Appendix 18

Responses to Public Comments

Addendum to
Souhegan River Protected Instream Flow Report

Final Comments

Watershed Management Bureau
NH Department of Environmental Services
PO Box 95 - 29 Hazen Drive
Concord, NH 03302-0095
Telephone 603-271-3548
Fax 603-271-7894
http://www.des.state.nh.us/rivers/instream/

Thomas S. Burack
Commissioner

Michael Walls
Assistant Commissioner

Harry T. Stewart. P. E., Director
Water Division

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This addendum contains DES's responses to the comments and questions concerning the February 5, 2006 Souhegan Protected Instream Flow Report. The February 2007 version of the report was the draft final. DES responses and any changes made to the Report follow each comment.

Background

Comments were solicited following the public hearing presenting the report's findings held March 21, 2007 in Milford, NH. The report describes the methods and results of an assessment of flow needs for the flow-dependent, protected entities listed in statute. A 30-day comment period was completed April 20, 2007. DES received comments on the Souhegan River Protected Instream Flow Report from the US Fish and Wildlife Service (April 13, 2007) and US Environmental Protection Agency (April 20, 2007.)

During early instream flow rulemaking attempts in 2001, the public made clear to DES that standard setting techniques were not acceptable, but rather that site-specific assessments of protected instream flow needs were required. DES developed Instream Flow rules that required site-specific assessments which it is generally accepted as meaning habitat simulation models for evaluating the flow needs for fish.

In March 2004, DES requested proposals for conducting a protected instream flow study and developing a water management plan on the Souhegan Designated River. Five firms submitted proposals describing their intended methods to assess protected instream flow. Each firm was interviewed and scored by members of a selection committee. The selection criteria were 1) specialized experience, 2) project personnel, and 3) project approach. These criteria were weighted respectively as 20, 30 and 50 percent of the overall scores. The selection team scored the selected UNH team and their proposed assessment methods relying largely on the MesoHABSIM analysis as significantly better than the other applicants.

UNH reevaluated the assessment methods described in their proposal following an on-stream survey of river features as part of a required task. This task was to document the features to be protected and identify the assessment methods that UNH proposed to use to determine their flow needs. A draft report was prepared July 2004. The Souhegan Technical Review Committee reviewed and commented on these methods in August. The methods UNH originally proposed methods were retained for the assessments. The final report describing the river features to be protected and assessment methods was issued October 2004.

Flow needs assessments were conducted during 2004 and 2005. Draft reports describing the results of the assessments were reviewed by the Souhegan Technical Review Committee beginning in January 2006. Revisions based on the Committee's comments ultimately result in the February 2007 draft final report containing many clarifications and additional details of processes and methods. The February 2007 version went to the public hearing in March 2007. The public comment period remained open 30 days until April 20, 2007.

This addendum containing the comments and comment responses is an attachment to the final Souhegan Protected Instream Flow report. The revisions resulting from these comments have been incorporated into the final report. DES will submit the revised report to the Commissioner of DES for his decision whether to establish the described flows as water quality standards for the Souhegan Designated River.

Comments
Comments are in italics text: **Responses** are in bold text directly below each comment.

US Fish and Wildlife comments:
"The MesoHABSIM method involves a number of complex procedures, including, but not limited to: the mapping, and collection of physical habitat variables in hydromorphological units (HMUs) at several different flows; development of habitat suitability criteria (HSC) models for selected fish species; identification of target fish communities for the study segments; computation of habitat suitability of each HMU using physical habitat variables obtained in field surveys identified above; and development of habitat rating curves showing the relationship between discharge and habitat. Each of these procedures involves a number of intermediate steps."

This is correct. The listed steps do not differ greatly from other physical habitat models, such as PHABSIM. Both evaluate fish habitat by comparing habitat suitability criteria to river conditions. MesoHABSIM is a modification of PHABSIM, which looks at habitat at the scale of hydromorphologic units (riffles, pools, and runs) instead of cross sections. Hydromorphologic units are more representative of the scale of habitat use by fish than cross-sections. MesoHABSIM is used, like PHABSIM, within the IFIM (Instream Flow Incremental Methodology) framework to identify protected flows. The major differences of the MesoHABSIM model are:

- **for hydraulic models, uses repeated mapping of flow conditions in hydromorphologic units instead of measuring cross sections**
- **application of multivariate habitat suitability criteria is at the scale of hydromorphological units and not at the scale of individual cross section location verticals**
- **includes a much broader range of cover attributes in the habitat suitability criteria**
- **emphasis on analysis of frequency and duration patterns in a habitat time series**

"Due largely to our being unfamiliar with the MesoHABSIM method and perhaps also due to the lack of opportunities to become closely involved with HSC model development and the selection of representative sites, as is normally done with IFIM/PHABSIM studies, we find ourselves in the awkward position of first being able to comment substantively on the study methodology only after the habitat rating curves are produced. By this time, a major segment of the study is largely completed."

DES provided opportunity to evaluate and comment on methods and representative sites beginning in 2004. One of the key milestones before conducting the assessments was a report (Task 4) describing the selection of appropriate methods and selection of representative sites. The report was prepared in the fall of 2004 before field work for the flow assessments began.

The report described the selection of representative sites. The selection of representative sites was preceded by a thorough reconnaissance survey of the entire study area, during which 43 miles of the river were hiked and canoed. During the survey, the proportions of hydromorphologic units were estimated, and stream characteristics and cover parameters were evaluated. The data were summarized in a

spreadsheet for 73 river sections identified on the Designated River. The proportions served as a foundation for the delineation of the river into 11 representative sites using cluster analysis of the data collected during reconnaissance survey. This site selection procedure is more objective and does not require as much involvement of expert opinion as is the case in many PHABSIM studies.

The PHABSIM sites are significantly shorter than those selected for MesoHABSIM due to the intensive effort involved in microscale data collection. Hence, in PHABSIM, the correct location of the sites is crucial for the results. This is not the case in MesoHABSIM first because the selection process is based on a quantitative assessment of the make up of the community of hydromorphologic units derived during the reconnaissance survey. Such rigorous procedures are almost unprecedented in habitat studies commonly used in regulatory processes. Also, the total length of Souhegan representative sites makes up about 25% of the study area, which is much more than in standard applications of PHABSIM.

