Lamprey River
Protected Instream Flow Study
• Introduction
• Acceptance of meeting minutes
• Presentation of draft Lamprey PISFs
  ➢ Natural flow paradigm concept
  ➢ Lamprey River hydrograph analysis
  ➢ Flow dependent protected entities
  ➢ Floodplain entities and transect findings
  ➢ Aquatic entities and MesoHABSIM findings
  ➢ Water supply
  ➢ Final recommendations
PISF Generalized Process

- Define protection goals
- Assess river conditions
- Define conditions to meet goals
- Establish numerical flow standards
- Evaluate problem reaches
- Evaluate management options
- Integrate options into a plan
- (Implement plans)
Some Protected Entities (Goals)

Human uses
- Recreation
- HE energy production
- Agriculture
- Natural resources
- Storage
- Wildlife
- Fish & wildlife habitat
- Vegetation
- Rare species or habitat
- Aquatic life and fish

Biological Integrity
- Fisheries
- Public water supply
- CWA Designated Uses
- Open space
- Geologic resource

Human uses
- Hydrologic resource
- Cultural resources
- Water quality
- Pollution abatement
- Aesthetic beauty
- Fisheries
- Public water supply
- CWA Designated Uses
- Open space
- Geologic resource

What is Needed to Describe PISFs?

• A systematic method of determining flow needs for human uses.

• A systematic method of determining flow needs for ecological integrity.

• A meaningful way to describe stream flow and protected flows.
How to Describe the PISF?

**EXPLANATION**
- **MDM** Daily Mean Discharge
- **MAF** Median Daily Streamflow based on 70 years of record
- **Q99** 99% Flow duration
- **7Q10** 7-day, 10-year low flow
- **CFF** Flow at station affected by ice
NFP = aquatic life is adapted to naturally occurring variability.

How to define the appropriate variability pattern for PISF?

Describe flow as; **timing**, **duration**, **frequency**, **rate of change** as well as **magnitude**.

How NFP flow components are described in the Lamprey PPISF report

- **TIMING** – Bioperiods – biologically significant divisions of the year.
- **MAGNITUDE** – three levels for each bioperiod.
- **DURATION** – for each magnitude - allowable and catastrophic thresholds marking when flows go too low for too long.
- **FREQUENCY** – used either to 1) define the duration, or 2) specified number of events for magnitudes.
Pair magnitudes with their natural durations at historically-significant frequencies

Decreasing flow magnitude

Let's only limited duration, low-flows get through
Souhegan River Stream Flow versus PISF magnitude and durations

Stream Flow
PISF Common
PISF Critical
PISF Rare
Common reset
Critical reset
Rare reset
Rare Flow Allowable
Rare Catastrophic

Days
CFSM

1 6 11 16 21 26 31 36 41 46
Lamprey Hydrograph Analysis

- UNH reviewed discharge records (1934 – 2007) for the USGS gaging station (#01073500) at Packers Falls.
- Created pre-development hydrographs by adding in permitted consumptive water use (DES data) and correcting for Pawtuckaway Lake releases and filling.
Lamprey Hydrograph Analysis

• 3-yr (wet, average and dry) and 5-yr records (last 5 yrs) were developed in accordance with project tasks.

• 30-yr record (1976 – 2005) used for development of PISF.
Lamprey Flow Measurements

• UNH measured concurrent instantaneous flows at Wadleigh Falls and Packers Falls 16 times (flows of 0.06 to 1.64 cfsm).

• Correlated concurrent flow measurements to instantaneous flows at the USGS gaging station at the same times:

\[ Q_{\text{upstream, cfsm}} = a \cdot Q_{\text{USGS}} \]

• 3-yr (wet, average and dry), 5-yr (last 5 yrs), and 30-yr hydrographs then developed the same for Wadleigh and Packers Falls.
Concurrent flows correlated with instantaneous flows at USGS gaging station using regression.

<table>
<thead>
<tr>
<th>Site Description</th>
<th>Area (mi²)</th>
<th>Ratio to USGS gage</th>
<th>Num. of Measures</th>
<th>a</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wadleigh Falls</td>
<td>135</td>
<td>0.738</td>
<td>16</td>
<td>0.7849</td>
<td>0.998</td>
</tr>
<tr>
<td>Lee Hook Road</td>
<td>161</td>
<td>0.880</td>
<td>16</td>
<td>0.8813</td>
<td>0.9902</td>
</tr>
<tr>
<td>USGS Gage</td>
<td>183</td>
<td>1.000</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Results show that Q can be estimated based on ratio of watershed area upstream of point to USGS gage.
Flow Duration of Selected Records

- 30-year record
- 3-yr low
- 3-yr high
- 3-yr ave
- last 5 yrs

Discharge (cfs) vs. Non-Exceedance Probability
Lamprey Hydrograph Analysis

Once PISF were developed:

• the three year,
• five year, and
• 30 year

stream flow records were evaluated to identify the statistical occurrences of when the river does not meet the PISF for each affected water user (AWU) location.

