

**INSTREAM PROTECTED USES, OUTSTANDING
CHARACTERISTICS, AND RESOURCES OF THE SOUHEGAN
RIVER AND PROPOSED PROTECTIVE FLOW MEASURES FOR
FLOW DEPENDENT RESOURCES**

JULY 2004

PRELIMINARY REVIEW DRAFT-DO NOT CITE

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**Prepared for
State of New Hampshire Department of Environmental Services**

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1.0 INTRODUCTION AND PURPOSE

The primary objective of this effort is to establish a comprehensive list of flow dependent Instream Protected Uses, Outstanding Characteristics and Resources (IPUOCR) entities for the designated reach of the Souhegan River and methods for assessing their flow dependence. Based on their seasonal flow requirements, these entities will serve as guideposts for designating protected instream flows. The IPUOCR evaluated included the list developed by the Department (NHDES 2004) as a starting point augmented by literature searches, stakeholder consultation and a field visit. Such information included but was not limited to designated river nomination reports, river corridor management plans, natural resources studies, natural heritage inventories and environmental assessments and impact statements. The draft IPUOCR list and supporting information was refined following review and comment by DES and the advisory committee and is the basis for the discussion of resources in this draft IPUOCR report. The final IPUOCR list was divided into flow dependent and non-flow dependent entities. Approaches for establishing protected instream flows (PISF) for flow dependent IPUOCR are presented in this report.

2.0 METHODS OF ASSESSMENT

2.1 OVERVIEW OF ALL POTENTIAL IPUOCRS

The New Hampshire Department of Environmental Services (DES) has defined the Instream Public Uses, Outstanding Characteristics, and Resources (IPUOCR) that must be evaluated and included in the development of a PISF Study and eventual Water Management Plan (WMP). Categories of potential IPUOCR include the following:

- **Navigation:** The use of the river for non-recreational, transportation purposes.
- **Recreation:** Use of the river for swimming, boating or significant shoreland recreation such as hiking, camping, picnicking and bird watching.
- **Fishing:** both Recreational Use and Commercial Use
- **Storage:** Natural or man-made attributes of a river for water storage.
- **Conservation/Open Space:** Issues concerning management of open space, conservation easements or municipal, state or federal parks.
- **Maintenance and Enhancement of Aquatic and Fish Life:** Those aquatic-dependent species that make up a balanced, integrated and adaptive community of organisms having a species composition, diversity and functional organization comparable to that of similar natural habitats of a region.
- **Fish and Wildlife Habitat:** Species that rely on flow and flow to regions which are important to the survival of fish and wildlife populations, including but not limited to: spawning and feeding beds, waterfowl breeding or wintering areas, freshwater wetlands or riparian habitat.

- Rare, Threatened or Endangered (RTE): fish, wildlife, vegetation or natural/ecological communities: As listed by New Hampshire Natural Heritage Inventory (NHI) and nomination papers.
- Water Quality Protection/Public Health: Characteristics that maintain water quality of the river including, but not limited to, chemical and physical parameters that support designated and existing uses.
- Public Water Supply: An existing source of public drinking water as defined in Env-Ws 302.02.
- Pollution Abatement: Wastewater treatment facilities or industrial treatment facilities and aspects of flow affecting assumptions of flow for dilution and dispersal of waste in mixing zones and the river's overall capacity to mitigate natural and non-point source contamination.
- Aesthetic Beauty/Scenic: Including but not limited to designated viewing areas, scenic vistas and overlooks.
- Hydroelectric Energy Production: An existing hydroelectric facility or a former hydroelectric facility site that has been unused for fewer than six years.
- Cultural: On-going river corridor management planning effort or other local efforts to protect or manage the river, riverside parks or other public areas, or community support for riverfront revitalization.
- Historical or Archaeological: Based on the presence or absence of known historical or archaeological resources.
- Community Significance: A natural, managed, cultural or recreational resource or use thereof associated with the river that is recognized by local residents or a municipal document as being important to the community adjacent to the river.
- Hydrological/Geological: A national, regional, state or local resource as determined by the state geologist or as listed in a national or state resource assessment.
- Agricultural: As defined by RSA 21:34a.

2.2 DRAFT LIST OF IPUOCR ENTITIES

From the universe of potential IPUOCR, the project team developed a draft list that included IPUOCR that were confirmed to be present along the designated reach or suspected to be present. Natural history and location information was reviewed for each IPUOCR, and compared to initial criteria for assigning an IPUOCR plant or wildlife species or natural community or other entity to a flow-dependency category. The criteria were:

Flow-Dependent – Species with one or more life stages requiring shallow standing/flowing water within banks of river channel during summer; or a community that provides habitat for such species as an important function were included in this category. Other entities such as canoeing and kayaking and hydropower were included in this category if they were determined to be reliant on flow.

Potentially Flow-Dependent – Entities with an unclear link to flow were included in this category as well as entities with known flow dependence but unknown or unconfirmed presence in the designated reach. A determination of flow dependence was to be made for these entities after further literature review and the site visit.

Non Flow-Dependent – Entities in this category met none of the above criteria. The life cycles of species or activities associated with the entities in this category were not dependent on water flow or levels within river channels or floodplain at any time of the year. These entities do not depend on flow.

The draft list was delivered to NHDES on June 21, 2004 and subsequently distributed within the NHDES and to the technical review committee (TRC) and the Water Management Planning Area Advisory Committee (WMPAAC). The draft list, comments on the draft list and observations from the site visit formed the basis for the final list of IPUOCR for the designated reach of the Souhegan River.

2.3 LITERATURE REVIEW

Numerous sources of information describing the resources of the Souhegan River have been reviewed including a nomination report (SRN 1999), watershed study (NRPC 1995), and water monitoring data (NHDES 2001). Other available information reviewed included NRCS soil maps, National Wetland Inventory maps, geologic resource maps, GRANIT GIS layers and aerial photos.

The reviews of available information was structured to develop the information base necessary to prepare a preliminary list of IPUOCR entities for the designated reach and to annotate each entity on the basis of river location and dependence on flow conditions. This preliminary list was confirmed to the extent possible and supplemented, where necessary, through consultation with state and local government and the field survey.

2.4 CONSULTATION

Agencies and organizations contacted by NAI or the NHDES included groups such as Souhegan Technical Review Committee and Water Management Area Advisory Committee members, New Hampshire Natural Heritage, Nashua Regional Planning Commission, Souhegan River Watershed Association, New Hampshire Fish and Game and the relevant conservation commissions. New information from these groups was added to the GIS database and used to describe the IPUOCR entities.

2.5 FIELD SURVEY

An on-stream survey was conducted on June 28-30, 2004 to verify the existence and occurrence of the IPUOCR entities. This 3 day field survey of the entire designated reach included stops at specific prescreened locations to document the presence of each entity or the presence of conditions or habitat suitable for each entity. Candidate locations for field verification were determined from data compiled by NHDES, GRANIT layers, New Hampshire Natural Heritage data and information obtained from watershed groups. The intent was to insure that examples of critical locations of flow dependent or potentially flow dependent resources were visited. The

field crew was split into two teams. One team led by University of Massachusetts, evaluated habitat and aquatic fauna within the stream channel while a second team led by Normandeau Associates and University of New Hampshire evaluated riparian and upland resources.

A set of maps was produced which presented the available geographic information on the critical resources of the designated reach along with points to be visited to guide the field visit. At each stop, the resources on the map were confirmed and photo documented according to the NHDES photo documentation procedures. The photos were geo-referenced using GPS and added as a layer to the GIS database. Occurrences of resources not represented in the existing database were documented. The procedures used for conducting the survey are provided in Appendix A. Locations along the designated reach upstream of the Route 122 Bridge in Amherst were visited on foot or by vehicle. The reach from Route 122 to the Turkey Hill Road Bridge was canoed. The reach from the Turkey Hill Road Bridge to the Merrimack River was visited on foot or by vehicle. Typical resources encountered are presented in Figures 2.1 and 2.2. (Note: these figures were too large to include in the electronic version of this draft).

HYDRMORPHOLOGY AND FISH

In the primary survey of the Souhegan River which began on June 28, 2004, the purpose was to identify stretches within the river, which identify unique hydro-morphological characteristics (HM), and instream public uses, outstanding characteristics and resources (IPUOCR's).

The equipment needed per team to perform the survey included a Hewlett Packard IPaq loaded with ESRI's ArcPad software, and ortho-photographs covering the Souhegan River and surrounding area. ArcPad was loaded with forms for entering hydro-morphologic data to be associated with the orthophotographs and sections of the river. A field notebook was used in collecting notes on each section, entrenchment, embeddedness, as well as velocity and depth percentages. A waterproof digital camera, used in conjunction with the standard operating procedure set by the New Hampshire Department of Environmental Services, was used to take photographs of some sections and points of interest along the river. A thermometer gun was used to take the surface temperature of much of the river. A canoe was used for navigating portions of the river too deep or inefficient to cover on foot. Using this equipment, the survey employed the following methods.

To begin the survey, the Souhegan River was entered at a known location, and followed either upstream or downstream. Locations were found by use of a global positioning system (GPS), which located the team's position upon the orthophotographs. If locations were easily identified by the characteristics of the river or surrounding areas, or the GPS was not available due to satellite coverage or canopy density, then locations could be determined manually. As each section of river was traversed, the characteristics of the river were considered.

These characteristics included the flow pattern, the substrate, surrounding banks and vegetation, canopy cover and the hydraulic patterns of the river. When the river had made an obvious change in characteristics, then the river was divided at that point, and the section traversed was mapped. In mapping, a polygon was created covering the section of the river on the ortho-photos in ArcPad, and an accompanying form was filled out for the hydro-morphologic characteristics

of that section. Once the data had been collected, each successive section upstream or downstream was mapped. Each section was numbered for identification. The river was mapped around impoundments, depending upon the size and influence each dam had upon the rivers form.

The polygons created in ArcPad were downloaded at the end of each day so the river could be considered and analyzed as a whole. In ArcMap, the sections were all included to form the study area of the river, and the results of the HMU data could then be analyzed.

Once these sections were merged in the data set, we performed a thorough analysis of collected data, aerial photographs as well as IPUOCR information. Consequently the river was concisely divided up into nine distinct reaches which generalized the 73 sections into which it was originally divided. The reaches were determined according to similar characteristics, particularly determined overall by the HMU's distribution, gradient, and substrate but also the level of human induced alterations. In these reaches, similar habitats and species could be assumed to be potentially present.

A hierarchical cluster analysis was performed using statistical software, which gathered similar sections within a reach according to their characteristics. Integrating the results of cluster analysis with expert opinion we identified 11 representative sites. These eleven sites cover about 7 miles of the Souhegan River and are the focus of the following survey in which the HMU's and IPUOCR will be surveyed for their influence upon the instream flow and habitat for fish and wildlife.

One impoundment will be also selected as a representative site of the other impoundments in the designated reach. The selection of an impoundment will be performed at a later time.

2.6 SCREENING METHODS

The IPUOCR contained in the draft list was augmented with a literature review and observations from the field reconnaissance survey. The revised list was then split into two categories based on the dependence of the entity on stream flow. These categories were flow dependent which included resources with specific well established flow requirements and non flow dependent. Potentially flow dependent resources from the draft list were assigned to either flow dependent or non-flow dependent categories.

The non-flow dependent IPUOCR are discussed below but are not expected to be addressed further in this study. The flow dependent resources are also discussed below along with proposed methods of assessment to be used establish a protective instream flow (PISF) for each resource requiring an acceptable minimum flow. Resources requiring flows other than acceptable minimums (appropriate average or floods flows for example) are also discussed. A flowchart describing the screening process for flow dependent resources is provided in Figure 2.1.

2.7 FLOW DEPENDENCE AND CRITICAL FLOW RELATED CHARACTERISTICS OF IPUOCR ENTITIES

The list of IPUOCR entities for the Souhegan River is extensive. However, many of these entities are not flow dependent. The matrix presented in Table 2.1 contains information from the preliminary list, comments on the list, literature review and the reconnaissance site visit. All IPUOCR entities were then classified as either flow dependent or non-flow dependent based on information known to the project team to date. Categories in the matrix include: the resource, the reason for inclusion, the local, regional and national importance of the resource and the flow requirement of the resource including seasonality and duration, if known. The specific locations of resources that are rare, threatened or endangered were reviewed to the extent they were available but they are not presented. Likewise infrastructure information (dams, POTWs, water supplies) that could be used in a destructive manner was reviewed but is not presented. The NHDES will make the ultimate decision on whether or not to publish these data. The matrix of IPUOCR entities provides essential information needed to screen candidate methods for the determination of protected instream flow.

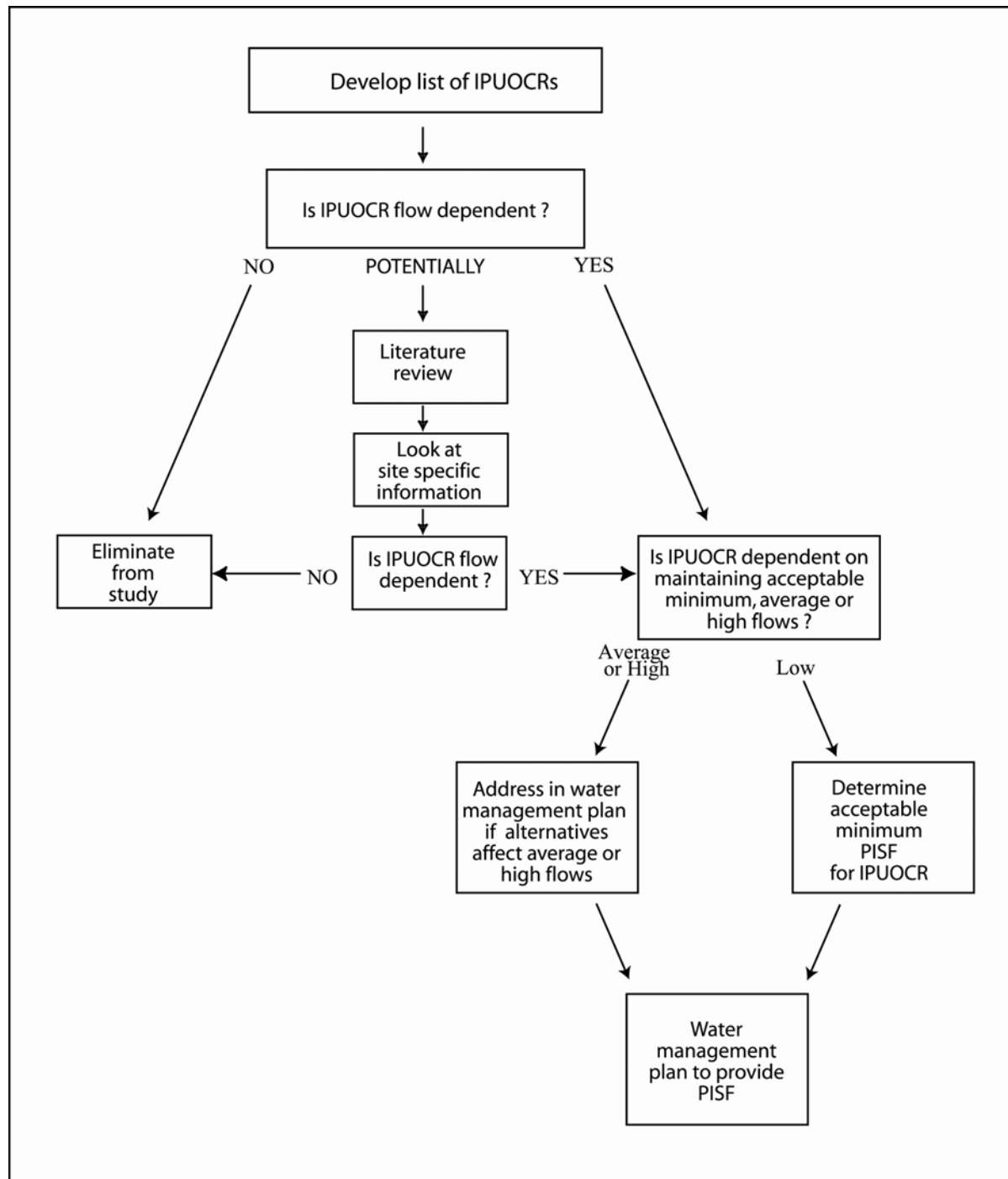


Figure 2.1. Flow chart of screening process

Table 2.1. Matrix of IPUOCRS including flow dependence, reason for inclusion, critical seasons, life stages and method of assessment.

