R-WD-10-5

Summary of the Instream Flow Council's review of the Souhegan and Lamprey Instream Flow Pilot Studies

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April 2010

Introduction

The NH Department of Environmental Services (DES) is conducting a pilot study to test methods for developing protected instream flows on the Souhegan and Lamprey Designated Rivers. In 2012, DES will be required to prepare a report summarizing for the legislature the results of this pilot program. DES initiated an independent review of the results and methods of a part of the pilot program. On September 25, 2009, DES received the Instream Flow Council's (IFC) submittals reviewing the final Souhegan Instream Flow Study and the draft Lamprey Instream Flow Study reports. The five IFC reviewers cover a range of experience and education in fisheries studies, and statistical and incremental modeling methods. DES has reviewed and summarizes in this document the IFC's review of the studies conducted by DES on the Lamprey and Souhegan Rivers. The first section of this document describes the commencement of the IFC's review of these studies. The second section summarizes the responses of the IFC reviewers to the questions developed by DES.

I. Commencement of the Independent Review

DES, in response to comments on the draft Souhegan Instream Flow Study, developed a plan to identify experts in the instream flow field who would conduct a review of the methods and results of the studies. DES defined the review parameters by developing a list of questions based on public comments and on an outline of the methods and results of the protected instream flow study. DES hired the Instream Flow Council (IFC) to act as sponsor of an independent review, including selection of suitable reviewers, compilation of their review comments and a final IFC-wide members' review of the individual reviewers' results.

The independent review began during the public review process of the studies. The Instream Flow Pilot Program includes two committees to advise on the development of the instream flows and the water management plans. The Water Management Planning Area Advisory Committee is made up of watershed stakeholders and its duty is "to assist in implementing the provisions of the pilot program."[1] The Technical Review Committee (TRC) is made up of water resources experts from government, industry and conservation groups and its duty is "to advise the department on the preparation and conduct of the protected instream flow study."[2]

These committees, and the TRC in particular, reviewed and approved the methods proposed for evaluating the protected instream flows prior to DES's consultants conducting the studies. The TRC also reviewed the results of the studies as steps were completed and memorialized in reports. The Souhegan TRC reviewed the methods and results of the Souhegan study documented in the Proposed Protected Instream Flow Study report draft. This report contained the evaluation of flow needs and the resulting protected flows for the Souhegan Designated River. The methods and results of the Souhegan instream flow study are complex and contain components requiring knowledge in several different disciplines. One member of the Souhegan TRC expressed concerns because he did not feel he had the expertise to evaluate certain components of the study. As a result DES determined that the support of additional experts would help to resolve these concerns. DES proposed an independent review to evaluate the completed Lamprey and Souhegan Protected Instream Flow Studies.

DES's purpose for this independent review was to present the results to the legislature as part of the supporting documentation for the final review of the pilot program that is to occur after the implementation of the water management plans. The independent review report will be used by DES to identify what changes may need to be made to the study methods. DES proposed to identify a panel of

[1] Laws of 2002, Chapter 278:3,II.(a)
[2] Laws of 2002, Chapter 278:3,I.(b)

experts with the appropriate multidisciplinary education and experience that would review both of the pilot river's studies' methods and results as documented in the final study reports. DES defined an independent review of the final Souhegan and Lamprey instream flow study reports that would evaluate the key components of the studies, but focusing on incremental modeling, fish studies and statistical methods.

Experts in the instream flow program interact frequently and it was not easy to identify potential reviewers who had not previously collaborated or interacted with DES's consultants. To avoid bias in the selection of reviewers, DES determined to have a third party identify the reviewers and coordinate the compilation of results. DES identified the Instream Flow Council (IFC) to choose and recruit reviewers and coordinate the review. IFC is made up of instream flow experts from fish and wildlife agencies throughout the United States and Canada, and the organization has published two books edited by its members on instream flows.

In September 2008, DES developed a series of questions, structured on the Instream Flow studies' components, for IFC to evaluate when selecting reviewers. The instream flow reports and supporting material including the studies' work scopes, relevant regulations, guidance documents, and interim reports were provided to representatives of the IFC. DES asked IFC to provide at least 3 reviewers with expertise in incremental modeling, fish studies and statistics. The last question was open-ended as an opportunity for reviewers to provide any other comments that seemed relevant.

On June 1, 2009, DES contracted with the IFC to provide the third-party review with their review and report due September 30, 2009. The review consisted of the Final Souhegan River Protected Instream Flow Report and the Draft Lamprey River Proposed Protected Instream Flow Report. The draft Lamprey report was used because the final Lamprey report was not ready until July 13. DES went forward with the review using the draft report because of the availability of the reviewers, timing of available funding and comments concern the Lamprey Protected Instream Flow report.

IFC identified five reviewers. The IFC reviewers were Hal Beecher (Washington), Adam Kaeser (Georgia), Bob Metcalfe (Ontario), Ron Ptolemy (British Columbia), and Bob Vadas, Jr. (Washington). The review was done during spring and summer of 2009. The reviewers completed their reviews July 30 and IFC circulated the compiled reviews to its members for comments. IFC submitted their report to DES on September 25, 2009. The IFC review documents consisted of a cover letter, the main IFC document responding to the DES questions, Appendix A documenting where NH's program is consistent with IFC's instream flow policies called Summary of Instream Flow Council Policies, a review by Hal Beecher of the Lamprey Protected Instream Flow reports responses to public comments in Appendix 14, and curricula vitarum of the five reviewers.