MORE ABOUT THIS LATER!
Flow Dependent Protected Entities

INSTREAM PUBLIC USES, OUTSTANDING CHARACTERISTICS, AND RESOURCES OF THE LAMPREY RIVER AND PROPOSED PROTECTIVE FLOW MEASURES FOR FLOW DEPENDENT RESOURCES

FINAL REPORT

NOVEMBER 2006

NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES
Flow Dependent Protected Entities

Evaluation of flow dependent instream public uses, outstanding characteristics and resources (IPUOCR) aka Protected Entities.

Protected Entity categories:

- Recreation
- Maintenance and Enhancement of Aquatic Fish and Life
- Fish and Wildlife Habitat
- Rare, Threatened and Endangered Species or Natural Ecological Communities
- Public Water Supply
Flow Dependent Protected Entities

Recreation
• Boating
• Fishing
• Swimming

Natural Communities
• Floodplain Forests
• Oxbow/backwater Wetlands
• Vernal Pools
• High Energy Riverbanks
• River Rapids

RTE Plants
• Water Marigold
• Sharp-flowered Mannagrass
• Knotty Pondweed
• Small-crested Sedge
• Slender Blue Flag
• Climbing Hempweed

RTE Wildlife
• Wood Turtle
• Spotted Turtle
• Blanding’s Turtle
• Pied Billed Grebe
• Osprey
• Bald Eagle
• Sedge Wren

Aquatic Life and Habitat
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• T/E Bridled Shiner
• Banded Sunfish
• Endangered Brook Floater

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Public Water Supply
Recreation Protected Entities:

- Boating
- Fishing
- Swimming

All noted as important resources in the documents submitted to DES applying for designation in 1990.
Recreation - Boating
Recreation - Boating

• Evaluated by field surveys (including swimming survey).

• Surveys performed in spring, summer and fall of 2006 and spring 2007.

• Surveyed participants of 2006 Lamprey River Canoe (& Kayak) race.

• Visited popular boat launch locations on upper and lower portions of the designated segment.
Recreation - Boating

Flatwater upstream of:

- Wadleigh Falls
- Lee Hook Road
- Wiswall Dam
- Packers Falls
- Macallen Dam
Recreation - Boating

Rapids at or below:

- Wadleigh Falls
- Lee Hook Road
- Wiswall Dam
- Packers Falls
**Recreation - Boating**

Lamprey River Flow (USGS gage at Packers Falls) for survey dates:

<table>
<thead>
<tr>
<th>Survey Date</th>
<th>CFS</th>
<th>CFSM</th>
<th>(CFS)</th>
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<tbody>
<tr>
<td>April 16 2006</td>
<td>185</td>
<td>1.01</td>
<td>698</td>
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<tr>
<td>April 29 2006</td>
<td>154</td>
<td>0.84</td>
<td>477</td>
</tr>
<tr>
<td>July 1 2006</td>
<td>249</td>
<td>1.36</td>
<td>127</td>
</tr>
<tr>
<td>July 3 2006</td>
<td>177</td>
<td>0.97</td>
<td>292</td>
</tr>
<tr>
<td>July 20 2006</td>
<td>100</td>
<td>0.55</td>
<td>80</td>
</tr>
<tr>
<td>Oct. 8 2006</td>
<td>64</td>
<td>0.35</td>
<td>99</td>
</tr>
<tr>
<td>May 26 2007</td>
<td>353</td>
<td>1.93</td>
<td>322</td>
</tr>
</tbody>
</table>
Upper Lamprey (Not Designated):

- Most paddle 1-2 times a year, usually spring.
- Paddlers from southern NH, also MA + ME.
- Monitor flow by word of mouth or visual.
- Typically paddle from Blair Park to Rte 87.
- Minimum flow should be higher than on April 16 and 29 2006 (0.8 to 1.0 cfs/m).
- Attraction of river: wildlife, feeling of remoteness, beautiful scenery, variable paddling conditions.
Boating Survey Results

Lower Lamprey (Designated):

- Most paddle more than 2 times a year, during spring, summer and fall.
- Paddlers from Durham and Dover NH.
- Monitor flow by word of mouth or visual.
- Paddle flatwater sections upstream of falls or dams.
- Minimum flow should be about what was observed on July 1 2006 (1.4 cfs).m.
- Attraction of river: quiet, lack of development, beautiful scenery and fishing.
Other sources of information on recommended flow levels for paddling Lamprey River:

- AMC Guidebook Discover Southern New Hampshire by Monkman and Monkman (2002) suggests that running the Lamprey at flows below 200 cfs (1.09 cfsm) should not be attempted.