Category	Entity	Location	Flow Dep. F, P, N	Critical Flows High, Avg., Low High, Ave	Critical Life Stage	Critical Season Sp Su F W	Method of Assessment
Recreation	Boating		F			Sp, F	compare water management alternatives to flow needs
Storage	SOUHEGAN RIVER DAM - New Ipswich	NEW IPSWICH	N				
	WATERLOOM POND DAM-New Ipswich	NEW IPSWICH	N				
	OTIS DAM-Greenville	GREENVILLE	N				
	SOUHEGAN RIVER DAM-Wilton	WILTON	N				
	SOUHEGAN RIVER III DAM	GREENVILLE	N				
	SOUHEGAN RIVER III DAM	GREENVILLE	N				
	SOUHEGAN RIVER III DAM	WILTON	N				
	SOUHEGAN RIVER DAM	WILTON	N				
	PINE VALLEY MILL DAM	WILTON	N				
	GOLDMAN DAM	MILFORD	N				
	MCLANE DAM	MILFORD	N				
	MERRIMACK VILLAGE DAM	MERRIMACK	N				

Category	Entity	Location	Flow Dep. F, P, N	Critical Flows High, Avg., Low	Critical Life Stage	Critical Season Sp Su F W	Method of Assessment
Fishing			F	Low	Adults	Su	mesohabsim
Conservation/ Open Space			N				
Aquatic and Fish Life Maintenance	Native Fish		F	Low			mesohabsim
	Introduced Fish		F	Low			mesohabsim
	Mussels		F	Low			mesohabsim
	Insects		F	Low			mesohabsim
Fish and Wildlife Habitat			F	Low			mesohabsim
RTE Species/Ecol. Communities	Banded Sunfish		F	Low	unknown	unknown	mesohabsim
	Fowler's Toad	Milford, Amherst	F	Low	Eggs, Larvae	Su	Transect/Seasonal Water Level Assessment
	Pied-billed Grebe	Amherst	F	Low, Avg, High	Eggs, Nest., Ad.	Sp, Su	Link to Emergent Wetland Model
	Long's Bitter Cress	Greenville	F	Low	All	Su	Transect/Seasonal Water Level Assessment
	Emergent Wetlands	Greenville, Amherst, Merrimack	F	Low, Avg, High	All	Su	Transect/Seasonal Water Level Assessment

Category	Entity	Location	Flow Dep. F, P, N	Critical Flows High, Avg., Low	Critical Life Stage	Critical Season Sp Su F W	Method of Assessment
	Wood Turtle	Amherst, Merrimack	F	Low	Adult	W	Transect/Seasonal Water Level Assessment
	Osprey	Milford	F	Low, Avg	Adult	Sp, Su, F	Link to Fish Model
	Common Loon	Amherst	F	Low, Avg	Adult	Sp, Su, F	Link to Fish Model
	S. New Eng. High Energy Riverbank Community	Greenville, Wilton	F	High, Avg	All	Sp	Transect/Seasonal Water Level Assessment
	S. New Eng. Floodplain Forest Comm.	Merrimack, Amherst	F	High, Avg	All	Sp	Transect/Seasonal Water Level Assess.
	Wild Garlic	Merrimack	F	High, Avg	All	Sp	Link to Floodplain Forest Model
	Eastern Hognose Snake	Amherst, Merrimack	N				
	Grasshopper Sparrow	Amherst, Merrimack	N				
	Giant Rhododendron	Greenville, Milford, Wilton	N				
	Siberian Chives	Merrimack	N				
	Birds Foot Aster	Merrimack	N				
	Skydrop Aster	Merrimack	N				
	Goat's Rue	Merrimack	N				
	Stiff Tick Trefoil	Merrimack	N				

Category	Entity	Location	Flow Dep. F, P, N	Critical Flows High, Avg., Low	Critical Life Stage	Critical Season Sp Su F W	Method of Assessment
Water Quality Prot./Public Health			N?	Low?			review volunteer and NHDES monitoring data
Public Water Supply	Pennichuck Water Works		F	Low			Task 2 hydrogeo investigation
Pollution Abatement	Greenville WWTF (wastewater), Souhegan Wood products (non-contact cooling waters)		F	Low		Su	review permits and NHDES holdings
	Hitchiner Manufacturing (non- contact cooling waters), Milford WWTF (wastewater)		F	Low		Su	review permits and NHDES holdings
	Harcros Chemicals (non-contact cooling waters). Savage Well Superfund site		F	Low		Su	review permits and NHDES holdings
	Fletcher Paint Superfund site		F	Low		Su	review site documents
Aesthetic Beauty/Scenic			N				review site documents

Category	Entity	Location	Flow Dep. F, P, N	Critical Flows High, Avg., Low	Critical Life Stage	Critical Season Sp Su F W	Method of Assessment
Hydroelectric Energy Production	Waterloom Pond Dam	New Ipswich	F	Low?, Ave		Sp, Su, F W	interview dam owner
	Otis Dam	Greenville	F	Low?, Ave		Sp, Su, F W	interview dam owner
	Souhegan River III Dam	Greenville	F	Low?, Ave		Sp, Su, F W	interview dam owner
	Souhegan River Dam	Greenville	F	Low?, Ave		Sp, Su, F W	interview dam owner
	Souhegan River III Dam	Wilton	F	Low?, Ave		Sp, Su, F W	interview dam owner
	Pine Valley Mill	Wilton	F	Low?, Ave		Sp, Su, F W	interview dam owner
	McLane Dam	Milford	F	Low?, Ave		Sp, Su, F W	interview dam owner
Cultural Historical or Archaeological Community Significance			N				
Hydrological/ Geological	River Morphology		F	High		Sp, F	

3.0 DISCUSSION OF IPUOCR ENTITIES AND PISF METHODS

3.1 FLOW DEPENDENT IPUOCRS

Fishing

The majority of the fishing in the river is for stocked trout. The Souhegan River is regularly scheduled for stocking, and their stocking schedule can be found on the New Hampshire Fish and Game website. The species stocked in the river for 2003 were Brown Trout, Eastern Brook Trout and Rainbow Trout (see Table 3.1). The Souhegan River is a popular river for recreational fishing, as it is easily accessible, and provides a variety of habitats.

Table 3.1 Fish Stocked in Souhegan River in 2003.

TOTAL FISH STOCKED IN SOUHEGAN RIVER - 2003				
TOWN	SPECIES	AGE OF FISH	# OF FISH	LBS. OF FISH
AMHERST	BT	1+YR	945	390
AMHERST	EBT	1+YR	645	268
AMHERST	RT	1+YR	670	670
GREENVILLE	BT	1+YR	945	390
GREENVILLE	EBT	1+YR	730	329
GREENVILLE	RT	1+YR	310	310
MERRIMACK	BT	1+YR	400	168
MILFORD	BT	1+YR	995	411
MILFORD	EBT	1+YR	625	260
MILFORD	RT	1+YR	970	970
NEW IPSWICH	EBT	1+YR	600	272
NEW IPSWICH	RT	1+YR	200	200
WILTON	BT	1+YR	945	389
WILTON	EBT	1+YR	690	290
WILTON	RT	1+YR	590	590
BT	BROWN TROUT			
EBT	EASTERN BROOK TROUT			
RT	RAINBOW TROUT			

Maintenance and Enhancement of Aquatic and Fish Life

Resident Native Fish Community

We are in the process of defining a resident native fish community for the Souhegan River. Our strategy is to divide the Souhegan River into two separate fish communities. Producing an upper reach and a lower reach with the line of demarcation taking place in Milford, where a distinct change in river morphology is observed. Upon completion of this task target headwater and base level fish communities will be generated. See Tables 3.2 and 3.3.

Table 3.2. Breakdown of species by tributary and incorporated into single chart of Souhegan River

SOUHEGAN RIVER		
Species	Number of Fish	Percent of Total Fish
Longnose dace	231	28.88
Blacknose dace	212	26.50
Common shiner	148	18.50
Common White Sucker	79	9.88
Fallfish	73	9.13
Atlantic Salmon (stocked)	31	3.88
Golden Shiner	10	1.25
Yellow perch	4	0.50
Brown bullhead	3	0.38
American Eel	3	0.38
Redbreasted sunfish	2	0.25
Rainbow Trout	2	0.25
Pumkinseed sunfish	1	0.13
Brown Trout	1	0.13
Total	800	100
Purgatory Brook		
Species	Number of Fish	Percent of Total Fish
Common Shiner	98	37.98
Blacknose Dace	81	31.40
Common White Sucker	76	29.46
Longnose Dace	3	1.16
Total	258	100

Riddle Brook		
Species	Number of Fish	Percent of Total Fish
American Eel	1	20.00
Eastern Chain Pickerel	2	40.00
Blue Gill	1	20.00
Golden shiner	1	20.00
Total	5	100

S.B. Souhegan River Ashby		
Species	Number of Fish	Percent of Total Fish
Fall fish	44	26.51
Brown bullhead	44	26.51
Creek chubsucker	30	18.07
Common white sucker	25	15.06
Pumpkinseed	11	6.63
Yellow bullhead	4	2.41
Brown trout	2	1.20
Chain pickerel	2	1.20
Largemouth bass	2	1.20
Brook trout	1	0.60
American eel	1	0.60
Total	166	100

Mcquade Brook		
Species	Number of Fish	Percent of Total Fish
Banded Sun fish	3	37.50
Eastern Chain Pickerel	3	37.50
American Eel	1	12.50
Yellow Bullhead	1	12.50
Total	8	100

Table 3.2. cont. Breakdown of species by tributary and incorporated into single chart of Souhegan River

Baboosic Brook		
Species	Number of Fish	Percent of Total Fish
Longnose Dace	15	18.75
Silvery Minnow	13	16.25
Blacknose Dace	11	13.75
Brown Bullhead	6	7.50
Margined Madtom	6	7.50
Longnose Sucker	5	6.25
Tessellated Darter	5	6.25
Common Shiner	5	6.25
American Eel	3	3.75
Fallfish	3	3.75
Bluegill	2	2.50
Black crappie	2	2.50
Creek Chubsucker	2	2.50
Yellow Perch	1	1.25
Brown Trout	1	1.25
Total	80	100

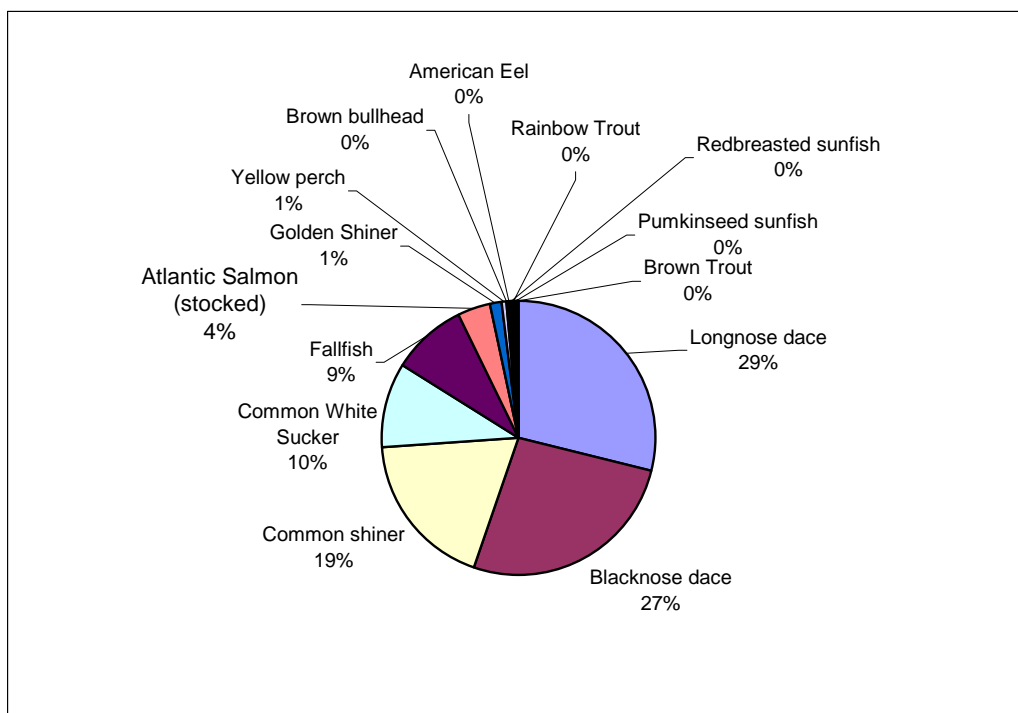


Figure 3.1 Historical Souhegan fish catches

Methods for achieving this goal include the selection of quality comparable rivers that are representative of both the upper and lower sections of the Souhegan River. Our representative rivers must possess physical similarities to the Souhegan and have sufficient historical data before target communities can be derived. At this time, due to a lack of historical fishing data our objectives can not be completed, but is planned for the near future.

Species	Month											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
American Eel	■	■	■									
Atlantic Salmon										■	■	■
Blacknose Dace					■	■	■					
Brook Trout									■	■	■	■
Brown Trout										■	■	■
Common Shiner					■	■	■	■				
Creek Chubsucker												
Golden Shiner						■	■	■	■			
Longnose Sucker				■	■							
Margined Madtom						■	■					
Rainbow Trout		■	■	■	■							
Smallmouth Bass					■	■	■					
Yellow Bullhead					■	■	■					

Native Fish Species

Species present in Souhegan River include American eel, Atlantic Salmon, Blacknose Dace, Brook Trout, Brown Bullhead, Chain Pickerel, Common Shiner, Common White Sucker, Creek Chub Sucker, Fallfish, Golden Shiner, Longnose Dace, Longnose Sucker, Pumpkinseed, Redbreast Sunfish, Spottail Shiner, Yellow Perch (SRWR 1997).

Introduced Fish Species

Species present in Souhegan River include Brown Trout, Largemouth Bass, Smallmouth Bass, Margined Madtom, Yellow Bullhead, and Rainbow Trout. Although these species are not native, they have been introduced and are part of the aquatic community (SRWR 1997).

Mussels

There are 12 species of freshwater mussels found in the northeast. A concise list of species can be obtained from the Connecticut Department of Environmental Protection. These species are important in bodies of water as they maintain clean water by filtering algae and plankton, and are eaten by many species of wildlife. The species with potential to be present in the Souhegan River include Eastern Pearlshell, Triangle Floater, Brook Floater, Creeper, Eastern Elliptio, Eastern Floater, Alewife Floater, Eastern Pondmussel, Tidewater Mucket, Yellow Lampmussel, and Eastern Lampmussel.

Most freshwater mussels live burrowed in sand and gravel substrates, often occurring in the shallows of rivers and streams. Many species prefer a habitat that offers highly oxygenated water and moderate current. Only a few species have adapted to life in lacustrine zones such as lakes, ponds, and reservoirs. Mussels play an important role in river ecology. Their filtering ability makes them natural water purifiers. They are an integral part of the food web as a food source for raccoons and muskrats. Mussels also depend on many different fish species as a means of locomotion. Some of the identified hosts include blacknose dace, golden shiner, longnose dace, margined madtom, pumpkinseed, slimy sculpin and yellow perch. Mussels are good indicators of water quality. Factors such as water pollution, siltation, and impoundments have been known to cause declines in mussel populations. Well-established, diverse mussel colonies generally indicate a healthy aquatic environment.

The life cycle of mussels starts with the release of sperm into the water by a male mussel, which a female mussel collects when siphoning water for food. The sperm is retained upon her gills, where her eggs are fertilized and develop in a few weeks. The next generation of mussels emerges after this time period as glochidia, the larvae of mussels. Fish play a host, as the glochidia attach to the gills of specific fish species. These host species of fish are attracted to the area through a lure, which the female mussel produces. The glochidia is capable of reaching new locations in which they can reproduce to start new populations. These mussel larvae disengage from the host fish after a period of time, and if they relocate onto suitable substrate and the flow of the river is appropriate, the immature mussel will develop, and continue the life cycle.

Many of the species of mussels found in the northeast are considered threatened, or of special concern to the states in New England. Only one species, the Dwarf Wedgemussel, is considered endangered in the state of New Hampshire, as it is listed nationally as endangered, however in the Souhegan River it is outside of its zoogeographical range.

Insects

There are a variety of insects which are dependant upon a river system for habitat and breeding grounds. In this study, dragonflies and damselflies are of most concern. These insects are in the family Odonata. There are many different species of dragonflies and damselflies, and many have been located in Hillsborough County, the county in which much of the Souhegan River and its

watershed is found. Dragonflies and damselflies are good indicators of water quality and are identifiable by their shed exoskeletons and adult forms. If water is impacted through sedimentation, an increase or decrease in stream flow or other drastic event, these insects are affected, as their presence indicates high quality water.

As of January 2003 there were 108 species of dragonflies and 44 species of damselflies in the State of New Hampshire. Currently, the only dragonfly species listed as endangered in the state of New Hampshire is the Ringed Bog Haunter (*Williamsonia linteri*.) Odonates occur around most types of fresh water, but are uncommon in fast moving sections of streams. Both dragonflies and damselflies seem to thrive near sluggish waters. As a family, Odonata require a diversity of substrates upon which their eggs are laid. Several characteristics of these organisms make them useful indicators of water quality: many are sensitive to physical and chemical changes in their habitat, many live in the water for periods exceeding one year, they cannot easily escape pollution as some fish can. Odonata are easily collected in many streams and rivers for research.

Biological summary of order (*Odonata*)

A. Life history

1. Eggs - usually several hundred to several thousand; either in water or in plants; usually hatch in several days to 1 month
2. Nymphal Stage (immature stage) - nymphs; usually almost 1 year (ranges from 3 weeks to 5 years)
3. Adults
 - A. Most species live 40 to 50 days
 - B. Crawl out of water to molt
4. Number of generations per year - most univoltine (some semivoltine or merovoltine)
5. Time of emergence - most spring and summer (some early fall)
6. Delays in development – during periods of adverse abiotic conditions diapause in the egg stage may commence for periods up to 7 months.

B. Habitat and habits

1. Adults - many disperse widely but return to spend most of adult life near preferred aquatic habitat (not necessarily their natal habitat); some fly almost all of the time, others perch for short periods between flights
2. Nymphs - dragonflies common in slow-moving flowing waters and standing waters; not many damselflies found in flowing waters; nymphs move rather slowly, if at all; lie in soft sediment or climb about in vegetation or plant debris

C. Food

1. Adults
 - A. Capture insects with spines on front legs
 - B. Large eyes, 360 degrees to capture prey
2. Nymphs - capture invertebrates (anything they can subdue) with hinged labium

D. Respiration of immature stages

Closed tracheal system with gills at end of abdomen; external in damselflies, internal in dragonflies

E. Behavior

Adults - male dragonflies defend territories; unique copulatory loop; some males remain with females during oviposition

F. Significance

Important source of food for many fish species.