II. IFC Review Summary

The IFC review document is made up of several parts. The cover letter and the IFC responses to DES's questions represent the IFC-reviewed opinions. There was also a document that summarizes one of the reviewer's comparisons of the IFC's policy positions with DES's program. These three parts of the IFC are summarized below.

II A. Cover Letter

The cover letter outlined the review program and described the contents of the attached documents. It summarized the contents of the review documents and concluded with: "New Hampshire is to be commended for its vision and effort and we wish you success in protecting New Hampshire's aquatic ecosystems."

II B. Questions

DES had developed 38 questions structured on the instream flow studies components to coordinate the review process and facilitate our evaluation of the responses. Reviewers responded to the questions. In some cases the opinion of one reviewer was not consistent with that of another. This is to be expected since there are many methods for defining instream flows other than those chosen for these studies. Several responses appear to be directing the instream flow reports towards the level of detail of a published journal article on a single topic, which is not, and could not be, the purpose of these reports. The purpose of this document is to highlight problem areas identified by the reviewers and determine if changes in future instream studies should be made.

Each section of the DES questions included an introductory paragraph putting the section in context. These have been omitted in this summary, but may be found in the attached document: IFC NH questions.doc, which includes the compiled responses of the IFC reviewers. In the following summary, the DES questions are presented in **bold**. The summaries of the response are in *italicized* text and draw as much as possible on the actual wording of the reviewers. Some comments were deleted from subsequent questions where they had no additional bearing on the topic and had been evaluated and discussed by DES earlier in the document. Separate spacing between paragraphs represents a different reviewer's thoughts. Any further discussion by DES is prefaced by **DES notes** and continues in **bold text**.

RIPARIAN WILDLIFE AND VEGETATION FLOW ASSESSMENT - FLOODPLAIN TRANSECT METHOD

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

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

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

Yes, they are appropriately located.

DES notes that developing a standardized method for the selection, quantity and location of transects when using this method would be more defensible than transects across each of the sensitive environments.

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

The protected flows describe variable flow needs starting at a relatively high flow need and with lesser flows at other times and defined with magnitude, timing and duration.

Infrequent high flows are not addressed, although the broad snowmelt peak is protected. Neither is the potential for increased frequency of infrequent high flows.

One reviewer suggested the assessment does not show response trends for various flows.

DES notes that the Flood Plain Transect method is not an incremental method that would result in response trends. Such a study as proposed would require years of continuous monitoring to develop.

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.

Yes. Responses included suggestions for additional work that would improve the results. Calibration of species responses to flow and soil mapping to identify shifts in soil types with modification of flows were suggested.

DES notes that the suggested flow and soil mapping studies are beyond the scope of the project's duration.

FISH AND AQUATIC LIFE ASSESSMENT – MESOHABSIM

Target Fish Community

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

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

There is insufficient information to make a judgment 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.

DES notes that these were the selection criteria as is described in Appendix 6 of the Souhegan Report and in the Final Lamprey Target Fish Community Model Report (June 2007).

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

Yes, with some caveats. Use of the Bain and Meixler (2008) fish community reconstruction seems a reasonable approach for determining the historical fish community. Using numbers rather than weight of fish biases the focus towards small schooling species, however, 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.

I feel comfortable with the ultimate selection of the five Souhegan River species that were the most commonly occurring members of the Target Fish Community observed in the study rivers.

DES notes that many variations on this method might have been used, but the Bain and Meixler method, as applied, was identified by the consulting team and approved for use by the Technical Review Committee.

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

Relative to inclusion of Atlantic salmon - If no measures for restoration will be implemented, then inclusion of species that require restoration is questionable.

DES notes that the Instream Flow Program's goal of meeting biological integrity requires defining conditions that support the range and variability of flows that will support a community of organisms comparable to that of similar natural habitats. The community is described in part by the Target Fish Community. The Target Fish Community uses reference rivers to describe the fish in similar natural habitats, which in these pilot river cases results in the inclusion of Atlantic salmon.

While the salmon restoration program has been suspended indefinitely on the Lamprey, removing this species as part of the biological community is not a decision to be unilaterally made by the Instream Flow Program. Furthermore, NH Surface Water Quality Standards require maintenance of the physical, as well as the biological integrity of surface waters, such that these flows should be maintained.

Also, IFC President-elect Chris Goudreau's comments included in the IFC review support DES's position.

> **"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."**

I was satisfied to find that brook trout and slimy sculpin were included [for the Souhegan Designated River] in the final list of indicator species.

It would be really useful to have a table or figure which clearly show what depth, velocity, etc. Habitat Suitability Index curves apply for each species and life-stage.

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.

DES notes that the Target Fish Community defines what fish are expected under low-impact conditions. The HSI has nothing to do with developing the Target Fish Community. Also, fish presence is due to a combination of environmental factors. While some models utilize univariate habitat suitability criteria to evaluate microscale habitat, MesoHABSIM assesses habitat use at the mesoscale maintaining the assumption that fish select habitat by the combination of habitat parameters that match their requirements as a whole. The pilot studies' habitat assessment method used multivariate, logistic regression. This regression technique eliminates subjectivity associated with the use of selected individual parameters. The goal is to predict habitat use, not to identify the fish preferences for individual habitat components.

