R-WD-10-16

The Instream Flow Council's Review of the New Hampshire Instream Flow Pilot Program: Protected Instream Flow Study Phase

Compiled by Hal Beecher
Review coordinator
Past-president, Instream Flow Council

September 29, 2009

for

New Hampshire Department of Environmental Services
PO Box 95
29 Hazen Drive
Concord, NH 03302-3503
(603) 271-8865
www.des.nh.gov

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25 September 2009

C. Wayne Ives, P.G., Hydrogeologist
Instream Flow Specialist
Watershed Management Bureau
New Hampshire Department of Environmental Services
PO Box 95 - 29 Hazen Drive
Concord, NH 03302-0095

Dear Mr. Ives:

In 2008 the New Hampshire Department of Environmental Services (NHDES) requested the Instream Flow Council (IFC) to review two instream flow setting pilot programs on the Lamprey and Souhegan rivers. After getting approval from John Magee, the IFC representative for New Hampshire Fish & Game Department, and from the IFC Executive Committee, IFC agreed and contracted with NHDES to review the documents for these rivers. Adam Kaeser (Georgia), Bob Metcalfe (Ontario), Ron Ptolemy (British Columbia), and Bob Vadas (Washington) agreed to assist me on this review (NHDES wanted at least 3 reviewers).

NHDES sent us a list of questions to answer. These are found in *IFC NH questions.doc*, the main product that is provided in fulfillment of the contract. In this file, questions and background from NHDES are in Calibri font, while IFC response is in Times New Roman font. I considered merging the responses into a single IFC response, but each reviewer brought different areas of expertise to the review and NHDES was anxious to have at least 3 reviews. On conference calls we had no obvious conflicts of opinion, but not every reviewer answered every question. Considering these factors and the challenge of editing into a single smoothly-flowing response, I chose to stick with identifying each reviewer's specific input.

In addition to the list of questions, I reviewed the list of IFC policies from Book 2, as requested by Tom Annear (Wyoming representative and IFC Director At-Large) when the IFC Executive Committee approved the review contract. This is found in *IFC Policies Annear et al 2004 Appendix A-final.doc*. Note that the policies were aimed at member agencies, rather than at sister water resource agencies, so there are a number of NA entries. I wrote this document, so it has not had separate input from the other members of the review team.

Hal Beecher • Washington Department of Fish and Wildlife
600 Capitol Way N. • Olympia, WA 98501-1091
Phone: (360) 902-2421 • Email: beechhab@dfw.wa.gov

About a week before all reviews were due to me from the team, NHDES provided an additional 100 page appendix to the Lamprey report in which NHDES had responded to public written comments on the draft report. I read this appendix and provided comments on some of NHDES's responses in *HB comments on Lamprey Appendix 14.doc*, but did not send to other reviewers because of the late date.

The material being submitted in fulfillment of the contract between IFC and NHDES has been sent, with the exception of resumes/curricula vitae, to IFC Governing Council members for their review. The few substantive comments were incorporated.

After the last material was incorporated from reviewers, Dr. Vadas provided an additional analysis that is consistent with the material provided by him and Ron Ptolemy. As it was too late to send as part of the IFC response, I want you to know that it is available independently from him (Robert.Vadas@dfw.wa.gov). Dr. Vadas has a very strong statistical background as well as expertise in mesohabitats and instream flow, so I encourage you to follow up with him.

New Hampshire is to be commended for its vision and effort and we wish you success in protecting New Hampshire's aquatic ecosystems.

Sincerely,

Hal A. Beecher

Hal Beecher
Review coordinator

Enclosures: *IFC NH questions.doc*
IFC Policies Annear et al 2004 Appendix A-final.doc
HB comments on Lamprey Appendix 14.doc
Curriculum vitae/resumes (Beecher, Kaeser, Metcalfe, Ptolemy, Vadas)

Cc: Peter Aarrestad
Kathleen Williams (Executive Director)
John Magee (New Hampshire Fish & Game Department)
IFC peer review team (Beecher, Kaeser, Metcalfe, Ptolemy, Vadas)

Hal Beecher • Washington Department of Fish and Wildlife
600 Capitol Way N. • Olympia, WA 98501-1091
Phone: (360) 902-2421 • Email: beechhab@dfw.wa.gov

Instream Flow Council (IFC) Preface to Review

This file is the main IFC review of two New Hampshire Department of Environmental Services (NHDES) instream flow reports on the Souhegan and Lamprey rivers (see http://des.nh.gov/organization/divisions/water/wmb/index.htm although the Lamprey report must be tracked using the search window). The two reports together were over 1,000 pages, including all appendices. Both used similar approaches.

NHDES asked IFC to provide at least 3 reviewers and to answer a series of questions. The last question (#38) was open-ended, an opportunity for reviewers to provide any other comments that seemed relevant. In this file, questions and background from NHDES are in Calibri font, while IFC response is in Times New Roman font. The mean annual discharge of a river is abbreviated throughout much of this review as mad.

Because NHDES requested multiple reviewers and asked for their qualifications, it seemed appropriate to list each reviewer's responses separately, in alphabetic order by last names, rather than to merge them into a single IFC answer. Different reviewers have different areas of expertise in instream flow and so concentrated on different questions. They also differed somewhat on some responses.

Reviewers were Hal Beecher (WA), Adam Kaeser (GA), Bob Metcalfe (ON), Ron Ptolemy (BC), and Bob Vadas (WA). Bob Vadas' review focused primarily on the supporting literature related to MesoHABSIM.

REVIEW QUESTIONS

Reviewers – For both the Lamprey and Souhegan river studies please discuss in writing the following topics. A brief statement for context precedes the review questions in each section. Your responses to these topics will be compiled with those of the other reviewers. Please answer them completely. Feel free to expand upon any topic or discussion point.

RECOMMENDED PROTECTED FLOW VALUES OVERVIEW

The protected flows resulting from three main areas of instream use: human use, fish and aquatic life, and riparian wildlife and vegetation are used to set the recommended protected flows. The program's overarching conceptual model is that protected flows should be consistent with the Natural Flow Paradigm (Poff et al., 1997.) The protected flows developed therefore attempt to meet natural variability shown in the stream's hydrograph by framing the

protected flows in terms of frequency, duration, timing and magnitude. (Rate of change will be considered more during the Water Management Plan phase of these pilot studies and is not part of this review.)

The protected flows described begin with the results of the fish assessment using an incremental modeling method. These results include components of timing, duration, frequency and magnitude. Timing is related to biologically significant periods called bioperiods. Each bioperiod has three flow magnitudes derived from uniform continuous under-threshold habitat-duration curves (UCUT curves). Frequency changes represented by slope inflections in UCUT curves are identified. These inflection points mark the durations beyond which hydrologic events are significantly less common. The use of three magnitudes combined with defined durations for allowable and catastrophic conditions allows normal low flows to occur. It also signals management alternatives to protect flows at the normal, rare and critical levels from unnaturally long durations that would result in significantly reducing habitat availability during critical bioperiods.

The protected flows also include recommendations based on the floodplain transect assessments. These results also include components of timing, duration, frequency and magnitude. Timing is related to biologically significant periods appropriate to the riparian species. These flow recommendations are for inundation events to occur during certain seasons. The higher flow requirements generally are expected to occur infrequently over longer time periods of years to decades and are not considered manageable. There are also limits on high flows during certain periods that will not be managed except to avoid management activities that would result in these high flows.

Recommendations for human uses, such as hydropower and recreation among others, recognized this use relied largely on seasonal higher flows and the opportunistic use following storm events. Hydroelectric use is more likely to rely on seasons of prolonged higher flows than on brief storm flows. Flow recommendations were to continue to rely on seasonal and opportunistic use and to monitor long term frequency. Human uses are not being considered in this review since the expertise of the reviewers is in ecosystem water needs.

PROTECTED ENTITIES

Categories of protected entities are identified in RSA 483. Evaluation of the presence and flow-dependent nature of specific instances of protected entities in each Designated Rivers were determined in the studies by literature searches and river surveys. A report was compiled describing river-specific protected entities and whether or not they were flow-dependent. Flow assessment methods were identified for those entities considered flow-dependent.

RIPARIAN WILDLIFE AND VEGETATION FLOW ASSESSMENT - FLOODPLAIN TRANSECT METHOD

The floodplain transect method evaluates the flow needs of riparian wildlife and vegetation. The floodplain transect method relates the elevation of plant communities along transects to inundation of these communities at observed flows. The necessary frequency and duration of inundation associated with these plant communities under the Natural Flow Paradigm was estimated based on community type descriptions in the literature. Protected flows were defined for flow-dependent protected entities. The resulting protected flows were defined by time of year, flow magnitude, flow frequency and flow duration.

1. Were the number of transects adequate to develop protected flows for the protected entities described?

Souhegan

Beecher:

There were 1 or 2 transects for each of the special plant communities. These communities are apparently small and localized. The smaller and more localized they are, the smaller the number of transects needed to represent or assess them. If they are variable in shape and size, then more transects might be used or a conservative placement of transects could assess the most sensitive part or representative of the community. Are the community examples sampled the only examples of those communities along the river? If not, how were these examples chosen and how were transects selected? One or two transects per community precludes some standard statistical characterizations, but may be reasonable for making judgments about important flows, particularly if they cross the main or only example of the community type. What limits the extent of the community? There is some discussion, but it is limited. Ice scour is mentioned for the High Energy Riverbank Community, and it is suggested that flow reduction would increase the community downslope, but what about upslope? Statement that reduction in flows would reduce ice scour is not well supported because scour often occurs during peak flows that break

up ice and it is unclear that reducing flow would also reduce peaks. This implies that ice scour is a limiting factor for the High Energy Riverbank Community. For the Oxbow/Backwater Marsh, a combination of transects and MesoHABSIM maps determined draining flows, but the role of the transects seems incidental.

Ptolemy:

The information including mapping and photographs suggests that the number and quality of transects is adequate to develop protection flows.

Lamprey

There were several wetland transects. How were the transects selected? The absence of a method description for selecting transects suggests that they were based on professional judgment. Professional judgment is acceptable, but not as defensible as a more rigorous sampling protocol that allows statistical analysis. The small number of transects per precludes some standard statistical characterizations, but may be reasonable for making judgments about important flows, particularly if they cross the main or only example of the community type. The smaller and more localized the wetlands are, the smaller the number of transects needed to represent or assess them.

2. Were the locations of transects appropriate to develop protected flows for the protected entities described?

Beecher:

See #1 above for both rivers.

For Souhegan, transects intersect the channel – a minimum standard. Otherwise more information is needed about the population of vegetation communities being sampled – number and size of each type and location of any examples remote from the river. The full rationale for sampling methodology is not presented and without the full rationale and details of the methods, presented as for a scientific journal publication, it is difficult to fully evaluate how satisfactory the method was.

Ptolemy:

Yes they are appropriately located.

3. Within the context of the Natural Flow Paradigm, were the protected flows appropriate to support riparian wildlife and vegetation?

Beecher:

If the mechanisms for implementation are adequate (and the material provided does little to address enforcement/management of instream flows beyond Env-Ws 1907.01, 483:9-a V, 9-c IV, and 9-c V), then the approach developed in the technical documents appear consistent with the Natural Flow Paradigm of Poff et al. (1997), at least to a point. In general, the instream flows are designed to prevent excessive reduction below natural variation. Infrequent high flows are not addressed, although the broad snowmelt peak is protected. Neither is the potential for increased frequency of infrequent high flows.

Ptolemy:

Within the context of NFP, the protection flows rationalize a relatively high flow need (about 200%mad) and coupled with lesser flows at other times, they describe variable flows needs with magnitude timing and duration being defined. Whether the 3.8 cfsm value is too high is debatable since the material does not show a performance trend or inflection point as done with some other empirical plots (habitat rating curves for fish). Critical flows for off-channel connectivity in other streams is typically near 100%mad or 292 cfs or 1.71 cfsm in the lower Souhegan River example.

4. Is the transect method an appropriate method for developing these protected flows? Please discuss any concerns with the overall investigation techniques and the resulting protected flows developed for riparian wildlife and vegetation.

Beecher:

The transect method is a reasonable approach to addressing protected flows for riparian wildlife and vegetation. Incorporation of soil types and boundaries and discussion of soil moisture as related to flows would strengthen the approach. Do plant community boundaries depend only on frequency and duration of inundation or are there shifts in soils at those boundaries? Are the

boundaries created by inundation and deposition or are they the result of older rock and soil formation?

Ptolemy:

Yes, this is an appropriate procedure if properly calibrated with explicit risk factors attached. Insight on failures of some species to reproduce or propagate would be useful. For example, what insights are available to suggest there was a failure for wildlife, riparian or aquatic species in a drought year like 1965 when annual inflows were third of normal? Mean monthly flow (April) in the lower river was 406 cfs or 139%mad or 2.4 cfsm. Did the oxbows and backwater marshes fill in 1966? Since the stream is flow regulated due to various reservoirs and dams, are the flows in 1966 an artefact of regulation or are the reservoirs too small to account for the much lower flows in 1966?

FISH AND AQUATIC LIFE ASSESSMENT - MESOHABSIM

Fish and aquatic life were assessed using the MesoHABSIM incremental model. This model used hydrologic data and habitat assessments to evaluate the habitat conditions within a range of flows. The assessment of the variability of habitat availability forms the criteria for defining protected flow as three flow magnitudes each with two defined durations based on the frequency of occurrence. The flow durations defined limits on persistent and catastrophic events at the specified flow magnitude. Describing protected flows at multiple magnitudes with frequency-based durations meets the Natural Flow Paradigm concept by allowing low flows to occur, but restricting them to natural durations after which management options are required to relieve the unnatural conditions.

Inputs to the model include hydrologic data, a defined fish community, habitat criteria, and mapped habitat conditions. These inputs result in habitat rating curves that are tied to flow conditions and evaluated for changes in frequency representing critical changes in habitat availability. Protected flows are defined at critical inflection points on the habitat availability curves.

Target Fish Community

A target fish community is used to identify the appropriate species structure for the pilot rivers based on other rivers that are the least impacted, similar in character, and have fish collection data. The model is run to evaluate the habitat availability for these fish species.

5. Were the rivers selected as reference sites appropriate for the Souhegan and Lamprey Rivers?

Beecher:

I do not know the rivers selected as reference sites, nor do I know the Souhegan and Lamprey. As a map-based exercise the approach seems reasonable for development of a Target Fish Community because all the rivers were in the same ecoregion as the Souhegan and Lamprey and the two Souhegan sections (upper and lower) were different stream orders and consistent stream orders were used in the reference rivers. In other regions of North America, within an ecoregion and similar stream order the fish species should be similar with the exception of endemics or colonization barriers (I do not believe either is an issue here); near ecoregion boundaries there can also be differences between high and low gradient streams of the same order.

Kaeser:

The approach undertaken to select reference rivers seemed appropriate and defensible.

Ptolemy:

There is insufficient information to make a judgement here. What is critical for reference streams (Appendix 6-Table 3) are to understand that they exist in the same ecoregion, have similar physical and chemical properties, and the reference sites must have a demonstrated natural or unregulated flow regime. A useful table or matrix might show the comparability of the test cases with the reference cases. Since the comparisons are fish-based or numbers of captures, how do we know the sampling strategies were similar among all examples? It is also clear in Table 4 that (for example) longnose dace in several reference streams is far less than 15% quoted for the Upper Souhegan River; namely, Burntshirt and Suncook. Reference percentage value for other streams was considerably higher; namely in the Piscatapuog and Swift rivers presumably due to differences in fast-water meso-habitat quantity.

Other aquatic reference data should have included swift-water dependent invertebrates such as *Simulium*, Plecoptera, Ephemeroptera, and *Hydropsyche* since these animals provide the primary food source for fish in slower meso-habitats. Considerable empirical observations of where fish live or station within meso-habitats suggest species such as adult Common Shiner and the like, orient to the fast-water interface with pools or runs. I'm uncertain whether the MesoHabSim assessment is all that definitive and may not be any better than PHabSim. I remain puzzled why Odonates would be selected as a sensitive species to changes in flow.

6. Are the fish selected for modeling appropriate for the Souhegan and Lamprey Rivers?

Beecher:

Yes, with some caveats. Use of the Bain and Meixler (2008) fish community reconstruction seems a reasonable approach for determining the historical fish community. They include the likely dominant species and species of high value for restoration. In the latter group are species known to be sensitive to flow. However, inclusion of restoration species is more appropriate if restoration is part of the goal and restoration measures are planned. Using numbers rather than weight of fish biases the focus towards small schooling species, but suckers were included. Uncommon species may also be important, and flow-sensitive species should be included. My concerns are (1) the (pointless) effort to determine the percentages of different species in the fish community and (2) the cut-off of the most abundant species as the ones on which to focus. Using the samples from different southern New England rivers, together with faunal surveys of the ecoregion, any restoration goals, and any established non-native species, a fairly complete species list can be compiled. Caution should be used in weighting species by abundance; a single adult sucker in a pool may outweigh hundreds of common shiners. At certain seasons young-of-the-year of certain species may be very abundant, but survival is small, so that the numerical abundance will quickly decline while the contribution to weight is negligible. Percentages of different species in different rivers in the same ecoregion vary, and the variation may be as informative as the average percentage of common shiners or white suckers. Differences in percentages among rivers may reflect differences among the rivers in any number of habitat features.

Kaeser:

I feel comfortable with the ultimate selection of the 5 SR species that were the most commonly occurring members of the TFC community observed in the study rivers (as stated on page 269 of

the Souhegan report). I was derailed by the time spent comparing the entire suite of species (expected proportions and densities) in the TFC to the study river samples given the disparities in "sampling effort" that each collection of species represents. These concerns are discussed briefly at the end of the Appendix section (page 270). When the species pool of several separate reference river reaches are combined you end up with multitude of rare species, as expected. Sampling the one study stream is unlikely to produce a comparable assemblage without considerable and exhaustive effort. In parts of the report, it was unclear how much sampling was conducted to assess the Souhegan fish assemblage in the upper reaches (pages 42-43 and on page 246- Appendix 7 should be referenced at these points specifically for fish collection methods). Reference to Appendix 7 appears only at end of paragraph on invertebrates and mussels (page 43).

A minor point- Is it appropriate to classify redbreast sunfish as a MG? In the Southeast these fish do not inhabit lacustrine environments, and all but disappear from impounded river reaches (reservoirs). I'd classify them as fluvial.

Ptolemy:

While the selected species are appropriate in both streams, the size class per species is a critical factor in addressing highest flow standards among competing species at a particular time. Such is the case for YOY longnose dace and that for adult longnose dace. Fish sampling of adult longnose dace in riffles, rapids and cascades may be under-represented leading to false conclusions about modelling appropriate common flows for the rearing/growth period.

