disease is widespread in the Upper Great Lakes, with symptoms occurring in ~30-40% of Coho, Chinook, and Steelhead salmon there. The disease is vectored by spawning fish migrating back into the river from Lake Ontario.

Current Condition - Fair: The bacterium has occurred sporadically in the Salmon River fishery but has not been detected since 2003.

Indicator – Furnunculosis Occurrence: Furnunculosis is a bacterial disease caused by *Aeromonas salmonicida.* The bacterium causes severe blood poisoning and acute mortality. Fish affected with pathogen may be found swimming erratically, appear sluggish and stop feeding. The disease is common throughout North America and the Great Lakes. (For more information see http://www.lsc.usgs.gov/FHB/leaflets/FHB66.pdf)

Current Condition - Good: The pathogen has recently been detected in approximately 5-10% of fish in the Salmon River, but no disease symptoms have been observed.

Indicator – Infectious Pancreatic Necrosis (IPN) Occurrence: IPN is a viral disease that infects all ages and varieties of salmonids and in transmitted vertically (adults to eggs), or horizontally (consumption of infected dead fish or by fish excretions in the water). Infected fish may have swollen stomachs, swim in spiral manners, be inactive and produce white fecal casts. (For additional information see http://www.mass.gov/czm/wpfshlth.htm, http://www.disease-watch.com/documents/CD/index/html/fv035ipn.htm)

Current Condition - Good: This disease was present in the Salmon River fishery in the 1950's and 1960's, but has not been detected recently. It continues to be monitored.

Indicator – Yersinia ruckeri *Occurrence:* This bacterium is the causative agent of enteric redmouth (ERM), referring to symptomatic red mouths of infected fish. ERM most often infects rainbow trout, but it also affects several other salmonids. Infected fish are often found at the top of the water, isolated from other fish, and they may stop eating. The bacterium is common in Appalachian and mid-Atlantic fisheries as well as in the western Great Lakes. (For more information see http://www.mass.gov/czm/wpfshlth.htm.)

Current Condition - Fair: It is present but not common in the Salmon River.

Indicator – Viral Haemorrhagic Septicaemia (VHS): The IV-B strain of this virus was detected in Nova Scotia in the 1990s. Current evidence suggests this is probably an Atlantic strain of the virus that is just now making its way into the Great Lakes. This particular strain does not target salmonids as the other strains do (I, II and IV on salmonids in Europe and Asia; and IV-A in the Pacific Northwerst), but rather walleye, perch, minnows and gobies. Infected fish show the following symptoms: dark color, pale gills, sluggishness, erratic swimming. (For more information see http://www.mass.gov/czm/wpfshlth.htm, http://www.dec.state.ny.us/website/dfwmr/fish/vhsv.html.)

Current Condition - Fair: The virus has been detected in the Great Lakes and nearby Skaneateles Lake, but not yet in the Salmon River.

2.3.2.7 KEA – LANDSCAPE CONTEXT – Barriers to Migration

Structures such as dams and culverts can inhibit the migration of fish and other aquatic organisms through the watershed. Therefore, some segments of the river system, although suitable for habitat, may not be accessible to organisms that would utilize them.

Indicator – Dam Density (#dams/stream mile):

Current Condition - unranked: Twenty-four dams are currently known to be present within the watershed; 19 within the lower sub-watersheds, and five within the upper sub-watersheds. Seven sub-watersheds (all above the reservoir) have no impoundments (Table 15, Figure 24). No guidance was obtained with which to rank this indicator. However, these data suggest that migration capacities of aquatic organisms are more impaired by dams at the lower sub-watersheds (average of BBMC, LSRM, ORPE, TRBR dam density = 0.07/mile) than at the upper sub-watersheds (average = 0.03/mile).

Indicator – Road Crossing Density (# road crossings/stream mile):

Current Condition - unranked: There are 314 road-stream crossings within the entire watershed (Table 15, Figure 24). Crossings within sub-watersheds range from 6 (Cold Brook) to 46 (Beaverdam Brook-Meadow Creek-Reservoir), and crossing densities range from 0.14/mile (Upper Salmon River) to 0.96/mile (Lower Salmon River – Main Stem). It should be noted that these data do not differentiate the types of stream crossing (culvert versus bridge span). No guidance was obtained with which to rank this indicator, and the degree to which culverts serve as barriers to migration varies with species and life stage animal being considered, dimensions and internal roughness of the culvert, and the height at which the culvert is seated above the stream bed (USDA Forest Service 2002). However, these data suggest that migration capacities of aquatic organisms are more impaired at the lower sub-watersheds (average road crossing density of lower sub-watersheds = 0.72/mile) than at the upper sub-watersheds (average = 0.35).

Table 15. Dam and stream crossing densities within the sub-watersheds of the Salmon River drainage (data are from Howard 2006). These values apply to both main branch & major tributaries, and headwater streams.

Subwatershed	total stream length (miles)	number of dams	dam density (no. per stream mi)	number of road crossings	road crossing density (no. per stream mi)
Beaver-Gillmore-Willow-McDougal	32.6	0	0	8	0.25
Beaverdam Brk-Meadow Crk-Reservoir	69.5	11	0.16	46	0.66
Cold Brook	32.0	0	0	6	0.19
Fall Brook-Twomile-Threemile	32.1	1	0.03	19	0.59
Grindstone-Mill-Muddy	56.6	0	0	14	0.25
Keese-Smith-Finnegan	24.7	2	0.08	10	0.41
Lower Salmon River-Main Stem	40.5	8	0.20	39	0.96
Mad River	98.5	0	0	15	0.15
North Branch	69.3	1	0.01	33	0.48
Orwell-Pekin	50.6	1	0.02	32	0.63
Pennock-Coey-Kenny	44.0	1	0.02	29	0.66
Prince-Mulligan-Little Baker	28.2	0	0	13	0.46
Stoney Brook-Lime Brook	22.2	0	0	7	0.32
Trout Brook	55.5	3	0.05	35	0.63
Upper Salmon River	58.3	1	0.02	8	0.14

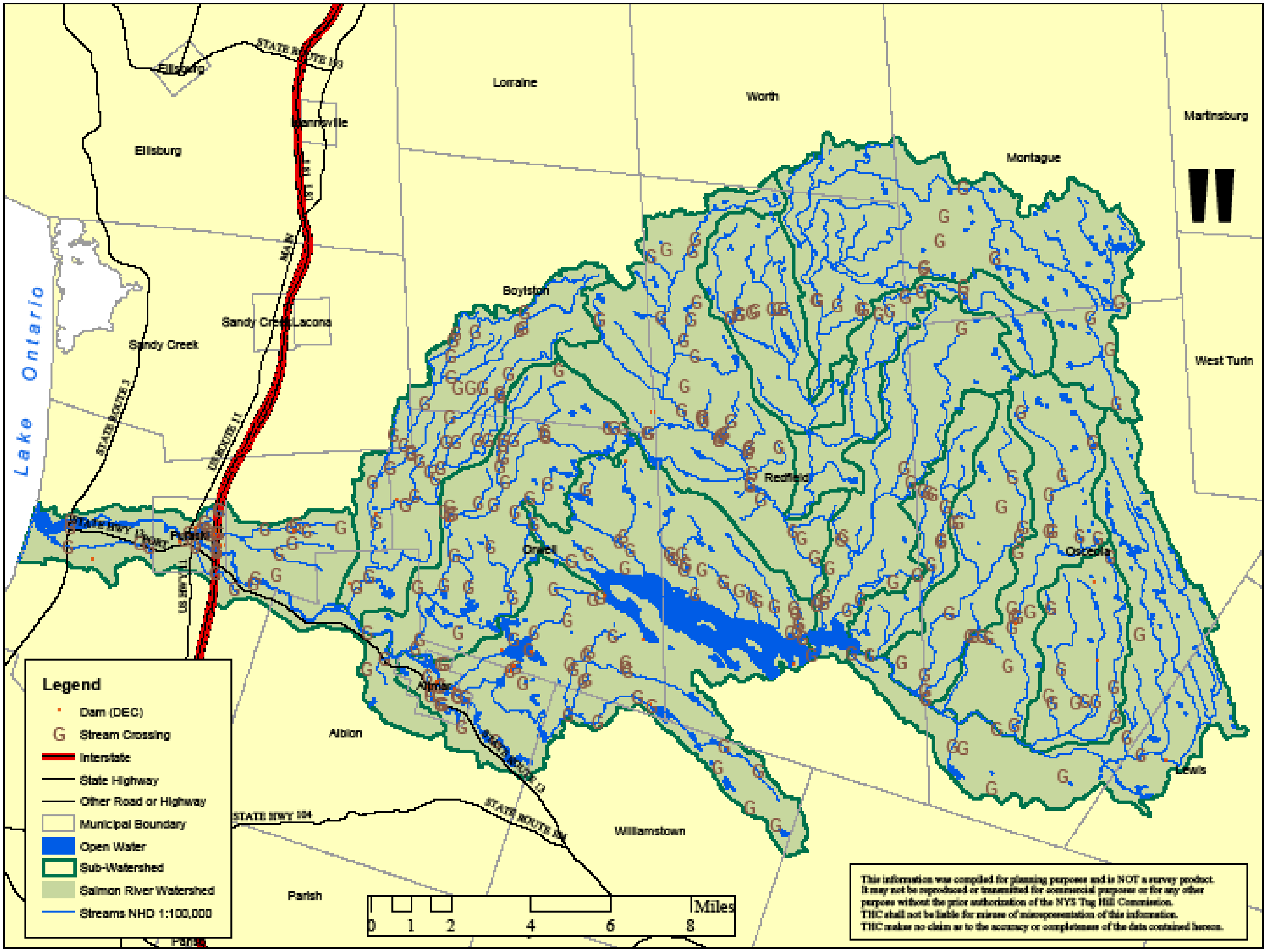


Figure 24. Locations of dams and stream crossings within the Salmon River watershed.

Indicator – Percent Natural Cover in 540-ft buffer. Naturally-vegetated buffers provide opportunities for wildlife species to simultaneously utilize upland and wetland habitats within their home ranges, to migrate along water features, and to disperse from wetlands into adjacent upland communities. For instance, amphibians are known to travel 1000-1800 ft, and up 4500 ft between breeding grounds and hibernation areas, (Hels and Buchwald 2001; Gibbs and Shriver 2005). Semlitsch (1998) found adults of six salamander species at an average of approximately 375 ft distance from the edge of aquatic habitats, and suggested that a buffer of ~540 ft from wetlands would capture 95% of the individuals within populations of those species.

Ranking criteria for this indicator are presented in Table 6.

<u>Current Condition: Upper sub-watersheds, Good; Lower sub-watersheds, Fair-Poor:</u> A stream buffer analysis was conducted by constructing 540-ft wide buffers along each edge of mapped stream segments (mapped at 1:100,000 scale) to calculate the percent unnatural cover (developed, roads, crops and hayfield, barren) occurring within the buffers. The analysis was conducted by stream reach (between mapped stream confluences) and presented by cover classes defined in Table 6.

This analysis (Figure 25) reveals that the vast majority of stream reaches within the upper sub-watersheds are well-buffered by natural vegetation (>90% cover of natural vegetation types) and only one stream reach ranked fair for this indicator (75-90% natural vegetation cover). The majority of stream reaches in the lower sub-watersheds ranked fair or poor (<75% natural cover) with regard to natural vegetation cover in the 540-ft buffers.