- Survey respondents from 2006 Lamprey Canoe Race indicated that flows should have been higher than what they were (154 cfs, 0.84 cfsm) the day of the race.
Other sources of information on recommended flow levels for paddling Lamprey River:

- Indicator of water level – flow over rapids/riffles downstream of Lee Hook Road Bridge. If you can pass this with a canoe, whole trip usually good.

- Passage of canoes and kayaks through rapids downstream of Lee Hook Road bridge observed in April and May 2008 at flows of 425 and 205 cfs.
Recreation - Boating

July 12 2007  Q = 150 cfs

May 14 2008  Q = 205 cfs

March 13 2007  Q = 323 cfs

April 19 2008  Q = 425 cfs
Protected Instream Flow for Recreational Boating:

- Paddling through rapids flow dependent, flatwater paddling not flow dependent, but levels controlled naturally or artificially.

- Observed flow conditions at rapids sections suggest flows greater than 200 cfs (1.1 cfsm) needed to navigate rapids.

- Based on field crew observations a flow of 275 cfs (1.5 cfsm) proposed as PISF for whitewater recreational boating.
Recreation - Fishing
Recreation - Fishing

Report discusses:

• Location of popular fishing spots along the designated segment.

• Coldwater and warm water fishing resources.

• Issue of anadromous fish passage.

• NH Fish and Game Department management program and Trout Unlimited fish stocking.

• Fishing on the Lamprey is flow dependent, but the instream flows required to maintain the fish habitat will be adequate to preserve fishing on the river. So a recreational fishing study was not performed.
Recreation - Swimming

Ferndale Acres Campground

Image 1: Sign indicating Ferndale Acres Campground
Image 2: View of a calm lake with a sandy beach and trees in the background.
Swimming popular recreational activity at designated beaches and swimming holes along the Lamprey River.

Recreational swimming assessed by surveys performed at four designated beaches and two swimming holes.

Interviews were conducted on July 29 and August 5, 2006.
Recreation - Swimming
Swimming Survey

The survey included questions regarding:

- Use of the river
- Frequency of use
- Favorite swimming locations
- Preferred flow conditions or levels, sources of information on swimming conditions.
Swimming Survey

- One location did not have a usable beach (Glenmere).
- Two of the locations have both a beach and a pool (Ferndale and Wadleigh).
- The three campgrounds restricted access to beach and/or pool to registered campers and daily guests (paid pass required).
Swimming Survey Results

• Months of use ranged from April to October, most activity centered June to August during periods of hot weather.

• Few people monitor flow conditions other than by driving by or checking when they arrive at their campsite.

• Outside of large-scale drought or flood events, swimmers will use the river when it is convenient and it is warm enough.
Recreation - Swimming

• Most popular sections of river used for swimming are impounded by dams or bedrock falls.

• Due to control of water levels in these sections, they are less flow dependent than in other sections and for other recreational uses.

• Since swimming conditions are dependent on multiple variables a specific instream flow value cannot be established or proposed.
# Flow Dependent Protected Entities

<table>
<thead>
<tr>
<th>Recreation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Boating</td>
</tr>
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<td>• Fishing</td>
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</table>
Plant Communities/Wildlife Habitat

[Map showing various habitats such as High Energy Riverbank, Backwater Marsh, Bordering Shrub Swamp, Bordering Marsh, Silver Maple Floodplain Forest, Swamp White Oak Floodplain Forest, Floodplain Wetland Complex, Rapids, Channel Habitat, and location names like Durham, Newmarket, Epping, Nottingham, Madbury, Lee.]
Associated Flora and Fauna
RTE, SC, SGCN, Others
Floodplain Forests and Pools

(Low Energy/Above Channel)
Periodic flooding (1-100 years) – early spring

Sensitive Resources:
• Swamp White Oak, Red Maple, Silver Maple Floodplain Forests
• Ground-nesting turtles and birds
• VP breeders/feeders
• Slender Blueflag Iris
Sensitive Resources:

- Overwintering Blanding’s/Spotted Turtles
- Nesting Birds - Pied-billed Grebe/Sedge Wren
- Water Marigold/StarDuckweed/Climbing Hempweed
- Invertebrates/larval amphibians

Oxbow/Backwater/Fringe Wetlands (Low Energy/Channel)

Channel margins, pools, tributaries & oxbows
Permanent inundation to seasonal saturation
Variable flow dependence – dams, levees, tribs
Riverbanks and Rapids
(High Energy)

Continuous to seasonal inundation
Seasonal ice and flood scour

Sensitive Resources:
- Herbaceous Low Riverbank Community
- Riverweed Rapid Community
- Sharp-flowered Mannagrass
- Knotty Pondweed
- Aquatic macroinvertebrates
Transect Method

Cross valley transects

Transect #1

- Forested Floodplain
- Forested Wetland
- Shrub Swamp
- Shrub Swamp
- Emergent Marsh
- Forested Floodplain
- Forested Wetland
- Water