Mussels and Dragonflies as Bioindicators

The presence of freshwater mussels and dragonflies in a river represent the water quality of that particular body of water. Surveying for these species would provide depth into understanding how water flow, substrate and water quality provide habitat for certain species and have potential for other species. The methods of surveying for dragonflies could be applied to mussels as well. In a given section of the river, ten to twenty samples should be taken from the substrate, either with a net or a collection box. These samples should then be identified and classified. For modeling purposes, specific species should be focused on, species which are likely to be found, and represented through the river. In modeling for mussels and dragonflies, a generic model can be proposed. This model states that there is a potential for certain species to be present in a given area and time for a given substrate and given flow. This model can be applied to either dragonflies or mussels, and could potentially be used for amphibians or other species.

Fish and Wildlife Habitat

The Souhegan is a Salmon Restoration river. The river is integral to the extremely successful US Fish and Wildlife Service (FWS) Adopt-a-salmon family project that uses a watershed approach for environmental education. At present, the river is the main release site for the program that currently involves approximately 25 schools in Massachusetts and New Hampshire. The river contains Atlantic salmon nursery habitat (gravelly, sloping bottoms, water temperatures, oxygen levels, and food sources), identified by FWS as the best nursery habitat in the region. The river is part of the Merrimack River anadromous fish restoration program and is considered one of the most productive rivers in the watershed (SRN 1999).

Life Histories

Fish use habitat for spawning, feeding, nursing grounds, migration, and shelter, but most single habitats do not meet all of a fishes needs. Fish change habitats with changes in life history stage,

seasonal and geographic distributions, abundance, and interactions with other species. The type of habitat, as well as its characteristics and functions, are important to a diversity of fish species, and their changing life history needs. Descriptions of fish species, their characteristics, and habitats may be found in Appendix 1.

LITERATURE CONSULTED FOR SOUHEGAN RIVER FISH HABITAT AND PISF

For this survey, a number of literature sources were consulted to provide insight into methods for surveying the Souhegan River. Each of the writings discusses methods of surveying flowing water, and eventually modeling its outcome. One source is a paper entitled “Overseas approaches to setting River Flow Objectives” by M. J. Dunbar et al. from the Environmental Agency and the Institute of Hydrology from the United Kingdom. Another source is “A Global Perspective on Environmental Flow Assessment: Emerging Trends in the Development and Application of Environmental Flow Methodologies for Rivers”, by R. E. Tharme of the Freshwater Research Institute at the University of Cape Town, South Africa. A third source consulted is “Instream Flows for Riverine Resource Stewardship”, by the Instream Flow Council. The fourth literature cited is “State-of-the-art in data sampling, modeling analysis and application of river habitat modeling,” a Cost Action 626 Report written by Atle Harby et al. Each approach, as described by this literature is individually determined, however, there is a definitive theme, which can be taken from their research, particularly concerning the assessment methods

A report by Dunbar et. al. identified three types of methods applied world-wide for the purpose of setting PISF.

“Look up” or standard-setting techniques, based upon simple hydrological indices such as percentage of the natural mean flow or an exceedance percentile on a natural flow duration curve are the most commonly applied. They generally aim to determine some sort of minimum ecological discharge, sometimes with seasonal considerations, sometimes with other thresholds (desirable, optimum). “Such methods require considerable resources to set up initially; but once developed require a relatively low level of resources per site. These standards can play an important monitoring and strategic role and provide interim objectives, where further investigation is justified. Good examples of look-up techniques include the “Tennant and Texas” method, and the “Basque” method.

The other set of methods is called “Discussion-based approaches and hydrological analysis”. These methods use “structured consideration of expert opinion”. “The methods are able to consider broad ecological functioning, plus species requirements at an intermediate level of detail. They may include elements such as hydraulic modeling, but the key assessment is undertaken at an expert panel workshop. This would be of particular use for setting more specific interim flow objectives, especially in the absence of clear species-related management targets, and ensuring effective targeting of further study.”

The third category is “Biological response modeling”, which refers to the Instream Flow Incremental Methodology (IFIM), and variations. “This type of approach is considered to be the most resource-intensive and defensible. Some countries have incorporated elements of the

holistic approaches into their IFIM-equivalent framework. Another common approach is to incorporate multivariate classification of river sector types and their biotic communities.”

The IFIM uses habitat simulation models as a basis for an integrative decision making process. It is frequently misunderstood and falsely considered to be equivalent to the Physical Habitat Simulation model (PHABSIM), which was the first modeling technique used for IFIM. Over the last twenty years the models have been applied at numerous sites and improved. There has been substantial debate regarding the validity of the models (for a review see Gore and Nestler, 1988). Since the elaboration of the original PHABSIM habitat modeling software (Bovee, 1982) there have been a number of important developments (see Parasiewicz and Dunbar, 2001).

The other two sources “A Global Perspective on Environmental Flow Assessment: Emerging Trends in the Development and Application of Environmental Flow Methodologies for Rivers”, by Tharme and “Instream Flows for Riverine Resource Stewardship”, by the Instream Flow Council provide similar perspective. They both identify standard setting approaches and concur with the notion that these methods are adequate only for reconnaissance-level studies. Both sources also identify modeling techniques as effort intensive but precise techniques that are applicable for negotiations and detailed resource use planning. As a third category Tharme identifies holistic methods that are in some sense similar to Dunbar's et. al. discussion based techniques, however at higher level of sophistication. In Annear et. al the third category is named “Monitoring and Diagnostic Methods that Assess the Conditions”. Those however are considered a tool of adaptive management.

“State-of-the-art in data sampling, modeling analysis and application of river habitat modeling,” is a report which has been created by the European Aquatic Modeling Network. The paper includes case studies from a variety of countries, and many examples of methods and equipment used to develop these surveys. This paper focuses on modeling techniques incorporating a wide scope of riverine habitat modeling that includes another taxonomic groups like pollution monitoring, etc.

One of the key conclusions is that identification of appropriate scales is a crucial element of instream habitat modeling. The authors emphasize the importance of a multi-scale approach to assessment to assure that analysis can be performed at the scales corresponding with the way biota utilize their environment and to allow for more comprehensive management. The report also states that frequently habitat assessment at some scales can be considered inefficient.

Scales can range from microscopic to macroscopic. At a microscopic scale, which deals with samples, it is ineffective to assume that a sample taken from one location could yield the same results over the entire area, which the sample is meant to represent. Two areas with similar characteristics could contain entirely different species on the microscopic scale. On the other hand, at a macroscopic scale, for example the entire river, shows that the function and species diversity is determined by the stability of the system. The problem with this scale is lack of the precision necessary for resource use decision-making.

“Mesohabitat scales are becoming more popular worldwide and are increasingly recognized as adequate scales for fish. Most commonly the size of mesohabitats correspond with the size of

hydro-morphologic units, such as entire pools, riffles, runs or backwaters, They create a “functional habitat” pattern identifiable for the entire river and allow to create a basis for multi-scale assessment” (Harby et al. 2004).

In summary the following can be concluded from our literature review.

The diversity of approaches can be clustered into a few groups based on the required effort, resolution (scale), and accuracy of the results. One possible grouping of common instream flow methods is presented in Figure 3.2.

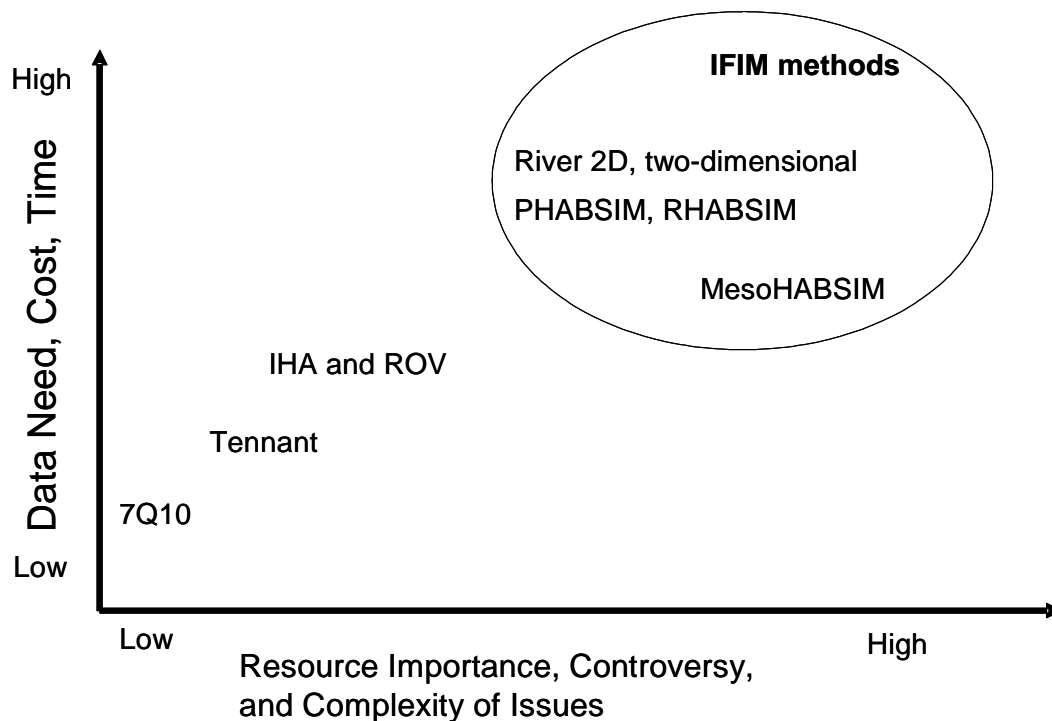


Figure 3.2. Example of qualitative comparison of Instream Flow Methods. The names represent the clusters of similar approaches.

The four cited publications describe their individual assessments on research of instream methods but have a common conclusion. The methods outlined in the literature indicate differences between approaches, ranging from surveys creating entirely new data including expert panels and utilizing available data. However, each of these four publications has separate groupings of methods, as well as a desire to create a homogenous method, which is applicable over a wide spectrum.

In addition to the desire for a unified method, most papers discussed the development of IFIM and PHABSIM, with MesoHABSIM becoming the latest, and most intriguing method discussed at this time. MesoHABSIM is a method, which is an incremental method, as it is relatively easy to apply, and would deliver appropriate results. MesoHABSIM integrates the ideas of IFIM and PHABSIM, while studying rivers at a functional scale, which can be studied at a small scale, or included in a trend to create an overall model of the river. This method identifies the species and

the influences affecting individual sections of the river, or hydro-morphological units (HMU's). Once each section of the river has been specifically cataloged, then an average inclusion can be made to consider the influences on species within these areas of similar characteristics. These areas can then be modeled, and the effects of outside influences can be determined with a management plan developed to determine the best situation possible for species within that reach.

Selected methods for fish habitat modeling.

Our approach is to develop criteria for a flow regime that protects aquatic and riparian life while balancing those needs with public and private water uses. Methods for accomplishing this task are numerous and vary greatly in their appropriateness to specific situations. Intensive analysis of techniques leads to the conclusion that physical habitat simulations provide the most desirable base and such approaches have the greatest potential for broad application on the Souhegan River.

Physical habitat models link a small number of hydraulic (depth, velocity) and habitat variables (cover, substrate) to models of suitability for target biota (habitat suitability criteria) and are useful for establishing criteria when a specific site or sites have high importance to an IPUOCR. The most common method has been physical habitat modeling using PHABSIM techniques and software, or analogous procedures (e.g., RHABSIM or EVHA). However, these techniques are limited in their resolution and applicability when extrapolated to many river miles.

MesoHABSIM modifies the data acquisition technique and analytical approach of earlier efforts by changing the scale of resolution from micro- to meso- scales, providing a mechanism that allows the assessment of habitat changes at the watershed scale. When applying the MesoHABSIM survey approach, mesohabitats (e.g. riffles, runs, and pools) are mapped at different flows along many miles of a river. The suitability of each mesohabitat for a target fish community is assessed using field surveys, and field data are subsequently analyzed using multivariate statistics. The variation in cumulative area of suitable habitat is a measure of environmental quality associated with alterations in flow and channel structure (Figure 2).

We propose to apply this method to all free flowing section of Souhegan River. In addition we propose to perform a reconnaissance level survey in one of the impoundments. The purpose of the latter survey is to identify the species that utilize impoundment habitats and roughly estimate the value of this habitat for the aquatic community.

To create a habitat model, it is necessary to have two types of data. The characteristics of the stream and biological response functions, (habitat use criteria) that allows us to evaluate HM in terms of habitat suitability. Because of our experience working in the Northeast, we already have a well-developed habitat database on adult and early life stages of resident native fish for regional river systems (Quinebaug River, Mill River, Fort River, Manhan River, Pomperaug River, Fenton River, Stony Clove Creek, etc.) collected from instream surveys. This data allows for the development of habitat use criteria for the majority of fish species identified in this IPUOCR report. We propose to use these criteria as a basis for evaluation of habitat quality for these species in the areas mapped with MesoHABSIM technique.

We propose to select the species to be modeled using the Target Fish Community approach as well as literature information on seasonal habitat needs of species present in Souhegan River. The species or species groups that have highest flow needs in particular season (eg. spawning salmon in the fall) will be selected as indicators for PISF needs and for habitat modeling. For species that are not included in our database, we will develop habitat selection criteria using literature values, e.g. Parasiewicz and Goettel (2004).

To verify data from our habitat database we propose to include an instream community survey using underwater observation in the areas previously mapped during habitat survey.

We propose to conduct mesohabitat mapping collecting from three study flows in the range between 0.15 cfsm and 2 cfsm as the primary approach to describing flow related habitat changes. [Note, on July 28, 2004, with the flow at 40 cfs at the USGS gage, the river was at 0.23 cfsm.] The survey will be conducted at representative sites covering approximately 7 miles of river. We will collect the same data as during the reconnaissance survey, however with a much higher level of precision.

The collected data will be integrated into a GIS database and habitat quality in the sites will be evaluated using criteria established as described above. We will compute habitat flow rating curves for every hydro-morphologic unit and generalize the curves to reach level according to proportion of the units in the reach (Figure 3.3).

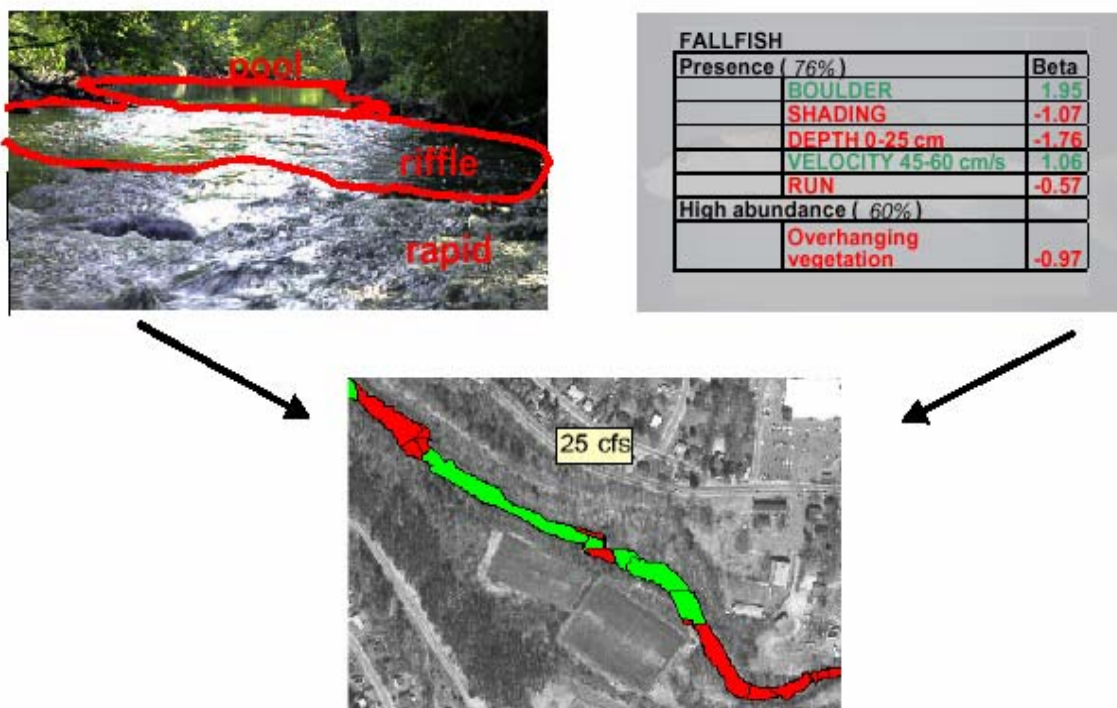


Figure 3.3. The habitat survey delineates hydromorphologic units and their physical attributes (top left). The fish survey identifies key habitat attributes affecting fish (top right). The model calculates the probability of fish presence in each habitat and delineates areas of suitable and unsuitable habitat.

Using habitat rating curves developed from any method, in conjunction with flow time series for each river segment or IPUOCR site, we will create a time series of baseline habitat conditions which will be analyzed for flow levels critical to the protected use. We will apply continuous under threshold habitat duration curves (CUT-curves) using the technique described by Capra et al. (1995). The process is illustrated in Figure 3.4. Using this method we identify four habitat levels that correspond with different protection thresholds. These levels divide the flow regime characteristics along a gradient of potential impact and are named *absolute minimum*, *trigger*, *critical*, and *typical*.