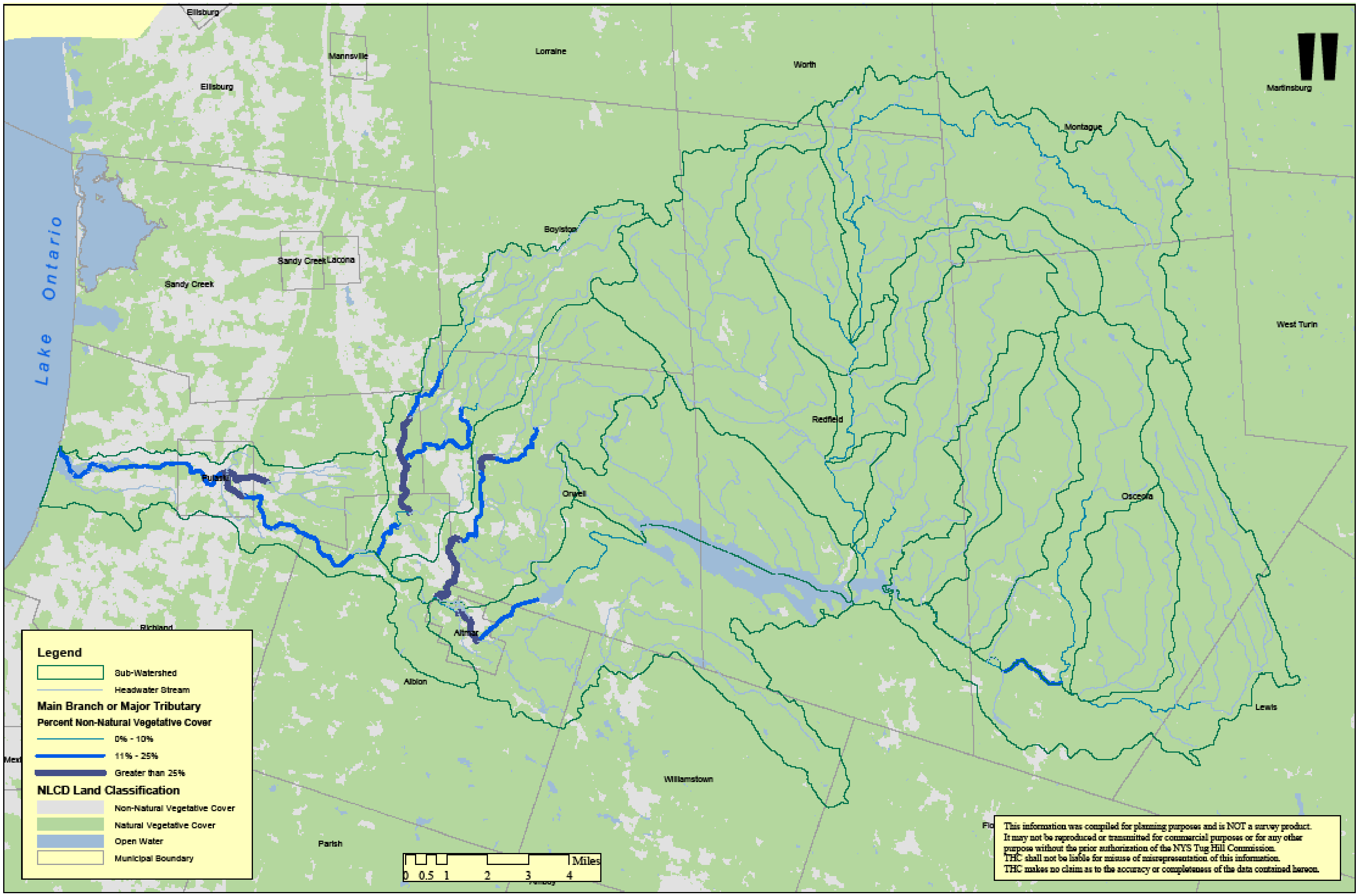


Figure 25. Analysis of land-cover types in 540-ft buffers of the Main Branch of Salmon River and its major tributaries.

2.3.3 Main Branch Salmon River & Major Tributaries

Viability Summary

Notes on Guidance for Current Condition:

"NG"	No guidance was obtained to rank this indicator
"SGR"	Subjective guidance and/or ranking based on professional opinion
"ND"	No data are available with which to rank this indicator

	Exellent	Good	Fair	Poor	Current Condition	Notes on Guidance for Current Condition
KEA-Size						
Ind. - Freq. Salmon River summertime flow <200 cfs		0%	1-50%		Good	SGR, FERC (1996)
KEA-Condition-Water Quality						
Ind. - % natural cover-types within 100-ft buffer		>90	75-90	<25		SGR, Klapproth & Johnson (2000), Baird & Wetmore (2006)
Upper sub-watersheds					Good	
Lower sub-watersheds					Fair	
Ind. - embeddedness					Unranked	NG, ND
Ind. - summertime high temperatures (°F)		<70		>73		Eastern Brook Trout Joint Venture (2005)
Upper sub-watersheds					Good	
Lower sub-watersheds					Good-Fair	
Ind. – pH		>6.5	5.0-6.5	<5	Good	Driscoll et al. (2001), Stoddard et al. (2003), Shreiber (2007)
Ind. - Alkalinity (mg/L CaCO3)	>100	2.5-100	0-2.5	<0	Good	Driscoll et al. (2001)
Ind. - Dissolved oxygen (mg/L)		>6		<6	Good	Kozuchowski et al. (1994)
Ind. - Total phosphorus concentration (mg/L)		<0.01	.01-0.1	>0.1		Mueller and Helsel (1996)
Upper sub-watersheds					Good	
Lower sub-watersheds					Fair	
Ind. - Total nitrogen concentration (mg/L)		<0.35	.35-10	>10	Fair	Driscoll et al. (2003)

	Exellent	Good	Fair	Poor	Current Condition	Notes on Guidance for Current Condition
KEA-Condition-Macroinvertebrate Communities						
Ind. - Richness	>26	19-26	11-18	<11	Excellent	Bode et al. (1997)
Ind. - EPT	>10	6-10	2-5	<2	Excellent	Bode et al. (1997)
Ind. - Hilsenhoff Biotic Index	0-4.50	4.51-6.50	6.51-8.50	8.51-10.0	Excellent	Bode et al. (1997)
Ind. - Percent Model Affinity	>65	50-64	35-49	<35	Excellent	Bode et al. (1997)
KEA-Condition-Fish Communities						
Ind. - Observed richness					Unranked	NG
Ind. - Predicted richness					Unranked	NG
Ind. – Fish species distributions (modeled)						
Common species, white sucker & blacknose dace					Unranked	NG
Uncommon species, fantail darter & mottled sculpin					Unranked	NG
Exotic species, common carp					Unranked	NG
Game species, brown trout & brook trout					Unranked	NG
KEA-Condition-Natural Salmonine Reproduction						
Ind. – salmonine spawning habitat						
Number Chinook redds		1900-2900			Good	SGR-Everett (2006)
Percent substrate acceptable for Chinook redds		15%			Good	SGR-Everett (2006)
Ind. - Natural Chinook egg production		15-41 x 10^6			Good	SGR-Everett (2006)
Ind. - Rainbow trout recruitment (no. "yr1+" per km)		450-900			Good	SGR-Wildridge (1990)
KEA-Condition-Toxins						
Ind.– Game fish mercury concentration (ppm)		0	0-1	>1		
Upper sub-watersheds					Poor	NYS Dept. Health (2006)
Lower sub-watersheds					Fair	
Ind.– Game fish PCB concentration (ppm)						
Upper sub-watersheds					Unranked	NYS Dept. Health (2006)
Lower sub-watersheds					Poor	
Ind. – PCB-induced mink jaw lesions (ppb)		0	<40	>40		Haynes et al. (2007)
Upper sub-watersheds					Unranked	
Lower sub-watersheds					Poor	

	Exellent	Good	Fair	Poor	Current Condition	Notes on Guidance for Current Condition
Ind.- game fish Mirex concentrations (ppm)						
Upper sub-watersheds					Good	NYS Dept. Health (2006)
Lower sub-watersheds					Poor	
KEA-Condition-Point Sources of Pollution						
Ind. - NPDES&Toxic Discharge violations last 5 yrs		0	1	>1		SGR
Schoeller					Good	
Pulaski Sewage					Fair	
Pulaski Ford/Mercury					Unranked	
NY Fish Hatchery					Fair	
KEA-Condition-Pathogens						
Ind. - % of population displaying disease symptoms		0	1-5	>5		SGR
Bacterial Kidney Disease occurrence					Fair	
Furnunculosis occurrence					Good	
Infectious Pancreatic Necrosis occurrence					Good	
Yersinia ruckeri occurrence					Fair	
Viral Haemorrhagic Septicaemia occurrence					Fair	
KEA-Landscape Context						
Ind. - No. dam per stream mile					Unranked	NG
Ind. - No. road crossings per stream mile					Unranked	NG
Ind. – Percent natural cover in 540-ft buffer		>90	75-90	<75		SGR, Semlitsch (1998)
Upper sub-watershed					Good	
Lower sub-watershed					Faur-Poor	

4 Headwaters

2.4.1 Headwaters Target Definition

This target represents 1st- and 2nd-order perennial streams described by Edinger et al. (2002). Following the same rationale outlined in section 2.3.1, the headwaters target will frequently consider aspects of the upper and lower watershed separately. The following generalized community descriptions are derived from Edinger et al. (2002).

-Intermittent streams: These are communities associated with small, ephemeral streambeds in the uppermost reaches of stream systems where surface water flows only during the spring or following heavy rains. These streams often have a moderate to steep gradient and hydric soils. Streambeds may be covered with emergent or submergent bryophytes including *Bryhnia novae-angliae, Bryum pseudotriquetrum, Chiloscyphus polyanthus, Hygrohypnum ochraceum, H. eugyrium ,Hygroamblystegium tenax, Fontinalis spp., Brachythecium rivulare, B. plumosum, Eurhynchium ripariodes, Mnium affine, Scapania nemorosa and S. undulata*. Characteristic vascular plants are hydrophytic and may include water-carpet (*Chrysosplenium americanum*) and pennywort (*Hydrocotyle americana*). The potential fauna are limited to species that do not require a permanent supply of running water, that inhabit the streambed only during the rainy season, or that are pool specialists. Characteristic fauna include amphibians such as green frog (*Rana clamitans*) and northern two-lined salamander (*Eurycea bislineata*), and macroinvertebrates such as water striders (*Gerris* sp.), water boatman (Corixidae), caddisflies (Trichoptera), mayflies (Ephemeroptera), stoneflies (Plecoptera), midges (Chironomidae), blackflies (Simulidae) and crayfish (*Cambarus bartoni*). Ecoregional variants occur throughout the state, which differ in dominant and characteristic bryophytes and insects, as well as water chemistry and temperature, underlying substrate type, and surrounding forest type.

-Headwater Streams: These community types (Figure 26) include both “rocky” and “marsh” headwaters, which share the characteristics of being small- to moderate-sized perennial, 1st- to 2nd-order streams, with biotic energy derived from adjacent terrestrial systems (leaf litter and other organic matter).

> -*Rocky headwaters* are typically shallow and narrow, and possess moderate to steep gradients, with cold water flowing over bedrock, boulders and cobbles. They contain alternating riffles and pools. High gradients lead to downward erosion with minimal deposition of sediments. They are typically surrounded by upland forest and are situated in confined valleys. Water has high levels of clarity and oxygenation.
>
> -*Marsh headwaters* are small, shallow brooks with very low gradient and slow flow rates occurring within marshes, fens or other swamps. The streams normally have well defined meanders and are in unconfined, broad, shallow valleys. They are dominated by runs with interspersed pools with substrates dominated by gravel or sand, but sometimes with silt, muck or peat. These streams may have high turbidity and varying color and sometimes be somewhat poorly oxygenated.