Reliance in logistical regressions is OK if we understand the HSI [Habitat Suitability Index] *values by species and life-stage. Logistic regression ROC* [Relative Operating Characteristic] *AUC* [Area Under Curve] *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* [Souhegan] *Appendix 8 are <0.7 and generally poor predictors.*

DES notes that this variability is in the nature of biological data; that there are not always perfect predictors. AUC values less than 0.7 occur for some of the species on the Souhegan, and on the Lamprey only for Redbreast Sunfish. For the Lamprey it is not consequential because Redbreasted Sunfish habitat is not used for flow settings. In the Souhegan, the low AUC values do not affect the suitable habitat, only the optimal habitat predictions in summer. Appendix 8 of the Souhegan model demonstrates the ROC curves and the curve with low AUC values is that for abundance for fallfish. Appendix 14 demonstrates through validation that the model predicts correctly.

Habitat Suitability Criteria

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?

Yes. Where the fish species are mostly the same, similar habitat use is expected.

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?

DES notes that the samples used to develop habitat criteria during the summer bioperiods were collected in the summer. Samples were collected from rivers over a number of years taking annual variability into account. The suitabilities for bioperiods other than summer were defined using literature information from multiple years of sampling, which reflects in some sense the interannual variability.

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.

Yes they are if the data show preferences rather than restricted use according to available habitat.

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?

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).

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.

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.

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

Logistic regression is often used for developing habitat suitability. . . . 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.

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 results 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.

DES notes that these assessments are not trying to identify the species' individual habitat use parameters. Because the purpose was to identify the combination of habitat parameters most suited

to fish based on their actual usage, some individual parameters do end up being less influential. The parameters that might be chosen individually were ignored by fish when habitat conditions as a whole were selected. There is no contradiction in positive and negative beta values for presence versus abundance, because the presence and abundance models are independent. There is nothing wrong with the same variable correlating positively with fish presence and negatively with higher abundance. For example, increase of woody debris may cause presence of certain species but only in low numbers.

Another problem with Parasiewicz's four papers [referring to papers published earlier describing the MesoHABSIM method] *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 cover results often diverged from my own work.*

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).

DES notes that logistic regression is used to calculate complex indices that consider the interactive nature of multiple physical attributes. Logistic regression was chosen because it is very robust in countering redundancy. A cross-correlation analysis was also run on the Lamprey data to remove the most obvious redundancies before running the logistic regression. That is also why Froude number is not included in the Lamprey analysis.

11. Was the logistic regression conducted appropriately?

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.

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?

DES notes that logistical regression is very robust with respect to redundancy and that is why it was chosen. Details are found in Appendix 17 in the Souhegan report and in a very comprehensive description in the Lamprey report. The logistical regression model uses likelihood ratios to determine which parameters should be included. The iteration continued until the results were optimized. Cross-correlation analysis was also run to remove those most obvious redundancies.

Habitat Mapping Surveys

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

The selection appears representative given the large fraction of each reach that were surveyed systematically.

The sensitivity to site selection decreases because each site includes a number of replicates of each mesohabitat type.

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.

Not enough information is provided to evaluate whether the sites selected were representative. 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.
The upper third of the Souhegan River seems to be underrepresented in the sampling effort.

DES notes that the selection of representative sites at each Designated River is described in the Task 4 reports. Both Task 4 reports include the proposed methods of protected flow assessment and where they were to be applied. These reports were reviewed by the Technical Review Committees before the contractors conducted the field work.

The Souhegan Task 4 report describes in Section 2.5 the field survey where the Designated River was divided into hydromorphological units based on "the flow pattern, the substrate, surrounding banks and vegetation, canopy cover and hydraulic patterns of the river. When the river had made an obvious change in characteristics, then the river was divided at that point." Section 2.6 Delineations of the Sections and Reaches continues by describing how the river was divided into nine distinct reaches which generalized the 73 hydromorphological units. The reaches were determined by the units' characteristics of distribution, gradient, and substrate and where similar habitats and species were assumed to be present. A hierarchical cluster analysis was performed which gathered similar sections within a reach according to their characteristics. The eleven representative sites for study were defined based on the cluster analysis results and expert opinion. See also page 743-744 where further discussion summarizes the process.

Page 76 of the Lamprey River final report which describes the River Sections and Representative Sites begins as follows.

> **The river was divided into eight sections using changes in gradient, hydromorphologic assemblages, and cover attributes, which are described below. By prioritizing the mapping to the higher gradient, and thus dynamically changing, portions of the river, the majority of changing [hydromorphological unit] assemblages on the designated river were captured. During the reconnaissance survey almost no riffles, ruffles, or rapids were observed outside of these areas. The stepped nature of the Lamprey Designated River between these high-gradient sections made for natural divisions between the areas of interest, where slower moving and impounded areas could be sampled as well.**

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

The use of relatively long sites and the general methodology of MesoHABSIM make it likely that the area measured is sufficient to represent the river segment or reach.

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

A metric such as % of reach represented (study reach length/total segment length) would be helpful to assess the areal representation among the defined river segments.

DES notes that this information was not presented for the Souhegan, but is presented now in the table below. Lengths of river sections and representative study sites are presented in the

Lamprey report under the heading "Study Areas of the Lamprey Designated River" beginning on page 75 and is summarized below.