Similarly, in the development of the habitat suitability criteria, the rigorous statistical procedures allow for less latitude and influence by subjective opinion. The habitat suitability criteria were developed from literature values or from empirical data – both of which are common methods for developing habitat suitability criteria. The habitat suitability criteria from empirical data are developed using multivariate, logistic regression with a log-likelihood ratio calculation of a large population of fish collections. This is a quantitative, standardized process that builds upon a large amount of data. The large data sets result in less need for professional judgment than when creating habitat histograms from a small pool of data. Literature values were used to develop habitat suitability criteria where empirical data were not available.

These data and proposed assessment methods were presented in the draft Task 4 report to the Technical Review Committee (TRC) in July 2004 with request for comments. The final Task 4 report was distributed to the TRC and interested public October 2004. The assessment methods selected and described in the Task 4 report were those that had been originally presented in the proposal from UNH selected by DES. No changes were made from the proposal as the types of features identified in the on-stream survey were consistent with the preliminary lists that DES made to assist the contractors in developing their proposals. The choice to use the MesoHABSIM model was made by the selection committee, agreed on by DES, and confirmed by the TRC reviewing the Task 4 report.

" 1. The fish data used to construct the HSC models used in the Souhegan study were obtained from streams in Connecticut and southern New York. These data were collected using the electrofishing grid sampling technique. As described to us, the sampling approach used for each HMU was to attempt to sample all of the habitat types present. A random sampling approach was not used. However, random sampling was used when deciding which data points from the grids were used as source data for the various fish models and to evaluate transferability of the data from one stream to another."

The last sentence of this statement is incorrect. Each hydromorphological unit is sampled with multiple grids, placed to best represent the hydraulic conditions within.

Fish data from the grids are related to the habitat attributes mapped for each hydromorphological unit. These attributes include at least seven random samples of depth and velocity. All fish data gathered in each hydromorphological unit are used in the development of habitat suitability criteria models, and for the validation of transferability.

" Given the variation in location, size, environmental conditions, and complexity of the various HMUs from which grid sampling data was collected in the manner described and subsequently used for the HSC models, does this result in a bias in the data for particular conditions and/or results? For example, does a bias exist for shallow, slow habitat? If a bias exists in the data, would the logistic regression and relative operating characteristic process identify it or simply incorporate the bias into the fish models?"

Bias related to better fish capture in shallow areas is a permanent issue of electrofishing, regardless of whether the grid technique or another method is used. Because logistic regression analyses measure proportions of occupied and non-occupied habitats, it acts similar to the preference curves used in PHABSIM, and corrects for the limited availability of specific habitats in the samples.

We used data from multiple rivers to better capture the habitat selection by fish without being confined by absence of habitat availability on any one river. Data used to create habitat suitability criteria were selected from rivers of a similar size and category (2nd to 4th order upland streams.) Large numbers of fish collection grids (from 815 to 1504) from a variety of circumstances were used for the development of habitat suitability criteria creating a very robust data set.

"2. As described in Appendix 17, page 727, habitat rating curves are constructed by plotting the area of suitable and optimal habitat against the three measured flows at the time of each HMU survey. Linear interpolation was used to calculate habitat values between 0 and 1 cfsm in 0.125 increments. The habitat rating curves are drawn between these values using a smooth curve.

This is correct.

The estimated flows at Site 3 for the HMU surveys were 0.07, 0.31, and 1.78 cfsm. For Site 4, they were 0.07, 0.24, and 1.84 cfsm. Note the discrepancy in Appendix 17, Table 1 and Figure 3, and Appendix 10 for the Site 3 high flow—is it 1.78 or 2.39 cfsm?"

Thank you for this note. The correct value for site 3 is 1.78 cfsm. The maps in Appendix 10 were created before the concurrent flows modeled for the sites were available to us, and we related our habitat observations to the flows and the USGS gauge in the Merrimack. Unfortunately, in this case the correction of the map legend after the data was available was overlooked. It will be corrected in the report.

The consultants attempted to measure representative sites at the target flows, but stable flows at the target rates were frequently not to be had so measurements were made as close as flow availability allowed.

"3. Since the MesoHABSIM approach does not collect precise hydraulic information along a series of river transects simulation of wetted area, depth, velocity, and other parameters using a hydraulic simulation model is not possible.

It is not possible to use standard mechanistic hydraulic models because the hydraulic data are not collected in a line, but instead are distributed at a number of locations within each hydromorphological unit. However, statistical hydraulic models such as those developed by Lamouroux can be applied using the hydraulic measurements collected this way. We are currently working on adding this option to the model software.

Lamouroux, N., 1998, Depth probability distributions in stream reaches, Journal of Hydraulic Engineering, 124(2), 224-227.

"Given the range of flows for Site 3 above, is interpolation between these data points valid? Is any amount of interpolation valid; if so, what amount and why? Is interpolation of wetted area more valid than interpolation of hydraulic data such as depth or velocity? How was the 0.125 cfsm increment determined to be an acceptable increment for the development of habitat rating curves? Since all of the data points for estimated flows during HMU mapping of Sites 3 and 4 exceed the 0.125 increment by a considerable margin at low flows and by a very wide margin at high flow, is interpolation between 0.07 and 0.31 cfsm or between 0.31 and 1.78 cfsm valid? The endpoint on the habitat rating curve was 1.0 cfsm, whereas the high flow measurements in the HMUs were either above or below this flow. Would these data affect the interpolation process?"

Interpolation between flow measurements is a necessary tool in hydraulic assessments. It is obvious that wetted area changes continuously with change in flow; hence the amount of area between measurements can be interpolated. The hydraulic simulation models, and specifically one-dimensional models such as those applied in PHABSIM, are also based on principles of interpolation. The approach in many recognized studies employs extrapolation based models using measurements of hydraulic conditions at one flow only. Moreover, in PHABSIM, the velocities in cross-section verticals are interpolated from the mean velocity computed for the entire cross section. In MesoHABSIM, three measured flows are always used and more whenever possible. There is no reason to believe that the interpolation across three points for MesoHABSIM would not be valid.