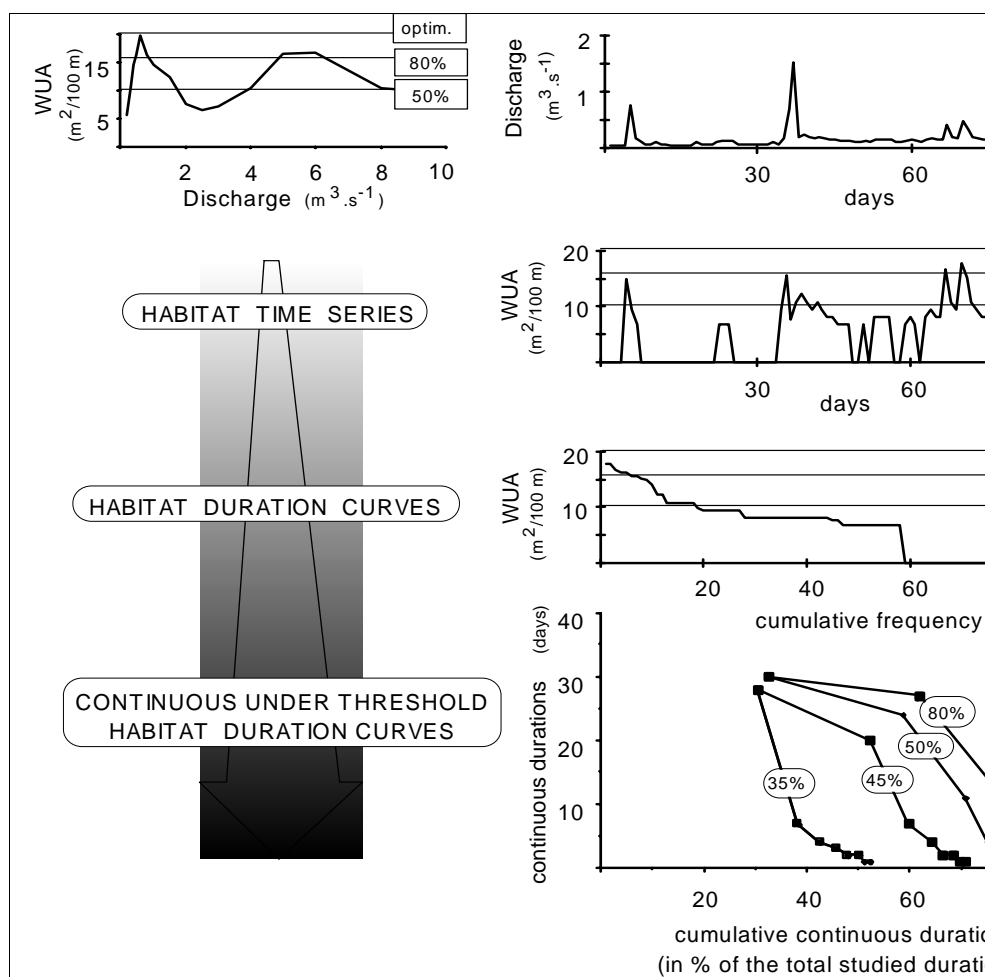


Figure 3.4. CUT curves from habitat time series (source: Capra et al., 1995)

The result will be recommendations for seasonal habitat regimes consisting of allowable habitat quantity together with duration and frequencies of flow events with habitat under specific thresholds. In addition, the amount of water necessary to fulfill the above criteria will be defined for every season. Eventually we will develop a concept for the application of these criteria by

introducing dynamic flow management rules. This will include flows that trigger protective actions, allowable durations of these flows, together with duration and magnitude of protective flow pulses.

In subsequent steps we will list river channel improvement opportunities by identifying areas where such measures could be more easily applied than on private property (e.g. public parks). The potential of these measures can be analyzed by simulation of the gain in fish habitat. This step will assist in the evaluation of potential water management vs. restoration trade-off options in the water management plan. The water management plan will build upon simulation results and determine how water can be allocated in order to satisfy the above flow recommendations.

Proposed time line and tasks:

Assuming that we begin on August 16, 2004, we will conduct the following field tasks:

1. Mesohabitat Survey of Representative sites (8/16 – 9/1)
 - This survey will be conducted in depth, collecting PISF data on representative sites on the Souhegan River. The sites were outlined during the June survey of the entire river.
2. Scuba- survey of impoundments.
 - Scuba diving of impoundments, which were not originally surveyed in June, 2004.
3. Underwater survey of fish distribution.
 - Fish observations, which can be included with historical fish data.
4. Mussel and invertebrate survey.
 - This survey will entail sampling from given areas within representative sites to determine their presence, and to create a model from the results.
5. Second and third Mesohabitat survey. (September-October)
 - This survey will be conducted to acquire multiple river flow stages, which create a more thorough model for the river.

The exact dates cannot be determined at this time, but the September-October sampling events will correspond to flows in the middle and at the upper end of the 0.115 – 2 cfsm range..

RTE: fish, wildlife, vegetation or natural/ecological communities

Fish

The river is habitat for the endangered Banded Sunfish (*Enneacanthus obesus*). This fish occurs in slow-water areas and impoundments and prefers heavily vegetated areas (Cairns 2004). Two other species are considered endangered in New Hampshire, though they have not been identified in the area of the Souhegan River. These two species of fish are the Sunapee trout

(*Salvelinus alpinus*) and the Shortnose sturgeon (*Acipenser brevirostrum*). The Shortnose sturgeon is federally listed as endangered, in addition to being listed in New Hampshire. (New Hampshire Fish and Game Department) We will use the same technique as described above to determine the habitat for RTE.

Wildlife

Fowlers Toad

Historical records of the rare Fowler's Toad (*Bufo fowleri*) include several locations along the Milford to Merrimack reach of the Souhegan River, and although this species was not observed during the field investigation, suitable habitat is certainly present. This species prefers sandy outwash soils. As with the common American Toad (*Bufo a. americanus*), which was observed, Fowler's Toads are water dependent for breeding, eggs, and larval stage, and would likely use the same shallow, still margins of the Souhegan River in which American Toad tadpoles were observed, although breeding in other water bodies is also possible. Reduction in flows that expose the shallow river margins, backwaters and oxbows during larval development may strand and eliminate cohorts of toad tadpoles. Fowlers Toad breeds from late May to August, about one month later than American Toads, with tadpoles transforming in midsummer (Degraaf and Yamasaki 2000).

The method for evaluating habitat for Fowlers toad is provided in more detail under emergent wetlands below. In addition to the metrics developed for the emergent wetlands, the determination of minimum flow requirements for the Fowler's Toad will include:

- topographic cross sections of river channel along transects at previously mapped historical Fowler Toad habitats;
- identification of flows required to flood shallow margins and backwater areas within river banks (but beyond the main deep channel of the river) through mid-August.

Pied-Billed Grebe

The State-endangered Pied-Billed Grebe (*Podilymbus podiceps*) was reported from the Amherst Country Club. This species was not observed during the field visit June 28-30, 2004. Preferred habitat is densely vegetated emergent and deep marsh interspersed with open water that is more than 12 acres in size ((Degraaf and Yamasaki 2000; Banner 1998). To the extent that such a marsh is dependent on river flow, this marsh bird species would be flow dependent. A preliminary inspection of aerial photos of the Souhegan River floodplain indicates that there are several marshes that could be habitat for the Pied-billed Grebe, and some of these have a direct connection to the Souhegan River.

The evaluation of flow-dependency for the Pied-billed Grebe is similar to that for emergent wetland so the procedure detailed for emergent wetland will be used to evaluate this species. Specific needs of the Pied-billed Grebe are that standing water must always be present.

Wood Turtle

The Wood Turtle is a rare species that was observed basking on a log in the reach between Milford and Merrimack. This turtle overwinters on the bottoms of streams and feeds both on land and in the water (Taylor 1993) eating aquatic and upland plants and animals. This mobile, semi-aquatic species is not

likely to be directly harmed by seasonal low flow reductions. However, this species is reported to be intolerant of pollution (DeGraaf and Yamasaki 2000), and therefore also indirectly flow dependent. Wood Turtles could also be harmed by a major decrease in winter water levels that could expose a hibernating turtle to freezing conditions (an event that would be of concern to many other IPUOCRS). The flow regime proposed under the WMP will be examined to insure that winter water flows are protective of hibernating turtles. The likely overwintering habitat will be examined during the emergent wetland surveys and flows sufficient to keep those areas inundated will be determined.

Osprey

The Osprey (*Pandion haliaetus*) is a State-threatened bird-of-prey observed foraging over the fish hatchery in Milford and over the river during the field survey, and reported from the Amherst Country Club. The closest known osprey nest in New Hampshire to the hatchery is at Lake Massabesic in Auburn/Manchester (NH Fish & Game website), which is well beyond the approximate 7 mile maximum foraging range reported for ospreys (Vana-Miller 1987). Ospreys observed along the Souhegan River in summer could be transient individuals. Ospreys consume primarily fish from clear, unobstructed water bodies. They dive up to 3 feet into the water, and so are most likely to feed in the pools and reservoirs, not shallow riffle areas. Only changes in flow that eliminate pools, reduce fish abundance, increase turbidity, or increase aquatic plant cover are likely to affect Ospreys. Flows that are protective of a healthy fish community will be protective of this species.

Common Loon

The Common Loon (*Gavia immer*) was reported from the Amherst Country Club, although it is unlikely to be nesting along the river. This State-threatened bird could be using river seasonally to forage for fish, its primary food. The Souhegan River is not likely to be a primary habitat for the Common Loon, but foraging opportunities for loons would be indirectly affected by changes in flow as for the Osprey. Like the Osprey, flows that are protective of a healthy fish community will be protective of this species.

Vegetation

Long's Bitter Cress

Long's bitter cress (*Cardamine longii* Fern.) is an obligate aquatic plant that has only been recorded from one location in NH (Greenville) and this was prior to 1984. It was not observed during the IPUOCR survey conducted by the field team on June 28-30, 2004. It is listed as a New Hampshire-Threatened plant, State rank is H (historical), and has Global Rank 3 (either very rare and local throughout its range or found locally in a restricted range, or vulnerable to extinction because of other factors). This plant is reported from tidal banks, usually shaded, mostly coastal (Crow and Hellquist 2000). In Maine it is estuarine (tidal wetland (non-forested, wetland)) and grows on sandy muck and cobbles (Maine Dept. of Conservation Natural Areas Program Fact Sheet, Long's Bitter Cress). In Bowdoinham, Maine it occurs on tidal banks and muck-covered ledges shaded by northern white cedar and yellow birch and experiences inundation twice daily (Crow 1982). There may be some taxonomic confusion associated with this plant. If present in the project area, it is likely to be flow dependent. Maintenance of a healthy natural community of aquatic plants will likely benefit this plant.

More information is needed prior to determination of assessment methods for flow requirements for this species. The presence of this plant in the designated reach should be confirmed prior to further evaluation.

Wild Garlic

Wild Garlic (*Allium canadense*) is a Faculative Upland plant on the State-Threatened List in NH with a State Rank of 1 (imperiled because rarity (generally less than six occurrences) or other factors demonstrably make it very vulnerable to extinction).

An historical record exists for the Town of Merrimack, but the location is unknown and may not be within Souhegan watershed. In Maine, the habitat for this species is described as usually found in rich, wooded bottomland hardwoods, in alluvial soils near streams (Maine Department of Conservation, Natural Heritage Program Biological and Conservation Database 2004). Magee and Ahles (1999) describe its habitat in New England as low wet woods and thickets, and rich woods. Though little information was available about the habitat of wild garlic in Merrimack, its wetland status and habitat information suggest it occurs on the upper terraces of streams and rivers. These terraces are typically affected by infrequent flooding events (often 10-year storms or greater), and so may be somewhat dependent on periodic scouring for survival. It was therefore considered flow-dependent on higher flows. Study sites for other IPUOCR will be selected to overlap with these sites, where possible. Alternatives in the WMP which may affect high flows will discuss potential impacts to this IPUOCR.

Natural/Ecological Communities

Emergent Wetlands

The floodplain of the Souhegan River includes floodplain forest and oxbows and backwater areas with emergent wetlands. Several such marshes were observed between the Amherst Country Club and Turkey Hill Road; another large marsh is located just upstream of the Dam in Merrimack, and there is another large wetland complex above the dam in Greenville. Emergent wetlands are seasonally flooded to permanently flooded. Prolonged changes in depth or duration of water levels during the growing season could cause vegetation stress and changes and/or affect habitat functions of these wetlands. Numerous small fish, Painted Turtles (*Chrysemys p. picta*), and Green Frogs (*Rana clamitans melanota*) were observed in these marshes. Changes in river water levels would affect primarily those wetlands with direct and unrestricted surface water connections to the river. The magnitude of the impact would depend, in part, on the elevation of the marsh relative to the river channel, the constriction of the surface water connection, and the frequency, regularity and duration of any flow changes.

Determination of minimum flow requirements (preliminary approach):

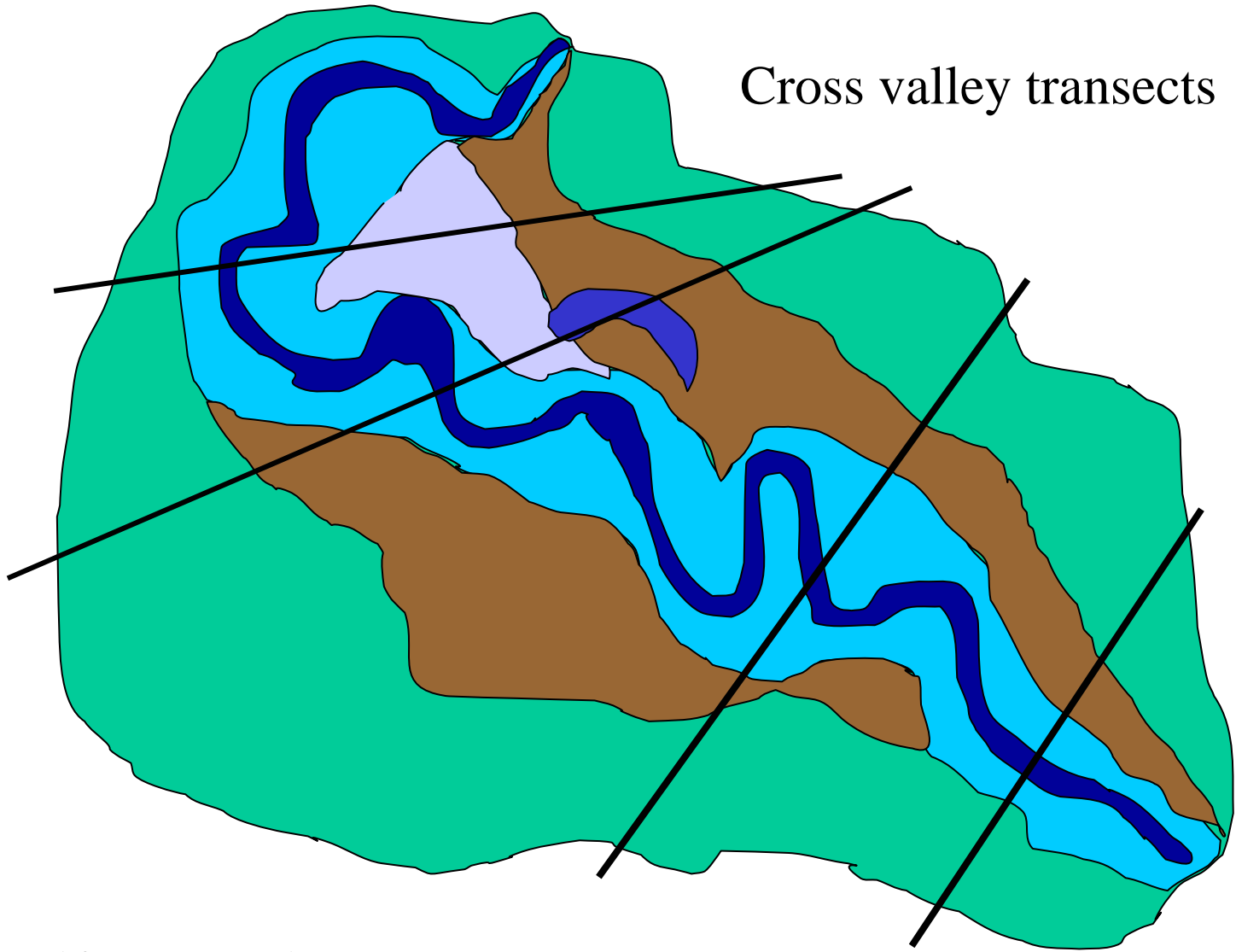
- topographic survey of wetland and adjacent river channel along transects, including the lowest point of connection with the river channel and deepest point of marsh;
- elevation of water recorded simultaneously in wetland and river at seasonal low flow (or as determined by historical data), average and high flows. An attempt will be made to coordinate these evaluations with the evaluation of aquatic habitat and fauna.
- Use of a stage-discharge relationship and topography at each transect to determine profiles of water levels along each cross section at representative flows.
- primary vegetation types (emergent, floating leaved or submergent) in the wetland plotted along the transects;
- estimation of minimum flow required to maintain low flow surface water elevations of:

- 0 (sediment surface) for emergents,
- 6 inches for floating-leaved;
- 12 inches for submergents.

This methodology will be applied at 3-4 sites in the designated reach. A minimum of five transects will be evaluated at each site. These sites will be chosen to overlap with the range of flow dependent species wherever possible. Examples of the type of output from this effort are presented in Figures 3.5 through 3.9.