Representative Study Site Length by River Reach for the Souhegan and Lamprey Rivers			
Souhegan			
River Reach/Section	River Reach/Section length (miles)	Representative Study Site length (miles)	Percent of River Section studied
Reach 1	8.8	0.86	12.3%
Reach 2	2.2	0.62	28.5%
Reach 3	2.9	0.42	14.6%
Reach 4	3.0	0.99	32.9%
Reach 5	3.3	1.44	43.8%
Reach 6	4.4	0.90	20.4%
Reach 7	5.8	1.43	24.5%
Reach 8	1.3	0.46	34.0%
Totals	**31.7**	**7.1**	**22.4%**
Lamprey			
River Section	River Section length (miles)	Representative Sites length (miles)	Percent of River Section studied
Section I	1.35	0.44	33%
Section IIa	0.47	0.40	85%
Section IIb	1.47	0.21	14%
Section III	2.92	0.47	16%
Section IV	1.3	0.52	40%
Section V	1.67	1.0	60%
Section VI	0.70	0.50	71%
Section VII	0.5	0.50	100%
Section VIII	1.6	0.88	55%
Totals	**11.98**	**4.92**	**41%**

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

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.

Yes. The high degree of coverage is compelling and the fact the stream [Souhegan] 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?

The range of flows [for the Souhegan] *covers the spread of the natural hydrograph well. The only part of the hydrograph not covered by the three mapping flows was the highest flows, many of which are short duration. 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.

We would expect flows from 3% to 100% of the mean annual discharge or 0.05 to 1.71 cfsm to be represented in a small stream such as the Souhegan River. The actual range in flows [for the Souhegan] 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.

DES notes that no flows below 0.11 cfsm on the Souhegan have occurred since the 1960s drought so lower flows were not available for mapping during the field investigations.

Higher flow requirements were defined for riparian vegetation using the Floodplain Transect method assessment. Magnitudes of flow were defined with required durations and within certain periods to maintain variability.

Target flows for mapping [in the Lamprey] were 0.1, 0.2, 0.5, 1.0, and 1.5-2.0 cubic feet per second per square mile. 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?

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 show similar means and variances as seven?

DES notes that Dr. Parasiewicz conducted these tests during the development of the MesoHABSIM model where he determined that more than seven measurements do not improve the resulting mean or variance. These assessment methods were identified and accepted during Task 4. Further testing of the assessment method was not a task of the pilot studies.

The main problem with these [Habitat Suitability Index curves in Parasiewicz and Walker (2007)] *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). *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. Hence, habitat-model smoothing (sensu WDFW and WDOE 2004; Vadas et al. 2008) should have been done.*

DES notes that these are data from a different project. The Lamprey and Souhegan projects used habitat data from many projects to avoid gaps in sampling of habitat conditions. The Lamprey and Souhegan studies used many fish collection data sets from multiple rivers to better capture the habitat selection by fish without being confined by absence of habitat availability on any one river. From 815 (Souhegan) to 1504 (Lamprey) fish collection grids from a variety of rivers were used for the development of habitat suitability criteria creating a very robust data set. Data used to create the habitat suitability criteria were selected from rivers of a similar size and category (2nd to 4th- order, upland streams.)

Within each HMU, seven measurements of velocity, depth, and substrate were made on each of three occasions. [Three occasions applies to three habitat measurements at different flow made on the Souhegan--five flows were measured on the Lamprey.] *How variable were these seven actual*

measurements? Seven measurements may be adequate to evaluate a small hydromorphological unit, but what happens to the variance for each parameter when we obtain seven measurements from an hydromorphological unit that is ten times the size of the smallest hydromorphological units? That is, was there a relationship between hydromorphological unit size and variance for each measured variable?

DES notes that this may be a valid concern. For both studies, a new individual hydromorphological unit was created where flow and hydraulic patterns of the river varied. No evaluation of a relationship between hydromorphological unit size and variance of measured variables was conducted. However, stratified random sampling was applied on the Lamprey. Stratified random sampling subdivides the area to homogeneous patches and distributes measurement points in relation to the patch size. On the Lamprey, there was no limit on the number of points.

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.

DES notes that hydromorphological units may change with changing flow such as a rapid that turns into a run. However, new measurements of velocity and depth were made at each flow. Conditions such as substrate that would not change were not remeasured.

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

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).

In general, the habitat details are appropriate for the type of meso-habitat analyses and mapping.

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

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.

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 hydromorphological unit (HMU) polygon simply changed from one class to another under a different flow condition.

DES notes that all mapping has the challenge between lumping and splitting. HMUs do change types when flow increases usually at the expense of the shallow riffle zones. Mapping was typically done so that HMUs were mapped at a scale of one to two times the stream width, although smaller units were mapped where appropriate because differences in conditions were more than transitional.

For the most part yes the methods were appropriate given [concerns about loss of resolution as higher flows cause washing out of riffles and runs.]

Baseline river structure

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

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.

The answer should not only include structure (new or otherwise) but also the baseline or natural flows prior to flow regulation.

DES notes that it agrees and has modeled the protected flows using not only baseline river structure, and naturalized flows, but also the Target Fish Communities which are considered the baseline fish species expected in the pilot rivers.

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

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.

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. . . . 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.

Generally speaking, condensing continuous data (counts) into categorical data results in a loss of information.

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.

DES notes that in its opinion three classes better reflect the models accuracy and uncertainties.

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

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.

The weightings are entirely arbitrary and the results may be non-informative.

DES notes that opinions on the weighting of habitat conditions are varied.

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

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.

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.

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

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.

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?

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.

DES notes that this is the difference between management for individual species and management for the river community. Because the proportions of the species in the community are essential to defining community curves, the combined curves better represent the community needs. This avoids defining conditions ideal for a single, high flow species.

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.

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.

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.