Greater amounts of data create better models. Four flows were planned for the Souhegan study. The late start of the project (caused by delays in contracting) narrowed the window for data collection to late summer 2004 and spring 2005. Because of unusual weather patterns in 2004, the higher flows in the Souhegan River were very unstable. The planned fourth survey had to be cancelled and it became difficult to capture flows closer to our remaining target flows of 0.2 cfsm, 0.5 cfsm, and 1.0 cfsm. The large gap between the second (0.31 cfsm) and third flow (1.78 cfsm) was not intentional, but a limitation imposed by the existing flow conditions. One more survey at the flows between 0.31 and 1 cfsm would be helpful. However, due to the principles of open channel hydraulics, the greatest changes in hydraulic conditions will occur at very low flows as the channel fills with water. At the higher end of flows, the change is

more gradual. Hence, using habitat values derived at a flow of 1.78 cfsm instead 1.0 cfsm has limited effects that are not as critical to the shape of the rating curve as other factors. (In the Quinebaug study, error that stemmed from the use of inaccurate suitability criteria was far greater than errors that could arise from any sort of interpolation between the resulting points.) Even if one or more observations were added between the measured flows resulting in a change that adds a peak or dip to the rating curves, because the protected flows are defined based on the frequency of occurrence of habitat conditions, and because the highest of flows providing this habitat is chosen, it is unlikely to change the protected flow and durations significantly.

This idea was tested using data from the Pomperaug study. To evaluate the validity of using the habitat curves generated with the existing data using the three measured Souhegan flows, the consultants conducted a sensitivity experiment using the data from a project on the Pomperaug River in Connecticut. In this project, five surveys had been measured at target flows of 0.1 cfsm, 0.2 cfsm, 0.5 cfsm, 0.75 cfsm, and 1 cfsm. To simulate flow distributions similar to the Souhegan where three flows were measured, two flow mappings were removed from each site in the Pomperaug data set and UCUT curves were developed for time series analysis. The resulting habitat rating curves, UCUT curves, and flow recommendations were compared with those of original Pomperaug project (Table 1.)

Indeed, at the scale of individual sites, the rating curves become much less variable and rise less steeply (see Figure 1 and 2.) However at the river-scale, while these differences are still visible, they are less pronounced (Figure 3.) This indicates that for modeling at the site-scale, more flows must be measured, but at the river-scale it is not as necessary.

Both data sets were then linked to the flow data and formulated into the UCUT curves for time-series analysis. The UCUT analysis identifies flow magnitudes across the continuum of rare to common flows defined at discrete habitat threshold levels. Each habitat threshold is directly related to a flow magnitude. Analysis of the UCUT curves show the flow frequency and durations associated with these magnitudes. Higher habitat thresholds will be exceeded less frequently, therefore the durations of non-exceedence will be longer.

The UCUT curves generated from the three measured flows and five measured flow habitat curves were very similar. The similar UCUT curves resulted in very similar habitat values identified as rare, critical and common thresholds and finally in very similar flow criteria (Table 2.)

In the test, the only difference in the protected flow magnitudes identified using three of five measured flows (Table 1) is at the common habitat level (0.72 cfsm); which is 0.13 cfsm higher. This difference in protected flow magnitude is offset by the longer durations identified for this flow. Recognizing that for higher habitat thresholds, levels are expected to be unmet for longer durations. This shows that very similar conditions are determined from the time-series analysis, even when using the less detailed habitat curves generated from three flows.

The consultants performed the same test on two other rivers in the Pomperaug watershed – the Nonnewaug and the Weekeepeemee - and obtained even less diverging results. We can safely conclude that the lower density of mapped flows did not have any influence on the flow recommendation. The use of time series analysis is a particular strength of the approach. It is necessary, though, to recognize the three dimensional view (magnitude, duration and frequency) on the flow prescription as it is advanced through this project and the Natural Flow Paradigm.

The interpolation intervals do not determine the shape of the rating curve, and can be freely selected. We use uniform values and increments for the purpose of aggregating the habitat rating curves from multiple sites that could not be mapped at the same target flows. Increments of 0.125 cfsm were chosen to provide 8 intervals between 0 and 1 cfsm. Still, these numbers are fit on a straight line between the habitat points at the measured flows. The use of a different interval would not change the shape of the rating curve significantly.

Table 1: Mapping flows in cfsm on the Pomperaug River. The mappings with flow values in light grey have been removed from the simulated model.

Site 1	Site 2	Site 3	Site 4
0.13	0.12	0.12	0.12
0.16	0.17	0.13	0.19
0.47	0.47	0.55	0.57
0.81	0.87	0.77	0.75
1.16	1.31	1.31	1.41

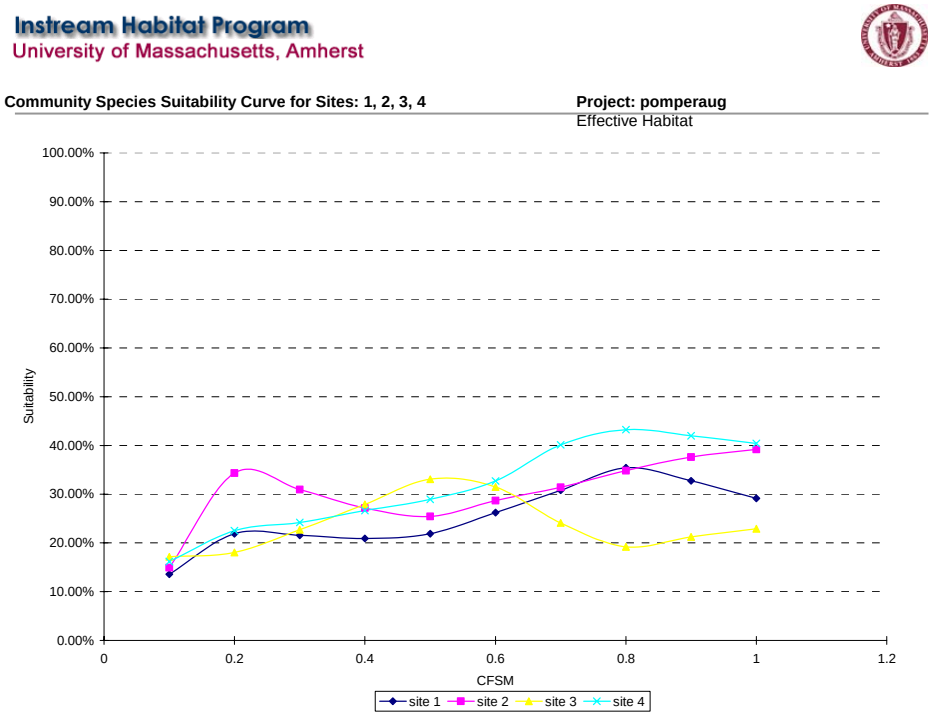

Figure 1: Effective habitat rating curves for sites Pomperaug River project (original)