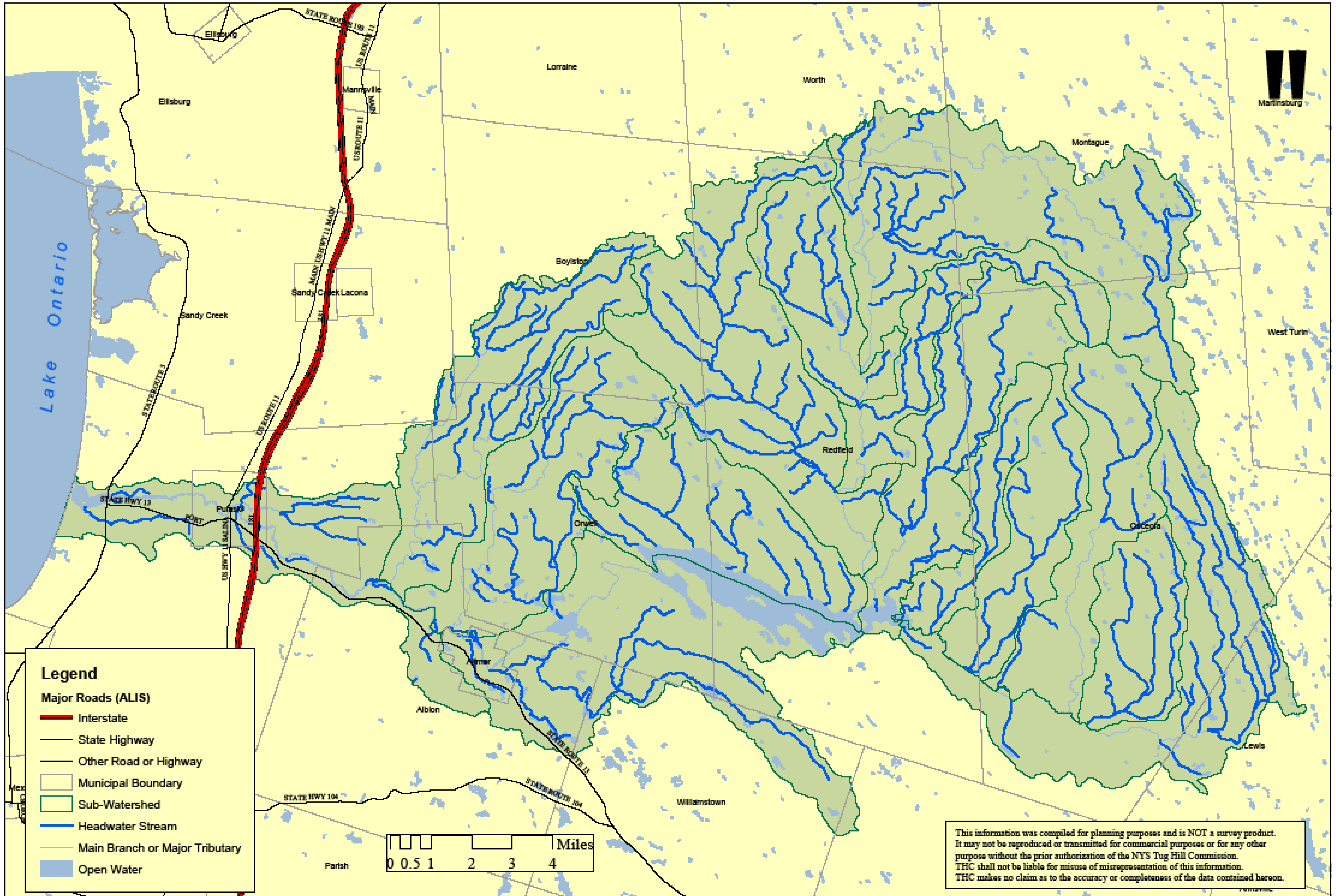


Figure 26. First- and second-order, perennial headwater streams of the Salmon River watershed.

2.4.2 Headwaters Viability Analysis

2.4.2.1 KEA-AREA

Headwater habitat availability is a function of the total length and width of 1st and 2nd order streams, and ephemeral streams within the watershed. Area of within stream aquatic habit varies annually and seasonally with hydrologic recharge by overland flow and groundwater. Groundwater recharge becomes the primary source of water during summer low-flow periods.

Indicator – Total Stream Length (mi) and Stream Density (mi. stream/mi.^{2} area): Total available aquatic habitat within an area can be quantified as total length of stream. This measure is often standardized to a per-unit-area basis (mi. steam/mi.^{2} area). Stream lengths vary with size of watershed considered, and stream density is relatively constant for a given ecoregion, given long-term climatic and hydrologic conditions. This indicator is not ranked, but is provided for baseline information.

Current Condition –Unranked: Table 16 summarizes total stream length and stream densities for the subwatersheds of the Salmon River watershed. Note that these calculations are based on stream segments mapped at the scale of 1:100,000, and therefore do not include many smaller perennial streams or any ephemeral streams. Mid-reach streams are also included in these estimates. Stream densities for the watershed average 2.1-3.2 mi/mi^2, and are consistent with stream densities mapped in the Catskill/Delaware watersheds (Mehaffey et al. 2001).

Table 16. Stream densities within the Salmon River watershed. Data are from Howard (2006) and are based upon all stream segments mapped at 1:100,000 scale.

	area (mi^2)	total stream length (mi)	stream density (mi/mi^2)
Upper Subwatersheds			
Beaver-Gillmore-Willow-McDougal	10.9	32.6	3.0
Cold Brook	10.2	32.0	3.1
Fall Brook-Twomile-Threemile	15.4	32.1	2.1
Grindstone-Mill-Muddy	17.5	56.6	3.2
Keese-Smith-Finnegan	10.0	24.7	2.5
Mad River	32.8	98.5	3.0
North Branch	28.1	69.3	2.5
Pennock-Coey-Kenny	17.0	44.0	2.6
Prince-Mulligan-Little Baker	11.3	28.2	2.5
Stony Brook-Lime Brook	7.2	22.2	3.1
Upper Salmon River	25.6	58.3	2.3
		average	2.7
Lower Subwatersheds			
Beaverdam Brook-Meadow Creek-Reservoir	30.8	69.5	2.3
Lower Salmon River-Main Stem	18.0	40.5	2.2
Orwell-Pekin	20.3	50.6	2.5
Trout Brook	20.2	55.5	2.7
		average	2.4

2.4.2.2. KEA-CONDITION-Water Quality

Indicator - Percent Natural Cover in 100-ft Buffer: Background and ranking for this indicator are presented in section 2.3.2.2 (Table 6).

Current Condition: Upper sub-watersheds, Good; Lower sub-watershed, Fair to Poor: An analysis of land-cover types occurring within 100-ft-wide buffers of headwater streams (Figure 27) revealed that only two headwater stream reaches in the upper sub-watersheds exhibited 75-90% natural cover, while all others contained >90% cover of natural vegetation. However in the lower sub-watersheds this indicator received a ranking of poor (<75% natural cover) to fair (75-90%) for numerous stream reaches.

Indicator – Summertime High Temperatures: Background and ranking stream temperature is provided in Section 2.3.2.2.

Current Condition – Upper sub-watersheds, Good; Lower sub-watersheds, Fair: No data reporting actual stream temperature measurements are available for the headwaters of the Salmon River watershed or for the greater Tug Hill region. Predicted summertime temperatures were estimated through a GAP model (J. McKenna, unpublished data). This model (Figure 14) predicts summer temperatures remain below 64 °F for the majority of headwater streams in the upper sub-watersheds. Headwaters of all the lower sub-watersheds (Beaverdam Brook-Meadow Creek-Reservoir, Lower Salmon River-Main Stem, Orwell-Pekin, and Trout Brook) have predicted summertime temperatures ranging from 70-73 °F, which is beyond the optimal range of some cold-water fish species (e.g., brook trout), and approaches their limits of tolerance. Brook trout thrive in water temperatures < 65 °F and tolerate brief periods of up to 72 °F; optimum growth occurs between 55 °F and 65 °F. Exposure to temperatures of °75 F for only a few hours is usually lethal (reviewed by Eastern Brook Trout Joint Venture 2005).

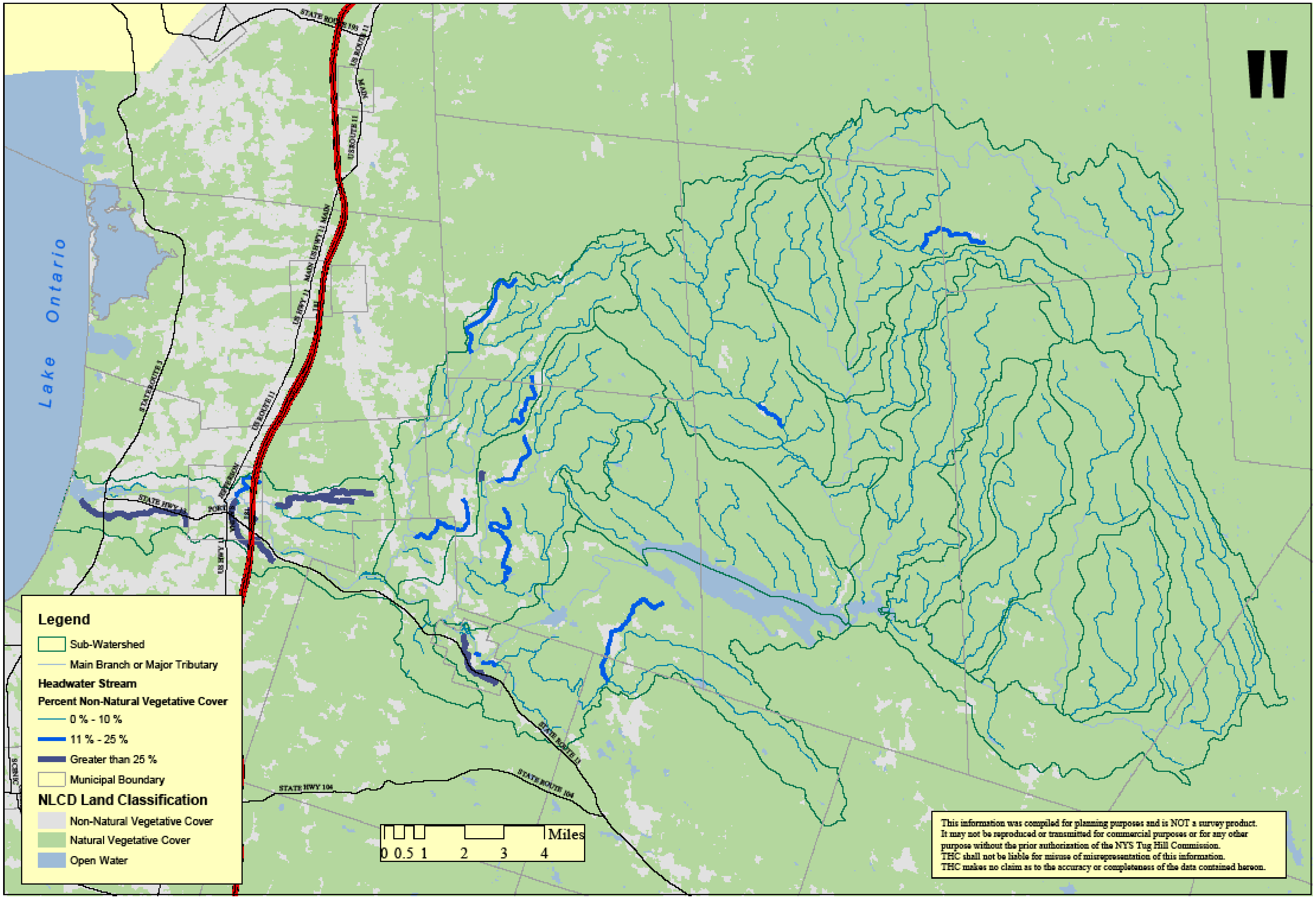


Figure 27. Analysis of land-cover types in 100-ft-wide buffers along headwaters of the Salmon River watershed.

Indicator – pH: Background and ranking criteria for surface water pH is provided in Table 13.

Current Condition – Upper sub-watersheds, Good; Lower sub-watersheds, Unranked: No water quality data are available for headwater reaches in the lower subwatersheds, but based upon the rankings for the main branch target (section 2.3.2.2), pH values are probably good for the lower sub-watersheds. Ranking for upper sub-watersheds is based on data provided for several headwater streams across the Tug Hill, including some within the Salmon River watershed westward to approximately Redfield, that were sampled under springtime high flow and summertime base flow conditions in 2005 and 2006. Springtime average pH averaged approximately 6.4 in both sample years. Summertime averages were approximately 7.2 across the Tug Hill (Figure 28).

Indicator – Total Alkalinity: Background and ranking criteria for surface water alkalinity is provided in Table 13.