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%*** [of mean annual discharge] *or 58 cfs*

on the lower river. If side channels and off-channel habitats are critical to over-wintering fish, the required flow will be closer to ***100%*** [of mean annual discharge] *or 292 cfs in the lower river or 174 cfs in the upper river. The 1 in 2 yr winter baseflows are* ***41%*** [of mean annual discharge] *or 119 cfs in the lower river.*

DES notes that there is very little data describing the biological flow needs for fish during winter and spring. The winter and spring bioperiods' protected flows were developed using flow-based criteria that were defined with the components of the Natural Flow Paradigm (magnitude, duration, frequency and timing). This approach, while not ideal because it is not tied to biological thresholds at least defines conditions that will mimic natural variability. The rule-of-thumb flows suggested above for overwintering vary from 20% to 41% mean annual discharge: choosing between them seems subjective, whereas magnitudes and durations derived with naturally-occurring slope breaks in flow frequency define objective thresholds.

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. The necessary flow for this action is typically near 20%mad or 57 cfs.

DES notes magnitude is only part of the flow protection description under the concepts of the Natural Flow Paradigm and should not be seen as the only component of the protected flows. Protected flows also include durations based on frequency analysis for stream flow to occur below the common flow. Since the common flows represent near-ideal conditions, these flow magnitudes are not expected to be continually met. Flows below this level are not a concern unless they exceed the durations to which species are adapted. All the Protected flows are defined as magnitudes with their durations based on frequency analysis.

Hydrologic data

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?

In the Souhegan River, 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.

The gauged data used in the Lamprey River study was appropriate.

Yes it does for high flows such as mean annual discharge. There may be a disconnect for baseflows measured in the headwaters versus in the lower river near the primary USGS gauge.

DES notes that additional USGS gages have been installed in the middle portion of the Souhegan Designated River and upstream of the Lamprey Designated River in addition to the existing gages on the lower reaches of these rivers. Also, concurrent flow measurements were made on both rivers at intervals upstream of the gages at various flow levels to compare the flow at those locations relative to the flow being recorded at the stream gage.

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?

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.

DES notes that the Lamprey hydrologic record was assessed and naturalized through 2006 and at the time that the analysis was performed the last complete annual water year (October 1-September 30) data set available was the 2005 water year.

The availability of Souhegan flow data was limited because the gage was closed October 1, 1976 through September 30 2001 so watershed-specific data were not available during a significant portion of the immediately preceding years and so the earlier data were used.

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

No. There is no clear description of the procedure that accounts for known impoundments, dams and surface/groundwater abstractions.

DES notes that the Souhegan naturalized flows differed so little from the recorded gage flows that the gage flows were used and no description was included. The Lamprey report that the IFC reviewed was the draft report and did not contain a complete description of the naturalization procedure. In the final report the method for developing the naturalized flow was included as well as a compact disc with the raw and naturalized flow data.

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, % [mean annual discharge] *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 deficiencies. 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.*

DES notes that the gage data are readily available from the USGS website. Figure 10 of the Souhegan report (and Figure 14 in the Lamprey report) are not related to the baseline or naturalized flow process. These figures depict the bioperiod distributions as shown on a template of the mean of daily mean flows.

DES was determined not to plot the protected flows magnitudes against annual flows or other hydrographs again in the Lamprey report. This was done in the Souhegan report, but was unclear to readers since only the magnitude thresholds were plotted. A complete plot would need to incorporate the counting of duration under the magnitudes. Without the duration analysis of the hydrograph, these plots do not adequately depict the components of duration or frequency of the protected flows.

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

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.

DES notes that protected flow conditions are frequently evaluated against dry, wet and average conditions. DES defined this task to assess the protected flows against these key conditions. The method identified representative periods of stream flow based on precipitation statistics and stream flow records. It was not looking for extreme cases, but instead selected sets of years that were representative of these conditions.

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

DES notes that in addition to the assessment using 3-year periods of high, low and average conditions, the assessment was conducted using the previous five-year period and either the 30 years of record used in the modeling or the entire period of record. The assessments were done for each bioperiod, which were determined as biologically-significant portions of the year.

Development of UCUT Curves

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?

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.

DES notes that explicit criteria for identification of inflection points are desirable and will work to see that these are documented. Dr. Parasiewicz has notified DES that the upcoming version of MesoHABSIM uses a "broken stick" method as an automated procedure for defining thresholds. The points with the greatest gradient change are selected and regression line estimates the thresholds.

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.

DES notes that these durations below flow magnitude thresholds are considered biologically relevant since habitat loss beyond these durations are outside the ranges to which species are adapted. Changes in UCUT curve slope and line density represent changes in frequency outside of the natural frequency of occurrence of habitat magnitudes and durations.

An incremental flow model's main assumption is that flow is a component of habitat availability. The Natural Flow Paradigm states that aquatic species are best supported by the naturally varying flows to which they are adapted. It is universally understood that habitat limitations represent stressful, and in the extreme, harmful conditions. Flows that vary outside the natural magnitudes and durations therefore represent habitat restrictions that species are unused to and represent stressful conditions and lack of habitat for longer than normal durations represent harmful conditions.

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

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.

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

DES notes that as a reality check, monitoring of changing conditions over several years will be necessary to show the relationship between maintaining protected flows and improved habitat conditions represented by a closer affinity index between the existing and the target fish community. However, the theory behind the Natural Flow Paradigm and the concept of limiting loss of habitat through protection of flow conditions is sound.

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

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.

DES notes that explicit criteria for identification of inflection points are desirable and will work to see that these are documented.

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.

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. 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 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. . . . in Washington state, which uses western water law (prior appropriation). . . . 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.