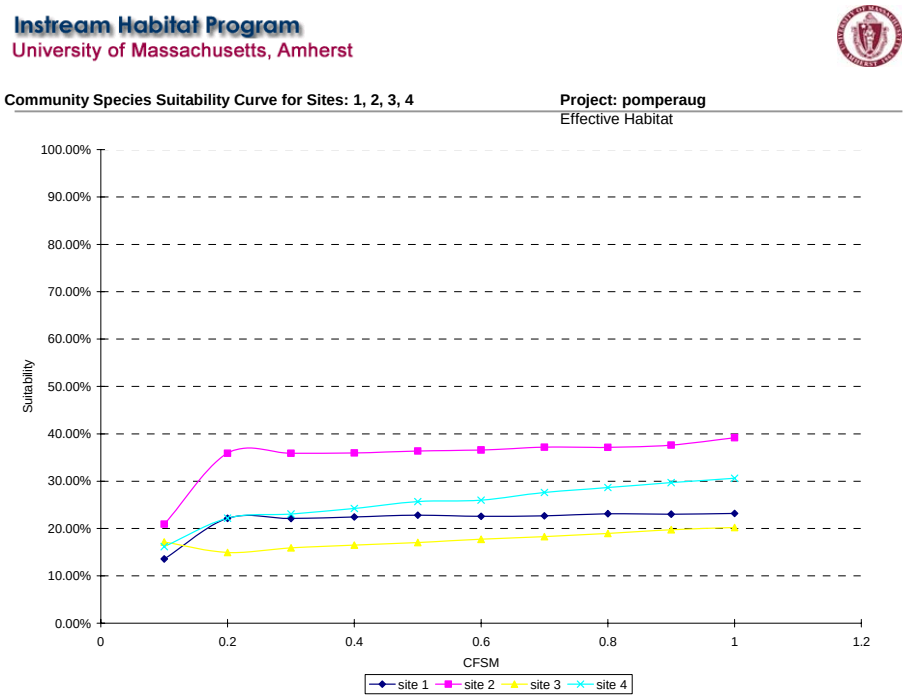

Figure 2: Effective habitat rating curves for sites Pomperaug River project (using 3 mapping flows)

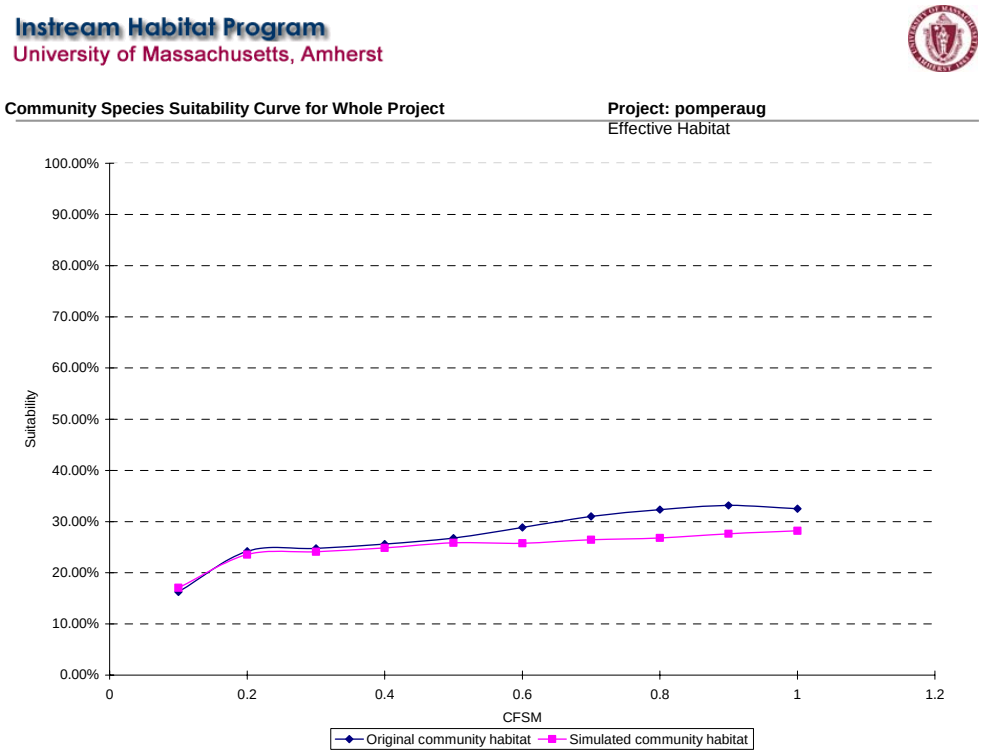

Figure 3: Effective habitat rating curves for entire river Pomperaug River.

Table 1: comparison of flow recommendations for Pomperaug original and with 3 surveys only.

Rearing & Growth July 15 - Sept. 30	Origina	Simulated
Watershed area (mi2)	89	89
Location	Pomperaug	Pomperaug
Common habitat (% Channel Area)	**28%**	**26%**
Persistent duration (days)	27	36
Catastrophic duration (days)	43	58
Corresponding flow restored (cfsm)	0.59	0.72
Critical habitat (% Channel Area)	**16%**	**15%**
Persistent duration (days)	15	15
Catastrophic duration (days)	23	23
Corresponding flow restored (cfsm)	0.12	0.12
Rare habitat (% Channel Area)	**13%**	**12%**
Persistent duration (days)	9	9
Catastrophic duration (days)	12	12
Corresponding flow restored (cfsm)	0.10	0.10

"4. We note an apparent anomalous result on Table 2, page 718 of Appendix 17 in the area column for the 0.5 flow. The area for the 0.2 flow is 12,447; for 0.5, it is 12,259; and for the 1.0 flow, it is 12,618. As we interpret these data, the wetted area decreased between 0.07 and 0.31 cfsm. Are these figures correct? Do other anomalous results exist in these data for other sites? Might these results have an effect on habitat rating curves?"

This observation is correct. Thank you for finding this error. This causes less than a 2% discrepancy in wetted area for this site, and as such, has a minimal influence on the results, and no influence on the conclusions. This is one of two such errors in 32 surveys that mapped 1179 HMUs. At the time of processing data for the Souhegan River, which was over a year ago, MesoHABSIM software was not yet available and our capability of data quality control for such large amounts of data was much more limited than it is now.

"5. Aside from the HSC models and the model verification analysis, what evidence exists that measurements of depth and velocity and estimates of substrate and other physical parameters at seven random locations in each HMU at three different flows combined with criteria from models for selected fish are sufficient to predict the complex physical, chemical, and biological relationships affecting presence and abundance that occur between the top of the water column and the bottom of the stream in each HMU where measurements or estimates were made?