Transect #2

- Forested Floodplain
- Shrub Swamp
- Shrub Swamp
- Pool
- Forested Wetland
- Forested Wetland
- Water

Adapted from Scott Jackson, UMASS
Transect #1

Flow regime 1

Flow regime 2

Adapted from Scott Jackson, UMASS
Change in Area

Flow regime 1

Flow regime 2

Adapted from Scott Jackson, UMASS
T-1 Tuttle Swamp

Protected Entities

• Exemplary Swamp White Oak Floodplain Forest
• Silver Maple Floodplain
• Backwater Swamp
• RTE Plant – Knotty Pondweed
• Wildlife Habitat
T-2 Lee Hook Road Rapids

Protected Entities

- Herbaceous Low Riverbank Community
- Riverweed Rapids Community
- Low and High Floodplain Terrace
T-3 UNH Marsh

Protected Entities

- Marsh, Shrub and Forested Wetlands
- Silver Maple Floodplain Forest
- Wildlife Habitat – waterfowl, raptors, shorebirds, amphibians
T-4 – Glenmere Swamp

Protected Entities
- Vernal Floodplain Pools
- Red Maple/Oxbow Shrub Swamps
- High Floodplain Terrace
- Potential Spotted and Blanding’s turtles
- Wildlife Habitat
Moat Island Marsh

- RTE Plants
- Pied-billed Grebe
- Waterfowl and Shorebird Habitat

This location will be evaluated through aerial photo/digital elevation modeling only
August 28 2007  $Q = 10$ cfs

July 12 2007  $Q = 150$ cfs

March 13 2007  $Q = 323$ cfs

April 19 2008  $Q = 425$ cfs

March 16 2006  $Q = 510$ cfs

June 13 2006  $Q = 1,670$ cfs
T-1 Tuttle Swamp Transect (excerpt)

RIVER CHANNEL-R2UBH/R2AB4

(Sparse Potamogeton)

LOW FLOODPLAIN
FOREST TERRACE
PFO1

(Acer, Quercus bicolor, Caryx, Carpinus)

1,670 cfs
(6/13/06)

1,200 cfs
(10/31/06)

LAMPREY RIVER

520 cfs
(3/16/06)

370 cfs (10/12/06)

157 cfs (7/12/06)

58 cfs (10/9/06)

10 cfs
(8/23/07)

WETLAND FLOODPLAIN
PFO1/SS1
(Cornus, Acer)

MUCK

SAND
<table>
<thead>
<tr>
<th>Protected Entity</th>
<th>Sensitive Bioperiod(s)</th>
<th>General Flow Requirements.</th>
<th>Preliminary PISF (at Gauge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Floodplain Forest</td>
<td>Growing season</td>
<td>1-3 year flooding (&lt; 2 yr return flood)</td>
<td>&gt;500 cfs every 1-3 years For 5-50 days</td>
</tr>
<tr>
<td>Herbaceous Low Riverbank</td>
<td>Winter/Spring dormancy</td>
<td>Flood/ice scour of channel</td>
<td>December 1 to April 30 500 cfs for 1 week</td>
</tr>
<tr>
<td>Deep and Shallow Marsh</td>
<td>Early-mid growing season</td>
<td>Flooding of marsh for dependent fauna</td>
<td>April 1 to July 31 &gt;10 cfs daily mean flow</td>
</tr>
<tr>
<td>Riverweed River Rapid</td>
<td>Spring growth</td>
<td>Flooding of Riffles</td>
<td>May 1 to June 30 &gt;100 cfs mean monthly flow</td>
</tr>
<tr>
<td></td>
<td>Late summer flowering</td>
<td>Low flow to expose riffles</td>
<td>August 1 to September 30 &lt; 100 cfs mean monthly flow</td>
</tr>
<tr>
<td>Wood Turtle <em>Clemmys insculpta</em></td>
<td>Spring-summer nesting</td>
<td>No flooding during nesting in mid to high floodplain</td>
<td>June 1 to October 15 &lt;500 cfs daily flow</td>
</tr>
<tr>
<td></td>
<td>Winter hibernation</td>
<td>Avoid dewatering of in-channel hibernation sites</td>
<td>December 1 to March 31 &gt;130 cfs monthly mean &gt;50 cfs daily mean</td>
</tr>
</tbody>
</table>
Flow Dependent Protected Entities

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Public Water Supply
Lamprey River
MesoHABSIM Application
1. Biological targets and indicators
   a. Reference fauna
   b. Bioperiods
   c. Indicators

2. Biological filters
   a. Literature based criteria
   b. Empirical data

3. Instream Habitat classification
   a. Delineation
   b. Evaluation
   c. Upscaling

4. Adjusting biophysical template
   a. Identify habitat deficiencies
   b. Simulate habitat improvements

5. Time Series Analysis

6. Interpretation and Application
   a. Restoration recommendations
   b. Flow management criteria
Example of proposed use of multispectral high-resolution imagery to remotely classify hydro-morphological units. Close-up area (lower left) shows Packers Falls region along Bennett Road.
Target Fish Community

[Diagram showing a pie chart with various fish species categories and their proportions.]