Current Condition – Upper sub-watersheds, Good; Lower sub-watersheds, Good: No water quality data are available for headwater reaches in the lower sub-watersheds, but based upon the rankings for the main branch target (section 2.3.2.2), alkalinity values are probably good for the lower sub-watersheds. Ranking for upper sub-watersheds is based on data provided for several headwater streams across the Tug Hill, including some within the Salmon River watershed westward to approximately Redfield, that were sampled under springtime high flow and summertime base flow conditions in 2005 and 2006. Total alkalinity ranged from approximately 6-12 mg/L $CaCO_3$ during spring snowmelt, and approximately 35 mg/L during summer baseflow conditions (Figure 28), indicating that the headwater streams of the upper sub-watersheds are not currently sensitive to acidification.

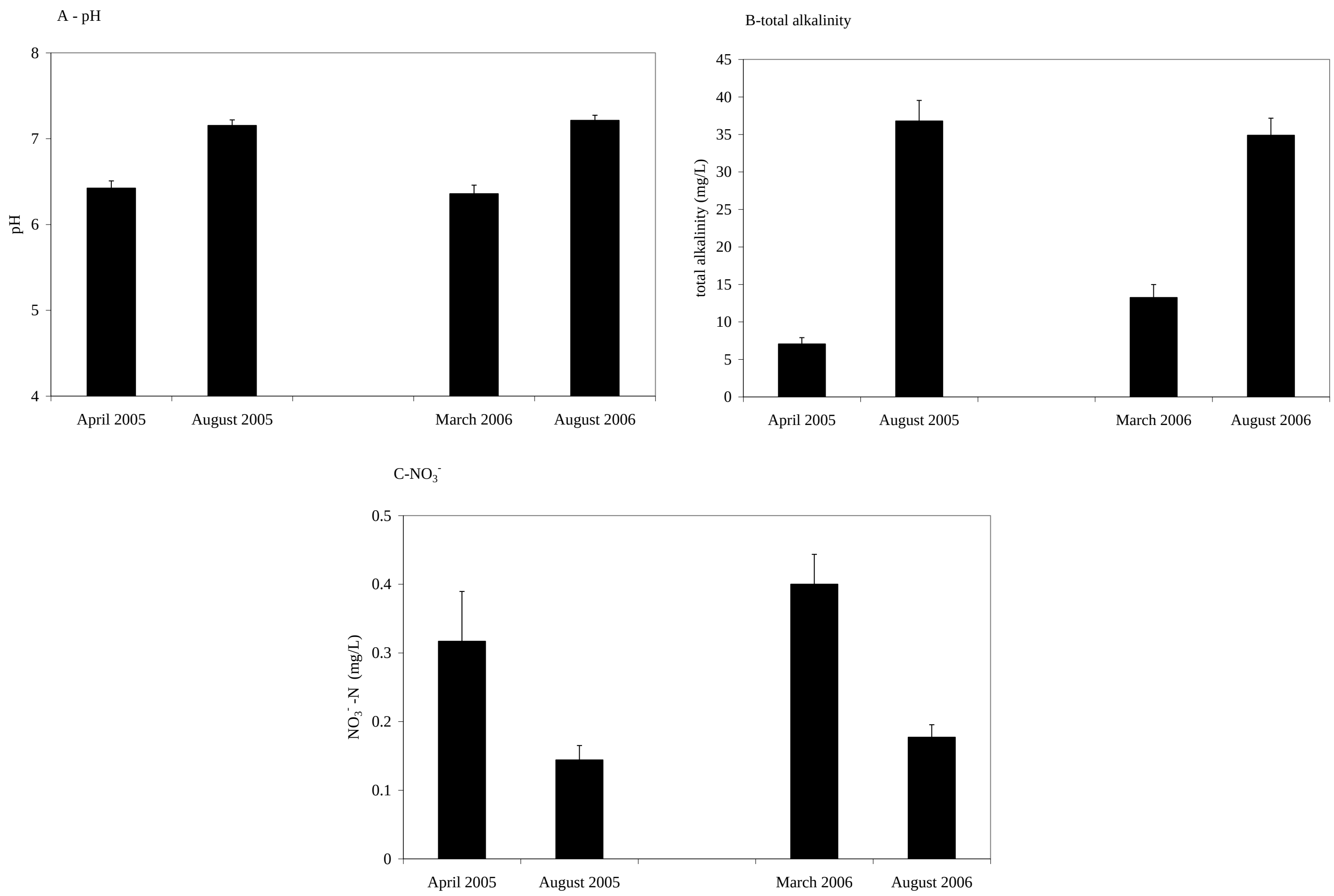


Figure 28. Stream chemistry of headwater streams on the Tug Hill, including some within the Salmon River watershed, east of the Redfield Reservoir. Values are averages (1SE) for replicate samples collected during peak snowmelt and summer baseflow conditions in 2005 and 2006. Panels are A-pH, B-total alkalinity, C-nitrate. (Source: McGee, unpublished data).

Indicator: Dissolved Oxygen (mg/L): Background and ranking criteria for surface water total dissolved oxygen concentrations are provided in section 2.3.2.2.

<u>Current Condition – Unranked:</u> No data are available on headwater stream oxygen concentrations within the watershed. Based upon the rankings of the main stem target (section 2.3.2.2), it is likely that oxygen concentrations are good within the rocky headwater streams throughout the watershed, but this extrapolation cannot be applied to marsh headwater streams.

Indicator: Phosphate Concentration: Background and ranking criteria for surface water total phosphate concentrations are provided in section 2.3.2.2.

<u>Current Condition – Upper sub-watersheds, Good; Lower sub-watersheds, Fair:</u> There are currently no data available with which to rank this indicator for the headwaters of the watershed. However, given the condition of the main branch and major tributaries target, it is likely that phosphorus concentrations in the upper subwatersheds are good, while those of the lower subwatersheds are fair.

Indicator – Nitrogen Concentrations: Background and ranking criteria for surface water total nitrogen concentrations are provided in section 2.3.2.2.

<u>Current Condition - Fair</u>: Average stream water nitrate (NO_3^-) concentrations in the headwaters of the upper sub-watersheds averaged approximately 0.35 mg NO_3-N/L during spring snowmelt periods in 2005 and 2006, and approximately 0.15 mg NO_3-N/L during summer baseflow conditions (Figure 28). These values underestimate the total N in these waters because they do not report dissolved organic nitrogen. The springtime values of 0.35 mg/L are approaching lower limits of conditions signaling polluted forest conditions (0.37 mg/L for <u>total</u> N). No data are available for headwaters of the lower sub-watersheds, but headwater conditions are probably consistent with those of the main branch and major tributaries, which exhibited elevated total N concentrations during summer baseflow periods. N concentrations remain well below USEPA drinking water standards.

2.4.2.3. KEA – CONDITION – Trout Habitat

Indicator – Trout Habitat – Native trout populations are good indicators of stream quality. Apart from requiring cold to cool water temperatures and high dissolved oxygen concentrations, trout habitats are correlated with (a) abundant cobble and gravel substrate for spawning; (b) fast flow; (c) abundant riffles; (d) abundant coarse woody debris (Hunt et al. 2005); and (e) upwellings of groundwater into gravel substrate for suitable spawning habitat. For instance, Brabrand et al. (2002) determined that high density spawning areas (>100 redds/ha) used by brown trout received groundwater influx of 1200 ml/m^2/min, while low density spawning areas (5-10 redds/ha) received an average influx of 113 ml/m^2/min. No guidance was obtained to rank specific substrate quality, stream velocity, riffle occurrence or coarse woody debris volume for this indicator.

<u>Current Condition – Unranked</u>: Hunt et al. (2005) reported that the cobble/gravel substrate, fast flow and riffle habitats occur within rocky headwater stream communities and that these features occurred in all of the exemplary headwater streams they described (no quantitative estimates were provided). Furthermore, these conditions occur in approximately 5-10% of the reaches in exemplary marsh headwater streams that Hunt et al (2005) studied. However, no information is available on the range of habitat conditions within the watershed or greater Tug Hill region.

Indicator – Trout Densities: No data were obtained that describe observed densities of brook (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) in the headwaters of the watershed. Section 2.3.2.4 describes the application of a GAP analysis, developed for the entire Great Lakes basin, and tested within the Genesee River drainage, to predict distributions of fish species within the watershed (J. McKenna, unpublished). This model has been applied to both headwater and mid-reach stream segments of the Salmon River watershed.

<u>Current Condition – Game Species – brown and brook trout - Unranked:</u> This analysis does not permit a ranking of this indicator, but rather is presented to provide an overview of conditions within the various sub-watersheds of the Salmon River drainage. Results of the analysis (illustrated in Figure 22) indicate that both trout species occur in headwaters throughout the watershed. When the predicted densities of these species differ within a given headwater reach, brook trout tend to occur in higher densities in the upper sub-watersheds, while brown trout tend to occur in higher densities in the lower sub-watersheds.

2.4.2.4 KEA – CONDITION – Macroinvertebrate Communities

Indicator – Indices of Biotic Integrity: Section 2.3.2.3 describes several indices that have been developed to assess mid-reach stream water quality using information describing the community composition of stream macroinvertebrates (Bode et al. 1997). These indices of biotic integrity could be applied to headwater streams only with caution since they were developed for aquatic invertebrate communities inhabiting riffles of streams with gravel/cobble streambeds and moderate velocity (M. Novak, NYSDEC, personal communication). The indices should not be applied to marsh headwater streams, which due to the abundance of wetlands and beaver flows in the Tug Hill region, may represent a substantial proportion of the watershed's headwaters. Furthermore, headwaters generally support lower densities of invertebrates due to down-stream drift of these organisms.

Current Condition – Unranked: No data describing stream invertebrate communities were obtained that could readily be used to calculate indices of biotic integrity in the headwater streams of the watershed.

Indicator – Macroinvertebrate Abundance (#/m^2): This indicator provides general information regarding the potential ecosystem productivity of stream communities (amount of energy being transferred up the food chain). Headwater streams will typically exhibit lower macroinvertebrate abundance than mid-reach (3rd-4th order) streams.

Hunt et al. (2005) reported macroinvertebrate abundances only for headwater streams that they considered exemplary in the Tug Hill region, including sites in the Salmon River watershed (Table 17).

Table 17. Estimated macroinvertebrate abundance in exemplary streams of the Tug Hill region (from Hunt et al. 2005).

	invertebrate abundance (no. per m^2)		
Stream system	midreach	rocky headwater	marsh headwater
East Branch Fish Creek	3000	2500	2000
East Branch Salmon River	3000	1500	2500
N. Br. Salmon River – Mad River	--	2000	--
Deer River	1500	800	1000
Average	~2500	~1600	~1800

Current Condition – Unranked: Data presented in Table 17 are provided for baseline information on exemplary streams. No similar data were obtained for streams of lower sub-watersheds, or for streams representing the range of conditions within the watershed.

Indicator – Macroinvertebrate Species Richness: Species richness is influenced by stream water quality as well as the availability of diverse substrates and energy sources to support a wide range of species. Hunt et al. (2005) reported macroinvertebrate richness only for headwater streams that they considered exemplary in the Tug Hill region, including sites in the Salmon River watershed (Table 18).

<u>Current Condition – Unranked</u>: Data presented in Table 18 are provided for baseline information. No similar data were obtained for streams in the lower sub-watersheds, or for streams representing the range of conditions within the watershed. Comparisons of species richness among studies are hindered by differences in sampling procedures and effort.

Table 18. Macroinvertebrate species richness of exemplary Tug Hill stream systems (from Hunt et al. 2005).

	--------Biotic richness (minimum number of species)-------									
Community/Stream System	M	P	E	T	Di	C	O	De	Hi	He
Midreach Streams										
E. Branch Fish Creek	2	3	11	19	3	3	-	2	-	-
E. Branch Salmon River	-	7	7	17	4	2	-	-	-	-
Mad River	2	3	6	10	2	-	-	-	-	-
Deer River	2	6	9	12	4	2	3	-	-	-
Average	*2*	*5*	*8*	*15*	*3*	*2*	*1*	*1*	*0*	*0*
Rocky Headwater Streams										
E. Branch Fish Creek	3	8	7	17	3	4	-	-	-	-
W. Fork Salmon River	-	5	7	13	4	4	4	2	-	-
Mill Stream	3	3	6	12	3	3	-	-	-	-
E. Branch Deer River	3	6	9	14	3	4	3	-	-	-
Average	*2*	*6*	*7*	*14*	*3*	*4*	*2*	*1*	*0*	*0*
Marsh Headwater Streams										
E. Branch Fish Creek	5	-	4	7	2	2	-	-	-	-
W. Fork Salmon River	2	-	2	12	2	2	3	-	2	-
W. Branch Deer River	2	-	5	8	3	3	4	-	3	-
Average	*3*	*0*	*4*	*9*	*2*	*2*	*2*	*0*	*2*	*0*

M: Mollusca, P: Plecoptera, E: Ephemeroptera, T:Trichoptera, Di:Diptera, C:Coleoptera, O:Odonata, De:Decapoda, He:Hemiptera, Hi:Hirudinea, - not assessed (<=1).