None of the physical habitat models are intended to predict biological and chemical relationships. They merely describe the biological responses to physical patterns. An underlying assumption of habitat models is that habitat availability correlates positively with population and that if natural levels of habitat availability are maintained, the habitat will support the natural community.

(A correction to the above description: only depth, velocity, and substrate are measured at seven random locations.)

What about at a point of 5, 10, or 20 meters distance from these random locations? The data from the seven random points are converted into categories of relative abundance in part to help minimize sampling effort and bias. Given that each of the seven random sampling points is about one meter square in size and that the HMUs vary greatly in size and complexity, is it possible or likely that precision and confidence in the data will vary from one HMU to the next? Does the conversion of point data to categories of relative abundance make a real difference in sampling adequacy?"

We convert these point data to categories, not for reasons of sampling effort reduction, but to reach the resolution consistent with meso-habitat scale (i.e., we measure at microscale at multiple locations to estimate hydraulics at the mesoscale.)

Samples are collected at a minimum of seven locations within each hydromorphological unit. Seven locations are selected at random to describe the hydromorphological unit. The areas of the hydromorphological unit within a range of depth and velocity can be called hydraulic areas. In contrast with other hydraulic models, MesoHABSIM uses the proportion of hydraulic areas as a hydraulic variable. The seven random measurements serve to assess these proportions.

Tests indicate that seven measurements adequately describe conditions within a hydromorphologic unit. The number seven was originally selected based on professional judgment of Dr. Mark Bain and Dr. Piotr Parasiewicz. Since then, statistical tests have confirmed that seven measurements produce distributions that are not significantly different from distributions created with larger numbers of random samples. The statistical tests were applied to data from a study where a large number of depth and velocity measurements had been collected with an Acoustic Doppler Profiler. Repeated application of these tests will be conducted to assure that the conclusion holds under different circumstance.

"6. Given the sampling methods described in the report and above, is it possible that mapped HMUs and mesohabitats contain inclusions of other meso- or microhabitat types within the mapped unit? How variable might these inclusions be, based on a percentage of the area of the mapped unit? Would the number and interspersion of other meso- or microhabitat types within a HMU affect the suitability of the HMU for the various evaluation species?"

Hydromorphological units on the Souhegan were measured to a resolution of approximately five meters square. Each hydromorphological unit is mapped separately so that the mapped area contains only that type. The mapping of a hydromorphological unit at different flows shows changes in its shape, dimensions, and even type. Mapping is sufficiently detailed to show different hydromorphological units on either side of the river and hydromorphological units where an island emerges when flows drop.

Hydromorphologic units naturally will be larger when conditions are more uniform. Larger hydromorphologic units occur in downstream reaches where the river is wider

and conditions are uniform over longer distances then in the smaller, upstream reaches. Consequently, the largest hydromorphologic units were mapped in the Lower Souhegan. The smallest hydromorphological unit measured in the Souhegan study was five square meters. The largest was 10,720 square meters. The mode was 564 square meters.

Regardless of size a hydromorphologic unit represents an area of similar hydraulic conditions. The measurement of multiple hydraulic areas within a hydromorphological unit describes the range of hydraulic conditions within the hydromorphological unit. Measurements of canopy, substrate, and bank characteristics further describe habitat parameters.

We strive to capture the proportions of the hydraulic areas within each hydromorphological unit. It is not our intention to break the mesohabitat into units smaller than hydromorphological unit size. This would be contrary to the concept and intention of MesoHABSIM, which aims to survey the river at a more biologically significant scale than micro-habitat models.

"7. Binary criteria are used in the fish models to predict presence/absence and high/low abundance. These models used the data collected from seven random sites in each HMU at three measured or, in most instances, estimated flows.

The last statement is incorrect. During mapping a minimum of seven locations are measured for depth, velocity, and substrate data within each hydromorphological unit. Seven values are selected at random to represent the hydromorphological unit's conditions. Measurements are taken when flows are near the target flows, but actual stream flows are measured for all instances of mapping. Other parameters affecting habitat in the hydromorphologic unit (woody debris, overhanging canopy, etc.) are described as absent, present, or abundant representing tertiary criteria.

The outcomes for each HMU are limited to unsuitable, suitable, or optimal habitat. In our review of the HMU maps in Appendix 10 and adult suitability maps in Appendix 11A, HMUs are often aggregated to identify one of the suitability categories, but we could find no obvious instance where an HMU at a mapped flow was partitioned into two or more suitability categories. In other words, mapping conventions and the binary criteria seem to force an all or nothing declaration for the HMU as a whole into one of the three suitability categories. Is it possible that some HMUs would have inclusions of two or more of the suitability categories present?

No, all habitat within a hydromorphologic unit is either 'not suitable,' 'suitable,' or 'optimal' at this meso-scale. The partitioning of hydromorphological units into areas of different suitability is against the concept of the meso-habitat model which considers hydromorphological units as the basic scale unit for fish studies. Inclusion of other suitability categories within a hydromorphological unit brings us back to micro-habitat models, and therefore all the limitations associated with such models. Hydromorphological units may expand or contract with flow change, but they are not being aggregated. The hydromorphological unit type may also change when flow changes, but hydromorphological units are neither aggregated nor partitioned.

If so, would this be likely to affect the sensitivity of the procedure to detect and describe the relationships between habitat suitability and streamflow for the various evaluation species?

No. Otherwise we would observe the same phenomenon at the projects on rivers other than Souhegan and we did not. We believe that this lack of sensitivity to flow change is derived from the river conditions on the Souhegan.

Could the probability thresholds for the presence model be adjusted to provide for greater sensitivity to changes in habitat as discharge changes?

No. The probability thresholds cannot be adjusted for the purpose of increasing the sensitivity of rating curves to flows, because it would violate the basic principles of modeling fish behavior to the best possible extent. Thresholds are set at the levels that achieve the best model results.

Is MesoHABSIM simply an overly blunt instrument to provide this level of detail?"

Dr. Parasiewicz argues that MesoHABSIM is a more precise instrument because it takes into account the influence of factors other than depth and velocity on habitat use by fish. Use of multiple parameters in the MesoHABSIM approach is better because depth and velocity only play the greatest role in habitat suitability when the refugia are very limited. Most of the time that is not the case and habitat use is also influenced strongly by other parameters. MesoHABSIM identifies these parameters using the step-wise regression analysis that also develops habitat preferences values (beta values) for each fish species using the hundreds of sampling grids where both fish and habitat parameters have been measured.