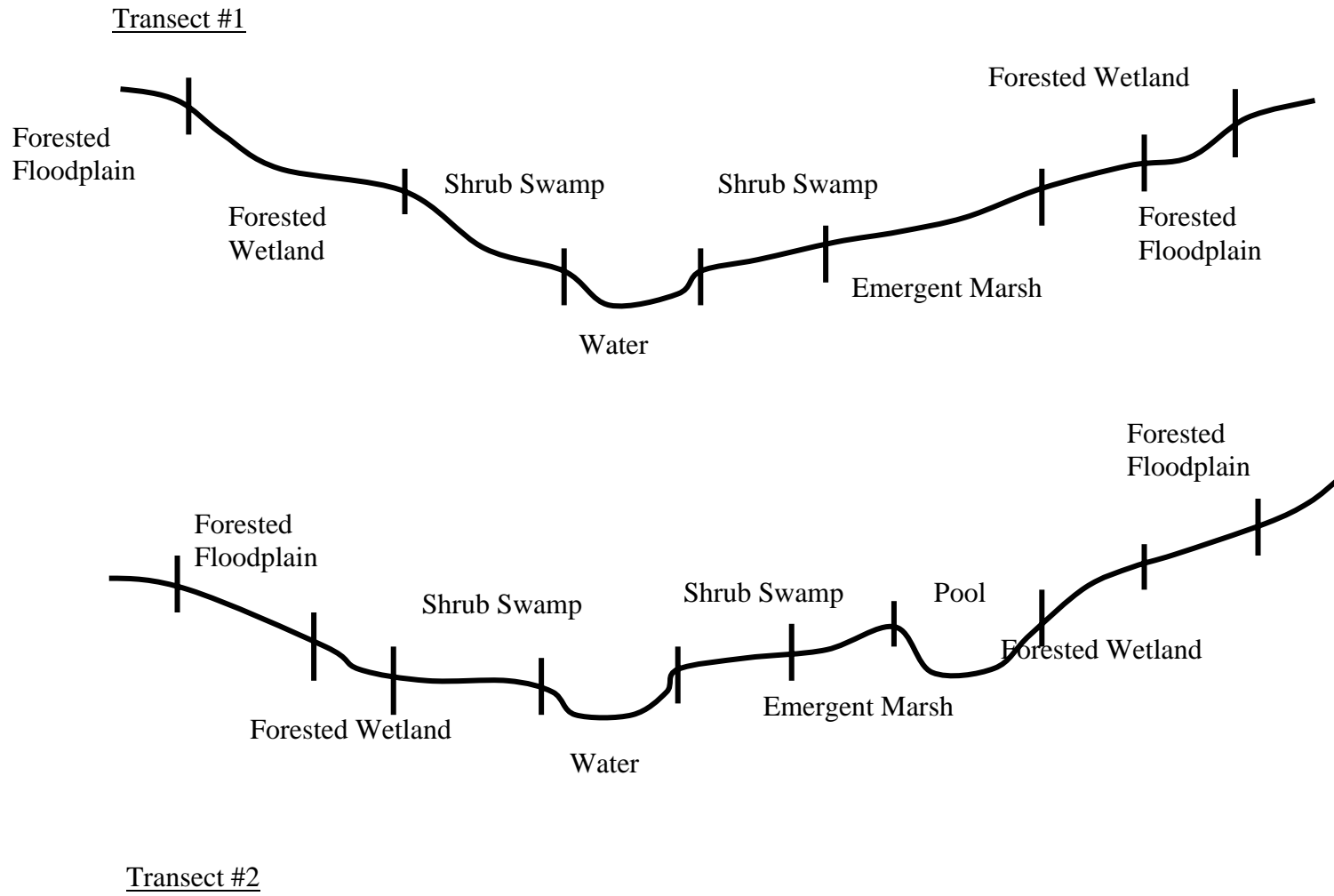
Southern New England High-Energy Riverbank Community

Sand and cobble bars with plant communities resembling the Southern New England High-Energy Riverbank Community (listed by New Hampshire Natural Heritage Inventory NNNHI) were observed in several locations along the Souhegan. Dominant species included twisted sedge (*Carex torta*), dogbanes (*Apocynum sibiricum*; *A. cannabinum*), Joe-pye weeds (*Eupatorium* spp.), reed canary grass (*Phalaris arundinacea*), swamp candles (*Lysimachia terrestris*), Willow (*Salix* spp.), and Grapes (*Vitis* sp.). At slightly higher elevations, shrubs such as silky dogwood (*Cornus amomum*) and alder (*Alnus incana*) along with several species of ferns and other herbaceous plants are often dominant. These habitats are dependent on periodic high flow scouring to reduce competition from plants less tolerant of flooding and coarse soils. The communities most dependent on scour are those at the lowest elevations in the channel. Prolonged absence of high seasonal or storm flows, or prolonged flooding during the growing season could adversely affect these communities. Reductions in seasonal low flows are unlikely to endanger these communities. Study sites for other IPUOCR will be selected to overlap with these sites, where possible. Alternatives in the WMP which may affect high flows will discuss potential impacts to this IPUOCR.



Adapted from Scott Jackson, UMASS

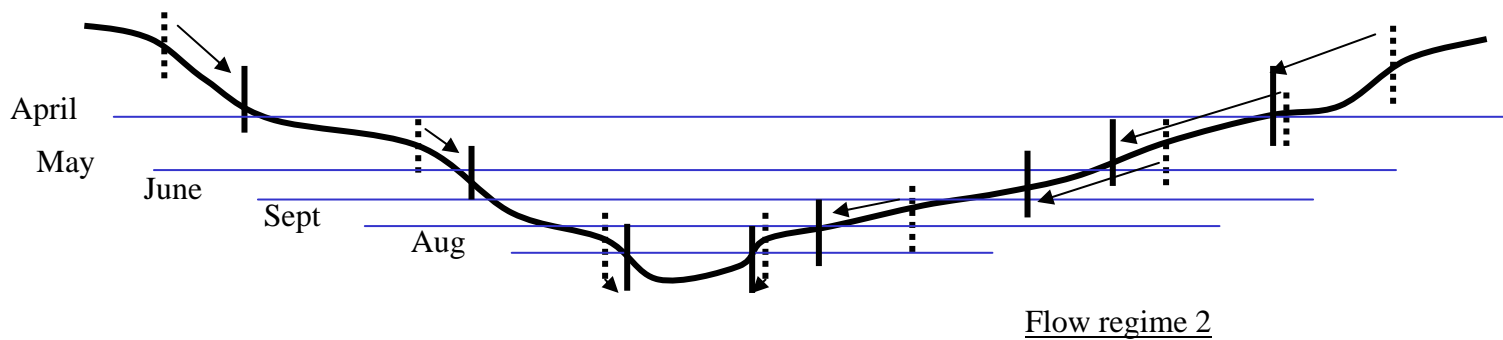
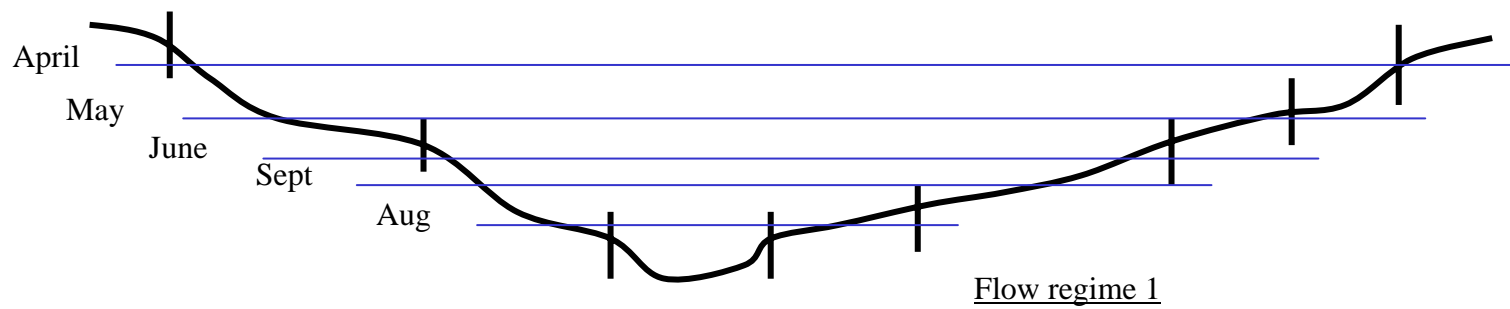
Figure 3.5 Layout of transects.



Adapted from Scott Jackson, UMASS

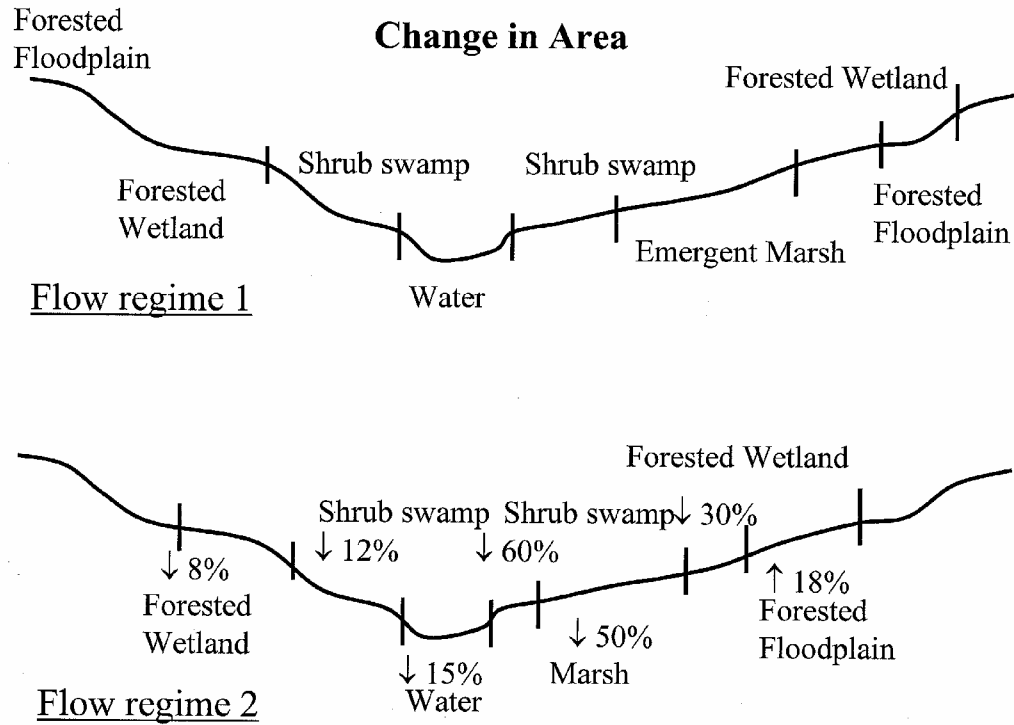
Figure 3.6 Transect habitat mapping.

Transect #1



Adapted from Scott Jackson, UMASS

Figure 3.7 Habitat under different flows.



Adapted from Scott Jackson, UMASS

Figure 3.8 Relative change between flow regimes.

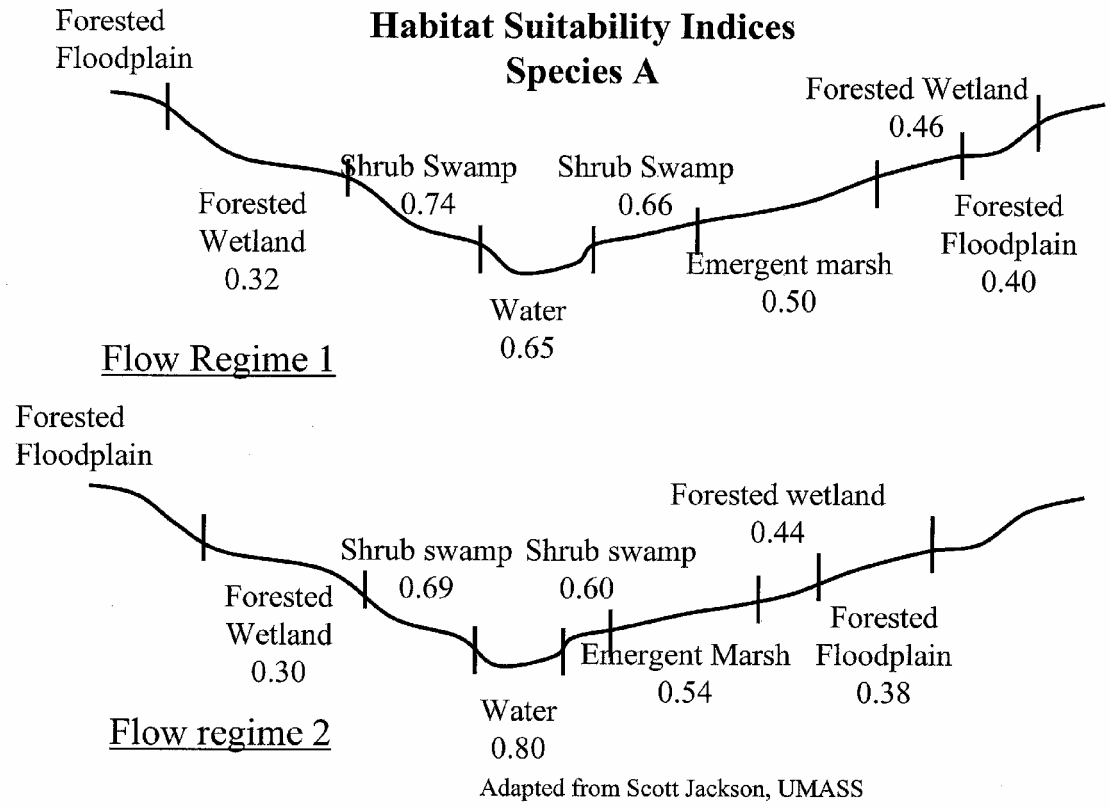


Figure 3.9 Habitat suitability under different flows.

Southern New England Floodplain Forest

Two Southern New England Floodplain Forest types were observed along the Souhegan River. Above the Town of Merrimack, floodplain forests were the Red Maple (*Acer rubrum*) Floodplain Forests typical of smaller rivers. Dominant plants observed also included Sycamore, White Ash, Ironwood, False Nettle, Ferns, Grapes, and Sedges. Within the Town of Merrimack, Silver Maple (*Acer saccharinum*) Floodplain Forests typical of larger rivers in the state were observed. Floodplain forest plant communities are dependent on periodic flooding and scouring to provide nutrients and reduce competition from flood-intolerant plant species. These communities often have a mesic moisture regime during the rest of the growing season, and are less dependent on low flows than flood flows. As with the forested wetlands, flow dependency is low relative to other IPUOCR entities. Study sites for other IPUOCR will be selected to overlap with these sites, where possible. Alternatives in the WMP which may affect high flows will discuss potential impacts to this IPUOCR.

Public Water Supply

The Pennichuck Water Works (PWW) historically withdrew water for public supply from 1965-1984 and maintains the right to withdraw water in the future from the Souhegan Woods Water System. The sources of this water supply are two wells located off Amherst Road in Amherst. The hydrogeologic investigation to be conducted as a part of Task 2 will result in a clearer delineation of these wells with a river flow component: that is the ability of wells to induce recharge from the river. If these wells are substantially connected to the river and creating induced recharge, the influence of the operation of these wells on river flows and achieving instream flows will be examined further as part of the water management plan. Although low river flow may be associated with low groundwater levels and possibly lower well yields, maintaining high river flows in order to support enhanced well yields is an extremely inefficient mechanism and management strategy, and therefore is not considered.

Hydroelectric Energy Production

The river corridor currently contains seven hydroelectric facilities:

<i>Hydroelectric Facility</i>	<i>Location</i>
WATERLOOM POND DAM	NEW IPSWICH
OTIS DAM	GREENVILLE
SOUHEGAN RIVER III DAM	GREENVILLE
SOUHEGAN RIVER	GREENVILLE
SOUHEGAN RIVER III DAM	WILTON
PINE VALLEY MILL DAM	WILTON
MCLANE DAM	MILFORD

Hydroelectric energy production is dependent on the river flow. However, energy production in a low flow environment is often uneconomical or technologically unfeasible. The flows in the Souhegan River are low for much of the summer and at other times during the year (such as February) likely precluding hydroelectric energy production. During average and high flow periods, energy production does occur. It is possible that some alternatives to be considered in

the water management plan will change the frequency of occurrence or the magnitude of high and average flows and may change the available period of time suitable for energy production. These situations will be addressed in the water management plan. Information to be obtained through interviews with affected dam owners (ADO) is essential to fully understanding the relationship between flow and energy production at each of these facilities. If hydropower is not produced at low flows, then there is no instream flow method for hydropower. If there is energy production at low flows, then these facilities require that their instream flow needs be addressed. For any of these facilities producing power at low flows, the nature of this power production will first be identified (for example production for a few hours per day from stored water, and the remainder of the day re-filling that storage). At that point, the hydropower ISF will be integrated into the WMP. Ramping studies related to hydropower production will not be included as a part of this effort.

Hydrological/Geological/Habitat

River Morphology and Aquatic Habitat

From aerial photographs and visual observation of the river, the form of the river varies throughout its length. Characteristics such as oxbows and meanders can be determined from maps and photographs, while substrate, width, depth and other characteristics are to be viewed at the small scale. Flow has the ability to alter the morphology of the river.

The Souhegan River channel cuts through numerous ledges that define its morphological character. The morphological character of the Souhegan ranges from a high gradient, straightened third order stream to a low gradient meandering fourth order river.

The high gradient portion of the Souhegan is located upstream of the confluence with Stony Brook in Wilton, NH. This portion is approximately nine miles long and is representative of a third order stream. In this upstream portion (our sections 1-24), the average width is 5 to 15 meters and the river is characterized by a relatively shallow and fast flowing current.