2.4.2.5 KEA – CONDITION – Fur-Bearing Animals

Animals such as beaver and river otters utilize headwater stream habitats. Their respective abundance provides an indicator of habitat quality and food availability within headwaters.

Indicator – Beaver and Otter Population Densities: No population estimates were obtained for these species within the Salmon River watershed. The only data available are NYSDEC fur-bearer trapping records, which are assembled on a town-by-town basis. Trapping records for Jefferson, Oswego, Lewis and Oneida counties were provided by J.E. Kautz, NYSDEC Bureau of Wildlife. Records specific to towns within the watershed were insufficient to adequately illustrate population trends for these species. Therefore, data from the entire four-county area were used to illustrate trends for the greater region. These data cannot be used to estimate populations, and therefore are of limited value for ranking this indicator. They are provided here to illustrate general, regional population trends over the last forty years.

Current Condition - Unranked: Figure 29 illustrates the number of trapped beaver and otter that were reported to NYSDEC between 1958 and 2005 in the area encompassing Jefferson, Lewis, Oneida and Oswego counties. These data indicate increasing levels of trapped beaver between 1960 and the mid-1980s. The recent leveling of the beaver trend may reflect real population dynamics or the influence of market forces on trapping effort. These data also indicate a slight increase in the number of trapped otter throughout the period of the record.

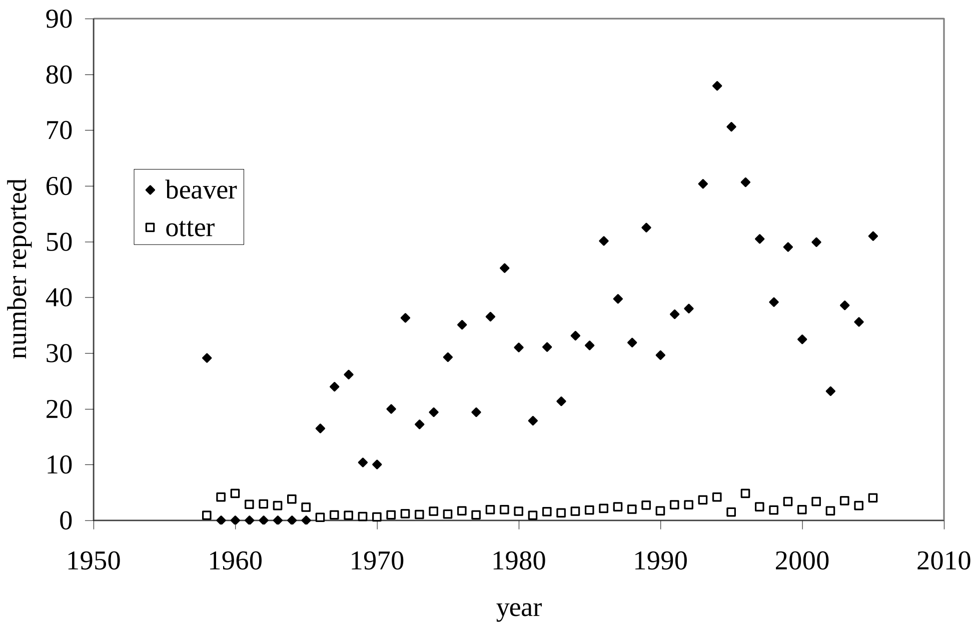


Figure 29. Average numbers (per town) of trapped beaver and otter reported to NYSDEC in Jeferson, Lewis, Oneida and Oswego Counties, New York. (Source: NYSDEC).

2.4.2.6 KEA – LANDSCAPE CONTEXT – Barriers to Migration

Structures such as dams and culverts can inhibit the migration of fish and other aquatic organisms through the watershed. Therefore, some segments of the river system, although suitable for habitat, may not be accessible to organisms that would utilize them.

Indicator – Dam Density (#dams/stream mile):

Current Condition - Unranked: Viability ranking of this indicator was conducted for the Headwaters target together with the Main Branch Salmon River & Major Tributaries target, and is outlined in section 2.3.2.7 (including Table 15, Figure 24).

Indicator – Road Crossing Density (# road crossings/stream mile):

Current Condition - Unranked: Viability ranking of this indicator was conducted for the Headwaters target together with the Main Branch Salmon River & Major Tributaries target, and is outlined in section 2.3.2.7 (including Table 15, Figure 24).

Indicator – Percent Natural Cover in 540-ft Buffer: Discussion regarding the ecological importance of natural vegetation cover in wide buffers strips along streams and other water bodies is provided in Section 2.3.2.7 and ranking criteria for this indicator is presented in Table 6.

Current Condition: Upper sub-watersheds, Good; Lower sub-watersheds, Fair-Poor: A stream buffer analysis was conducted by constructing 540-ft wide buffers along each edge of mapped headwater stream segments (mapped at 1:100,000 scale) to calculate the percent unnatural cover (developed, roads, crops and hayfield, barren) occurring within the buffers. The analysis was conducted by stream reach (between mapped stream confluences) and presented by cover classes defined in Table 6.

This analysis (Figure 30) reveals that the vast majority of stream reaches within the upper sub-watersheds are well-buffered by natural vegetation (>90% cover of natural vegetation types). Three stream reaches ranked fair for this indicator (75-90% natural vegetation cover) and one was ranked as poor (<75% natural cover). In the lower sub-watersheds, 29 headwater stream segments received a ranking of fair (18) or poor (11) with regard to the natural vegetation cover in the 540-ft buffers.

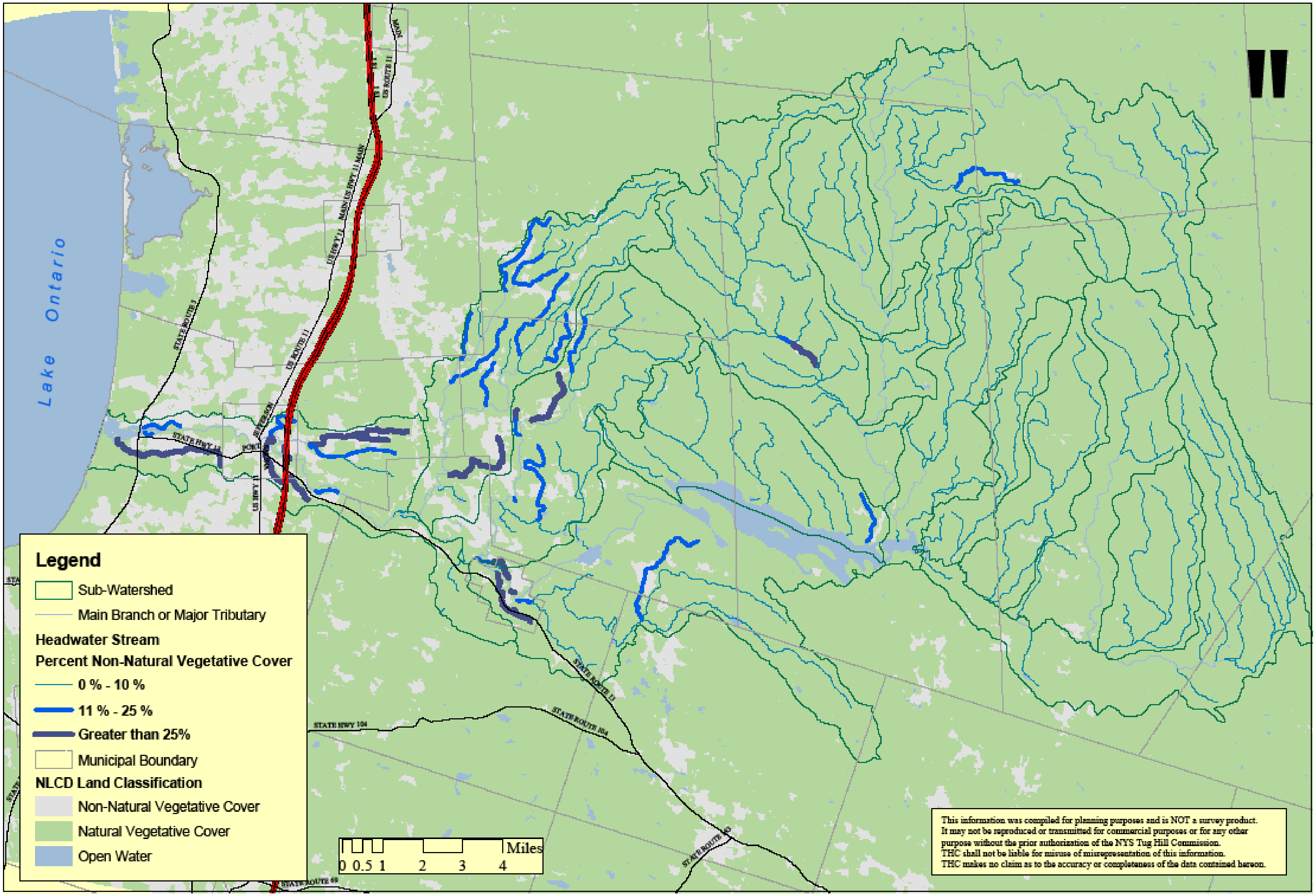


Figure 30. Analysis of land-cover types in 540-ft-wide buffers of headwater streams (1st- and 2nd-order) of the Salmon River watershed.

2.4.3 Headwaters
Viability Summary

Notes on Guidance for Current Condition:

"NG"	No guidance was obtained to rank this indicator
"SGR"	Subjective guidance and/or ranking based on professional opinion
"ND"	No data are available with which to rank this indicator

	Exellent	Good	Fair	Poor	Current Condition	Notes on Guidance for Current Condition
KEA-Size						
Ind. - Stream density (stream mi / mi^2)					Unranked	NG
KEA-Condition-Water Quality						
Ind. – % natural cover types within 100-ft buffer		>90	75-90	<75		SGR, Klapproth & Johnson (2000), Baird & Wetmore (2006)
Upper sub-watersheds					Good	
Lower sub-watersheds					Fair-Poor	
Ind. - Summertime high water temperature (°F)		<65	72	>72		Eastern Brook Trout Joint Venture (2005)
Upper sub-watersheds (predicted)					Good	
Lower sub-watersheds (predicted)					Fair	
Ind. – pH		>6.5	5.0-6.5	<5		Driscoll et al. (2001), Stoddard et al. (2003), Shreiber (2007)
Upper sub-watersheds					Good	
Lower sub-watersheds					Unranked	
Ind. - Alkalinity (mg/L CaCO3)	>100	2.5-100	0-2.5	<0		Driscoll et al. (2001); lower sub-watersheds, ND - extrapolated from main branch target
Upper sub-watersheds					Good	
Lower sub-watersheds					Good	