Ptolemy (from General #4 in #38 below):

Common shiners are the indicator species for July 5-Oct. 6 period yet they are pool dwellers. Surely fast-water taxa would be more sensitive to dewatering event than are pool-dwellers; this includes mayflies, stoneflies and simulids. Adult Common Shiners have been consistently observed near fast-water interfaces with slow habitats presumably due to the proximity of food items (insect drift) originating in riffles and rapids. It remains likely the meso-habitat approach is the wrong tool to address things like drift rate and density of food being delivered to species like Common Shiner. Adult longnose dace are probably a better fish indicator as they are found primary in riffles and rapids; while dace fry are more common to the perimeter of fast-water and slow-water habitats.

Vadas (from #38 below):

Bain and Meixler (2000, 2008) examined freshwater-fish assemblages in tributary rivers in the Quinebaug River basin of southern New England, using the Target Fish Community approach to identify pristine ichthyofaunal conditions for use in assessing human impacts (e.g., channelization and hydropower dams) and river-restoration needs (cf. Parasiewicz 2003, 2007a,c, 2008b; Jacobson 2008). Species were ranked for abundance and then converted to relative-abundance data based on the theoretical log-log (power-law) relation between species abundance and occurrence expected by community ecologists (cf. Parasiewicz 2003) that has been partially corroborated for Virginia fish assemblages (Vadas 1991; Vadas and Orth 1997). For Bain and Meixler's (op. cit.) fish assemblages, cypriniforms were especially prevalent, including the dominant fallfish, subdominant common shiner, and several common species that included dace and various non-cypriniform fishes (i.e., darter, sunfish, perch, and eel species); most of these fishes were native. But some sites were unusual in showing dominance by (a) centrarchids like the native redbreast sunfish and exotic smallmouth bass and bluegill sunfish (various habitat and pollution/thermal impacts) or (b) native minnows like spottail and common shiners (recent inundation after a dam failed) (Bain and Meixler 2000; Parasiewicz 2003)). Bain and Meixler (2000) also classified species into three macrohabitat guilds in increasing order of conservation concern based on literature data; the guilds were generalists, fluvial dependents, and fluvial specialists. The above target species were especially fluvial specialists, but the other two guilds were also represented.

For the Quinebaug River basin, Parasiewicz (2001, 2007a,b, 2008b) undertook an instream-flow (ecohydrologic) study at the mesohabitat level, …. The focus was the six more-abundant species from the Bain/Meixler study, including cypriniforms (fallfish, common shiner, white sucker, and longnose and blacknose dace) and (to a lesser extent) the native tessellated darter and the exotic bluegill sunfish, which were sampled using the (a) Bain electro-grid technique or (b) other techniques for non-wadeable conditions (i.e., snorkeling unless turbid enough to require boat electrofishing) (op. cit.; Parasiewicz and Walker 2007). Parasiewicz (2003, 2008a) also considered spawning life stages of anadromous fishes, including American shad and Atlantic salmon, to provide for adequate spring vs. fall flows, respectively, as these seasons typically require higher flows that during summer (Vadas and Weigmann 1993; Vadas 2000). I address the mesohabitat-guild status of the resident fishes below.

Parasiewicz's crew (Parasiewicz 2001, 2003, 2007b, 2008b; Parasiewicz and Walker 2007) undertook stepwise-forward, logistic (multivariate) regressions to identify important habitat variables (each segregated into multiple classes) for most of the above target-fish species. This was based on two binary analyses on adjacent suitability classes, i.e., optimal, suitable, and unsuitable, as estimated via density (fish/m^2) thresholds (for high vs. low abundance) of (a) 0.30 for gregarious (schooling) cypriniforms (fallfish, common shiner, and white sucker) and (b) 0.15

for solitary species (longnose and blacknose dace) at the mesohabitat level (Parasiewicz 2007b). …

Bluegills … This species wasn't used in [Quinnebaug] instream-flow analysis….

Fallfish (Parasiewicz 2001, 2003, 2008b; Parasiewicz and Walker 2007) liked boulders and medium-high velocities (45-60 cm/s), the latter indicative of slow-riffle and run habitats (sensu Vadas and Orth 1998). But weirdly, negative relations were seen for runs, as well as for shallow depths (≤ 25 cm) and canopy-cover (overhanging-vegetation) shading, the latter two parameters likely reflecting avoidance of shoreline habitats. But at the microhabitat level (HARPHA model), mid-sized substrata (larger gravels and cobbles) and submerged vegetation were also avoided (Parasiewicz and Walker 2007). … But this species is better classified as being in the fast-generalist guild of Vadas and Orth (2000, 2001), for which mid-sized substrata are actually preferred.

Common shiners (Parasiewicz 2003, 2008b; Parasiewicz and Walker 2007) liked boulders and riprap, but showed negative relations for moderate depths (50-75 cm) and canopy-cover shading. The lack of a velocity preference may reflect the habitat-generalist nature of the pool/run guild that I've found this species to be in for Virginia (Vadas 1992a), where I instead found moderate depths to be well-used habitats.

White suckers (Parasiewicz 2003, 2008b; Parasiewicz and Walker 2007) liked deep (75-100 cm) better than medium depths (50-75 cm), as well as cobbles and undercut banks. The lack of a velocity preference may reflect the habitat-generalist nature of the pool/run guild that I've found this species to be in for Virginia, albeit its use of deeper habitats than I found likely reflects my inadequate sampling of adults (Vadas and Orth 1997, 2000). But this species probably still belongs in the pool-cover guild.

Longnose dace (Parasiewicz 2003, 2008b; Parasiewicz and Walker 2007) liked faster (riffle and fast-run) habitats, moderate velocities (45-60 cm), large-woody debris (LWD), and riprap. But at the microhabitat level (HARPHA model), this dace also liked fast velocities (75-90 cm/s) and shallow depths (≤ 25 cm) but avoided overhanging vegetation (Parasiewicz and Walker 2007), likely reflecting avoidance of slow shorelines. This is mostly consistent with my fast-riffle guild classification, as derived from sampling in mid-Atlantic states (RLV, unpubl. data) and British Columbia (Vadas 1996, unpubl. data); the exception is LWD usage that I've found to be consistently important only for the pool-cover guild in Virginia (Vadas and Orth 2000, 2001).

Blacknose dace (Parasiewicz 2003, 2008b; Parasiewicz and Walker 2007) liked divergent substrata (boulders and mud), moderate velocities (45-60 cm), and shallow depths (≤ 25 cm), the latter often along shore. But they avoided larger gravels, submerged vegetation, and canopy-cover shading, which seems inconsistent with their boulder vs. mud vs. shoreline habitat preferences, respectively. Based on my sampling in mid-Atlantic states (RLV, unpubl. data),

including this dace's association with mountain redbelly dace (*Phoxinus oreas*) (Vadas and Orth 2000), I would classify this minnow as being in the shallow-rheophilic guild that likes mid-sized substrata. This is more consistent with Parasiewicz's (op. cit.) hydraulic than substratum results.

Although logistic regression wasn't run on *tessellated darters*, my own observations on it (Vadas 1992a) and the taxonomically similar johnny darter (*Etheostoma nigrum*) (cf. Lee et al. 1980) classify it in the pool-cover guild. This species wasn't used in [the Quinnebaug] instream-flow analysis ….

Although Jacobson (2008) considered minnows to be habitat generalists that show more specialization when predators constrain them, this would have to be a multispecific generalization. Indeed, individual species in the upper Roanoke River drainage, VA, showed mesohabitat specialization that allowed them to be classified into individual guilds, albeit the fish family as an aggregate occupied six of the seven guilds identified by Vadas and Orth (2000, 2001).

Hence, Parasiewicz's (2001, 2007b) 5-7 resident, target species showed the following species richness in these seven guilds: fast-riffle (1), riffle/run (0), fast-generalist (1), shallow-rheophilic (1), pool/run (2), open-pool (0), and pool-cover (0-2). These results reveal that one rheo- and limnophilic guild each (sensu Vadas and Orth 1997, 2000, 2001) weren't represented at all, whereas the pool/run guild was the best-represented guild. Hence, I don't think that Parasiewicz's (op. cit.) target species well-represented the full fish assemblage, thus making assessment of fish instream-flow needs (see below) somewhat biased. Although Parasiewicz (2007c) asserted that fish species and life stages with the "most demanding" habitat requirements should be used in instream-flow assessments, I prefer a balanced, ecosystem-based approach based on all available mesohabitat guilds (Vadas and Weigmann 1993), as all guilds are habitat specialists to varying degrees (Vadas and Orth 2000, 2001). Notably, Vadas and Orth (op. cit.) found that the most habitat-generalized guilds were fast-generalist and pool/run species, both which were prominent in Parasiewicz's (2001, 2007b) instream-flow analyses. I do agree with Parasiewicz (2008a), however, that lentic and macrohabitat-generalist animals may benefit most from instream-flow reductions that cause habitat, thermal, and pollution problems (cf. Vadas 1997, 1998).

7. Discuss any items of concern or of confidence you may have related to the fish community selected for evaluation under the model.

Beecher:

Species known to be sensitive to flow include Atlantic salmon (Flanagan 2003; Frenette et al 1984) and American shad (Crecco and Savoy 1984). If no measures for restoration will be implemented, then inclusion of species that require restoration is questionable.

The MesoHABSIM approach is designed to assess flow sensitivity at the mesohabitat scale for any fish (or other aquatic organism) whose habitat requirements at the mesohabitat scale are known. It would be desirable to search a database or bibliography (such as the one at www.instreamflowcouncil.org) for literature that may indicate known (direct or indirect) flow sensitivity of other Souhegan and Lamprey fishes and aquatic invertebrates. Although many state or regional fish books do not explicitly state flow-sensitivity in species accounts, it is possible to categorize species as highly flow-dependent, moderately flow-dependent, or minimally flow-dependent, as I did for the fishes of Alberta using Scott and Crossman's (1973) *Freshwater Fishes of Canada*, and a similar exercise would improve this selection of fish species. Use of the Natural Flow Paradigm (i.e., retain the flows that the existing fish community has experienced, including seasonality and natural variability) covers for some of the uncertainty, but recognition of specific flow sensitivities could further ensure that no inadvertent management action (or inaction) causes unintended risk.

During Governing Council review, IFC President-elect Chris Goudreau (North Carolina) wrote (in reaction to Beecher's first paragraph): "Our approach has been to be very inclusive of potential restoration species. Although we might not have restoration plans in the near term (or even for decades), if the species were historically present, particularly diadromous species, then we like to include them in the analysis.

"Restoration is often opportunistic, so even if we have no plans to restore a species for 30 years, it might happen in 5 years under the right circumstances. For that reason, it is better to have that species in the analysis. Nobody can accuse us of being short-sighted or wanting a new study."

Kaeser:

I was satisfied to find that brook trout and slimy sculpin were included in the final list of indicator species (but it is unclear if any habitat curves related to these 2 species inform the ultimate selection of PISFs). According to assemblages among the reference streams, these 2 species should have been represented in the Upper Souhegan.

Ptolemy:

My lack of confidence in the fish community data originates from the overall concern over and lack of habitat suitability criteria (HSI curves) and univariate plots (depth, velocity, substrate size) that you can verify by life-stage. Reliance in logistical regressions is OK if we understand the HSI values by species and life-stage. Logistic regression ROC AUC values that are 0.7-0.8 are acceptable while AUC values < 0.6 are poor; AUC values <0.5 are not discriminating. Many of the abundance-based AUC values quoted in Appendix 8 are <0.7 and generally poor predictors.

See answer to #6 above. (From Specific #3 in #38 below for Souhegan): The Atlantic salmon spawning (and upstream passage?) flows appear too low and at variance with published accounts of upstream passage flows and spawning habitat criteria. Successful spawning does not require sustained flows during October 7-December 8 of 62 days. Spawning can occur over days to a few weeks. Should Atlantic salmon spawning needs be similar to that of steelhead, a flow of 200 cfs is required as an optimum. 90 cfs is too low. (From Specific #6 in #38 below for Souhegan): No real comment on either clupeid or GRAF spawning other than they do perform as intermediate flows to those of Spring Flood and Rearing -Growth bioperiods. Again understanding the inferred HSIs would be useful at the univariate level (depth, velocity, etc.).

Vadas' concerns are addressed in #6 above.

Habitat Suitability Criteria

Habitat suitability criteria were developed to evaluate the habitat conditions in the Souhegan and Lamprey Rivers using available literature, professional judgment and empirical data from fish collections. A list of physical criteria associated with suitable habitat for the indicator species of the Target Fish Community was developed. Unsuitable, suitable, and optimal habitats were distinguished corresponding with high probabilities of fish absence, presence and high abundance, respectively.

8. Are the source data used to develop fish habitat criteria, coming largely from fish collections from other states, appropriate for use in the two New Hampshire rivers being studied?

Beecher:

Yes. Where the fish species are mostly the same, similar habitat use is expected. If some source data are farther away (e.g., southwest of the Hudson drainage or in the St. Lawrence drainage), different competitors/community members might result in a different use of habitat, so emphasis should be on southern New England, as it is (Hartel et al. 2002; Scarola 1987). Species-specific literature covers fallfish (regional; Ross and Reed 1978), Atlantic salmon (New England, eastern Canada, Iceland, Norway, Britain, down to western France), and American shad (New England to Florida). Although the last two species have wide geographic ranges, they are also intensively studied, so using geographic filters for habitat information for these species is reasonable when using the cited sources (Armstrong, et al. 2003; Stier and Crance 1985).

Kaeser:

Perhaps, but not enough information is provided to make a general determination. I might assume, based on the number of grid samples reportedly used from the reference rivers, that samplings occurred over a number of seasons and years, but it is not explicitly stated (at least in the early part of Appendix 8 of Souhegan study). We would expect species abundance and site occupancy to vary considerably by year and season- does the pooled data set capture and reflect all of that potential variability- or are the samples used to develop the habitat suitability criteria mostly from summer low flow periods on the reference rivers?

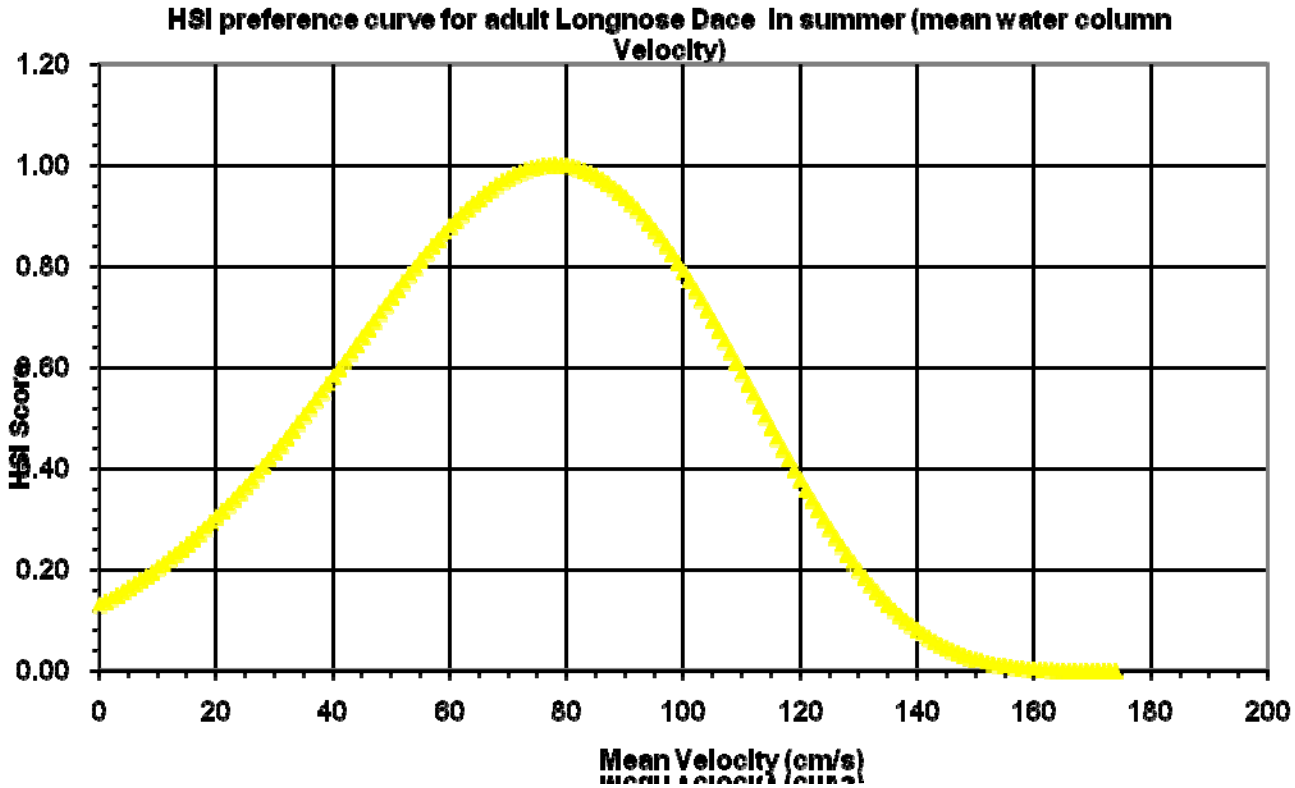
Given that empirical data from the study rivers was collected by grid electrofishing, why not use it as a validation data set to examine the fit of the logistic model to actual data from the study systems in question? …OK, this was accomplished when developing the ROC curves for presence and abundance at each HMU that was grid sampled.

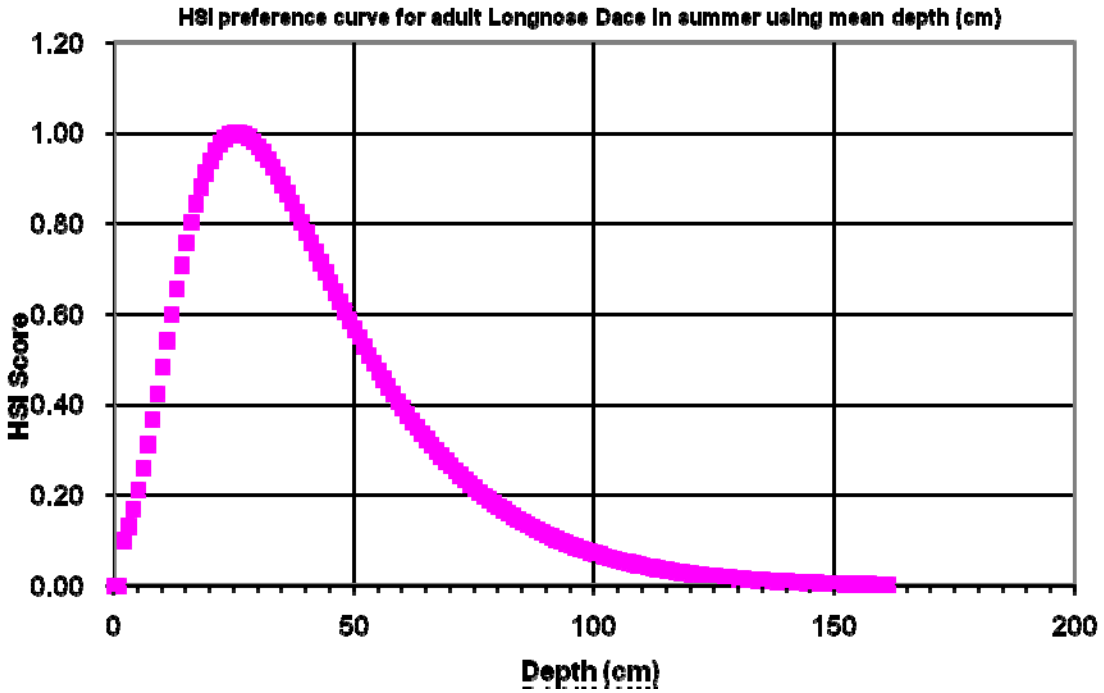
It was not clear to me when the literature based spawning model was discussed (page 329- Souhegan) what was being described- is this model a logistic model? Are the 4 out of 7 measured values discussed of those listed in Table 12- page 330?