- Common Winter: 21%
- Pacific Salmon: 18%
- Groundfish: 15%
- Hake: 12%
- Other Species: 10%
- Sablefish: 7%
- Pink Salmon: 6%
- Red Salmon: 5%
- Yellowtail: 4%
- Black Rockfish: 3%
- Greenling: 3%
- Halibut: 2%
- Other Species: 2%
- Balaenoptera: 1%
Bioperiods

Day of the Year

Mean of Daily Flows (cfs)

- Winter Survival Bio-period: Resident Fish Species Survival and Atlantic Salmon Egg Development
- Spring Flooding Bio-period: Spring Floods
- Spring Spawning Bio-period: Resident Adult Fish Species Spawning
- Summer Rearing and Growth Bio-period: Juvenile and Adult Fish Rearing, Growth and Maintenance
- Atlantic salmon Spawning Bio-period: Atlantic Salmon Spawning

Atlantic salmon Spawning Bio-period:

- Spring Flooding Bio-period:
  - Spring Floods

- Spring Spawning Bio-period:
  - Resident Adult Fish Species Spawning

- Summer Rearing and Growth Bio-period:
  - Juvenile and Adult Fish Rearing, Growth and Maintenance

- Atlantic salmon Spawning Bio-period:
  - Atlantic Salmon Spawning
Species Selected for Habitat Modeling (summer)

- Fallfish
- Redbreast sunfish
- Common shiner
- Longnose dace
- White sucker
- Blacknose dace
- American Eel
- Atlantic salmon
### Longnose dace

#### Presence Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
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<tbody>
<tr>
<td>Area Under ROC curve</td>
<td>0.86</td>
</tr>
<tr>
<td>Selected cut-off (PT)</td>
<td>0.1</td>
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<tr>
<td>Variables in the Equation</td>
<td>b</td>
</tr>
<tr>
<td>Riprap</td>
<td>0.828</td>
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<tr>
<td>Overhanging Vegetation</td>
<td>-0.433</td>
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<tr>
<td>Riffle</td>
<td>2.342</td>
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<tr>
<td>Ruffle</td>
<td>1.667</td>
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<tr>
<td>Depth 0 - 25 cm</td>
<td>1.963</td>
</tr>
<tr>
<td>Current Velocity 0 - 15 cm/s</td>
<td>1.821</td>
</tr>
<tr>
<td>Current Velocity 15 - 30 cm/s</td>
<td>1.435</td>
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<tr>
<td>Current Velocity 75 - 90 cm/s</td>
<td>5.065</td>
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<tr>
<td>Akal</td>
<td>3.32</td>
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<tr>
<td>Megalithal</td>
<td>1.925</td>
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<tr>
<td>Constant</td>
<td>-6.273</td>
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#### Abundance Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
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<tbody>
<tr>
<td>Area Under ROC curve</td>
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### Lamprey HMU Survey Chart

**Watershed area = 183 mi²**

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Start/stop refers to the cfs at the Newmarket gauge at the start and finish of each mapping of a representative site. The cfs at the time of mapping was then calculated by taking the average of these two numbers.
Suitable Habitat for Fish

Suitability Curve(s) for whole Project

Project: Lamprey River AIC
Curve: Suitability

FLOW (CFPD)

- ATLANTIC SALMON
- REDBREAST SUNFISH
- WHITE SUCKER
- LONNOSE DACE
- AMERICAN EEL
- FALLFISH
- COMMON SHINER

CHANNEL AREA
Optimal Habitat for Fish

Suitability Curve(s) for Whole Project

Project: Lamprey River AIC
Curve: Optimal

FLOW (CFS)

CHANNEL AREA

ATLANTIC SALMON
RED BREAST SUNFISH
WHITE SUCKER
LONG NOSE DACE
AMERICAN EEL
FALLFISH
COMMON SHINER
Effective Habitat for Fish

Suitability Curve(s) for Whole Project

Project: Lamprey River AIC
Effective Habitat

Graph showing flow (cfs) vs. channel area with different species depicted by lines and markers.