	Exellent	Good	Fair	Poor	Current Condition	Notes on Guidance for Current Condition
Ind. - Dissolved oxygen (mg/L)		>6		<6	Unranked	ND, Kozuchowski et al. (1994)
Ind. - Total phosphorus concentration (mg/L)		<0.01	.01-.1	>0.1		Mueller & Helsel (1996)
Upper sub-watersheds					Good	ND, ranking extrapolated from main branch target
Lower sub-watersheds					Fair	ND, ranking extrapolated from main branch target
Ind. - Total nitrogen concentration (mg/L)		<0.35	.35-10	>10		Vitousek et al. (1997), Driscoll et al. (2003)
Upper sub-watersheds					Fair	
Lower sub-watersheds					Fair	ND, ranking extrapolated from main branch target
KEA-Condition-Trout Habitat						
Ind. - Gravel substrate					Unranked	NG, ND, Hunt et al. (2005)
Ind. - Stream flow					Unranked	NG, ND, Hunt et al. (2005)
Ind. - Riffle habitat					Unranked	NG, ND, Hunt et al. (2005)
Ind. - Coarse woody debris					Unranked	NG, ND, Hunt et al. (2005)
Ind. - Groundwater discharge (ml/m^2/min)		1200	100		Unranked	ND, Brabrand et al. (2002)
Ind. - Trout densities (observed or predicted)					Unranked	NG, ND
KEA-Condition-Macroinvertebrate Communities						
Ind. - Richness	>26	19-26	11-18	<11	Unranked	ND, Bode et al. (1997)
Ind. - EPT	>10	6-10	2-5	<2	Unranked	*Note: indices developed*
Ind. - Hilsenhoff Biotic Index	0-4.50	4.51-6.50	6.51-8.50	8.51-10.0	Unranked	*for mid-reach streams and should not be applied*
Ind. - Percent Model Affinity	>65	50-64	35-49	<35	Unranked	*to marsh headwaters*

Ind. - Bacroinvertebrate abundance (#/m2)	1600-1800				Unranked	ND, Hunt et al. (2005)
Ind. – Macroinvertebrate species richness					Unranked	ND, Hunt et al. (2005)
KEA - Condition - Furbearer Populations						
Ind. - NYSDEC trapping reports (#/town/yr)						NG
Beaver					Unranked	
Otter					Unranked	
KEA-Landscape Context						
Ind. – Number of dams/stream mile					Unranked	NG
Ind. – Number of road crossings/stream mile					Unranked	NG
Ind. - % natural cover in 540-ft buffer		>90	75-90	<75		SGR, Semlitsch (1998)
Upper sub-watersheds					Good	
Lower sub-watersheds					Fair-Poor	

2.5 Open Waters

2.5.1 Open Waters Target Definition

Open waters include lakes, ponds and reservoirs. The Salmon River watershed contains no large, naturally occurring lakes or ponds. However several small open ponds occur naturally within the watershed resulting from impeded surface flow by glacial deposits and beaver dams. In addition numerous farm ponds and two notable impoundments (the Lighthouse Hill and Redfield Reservoirs) exist in the watershed (Figure 31).

2.5.2. Open Waters Viability Analysis

2.5.2.1. KEA-SIZE

Indicator – Open Water Area (acres): Total area is a direct indicator of open water habitat availability. The component of total open water area most subject to change over time may be the numerous, small beaver dams that exist in the watershed, while the areas Lighthouse Hill and Redfield reservoirs will remain regulated at a relatively static level. Therefore, rankings for this target will be based upon total area of open waters other than the two reservoirs in order to provide a measure that is most sensitive to potential future changes within the watershed.

No historic estimation of open water exists for the watershed, and this was probably a dynamic level that fluctuated with local cycles in beaver populations. Viability rankings for open water area will be based upon current conditions since beaver populations have recovered across northern New York from historic lows in the 19th century (Brocke and Zarnetske 1974). Therefore, open waters may currently be near expected natural levels, at least in some subwatersheds. Viability rankings for this indicator are presented in Table 19.

Table 19. Ranking criteria for open water habitat area in the Salmon River watershed. Baseline open water area is based upon the National Land Cover Database (2001).

	poor	fair	good
Percent of the baseline 2001 total open water area in watershed (excluding Lighthouse Hill and Redfield Reservoirs).	<75%	75-90%	>90%

<u>Current Condition – Good:</u>

Analyses conducted using National Wetland Inventory data provide an estimate of approximately 4,300 acres of open waters within the watershed (Table 20). Note that for the Beaverdam Brook-Meadow Creek, Keese-Smith-Finnegan, Fall Brook-Twomile-Threemile and Upper Salmon River sub-watersheds, NWI data were incomplete, and therefore area of open waters in these sub-watersheds are underestimated.

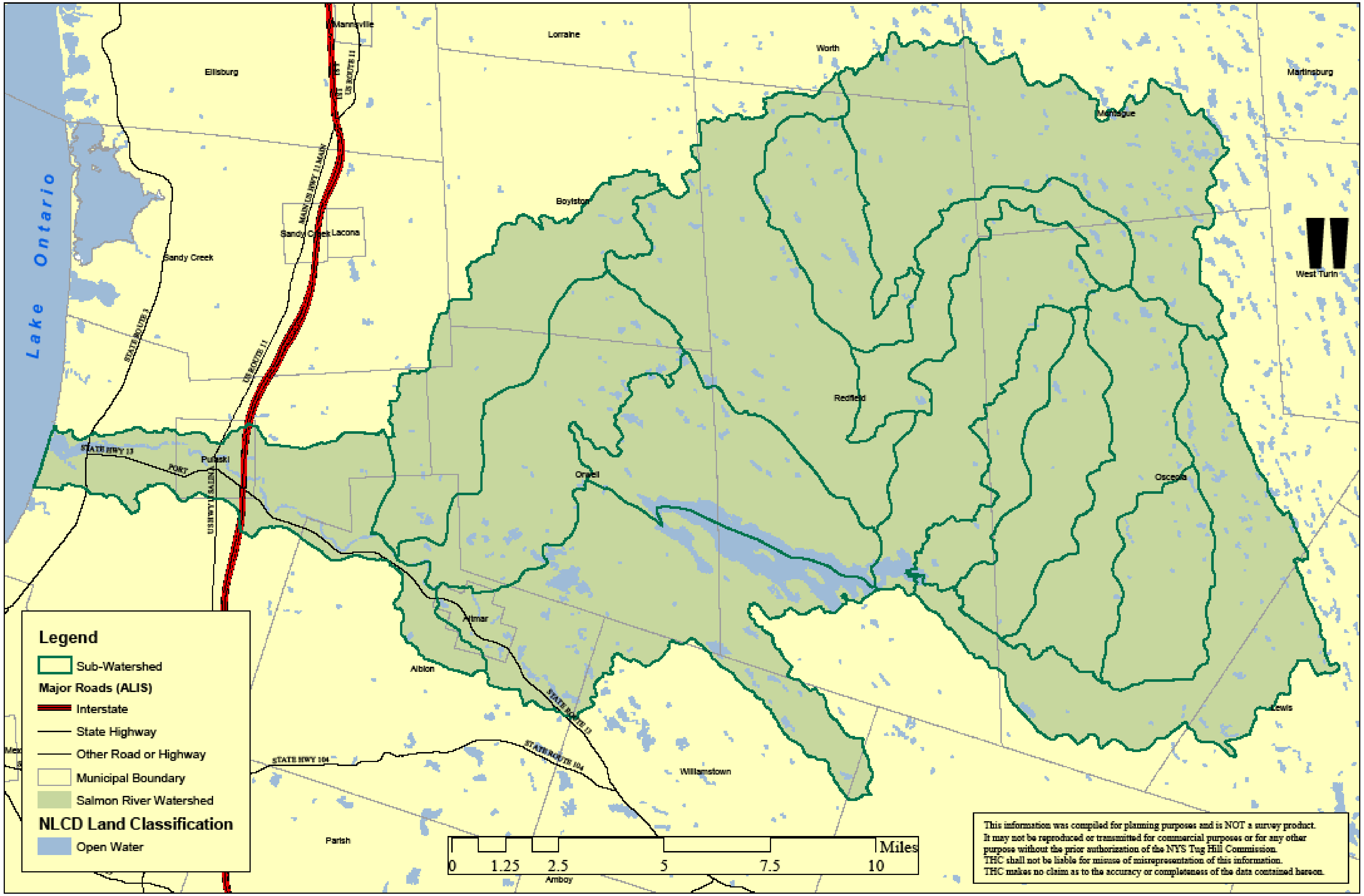


Figure 31. Open waters of the Salmon River watershed.

The areas of the Redfield and Lighthouse Hill Reservoirs are 2,660 and 150 acres, respectively. Together they account for 65% of the total open waters in the watershed. Note that for the purpose of the sub-watershed analyses (presented in Table 20) it was necessary to partition the area of the Redfield Reservoir between the Beaverdam Brook-Meadow Creek-Reservoir and Pennock-Coey-Kenny sub-watersheds.

A total of 454 water bodies (excluding the two reservoirs) were identified in the entire watershed, collectively accounting for approximately 1,520 acres. Of these non-reservoir water bodies, 92% are smaller than 10 acres (accounting for 45% of the total open water area). Three water bodies (accounting for <1% of the total number and 18% of the total area) are greater than 100 acres in size.

Table 20. Estimated numbers and areas of open waters in sub-watersheds of the Salmon River Watershed. Sub-watersheds for which data were incomplete are indicated with an asterisk. For the purpose of the sub-watershed total, open waters occurring at the confluence of streams draining two different sub-watersheds were necessarily partitioned between those two sub-watersheds. (Data Source: National Wetland Inventory).

Subwatershed	sub-watershed area (ac)	area open water (ac)	percent open water
Beaverdam Brook-Meadow Creek-Reservoir *	19,720	2,193	11.1
Pennock-Coey-Kenny	10,880	957	8.8
Grindstone-Mill-Muddy	11,183	293	2.6
Mad River	21,013	228	1.1
Orwell-Pekin	12,992	127	1.0
Stony Brook-Lime Brook	4,623	43	0.9
Upper Salmon River*	16,365	145	0.9
Cold Brook	6,558	51	0.8
Beaver-Gillmore-Willow-McDougal	6,962	48	0.7
Fall Brook-Twomile-Threemile*	9,862	57	0.6
North Branch	17,993	82	0.5
Trout Brook	12,938	54	0.4
Lower Salmon River-Main Stem	11,544	31	0.3
Prince-Mulligan-Little Baker	7,245	17	0.2
Keese-Smith-Finnegan*	6,419	6	0.1
TOTAL	176,298	4,332	2.5

*Available NWI data are incomplete for these sub-watersheds, resulting in expected underestimations of open water area.

2.5.2.2 KEA – CONDITION - Beaver Dams

The treatment of beaver-influenced communities is included in this section on open water (rather than wetlands) due to the analytical methods available for detecting and quantifying them. Using the National Wetland Inventory (NWI) database it is possible to discern open waters of beaver origin. These open waters are accompanied by a variety of wetland types that are given consideration in Section 2.6. Beaver (*Castor canadensis*) are recognized as important ecosystem "engineers" whose presence and activities contribute to maintaining diverse and variable natural communities. Wright et al. (2002) determined that beaver activities increase vascular plant diversity in Adirondack riparian zones by more than 33%.

Indicator – Proportion of Total Open Waters as Beaver-Influenced:

Current Condition – Unranked: Figure 32 illustrates the beaver-influenced open waters of the watershed. Beaver-influenced open waters are quantified in Table 21. No guidance is available for estimating expected, natural beaver populations in the watershed or areas of wetlands within the watershed expected to be influenced by beaver activities. The data in Table 21 are provided as baseline data for comparisons among sub-watersheds and to facilitate future comparisons. The analysis summarized in Table 21 indicates that approximately 11% of the watershed's water body area is influenced by beaver, with beaver influence ranging from 0 (Lower Salmon River sub-watershed) to 28% (Beaver-Gilmore-Willow-McDougal sub-watershed).

Table 21. Summary of beaver-influenced wetland and open water areas in the Salmon River Watershed.

Subwatershed	wetland area (ac)	open water area (ac)	total area (ac)	beaver-influenced area (ac)	beaver-influenced percent
Beaverdam Br.-Meadow Cr.-Reservoir*	1,639	2,193	3,831	268	7
Beaver-Gilmore-Willow-McDougal	1,104	48	1,152	319	28
Cold Brook	1,117	51	1,167	184	16
Fall Brook-Twomile-Threemile*	1,674	57	1,731	209	12
Grindstone-Mill-Muddy	1,338	293	1,632	223	14
Keese-Smith-Finnegan*	442	6	448	52	12
Lower Salmon River – Main Stem	1,345	31	1,376	0	0
Mad River	4,848	228	5,077	701	14
North Branch	3,061	82	3,143	213	7
Orwell-Pekin	1,623	127	1,750	279	16
Pennock-Coey-Kenny	1,272	957	2,228	157	7
Prince-Mulligan-Little Baker	847	17	864	85	10
Stony Brook – Lime Brook	468	43	511	35	7
Trout Brook	1,065	54	1,120	20	2
Upper Salmon River*	1,148	145	1,292	269	21
TOTAL	22,991	4,332	27,323	3,012	11

*Available NWI data are incomplete for these sub-watersheds, resulting in expected underestimations of open water and wetland area, and additional error in estimating areas of beaver-influenced water bodies.