Habitat suitability for all investigated species was calculated for each HMU, species, and life stage (pg 54). With respect to life stage, how did the logistic models capture the variation among life stages? Was life stage data part of the data set provided from the reference river samples?

Ptolemy:

Yes they are if the data show preferences rather than restricted use according to available habitat. Again it would be really useful to have a table or figure which clearly show what depth, velocity, etc. HSI curves apply for each species and life-stage. A qualitative summary of the habitat preferences would include the primary meso-habitat the size class is found in and which particle size is favoured. It would look like





9. Is the use of source data collected from electrofishing grid sampling of concern? Does this collection method create an unacceptable bias for fish from shallow, slow moving (i.e., wadeable) environments?

Beecher:

Short of destructive sampling, there are biases with any fish sampling. Pre-positioned electrofishing is favored for habitat suitability determination and evaluation (Thomas and Bovee 1993). Appendix 7 lists results but does not describe how much time is allowed between set-up and electrofishing; some time is needed for fish to return to normal behavior after the disturbance of set-up. A more complete description of the electrofishing procedure would help, but, in general, experienced electrofishers can provide a reasonable assessment of fish community composition.

Kaeser:

Grid sampling is likely better at providing accurate data on fish presence and abundance in wadeable areas- thus shallower habitat patches, and may be more dependable for evaluating lower flow habitat associations.

Ptolemy:

Grid electrofishing by its nature may give biased low results in fast-water habitats since fish can be missed through low capture efficiency and current drift/loss. This may reduce the apparent use criteria of longnose dace adults in riffles and rapids; as zero use is inferred from the (Souhegan) Appendix 8 Table 2 regression coefficients and text description.

10. Is the use of logistic regression to define the habitat suitability criteria an acceptable practice?

Beecher:

Logistic regression is often used for developing habitat suitability, but I have not used it. I have consulted with two biologists with varying amounts of experience with logistic regression. Kirk Krueger (Washington Department of Fish and Wildlife, Habitat Science Division), who used it in his doctoral work, said that use of ROC curves is evidence of good use of logistic regression. As with many statistical techniques, there are some pitfalls of logistic regression, but it is becoming one of the standards for habitat suitability development, particularly when suitability addresses more than just depth, velocity, and substrate. One of its merits is in being able to incorporate both continuous and categorical variables and another is its independence from assumptions about normality of distributions. Another advantage is that it is capable of distinguishing relative influence of different factors, although other multivariate techniques can do the same. It would be valuable (but not essential) to compare several statistical approaches to see if they yield comparable results; if they do, one would have more confidence in the results.

Ptolemy:

The use of logistic regression for aquatic habitat suitability criteria is fairly novel and comes with a problem of incompatibility with more traditional means of seeing or reviewing HSI criteria. The meso-habitat analyses is very sensitive to a number of assumptions such as HSI curves, meso-habitat fish catch results (true abundance), the change in hydraulic suitability with

increased flows, and the art-form of describing meso-habitat boundaries where some fast-water habitats are washed out at high flows and turn into runs.

Vadas (from #38 below):

Parasiewicz's crew (Parasiewicz 2001, 2003, 2007b, 2008b; Parasiewicz and Walker 2007) undertook stepwise-forward, logistic (multivariate) regressions to identify important habitat variables (each segregated into multiple classes) for most of the above target-fish species. This was based on two binary analyses on adjacent suitability classes, i.e., optimal, suitable, and unsuitable, as estimated via density (fish/m^2) thresholds (for high vs. low abundance) of (a) 0.30 for gregarious (schooling) cypriniforms (fallfish, common shiner, and white sucker) and (b) 0.15 for solitary species (longnose and blacknose dace) at the mesohabitat level (Parasiewicz 2007b). But Parasiewicz and Walker (2007) described the cutoff values for low vs. high abundance categories as being HSI values of 0.2 vs. 0.5, respectively, which is a different approach than the earlier thresholds based on fish density (see above), though all four of Parasiewicz's papers cited above provide the same statistical results. So this is a confusing aspect of the methodology. Moreover, the results below are contradictory in some ways, as indicated by beta coefficients of positive (preference) or negative (avoidance) values (Parasiewicz op. cit.). Hence, I question the use of logistic regression as a replacement for standard habitat-suitability-index (HSI) modeling with more-quantitative data, the latter of which are provided by Parasiewicz and Walker (2007) as a useful reality check. The main problem with these HSI curves was the bimodality of the substratum histograms for all five cypriniform species, in all cases because of under-representation of the 17-64 mm size class (i.e., large gravel) (op. cit.). This suggests that large-gravel habitats weren't properly sampled to build the micro- and mesohabitat models, and is definitely a major reason that substratum results often differed from my own work (see below). Hence, habitat-model smoothing (sensu WDFW and WDOE 2004; Vadas et al. 2008) should have been done. Another problem with Parasiewicz's four papers is that inorganic and organic cover types were split into several categories, rather than pooled together as advocated by Vadas and Orth (2000, 2001) to enhance the generality of results; type of cover doesn't matter as much as the amount of total cover for fishes. Hence, Parasiewicz's (op. cit.) cover results often diverged from my own work (see below). Furthermore, the results for Parasiewicz's (op. cit.) logistic-regression analyses may have been affected by redundant habitat variables, included Froude number (with velocity) and shallow margins (with depth) (cf. Vadas 1994; Vadas and Orth 1998, 2000).

11. Was the logistic regression conducted appropriately?

Beecher:

See #10 above. The feedback I get is that there is considerable art to logistic regression, but the use in these studies appears reasonable. I defer to other reviewers for more detailed evaluation. I note that Dr. Meeker, a mathematics professor, also commented specifically on this issue (Appendix 14 for Lamprey River), and his comments seemed to reflect expertise and understanding of the technique.

Kaeser:

A limited amount of detail is provided to evaluate the development of the logistic models. For example, what criteria (thresholds?) were used when selecting variables to include or exclude from the model?

Ptolemy:

The regression procedure appears to be done correctly however the inputs are suspect since the outcome for longnose dace adults (none in rapids?) is out-of-character. Adults generally prefer really fast boulder habitats and yet the logistic regression says the dace prefer slow riffles and avoid large substrates. I suspect the model is really talking about YOY dace which are not flow sensitive since they exist and prefer shallow, low velocity habitats across the meso-habitat spectrum.

See #10 above for Vadas' concerns.

Habitat Mapping Surveys

Representative sites representing segments of the river were measured for a variety of attributes and at multiple flows to develop relationships between habitat parameters and flow. Representative sites were divided into hydromorphological units (riffles, pools, runs, glides, etc.) and each hydromorphological unit was measured for velocity, substrate, depth, and other

habitat parameters. These measurements were collected at selected flows ranging from very low to intermediate flows.

12. Evaluate the selection of the representative sites. Were these sites selected using appropriate criteria?

Beecher:

One of the claimed benefits of use of MesoHABSIM is that coverage is greater than PHABSIM (although I do not agree with this claim – it is a function of the specific application) and the sensitivity to site selection decreases because each site includes a number of replicates of each mesohabitat or hydromorphological unit (HMUs). Segmenting the river into reaches is an important first step. If the question is whether the sites selected were appropriate, then it appears that they were at least reasonable. If the question is about the criteria used for selecting these sites, the criteria for site selection were not clearly articulated (random within a reach, accessibility, proportion of HMUs similar to whole reach – this is another example of where the methods were not as clearly stated as would have been done for a journal publication, resulting in some uncertainty on the part of a reviewer).

Kaeser:

Not enough information is provided to evaluate whether the sites selected were representative. Reading through pages 14-19 my impression is that site selection was based on field recon/observation by the crew. This approach may introduce subjectivity, but it is not clear to me whether such bias is important. I was surprised to find only 2 sites in the upper third of the Souhegan River- this reach seems to be underrepresented in the sampling effort.

Ptolemy:

The selection appears representative given the large fraction of each reach that were surveyed systematically. The sites were selected using appropriate criteria however the boundaries were approximated visually and are subject to observer differences.

13. Is the amount of area measured in the representative sites sufficient to represent that river segment or reach?

Beecher:

See response #12. Numerical standards (e.g., sites/mile, area of site/mile of reach, etc.) are not easy to find in the reports and appendices to determine adequacy, but the use of relatively long sites as illustrated in Appendix 10 and the general methodology of MesoHABSIM make it likely that the area measured is sufficient to represent the river segment or reach.

Kaesar:

A metric such as % of reach represented (study reach kms/total segment kms) would be helpful to assess the areal representation among the defined river segments. Some reaches are much longer than others, some are more heterogenous than others, some have few HMU classes present. What was the criteria used for selection? Was each study reach to include at least one HMU (one representative) from the suite of HMUs that the entire segment contained? …OK, some of the requested detail provided for the methods used to select sites on page 744. These details could be provided up front in the report.

Ultimately the rating curves for effective habitat are extrapolated (generalized) to the reach level based on the proportional length of the study section. This suggests that the representative-ness of the study reach is important to the MesoHABSIM end products.

Ptolemy:

Given the photographs, mapping evidence and high degree of coverage, the sites chosen appear to represent the reach in sufficient detail.

14. Is the quantity of area measured in aggregate sufficient to represent the designated river?

Beecher:

Yes. The area sampled is greater than used in most of the more intensive watershed instream flow assessments using PHABSIM and greater than most of the standard-setting methods. However, better explanation of the site selection criteria and methods would improve the reports.

Ptolemy:

Yes. The high degree of coverage is compelling and the fact the stream was separated into lower and upper watersheds does cover the universe well.

15. Were the selected river flows when habitat mapping was conducted of sufficient range and distribution to develop adequate habitat rating curves?

Souhegan

Beecher:

Target flows for mapping were 0.2, 0.5, and 1.0 cfsm (cubic feet per second per square mile). For one gage (Wildcat Falls), these flows are clearly shown relative to the annual hydrograph in Figure 16, and the range of flows covers the spread of the natural hydrograph well. The only part of the hydrograph not covered by the three mapping flows were the highest flows, many of which are short duration. Figure 54 shows the flows throughout the year at the Merrimack gage and the target flows bracket most of the flows except for the spring snowmelt (March-April). As stated in the text, the short duration high flows and the snowmelt flows may be considered outside of the MesoHABSIM analysis as important for other processes, such as plant community maintenance and related off-channel habitat for amphibians, etc. Those flows typically occur when water temperature is low and fish activity is reduced. As stated in the text, habitat suitability is not well understood during cold water periods; the assumptions and approaches are reasonable and consistent with the Natural Flow Paradigm.

Ptolemy:

The coverage should range from the flow extremes measured but less than those that pose a serious safety hazard for data collection. We would expect flows from 3% to 100%mad or 0.05-

1.71 cfsm to be represented in a small stream such as the Souhegan River (mean annual discharge = 292 cfs; mad = 1.71 cfsm; DA = 171 mi^2). The actual range in flows was less at 0.2 to 1 cfsm. The surveyed range is likely adequate for refining instream flow needs for spawning, summer rearing and over-wintering with some error associated with extrapolations. As a check on the rearing flow outcome, the typical flow necessary to sustain high quality riffles and rapids and food supply (invertebrate drift) to pools, runs and glides is near 20%mad or 0.34 cfsm. This generic value is very close to the July 15-Sept.30 target rearing flow of 0.3 cfsm for the upper river however it is lower than the common rearing flow target of 0.6 cfsm in the lower river. Presumably if the true target was 0.6 cfsm then the tributary and upper river flows would have to be 0.6 cfsm as well since water flows downhill. There is a need for hydrologic consistency.

Lamprey

Beecher:

Target flows for mapping were 0.1, 0.2, 0.5, 1.0, and 1.5-2.0 cfsm (cubic feet per second per square mile). As stated in the text, the short duration high flows and the snowmelt flows may be considered outside of the MesoHABSIM analysis as important for other processes, such as plant community maintenance and related off-channel habitat for amphibians, etc. Those flows typically occur when water temperature is low and fish activity is reduced. As stated in the text, habitat suitability is not well understood during cold water periods; the assumptions and approaches are reasonable and consistent with the Natural Flow Paradigm.

16. Were the habitat data collected in sufficient quantity in each hydromorphological unit to adequately describe the habitat suitability?

Beecher:

Habitat data were collected in sufficient quantity to reasonably describe the habitat suitability, but the information was never presented in a way that the reader could make any sense of it. In developing the MesoHABSIM method, it would be valuable to conduct some nested validation. For example, do 30 randomly placed measurements in a single hydromorphological unit (HMU) show similar means and variances as 7? Do 7 randomly placed measurements in a single HMU at 0.1 cfsm show similar means and variances as 7 randomly placed measurements in the corresponding HMU at 1.0 cfsm or other flows? This seems to be an assumption of MesoHABSIM, but it is not validated in the studies (or I couldn't find it). It is a somewhat reasonable assumption for pools, but much less so for runs and riffles and cascades (as anyone

who has conducted PHABSIM studies in such habitats could verify). If this assumption (that a pool is a pool, a run is a run, and a riffle is a riffle – i.e., similar hydraulic characteristics – whether flow is high, medium, or low) is not validated, the MesoHABSIM method is open to question. (Not every assumption must be validated immediately if all users agree that the assumption is reasonable, but I think there is enough doubt about this that it deserves attention, but I defer to Dr. Vadas and his publications on Virginia rivers, fish, mesohabitats and hydraulic conditions.)

Kaesar:

Within each HMU, 7 measurements of velocity, depth, and substrate were made on each of three occasions (= to 3 flow levels). It was not clear to this reader how these data were fed into the logistic models to classify the HMU as optimal, suitable, or unsuitable. Was the average of 7 velocity observations calculated, and this fed into the model for the velocity parameter? And so on. *UPDATE- Appendix 17 explains how these measurements were used to populate the data matrix- the values were converted to %s of velocity bin classes- resulting in a loss of information.* How variable were these 7 actual measurements? 7 Measurements may be adequate to evaluate a small HMU, but what happens to the variance for each parameter when we obtain 7 measurements from an HMU that is 10x the size of the smallest HMUs? That is, was there a relationship between HMU size and variance for each measured variable? Can (or were) these field measurements be used to validate the observer-based classifications/mapping of the HMUs? How important would such a validation be to the end products of this MesoHABSIM exercise?

Ptolemy:

Probably not. Since the meso-habitat boundaries are perceived by a surveyor, it is conceivable that a rapid that turns into a run will have “run” fish weighting based on typical run size substrates however the particle size remains large and consistent with a rapid habitat character.

Yes there appears to be sufficient data quality for each meso-habitat class however there is no test using independent measures of data consistency such as paired whole-stream cross-sections with “random” measures of depth-velocity-substrate. The primary limitation is mainly the moving meso-habitat boundaries at higher flows and the uncertainty in weighting meso-habitat units for suitability by species or life-stage.

Vadas (from #38 below):

The main problem with these HSI curves was the bimodality of the substratum histograms for all five cypriniform species, in all cases because of under-representation of the 17-64 mm size class (i.e., large gravel) (op. cit.). This suggests that large-gravel habitats weren't properly sampled to build the micro- and mesohabitat models, and is definitely a major reason that substratum results often differed from my own work ….

17. Were the habitat data appropriate in the types of data being collected?

Beecher:

The habitat data were many of the variables normally considered in habitat suitability for fish when the influence of different flows is being considered (e.g., depth, velocity, substrate, cover). The sampling appeared compatible and consistent with mesohabitat work by Dr. Robert L. Vadas, Jr. (one of the other IFC reviewers), but I defer to his review. The basis of MesoHABSIM (and Dr. Vadas' work is fundamental to the foundation of MesoHABSIM) is that many fishes, and certainly most of those in the GRAF group, spend much of their time in a particular mesohabitat type and the extent of a mesohabitat determines the habitat quantity and is a significant factor in carrying capacity for those fishes. (Although the report seems to discredit PHABSIM as a less appropriate scale, PHABSIM is often a very appropriate scale for territorial fishes, such as rearing and spawning salmonines [coregonines are less territorial and might be better addressed by MesoHABSIM, but the only salmonids considered in this study are salmonines and not coregonines].) However, if the assumption discussed in #16 above are not validated, then the validity of MesoHABSIM is questionable. Is a mesohabitat as delineated by eye a good proxy for a product of habitat quality and quantity?

Ptolemy:

If the habitat boundaries change due to washing out of details at higher flows (e.g. riffles and rapids disappear), there may be inappropriate data being collected. In general, the habitat details are appropriate for the type of meso-habitat analyses and mapping.

Vadas:

[Excerpt from email to IFC review panel, other detailed analysis of habitat data omitted] … [U]se of reasonable mesohabitat or guild criteria can be relevant to individual species, because fishes tend to segregate pretty well into rheophilic (shallow-fast) vs. limnophilic (deep-slow)

superguilds (cf. Vadas and Orth 1997, 2000, 2001). But because fish species and guilds typically use multiple mesohabitat types (Vadas 1992; Vadas and Orth 1997), mesohabitat and HSI criteria don't always match. A caveat would be that where habitat-generalist (e.g., exotic) fishes are dominant, then such mesohabitat and guild criteria may create more problems for instream-flow analysis. But to my knowledge, that's not a big issue for the NH studies, ….

18. Were the collection methods of these habitat data appropriate? And did the collection methods of these habitat data allow for sufficient data quality?

Beecher:

Two levels of habitat data collection were used: (1) mapping of hydromorphological units (mesohabitats) at different discharges (flows), and (2) characterization of hydromorphological units. Both appeared to be a very reasonable effort for the purpose of basin-wide instream flow recommendation. As discussed elsewhere, the description of methods is somewhat fragmented between main report and appendices and does not include the detail one would expect in a journal publication. See also answers to #16 and #17 above.