It appears that the limited response in habitat rating curves may be a reflection of the Souhegan River riverbed structure, which has been affected by numerous dams. Dams act to reduce high flows: high flows are necessary for moving sediment to reform the river structure. In a relatively well structured river, changes in velocity and depth are compensated for by higher spatial variability. In the case of the Souhegan, low variability of habitat with flow change may be exacerbated by an overwidened riverbed. In overwidened river beds hydraulic change is very gradual causing the flatness of the curves (see Appendix 17 for explanation and numeric justification.) Figure 4 presents the cross section at reach 2 at 0.3 cfsm flow. It is 56 feet wide and the maximum depth is less than 1 foot and all velocities are less than 1 cfs. It is very wide shallow and relatively slow flowing. At low flows an increase in flow has a very subdued influence on depth and velocity resulting in limited habitat response.

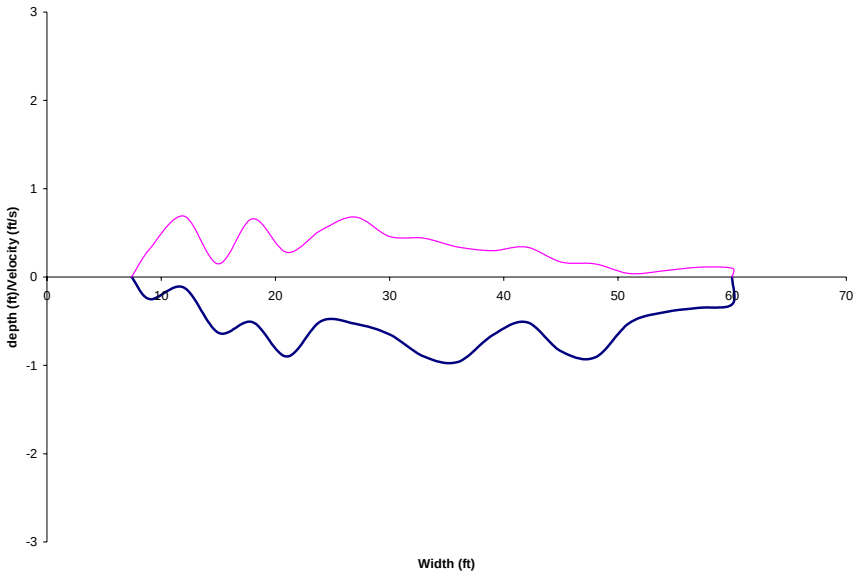

Figure 4. Cross section used for flow measurements at the Site 3. The pink line represents velocities and the blue line the depth.

"8. We have questions concerning the sensitivity of the fish models to detect and describe the relationship between habitat suitability and streamflow due to the use of binary versus sliding scale suitability criteria and the grid sampling technique versus individual fish sampling for the purpose of developing suitability criteria. However, since this MesoHABSIM procedure is constructed with grid sampling data and binary criteria, we have not pursued these subjects further at this time pending resolution of the present set of questions on the other methods used in the study."

The use of tertiary habitat classification schemes, and the use of the grid technique, are two fully independent issues. The grid sampling technique is already used in many studies that have been published and peer-reviewed. It has been recognized by many scientists as a good method for the identification of habitat used by fish. It has also been used successfully in micro-habitat studies, and there is no reason to believe that it has any limitations other than standard electro-shocking techniques.

As for using categorical versus sliding scale suitability criteria, the goal of the tertiary system is to put a stronger emphasis on the availability of high quality habitats. Sliding scale methods have difficulty distinguishing between sites that have large areas of low suitability habitats, and sites that have small areas of habitat with high suitability. For example, 100 square feet of habitat with a suitability of 0.2 will be considered as valuable as a 20 square feet of habitat with a suitability factor 1, both have a WUA of 20 square feet. The tertiary criteria also have great advantages with regard to the interpretation and explanation of modeling results. Use of these criteria can not be a reason for the shape of the curves, because it would have the same effect in studies on other rivers. We recently completed two other studies on the Pomperaug and Eightmile Rivers, and the rating curves were much steeper, suggesting that the problem is specific to the Souhegan River.

"9. Figure 1 in Appendix 14 (Verification of Model Transferability) indicates a greater likelihood of false predictions of no fish being present in areas that the model predicts to be suitable or optimal (left side of graph) than is the case for correctly predicting fish presence in areas where they are present (right side of graph). In addition, the number of grids where fish were present but the model predicted absence was greater than the number of grids where the model predicted suitable habitat and fish were present. These data could be affected by a number of factors as discussed in the report. However, is it equally plausible that transferability of the CT/NY grid data has not been adequately demonstrated despite the analysis in Appendix 14? The authors describe the data as noisy but satisfying, and it is not clear that both data sets shown on Figure 1 were subjected to analysis."

The above interpretation is incorrect. Please see the figure 5 below from Appendix 14 (Figure 1, page 664.) As stated in the main body of the report, we determined that compared to other rivers sampled in the region, fish density is very low in the Souhegan River. This may be due to high summer temperatures. Therefore, we did not catch any fish in a large number of the grids. On the other hand the majority of the sampled habitat was predicted to be suitable. Obviously, many of the areas that were suitable were not occupied by fish just because there are not enough fish in the river. Hence, the number of empty grids predicted to have high habitat suitability can not be compared to the number of suitable grids that had fish.

The only legitimate comparison, then, is within each category of occupation. The grid population was divided between those with fish and those without. Within the population of grids without fish, the number of unsuitable hydromorphologic units is greater than those deemed to be suitable and optimal. Most importantly, the majority of grids occupied by fish are in suitable and optimal habitats. The difference between the non-suitable and the suitable not optimal area is insignificantly low. The statistical tests (Chi-square) confirm high significance of this observation for p=0, i.e. indicating high level of confidence that model predictions correspond with reality. That most of the fish were caught in areas identified as suitable is not disputable.

The term "transferability" does not reflect the modeling process well. The consultant did not develop a model for one particular river and transfer it to another one, but used regional fish data collected on multiple rivers to develop a model for the Souhegan River. Hence, it is not his objective to document transferability, but to verify model predictions.