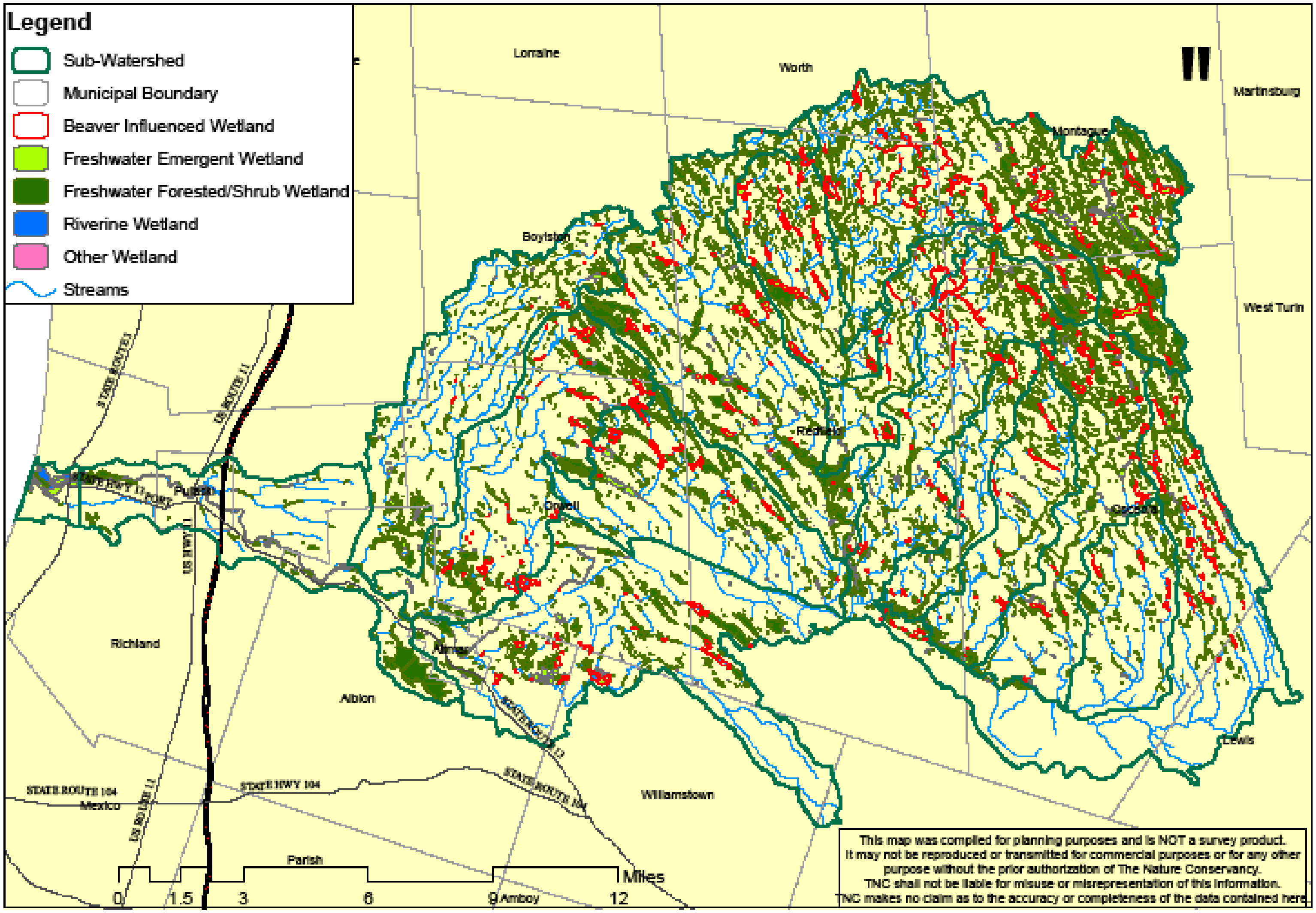


Figure 32. Beaver-influenced wetlands of the Salmon River watershed.

2.5.2.3 KEA – CONDITION – Water Quality

Indicator - Percent Natural Vegetation in 100-ft-wide Buffer: Section 2.2.2.6 provides background and rationale for this indicator. Ranking criteria for this indicator are provided in Table 6. Buffer analyses were conducted only for the large open waters of the watershed (Lighthouse Hill and Redfield Reservoirs).

Current Condition – Lighthouse Hill Reservoir, Good; Redfield Reservoir, Good: Figure 33 illustrates land-cover types surrounding the Lighthouse Hill and Redfield reservoirs. Natural vegetation represents 91% and 98% of the land-cover types within the 100-ft buffers of the Lighthouse Hill and Redfield reservoirs, respectively.

Indicator - Carlson Trophic State Index: The Carlson TSI index (USEPA 2007a) synthesizes related data associated with indicators of trophic condition. This index is described in section 2.2.2.6.

Current Condition – Unranked: No data are available for chlorophyll *a* or total P in any of the ponds or lakes of the sub-watershed. Harman et al. (2000) classified the Redfield Reservoir as oligotrophic. They reported Secchi disk measurements of 2.2 m at the west end near the dam (with disk site limitation due to water color), and 1.5 m (depth to bottom) on the east end, and noted that nutrient loading does not appear to be substantial enough to support planktonic algal blooms. The potential for eutrophication in farm ponds in the western sub-watersheds is high.

Indicator – pH: pH is a measure of acidity, which may vary naturally across the watershed based upon the acid buffering capacity of soils and bedrock. Table 13 summarizes viability rankings for surface water pH.

Current Condition- Good: Available data (NYSDEC, Bureau of Fisheries, unpublished data) report the pH of the Redfield Reservoir in June 2003 to be 7.0 (neutral). No information is available for pH of the watershed's other open waters, but they probably do not vary greatly from those of other surface waters in the watershed (Sections 2.4 and 2.5).

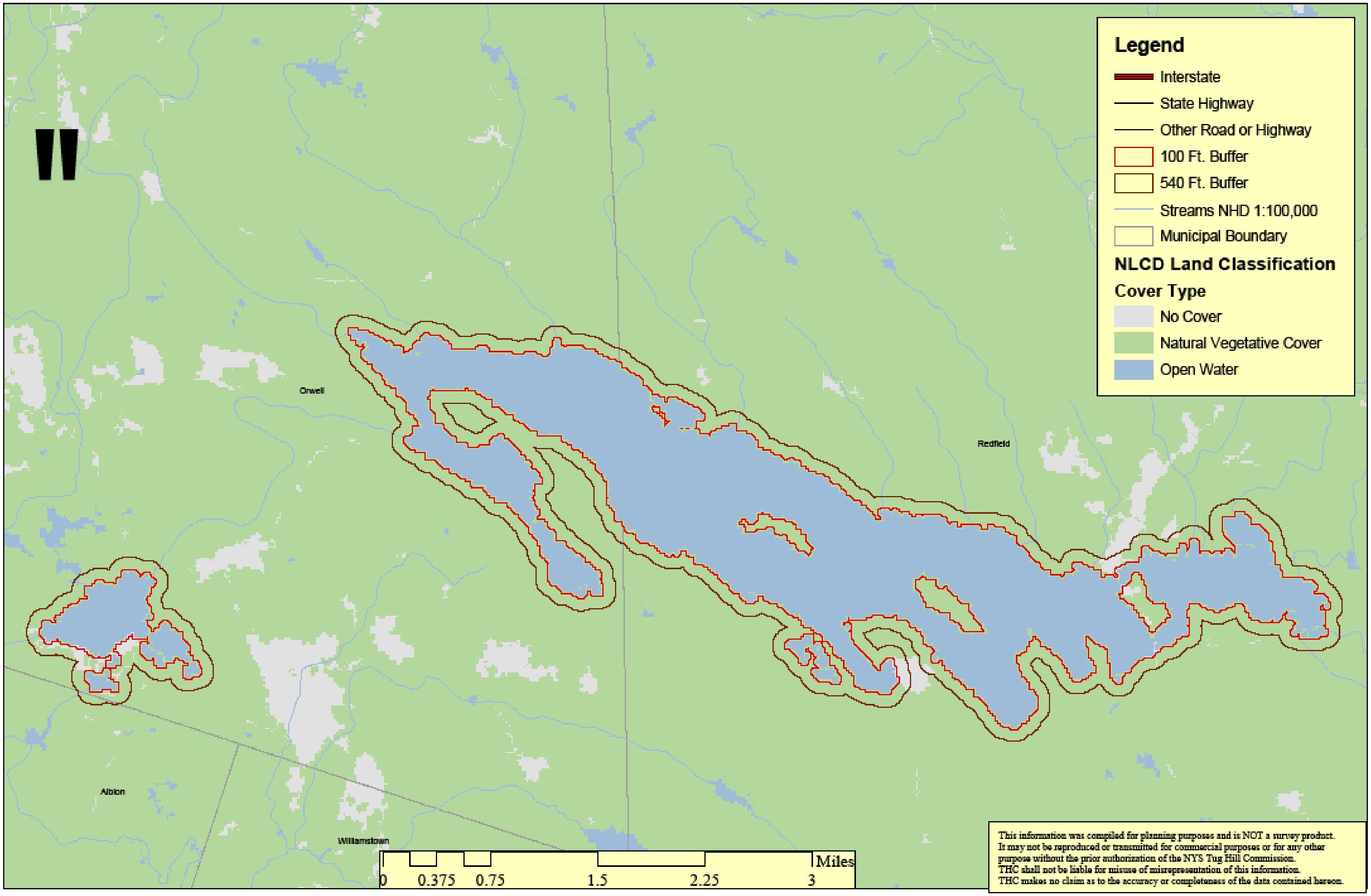


Figure 33. Analysis of land cover-types in 100- and 540-ft-wide buffers of the Lighthouse Hill and Redfield Reservoirs.

Indicator – Total Alkalinity: Table 13 presents viability rankings for surface water alkalinity, based upon susceptibility of waters of given alkalinity to acidification.

Current condition – Good: Available data (NYDEC unpublished data) indicate total alkalinity of the Redfield Reservoir in June 2003 to be 68.4 mg/L $CaCO_3$. No information is available for alkalinity of the watershed's other open waters, but they probably do not vary greatly from those of other surface waters in the watershed (Sections 2.4 and 2.5).

2.5.2.4 KEA – CONDITION - Toxins

A number of environmental toxins are of concern in the watershed, several of which are described in Section 2.2.2.8 along with viability ranking criteria using game fish health advisories and snapping turtle egg concentrations (Table 9). Conditions for toxins are ranked separately for waters below and above the Lighthouse Hill Reservoir due to the migration barrier imposed by the dam on fish returning from Lake Ontario, and for the Redfield Reservoir in the case of mercury. The Great Lakes are important sources of Mirex and PCBs and contaminated salmonines returning from Lake Ontario are believed to be a major source for these contaminants within the lower Salmon River watershed.

Indicator – Game Fish Tissue Mercury Concentration:

Current Condition – Redfield Reservoir - Poor: In 2006 the NYSDEC listed the Redfield Reservoir as a Section 303(d) Impaired Water due to mercury contamination in some game fish (NYSDOH 2006). It is likely that that mercury is being liberated from the reservoir sediments due to effects of fluctuating water levels on sediment chemistry (Evers et al. 2007).

Current Condition – Upper sub-watersheds - Unranked: Although the Redfield Reservoir was listed as an Impaired Water in 2006 due to mercury contamination, it is likely that that mercury is being liberated from the reservoir sediments. This mercury source is not expected to affect other water bodies upstream of the reservoir. However, it is also possible that mercury may be liberated from the extensive wetland systems, including small open waters, in the upper sub-watersheds due to similar interactions of fluctuating water chemistry on mercury liberation from sediments (Evers et al. 2007). No information is available on mercury contamination for other open water bodies of the upper watershed.