Kaeser:

A cursory examination of the Site Habitat Maps suggests that the mapping was fairly coarse, perhaps given the scope of the project and time and money available. It would appear that the boundaries defining the head and tail of each HMU were identified by visual inspection of 1+ observers from the one or both banks. Perhaps this system is quite uniform, and HMUs do typically extend across the whole channel in uniform fashion. I can imagine a system where one side of a channel could be riffled while the other, deeper half is more run-like at a given flow. There is little evidence in these maps of this level of discrimination/detail. In many cases, the entire HMU polygon simply changed from one class to another under a different flow condition. This issue may only be important if the site has a very limited availability of a certain habitat type, or small patches that were overlooked – not mapped out – because they were below the minimum mapping unit. What is the minimum mapping unit for these maps? Should we be concerned that the minimum mapping unit for HMU delineation differs from the scale (m^2) at which fish data (that are used to develop the habitat rating curves) were collected using grid electrofishing??

Ptolemy:

For the most part yes the methods were appropriate given the annotations and limitations in Answer 17. The mapping (Appendix 10—HMU) showing how meso-habitats change ("side channels become connected) with flow are believable except where riffles or rapids disappear.

Baseline river structure

The Souhegan protected flows were developed using the existing river structure as the model template. The model results seem to indicate there maybe channel impairments including lack of instream wood structures and overwidening. Because of the known channel impairments present as the impounded sections of the Lamprey Designated River and because these impounded segments comprise a large part of the river, the Lamprey was modeled for habitat availability using a baseline river structure that simulated conditions in the impounded areas as if the dams were removed. Use of the simulated baseline river structure results in modeling that approximates conditions in the natural, undammed river.

19. Discuss the implications of using existing or baseline structures of these rivers as the physical template for the habitat modeling.

Beecher:

Having a simulated "baseline river structure" is useful for assessing river and watershed management alternatives if existing channel (and perhaps other management options) is also assessed. A baseline could be conditions at any time when the conditions are well documented, not necessarily pre-colonial times. It is not realistic in southern New England to try to simulate the river as it might have been in 1600 AD or earlier; there are too many variables and those conditions will almost certainly not be restored. It may not be realistic to assume that the channel type of the baseline river structure can be restored and some of the baseline river structure may, itself, be a result of impoundments, confinements, overwidening, or lack of wood. Land use in the watershed may preclude some options and make others more realistic. If the goal is to make these rivers as productive as possible for instream values (including fish, wildlife, riparian vegetation, water quality, dilution of unavoidable pollution, various forms of aquatic recreation [not just whitewater boating], water supply, hydroelectric power generation, and other uses), the existing channel and associated flows are a benchmark and the estimate of what the river would have been if undisturbed or less disturbed is another possible target condition. Achieving a desired level of productivity for instream values may entail various combinations of channel modifications and flow modifications. Basing the instream flow on the

baseline river structure puts some expectation on the state and people of New Hampshire to attempt to restore the rivers toward the baseline river structure so that the instream flows will be suitable for the rivers; if there is no intention to modify the channel, then there is little point in modeling flows in a channel that might have been.

Ptolemy:

The answer should not only include structure (new or otherwise) but also the baseline or natural flows prior to flow regulation. It remains uncertain as a result of known reservoirs, dams and lakes, what the natural baseflows were. It remains unlikely that severe low flows measured (3%mad for a month) in the lower Souhegan River in 1965 and 1966 were fully natural given the degree of potential regulation upstream of the USGS guage.

River flood training works, bank armouring, channel widening from riparian logging or tree removal, and channel narrowing all can influence instream flow needs. Where channel inundation by the riparian zone causes reduced stream width, lesser flows can provide suitable habitats. In cases of channel widening, greater flows are required for meso-habitat diversity and quality. In the case of the impounded reaches of the Lamprey River, the option for simulated habitat conditions for a natural channel are appropriate if done correctly. This may involve the use of reference reaches that are largely natural of the same gradient, geology, unit runoff and stream power.

Development of Habitat Rating Curves

The habitat quality in the representative sites was evaluated using the habitat suitability criteria and the mapped habitat conditions measured at each target flow. Habitat suitability for each investigated species was calculated for each hydromorphologic unit. Rating curves for individual species and composites of species were developed showing the relationship between habitat and flow. The habitat suitability for each species was calculated for each hydromorphologic unit and each unit was assigned to unsuitable, suitable, or optimal categories. The area of suitable and optimal habitat was determined for each target flow as a proportion of wetted channel area. For species where an optimal habitat model could be established the habitat area was computed by weighting the suitable habitat at 25% and the optimal habitat at 75% and adding them. For other species only suitable habitat was evaluated.

20. Discuss the consequences of using three categories (unsuitable, suitable, or optimal) instead of using a numerical scale as to how it affects the results of the protected flows.

Beecher:

Although we often assume that biological response to continuous variables should follow some gradually increasing and decreasing function, documenting the exact shape of such a response is difficult, often requiring either an extremely large sample size or highly controlled (and thus highly artificial and unrealistic) experiments. Using a very different approach for use with PHABSIM (rather than MesoHABSIM), my colleagues and I have developed habitat suitability criteria that were criticized as city skyline-like (Beecher et al. 1993, 1995, 1997), in other words block-like, yet they resulted in accurate prediction of fish distribution. We assumed that with sufficiently large sample size resolution would be finer and these blocks would be smoothed. What is important is to be able to distinguish more favorable habitat conditions from less favorable and unfavorable habitat conditions. The most basic level is suitable-unsuitable. A second level is to add a preferred condition. These basic categories are useful in that they do not imply any additional knowledge of incremental preference when that knowledge does not exist. Use of the 25-75 weighting is a subjective decision about relative value of suitable and preferred habitat, but it is also a reasonable approach for incorporating two categories of suitable habitat; a caveat about the arbitrary weighting is warranted.

Kaeser:

Generally speaking, condensing continuous data (counts) into categorical data results in a loss of information. At page 310 of the report, I was unable to find information on the threshold for high abundance (optimal) of slimy sculpin, yet a logistic model for high abundance was developed.

Ptolemy:

The implications are not tested in the available material. The three classes are likely to be blunt instruments and less sensitive to numerical means. The affect on the results would be flat curves showing habitat versus flow. Many of the curves tend to be flat or non-responsive.

21. Discuss the consequences of weighting the optimal and suitable habitats relative to how the weighting affects the results of the protected flows.

Beecher:

As discussed above, the 25-75 weighting of optimal and suitable habitats appears both arbitrary and reasonable. The relative weighting of optimal habitat used in this study should have highlighted flows that provided the most optimal habitat; in trying to provide favorable conditions for fish this approach ought to identify flows that are best for fish habitat. Sensitivity analysis could be done by multiple iterations with different weightings. However, the results of the sensitivity analysis would mean little without an analysis of fish response: how many more fish use optimal compared to suitable habitat (e.g., Thomas and Bovee 1993; Beecher et al. 1993, 1995, 2002)? Using both approaches (suitable alone and suitable-optimal) may increase sensitivity to flow effects. Habitat responses to flow changes were quite gradual over the range of flows modeled in this report, so it is unlikely that use of other weighting would have made much difference.

Kaeser:

Page 728- "Because the pattern of the GRAF curve does not indicate sensitivity to flow change, the habitat rating curve for Atlantic salmon was selected as an indicator for the determination of protected instream flows." Does this mean that the PISF endpoints for this exercise are ultimately entirely/solely based on the relationship of Atlantic salmon to flows in reference streams? I find this confusing. We don't have any Altantic salmon in the SR to validate the flow/habitat quality relationships developed from other data sources…and maybe there never will be any Atlantic salmon in this system for the purpose of monitoring the outcome of PISF management. In fact, there aren't any brook trout either, so no data or opportunities available for future assessments of the effects of implementing these PISF in the SR. This makes me a bit uncomfortable. I'd prefer to see PISFs based on resident fish where some monitoring could be conducted to assess the performance of the management scenarios.

Ptolemy:

The weightings are entirely arbitrary and the results may be non-informative. Since the predictive ability of the habitat index with fish abundance is generally poor, the weightings may not add very much to insights on preferred flows to sustain all aspects of the fish community of interest.

22. Discuss the implications of combining individual fish species rating curves into community rating curves.

Beecher:

It is good holistic management to consider the suite of fish species and their habitat needs. However, combining individual fish species rating curves into community rating curves has possible risks. At the same time, it may be a prudent approach if knowledge of special flow-sensitive limiting factors for the individual species is limited. Just as the overall approach in the New Hampshire process is to compare among instream flow uses and use the highest required use (as opposed to facultative or opportunistic use) as the flow to set as the instream flow, it would be prudent to review the life histories and flow-sensitivities of each species within the fish community to ensure that no flow-dependent limiting factor is overlooked. Dr. Robert L. Vadas, Jr., has considerable experience with evaluating instream flow sensitivities of fish communities and guilds, and his comments on this topic should be given considerable weight.

Ptolemy:

The procedure is likely to washout or dilute the sensitivity of some fast-water dependent species or life-stages with most others that are insensitive. It is curious that pool-oriented species such as Common Shiner showed sensitivity to flows with higher optimums compared to riffle-rapid species (adult longnose dace) that showed reduced habitats at higher flows in the lower river.

Ptolemy (Specific response #6 from #38 below):

No real comment on either clupeid or GRAF spawning other than they do perform as intermediate flows to those of Spring Flood and Rearing -Growth bioperiods. Again understanding the inferred HSIs would be useful at the univariate level (depth, velocity, etc.).

23. Discuss the implications of combining individual fish species rating curves into generic fish rating curves.

Beecher:

No two species have identical niches, but some groups of species commonly associate. They use different components of the same habitat in different ways. Combining different individual species rating curves into generic fish rating curves may reflect the best knowledge we have of these species' habitat needs. If they commonly occur together it is reasonable to protect them by characterizing the habitat where they commonly occur together. Again, Dr. Vadas' comments should be given considerable weight.

Kaeser:

The GRAF curves show no relationship or sensitivity to flow variation so I guess the implication is that you have a new variable that doesn't help to identify PISFs?

Ptolemy:

The implications are the same as in A22.

Ptolemy (Specific response #6 from #38 below):

No real comment on either clupeid or GRAF spawning other than they do perform as intermediate flows to those of Spring Flood and Rearing -Growth bioperiods. Again understanding the inferred HSIs would be useful at the univariate level (depth, velocity, etc.).

Vadas (from #38 below):

Although Jacobson (2008) considered minnows to be habitat generalists that show more specialization when predators constrain them, this would have to be a multispecific generalization. Indeed, individual species in the upper Roanoke River drainage, VA, showed mesohabitat specialization that allowed them to be classified into individual guilds, albeit the fish family as an aggregate occupied six of the seven guilds identified by Vadas and Orth (2000, 2001).

24. Habitat needs are not well known for overwintering and spring flood bioperiods. Discuss the implications of using flow-based criteria to develop protection goals for these periods.

Beecher:

Poorly known winter and flood habitat use and behavior is a common problem in instream flow management that is probably best addressed through following the principles of the Natural Flow Paradigm: flows close to natural flows, including natural timing and variability, are appropriate for natural channels and the native plants and animals (including fish) in them. Fish in these rivers have persisted and in many cases thrived in the face of natural winter conditions and floods. The expression, "If it ain't broke, don't fix it," applies to natural rivers, their hydrology, and flora and fauna. We know natural hydrology produces fish and other instream resources and values in natural channels, but our track record with modifying hydrology and/or channels has not been favorable to many of the native species and communities that we value. The more we learn about the role of floods, particularly at their normal time, the more we learn that they are essential at a natural frequency, magnitude, and timing for the natural functioning of the aquatic and riparian ecosystems.

Kaeser:

Without any hard data on the effects of spring floods and winter flow conditions on the habitat use of resident fish I'd say it's a stretch to develop quantitative, predictive models that include flow-based criteria. Generally speaking, the Natural Flow Regime paradigm identifies the needs for floods and high flow events to maintain habitat, provide access to new habitats, energy inputs, etc. Thus, managing for a natural flow regime includes such events.

Ptolemy:

The implications of using flow criteria with unknown habitat requirements are uncertain flow protection goals that have little science backing. It should be possible to simply describe a flow that wets all of the channel width which has cover elements (cobbles/boulders in riffles) that fish burrow into or find refuge. Flows that accomplish this are in the magnitude of 20%mad or 58 cfs on the lower river. If sidechannels and off-channel habitats are critical to over-wintering fish, the required flow will be closer to 100%mad or 292 cfs in the lower river or 174 cfs in the upper river. The 1 in 2 yr winter baseflows are 41%mad or 119 cfs in the lower river.

Ptolemy (Specific #4 in #38 below):

Over-wintering common flow (238 cfs) appears too high for the lower Lamprey River and is at variance with the 1 in 2 yr winter baseflow (30-day minimum) of 151 cfs. This reviewer assumes that winter baseflows are largely controlled by nature. Presumably protection flows would be described to minimize dewatering of the channel toe-width and reduce icing damage. The necessary flow for this action is typically near 20%mad or 57 cfs.

Hydrologic data

For the Lamprey River study, a baseline hydrologic data set was developed from the historical record to simulate natural flow conditions. These data were adjusted to remove the impacts of certain human diversions and then applied to the model's habitat rating curves. Flow data were described in cubic feet per second per square mile (cfsm) of watershed and applied to the rating curves developed at the representative sites. For the Souhegan, the flow data is based on the historical data without adjusting for human impacts.

25. Are the gage locations, when used in concert with the contemporaneous flow measurement stations, adequate to describe flow at all points on the Designated Rivers?

Beecher:

In the Souhegan River (or any instream flow management situation), it is valuable to have a gage with a long period of record and to have the gage where it reflects much or all water use (e.g., near the Souhegan's confluence with the Merrimack River). More gages are always useful, and the Stony Brook gage is a useful addition in the Souhegan. Additional flow measurements are also useful. There will be uncertainties and assumptions required for ungaged locations, but the significance of these will depend somewhat on the implementation of the instream flow program. Gage records are either available or not and the period of record is what it is. Instream flow management requires use of the best information available, whether a long period of record or simulated, with appropriate precautions for poor gaging. What decisions and actions will depend on flow measurement? Will those decisions and actions be contentious? Will they be enforceable? Will they be defensible in the face of any potential litigation? The sections of Chapter 483 – New Hampshire Rivers Management and Protection Program that I read, including 483: 9, did not show clear evidence that the program would be more than a wish for certain flows. There is sufficient hydrological information that a presumption of correct

inferences from the Merrimack gage by NHDES could be established so that the burden to disprove those hydrological inferences would be placed on the party taking exception to NHDES's action or decision, but it is not clear that such a presumption is established. Dr. Robert Metcalfe is a hydrologist and one of the IFC reviewers; I defer to his opinion in any cases of disagreement.

Metcalfe:

Ideally one would have a long-term observed streamflow time series available at a site for determining instream flow recomendations. In the case of ungauged sites the preferred alternative is to prorate streamflow records from a nearby location on the same river. Therefore the gauged data used in the Lamprey River study was appropriate.

Ptolemy:

Yes it does for high flows such as mean annual discharge. The area proration method appears to work well here as it does in most areas of North America. It likely does not work well below points-of-diversions at lower flows. There may be a disconnect for baseflows measured in the headwaters versus in the lower river near the primary USGS guage.

26. Was sufficient duration of flow data used to adequately conduct the incremental flow modeling? Was sufficient time period encompassed to model the range of variability in the hydrologic record?

Beecher:

Again I defer to Dr. Metcalfe, but in my experience the period of record of the Merrimack gage appears to be adequate.

Metcalfe:

A minimum of twenty years of stream flow time series is required to adequately characterize the natural variability in a flow regime (King *et al.*, 2003). Longer time series or twenty year time series not immediately preceding the current date are to be used cautiously as past climate trends and changing basin conditions could result in characterizing a flow regime that may be less representative of current conditions. Thus the period of record used in the Lamprey River study

was appropriate to adequately characterize natural variability in streamflow however, the exclusion of the most recent years from the analysis is not justified.

Thus the period of record used in the Souhegan River study was appropriate to adequately characterize natural variability in streamflow. However, the use of data from 1948 to 1977 to characterize a 30-year period that may no longer be representative of current flow conditions is questionable.

Ptolemy:

Yes to both questions. However it is unclear the analyses are primarily describing residual flows as now measured at the USGS guages or whether the analyses includes naturalized flow particularly in the June-October period when flow regulation is likely to be strong. If the analysis applies to naturalized flows, a graph showing the daily adjustments by year might be useful. Part of the range in variability in the hydrologic record is man-induced such as the minimums.

27. Was the hydrologic data processed according to reasonable standards in order to generate simulated unimpacted (baseline) flows?

Beecher:

Again I defer to Dr. Metcalfe.

Metcalfe:

Proration is used to transfer streamflow time-series from a gauged site to an ungauged site using the ratio of the respective drainage basin areas as a correction factor and is based on a general assumption frequently made in hydrology that stream discharge and drainage area scale linearly or in a near linear fashion (Dunne and Leopold, 1978; Galster et al., 2006; Galster, 2007). It is best applied at sites with drainage areas > 100 km^2 and where there is not a significant difference (orders of magnitude) between drainage basin areas of the two sites. Uncertainty in prorated streamflow estimates increases when more than one explanatory variable underlies hydrological similarity between basins (e.g. landcover and landuse).

The decision to use regression relationships to transfer streamflow records in the Lamprey River Study is somewhat peculiar, particularly since linear relationships were used. Methods and instrumentation used to obtain the 16 discharge values were not described. The effect of

measurement error and uncertainty in the regression relationship on the simulated streamflow time series were not discussed. There was also no discussion on whether other relationships were tested (i.e. non-linear). The report rightly points out the issues of estimating flow values that extend outside the range used to develop the relationship, arguably the most important flow values. Thus given the potential error in the simulated values using the regression method it is unclear whether this was the best approach for deriving the flow regimes for the ungauged sites.

It was not clear if any of the earlier streamflow time series contained any semblance to a natural flow pattern. If so it would be interesting to compare this with a portion of the simulated 'unimpacted' time series to assess the effectiveness of the 'restoration'.

Ptolemy:

No. There is no clear description of the procedure that accounts for known impoundments, dams and surface/groundwater abstractions. In essence, the data processed accounts for the flows that are left over or residual. What would be more useful would be to compare a USGS station in the same ecoregion with that of the two test cases in a dry, normal and wet year. In addition, the probable consumptive use in each year type would be used to rationalize why the residual flows are as low as they are (e.g. 1965 and 1966 summer droughts where 30-day baseflows were near 3%mad or 8 cfs or 0.05 cfsm). The 1 in 2 yr 30-day summer baseflows are fairly low now at 39 cfs or 14%mad or 0.23 cfsm. The natural 1 in 2 yr baseflows may have been in the 20-30%mad magnitude. Modelling of groundwater-influenced summer baseflows is typically challenging since surface runoff is always greater than what is assumed from zero precipitation periods. The difference in residual flow versus natural flow in the lowest month (July-October period) is about 31 cfs for 30 days or 80.4 million cubic feet or 1846 ac-ft.