Species:
- Atlantic Salmon
- Redbreast Sunfish
- White Sucker
- Longnose Dace
- American Eel
- Fallfish
- Common Shiner
Effective Habitat for Fish Community

Community Habitat Suitability Curve for Whole Project

Flow (CFM)

- GENERIC FISH
- Community/habitat
Suitability Curve(s) for Whole Project

Project: Lamprey River Bugs AIC
Effective Habitat

FLOW (CFSM) vs CHANNEL AREA

- GENERIC BUG
- Ephemeroptera
- Odonata
- Plecoptera
- Trichoptera
Habitat vs. Fish Community

![Habitat vs. Fish Community Diagram]
Effective Habitat for Fish Restored

Current

Baseline
Effective Habitat for Fish Community

Current

Baseline
UCut Curve

Project: Lamprey River AIC

C. Shiner
The common flow:

- corresponding to the highest habitat magnitude above which the frequency of occurrence begins to decline significantly with incremental increase in habitat magnitude.
- near optimal habitat availability conditions.
- exceeded approximately 45% of the bioperiod.
Flow Thresholds

The critical flow:

• corresponding to the second to the lowest habitat magnitude for which the frequency of occurrence increases significantly with incremental increase in habitat magnitude.

• less habitat availability than that provided by the common flow, but this habitat magnitude is not unusual.

• exceeded approximately 65% to 85% of the bioperiod.
Flow Thresholds

The rare flow:

– corresponding to the lowest of habitat magnitudes for which the frequency of occurrence increases significantly with incremental increase in habitat magnitude.

– habitat availability is severely reduced and very uncommon.

– exceeded more than 90% of the bioperiod.
Flow Duration Threshold

- **Allowable** – consecutive days with flow below protected magnitude for ordinary conditions – no flow management.

- **Catastrophic** - consecutive days with flow below protected magnitude for unacceptable conditions – trigger management.

- **Persistent** – longer then allowable, but shorter then catastrophic - trigger management after 3rd consecutive year.
## Bioperiod Approximate dates

<table>
<thead>
<tr>
<th>Bioperiod</th>
<th>Rearing &amp; Growth</th>
<th>Salmon Spawning</th>
<th>Overwintering</th>
<th>Spring Flood</th>
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<td>Oct. 7 - Dec. 8</td>
<td>Dec 9 - Feb. 28</td>
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### Indicator

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| Watershed area (mi²) | 183 | 183 | 183 | 183 |

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## Bioperiod Approximate dates

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## R&G Season

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Flow Dependent Protected Entities

Recreation
• Boating
• Fishing
• Swimming

Natural Communities
• Floodplain Forests
• Oxbow/backwater Wetlands
• Vernal Pools
• High Energy Riverbanks
• River Rapids

RTE Plants
• Water Marigold
• Sharp-flowered Mannagrass
• Knotty Pondweed
• Small-crested Sedge
• Slender Blue Flag
• Climbing Hempweed

RTE Wildlife
• Wood Turtle
• Spotted Turtle
• Blanding's Turtle
• Pied Billed Grebe
• Osprey
• Bald Eagle
• Sedge Wren

Aquatic Life and Habitat
• Fish and Fish Habitat
• Mussels
• Insects
• T/E Bridled Shiner
• Banded Sunfish
• Endangered Brook Floater

Public Water Supply
Public Water Supply

Laws of 1965 – Chapter 322

“An Act Relative to Future use of Portions of the Waters of the Lamprey River and/or its Tributaries for Public Water Supplies”. Based on results of study performed for the Town of Durham and UNH for an additional water supply source.

Grants the Towns of Durham, Epping, Lee, Newmarket and Raymond the use of the waters of the Lamprey River and its tributaries, in these towns, for the purpose of public water supplies to the exclusion of all other municipalities.
UNH/Town of Durham

- The only active user of water pumped directly from the Lamprey River within the designated segment.
- Withdrawal from Lamprey supplements water from Oyster River and pumping from Lee Well.
Section 401 Certificate Restrictions

• If summer flow between 45 & 21 cfs (0.25 & 0.11 cfsm), 1.8 cfs (0.01 cfsm) can be diverted.

• If summer flow between 21 & 13 cfs (0.11 & 0.07 cfsm), 0.4 cfs (0.002 cfsm) can be diverted.

• If summer flow less than 13 cfs (0.07 cfsm) outflow = inflow to dam.

• Pool elevation cannot be drawn down more than 0.5 in. in 24 hours with a six inch maximum.
System only pumps water from Lamprey when flow at Packers Falls gage > 45 cfs because a monitoring system is not in place above dam.

Investigating the development of new water supply well near Spruce Hole Bog.

May also consider artificial recharge, divert during spring runoff and recharge aquifer.
Newmarket Water Works

- Currently obtains water supply from Bennett and Sewall Wells in Newmarket Plain Aquifer.
- Formerly diverted water from Folletts Brook, the Piscassic River and the Lamprey River, but abandoned due to water treatment issues.
- Recently received Groundwater Discharge Permit for artificial recharge of Newmarket Plain aquifer.
Public Water Supply

Newmarket Water Works

• Proposed source for recharge water is a diversion from the Lamprey River. Estimated withdrawal of 500,000 gallons per day (0.77cfs or 0.004 cfsm).