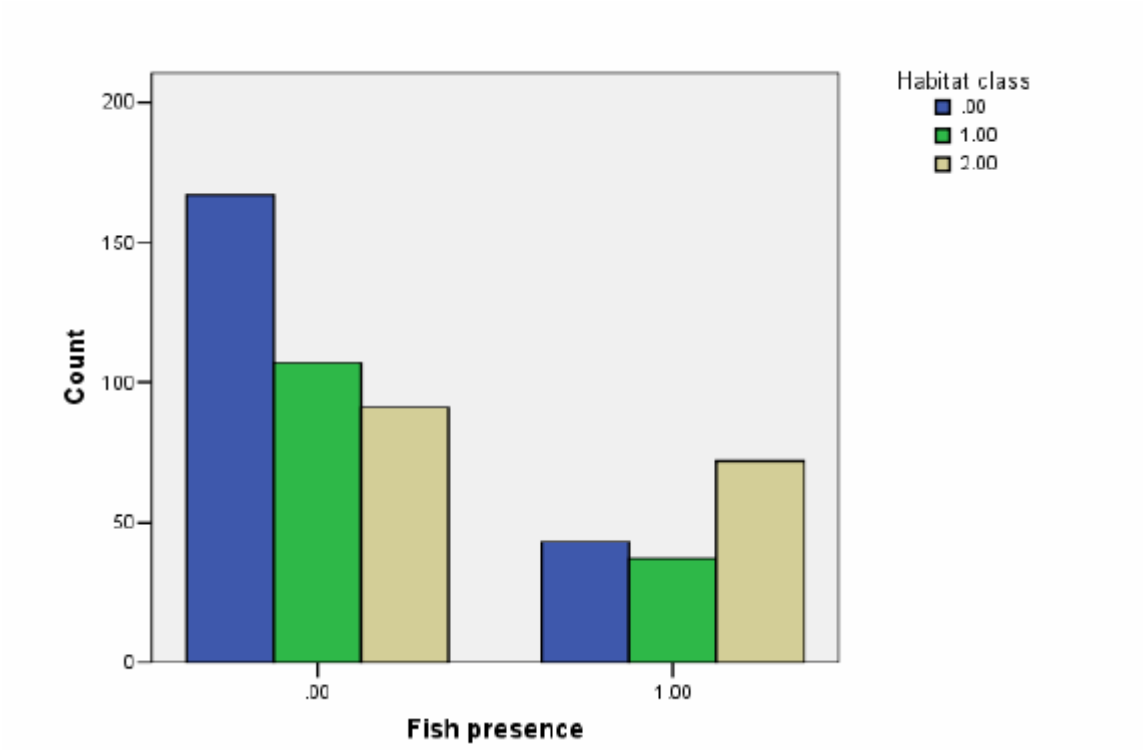

Figure 5: [Appendix 14, Figure 1] Number of grids without fish (0) and with fish (1) and areas of different habitat suitability (0 not suitable, 1 suitable and 2 suitable optimal).

"10. In Appendix 17, page 730, a statement is made that the generic resident fish curve does not indicate sensitivity to flow change and as a consequence, the habitat rating curve for Atlantic salmon was used for time series analysis. As we interpret Figures 13 and 14, longnose dace, common shiner, brook trout, young of year (YOY), and Atlantic salmon show a slight positive response as flow increases from about 0.1 to 0.25 cfsm and then remain stable or show a decrease in available habitat as flow increases. None of these habitat rating curves show sensitivity to flow over the range of flows on these graphs other than as described above. One of the consequences of these results is that the rating curves are of little use for identifying flow regimes that provide optimum habitat for evaluation species. As described in earlier comments in this letter, questions exist regarding the procedures used to extrapolate between the measured or estimated flows during the HMU habitat mapping phase. These questions need to be addressed to determine the validity of the habitat rating curves and whether additional mapping at appropriate intervals of flow would reveal the relationships between habitat and flow over a range of flows for the evaluation species."

(Please see also the discussion in response to question 3.) Rather than using rating curves alone to determine protected habitat levels, the habitat time-series is used for defining important habitat levels. It is a long standing recommendation of the Instream Flow Group in Fort Collins, that IFIM studies should not use habitat rating curves as a final step of the study, but continue with a thorough analysis of habitat time-series. This is a key step to the application of the Natural Flow Paradigm, which is a leading concept of this study. Even the slightest amount of change in the shape of the rating curves will create detectable patterns when combined with the frequency and duration of occurrence under the natural flow regime.

Using habitat time-series means protected flows are not determined by visual observation of the magnitude of habitat increase in response to flow or by the inflection point of the curve. The common, critical and rare habitat thresholds are selected based on the natural frequency of occurrence of habitat conditions shown in the distribution of the UCUT curves. Furthermore, the highest flow levels providing these habitat conditions are chosen.

"11. Simulated hydrologic records and the habitat rating curves were utilized to construct a habitat time series for each site. The uniform continuous under-threshold habitat-duration curve (UCUT curves) procedure described by Capra (1995) was modified for use to interpret the habitat time series data, Appendix 17, page 730. We question to what extent, if at all, the procedure described by Capra is transferable to the Souhegan study. Capra et al. had the benefit of 10 years of population data on brown trout in two different minimally impacted reference streams. While fishing pressure was described as light, predation by other mammals, by birds, reptiles, or by large trout, was not described for the data set. In addition, data on the temperature and ice regime, if any, during the incubation period was not described. The study objective in Capra was to determine if low flow conditions during spawning season were related to recruitment of 0^+ age fish the next year. This is a much more sharply defined study objective than the objective of using a statistical analysis of a simulated habitat time series to identify growth and development bottlenecks in the case of the Souhegan study. The Souhegan MesoHABSIM study does not have any population data on any evaluation species from which a comparable analysis could be conducted for a spawning/recruitment or a growth and development phase. Capra et al. did not demonstrate that the UCUT curve procedure could be applied to other life cycle or bioperiod phases such as growth and development that are more complex to monitor and measure. Experience in this country on the Huron River, Michigan, and Clay Brook, Vermont, indicates that it is very difficult to identify, understand and control or account for the variables that affect fish populations even when we have long-term data available."

The study design described by Capra et al. was not transferred to the Souhegan study. The consultants merely use the accounting procedure for duration/frequency analysis that his study applied. This procedure is used to identify occurrences of habitat events (based on their magnitude, frequency and duration.) We build here upon the recognized concept of bio-physical templates (Poff NL, and Ward JV. 1990, The physical habitat template of lotic systems: recovery in the context of historical pattern of spatio-temporal heterogeneity. *Environmental Management* 14: 629-646), which states that events that are unpredictable (or rare) pose limitations to normal behavior and survival of fauna. We look for most frequent rare events and classify them as thresholds for flow management. Durations are identified for these thresholds that would mimic natural patterns. We do not intend to predict population size for any life stage using this method.