28. Discuss any items of concern or of confidence you may have related to the hydrologic data and its use.

Beecher:

Again I defer to Dr. Metcalfe.

Metcalfe:

The method to identify wet, dry and average flow years is somewhat peculiar and the reasoning difficult to follow. Other published examples should be referenced to support the approach.

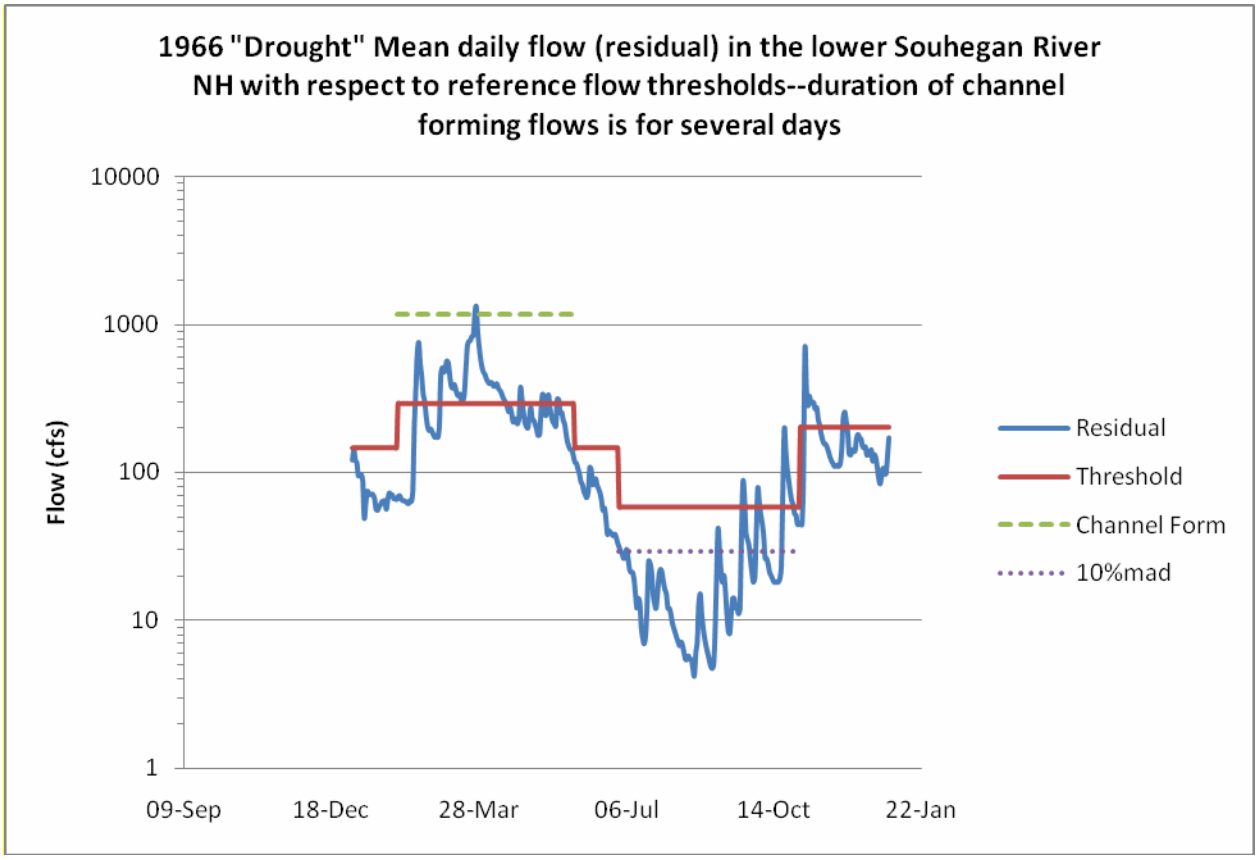
Although the approach would provide some reasonable estimates for conditions during high, low, and average low flow 'periods' it ignore the ecological importance of more extreme low and high flow conditions that would be reflected in annual values.

On a minor note, use lines to represent flow duration curves rather than points and make graphs larger to enable better comparisons between FDCs. This would avoid the need for "amplified" graphs and aid interpretation by always showing the full distribution of flows.

Use a non-parametric tests to test for trends in hydrologic data (e.g. Mann-Kendall non-parametric test and Sens Slope Method).

Ptolemy:

The primary indication of the annual hydrograph is Figure 10. It shows a generic, artificial pattern only; which is quite different from real daily flows measured in any given year. This reviewer was not provided the raw data from which to appreciate mean monthly flows, %mad and more critically, the timing and magnitude of base-flows for both winter and summer periods. The data were extracted from web-based USGS records. For simplicity, it was more useful to display mean daily flows for particular years and overlay the seasonal protection flow thresholds. This permitted a good visualization of flow deficencies; see the example following. Flows in 1966 were deficient for much of the year except in the traditional high flow months. Since the natural variation in annual runoff is very large (33-170%Normal), we might expect that nature will largely dictate what flow thresholds are achievable by any new management of water use. Perhaps thresholds (particularly those after May) should be proportunate to probable inflows. Another solution is to use a multiplier of inflows measured in an unregulated sub-basin or neighbouring stream.



Development of UCUT Curves

Uniform continuous under-threshold habitat-duration curves (UCUT curves) are the result of frequency analysis of habitat magnitude over time developed for bioperiods. UCUT curves are analyzed to define the flow magnitudes and flow durations (allowable and catastrophic) that are proposed for some of the protected flow criteria.

To generate the UCUT curves, habitographs showing daily habitat conditions were developed from the habitat rating curves (as habitat versus flow) compared to daily flow values (flow versus days. The habitographs were compiled for thirty years of flow data. Frequency analysis was conducted at incremental habitat levels in each habitograph to describe the durations of continuous habitat availability at each incremental habitat level. The frequency analysis for the durations at each incremental level is plotted cumulatively using the results from each year as a series of UCUT curves representing each increment of habitat availability. The shape,

distribution and location of the UCUT curves are analyzed to identify common and less common habitat conditions representing key habitat thresholds used as flow criteria. .

29. Are the methods for the selection of UCUT curves and inflection points that are used to identify the protected flow magnitudes and durations reproducible?

Beecher:

The methods for selection of UCUT curves and inflection points are generally reproducible, although identification of inflection points appears somewhat subjective. The process is logical but far from intuitive and it takes time to get accustomed to the UCUT graphs, even after decades of reviewing hydrological-habitat graphs of one sort and another. Generating a family of %Wetted Area curves has a minor uncertainty associated with intervals between %WA curves, and standardizing this choice would be desirable. Establishing explicit criteria for identifying inflection points would be a useful addition to this process that would make enforcement and implementation more predictable.

Ptolemy:

No. This procedure is somewhat arbitrary and subjective. The biological relevance is highly suspect since there are no empirical data to infer harm due to duration of flow magnitude.

30. Discuss the implications of the method of selection of UCUT curves to define flow magnitude.

Beecher:

UCUT curves are developed to select flow magnitudes that are a transition between commonly occurring flows, rare flows, and extremely rare flows that correspond to frequencies of typical amounts of habitat, infrequently low amounts of habitat, and catastrophically low amounts of habitat. The methodology integrates hydrology with the relationship between flow and habitat. An important and logical underlying assumption is the Natural Flow Paradigm, which means that the historical natural amounts of habitat and their associated flows (hydrology) should continue to support the aquatic communities (biology) that have inhabited the rivers in the past, assuming other features of the aquatic habitat (e.g., geomorphology, connectivity, and water quality) also

remain relatively natural. Specifically, this assumption means that the less frequent events that may be stresses on some elements of the aquatic community are also important for and tolerable for the long-term health of the aquatic community. Conversely, the process identifies flow events that are outside the normal or even the extreme range experienced in recent decades; for these flow events there is substantial risk to the aquatic community, particularly if they increase in frequency and duration.

Implications of identifying flow events that pose a substantial risk to the aquatic community are that some decisions and actions will be taken by NHDES to avoid or otherwise mitigate these risky events. Although Sections 483: 9 IV, V; 483: 9-a II, III, IV, V; 483: 9-aa II, III, IV, V; 483: 9-b II, III, IV, V; 483: 9-c IV, and V address implementation of instream flows, it is not apparent that there are sufficient provisions to guarantee that the intent of retaining instream flows will be met. Implementation details of such a program are essential to effectiveness.

Ptolemy:

Unnecessary discussion since the procedure is entirely theoretical without reality checks.

31. Discuss the implications of the method used to select durations from UCUT curves.

Beecher:

Inflection points are a logical way to select durations from UCUT curves, but, as discussed above, it would be desirable to provide more explicit criteria for identifying inflection points.

Ptolemy:

As above.

32. Is this incremental modeling an appropriate method for developing these protected flows? Please discuss any concerns with the overall investigation techniques and the resulting protected flows developed for fish.

Beecher:

Incremental modeling is a well-established procedure in instream flow management and it provides more information on which to base decisions than standard-setting methods. When

instream flows conflict with other economic activities, increments of flow will be pushed, particularly when increments of habitat per increment of flow are relatively small. A clear rationale for decisions is needed and the overall methodology appears to provide some of that rationale.

It is not clear to me whether the regulatory or management framework associated with New Hampshire's instream flow program has the ability to ensure (absent climate change) that flows will continue to produce a hydrograph comparable to historic hydrographs. Is there a risk that flows would be gradually lowered and the hydrograph flattened, particularly during summer, to the thresholds for action or decision?

There are other approaches and standards used elsewhere. I am most familiar with approaches and standards in Washington state, which uses western water law (prior appropriation), rather than riparian doctrine. In Washington instream flows are established to indicate a "surplus" of flow when additional withdrawal (beyond what is already authorized as water rights and immune to instream flows) is acceptable. (This standard and associated laws do little or nothing about already authorized flow reduction in Washington.) This standard is to ensure no additional adverse impact to instream flows and salmon and trout habitat; maximizing salmonid production for harvest (or for recovery to harvestable levels) is a priority because of historical economic activity and federal treaty obligations. Furthermore, recent understanding of the importance of marine-derived nutrients for watershed ecosystems (e.g., Bilby et al. 1996) has placed additional importance on maximizing salmon habitat in order to maintain aquatic communities. New Hampshire should also consider the role of marine-derived nutrients in streams that support or formerly supported American shad and Atlantic salmon. The role of shad and other anadromous clupeids in Atlantic coast stream ecology has also been recognized (e.g., MacAvoy et al. 2009).

Ptolemy:

The approach of incrementalism is appropriate if the bases for the protection flows are factual and consistent. The meso-habitat weightings are suspect and may be an artefact of incomplete sampling. This keystone deficiency undermines all else that follows in the convoluted series of complex steps.

Comparison of the Lamprey and Souhegan studies:

While the two studies were completed by the same contractors, there were some differences.

33. Were the two studies completed using consistent applications of the three key assessment methods?

Beecher:

Concerns about the lack of clarity, tangents, and minimally described methods overwhelmed any differences in the two studies.

Riparian transects seemed to be more focused on plant communities in the Souhegan and more on wetlands in the Lamprey. This may reflect real differences in the two watersheds.

Because of the greater extent of impounded areas in the Lamprey, the attempts to "correct" for the inundated channel and model it as if it were undammed probably made a significant difference there. The correction would only be warranted if the goal were to remove the dams and restore those reaches.

Ptolemy:

No. The Lamprey River assumptions are much greater in scope due to the higher degree of channel alteration and impounded habitats.

34. What do you consider are the effects on the results of any differences?

Beecher:

See first sentence in #33 above.

Ptolemy:

The procedures in each case are in common and the outcomes or results may be in common too.

35. Are these effects from any differences of concern?

Beecher:

See first sentence in #33 above.

Ptolemy:

Not sure of the question intent. There are differences due to watershed and treatment of channels.

Recommendations

The Instream Flow Pilot Program has been a slow and expensive process. The pilot program will result in recommendations to simplify the assessment process, which is likely to reduce costs. With government funding constraints and time a consideration, New Hampshire needs to decide whether to continue to improve on the process developed in the pilot program or to resort to other mechanisms, such as standard setting techniques for conducting assessments on the other Designated Rivers of the state.

36. Do the pilot methods of evaluating flow needs applied in these studies result in the establishment of effective flow protection? Do the protected flows define appropriate protections for the range of flows needed to support instream uses assuming that the implementation under the Water Management Plan is effective in responding to events that do not meet the protected flow criteria and assuming that its management components for water withdrawals and dam management are designed to retain flow variability?

Beecher:

There are several questions: Do the methods identify flows that are protective of the aquatic community? Do the methods provide a defensible rationale for the selection of the flows to protect? The question asks the reviewers to assume that the Water Management Plan is effectively implemented, but the state of New Hampshire must give this assumption serious attention, including the relationship of groundwater withdrawal to streamflow.

The use of MesoHABSIM and associated tools and standards appear to identify flows that, if protected, should continue to provide habitat for the most common fishes as well as sensitive

plant communities and sensitive species. To the degree that the flows selected and protected are consistent with the Natural Flow Paradigm (i.e., natural timing, frequency, duration, and magnitude of flows) the existing community of plants and animals should be reasonably well protected. And the methods do provide a defensible rationale, at least up to a point. In their favor are the goal or standard (could be more clear, though), the assessment of a habitat variable (each of the mesohabitat types) with flow, the consideration of hydrology and frequencies of different flows and associated habitat values. As discussed elsewhere, clarity is sometimes lacking and the connections between different aspects of the procedures seemed uncertain.

Ptolemy:

No. Effectiveness should be based on performance. There is yet to be an application of flow protection to evaluate.

Ptolemy (General #2 in #38 below):

In general, the detailed meso-habitat mapping and colour coding provided in Appendix 8 show consistent loss of riffle/rapid and cascades as flow increases to 1.5 cfsm or 96%mad. There is a net loss of riffles, etc and an increase in slow-water habitats (pools, runs) as documented for Site 2. This has profound impacts on the interpretation of suitable flows and the use of indicator species like Common Shiner.

Ptolemy (General #2 in #38 below):

For each of the species- and life-stage drivers in Table 1—Protected instream flow criteria for fish in the Lamprey Designated River, it would be useful to have a HSI curve for each of depth, velocity and substrate preference. It would also be useful to have a text description of how the life-stages use various fluvial habitats. Common shiners are the indicator species for July 5-Oct. 6 period yet they are pool dwellers. Surely fast-water taxa would be more sensitive to dewatering event than are pool-dwellers; this includes mayflies, stoneflies and simulids. Adult Common Shiners have been consistently observer near fast-water interfaces with slow habitats presumably due to the proximity of food items (insect drift) originating in riffles and rapids. It remains likely the meso-habitat approach is the wrong tool to address things like drift rate and density of food being delivered to species like Common Shiner. Adult longnose dace are probably a better fish indicator as they are found primary in riffles and rapids; while dace fry are more common to the perimeter of fast-water and slow-water habitats.

37. Are these flow protections in accord with the Natural Flow Paradigm?

Beecher:

Yes, they are consistent with the Natural Flow Paradigm, at least as long as peak high flows are not precluded nor magnified by storage or development of too much impervious surface, respectively, and as long as summer-fall flows are not ignored until critical or catastrophic flows occur. For actual implementation, I am unclear that the mechanisms are established to ensure that the range of variation of flows will be protected. There is discussion of action to provide pulses of flow if flows reach extremely low levels, but it is unclear what measures would ensure that flows continue to display the natural range of variation.

Kaeser:

MesoHABSIM seems to be more appropriate for assessing low flow limits. The Natural Flow Paradigm includes components like flushing flows, floods, etc. whose effects cannot be adequately modeled or captured using this approach.

Ptolemy:

Yes to the degree that variable flow thresholds are rationalized however the ecological effectiveness of whatever flow thresholds are managed for is yet to be determined.

38. Please provide any recommendations or guidance that arose during the review for protecting New Hampshire's instream flows in the future.

Beecher (incorporating some of panel conference call):

Instream flow protection programs need several elements, a procedure for identifying flows to protect and a mechanism or collection of mechanisms to manage flows to achieve the flow protection identified. The New Hampshire instream flow programs for the Souhegan and Lamprey rivers address the procedures for identifying flows to be protected, but the management of flows is a later step. It is not possible to answer whether or not the program will be successful without review of the management plans, and even with management plans, actual success will depend upon how well the plans are implemented and enforced. Political will and competing demands will be significant factors in implementation and enforcement.

The New Hampshire instream flow program involves a series of steps and premises. The first premise is the Natural Flow Paradigm of Poff et al. (1997), that streams and associated

ecological communities need flows in the range of naturally occurring flows with the natural range of variation and seasonal timing of natural flows to protect the natural communities and the values they provide. The second premise is that some human uses of flows are opportunistic and can be used when nature provides those flows. Important steps are to identify flow-sensitive natural resources, including fish species, other animals, plant species, and plant communities; determination of flows that provide suitable habitat for these species and communities; and determination of the relationship between natural flows and the amount of habitat for different species at different seasons. An important element of the last two steps is to understand the life histories and flow sensitivities by species and season.

It would be desirable for clarity and public understanding to state objectives and assumptions. The first objective to be addressed should be whether protection or restoration or some other standard is intended and what level of what resources should be protected or restored (Beecher 1990); this has been done to some extent, but more clarity is needed. Then state all assumptions about how the flow levels were identified and related to flow-sensitive resources to be protected. Explain which assumptions were chosen as reasonable and which assumptions were explicitly supported, either in part or entirely, and explain any support for assumptions. Some assumptions may be several steps removed from the final train. Include all assumptions in all methods.

The Natural Flow Paradigm (as well as companion publications by many of the same authors) makes a strong case for natural flows in natural river channels. It is a specific case of precautionary principle. Most, if not all, instream flow ecologists and river ecologists would not dispute it and would probably acknowledge it as a principle (and I have been a proponent of this principle in training I gave to Washington agency and tribal personnel as early as the mid-1980s). It remains a unifying principle for aquatic and riparian communities, but some species (often not native) may thrive at the expense of others when hydrology is greatly modified. (As a unifying principle, much like the theory of evolution, it is difficult to prove or disprove, but a multitude of examples are consistent with it and no evidence discredits it.) It is not a principle of single species optimization, but a principle of how an entire system functions that has adapted to a range of hydrological conditions that include seasonal predictability and variability. Different species depend on different hydrological features in different ways and different places, from behavioral triggering flows to passage flows, to flows that stimulate or preclude riparian vegetation recruitment, to flows that provide habitat space, as addressed by MesoHABSIM or many other instream flow methods.

NHDES seems to have interpreted the Natural Flow Paradigm as requiring reconstruction (partial) of the natural channel and use of that reconstruction to estimate what flows are needed for the future, even though no restoration of the channel is envisioned. An instream flow regimen should be based on existing and desired/expected future channel condition, as well as <u>understanding</u> of seasonality and magnitudes of unmanipulated high and low flows. Part of the Natural Flow Paradigm is recognition that extreme flows (that are not indicated by standard instream flow methods) are essential to the channel form that then indicates flows for suitable habitat the rest of the time (as indicated by those standard instream flow methods, including MesoHABSIM). But reconstructing a hypothetical former channel (that will not be realized) for determining an instream flow does not make sense.