• Intake may be placed in Lee in the designated segment or in Macallen Dam impoundment downstream of designated segment.
Public Water Supply

- No specific water supply PISF proposed.
- Water use by Newmarket Water Works and Durham/UNH to be evaluated during development of Water Management Plan.
- Conservation and Water Use Plans to be developed for each system as part of WMP.
- Goal is to minimize impact of water supply use on instream protected entities.
Assessment of PISFs

As mentioned earlier UNH developed representative hydrographs for:

– Last five years (2003 – 2007)
– Wet three years (2005 – 2007)
– Average three years (1990 – 1992)
– Dry three years (1964 – 1966)

Proposed PISFs evaluated under these flow scenarios to estimate their impact and their range of influence.
Recreation PISF $Q \geq 275$ cfs

<table>
<thead>
<tr>
<th>Representative Hydrograph</th>
<th>Days</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last five years</td>
<td>549</td>
<td>30.1</td>
</tr>
<tr>
<td>Wet three years</td>
<td>510</td>
<td>46.5</td>
</tr>
<tr>
<td>Average three years</td>
<td>407</td>
<td>37.1</td>
</tr>
<tr>
<td>Dry three years</td>
<td>235</td>
<td>21.4</td>
</tr>
</tbody>
</table>
Vernal Floodplain Pool - Spring PISF (number of days in the hydrologic record and bioperiod that the reach meets the PISF and per cent of time in the representative hydrograph).

March 15 - July 31  Q < 1,500 cfs every day

<table>
<thead>
<tr>
<th>Representative Hydrograph</th>
<th>Days</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last five years</td>
<td>657</td>
<td>50.7</td>
</tr>
<tr>
<td>Wet three years</td>
<td>389</td>
<td>50.1</td>
</tr>
<tr>
<td>Average three years</td>
<td>405</td>
<td>52.1</td>
</tr>
<tr>
<td>Dry three years</td>
<td>417</td>
<td>53.7</td>
</tr>
</tbody>
</table>
Wood Turtle - Summer PISF (number of days in the hydrologic record and bioperiod that the reach meets the PISF and per cent of time in the representative hydrograph).

June 1 to October 15  Q < 500 cfs

<table>
<thead>
<tr>
<th>Representative Hydrograph</th>
<th>Days</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last five years</td>
<td>670</td>
<td>97.8</td>
</tr>
<tr>
<td>Wet three years</td>
<td>374</td>
<td>91.0</td>
</tr>
<tr>
<td>Average three years</td>
<td>394</td>
<td>95.9</td>
</tr>
<tr>
<td>Dry three years</td>
<td>411</td>
<td>100.0</td>
</tr>
<tr>
<td>Bioperiod</td>
<td>Rearing &amp; Growth</td>
<td>Salmon Spawning</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Approximate dates</td>
<td>July 5 - Oct. 6 (94 days)</td>
<td>Oct. 7 - Dec. 8 (63 days)</td>
</tr>
<tr>
<td>Watershed area (mi²)</td>
<td>183</td>
<td>183</td>
</tr>
<tr>
<td>Location</td>
<td>USGS Gage</td>
<td>USGS Gage</td>
</tr>
<tr>
<td>Common flow (cfs)</td>
<td>110</td>
<td>90</td>
</tr>
<tr>
<td>Common flow (cfsm)</td>
<td>0.60</td>
<td>0.49</td>
</tr>
<tr>
<td>Allowable duration under (days)</td>
<td>46</td>
<td>17</td>
</tr>
<tr>
<td>Catastrophic duration (days)</td>
<td>81</td>
<td>55</td>
</tr>
<tr>
<td>Critical flow (cfs)</td>
<td>22</td>
<td>40</td>
</tr>
<tr>
<td>Critical flow (cfsm)</td>
<td>0.12</td>
<td>0.22</td>
</tr>
<tr>
<td>Allowable duration under (days)</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>Catastrophic duration (days)</td>
<td>32</td>
<td>33</td>
</tr>
<tr>
<td>Rare flow (cfs)</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>Rare flow (cfsm)</td>
<td>0.09</td>
<td>0.11</td>
</tr>
<tr>
<td>Allowable duration under (days)</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Catastrophic duration (days)</td>
<td>28</td>
<td>11</td>
</tr>
</tbody>
</table>
## PISFs vs. 3 Year Average Flow Record