DES notes that in states where prior appropriation is in use, water quality standards may not be being met because of existing water uses. The result is that resource management agencies are restricted to limiting additional adverse impact and to campaigns to support individual game species. DES's goal is to manage in order to support appropriate water use and to support biological integrity. There is a risk of gradually flattening the hydrograph through increased water use. DES has identified a tracking mechanism to identify short- and long-term trends in loss of hydrograph variability to assist in the societal decisions for increased management or loss of species.

New Hampshire should also consider the role of marine-derived nutrients in streams that support or formerly supported American shad and Atlantic salmon.

DES recognizes the value of anadromous and catadromous species in the ecosystem. The Instream Flow Program seeks to support those species by maintaining the ecosystem to which these species are adapted through flow management.

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 artifact of incomplete sampling. This keystone deficiency undermines all else that follows in the convoluted series of complex steps.

DES notes that a large number of samples from data of actual fish use were used to develop the habitat suitability curves. In many studies, habitat use parameters are developed from best-professional-judgment. The statement concerning incomplete sampling refers to sampling conducted on another river and applied to the study on that river. Habitat availability in that study was measured as it occurred. The data sets used for the Lamprey and Souhegan studies used many additional data sets.

The purpose of habitat weighting is to emphasize flows that provide optimum habitat when it occurs. Otherwise altered flows would result in these habitats being replaced with larger quantities of lower quality habitat.

COMPARISON OF THE LAMPREY AND SOUHEGAN STUDIES

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

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

DES notes that the methods were previously described in the consultants' work plan and in the report on proposed methods for Task 4 (as well as in numerous presentations before, during and after the studies). DES considered that the original reviews and approvals of these methods by the instream flow committees meant that they already were sufficiently documented.

DES recognizes there is a need for better organization of the study reports. This to some degree resulted from the requests to add additional documentation during the review process. Documentation of the results of the study were not considered sufficient by the Technical Review Committee who recommended additional documentation of methods be included resulting in a more complex and larger document. However, more needs to be done.

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.

DES notes that the NH ISF program has only flow management for meeting its goal of biological integrity. The plan therefore is to define protected flows for the natural river conditions for riverine species, flow and river structure, which are the components of biological integrity. Some of the IFC reviewers approved and advocated for the use of naturalized flows and also accepted the Target Fish Community as the expected natural fish species in modeling the protected flow needs. So why not also the river structure? Protected flows defined for the river are thereby appropriate whether or not the existing river modifications are returned to the natural conditions. Defining the protected flows using naturalized river structure does not require the river structure to then be modified (which is outside the program's scope), but ensures that the protected flows would be appropriate in the case that it does.

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?

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?

There are differences due to watershed and treatment of channels.

RECOMMENDATIONS

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?

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, the assessment of a habitat variable with flow, the consideration of hydrology and frequencies of different flows and associated habitat values.

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

DES notes that Water Management Plans will be developed to implement the Protected Instream Flows.

In general, the detailed meso-habitat mapping a 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.

DES notes that the changes in habitat were defined by on-site measurements and stand for themselves. Common Shiner in the Lamprey and Souhegan were strongly associated with riffle run and habitat in contrast to the experience of some of the reviewers who found them near pools in their study locations. Riffle habitat is generally slower water than runs or ruffles because of its turbulence and provides significant cover, whereas run habitats are faster water and provide less cover from predators and from flow. Increases in flow raise the water level and increase the velocity making the riffle habitat change to ruffle (run/riffle) or run habitat. The increase in velocity results from the reduced influence of the river bottom roughness as water level rises.

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.

DES notes we are not trying to address drift rate or food density. Further, the results of the 2003 Lamprey Baseline Fish Community study demonstrably showed common shiners were strongly associated with the riffle habitats. Perhaps this is specific to NH rivers or at least for this river study. Riffle habitats are turbulent and velocities are lower because of this turbulence. Loss of flow dramatically reduces riffle area by dewatering. The mesohabitat approach used data from multiple fish collections to identify the habitat that fish were using and the conditions within those habitats.

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

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.

DES notes that initially natural variability will more strongly influence stream flow than most human modifications. Over time as water use increases, this may change. DES intends to track stream flow variability with the Ecologically Sustainable Water Management method

described by Richter and others, 2003[3] to ensure that short, intermediate and long-term variability trends continue.

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.

DES notes that the MesoHABSIM model is only one of the tools DES used to define the protected flows. MesoHABSIM is indeed focused on describing protections for low to moderate flows. High flow protection requirements required for scour and flooding needs were defined to a certain extent using the Floodplain Transect Methods. DES will incorporate a systematic evaluation specific to geomorphic flow requirements in future studies.

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.

DES notes that long-term monitoring is a desired component of the program, but is currently not in the budget. It should also be noted that flow protection is only one component of biological integrity and that other important components like instream and riparian physical habitat structure, water quality, and sources of energy, may continue to be impaired thereby reducing the improvements derived from flow protection. The flows determined by this study define habitat requirements for a variety of fish, and riparian plants and wildlife based on specific life-cycle requirements without which individual survival and species' reproduction are lost.

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

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.

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.