Below the confluence with Stony Brook the river maintains a high gradient until our section 33. Further downstream, the Souhegan River is a low gradient for almost the entire length. It meanders through the landscape, dotted with oxbows and remnants of side arms. Nevertheless, the 5-9 ft banks are steep suggesting a possible entrenchment tendency that is controlled by sporadic bedrock ledges and large cobble rapids. There are clear signs of some municipal pollution on almost the entire length of the river up to the mouth.

Reach 1

For approximately six miles at the uppermost length of the designated reach, the Souhegan River flows through forested areas and is therefore heavily shaded with large amounts of overhanging vegetation and noticeable woody debris. Only 8% of the length is impounded by a dam in Greenville. The substrate consists in majority of large cobble and bedrock, with low amounts of sand. For the three miles the Souhegan runs parallel to Route 31, the banks are sometimes stabilized by riprap and the morphology of short stretches has been altered. Within the river channel, there were discarded pieces of riprap, which alter the substrate and aquatic habitats.

During the survey flow of 0.5 cfs, the hydraulic patterns consisted primarily of run, riffles and rapids. The substrate consisted of mostly large cobbles and bedrock, with only small amounts of sand. Below the Greenville Bridge the river widens a little, and about a half a mile downstream there are the first cascades of the river (our section 6) in the Greenville Gorge where remnants of a breached dam were found. Further downstream the rivers' first island habitats are found and more glide types of habitat.

Our section numbers 6 to 12 were selected as representative sites of this reach.

Reach 2

Below the bridge next to the Monadnock Springs bottled water company (our sections 17-22), the river flows into more of an open space, although the banks remain mostly forested. In the vicinity of our section 21 and 22, the river flows through the Horseshoe Gorge. In this reach, the habitat types change including more runs and glides than found upstream.

Reach 1 and 2 of the river appears to be suitable for cold water, fluvial specialist fish fauna and we would expect an abundance of brook trout, salmon, daces, American eels and potentially for fallfish.

Our sections 16 to 18 were selected as representative sites of this reach.

Reach 3

Beginning with our section 23 which is impounded, the Souhegan River provides a dramatic contrast to upstream sections in terms of human induced alteration. Directly above the confluence with Stony Brook (our section 24), in which the stream order increases to 4th order, the Souhegan River enters urbanized areas with heavily stabilized banks. The confluence itself is created and enforced by old mill buildings and bridge crossings. Almost immediately after the confluence, two dams impound the river. Below the dams, the Souhegan River has been obviously realigned as a part of highway construction all the way down to our section 27. Twenty-five percent of the 3-mile length of Reach 3 is impounded.

In this reach the river still has a moderately high gradient yet substrate size reduces to more cobble, pebble, and gravel. The habitat type is dominated by glides and riffles. Consequently the boulder and woody debris cover is strongly reduced and banks are stabilized by riprap. Shallow margins (abundant upstream of this reach) are absent. Nevertheless, there is some overhanging vegetation and canopy cover shading.

In this area we would expect relatively poor habitats for the listed lotic species.

Our section 25 was selected as the representative site of this reach.

Reach 4

Beginning with our section 28 the river changes to a low gradient, wide (20 meter), meandering channel. This low gradient continues down to our section 32 and is accompanied by fields

covered with remnants of oxbows and former side arms. This approximately 2.6 mile long reach has no dams. A number of tributaries join the river in this area.

The substrate changes very dramatically to a high abundance of sand and fines. The riverbanks become steep but covered with overhanging canopy that provides shading and a source of woody debris. The habitat types consist of run, pools, glides and riffles and it could be expected to support white sucker, daces and fallfish as well as variety of lentic fauna (eg. Sunfish). The presence of mussels and dragonflies were first observed in this section

Our sections 30 and 31 were selected as the representative sites of this reach.

Reach 5

Our section 33 crosses the town of Milford where the river is impounded by two dams over the length of approximately 1 mile. This 1-mile stretch makes up 60% of the total length of this reach. Downstream of the dam (our section 34 and 35), the river continues to flow through residential area and is high gradient. It cuts through bedrock ledge, which could be also expected under the impoundments.

The river banks in this area have an abundance of riprap as well as overhanging vegetation that does not provide much shading, but indicates the age of the construction. Some woody debris was also observed. Downstream of the impoundment the habitat consists of rapids, riffles, and runs with coarse but mixed substrate embedded in sand.

This reach can be expected to provide good habitat for variety of lotic species such as trout, salmon, fallfish, common shiner, daces, but also white sucker. Mussels and dragonflies were also observed in this section.

Our sections 34 and 35 were selected as the representative sites of this reach.

Reach 6

This is the first low gradient reach and it does not have any ledge structure and stretches until our section 47 (upstream of Boston Post Road Bridge). Almost the entire length of this approximately 3-mile reach is accompanied by a golf course that reduces canopy shading and woody debris. Meandering banks are active and if a forest were present the trees along these eroded banks may find their way into the river channel, increasing woody debris and dramatically changing river morphology. In the areas of bridges we observed heavy bank stabilization with riprap. The substrate is dominated by sand with the presence of submerged underwater vegetation. Hydraulic habitats consist of runs, pools, and glides accompanied by some low gradient riffles.

This reach should provide relatively good habitat for white sucker, fallfish and variety of lentic species. We observed large amounts of freshwater mussels (mostly eliptio) and dragonflies.

Our sections 36, 37 and 47 were selected as the representative sites of this reach.

Reach 7

Beginning with our section 48 the River meanders through more forested and residential areas where the abundance of woody debris and canopy shading increases. We also observed increases in shallow margins and the appearance of a few backwaters. Submerged underwater vegetation is less abundant. The banks are still high and eroded.

The hydraulic habitat consists of runs, pools, and glides accompanied by low gradient riffle associated with woody debris.

This reach should provide relatively good habitat for white sucker, common shiner (?), fallfish (?), and variety of lentic species. We observed large amounts of young of the year fish, freshwater mussels (mostly eliptio) and dragonflies.

Our sections 48 to 50 were selected as the representative sites of this reach.

Reach 8

Downstream of our section 54, the river turns into a mosaic of long, low gradient stretches interrupted by ledges and large rapids. The river meanders less than it does upstream and the oxbows are less abundant indicating steeper topography of a surrounding landscape. The riverbanks continue to be high and steep, and are covered with mature vegetation.

The 6 mile long reach has no impoundments but riverbanks are associated with residential use. The dominating substrate continues to be sand with exception of bedrock in rapids areas. In the ledge and rapid areas the amount of woody debris is naturally lower. The river becomes over 30 meters wide such that canopy shading does not reach across its width. A large degree of shallow margins were observed on large sand banks in the middle of the river.

The hydraulic habitat is dominated by runs, riffles, pools, and glides accompanied by cascades and backwaters. This stretch of the Souhegan River can be expected to provide abundance and variety of habitat for fluvial and pond fish species. We observed large amounts of young of the year fish, freshwater mussels (mostly eliptio) and dragonflies.

Our sections 56, 57 and 61, 62 were selected as the representative sites of this reach.

Reach 9

Downstream of Wildcat Falls the river flows through the residential and urbanized town of Merrimack. The amount of cascades and ledges significantly increases (there are 3 cascades in this reach). Therefore the river has more moderate to high gradient character and does not meander. Of the approximately 2.5 mile length of this section, an inactive dam impounds 16% of the length. These impoundments create substantial wetlands.

The hydraulic habitat consists of runs, riffles, and cascades with abundance of boulders. Woody debris and shallow margins are present. At the bridge and residential areas the banks are stabilized with riprap. Substrate is a mixture of bedrock, cobble, gravel, sand and fines.

This reach is expected to provide habitat for a wide variety of species.

Our sections 67 to 71 were selected as the representative sites of this reach.

Recreation

Boating: Western sections of the river (from Greenville to Wilton) provide whitewater canoeing and kayaking during spring and periods of high water. The Wilton to Milford stretch provides limited opportunities for canoeing and kayaking because water is generally low and requires portage around dams. Below the Rt.122 bridge the river is flat and provides excellent opportunities for family canoeing. The stretch below Seaverns Bridge is impassable to watercraft because of Wildcat Falls. The river is impassable to motorboats except in western reaches, on the impoundments (SRN 1999).

Much of the river is considered passable only at high flow levels, according to the AMC River Guide (AMC 2002), with the exception of the reach from the Turkey Hill Bridge to the Merrimack which is listed as passable in medium flows. The river is apparently not considered to be runnable in a canoe or kayak under low flows although the project team did navigate the section from Route 122 to Turkey Hill Bridge on June 29, 2004 with some walking through the rapids sections. The flow on that day was between 67 and 77 cfs at the USGS gage above Wildcat Falls in Merrimack which would be considered low to moderate flow. Any potential changes to the average or peak flows in the river will be evaluated in the water management plan.

Pollution Abatement

Point source discharges include: Greenville WWTF (wastewater), Souhegan Wood products (non-contact cooling waters), Hitchiner Manufacturing (non-contact cooling waters), Milford WWTF (wastewater), and Harcros Chemicals (non-contact cooling waters). Savage Well and Fletcher Paint Superfund sites are located in Milford, NH adjacent to the river and have historically indirectly discharged pollutants into the waterbody. What about the fish hatchery?

The project team will review wasteload allocations and permits as well as superfund reports and relate prescribed protective flows to the discharges. It is worth noting that stressed vegetation was not observed in the designated reach in the vicinity of any of the permitted discharges during the field reconnaissance survey.

PRELIMINARY LIST OF NON-FLOW DEPENDENT ENTITIES:

Non-flow dependent entities are defined as those entities which do not directly depend on a prescribed minimum flow for their existence or survival. In some instances, non-flow dependent entities are dependent on flow dependent entities (for example wildlife that feeds on fish); in this case, the prescribed minimum flow would be based on the fish. If flows are sufficient to support fish then the wildlife would be sufficiently protected. In other instances the IPUOCR is related to a water use but not completely dependent on it. For example, a golf course uses water for

irrigation but will not close if sufficient water is not available. These IPUOCR are defined as non-flow dependent but will be addressed in the water management plan as water users.

Storage

There are 12 dams listed in the NHDES dams database on the designated reach (NHDES 2004):

<i>Impoundment Name</i>	<i>Location</i>
SOUHEGAN RIVER DAM	NEW IPSWICH
WATERLOOM POND DAM	NEW IPSWICH
OTIS DAM	GREENVILLE
SOUHEGAN RIVER DAM	WILTON
SOUHEGAN RIVER III DAM	GREENVILLE
SOUHEGAN RIVER	GREENVILLE
SOUHEGAN RIVER III DAM	WILTON
SOUHEGAN RIVER DAM	WILTON
PINE VALLEY MILL DAM	WILTON
GOLDMAN DAM	MILFORD
MCLANE DAM	MILFORD
MERRIMACK VILLAGE DAM	MERRIMACK

All of the dams in the designated reach are operated essentially as run-of-the-river operations. There are no large impoundments within the designated reach therefore; the opportunities for large amounts of storage within the designated system do not exist. The impoundments are essentially full most of the time precluding the need for water to refill after drawdown. Some of the dams are considered affected dam owners (ADO's) for purposes of this study while others are not. Dams with impoundment areas of less than 10 acres are considered non-ADO dams. Ten dams on the designated reach fall in this category. The only two dams with impoundments greater than 10 acres are the Waterloom Pond Dam in New Ipswich and the Merrimack Village Dam in Merrimack.

Surface water storage volume in reservoirs typically is reserved for one of three purposes: sedimentation, conservation, or flood control. The sediment storage is reserved for the sediment build-up over the life of the reservoir. Conservation storage is water that is released to meet needs (for example irrigation or hydropower) or maintained to meet needs (for example recreation). Flood storage is empty space intended to fill during flooding events. The objective for conservation storage is to be full all the time. The objective for flood control storage is to be empty all of the time. Per se, these types of storage themselves are therefore not flow dependant. The uses of the storage are flow dependant, and these uses are treated as their own separate IPUOCR categories. Therefore as an IPUOCR, storage is determined not to be flow dependant.

Recreation

Recreation resources in the vicinity of the designated reach include:

Golf: There are two public golf courses where the river crosses Route 122 in Amherst.

Other: Locations used for hiking, nature study, fishing access, picnicking and such include:

- the Taft Land owned by New Hampshire Fish and Game (NHF&G) in Greenville;
- the Town Forest owned by the Town of Wilton;
- Society for Protection of New Hampshire Forests (SPNHF) land in Wilton;
- the Souhegan River Scenic Easement owned by New Hampshire Department of Transportation (NHDOT) in Greenville/Wilton;
- The Horseshoe, a privately owned parcel in Wilton;
- the Milford Fish Hatchery, owned by NHF&G;
- Milford town land;
- Bicentennial Park, owned by the Town of Milford;
- Keyes field, owned by the Town of Milford;
- Emerson Park, owned by the Town of Milford;
- Kaley Park owned by the Town of Milford;
- Cemetery Fields on Merrimack Road near Beaver Brook (that feeds the Souhegan), in Amherst;
- Amherst canoe port, owned by the Town of Amherst;
- Route 122 access, owned by the Town of Amherst;
- the Sherburne Site, owned by the Town of Amherst;
- Eighty Acres, owned by the Town of Merrimack; and
- the Turkey Hill Bridge Site, owned by the Town of Merrimack.

The sites and activities listed above are not classified as flow dependent. The prescribed flow which will include sufficient flow in the river to maintain the aquatic environment will be sufficient to preserve the scenic value of the river.

Conservation/Open Space

Open Space parcels include the following:

Merrimack: Eighty Acres site-predominately forested includes Wildcat falls, Turkey Hill bridge site-open and forested, provides car top access to the River, Davidson Avenue green space-predominately forested, and Whippoorwill Boy Scout Camp

Amherst: Scott and Sherburne sites- predominately floodplain, The Currier Land- predominately floodplain, and The Curtis Well Site- public drinking water, mixed woods and fields.

Milford: An unnamed piece east of downtown- floodplain, forest, field, the site east of the swinging bridge-open area and woods, Emerson Park- a small developed park, Keyes Memorial

Park- floodplain, open recreational area, and an unnamed parcel adjacent to the fish hatchery- mixed fields and forest.

Wilton: The Town Forest, SPNHF owns a parcel along the River- forested, NHDOT owns a 3.2-mile scenic easement on Rt. 31 in Wilton and Greenville.

Greenville: NHF&G owns a large parcel that is predominately forested and includes the gorge.

New Ipswich: There are a couple of small pieces of land owned by the town along the River that are predominately forested.

The prescribed flow which will include sufficient flow in the river to maintain the aquatic environment will be sufficient to preserve the scenic value of the river.

Maintenance and Enhancement of Aquatic and Fish Life

Exotic/Invasive Species

There are exotic and invasive species of vegetation and invertebrates present in New Hampshire, which have the potential for causing harm to the watershed. These species can be found listed on the New Hampshire Department of Environmental Services website. The only aquatic invasive species found in a water body near the Souhegan River is Variable milfoil (*Myriophyllum heterophyllum*), which is very difficult to eradicate once it is established. This species was not observed in the river during the course of the study, and has not been evaluated further. It is unknown how this species responds to changes in river flow.

Several wetland and upland invasive species were observed during the field investigations, including Purple Loosestrife (*Lythrum salicaria*), a species that relies on water transport of seed to spread and germinates in seasonally exposed mudflats. This is a potentially flow-dependent perennial species that increases in periods of low flow, and could become more abundant if low water conditions are prolonged. Japanese knotweed (*Polygonum cuspidatum*) is a persistent perennial that spreads rapidly by rhizomes, though the seed is wind dispersed. This plant was observed on the river bank in some locations, and is not flow dependent. Asiatic bittersweet (*Celastrus orbiculatus*), European buckthorn (*Frangula alnus*) and Autumn Olive (*Eleagnus umbellata*) were present in open upland floodplains, and are not considered flow dependent.

These species are specifically flow dependent. A flow regime that encourages a healthy native community of flora and fauna in the designated reach will discourage the spread of exotic/invasive species.

RTE: fish, wildlife, vegetation or natural/ecological communities

Wildlife

The Eastern Hognose Snake (*Heterodon platyrhinos*) is a Threatened Species in New Hampshire found in sandy forests, fields and other openings (DeGraaf and Yamasaki 2000). Although Hognose Snakes may feed in riparian habitats, this species is not considered water dependent and therefore not flow dependent.

The Grasshopper Sparrow (*Ammodramus savannarum*) requires moderately open grasslands with patchy bare ground and some perches for singing (Degraaf and Yamasaki 2000). While such habitats may be present in the agricultural lands in the Souhegan River floodplain in Amherst and Merrimack (from which this species has been recorded), the bird itself is not dependent on the river, and is unlikely to use habitats with flooding during the growing season.

Vegetation

The Giant Rhododendron (*Rhododendron maximum*) is designated as a Facultative Wetland plant in this region, meaning it is equally likely to occur in wetlands and uplands. Giant rhododendron occurs on stream banks, pond margins, swamps, wet woods and moist uplands (Crow and Hellquist 2000). It grows in acidic and moist soils. In New Hampshire these sites are primarily found in basin swamps, along lower slopes, or alongside brooks and ponds. This species is usually found in shaded areas such as low-lying wooded areas of eastern hemlock, red spruce, oaks, red maple and beech (from NH Natural Heritage Program data base: Fact Sheet, Giant Rhododendron (*Rhododendron maximum* L.). One large NH population is located in Rhododendron State Reservation, Fitzwilliam, NH. This species is not currently listed in NH, but proposed for NH threatened status, with a State Rank of 2 (imperiled because rarity (generally six to 20 occurrences). Historically reported for the Towns of Greenville, Milford, and Wilton. Searches for this species in historically mapped locations were not successful in June and July 2004. Of the 15 known locations in NH, only six have been verified since 1980, and the Souhegan River population is not among them (from NH Natural Heritage Program data base: Fact Sheet, Giant Rhododendron (*Rhododendron maximum* L.), 2002). Giant Rhododendron is not particularly flood tolerant, and is therefore an unlikely component of the floodplain, and not a flow-dependent IPUOCR.