Current Condition – Lower sub-watersheds - Fair: Mercury is present in game fish below the dam, but no fish consumption advisories are currently in effect for mercury below the reservoir. It is not known whether mercury advisories are appropriately applied to other open water bodies in the lower watershed.

Indicator – Game Fish Tissue and Snapping Turtle Egg PCB Concentrations:

Current Condition – Upper sub-watersheds - Unranked: No information was available on PCB concentration in game fish above the Redfield Reservoir. There is currently no PCB fish consumption advisory for the Reservoir (NYSDOH 2006). No information is available on snapping turtle eggs in sections of watersheds that are isolated from Lake Ontario (available data are from Rice Creek Biological Station).

Current Condition - Lower sub-watersheds – Poor to Fair: There is currently a fish consumption advisory for PCBs in smallmouth bass taken from the Salmon River from the mouth to the Reservoir (NYSDOH 2006). It is not known whether PCB advisories are appropriately applied to other open water bodies in the lower watershed. In applying snapping turtle egg criteria, Pagano et al. (1999) reported snapping turtle egg concentrations to be 1.5 mg/kg at the nearby Rice Creek Biological Station in Oswego County, indicating the presence of PCBs in aquatic systems linked to Lake Ontario.

Indicator – Game Fish Tissue and Snapping Turtle Egg Mirex Concentrations:

Current Condition – Upper sub-watersheds – Good: Data made available by NYSDEC (J. Skinner, unpublished data) indicate that Mirex concentrations in fish taken above the Salmon River reservoir were below detection limits in 1988. Given that Mirex has shown a declining trend in the environment over the last few decades (J. Skinner, personal communication), and that Mirex appears to originate from sources in the Great Lakes, it is not believed that Mirex poses a threat to water bodies above the Lighthouse Hill Reservoir.

Current Condition - Lower sub-watersheds – Poor: There is currently a fish consumption advisory for Mirex in smallmouth bass taken from the Salmon River from the mouth to the Reservoir (NYSDOH 2006). It is not known whether fish consumption advisories for Mirex are appropriately applied to other open water bodies in the lower watershed. Pagano et al. (1999) reported Mirex concentrations in snapping turtle eggs to be 0.04 kg/mg at the nearby Rice Creek Biological Station in Oswego County.

2.5.2.5. KEA-CONDITION – Aquatic Plant Communities

Plant and algal communities will vary among the lakes and ponds of the watershed based upon water depth and trophic status of the water bodies. Guidance regarding the expected communities in small ponds of the region has not been obtained. The following considerations apply to the Redfield Reservoir.

Indicator – Total Macrophyte Cover: No information on the anticipated natural range of variation in aquatic vegetation of the reservoir could be located to serve as a quantitative baseline for estimating viability. Viability is ranked based upon the professional judgment of local researchers.

Current Condition – Good: Harman et al. (2000) conducted a survey of aquatic macrophytes in the Redfield Reservoir in 1999. They reported that most of the shoreline is emergent or shrub wetland, and that the lake supports little true aquatic vegetation. The submerged flora is diverse, but comprises little biomass within the reservoir. They concluded that cobble substrate, varying water levels, tea-colored water that precludes light penetration, and low nutrient status of the water combine to limit the production of aquatic macrophytes (including invasives) and algae. An earlier survey by (Petreszyn 1990) indicated the presence of no aquatic plants in the reservoir in 1990. Table 22 reports the Harman et al. (2000) data on macrophyte patches within the reservoir.

Table 22. Average cover (percent) of aquatic plant species at given depths in macrophyte beds of the Salmon River Reservoir in 1999 (Harman et al 2000). Data are averages of cover class midpoints from replicate transects placed systematically through macrophyte beds. Invasive species are indicated with an asterisk (*). These data do not estimate overall cover in the Reservoir.

	------water depth (m)-----			
Species	0.5	1	2	3
sedge (*Carex* spp.)	3			
knotweed (*Polygonum* sp.)	3			
broadleaf arrowhead (*Sagittaria latifolia*)	3			
bur-reed (*Sparaganium* sp.)	3			
*purple loosestrife (*Lythrum salicaria*)	3			
needle spikerush (Eleocharis acicularis)	3	3		
*Eurasian milfoil (*Myriophyllum spicatum*)		3		
wild celery (*Vallisneria americana*)		3		
bladderwort (*Utricularia* sp.)		15		
ribbonleaf pondweed(*Potamogeton epihydrus*)		3		
variableleaf pondweed (*Potamogeton gramineus*)	3	15		
Sago pondweed (*Potamogeton pectinatus*)	3	3	3	
small pondweed (*Potamogeton pusillus*)		3	3	
nodding water nymph (*Najas flexilis*)		37	3	
muskgrass (*Chara* sp.)		3		
total cover	24	88	9	0

Indicator – Invasive Species Dominance (% of total cover): Table 4 provides guidance for ranking macrophyte communities relative to invasive species dominance.

Current Condition – Good to Fair: Two potentially invasive macrophyte species (purple loosestrife and Eurasion milfoil, were observed in the Reservoir in 1999 (Harman et al. 2000), but when they were encountered, these species occurred in low relative abundance (Table 22). Purple loosestrife represented 12% of the total cover at 0.5 m depths, and milfoil accounted for 3% of total cover at 1 m depths. Milfoil was not thought to be a threat since it tends to occur in disturbed, eutrophic environments. This reservoir has a cobble bottom, with varying water levels and dark water color, which limits light penetration. All these variables limit milfoil.

2.5.2.6 KEA – CONDITION – Fish Community Composition

Fish communities of ponds, beaver dams and reservoirs will be dominated by warm water fish species, and will also reflect species that are introduced through stocking or by naturally reproducing species that are able to migrate to these waterbodies. Fish species frequently found in farm ponds include bluegill (*Lepomis macrochirus*) and yellow perch (*Perca flavescens*). Larger reservoirs support species such as chain pickerel (*Esox niger*), and other pikes (*Esocidae*); brown bullhead (*Ictalurus nebulosus*), yellow bullhead (*I. natalis*), bluegill (*Lepomis macrochirus*), pumpkinseed *L. gibbosus*), golden shiner (*Notemigonus crysoleucas*), and fathead minnow (*Pimephales promelas*). Reservoirs are often stocked with rainbow trout (*Salmo gairdneri*) (Edinger et al. 2002).

No information is available on fish communities inhabiting the smaller ponds of the watershed. The following information is specific to the Redfield and Lighthouse Hill Reservoirs.

Indicator – Fish Species Richness and Community Composition: This indicator is ranked based upon current management objectives for the Reservoir and the opinions of local fisheries managers.

Current Condition – Good: The Redfield Reservoir is a warm/cool water fishery that is managed by NYSDEC for game fish species. An NYSDEC survey was conducted in June 2003 using electroshocking techniques (Table 23). Certain biases are introduced to fish community composition data based upon season and methodology of sampling. This sample underestimates forage fish (minnows, young-of-year perch and panfish) which provide food base for other piscivores. The reservoir currently contains at least 16 species, including six game fish species. Stocking for walleye began in the reservoir in 2005 and therefore this species does not appear in the 2003 sample data. Tributaries to the reservoir are stocked with rainbow and brook trout. Bass were introduced in 1960s and these have flourished without additional stocking (F. Verdoliva, NYSDEC, personal communication). NYSDEC fisheries managers believe the Redfield Reservoir fishery to be in good condition.

The Lighthouse Hill Reservoir is managed as a cool water fishery, and is stocked with rainbow trout (~4000/yr). It was previously stocked with brown trout until 1991 (F. Verdoliva, NYSDEC, personal communication).

Table 23. Fish community composition of the Redfield Reservoir. Data are relative abundance of fish species in June 2003 electroshocking survey. (Source: R. Klindt, D. Bishop, NYSDEC, Region 7 Fisheries).

Species	Total
yellow perch	252
pumpkinseed	212
largemouth bass	120
smallmouth bass	92
rock bass	54
common shiner	10
golden shiner	5
white sucker	5
bluntnose minnow	3
rainbow trout	3
black crappie	1
brown bullhead	1
centeral mudminnow	1
creek chub	1
Etheastoma sp.	1

2.4.2.7 KEA – LANDSCAPE CONTEXT – Barriers to Migration

Indicator – Proportion of 540-ft Buffer in Natural Cover. Discussion regarding the ecological importance of natural vegetation cover in wide buffers strips along streams and other water bodies is provided in Section 2.3.2.7 and ranking criteria for this indicator is presented in Table 6. Buffer analyses were conducted only for the Lighthouse Hill and Redfield reservoirs.

<u>Current Condition – Lighthouse Hill Reservoir, Fair; Redfield Reservoir, Good:</u> Figure 33 illustrates land-cover types surrounding the Lighthouse Hill and Redfield reservoirs. Natural vegetation represents 87% and 98% of the land-cover types within the 540-ft buffers of the Lighthouse Hill and Redfield reservoirs, respectively.

2.5.3 Open Waters
Viability Summary

Notes on Guidance for Current Condition:

"NG"	No guidance was obtained to rank this indicator
"SGR"	Subjective guidance and/or ranking based on professional opinion
"ND"	No data are available with which to rank this indicator

	Exellent	Good	Fair	Poor	Current Condition	Notes on Guidance for Current Condition
KEA-Size						
Ind. -% of total current open waters (excluding reservoirs)		>90	75-90	<75	Good	SGR
KEA - Condition - Beaver Dams						
Ind. - % open waters beaver-influenced					Unranked	NG
KEA-Condition-Water Quality						
Ind. - % of 100-ft buffer in natural cover types		>90	75-90	<75		SGR, Klapproth & Johnson (2000), Baird & Wetmore (2006)
Redfield Reservoir					Good	
Lighthouse Hill Reservoir					Good	
Ind. - Carlson Trophic State Index		<50		>50	Unranked	ND - USEPA 2007
Ind. – pH		>6.5	5.0-6.5	<5		Driscoll et al. (2001), Stoddard et al. (2003), Shreiber (2007)
Redfield Reservoir					Good	
Other open waters					Good	extrapolated from headwaters

	Exellent	Good	Fair	Poor	Current Condition	Notes on Guidance for Current Condition
Ind. - Alkalinity (mg/L CaCO3)	>100	2.5-100	0-2.5	<0		Driscoll et al. (2001)
Reservoirs					Good	
Other open waters					Good	extrapolated from headwaters
KEA-Condition-Toxins						
Ind.– Game fish mercury concentration (ppm)			0-1	>1		NYSDOH (2006) fish consumption advisories
Redfield Reservoir					Poor	
Upper sub-watersheds					Unranked	
Lower sub-watersheds					Fair	
Ind.– Game fish PCB concentration						NYSDOH (2006) fish consumption advisories
Upper sub-watersheds					Unranked	
Lower sub-watersheds					Poor	
Ind.- Snapping turtle egg PCB concentrations		0	0-2	>2		Pagano et al. (1999)
Upper sub-watersheds					Unranked	
Lower sub-watersheds					Poor-Fair	
Ind.- Game fish Mirex concentrations (ppm)						NYSDOH (2006) fish consumption advisories
Upper sub-watersheds					Good	
Lower sub-watersheds					Poor	
Ind.- Snapping turtle egg Mirex concentrations		0	0-0.2	>0.2		Pagano et al. (1999)
Upper sub-watersheds					Good	
Lower sub-watersheds					Fair	

	Exellent	Good	Fair	Poor	Current Condition	Notes on Guidance for Current Condition
KEA-Condition-Aquatic Plant Communities						
Ind. - Macrophyte percent cover (for Redfield Reservoir)					Good	SGR, Harman et al. (2000)
Ind. - Invasive plant cover (avg % cover – Redfield Reservoir)	0	<5	5-25	>25	Good-Fair	Drake et al. (2003)
KEA-Condition-Fish Communities						
Ind. - Observed Richness (Redfield Reservoir)					>16 Good	SGR
KEA-Landscape Context-Barriers to Migration						
Ind. - % of 540-ft buffer in natural cover types		>90	75-90	<75		
Redfield Reservoir					Good	SGR
Lighthouse Hill Reservoir					Fair	SGR