The Natural Flow Paradigm makes a strong case for natural flows in natural river channels. Most, if not all, instream flow ecologists and river ecologists would not dispute it and would probably acknowledge it as a principle. It is 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. NHDES seems to have interpreted the Natural Flow Paradigm as requiring reconstruction (partial) of the natural channel [of the Lamprey River] 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,

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[3] Ecologically Sustainable Water Management: Managing River Flows For Ecological Integrity, Brian D. Richter, Ruth Mathews, David L. Harrison, and Robert Wigington, *Ecological Applications*, 13(1), 2003, pp. 206–224, Ecological Society of America

DES notes that defining instream flow protection based on existing conditions is arbitrary and contrary to the requirements of the program. It is arbitrary in that the existing conditions represent varying conditions of flow impairment that are changing with time. Defining flow protection based on existing condition would be contrary to New Hampshire instream flow legislation. Legislation requires that the rules "shall complement and reinforce existing state and federal water quality laws" both of which require biological, physical and chemical integrity of surface waters. The primary goal of the program is to first identify the appropriate flows to support biological integrity, defined as the "balanced, integrated, adaptive community of organisms comparable to that of similar natural habitats." This precludes defining protected flows for the existing community or predetermining a future desired condition. Flow protection goals can be curtailed only through a public process.

Too many places where the reports seem 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.

DES notes that the Lamprey report version that was reviewed by IFC was the draft version, whereas the organization of the final version was substantially improved. The Souhegan report began as a much simpler document, but additional information was added at the request of the review committees, increasing both its length and complexity. Nonetheless, DES recognizes that the future of instream flow reports will require both comprehensive documentation and brevity in a scientifically detailed report that is understandable by the layperson.

Good elements include attempting to reconstruct natural hydrology,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!).

Much effort was expended to identify the dominant fish species and their expected proportions [in the Target Fish Community], *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.*

DES notes that the Target Fish Community (TFC) describes the species that should be in the river. Identifying the river-appropriate species is part of defining the river's biological integrity. Knowing the appropriate species is required to identify critical life-cycles and then to describe flow protections for these species' life cycle needs.

Evaluation of differences between the existing and Target Fish Community determines whether the cause of these differences is flow related. If the cause is attributed to pollution-tolerance or a natural lack of suitable habitat and not to flows, then changing the flow regime would not improve the relationship between the existing and target. communities.

For the purpose of protection, which appears to be the objective, the effort to develop TFCs appears superfluous. Perhaps the TFC identifies species that, because they are, or should be, most common, should be the basis for instream flow determination? There is an apparent disconnect between the TFC and MesoHABSIM. However, this apparent disconnect is not a fatal flaw; it is merely superfluous. Are there uncommon fish that are flow-sensitive or flow-limited?

DES notes that the makeup of the fish community identified by the TFC is used as the definition of biological integrity, which is the basis for New Hampshire's instream flow determination. The fish species in the TFC are used in the MesoHABSIM model.

Uncommon fish are included where appropriate as defined by the TFC analysis. In the Souhegan, slimy sculpin and eastern brook trout are rare and were included in the TFC for the upper Souhegan. In the Lamprey, Atlantic salmon are rare and were included in the TFC. Each were included in the MesoHABSIM analysis, because the TFC analysis showed that other similar rivers in good condition have these species and therefore they should be present in the study rivers.

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. 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.

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.

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, then this benefit may be lost.

DES notes that habitat discrimination is accomplished by describing eleven different types of hydromorphological unit (riffle, pool, etc.) or mesohabitats. Each of these hydromorphological units is further qualified by describing the substrate, cover, velocity and depth such that each unit's habitat variability is further subdivided as variations on the mesohabitat type. This scale and approach is supported by other studies done using the MesoHABSIM model.

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).

DES notes channel area, not width, was used in both studies for the purpose of maintaining a constant reference area. In the Souhegan the largest channel area was used and all lower flows normalized to that area. Thus the amount of habitat is measured in relation to a constant channel area. Widths are remeasured at each flow as part of the remapping of each hydromorphological unit at each flow. The suitable habitat area is measured and varies because the width does change with flow.

MesoHABSIM is worth additional evaluation and may prove to be a useful method.

The key question 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).

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.

DES notes that BOTH the mesohabitat type and the habitat parameters (depth, velocity, substrate and cover) are used in the model.

To start with, the concept that area of suitable mesohabitats is related to fish habitat is a reasonable assumption.

Much work was done to develop habitat suitability criteria, but the link to mesohabitats is not crystal clear in these reports.

The use of naturally occurring hydrological extremes (UCUT curves) is a sound approach to assessing what extremes can be tolerated at what frequencies.

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

In the riparian transect sections, better description of the transect selection would better support the method should it be contested.

More directed studies of winter instream flows and ice should be undertaken.

DES notes that it recognizes that this is an under-studied area of riverine biology. Discussions with NH Fish & Game are underway concerning radio tagging fish for tracking winter habitat use, however there is no funding currently allocated to initiate this type of study.

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.

DES notes that this is a good idea and one that will be implemented.

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?

DES notes that Appendix 6 the Lamprey Report shows the regression coefficients of the logistic regression model. The magnitude and sign show the influence of the parameter on describing the habitat suitability. The standard error is also included.

I am somewhat unsettled that the MesoHABSIM approach 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 Souhegan River) 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.

DES notes that it is evaluating management actions for their thermal impacts. However, the relationship between flow and thermal problems is strongly influenced by other factors outside the scope of the Instream Flow Program. The Program's goal then is to maintain flows within the natural variability with the assumption that thermal problems will need to be managed separately.

I would strongly suggest that NH undertake a systematic review of the flow components necessary to sustain various ecological and fisheries functions.... unimpeded access and spawning by Atlantic salmon adults from radio telemetry studies.... kayak navigation.... channel maintenance flows.

DES notes that it has identified the existing flow-dependent protected entities as listed in statute and conducted analyses to define flow protections for all of them. Surveys were conducted of kayakers flow preferences and geomorphological studies are being conducted by DES under other programs. Because this is a management study, there is not the flexibility to conduct multi-year studies for some of the ideas presented.