Siberian Chives

Siberian Chives (*Allium schoenoprasum* var. *sibiricum* (L.) Hartman) is a facultative upland herb (Magee and Ahles 1999), meaning it is more likely to be found in uplands but tolerates wetland conditions, and is listed as Threatened in New Hampshire, State Rank 2 (imperiled because of rarity). Siberian chives is listed in New Hampshire and Minnesota as threatened, but listed as a noxious weed in Arkansas. There are 7 historical records from the Town of Merrimack, but none reported in the last 20 years from the town. The preferred habitat is gravelly river shores and fields (Magee and Ahles 1999), which could include the Southern New England High-Energy Riverbank Community. Since this species is also adapted to fields, it does not appear to be flow dependent.

Birds Foot Aster

The Birds Foot Aster (*Aster pedatus* var. *linearloba*) is a State Threatened plant Ranked 2 (imperiled because rarity (generally 6 to 20 occurrences) or other factors demonstrably make it very vulnerable to extinction. It was historically recorded (prior to 1984) from the Town of Merrimack, but the exact location is unknown and may not be within Souhegan watershed. It is not a recognized wetland plant, and a Minnesota web source describes it as occurring in upland sandy woods. Though no information was available about the habitat of birds foot aster in Merrimack, its wetland status and habitat information suggest it occurs in upland habitats and is unlikely to be affected by Souhegan river water levels.

Skydrop Aster

As with the Bird's Foot Aster, the Skydrop Aster (*Aster patens* var. *patens*) is a State-Threatened plant with little natural history or habitat information available. It was recorded for the Town of Merrimack but the exact location is unknown. All accounts indicate it occurs in dry woods and openings (Magee and Ahles 1999, Gleason and Cronquist 1963, and USDA Species-at-risk). Though no information was available about the habitat of skydrop aster in Merrimack, its wetland status and habitat information suggest it occurs in upland habitats and is unlikely to be affected by Souhegan river water levels.

Goat's Rue

Goat's Rue (*Tephrosia virginiana*) is listed as Endangered in New Hampshire, with a State Rank of 1 (imperiled because rarity (generally less than 6 occurrences) or other factors demonstrably make it very vulnerable to extinction). It was recorded from the Town of Merrimack prior to 1984, and again the location is unknown and may not be within Souhegan watershed. The USDA species-at-risk web site describes its habitat as well-drained soils in open oak and pine woods on ridges, sand prairies, sand dunes, roadsides, abandoned fields and other rural sites. Magee and Ahles (1999) describe its habitat in New England as open deciduous or pine woods and clearings, barrens, dunes and roadsides in sandy soil. This habitat information suggests that the plant occurs in upland habitats and is unlikely to be affected by Souhegan river water levels.

Stiff Tick Trefoil

The Stiff Tick Trefoil (*Desmodium rigidum*) is also designated as Endangered in New Hampshire, and was recorded historically (pre-1984) from Merrimack. (historical, recorded prior to 1984). No local information was found for this species, and it's location may not be within Souhegan watershed. Magee and Ahles (1999) and Gleason and Cronquist (1963) describe its habitat in New England as dry woods and thickets. Though no information was available about the habitat of stiff tick trefoil in Merrimack, its wetland status and habitat information suggest it occurs in upland habitats and is unlikely to be affected by Souhegan river water levels.

Water Quality Protection/Public Health

The river supports its water quality classification, class B, at all locations. According to the 1999 Souhegan River Nomination, certain sites exceeded acceptable limits for bacteria (below Wilton and at 122 bridge) and Phosphorous (Greenville and Milford wastewater treatment facilities and continued downstream). Low DO levels were also documented at the Pine Valley Mill site. The Souhegan River Watershed Report (1997) states "The Souhegan River, with one exception, met all of its water quality standards criteria during dry weather and demonstrated that it is fully supporting its Class B designation of being fishable and swimmable. However, the biotic integrity of the waterbody does show signs of impairment and degradation. Cold-water and pollutant intolerant non-game species were present in the Souhegan, indicating that chemical and physical water quality conditions are favorable to supporting a diverse cold and warm water fishery. While only one station was rated non-impacted, most supported healthy macroinvertebrate communities and fell into the slight impact range." Recent NHDES and Souhegan volunteer monitoring program water quality data will be reviewed to insure that this IPUOCR is still correctly classified as non-flow dependent.

Aesthetic Beauty/Scenic

These areas include: Route 31 along scenic Water Loom Pond and under High Bridge in the center of Town; in Greenville Route 31 affords views of pastures and agricultural lands and a scenic gorge; Route 31 proceeds through a 3.2 mile corridor protected by a scenic easement donated by the NHDOT; The Horseshoe in Wilton is an area where the River passes through a series of ledges that are steep on one side; in Milford the river passes under historic Green Bridge; The Souhegan River Trail in Milford follows the river along the state owned fish hatchery property and the adjacent Town owned property; in Merrimack are Indian Ledges and Wildcat Falls. There has never been a dry reading recorded throughout the record of flow for the gage above Wildcat Falls. The prescribed flow which will include sufficient flow in the river to maintain the aquatic environment will be sufficient to preserve the scenic value of the river.

Cultural/Community Significance

The river is discussed in each of the municipal master plans and is recognized as a significant community resource. The Souhegan River Watershed Study includes significant amounts of information about the river and provides specific recommendations for local and regional action. All communities in the watershed received the study well and some have started to implement the recommendations of the study. The study recommendations include amendments to local zoning ordinances and land use regulations, the development of a continuous trail along the River, additional public access sites in each community, public education on River resources and their protection, continuation of the volunteer monitoring program and state actions.

Historical or Archaeological

According to the New Hampshire Division of Historical Resources, New Hampshire Archaeological Inventory, there are four sites of historical significance within 100 meters of the Souhegan River along the designated reach. Three of these sites are located in Milford and one in Merrimack. Historical and archeological information is sensitive in nature therefore specific site locations are not identified in public documents.

Historical Resources located in the towns along the designated reach include the following:

- Merrimack: McClure--Hilton House 16 Tinker Rd. Listed; 12-01-1989, Signer's House and Matthew Thornton Cemetery S of Merrimack on US 3 Listed; 12-22-1978 Amherst Village Historic District 101 and NH 122 Listed; 08-18-1982
- Milford: Milford Cotton and Woolen Manufacturing Company 2 Bridge St. Listed; 08-18-1982, Milford Town House and Library Annex Nashua St. Listed; 12-01-1988, Peabody, William, House N.River Rd. Listed; 11-30-1979
- Wilton: County Farm Bridge NW of Wilton on Old County Farm Rd. 05-14-1981. Cragin, Daniel, MillW of Wilton at Jct. of Davisville Rd. and Burton Hwy. Listed; 03-23-1982, Hamblet--Putnam--FryeHouse 293 Burton Hwy. Listed; 06-22-2000, Stonyfield Farm NW of Wilton on Foster Rd. Listed; 08-03-1983, Whiting, Oliver, Homestead Old County Farm Rd. Listed; 03-09-1982, Wilton Public and Gregg Free Library Forest St. Listed; 01-11-1982, Monument Park, a 1.0 acre park that is identified as a historic site for passive use.

- New Ipswich: New Ipswich Center Village Historic District Roughly bounded by Turnpike Rd., Porter Hill Rd., Main St., NH 123A, Preston Hill, Manley and King Rds. Listed; 09-03-1991, New Ipswich Town Hall Main St. Listed; 12-13-1984.

Hydrological/Geological

Unique geologic formations

The river runs through a gorge in Greenville with steep sides. The Horseshoe in Wilton is another geologically significant area that serves as the local swimming hole. The prescribed flow which will include sufficient flow in the river to maintain the aquatic environment will be sufficient to preserve the scenic value of these formations.

Aquifers

The Milford-Souhegan aquifer consists of as much as 114 ft. thick of unconsolidated glacial sediments and has a maximum saturated thickness of approximately 100 ft. Horizontal hydraulic conductivity of stratified-drift deposits ranges from approximately 1 to 1,000 ft per day (Harte and Mack 1992). The groundwater flow is governed by the hydraulic connection between the Souhegan River and its tributaries. In the western reaches of the Souhegan River, the River recharges the aquifer and groundwater flow is away from the river. In the eastern reaches groundwater discharges into the river and groundwater flow is towards the river. Based on October 1998 stream flow data the aquifer is recharged from surface water infiltration at a rate of 1.44 ft³/s (Harte and Mack 1992). During extreme low-flow events, aquifer recharge from the river will be reduced. This may impact groundwater resources in the vicinity of the river. For this study, this IPUOCR is not considered to be flow dependent.

Agricultural

Abutting the river are parcels of land in Milford used as agricultural fields. Many of these fields are irrigated with water from the Souhegan. Agricultural uses of water will be addressed in the water management plan.

4.0 REFERENCES

- AMC. 2002. AMC River Guide, New Hampshire and Vermont. 3rd edition. The Globe Pequot Press, Inc. Guilford, CT.
- Annear, T. et al. 2002. Instream Flows for Riverine Resource Stewardship. Instream Flows Council. www.instreamflowcouncil.org
- Bain, M. and Meixler, M. 2000. *Defining a Target Fish Community for Planning and Evaluating Enhancement of the Quinebaug River in Massachusetts and Connecticut.*
- Cairns, S. 2004. Personal Communication. New Hampshire Natural Heritage Inventory (NHI). Concord, NH.
- Crow, G.E. 1982. New England's Rare, Threatened, and Endangered Plants. US Department of the Interior Fish and Wildlife Service, Northeast Region. 130 pp.

- DeGraaf, R.M. and M. Yamasaki. 2001. *New England Wildlife. Habitat, Natural History and Distribution*. University Press of New England. Hanover, NH. 482 pp.
- Dunbar, M. J., A. Gustard, M. C. Acreman, C. R. N. Elliott. 1998. *Overseas Approaches to Setting River Flow Objectives*. R&D Technical Report W6B(96)4. Institute of Hydrology, and Environmental Agency. Rivers House, Waterside Drive, Aztec West, Almondsbury, Bristol BS12 4UD. AN-03/98-OK-B-BBMC.
- Gleason, H.A., and A. Cronquist. 1963. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. Willard Grant Press, Boston, MA. 810 pp.
- Harby, Atle, M. Baptist, Michael J. Dunbar, and Stefan Schmutz. March 2004. *State-of-the-art in Data Sampling, Modeling Analysis and Applications of River Habitat Modeling*. Cost Action 626. European Aquatic Modeling Network.
- Harte, P.T. and T.J. Mack. 1992. *Geohydrology of and simulation of ground-water flow in the Milford-Souhegan glacial-drift aquifer, Milford, New Hampshire*. Report Number 91-4177. NHDES, Concord, NH.
- Hartel, K.; Halliwell, D. and Launer, A. 2002. *Inland Fishes of Massachusetts*. Massachusetts Audubon Society, Lincoln, MA.
- Magee, D.W. and H.E. Ahles. 1999. *Flora of the Northeast, A manual of the Vascular Flora of New England and Adjacent New York*. University of Massachusetts Press. 1213 pp.
- Mitchell, M. and Stapp, W. 1996. *Field Manual for Water Quality Monitoring*. Kendall/Hunt Publishing Co. Dubuque, Iowa.
- Nashua Regional Planning Commission (NRPC) 1995. *Souhegan River Watershed Study*.
- NHDES. 2001. unpublished water quality data for TMDL screening of the Souhegan River.
- NHDES. 2004. unpublished GIS data.
- NHDES. 2004. *Souhegan IPUOCR Entities-Preliminary List*. March 24, 2004.
- New Hampshire Fish and Game Department. 2004. *Endangered and Threatened Wildlife of New Hampshire*. http://www.wildlife.state.nh.us/Wildlife/Nongame/endangered_list.htm.
- New Hampshire Fish and Game Department. *Fishing Stocking Report*. 2003. http://www.wildlife.state.nh.us/Fishing/fish_stocking_report.htm.
- Normandeau Associates, Inc. (NAI). 2004. Bedford, NH.
- Page, L. and Burr, B. 1991. *Peterson Field Guides Freshwater Fishes*. Houghton Mifflin, Boston, MA.
- Smith, C. 1994. *Fish Watching An Outdoor Guide to Freshwater Fishes*. Cornell University Press, Ithaca, NY.
- Souhegan River Nomination (SRN). 1999. *Souhegan River Watershed Association and the Nashua Regional Planning Commission*. Milford, NH.
- Souhegan River Watershed Report (SRWR). 1997. NHDES, Concord, NH.
- Taylor, J. 1993. *The Amphibians & Reptiles of New Hampshire*. New Hampshire Fish and Game Department, Concord, NH. 71 pp.

Tharme, R. E.. 2003. A Global Perspective on Environmental Flow Assessment: Emerging Trends in the Development and Application of Environmental Flow Methodologies for Rivers. Freshwater Research Institute, University of Cape Town, Rhodes Gift, 7701, South Africa. *River Research and Applications* 19:397-441.

The Native Fish Conservancy <http://www.nativefish.org/Links/>

U.S fish and Wildlife Service <Http://news.fws.gov/mussels.html>

Wootton, R. 1998. *Ecology of Teleost Fishes, second edition*. Kluwer Academic Publishers, Norwell, MA.

Appendix I – Fish Species, Characteristics, and Habitat

Key to Information

(f): Female.

(m): Male.

SL (Standard Length): The measured straight-line distance from the most forward point of the head to the hidden base of the tail, as indicated by the crease formed when the tail is bent to one side.

TL (Total Length): The measured straight-line distance from the most forward point of the head to the end of the tail fin, with the lobes of the tail fin compressed.

Reproductive Guild: A group with similar strategies to raise their young (i.e., parental care).

Nonguarders: Open substratum spawners: Pelagophils - Large quantities of non-adhesive, near-neutral or buoyant eggs are scattered in open water. No parental care of eggs.

Nonguarders: open substratum spawners: Litho-pelagophils - Eggs are deposited on rocks and gravel, but eggs, embryos or larvae become sufficiently buoyant to be carried away from the spawning substrate by water currents. No parental care of eggs.

Nonguarders: Open substratum spawners: Phyto-lithophils - Deposit eggs in relatively clearwater habitats on submerged plants, if available, or on other submerged items such as rocks, logs or gravel, where their embryos and larvae develop. No parental care of eggs.

Nonguarders: Open substratum spawners: Phytophils - Scatter or deposit eggs with an adhesive membrane that sticks to submerged, alive or dead, aquatic plants or to recently flooded terrestrial vegetation. Sometimes woody debris. No parental care of eggs.

Nonguarders: Open substratum spawners: Psammophils - Usually small eggs with an adhesive membrane that are scattered directly on sand and/or the fine roots of plants that hang over the sandy bottom. No parental care of eggs.

Nonguarders: Brood Hiders: Lithophils - Eggs are hidden in specially constructed places. In most cases the hiding places (called redds in salmonids) are excavated in gravel by the female. No parental care of eggs

Nonguarders: Brood Hiders: Speleophils - Usually few large eggs with an adhesive membrane that are hidden in crevices. No parental care of eggs.

Guarders: Substratum choosers: Lithophils - Choose rocks for attachment of their eggs. Eggs are guarded, and possibly and ventilated.

Guarders: Substratum choosers: Phytophils - Choose plants for attachment of their eggs. Eggs are guarded, and possibly and ventilated.

Guarders: Nest spawners: Polyphils - No particular nest building material or substrate is chosen, however, a nest is constructed and the nest and eggs are guarded.

Guarders: Nest spawners: Lithophils - Eggs are deposited on cleaned areas of rocks or in pits dug in gravel. Nest is guarded.

Guarders: Nest spawners: Ariadnophils - The nest building male has the ability to spin a viscid thread from a kidney secretion, which binds the nest of different material together. The eggs are guarded and ventilated by the male, who also guards the young once they hatch.

Guarders: Nest spawners: Phytophils - Eggs are deposited in nests constructed above or on a soft muddy bottom, often amid algae or other exposed roots of vascular plants. Nest is guarded.

Guarders: Nest spawners: Speleophils - These fishes guard a clutch of eggs in natural holes or cavities, in specially constructed burrows, or where deposited on a cleaned area of the undersurface of flat stones.

Fresh Water Eel Family (*Anguillidae*)**American Eel (*Anguilla rostrata*)**

The American eel has a catadromous life strategy; that is the eggs hatch in the sea, the young migrate to freshwater to grow, and the adults return to the sea to spawn.