<table>
<thead>
<tr>
<th>Bioperiod</th>
<th>Rearing &amp; Growth</th>
<th>Salmon Spawning</th>
<th>Overwintering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>July 5 - Oct. 6 (94 days)</td>
<td>Oct. 7 - Dec. 8 (63 days)</td>
<td>Dec 9 - Feb. 28 (82 days)</td>
</tr>
<tr>
<td><strong>Approximate dates</strong></td>
<td><strong>Recommended flows</strong></td>
<td><strong>Recommended flows</strong></td>
<td><strong>Recommended flows</strong></td>
</tr>
<tr>
<td></td>
<td>Common shiner</td>
<td>Atlantic Salmon</td>
<td>Flow</td>
</tr>
<tr>
<td>Watershed area (mi²)</td>
<td>183</td>
<td>183</td>
<td>183</td>
</tr>
<tr>
<td>Location</td>
<td>USGS Gage</td>
<td>USGS Gage</td>
<td>USGS Gage</td>
</tr>
<tr>
<td>Common flow (cfs)</td>
<td>204</td>
<td>8</td>
<td>91</td>
</tr>
<tr>
<td>Common flow (cfsm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowable duration (days)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Catastrophic duration (days)</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Critical flow (cfs)</td>
<td>105</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Critical flow (cfsm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowable duration (days)</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Catastrophic duration (days)</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rare flow (cfs)</td>
<td>70</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rare flow (cfsm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowable duration (days)</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Catastrophic duration (days)</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Note:** 3 year average flow period = 1990 to 1992. Numbers listed as flows are the number of times in the record PISF not met. Numbers listed as durations are number of years PISF not met.
### PISFs vs. 3 Year Low Flow Record

<table>
<thead>
<tr>
<th>Bioperiod</th>
<th>Rearing &amp; Growth</th>
<th>Salmon Spawning</th>
<th>Overwintering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Approximate dates</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td></td>
<td>July 5 - Oct. 6</td>
<td>Oct. 7 - Dec. 8</td>
<td>Dec 9 - Feb. 28</td>
</tr>
<tr>
<td>Watershed area (mi²)</td>
<td>183</td>
<td>183</td>
<td>183</td>
</tr>
<tr>
<td>Location</td>
<td>USGS Gage</td>
<td>USGS Gage</td>
<td>USGS Gage</td>
</tr>
<tr>
<td>Common flow (cfs)</td>
<td>261</td>
<td>128</td>
<td>180</td>
</tr>
<tr>
<td>Common flow (cfsm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowable duration under (days)</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Catastrophic duration (days)</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Critical flow (cfs)</td>
<td>203</td>
<td>61</td>
<td>111</td>
</tr>
<tr>
<td>Critical flow (cfsm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowable duration under (days)</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Catastrophic duration (days)</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Rare flow (cfs)</td>
<td>167</td>
<td>15</td>
<td>58</td>
</tr>
<tr>
<td>Rare flow (cfsm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowable duration under (days)</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Catastrophic duration (days)</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Note:** 3 year low flow period = 1964 to 1966.
Numbers listed as flows are the number of times in the record PISF not met. Numbers listed as durations are number of years PISF not met.
Wiswall Dam and Durham/UNH Water Supply

45 cfs > Q > 21 cfs can withdraw 1.8 cfs
21 cfs > Q > 13 cfs can withdraw 0.4 cfs
Q < 13 cfs no withdrawal (only from storage)

<table>
<thead>
<tr>
<th>Representative Hydrograph</th>
<th>45-21 cfs</th>
<th>21-13 cfs</th>
<th>&lt;13 cfs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Days</td>
<td>%</td>
<td>Days</td>
</tr>
<tr>
<td>Last five years</td>
<td>150</td>
<td>8.2</td>
<td>99</td>
</tr>
<tr>
<td>Wet three years</td>
<td>86</td>
<td>7.8</td>
<td>64</td>
</tr>
<tr>
<td>Average three years</td>
<td>73</td>
<td>6.7</td>
<td>52</td>
</tr>
<tr>
<td>Dry three years</td>
<td>149</td>
<td>13.6</td>
<td>82</td>
</tr>
</tbody>
</table>
Final Recommendations

1. PISF for fish controlling flows.

2. Flow no less than 4 cfs.

3. Additional conditions for RTE, plant communities and wildlife habitat.

4. PISFs maintained by implementation of Water Management Plan.
Final Recommendations

Additional Conditions:

Winter Survival and Development - December 1 through April 30
- >130 cfs monthly mean – wood turtle
- >500 cfs for 1 week or more – herbaceous low riverbank, mannagrass, hempweed
- <1,500 cfs daily mean in April – vernal floodplain pool, Blanding’s turtle

Spring Spawning May 1 through June 30
- >100 cfs monthly mean – riverweed, knotty pondweed
- <500 cfs daily mean in June (wood turtle)
- <1,500 cfs daily mean in May - Blanding’s turtle, floodplain vernal pools

Summer Survival and Development – July 1 through Sept 30
- <500 cfs daily mean in July – wood turtle
- ≤60 cfs daily mean in August/Sept – Herbaceous low riverbank
- <100 cfs monthly mean – August /Sept – riverweed, knotty pondweed
Comments or Questions?
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