While there are many good elements in the NHDES instream flow reports, there are too many places where it seems to be like an unfinished jigsaw puzzle with lots of pieces but not in enough order to make complete sense yet. Several parts of the reports appear to be tangents: target fish communities, sampling of depths and velocities in mesohabitats, habitat suitability criteria. These could all be linked logically to a more rigorous process, but the linkage was missing. They are even first steps to a more rigorous process, but they appear to be related dead ends. Good elements include attempting to reconstruct natural hydrology (I defer to my colleagues who have greater hydrological expertise as to whether or not this was done successfully), identification of flow-sensitive and non-flow dependent resources and values, photographical and graphical illustration of how mesohabitats varied in extent with different flows, coverage of substantial portions of the channels, establishment of the Natural Flow Paradigm as a guiding principle, consideration of riparian communities and special species beyond fishes, and the concept of the UCUT curves (although they are not the most user-friendly display!).

Flows to protect the fish community were based upon MesoHABSIM and the dominant fishes expected in the fish community. Much effort was expended to identify the dominant fish species and their expected proportions, but it is not clear that this effort had a use in subsequent determinations of flows. If so, the rationale was not explained. The Bain and Meixler (2008) method provides more detail for the target fish community (TFC) than seems needed, particularly the calculation of how the existing New Hampshire stream fish communities differ from the TFC. For the purpose of protection, which appears to be the objective, the effort to develop TFCs appears superfluous. However, if a generic New Hampshire (or southeast New Hampsire and another for the rest of New Hampshire, following ecoregion boundaries) TFC (or expected dominant fish species list by stream order) can be established it might save work on other rivers. Perhaps the TFC identifies species that, because they are, or should be, most common, should be the basis for instream flow determination? The Bain and Meixler method has its primary use in river restoration, hence the term “target” in its product. Although instream flows are a significant consideration in river restoration, there is an apparent disconnect between the TFC and MesoHABSIM. However, this apparent disconnect is not a fatal flaw; it is merely superfluous. A simpler approach would have been to determine a list of present and potential (i.e., restoration , recovery, or introduction plans, including needed associated species if there are any critical interspecies dependencies) species, then consider flow sensitivities for each species by season and life stage. As mentioned above, documentation of fish-flow responses for New England would be helpful and might focus emphasis on the more flow-sensitive species. Are there uncommon fish that are flow-sensitive or flow-limited?

Uncommon species may be flow-sensitive and should not be disregarded for flow setting.

Some effort was expended on mussels and this was appropriate, given the concern over mussels in North American rivers and streams. It was also not surprising that mussels could not easily be linked directly to flow, consistent with Haag and Warren’s (2008) finding in the Southeast that mussels survived extreme drought in the short term fairly well if they were not desiccated (i.e., some ponded water persisted). In the long term, NHDES makes a reasonable assumption that, if the fish on which the mussels depend are protected, then the mussels should also be protected.

Establishing instream flows requires setting volumes of flow per unit time (e.g., cfs, m^3/s, l/s, etc.) that provide some level of protection for the instream values of interest. NHDES has done a good job of distinguishing non-flow dependent instream resources and values from flow dependent instream resources and values; the logic is clear. NHDES and its contractors have also identified critical seasons for different life history stages of different fish and other biological resources that depend on flow (flow-dependent resources). As noted above, although the identification of species in the fish communities was perhaps overkill, subsequent steps attempted to identify flows that provided suitable flows for the fish, aquatic, and riparian community members.

An instream flow method should either (a) show how a biologically important or limiting factor varies with flow or (b) identify a flow that either maximizes a biologically important or limiting flow-sensitive factor or minimizes rate of loss. The former are incremental methods.

Important considerations in instream flow method evaluation include (1) reliability, (2) ease or difficulty of use, and (3) cost. Reliability includes how well the method addresses flow-sensitive values and resources, repeatability and clarity of method description, and consistency of results.

MesoHABSIM, like PHABSIM, models amount of habitat as a function of flow. The single biggest difference between the two is the difference between microhabitat and mesohabitat. Mesohabitat may reflect microhabitat as Vadas has shown, although it is uncertain how well they correspond outside pools (and Vadas went into much more detail distinguishing habitat types). Even pools should be subdivided into shallow and deep pool areas and heads, bodies, and tails. A riffle at a high flow and the same riffle at low flow can be quite different in terms of habitat quality and quantity for riffle-dependent organisms. Pool-dwelling species appear to be the simplest and clearest case of potential correspondence between fish habitat and flow and presumably between fish and habitat area, but this is not well founded in literature and it ignores connectivity, food production and transport, and life history stages. In reviewing the first draft of this IFC review, John Magee (New Hampshire Fish and Game Department and IFC representative for New Hampshire) noted his research on brook trout habitat use: “An interesting observation we commonly make is that brook trout are often in the tail of a pool, in very shallow water, drift feeding, and quickly dart for the deeper areas of the pool or under instream wood when we walk nearby. This implies that different parts of a single pool offer different habitats and for different necessary life functions of this species. I suspect that the same is true for other fish species….”

One of the challenges with PHABSIM is how to interpret large areas of low quality habitat, but this challenge is not apparent with MesoHABSIM. This may be a benefit of MesoHABSIM, but if the mesohabitats do not discriminate finely enough (see previous paragraph), then this benefit may be lost.

The unit of measure of mesohabitat is an easily correctible problem. Instead of using mesohabitat area relative to a not clearly defined width (it reads as if it is wetted width), which itself may vary with flow, the amount of mesohabitat should be measured in relation to channel length (or some other constant feature of the reach or watershed).

Ease of use of MesoHABSIM and PHABSIM are probably comparable. Both require considerable training and equipment. If aerial photography is required at several flows for MesoHABSIM, then the cost could be substantial. This seems to be the case for both the New Hampshire rivers, but it is not clear that aerial photography is always required.

MesoHABSIM is worth additional evaluation and may prove to be a useful method. Claims of MesoHABSIM superiority to PHABSIM rest primarily on the ability to apply to larger reaches instead of extrapolating to them. Not all PHABSIM applications are good applications, but PHABSIM should not be condemned because of poor applications.

PHABSIM has considerable use for fish that maintain territories in streams, particularly in areas associated with higher velocities, where habitat quality relates strongly to velocity. Conversely, MesoHABSIM might be appropriate for pool-dwelling and perhaps other non-territorial fishes (but this has not been convincingly demonstrated).

Many instream flow practitioners employ some degree of subjectivity or professional judgment in selection of sites (representative or critical). (The widely used Tennant method was built on professional judgment of the habitat gestalt of many different flows at each of many different rivers.) Such subjectivity is not inherent in a method; it is a factor in application, usually determined by time and budget. Unfortunately, the NHDES report discredits itself somewhat in trying to incorrectly discredit another widely practiced instream flow method (PHABSIM) by incorrectly implying that PHABSIM is inferior in not sampling an entire river reach to select study sites. (I have participated in several PHABSIM studies that employed replicable random sampling of habitat types throughout an entire reach or larger river segment in order to weight transects.) Both tools have merit. MesoHABSIM may have considerable merit for evaluating habitat of fish that wander in a school over larger areas (e.g., the entire extent of a mesohabitat or hydromorphological unit), but PHABSIM is useful for evaluating territorial fishes such as salmonines. Both tools are flexible and allow the incorporation of new knowledge and understanding. The two approaches could be used in conjunction in some cases. There is no value in discrediting PHABSIM.

MesoHABSIM appears to offer promise as an instream flow method, but in over-selling it (and attempting to discredit other methods), the practitioners do it few favors. The key question, as Ron Ptolemy (British Columbia) has articulated clearly and Bob Vadas (Washington, with much experience in Maine, Ohio, and Virginia, as well as elsewhere) has concurred, is whether the fish or other aquatic organisms respond most to mesohabitats as defined in the method or whether they respond to particular contributing components to the mesohabitats (e.g., depth, velocity, substrate, cover, channel form).

To start with, the concept that area of suitable mesohabitats is related to fish habitat is a reasonable assumption. Clearly pools have slower water velocities than runs and riffles, and many fishes are pool dwellers, so determining the amount of pool habitat at different flows is a reasonable flow evaluation for pool species. Ron Ptolemy has emphasized the importance of flow over riffles for transporting food (drifting benthic invertebrates) into pools, so that pool area may not be the sole determinant of habitat quality x quantity, even for low velocity pool dwellers. It may be useful to distinguish different parts of pools as the method is refined.

It is not so clear that runs differ substantively from riffles or cascades for fish that prefer high velocities, particularly where the difference between a riffle and a run may be depth and surface turbulence (functions of gradient, depth, and substrate size). It would be valuable to assess the degree to which any fish that prefers higher velocity seeks run over riffle or vice versa.

Use of logistic regression to develop habitat suitability criteria is not a new approach (e.g., Thielke 1985), but it has been characterized by some practitioners as art as much as science. An advantage of logistic regression is that it provides relative weight to different habitat components (e.g., depth, velocity, cover, substrate, mesohabitat, distance from other features, water quality, associated species). Is mesohabitat, as defined by the practitioner, a heavily weighted part of the habitat suitability function or do other components outweigh it? This is a critical question in the applicability of MesoHABSIM. It is a can of worms that, once opened, must be evaluated. Alternative approaches to habitat suitability determination may be more transparent. The linkage between habitat suitability models and MesoHABSIM appears circular or extraneous. As in the case of the TFC, much work was done to develop habitat suitability criteria, but the link to mesohabitats is not crystal clear in these reports.

The index of mesohabitat, percentage of wetted area, is not the best way to use MesoHABSIM. This unit may be slightly misleading as at lower flows the denominator is smaller. The same %Wetted Area could be different amounts of habitat if the wetted area that is the denominator differs among flows. This could also be true at overbank flows. PHABSIM uses weighted usable area in square feet per thousand feet of channel length (or metric counterparts), which is a constant denominator rather than a sliding denominator. For example, pool could be 100% of wetted area at a flow of zero, but it might be much less pool habitat than occurs at a significantly higher flow. Use of absolute values (e.g., square feet or square meters per linear unit of channel) with a constant denominator would be more informative than relative values unless it can be shown that certain ratios of mesohabitats are critical for certain communities or species (and this is a reasonable possibility, particularly for pool species that require food transport from riffles).

The use of naturally occurring hydrological extremes (UCUT curves) is a sound approach to assessing what extremes can be tolerated at what frequencies. It is most relevant when the community of aquatic organisms being evaluated is a collection of species that currently inhabits the stream of interest and has done so for most of the period of hydrological record. If some species have been extirpated, the cause might have been an extreme condition that was part of the period of record. Setting flows based on UCUT curves requires some judgment, as the criteria appeared subjective.

At extremely low flows, flow can become a factor for water quality, particularly dissolved oxygen concentration and temperature, but the constraints in the New Hampshire approach, adhering to the Natural Flow Paradigm and avoiding such extremes, probably averts such water quality problems (except as climate changes).

In the riparian transect sections, NHDES appears to use a professional judgment standard for selecting transects; no methodology for randomization nor weighted representation is presented. This is not a fatal flaw in the method, but better description of the transect selection would better support the method should it be contested. Perhaps the practitioners can provide a clear rationale for transect selection, if needed. As mentioned above, professional judgment may be necessary when time or budget limit more rigorous approaches.

Winter habitat discussions, particularly as they relate to ice, seem to be reasonable approaches as long as no significant changes in winter water use are anticipated. However, if significant changes in winter water use are proposed or anticipated, more directed studies of winter instream flows and ice should be undertaken. Winter and ice are not hospitable conditions for study, but studies are necessary for understanding consequences of any changes to the stream community from winter changes in hydrology. Ice processes should be carefully considered. Ice can be a cause of mortality for fall-spawning salmonid eggs, particularly if flows decline after spawning. Ice scour is discussed under plant community limiting factors, but the role of spring floods and other factors in determining the extent of ice scour is not discussed. Considering that the NHDES website includes the US Army Cold Regions Research and Engineering Laboratory (http://www.crrel.usace.army.mil/; http://des.nh.gov/organization/divisions/waste/hwrb/fss/dod/crrel.htm), they should be consulted as they have relevant expertise.

The report rightly emphasizes that instream flows do not guarantee water quality and water quality should be monitored and regulated in addition to instream flow. Water temperature and other water quality components are sensitive to flow, as recognized in the discussion of dilution and the 7Q10 standard. Other discussion makes them seem independent.

Discussion on p. 89 of the Souhegan report talks about acceptable limits of extreme events with and without habitat restoration. However, it is not clear whether the restored habitat, which provides a greater amount of habitat area, means that a more extreme flow can be tolerated because the same habitat area would be left.

The reports should provide a link (http://water.usgs.gov/waterwatch) to get to map of USA with gages, then click on NH, then site; alternatively give direct link to gage data.

Recreation – The PISF for recreation is for whitewater recreation. It is misleading to say “recreation” because picnicking and small children playing in a stream is also recreation and is best with relatively low flows.

Figures 51 and 52 represents flows needed in upper and lower Souhegan. See caveat on p. 121 about daily averages potentially masking short-term extreme violations. (Note that Dr. Robert Metcalfe of Ontario, an IFC member and IFC review team member, has addressed this with software [Natural Flow Metric Tool].)

Kaeser:

As a novice to MesoHABSIM I found the task of reviewing these reports quite a challenge. Several of the questions posed to reviewers require a deep understanding of how the pieces of this rather intricate modeling effort come together and influence the final predictions- the protected instream flow values. In other words, putting all the pieces together required some mental gymnastics in addition to much back and forth flipping through the documents. From my own perspective, I highly recommend that a conceptual diagram (flow chart type) illustrating the sources of data and the MesoHABSIM modeling process from start to finish would be of great benefit to a reader/reviewer. Appendix 17 is a step in that direction, but definitely does not include the type of flow chart I have in mind.

Moreover, references to or information on the sensitivity of the model to changes in the model inputs would be of great benefit to a reviewer. Which inputs have the greatest impact on overall model performance? Which parts of the MesoHABSIM model and process demand the most attention and scrutiny in terms of data used and assumptions made? Given the information provided in the SR report, it is difficult for me to identify the most critical parameters, or otherwise rank their importance. This information is quite relevant to a scientific review. The sensitivity of the various model parameters could perhaps be identified/included in the flow chart.

Stepping back, I am somewhat unsettled by the fact that the MesoHABSIM approach taken here is one that primarily focuses on the physical habitat (velocity/substrate) relationships of fish to identify the PISFs, when other factors (namely thermal pollution- which all but eliminates habitat available to brook trout and slimy sculpin in the upper SR) are not seemingly addressed via the approach and are perhaps not addressed by maintaining PISFs identified via the method. Without regard to other habitat degradation factors on the SR, the actual fish community may never resemble the optimal target fish community.

The word MesoHABSIM does not appear in the Executive Summary of the SR Protected Instream Flow Report, and probably should. The Lamprey River Draft report contains a section up front on Fish and Aquatic Life Assessment using MesoHABSIM (page xviii). Why is this not part of the SR report?

Let it be known that I primarily reviewed the Souhegan River report, and hope that the comments provided will apply generally to the Lamprey River report as well.

Ptolemy:

Souhegan

I would strongly suggest that NH undertake a systematic review of the flow components necessary to sustain various ecological and fisheries functions. This would entail for example an understanding of the flows required for unimpeded access and spawning by Atlantic salmon adults from radio telemtery studies done everywhere. The type of flow needs would be summarized in a table. There is a great opportunity to qualify all flow needs by systematic review of things like kayak navigation. The flows required can be qualified by mean annual discharge with smaller streams requiring a much larger proportion of an unbiased index flow such as the long-term mean annual discharge. Another example includes channel maintenance flows. Stream bottom particles may become mobile at flows above 400%mad from gravel scour meter results. Both the Lamprey and Souhegan river studies show a large increase in certain mesohabitats with flow. Unfortunately the paper(s) does not qualify this. Riffles and rapids show considerable increase with higher flows. Perhaps a “Riffle Analyses” is more appropriate to address rearing flows for both riffle dependent and drift dependent “pool” species and life stages.

Lamprey

General

1. This review is a supplement to the detailed answers to structured questions already provided for the Souhegan River. Both the Souhegan and Lamprey studies are based on highly similar approaches and assumptions excepting for the fluvial habitat simulations in the impounded reaches of the Lamprey River. The merits and deficiencies identified for the Souhegan apply also to the Lamprey River.
2. In general, the detailed meso-habitat mapping and colour coding provided in Appendix 8 show consistent loss of riffle/rapid and cascades as flow increases to 1.5 cfsm or 96%mad (mean annual discharge). There is a net loss of riffles, etc and an increase in slow-water habitats (pools, runs) as documented for Site 2. This has profound impacts on the interpretation of suitable flows and the use of indicator species like Common Shiner.
3. The channel width extent of mapped riffle habitat in Site 2 at a flow of 0.1 cfsm or 6%mad appears much larger than is typical for streams where flows are below the

10%mad criteria. This leads to the primary complaint of using %channel area versus flow in most the plots; the superior approach would use m^2 values or hectares as appropriate to the reach or stream.

4. For each of the species- and life-stage drivers in Table 1—Protected instream flow criteria for fish in the Lamprey Designated River, it would be useful to have a HSI curve for each of depth, velocity and substrate preference. It would also be useful to have a text description of how the life-stages use various fluvial habitats. Common shiners are the indicator species for July 5-Oct. 6 period yet they are pool dwellers. Surely fast-water taxa would be more sensitive to dewatering event than are pool-dwellers; this includes mayflies, stoneflies and simuliids. Adult Common Shiners have been consistently observed near fast-water interfaces with slow habitats presumably due to the proximity of food items (insect drift) originating in riffles and rapids. It remains likely the meso-habitat approach is the wrong tool to address things like drift rate and density of food being delivered to species like Common Shiner. Adult longnose dace are probably a better fish indicator as they are found primary in riffles and rapids; while dace fry are more common to the perimeter of fast-water and slow-water habitats.

Specific

The following table is a reproduction of the Lamprey River instream flow criteria however the outputs utilize %mad for comparison to many other global habitat-flow studies and the experience of the reviewer. Both summer and winter baseflows are qualified using USGS data.