The fact that Capra used CUT* curves for the specific objective of population prediction does not prevent the use of this statistical technique for the purpose of defining habitat patterns. Similarly, flow duration curves were not developed to be applied to habitat but rather to flows; no one questions the use of this technique in habitat time series. The CUT curve technique is based on the so-called negative-run-

time length used in hydrology as presented by Fennessey in 1997 (Fennessey N.M. 1997 An event duration analysis of New Hampshire's proposed Instream flow rules *Journal NEWWA*.)

***Clarification: Capra described Continuous Under Threshold Technique (CUT curves.) MesoHABSIM uses a simple modification of this method called Uniform Continuous Under Threshold (UCUT.) This modification, which is described in Appendix 13 on pages 644-645, enhances our ability to interpret the patterns without modifying any principles.**

Because of the reservations we have over the Souhegan River MesoHABSIM study, we are of the opinion that more testing and critical review of the MesoHABSIM procedure by scientists is warranted before we would recommend its application in a regulatory context such as the instant case. We recognize that it would have been far better to have come to these conclusions three years or more ago, but this is one of the inherent risks associated with the application of new and untested methods.

DES, at the urging of Dr. Parasiewicz and in response to this and earlier comments, plans to add a third-party review to the Instream Flow program to evaluate Protected Instream Flow Studies on the Lamprey and Souhegan including the MesoHABSIM model. DES plans to conduct this review upon completion of the Lamprey Protected Instream Flow Study so that both studies are in it. While this will not be completed prior to using the Souhegan and Lamprey studies to develop Water Management Plans, the decisions has already been made to use the selected assessment methods, including MesoHABSIM, to develop the protected flows.

Two themes on MesoHABSIM modeling are being published in September and November 2007. These will be published as Arena papers by River Research and Application, which is the official journal of The International Society for River Science.

Regarding responses to EPA comments:
Because the EPA letter frequently refers to the US Fish and Wildlife's position and repeats many of the same arguments, DES is addressing only those parts not addressed earlier in the following responses to the comments from US EPA.

US EPA comments:
...assumptions were made in the development of specific fish models. While additional rationale is presented in Appendix 17 for many of the assumptions, it still not clear to us what effect the assumptions have on the rating curves. For example, the literature based spawning model (p.333) is described as being more conservative than the one used on the Quinebaug River because it requires four of seven values, rather than one of seven, to be met for the attribute to be considered as having met the criteria. What is the basis for this choice of four versus one (or two or three)? Is this an approach used in the literature or in other studies?

Response: Literature values are one method used in developing habitat suitability indices where sufficient observational data are not available. The selection of the more conservative criteria is based on sensitivity analysis of the results and our continuous desire to improve the model. If the consultants had used fewer criteria, most of the river would be suitable habitat and the difference in habitat suitability would be attributable more to the increase in wetted area, than to changes in other hydro-morphologic features. Furthermore, literature frequently and specifically defines some attributes (such as gravel substrate for Atlantic salmon) as absolutely necessary, so these attributes are defined as critical for spawning.

The decision on how many criteria make habitat suitable is still a judgment call in this case, but with growing experience and more thorough literature reviews, we believe that the model output is very reasonable and corroborates expectations. There are no examples in the literature of this sort of decision, but from descriptions of spawning habitat found in the literature we are quite confident in our decisions. The approach is similar to the applications in models using fuzzy logic that were applied at the micro-habitat sale. Use of fuzzy logic criteria has been widely published in recent years.

EPA comment:
We also asked that key steps in the multiple regression modeling be illustrated or summarized in a flow chart to help explain which variables entering the model tested as significant or insignificant. To date we have received raw logistic regression run data, but no summary of the modeling as requested.

The teleconference protocol calls for a flow chart that connects the data types and carries them through the assessment process. Such a flow chart has been developed and incorporated in Appendix 17. Components are then described on 711 – 712. MesoHABSIM uses the components shown in the flow chart and generates the results shown using standard processes described in the text. Page 720 – 723 include detailed discussions of the regression modeling of the habitat suitability criteria.

EPA comment: *We believe that it is important to look at whether or not fish are using the habitat that the model predicts they should. However, as Dr. Parasiewicz and other have*

said, there may be other reasons, such as temperature, why fish are not present. As such, the models which rely heavily on the presence of fish may become overly conservative. Previously, we suggested looking as the output expressed in Weighted Usable Area (WUA) or another suitable measure, instead of optimal or suitable habitat. While there are limitations to the WUA approach, it might allow reviewers to understand the effects and/ or biases of the presence/ abundance approach.

Using a different metric would not address the problem of low fish density caused by temperature or other factors. The increase of resolution from tertiary categories to continuous WUA will be more confusing, because the results will show even more scatter due to associated uncertainties. It was for this reason that Thomas and Bovee (1993) suggested using categories similar to the above.

Thomas, J.A., and K.D. Bovee, 1993, Application and testing of a procedure to evaluate transferability of habitat suitability criteria, Regulated Rivers: Research & Management 8: 285-294.

Appendix 17 suggests that geomorphology and water diversion may play a role in the relatively low PISF values in Reaches 1-3. We suggested earlier this year that a discussion of the channel cross section/ shape and its effect on the wetted area would be useful. On April 18, 2007 we received test simulations for Site 3 using revised river habitat components for several species with the purpose of investigating the influence of Souhegan-specific conditions on the habitat versus flow rating curves. We have not had a chance to carefully review this information.

A discussion of the geomorphology at Site 3 is presented above showing how stream conditions are very wide and shallow. Additional flow in these conditions does little to increase habitat. The simulations you received April 18, 2007 tested whether habitat rating curves would be more sensitive to flow if the channel conditions were less wide and shallow. Model parameters were revised minimally to reflect a narrower deeper channel and the model was rerun for several species including one that would be insensitive to flow change as a control. As expected the habitat rating curves for the flow-sensitive species responded more with narrow channel parameters, but the flow-insensitive species stayed the same. This is an indication that rating curves are responding to the river conditions as they exist.

Attachments:

1) US Fish & Wildlife letter dated April 13, 2007
2) US EPA letter dated April 20, 2007
3) Memo on Sensitivity test of habitat rating curves for fluvial specialists, developed for the Souhegan River, Dr. Parasiewicz, April 16, 2007