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	coolwater
Trophic Class	top carnivore
Habitat Preference	near cover over muddy, silty bottoms of lakes, rivers and creeks; preferred water temperature ~19.0 °C
Reproductive Guild	Nonguarders: Open substratum spawners: Litho-pelagophils
Spawning Habitat(s)	marine
Spawning Season	winter
Spawning Months	January-March
Spawning Temp	~17° C
Nursery habitat(s)	marine; estuarine; riverine
Diet	na
Age at maturity (yrs)	3-10 (m), 4-18(f)
Adult Length (cm)	25-40 TL (m), 70-100 TL (f)

Carp and Minnow Family (*Cyprinidae*)**Common Shiner (*Luxilus cornutus*)**

General Habitat(s)	riverine
Pelagic	no
Thermal Regime	coolwater
Trophic Class	generalist feeder
Habitat Preference	pools near riffles in clear, cool creeks and small to large rivers; preferred water temperature ~30°C
Reproductive Guild	Nonguarders: brood hiders: Lithophils
Spawning Habitat(s)	riverine
Spawning Season	spring -summer
Spawning Months	May-July
Spawning Temp	~16- 24°C
Nursery habitat(s)	riverine
Diet	feed mainly at surface or in midwater; opportunistic feeders: aquatic insects both adults and larvae are primary food source, occasionally small fishes and some plant material
Age at maturity (yrs)	1-3
Adult Length (cm)	7-14 TL

Golden Shiner (*Notemigonus crysoleucas*)

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	coolwater
Trophic Class	generalist feeder
Habitat Preference	clear, weedy, quiet waters of lakes, ponds, reservoirs, pools in slow moving rivers and streams; preferred water temperature~24°C
Reproductive Guild	Nonguarders: Open substratum spawners: Phytophils
Spawning Habitat(s)	lacustrine; riverine
Spawning Season	summer
Spawning Months	June-August
Spawning Temp	~20-27°C
Nursery habitat(s)	lacustrine; riverine
Diet	feed mainly at surface or in midwater, feed mainly on zooplankton, adults sometimes feed on insects and small fishes
Age at maturity (yrs)	2-3
Adult Length (cm)	10-15 TL

Spottail Shiner (*Notropis hudsonius*)

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	coolwater
Trophic Class	water column insectivore
Habitat Preference	Large lakes and rivers; slow to moderate current; sand, gravel, mud, or silt substrates; preferred temperature 13-22°C
Reproductive Guild	Nonguarders: Open substratum spawners: Litho-pelagophils
Spawning Habitat(s)	lacustrine; riverine
Spawning Season	spring
Spawning Months	May-June
Spawning Temp	~15-20°C
Nursery habitat(s)	lacustrine; riverine
Diet	tend to feed near bottom and consume small mollusks, mayflies, and other aquatic or terrestrial insects; adults also feed on fish eggs, including their own
Age at maturity (yrs)	1-2
Adult Length (cm)	6-12.5 TL

Blacknose Dace (*Rhinichthys atratulus*)

General Habitat(s)	riverine
Pelagic	no
Thermal Regime	coolwater
Trophic Class	generalist feeder
Habitat Preference	runs, pools, and riffles; in clear swiftly flowing creeks and small rivers with gravelly substrate
Reproductive Guild	Nonguarders: Open substratum spawners: Litho-pelagophils
Spawning Habitat(s)	riverine
Spawning Season	spring
Spawning Months	May-June
Spawning Temp	~15-22°C
Nursery habitat(s)	riverine
Diet	feed on a wide variety of aquatic invertebrates and terrestrial insects, aquatic fly larvae are a favored prey
Age at maturity (yrs)	1-2
Adult Length (cm)	6-7.6 TL

Longnose Dace (*Rhinichthys cataractae*)

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	coolwater
Trophic Class	benthic insectivore
Habitat Preference	Cobble, boulder or gravel riffles of clean swiftly-flowing, creeks and small to medium rivers; rocky shores of lakes; preferred water temperature ~21°C
Reproductive Guild	Nonguarders: Open substratum spawners: Litho-pelagophils
Spawning Habitat(s)	riverine
Spawning Season	spring-summer
Spawning Months	May-July
Spawning Temp	~11-23°C
Nursery habitat(s)	riverine
Diet	diet consists primarily of immature aquatic insects that cling to rocks and boulders; chief predator of larval blackflies and midges, but will also prey on other small aquatic invertebrates
Age at maturity (yrs)	2-3
Adult Length (cm)	6.5-11.8 TL

Fallfish (*Semotilus corporalis*)

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	coolwater
Trophic Class	generalist feeder
Habitat Preference	gravel and cobble bottom pools and runs of small to medium rivers; margins of lakes, ponds, or reservoirs; preferred water temperature ~22°C
Reproductive Guild	Nonguarders: Brood hiders: Lithophils
Spawning Habitat(s)	riverine: gravel, cobbles; adhesive eggs that stick to the nest
Spawning Season	spring
Spawning Months	May-June
Spawning Temp	~14-19°C
Nursery habitat(s)	riverine
Diet	omnivorous, eating mostly plankton until they reach~ 1.5 inches in TL, gradually switching to larger foods such as: algae, insects, crayfish, and fishes
Age at maturity (yrs)	3 (m), 4 (f)
Adult Length (cm)	15.5-25.5 TL

Sucker Family (*Catostomidae*)

Longnose Sucker (*Catostomus catostomus*)

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	coldwater
Trophic Class	benthic insectivore
Habitat Preference	clear, cold deep water of lakes and tributary streams; occasionally brackish water preferred water temperature ~8-17°C
Reproductive Guild	Nonguarders: Open substratum spawners: Litho-pelagophils
Spawning Habitat(s)	riverine: gravel, cobbles; adhesive eggs deposited over substrate
Spawning Season	spring
Spawning Months	April-May
Spawning Temp	~5-15°C
Nursery habitat(s)	lacustrine; riverine
Diet	longnose suckers vacuum a wide variety of aquatic invertebrates and algae off the bottom, including amphipods, copepods, and the larvae of blackflies, beetles, mayflies, dragonflies, stoneflies, and caddisflies
Age at maturity (yrs)	4-8 (m), 5-9 (f)
Adult Length (cm)	30.5-46.2 TL

White Sucker (*Catostomus commersoni*)

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	coolwater
Trophic Class	generalist feeder
Habitat Preference	rocky pools and riffles of creeks and rivers; lake embayments; preferred water temperature ~22°C
Reproductive Guild	Nonguarders: Open substratum spawners: Litho-pelagophils
Spawning Habitat(s)	lacustrine; riverine, migrate upstream to tributaries, or shoal areas if tributaries are not available
Spawning Season	spring
Spawning Months	April-May
Spawning Temp	~7-10°C
Nursery habitat(s)	lacustrine; riverine
Diet	benthic invertebrates, fish eggs, larval midges, detritus
Age at maturity (yrs)	2-3 (m), 3-4 (f)
Adult Length (cm)	30.5-50.8 TL

Creek Chubsucker (*Erimyzon oblongus*)

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	coolwater
Trophic Class	generalist feeder
Habitat Preference	creeks, streams, and lakes with moderate aquatic vegetation
Reproductive Guild	na
Spawning Habitat(s)	lacustrine; riverine, gravel runs; young move to downstream habitats after hatching
Spawning Season	spring
Spawning Months	na
Spawning Temp	na
Nursery habitat(s)	lacustrine; riverine
Diet	plant material, a wide variety of aquatic and terrestrial invertebrates
Age at maturity (yrs)	na
Adult Lenth (cm)	Usually less than 22.8 TL

Bullhead Catfish Family (*Ictaluridae*)

Yellow Bullhead (*Ameiurus natalis*)

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	warmwater
Trophic Class	generalist feeder
Habitat Preference	pools and backwaters over soft substrates in sluggish creeks and small to large rivers; oxbows, ponds, impoundments and heavily vegetated areas of shallow bays and small lakes; preferred water temperature ~28°C
Reproductive Guild	Guarders: Nest spawners: Speleophils
Spawning Habitat(s)	lacustrine; riverine
Spawning Season	Spring
Spawning Months	May-June
Spawning Temp	~23-27°C
Nursery habitat(s)	lacustrine; riverine
Diet	insects, crustaceans, mollusks, and small fishes, as well as some plant material
Age at maturity (yrs)	2-3
Adult Length (cm)	17.8-34.3 TL

Brown Bullhead (*Ameiurus nebulosus*)

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	warmwater
Trophic Class	generalist feeder
Habitat Preference	pools and sluggish runs over sand to mud substrates in creeks and small to large rivers; impoundments, ponds and lake embayments; preferred water temperature ~25-27°C
Reproductive Guild	Guarders: Nest spawners: Speleophils
Spawning Habitat(s)	lacustrine; riverine
Spawning Season	Spring
Spawning Months	May-June
Spawning Temp	~21-25°C
Nursery habitat(s)	lacustrine; riverine; young remain in areas with aquatic vegetation through the end of their first summer
Diet	omnivores feed on wide variety of animal and plant material
Age at maturity (yrs)	2-3
Adult Length (cm)	19.3-35.6 TL

Margined Madtom (*Noturus insignis*)

General Habitat(s)	riverine
Pelagic	no
Thermal Regime	warmwater
Trophic Class	benthic insectivore
Habitat Preference	riffles and runs of clear, fast-flowing creeks and small to medium rivers with cobble, boulder or coarse gravel substrates; lakes
Reproductive Guild	Guarders: Nest spawners: Speleophils
Spawning Habitat(s)	riverine; nest under flat stones
Spawning Season	summer
Spawning Months	June-July
Spawning Temp	na
Nursery habitat(s)	riverine
Diet	nocturnal omnivores feed on wide variety of aquatic insects and other invertebrates
Age at maturity (yrs)	1-2 (m), 2 (f)
Adult Length (cm)	9-12 SL

Pike and Pickerel Family (*Escidae*)**Chain Pickerel (*Esox niger*)**

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	coolwater
Trophic Class	top carnivore
Habitat Preference	typically live in ponds and quiet backwaters of medium to large rivers, less common in smaller streams, can occur in brackish waters
Reproductive Guild	Nonguarders: Open substratum spawners: Phytophils
Spawning Habitat(s)	lacustrine; riverine
Spawning Season	spring
Spawning Months	March-May
Spawning Temp	~8-11°C
Nursery habitat(s)	lacustrine; riverine; swampy, marshy, or flooded areas with abundant submerged vegetation
Diet	juveniles feed on smaller invertebrates and fishes, adults are highly piscivorous, large pickerel will eat small mammals, frogs, and snakes
Age at maturity (yrs)	na
Adult Length (cm)	33.0 TL

Salmon, Char, and Trout Family (*Salmonidae*)**Rainbow Trout (*Oncorhynchus mykiss*)**

General Habitat(s)	lacustrine; riverine
Pelagic	yes
Thermal Regime	coldwater
Trophic Class	Top carnivore
Habitat Preference	mid-waters of lakes; creeks and rivers with moderate flow, gravelly bottoms and riffle-pool habitat; preferred water temperature 11.3°C
Reproductive Guild	Nonguarders: Brood hiders: Lithophils
Spawning Habitat(s)	riverine
Spawning Season	spring
Spawning Months	March-May
Spawning Temp	~5-13°C
Nursery habitat(s)	Hatchery (reproducing populations in New Hampshire na) In Massachusetts reproducing populations are restricted to coldwater streams with high gradient (more than 75 feet per mile)
Diet	
Age at maturity (yrs)	3-5
Adult length (cm)	36.1-73.4 TL

Atlantic Salmon (*Salmo salar*)

The Atlantic Salmon has an anadromous life history. Young salmon remain in freshwater for two or three years, descending to the sea as smolts. At sea, they live for one or two more years before they return to their natal streams to spawn.

General Habitat(s)	lacustrine; riverine; marine
Pelagic	yes
Thermal Regime	coldwater
Trophic Class	top carnivore
Habitat Preference	mid-waters of lakes; rocky runs and pools of small to large rivers; preferred water temperature 16.0°C
Reproductive Guild	Nonguarders: Brood hiders: Lithophils
Spawning Habitat(s)	riverine: highly oxygenated, minimal pollution levels, and silt-free rocky or gravel substrate
Spawning Season	fall
Spawning Months	October- November (return to freshwater typically in May or June)
Spawning Temp	~4-10°C
Nursery habitat(s)	Riverine
Diet	Young Atlantic salmon feeds primarily on aquatic and terrestrial insects while they are in freshwater. Adult atlantics salmon do not feed in fresh water prior to spawning.
Age at maturity (yrs)	3-6
Adult Length (cm)	53.8-74.4 TL

Brown Trout (*Salmo trutta*)

General Habitat(s)	lacustrine; riverine
Pelagic	yes
Thermal Regime	coldwater
Trophic Class	top carnivore
Habitat Preference	creeks and rivers with moderate flow, gravelly substrates and riffle-pool habitat, and lake shallows; preferred water temperature ~21°C
Reproductive Guild	Nonguarders: Brood hiders: Lithophils
Spawning Habitat(s)	Riverine: spawning substrate with stones ranging from .25-3 inches in diameter
Spawning Season	fall
Spawning Months	October- December
Spawning Temp	~2-13°C
Nursery habitat(s)	riverine
Diet	juvenile brown trout are primarily insectivorous, until the onset of piscivory
Age at maturity (yrs)	2-4
Adult Length (cm)	25.8-63 TL

Brook Trout (*Salvelinus fontinalis*)

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	coldwater
Trophic Class	top carnivore
Habitat Preference	clear, cool, well-oxygenated streams, ponds and lakes with maximum water temperature less than 22°C; preferred water temperature 16.0°C
Reproductive Guild	Nonguarders: Brood hiders: Lithophils
Spawning Habitat(s)	lacustrine; riverine: gravel riffles coarse sand and stone up to 4 inches in diameter
Spawning Season	fall
Spawning Months	September-November
Spawning Temp	~4-10°C
Nursery habitat(s)	lacustrine; riverine
Diet	stream dwelling brook trout are primarily insectivores,
Age at maturity (yrs)	15.2-44.2 TL
Adult Length (cm)	2-3

Sunfish and Black Bass Family (*Centrarchidae*)

Redbreast Sunfish (*Lepomis auritus*)

General Habitat(s)	lacustrine; riverine
Pelagic	na
Thermal Regime	warmwater
Trophic Class	generalist feeder
Habitat Preference	clean water with rocky substrates; ponds, lakes, slow moving sections of streams and rivers; tend to avoid heavily vegetated areas
Reproductive Guild	Guarders: Nest spawners: Polyphils
Spawning Habitat(s)	sheltered areas: rocks and woody debris; build nests in sand or gravel substrate
Spawning Season	spring-summer
Spawning Months	May-august
Spawning Temp	na
Nursery habitat(s)	lacustrine; riverine
Diet	wide variety of larval and adult aquatic insects, including mayflies, caddisflies, midges, flies, mosquitoes, beetles, and dragonflies; scuds, aquatic snowbugs, mollusks, and small fishes occasionally eaten
Age at maturity (yrs)	na
Adult Length (cm)	10.1-20.3 TL

Pumpkinseed (*Lepomis gibbosus*)

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	warmwater
Trophic Class	generalist feeder
Habitat Preference	warm, shallow, vegetated lakes and ponds; quiet vegetated pools of creeks and small rivers; preferred water temperature ~26.0°C
Reproductive Guild	Guarders: Nest spawners: Polyphils
Spawning Habitat(s)	lacustrine; riverine; sand or gravel substrate
Spawning Season	spring-summer
Spawning Months	May-August
Spawning Temp	~20-28°C
Nursery habitat(s)	lacustrine; riverine
Diet	wide range of aquatic invertebrates, especially those bottom dwelling or in vegetation
Age at maturity (yrs)	1-3
Adult Length (cm)	12.7-19.0 TL

Smallmouth Bass (*Micropterus dolomieu*)

General Habitat(s)	lacustrine; riverine
Pelagic	no
Thermal Regime	warmwater
Trophic Class	top carnivore
Habitat Preference	clear, gravel-bottomed runs and flowing pools of small to large rivers; shallow, rocky and sandy areas of lakes; preferred water temperature ~30°C
Reproductive Guild	Guarders: Nest spawners: Polyphils
Spawning Habitat(s)	lacustrine; riverine
Spawning Season	spring
Spawning Months	May-June
Spawning Temp	~13-20°C
Nursery habitat(s)	lacustrine; riverine
Diet	generally, smaller individuals consume aquatic invertebrates, primarily zooplankton, and occasionally small fish, larger smallmouths mainly feed on crayfishes and fishes
Age at maturity (yrs)	3-5 (m), 4-6 (f)
Adult Length (cm)	25.4-40.6 TL

Largemouth Bass (*Micropterus salmoides*)

General Habitat(s)	Lacustrine; riverine
Pelagic	no
Thermal Regime	warmwater
Trophic Class	Top carnivore
Habitat Preference	clear, warm, shallow lakes, bays, ponds, marshes and backwaters and pools of creeks and small to large rivers; often associated with soft mud or sand substrate and dense aquatic vegetation; usually at depths <6 m; preferred water temperature ~30°C
Reproductive Guild	Guarders: Nest spawners: Polyphils
Spawning Habitat(s)	Lacustrine; riverine
Spawning Season	Spring
Spawning Months	May-June
Spawning Temp	~17-22°C
Nursery habitat(s)	Lacustrine; riverine
Diet	Young feed primarily on aquatic invertebrates and small fishes, as they mature fish become a greater part of their diet, sometimes larger individuals consume small mammals and birds
Age at maturity (yrs)	3-4(m), 4-5 (f)
Adult Length (cm)	30.5-53.3 TL

Perch Family (*Percidae*)

Yellow Perch (*Perca flavescens*)

General Habitat(s)	Lacustrine; riverine
Pelagic	no
Thermal Regime	coolwater
Trophic Class	Top carnivore
Habitat Preference	lakes, ponds and pools of creeks and small to large rivers with moderate aquatic vegetation and clear water, young inhabit weedy shallows, while adults prefer rock ledges usually at depths less than 9 m; preferred water temperature ~ 21°C
Reproductive Guild	Nonguarders: Open substratum spawners: Phyto-lithophils
Spawning Habitat(s)	Lacustrine; riverine: weedy areas
Spawning Season	Spring
Spawning Months	April-May
Spawning Temp	~6-12°C
Nursery habitat(s)	Lacustrine; riverine
Diet	Diurnal carnivores, feeding on small aquatic insects, crustaceans, and small fishes
Age at maturity (yrs)	2-3 (m), 3-4 (f)
Adult Length (cm)	15.2-30.5 TL