Summary of Stream Flows for the Protection of Aquatic Life in the Lamprey River, NH, USA

Event	Common	%mad	Critical	%mad	Rare	%mad
Rearing and Growth	110	38%	22	8%	16	6%
July 5-October 6						
1 in 2 yr residual baseflow	24	8%			3.4	1%
Riffle Target	57	20%	29	10%	14	5%
Salmon Spawning	90	31%	40	14%	20	7%
October 7-December 8						
Generic target for days-weeks	200	70%	100	35%	50	17%
Over-wintering	238	83%	110	38%	73	25%
Dec. 9-February 28						
Winter Base	151	53%			46	16%

Spring Flood March 1-May 4	622	217%	238	83%	146	51%
400%mad-channel maintenance	1148	400%	574	200%	287	100%
Clupeid Spawning May 5-June 19	143	50%	62	22%	57	20%
GRAF Spawning May 5-July 14	101	35%	22	8%	16	6%

LT Mean Annual Discharge (cfs) **287**

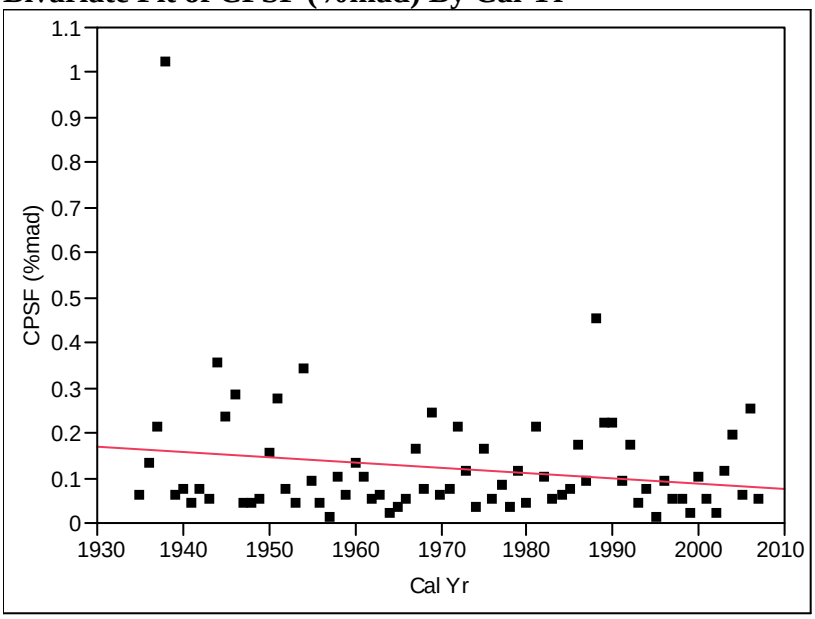
	cfs	**%mad**
Note habitat surveys conducted over a range in flows	14	5%
	360	125%

1. There is a disconnect between the measured residual flows (say lowest mean monthly flow in 1 of 2 yr frequency) for the July-October period and the suggested common flow for rearing and growth. The former value is 24 cfs (8%mad) which is frequent, severe, and variable by month and year; the latter is 110 cfs (38%mad) and appears both rich and unachievable. If we were protecting a 30-day baseflow each year within the limits of normal runoff, we might use a generic standard to maintain riffle/rapid health and insect drift into slower habitats of about 20%mad which is equivalent to 0.3 cfsm. The HMU maps for site 2 show a considerable stream length (width?) in riffle/rapid condition at 0.2 and 0.5 cfsm. The question is at what flow(s) are velocities optimized for insects and adult longnose dace? The flow extreme or record shows a 30-day mean flow of 3.4 cfs or 1%mad in September 1957. The most recent summer baseflow of note is 4.8 cfs or 2%mad in September 2002.
2. There is no clear indication to what degree the natural summer baseflows might be higher than the residuals now being recorded. What is the sum total abstraction in a dry summer (September)? Are the natural baseflows 25%mad in 1 or 2 yr? Are the 1 in 73 yr frequency flows 12%mad?
3. The Atlantic salmon spawning (and upstream passage?) flows appear too low and at variance with published accounts of upstream passage flows and spawning

habitat criteria. Successful spawning does not require sustained flows during October 7-December 8 of 62 days. Spawning can occur over days to a few weeks. Should Atlantic salmon spawning needs be similar to that of steelhead, a flow of 200 cfs is required as an optimum. 90 cfs is too low.

4. Over-wintering common flow (238 cfs) appears too high for the lower Lamprey River and is at variance with the 1 in 2 yr winter baseflow (30-day minimum) of 151 cfs. This reviewer assumes that winter baseflows are largely controlled by nature. Presumably protection flows would be described to minimize dewatering of the channel toe-width and reduce icing damage. The necessary flow for this action is typically near 20%mad or 57 cfs.
5. Spring flood flows (riparian needs) seems to be fairly well rationalized based on flood plain transects. However if substrate mobility issues along with channel geometry maintenance flows are a driver, flows of 400%mad are required. Spring flood flows are approximated by flows near 622 cfs or 217%mad. The duration of the flows nearer 1148 cfs is for days and not weeks or months.
6. No real comment on either clupeid or GRAF spawning other than they do perform as intermediate flows to those of Spring Flood and Rearing -Growth bioperiods. Again understanding the inferred HSIs would be useful at the univariate level (depth, velocity, etc.).
7. Clarity of results could be improved on by showing the flow targets as thresholds and overlay the daily flows for say a drought year like 1957. What flow targets were not met? What evidence do we have a biological failure? Do we have the right indicators? September 1957 flows of 3.4 cfs (1%mad) must have appeared as severe with nearly dry riffles and rapids. There may have been coupled high stream temperatures and reduced water quality then too.
8. The following regression of summer baseflows (%mad) and calendar year show no apparent trend and the slope is not significantly different to zero.

Bivariate Fit of CPSF (%mad) By Cal Yr



Linear Fit

Linear Fit

CPSF (%mad) = 2.4251407 - 0.0011693*Cal Yr

Summary of Fit

RSquare	0.031831
RSquare Adj	0.018194
Root Mean Square Error	0.137788
Mean of Response	0.120411
Observations (or Sum Wgts)	73

Analysis of Variance

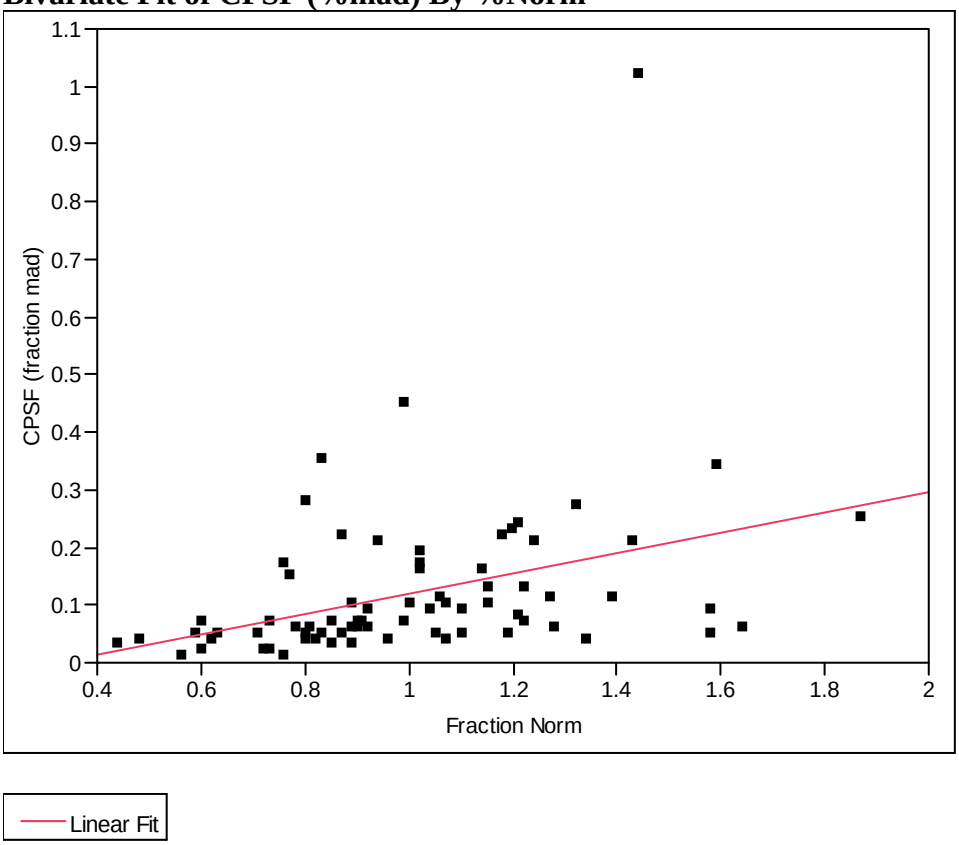
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.0443172	0.044317	2.3343
Error	71	1.3479704	0.018985	**Prob > F**
C. Total	72	1.3922877		0.1310

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.4251407	1.508584	1.61	0.1124
Cal Yr	-0.001169	0.000765	-1.53	0.1310

9. Water year type (%Normal Runoff) does have a significant, positive influence on summer baseflows as might be expected as the following regression shows. The trend line has a slope (+0.18) that is different from zero (t-ratio test where p<0.001). There is a high degree of scatter and the R^2 value is low (12%). The plot still shows some high runoff years producing a critical period streamflow (CPSF, fraction mad) that is <10%mad.

Bivariate Fit of CPSF (%mad) By %Norm



Linear Fit

CPSF (%mad) = -0.056687 + 0.1768556*%Norm

Summary of Fit

RSquare	0.135264
RSquare Adj	0.123085
Root Mean Square Error	0.13022
Mean of Response	0.120411
Observations (or Sum Wgts)	73

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.1883263	0.188326	11.1060
Error	71	1.2039614	0.016957	**Prob > F**
C. Total	72	1.3922877		0.0014

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.056687	0.055284	-1.03	0.3087
%Norm	0.1768556	0.053069	3.33	0.0014

Vadas:

1. Target-fish assemblages - Bain and Meixler (2000, 2008) examined freshwater-fish assemblages in tributary rivers in the Quinebaug River basin of southern New England, using the Target Fish Community approach to identify pristine ichthyofaunal conditions for use in assessing human impacts (e.g., channelization and hydropower dams) and river-restoration needs (cf. Parasiewicz 2003, 2007a,c, 2008b; Jacobson 2008). Species were ranked for abundance and then converted to relative-abundance data based on the theoretical log-log (power-law) relation between species abundance and occurrence expected by community ecologists (cf. Parasiewicz 2003) that has been partially corroborated for Virginia fish assemblages (Vadas 1991; Vadas and Orth 1997). For Bain and Meixler's (op. cit.) fish assemblages, cypriniforms were especially prevalent, including the dominant fallfish, subdominant common shiner, and several common species that included dace as well as various non-cypriniform fishes (i.e., darter, sunfish, perch, and eel species); most of these fishes were native. But some sites were unusual in showing dominance by (a) centrarchids like the native redbreast sunfish and exotic smallmouth bass and bluegill sunfish (various habitat and pollution/thermal impacts) or (b) native minnows like spottail and common shiners (recent inundation after a dam failed) (Bain and Meixler 2000; Parasiewicz 2003)). Bain and Meixler (2000) also classified species into three macrohabitat guilds in increasing order of conservation concern based on literature data; the guilds were generalists, fluvial dependents, and fluvial specialists. The above target species were especially fluvial specialists, but the other two guilds were also represented.

a. For the Quinebaug River basin, Parasiewicz (2001, 2007a,b, 2008b) undertook an instream-flow (ecohydrologic) study at the mesohabitat level, using the MesoHABSIM methodology that allows larger stream reaches to be examined than for standard microhabitat

models like PHABSIM (cf. Parasiewicz and Walker 2007) that (a) are less relevant to diurnal fish movements and the watershed scale (cf. Jacobson 2008) and (b) may not measure bed form accurately enough via transects. Indeed, MesoHABSIM application allows upscaling and GIS mapping that are needed for effective river restoration (Parasiewicz 2001, 2003, 2007a,b,c, 2008b). The focus was the six more-abundant species from the Bain/Meixler study, including cypriniforms (fallfish, common shiner, white sucker, and longnose and blacknose dace) and (to a lesser extent) the native tessellated darter and the exotic bluegill sunfish, which were sampled using the (a) Bain electro-grid technique or (b) other techniques for non-wadeable conditions (i.e., snorkeling unless turbid enough to require boat electrofishing) (op. cit.; Parasiewicz and Walker 2007). Parasiewicz (2003, 2008a) also considered spawning life stages of anadromous fishes, including American shad and Atlantic salmon, to provide for adequate spring vs. fall flows, respectively, as these seasons typically require higher flows than during summer (Vadas and Weigmann 1993; Vadas 2000). I address the mesohabitat-guild status of the resident fishes below.

2. Fish-habitat use, part I – Parasiewicz's crew (Parasiewicz 2001, 2003, 2007b, 2008b; Parasiewicz and Walker 2007) undertook stepwise-forward, logistic (multivariate) regressions to identify important habitat variables (each segregated into multiple classes) for most of the above target-fish species. This was based on two binary analyses on adjacent suitability classes, i.e., optimal, suitable, and unsuitable, as estimated via density (fish/m^2) thresholds (for high vs. low abundance) of (a) 0.30 for gregarious (schooling) cypriniforms (fallfish, common shiner, and white sucker) and (b) 0.15 for solitary species (longnose and blacknose dace) at the mesohabitat level (Parasiewicz 2007b). But Parasiewicz and Walker (2007) described the cutoff values for low vs. high abundance categories as being HSI values of 0.2 vs. 0.5, respectively, which is a different approach than the earlier thresholds based on fish density (see above), though all four of Parasiewicz's papers cited above provide the same statistical results. So this is a confusing aspect of the methodology. Moreover, the results below are contradictory in some ways, as indicated by beta coefficients of positive (preference) or negative (avoidance) values (Parasiewicz op. cit.). Hence, I question the use of logistic regression as a replacement for standard habitat-suitability-index (HSI) modeling with more-quantitative data, the latter of which are provided by Parasiewicz and Walker (2007) as a useful reality check. The main problem with these HSI curves was the bimodality of the substratum histograms for all five cypriniform species, in all cases because of under-representation of the 17-64 mm size class (i.e., large gravel) (op. cit.). This suggests that large-gravel habitats weren't properly sampled to build the micro- and mesohabitat models, and is definitely a major reason that substratum results often differed from my own work (see below). Hence, habitat-model smoothing (sensu WDFW and WDOE 2004; Vadas et al. 2008) should have been done. Another problem with Parasiewicz's four papers is that inorganic and organic cover types were split into several categories, rather

than pooled together as advocated by Vadas and Orth (2000, 2001) to enhance the generality of results; type of cover doesn't matter as much as the amount of total cover for fishes. Hence, Parasiewicz's (op. cit.) cover results often diverged from my own work (see below). Furthermore, the results for Parasiewicz's (op. cit.) logistic-regression analyses may have been affected by redundant habitat variables, included Froude number (with velocity) and shallow margins (with depth) (cf. Vadas 1994; Vadas and Orth 1998, 2000).

a. *Bluegills* (Parasiewicz 2001) liked medium-slow velocities (15-30 cm/s) better than medium velocities (30-45 cm/s), reflecting a greater preference for pools than slow-riffle and run habitats (sensu Vadas and Orth 1998). These sunfish also liked canopy-cover shading, likely reflecting a preference for shoreline habitats. But weirdly, negative relations were seen for glides (shallow pools) and submerged vegetation, even though I've found this species to be in the pool-cover guild (sensu Vadas and Orth 2000, 2001) based on my collective seining and fly-fishing of it in main- and off-channel habitats of Virginia (Vadas 1992a,b). This species wasn't used in instream-flow analysis (see below).

b. *Fallfish* (Parasiewicz 2001, 2003, 2008b; Parasiewicz and Walker 2007) liked boulders and medium-high velocities (45-60 cm/s), the latter indicative of slow-riffle and run habitats (sensu Vadas and Orth 1998). But weirdly, negative relations were seen for runs, as well as for shallow depths ($\leq$ 25 cm) and canopy-cover (overhanging-vegetation) shading, the latter two parameters likely reflecting avoidance of shoreline habitats. But at the microhabitat level (HARPHA model), mid-sized substrata (larger gravels and cobbles) and submerged vegetation were also avoided (Parasiewicz and Walker 2007). These results partly corroborate my past angling findings of these minnows in pool/run habitats, using (a) fly-fished poppers in Virginia (Vadas 1992b) and (b) streamer flies and lures in Maine (Vadas 2002, pers. obs.). But this species is better classified as being in the fast-generalist guild of Vadas and Orth (2000, 2001), for which mid-sized substrata are actually preferred.

c. *Common shiners* (Parasiewicz 2003, 2008b; Parasiewicz and Walker 2007) liked boulders and riprap, but showed negative relations for moderate depths (50-75 cm) and canopy-cover shading. The lack of a velocity preference may reflect the habitat-generalist nature of the pool/run guild that I've found this species to be in for Virginia (Vadas 1992a), where I instead found moderate depths to be well-used habitats.

d. *White suckers* (Parasiewicz 2003, 2008b; Parasiewicz and Walker 2007) liked deep (75-100 cm) better than medium depths (50-75 cm), as well as cobbles and undercut banks. The lack of a velocity preference may reflect the habitat-generalist nature of the pool/run guild that I've found this species to be in for Virginia, albeit its use of deeper habitats than I found likely reflects my inadequate sampling of adults (Vadas and Orth 1997, 2000). But this species probably still belongs in the pool-cover guild.

e. *Longnose dace* (Parasiewicz 2003, 2008b; Parasiewicz and Walker 2007) liked faster (riffle and fast-run) habitats, moderate velocities (45-60 cm), large-woody debris (LWD), and riprap. But at the microhabitat level (HARPHA model), this dace also liked fast velocities (75-90 cm/s) and shallow depths (≤ 25 cm) but avoided overhanging vegetation (Parasiewicz and Walker 2007), likely reflecting avoidance of slow shorelines. This is mostly consistent with my fast-riffle guild classification, as derived from sampling in mid-Atlantic states (RLV, unpubl. data) and British Columbia (Vadas 1996, unpubl. data); the exception is LWD usage that I've found to be consistently important only for the pool-cover guild in Virginia (Vadas and Orth 2000, 2001).

f. *Blacknose dace* (Parasiewicz 2003, 2008b; Parasiewicz and Walker 2007) liked divergent substrata (boulders and mud), moderate velocities (45-60 cm), and shallow depths (≤ 25 cm), the latter often along shore. But they avoided larger gravels, submerged vegetation, and canopy-cover shading, which seems inconsistent with their boulder vs. mud vs. shoreline habitat preferences, respectively. Based on my sampling in mid-Atlantic states (RLV, unpubl. data), including this dace's association with mountain redbelly dace (*Phoxinus oreas*) (Vadas and Orth 2000), I would classify this minnow as being in the shallow-rheophilic guild that likes mid-sized substrata. This is more consistent with Parasiewicz's (op. cit.) hydraulic than substratum results.

g. Although logistic regression wasn't run on *tessellated darters*, my own observations on it (Vadas 1992a) and the taxonomically similar johnny darter (*Etheostoma nigrum*) (cf. Lee et al. 1980) classify it in the pool-cover guild. This species wasn't used in instream-flow analysis (see below).