What flow targets were not met for say a drought year like 1957? What evidence do we have a biological failure?

DES notes that the Natural Flow Paradigm allows for droughts as naturally occurring events. Protected flows are not meant to prevent all stresses on the stream. Species are assumed to

be adapted to naturally occurring frequency and duration of these events. Not meeting protected flows requires multiple years of stresses before a defined non-natural catastrophic event occurs requiring management under the instream flow program. There may have been biological losses during that year of drought, but that is acceptable as a natural event from which species can recover.

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.

DES notes that the differences between and within rivers is the reason the results for one location cannot be used at all locations.

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.

DES notes that the Quinebaug study was conducted for different purposes (stream restoration) than the NH instream flow studies. Relating the Quinebaug studies to these studies seems inappropriate.

II C. Appendix A - Summary of Instream Flow Council Policies

Hal Beecher, the editor of the IFC's review comments, evaluated DES's program to date relative to IFC's policies for instream flow programs. He stated that DES practices are in agreement with most of the IFC policies (21 of 46). In the cover letter Dr. Beecher states, "Note that the [Instream Flow Council] policies were aimed at member agencies, rather than at sister water resource agencies, so there are a number of NA [Not Applicable] entries" (7 of 46). He also pointed out that some policies cover aspects that are not developed at this stage of the program which covered only the NH instream flow studies. For example, implementation of the protected instream flows will be defined under the water management plan and cannot be reviewed yet.

Compiled below are the subset of IFC policies where Dr. Beecher documented details beyond 'Yes' (meets IFC policy) or 'NA to this review'. The listing comprises the policy heading and Hal Beecher's discussion in Arial font and any DES discussion on the topic follows in **bold**. In instances where the policy is included for clarity, it follows the policy heading in [brackets].

3. Public Communication - 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.

DES notes that the original draft of the Souhegan Proposed Protected Instream Flows report was much simpler, but the Souhegan Technical Review Committee requested additional detail be included in the report. DES added these sections and that level of detail subsequently became the template for the Lamprey report. Numerous ublic meetings were held where presentations were made to describe the methods used and the details of the study.

11. Connectivity of Surface and Ground Water (Legal) - The hydrological interconnectivity of surface and groundwater is recognized, but it is not clear that they are connected in law and policy.

DES recognizes the connection between surface and groundwater, but there is no statutory recognition under the act governing Instream Flow Program. There are restrictions under many statutes including RSA 485-C:21 governing the approvals for groundwater withdrawals that recognize the connection. Expanding instream flow to include water withdrawals within 500 feet of a tributary was an effort of the early rulemaking staff. Establishing the appropriate role of groundwater withdrawals within this Instream Flow Program was and continues to be under discussion.

12. Fishery and Wildlife Agency Role - 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 - This may be the case in the water management plans to be developed after the instream flows are adopted.

Water conservation is a component of the Water Management Plans.

14. Water Quality Standards - 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.

19. Reservoir Management - Generally recognized [effects of new and existing dams], 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.

The NH Instream Flow Program supports actions that maintain the natural flows in a river, but does not have jurisdiction over activities like dam removals or river restoration, only over flow management. In the Lamprey report, the discussion of dam lowering is not a proposed plan under the Instream Flow Program, but a description of the Lamprey River conditions that were modeled to define flows under the reference habitat conditions. These reference conditions better fit the conditions that support biological integrity, but neither dam removal nor river restoration are part of the Water Management Plan or the Instream Flow Program.

21. Processes Development – Role of NHFGD in this program appears minimal – some consultation about Atlantic salmon restoration goals, but little else.

In NH protected instream flows go beyond flow needs for fish and wildlife to include public water supplies, hydropower, boating, swimming and waste disposal among other uses. DES, not NH Fish & Game, is the lead agency in the Instream Flow Program in New Hampshire. As a member of both Technical Review Committees, NH Fish & Game has been involved during the entire process on both of the pilot rivers and instrumental on the fish and wildlife aspects.

25. Interdisciplinary Teams - The lack of clear presentation of the logic of the process, with several apparent dead ends, suggests that interdisciplinary coordination is inadequate.

DES recognizes that there is a need for greater coordination of the parts of the assessment and for adequate staff, training, and funding. The final Lamprey Report is a much better representation than the draft report that was reviewed.

28. Flow Variability - 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.

DES applies the Natural Flow Paradigm by recognizing that the natural variability of flows is most suitable to meeting life needs of fish, plants and animals and defining protected flows that are similar to natural conditions in their variability. Further, that the description of flows requires evaluation of timing, magnitude, duration, frequency and rate of change. Protected flows are defined for biologically significant time periods. The flow magnitudes are defined with frequency-

based durations. The durations allow flows to fall below these magnitudes, as they naturally will, so long as the durations and frequency are not excessive (beyond the naturally occurring durations.)

33. Land Use - 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.

Although land use has significant affects on flow, there is no authority in this program to regulate land use.

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 [Target Fish Communities] and [Existing Fish Communities] should provide a valuable starting point, perhaps through a long-term contract with NHFGD.** [Bold by IFC]

DES recognizes the need for both baseline and long-term monitoring to evaluate the effects of the program and is looking for means to conduct that monitoring.

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.

DES intends that the protected instream flows represent the flow protections needed to meet the state's biological integrity goals and so will meet water quality standards. If that does not occur because of flow, then adaptive management will be applied. DES's expectation is that the protected flows and water management plans will meet water quality standards and protect off-stream use as a resource of the rivers.