3. Fish-habitat use, part II - Although Jacobson (2008) considered minnows to be habitat generalists that show more specialization when predators constrain them, this would have to be a multispecific generalization. Indeed, individual species in the upper Roanoke River drainage,

VA, showed mesohabitat specialization that allowed them to be classified into individual guilds, albeit the fish family as an aggregate occupied six of the seven guilds identified by Vadas and Orth (2000, 2001).

a. Hence, Parasiewicz's (2001, 2007b) 5-7 resident, target species showed the following species richness in these seven guilds: fast-riffle (1), riffle/run (0), fast-generalist (1), shallow-rheophilic (1), pool/run (2), open-pool (0), and pool-cover (0-2). These results reveal that one rheo- and limnophilic guild each (sensu Vadas and Orth 1997, 2000, 2001) weren't represented at all, whereas the pool/run guild was the best-represented guild. Hence, I don't think that Parasiewicz's (op. cit.) target species well-represented the full fish assemblage, thus making assessment of fish instream-flow needs (see below) somewhat biased. Although Parasiewicz (2007c) asserted that fish species and life stages with the "most demanding" habitat requirements should be used in instream-flow assessments, I prefer a balanced, ecosystem-based approach based on all available mesohabitat guilds (Vadas and Weigmann 1993), as all guilds are habitat specialists to varying degrees (Vadas and Orth 2000, 2001). Notably, Vadas and Orth (op. cit.) found that the most habitat-generalized guilds were fast-generalist and pool/run species, both which were prominent in Parasiewicz's (2001, 2007b) instream-flow analyses. I do agree with Parasiewicz (2008a), however, that lentic and macrohabitat-generalist animals may benefit most from instream-flow reductions that cause habitat, thermal, and pollution problems (cf. Vadas 1997, 1998).

4. Mesohabitat classification - Parasiewicz's (2001, 2007b) description of his mesohabitat methodology is definitely confusing and seemingly contradictory. First, he discussed and used a qualitative mesohabitat-classification system for hydromorphic units (HMUs), i.e., the U.S. Forest Service (USFS) method that has been used mostly on montane creeks of the Pacific Northwest (cf. Vadas and Orth 1998). Parasiewicz (2007b) collected hydraulic and bed-topography data within these HMUs. Second, he criticized such HMUs for varying in size based on stream size, emphasizing that his own mesohabitat units are fish-oriented by encompassing diurnal movements (but could change by season or life stage) (op. cit.). But the latter wouldn't be consistent enough for overall fish-assemblage use, in my opinion. Nevertheless, Parasiewicz (2008b) decided that HMUs approximated daily fish use. Third, he used the following hydraulic criteria during his reconnaissance survey (with other conditions being 'moderate'): shallow ($\leq$ 30 cm), deep ($\geq$ 1.5 m), slow ($\leq$ 20 cm/s), and fast ($\geq$ 80 cm/s) (Parasiewicz 2007b). These values are fairly similar to the mesohabitat criteria developed by Vadas and Orth (1998) for streams of various sizes throughout North America, including two average-velocity criteria (25 and 60 cm/s) but three (rather than two) depth criteria (20, 50, and 120 cm). As emphasized by Vadas and Orth (1998), the USFS method has fewer depth criteria because headwater streams tend to be

shallow, whereas Parasiewicz (2001, 2007b) sampled a larger New England River that's more amenable to the Vadas-Orth method. In any case, it's somewhat unclear how Parasiewicz (op. cit.) developed his MesoHABSIM methodology to reflect mesohabitat changes across flows. Are the mesohabitat units of MesoHABSIM really more fish-relevant than those used for mesohabitat-diversity modeling across flows (cf. KBA 1995; Courtney 1995; Bovee 1996; Hardy 2000)?

5. Instream-flow analysis - As emphasized by Parasiewicz (2001), streams typically lose their pool-riffle morphology at higher flows, reflecting homogenization into faster (especially run) habitats, albeit he also found greater off-channel habitat areas at higher flows. For this instream-flow analysis, relative community-habitat area (RCHA) was modeled as the proportion of wetted area for which fish-presence probabilities exceeded 50% for at least one species (cf. Parasiewicz 2007b,c, 2008b). Because this instream-flow showed an "inflection" point near a flow of 1.1 m^3/s but kept on increasing to the highest flow of 2.0 m^3/s (when RCHA exceeded 30%) (Parasiewicz 2001), it's unclear what the optimal fish-assemblage flow was. Notably, Parasiewicz (2007b) admitted that it may make more sense to weight RCHA by the relative abundance of fishes, which is consistent with the ecosystem-based approach that I described above. He also conceded that rarer fishes like diadromous or imperiled species may need special attention in instream-flow analyses (op. cit.; Parasiewicz 2008a). I agree with Parasiewicz (op. cit.) that instream-flow recommendations should be geared to the seasonally varying bioperiods of fish species, notably spawning vs. rearing functions (cf. Vadas and Weigmann 1993; Vadas 2000).

a. Based on my above guild classifications, I made two predictions for fish relative abundance. First, longnose dace should increase the most with flow yield (per unit drainage area), opposite of the shallow- and headwater-oriented blacknose dace. This prediction was indeed apparent from Parasiewicz' (2003, 2008b) analysis. Second, I expected the other three cypriniform species to show less-obvious (intermediate) differences across flow yields, but with the fallfish preferring higher flows than the other two species that were in the pool/run guild. This prediction was partially corroborated, albeit it's unclear why common shiners decreased with flow unlike white suckers (op. cit.). But Parasiewicz's (op. cit.; Parasiewicz and Walker 2007) MesoHABSIM curves for relative-suitable area vs. flow yield unexpectedly differed among papers, both for the entire study site and for individual sections/sites, such that I have QA/QC concerns with the results. In general, PHABSIM and MesoHABSIM were more likely to provide peaked curves (with clear optimal flows for fishes) than did the HARPHA model (Parasiewicz and Walker 2007), such that the latter's dependence on logistic regression at the microhabitat level may be especially problematic. Although these authors concluded that

MesoHABSIM gave more accurate instream-flow quantification than PHABSIM, this is based on sketchy substratum-use models (see above) that may've compromised the results. But interestingly, Parasiewicz (2008b) found that the RCHA vs. flow-yield curve became flatter with predicted dam-removal and channel-improvement (to combat channelization) projects, instead of peaking at lower flows. In contrast, such curves didn't change much with predicted dam removal alone (Parasiewicz 2003), as flow regime but not channel shape was modeled to change. These results make sense because naturally or artificially confined streams need relatively less flow to satisfy Pacific salmonids (Beecher 1990).

In sum, problems with the Quinebaug River instream-flow study strongly suggest that the methodology needs further QA/QC attention before being validly applied to other New England rivers.

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A P P E N D I X A

SUMMARY OF INSTREAM FLOW COUNCIL POLICIES

Policies are numbered for convenience, not priority.
Comments on NH Program: "Yes" (21/46) indicates that NHDES appears to be consistent with IFC policy to the degree that it can be determined (recognizing that the policies were aimed more at fish and wildlife agencies than at water resource agencies). "NA to this review" indicates that this review by IFC focuses on the technical aspects of the instream flow studies and the policies refer to aspects of instream flow and water management that are outside of the technical (hydrological, hydraulic, geomorphological, biological, statistical); i.e., we don't know.

Title	Policy	Comment on NH Program
1. Public Input	Effective instream flow programs should incorporate public input in the decision-making process.	Yes
2. Public Education	State and provincial instream flow programs should include specific actions to inform the public about instream flow concepts, how instream flows are administered, what benefits the programs provide, and what opportunities exist for public involvement.	Yes
3. Public Communication	Information intended for public consideration in instream flow decision-making processes should be straightforward, free of jargon, and provide a basic understanding of technical and legal concepts, biological processes, and trade-offs.	Some of technical material on MesoHABSIM is more complicated than it needs to be for public consumption. Lack of discussion of implementation makes it difficult to evaluate trade-offs.

Chapter 4 – Legal/Institutional Policies

Title	Policy	Comment on NH Program
4. Public Trust Doctrine	Laws, regulations, and/or policies affecting fishery and wildlife resources and the habitats upon which they depend should be based on the state or province's legal stewardship responsibilities to manage those resources for the benefit and enjoyment of present and future generations.	Yes
5. Federal Water Management	Federal agencies should integrate their water and riverine management efforts within the constructs of state and provincial laws, regulations, and policies to protect riverine resources.	Not addressed
6. State and Provincial Water Rights	State and provincial laws, regulation, and policies should provide the authority, opportunity, procedure, and process to enable a state or provincial fishery and wildlife agency the right to obtain and/or hold instream water rights, reservations or licenses in perpetuity for the specific purpose of protecting, rehabilitating, restoring and managing fishery and wildlife resources and habitats and other trust resources.	NH does this through state DES program
7. Private Instream Flows	State and provincial laws, regulations, and policies should provide the authority, opportunity, procedure, and process to enable an organization, group, or individual the right to obtain, retain, secure, and/or hold instream water rights for individual streams or rivers, or specific sections of individual streams or rivers, for the specific purpose of benefiting fisheries and wildlife and other in-channel purposes.	Not addressed
8. Priority and Legal Standing	Instream flow rights, reservations, and licenses to restore, manage, and/or protect the aquatic resources of streams, rivers, and lakes should have priority and legal standing to protect aquatic resources.	NH does this through state DES program
9. Water Rights Certainty	State and provincial instream water rights, reservations, and licenses should be afforded permanent status to enable them to fulfill their custodial trust obligations for riverine resources.	

Appendix A Continued.

Title	Policy	
10. Public Interest	States and provinces should designate instream uses of water as in the public interest and/or beneficial uses to ensure that riverine resources and processes are considered on an equal basis with other traditional uses of water.	Yes
11. Connectivity of Surface and Ground Water (Legal)	The hydrological interconnectivity between ground water and surface flows should be recognized, and these waters should be conjunctively managed to protect the short- and long-term fundamental public value of fishery and wildlife resources and habitats.	The hydrological interconnectivity of surface and groundwater is recognized, but it is not clear that they are connected in law and policy.
12. Fishery and Wildlife Agency Role	State and provincial fishery and wildlife agencies should have the primary authority for determining appropriate stream and river flow quantity, quality, and other needs and requirements necessary to restore, manage, and protect fishery and aquatic wildlife resources and processes.	The New Hampshire Fish and Game Department (NHFGD) appears to be consulted somewhat, but not to be a full partner in the instream flow program, as they ought to be. John Magee (NHFGD) wrote: "Although NHFGD is an active partner in the NHDES instream flow program, this is not made clear in the two reports. NHDES and NHFGD have worked very well together on this and other topics, and NHFGD staff, specifically John Magee, have been on the Technical Review Committee for these two studies. I have put many long days into this topic with NHDES, and I have found NHDES very easy to work with, and NHDES is very interested in protecting biological integrity. In NH, NHDES has the legal

		authority regarding water quality, which includes biological integrity, whereas NHFGD has little authority over water quality except in hydroelectric relicensing and NPDES permits.”
13. Water Conservation	State and provincial governments should develop and implement legal opportunities to enable consumptive water users to conserve water and dedicate conserved or unused water to instream purposes.	This may be the case in the water management plans to be developed after the instream flows are adopted. The IFC policy appears to be aimed more at prior appropriation states and provinces (western) than riparian doctrine states.
14. Water Quality Standards	State and provincial fishery and wildlife agencies should include stream and river flow quantity and other needs and requirements necessary to restore, manage, and protect aquatic and riparian fishery and wildlife resources and habitats within water quality standards and permitting processes.	It is unclear what NHFGD standards and authorities on instream flow are; NHDES is the lead agency and appears to be taking a comprehensive view of water management.
15. Public Funding	Public funding for water management projects should include conditions for the protection of instream flows necessary to meet the needs and requirements of aquatic and riparian fishery and wildlife resources and habitats.	Yes

Appendix A Continued.

Chapter 5 - Instream Flow Programs and Site-Specific Prescriptions

Title	Policy	
16. Riverine Resource Stewardship	All streams and rivers should have instream flows that maintain or restore, to the greatest extent possible, ecological functions and processes similar to those exhibited in their natural or unaltered state.	Yes
17. Public Trust Advocacy	Advocacy for and protection of the principles of the Public Trust Doctrine must be among the fundamental guiding principles of an effective instream flow program.	Yes
18. Native Species	Instream flow programs should acknowledge the importance of and need to manage stream communities and indigenous aquatic biota. Management of nonnative species should not threaten the long-term health or survival of native species and their habitats.	Yes
19. Reservoir Management	Instream flow programs should acknowledge the effects of new and existing dams on sediment transport and allow managers the ability to recommend strategies for water releases and sediment management that minimize negative effects to existing channel, riparian, and floodplain properties and processes below the dam.	Generally recognized, but storage is modest in dams considered.
20. Dam Removal	Instream flow programs should support the removal or modification of dams or in-channel barriers and restoration or rehabilitation of affected riverine resources to more natural conditions and functions when those structures' benefits no longer outweigh their societal costs.	Some discussion of dam lowering, but not a part or goal of instream flow program for these rivers.
21. Processes Development	Instream flow programs should establish a process for quantifying instream flow needs that allows the state, or provincial, fishery and wildlife management agency to identify or approve study needs, study design, data analysis, and flow implementation.	Role of NHFGD in this program appears minimal – some consultation about Atlantic salmon restoration goals, but little else.
22. Legal Authority	Instream flow programs should have ready access to specifically trained legal counsel familiar with water law statutes and instream flow programs in order to obtain consistent representation and maximize instream flow benefits under existing laws and regulations.	NA to this review.

Appendix A (continued)

Title	Policy	
23. Legal Counsel	Instream flow programs should have ready access to specifically trained legal counsel familiar with water law statutes and instream flow programs in order to obtain consistent representation and maximize instream flow benefits under existing laws and regulations.	NA to this review
24. Negotiation	Effective instream flow programs should include personnel who are trained in negotiation skills, supported by their agency administration, and engaged in appropriate negotiation from the start of projects.	NA to this review
25. Interdisciplinary Teams	Effective instream flow programs require a well-coordinated, interdisciplinary team with adequate staff, training, and funding to address all instream flow and related issues that fall under the agency's responsibilities.	The lack of clear presentation of the logic of the process, with several apparent dead ends, suggests that interdisciplinary coordination is inadequate.
26. Comprehensive Water Resource Planning	Comprehensive water resource planning that includes recognition of instream flows as an essential water use is an important part of an effective instream flow program.	Yes
27. Drought Planning	State and provincial instream flow programs should support and participate in development of mechanisms or plans to implement water use reductions during drought periods to protect essential instream flows.	To be developed at water management plan following adoption of instream flows
28. Flow Variability	Instream flow prescriptions should provide intra-annual and interannual variable flow patterns that mimic the natural hydrograph (magnitude, duration, timing, rate of change) to maintain or restore processes that sustain natural riverine characteristics.	This is recognized in recognition of Natural Flow Paradigm (although some apparent misunderstanding of NFP raise some doubts), and should be addressed in water management plans
29. Riverine Components	Instream flow studies must evaluate flow needs and opportunities in terms of hydrology, biology, geomorphology, water quality, and connectivity.	Yes
30. Stream Gaging	Instream flow programs must support individual gaging stations and networks of gaging stations necessary to quantify hydrographs, make and defend instream flow prescriptions, and monitor and enforce instream flow compliance.	Yes
31. Discharge Measurements	Discharge meters, stream gaging devices, and flow data collection protocols should meet accepted standards of the U.S. Geological Survey and/or Environment Canada.	Yes

Appendix A (continued)

Title	Policy	
32. Synthetically Derived Hydrologic Data	Instream flow assessments based on synthetically developed hydrologic information should acknowledge the source and quality of data. Final decisions or agreements should be based on collection and use of appropriate field data to refine the precision of the original estimates.	Yes
33. Land Use	Instream flow practitioners should recognize the effects of land use practices on instream flows and work with land managers to promote land use practices that maintain or restore the natural hydrograph and avoid or minimize those that negatively affect the natural hydrograph.	Influence of land use is recognized, but it appears there is little or no authority to regulate land use as a part of water management
34. Habitat	Instream flow prescriptions must maintain spatially complex and diverse habitats, which are available through all seasons.	Yes
35. Ice Processes	Water management decisions for streams that are prone to ice formation should document the potential effects that the proposed action might have on the stream channel or associated aquatic organisms and, where appropriate, include measures to minimize or avoid potentially negative effects of project-related ice forming processes.	Yes (at least to some degree)
36. Channel Maintenance	Channel maintenance flow is an essential component of instream flow prescriptions for alluvial channels, and the maintenance, rehabilitation, restoration, and preservation of stream channel form and associated biological communities.	Yes
37. Flushing Flow	For many stream types, a flushing flow for removing fine sediments is a necessary component of instream flow prescriptions.	Yes
38. Channel Modification	Any proposed stream channel modification should document the hydrologic and geomorphic character and function of the watershed and floodplain and incorporate principles of applied fluvial geomorphology and natural habitat features.	No channel modification proposed
39. Instream Mining	Instream mining as a source of sand, gravel, or other materials should only be considered as a last option, and the mining operation should only be allowed to remove material in excess of the normal sediment transport carrying capacity of the stream.	NA to this review

Appendix A (continued)

Title	Policy	
40. Water Quality	Instream flow prescriptions must recognize the relation between the quantity and quality of water in streams, document the effects of water quality changes on riverine resources, and implement prescriptions that maintain or improve water quality characteristics for natural riverine resources.	Yes
41. Riparian Connectivity	Instream flow prescriptions must recognize the connectivity between instream flows and riparian areas and maintain or establish riparian structure and functions.	Yes
42. Floodplains Connectivity	Instream flow prescriptions should maintain or re-establish connectivity between instream flows and floodplains.	Yes
43. Groundwater Connectivity (Management)	Instream flow prescriptions should recognize and describe the extent and nature of connectivity between instream flows and groundwater and manage groundwater withdrawals to avoid potentially negative impacts on instream flows and riverine resources.	NA to this review (see #11 above)
44. Longitudinal Connectivity	Instream flow prescriptions should recognize and document the importance of connectivity within defined stream segments and the stream system in general. Management actions should avoid creating longitudinal disconnectivity where appropriate and restore connectivity where needed.	Yes
45. Monitoring	Monitoring riverine resource responses to instream flow prescriptions is a fundamental component of effective instream flow programs. Monitoring studies should be based on long-term ecosystem processes as opposed to short-term responses of individual species.	**This should be highlighted as a need for New Hampshire's instream flow program. The background work towards developing TFC and EFC should provide a valuable starting point, perhaps through a long-term contract with NHFGD**
46. Adaptive Management	Adaptive management can be an effective tool but should be used selectively to answer critical uncertainties for instream flow-setting processes.	Riparian doctrine may facilitate adaptive management, if needed, but adaptive management should not be an excuse for causing deterioration of instream resources, and should only be implemented after thorough review of monitoring results and subject to continued monitoring.