Ecological Flows Science Advisory Board (EFSAB)
Meeting Summary May 14, 2013
Stan Adams Training Facility, Jordan Lake, Chapel Hill, NC

X Approved June 18, 2013

Attendance

Members
Hugh Barwick, Duke Energy
Mark Cantrell, USFWS
Linda Diebolt, NC League of Municipalities
Chris Goudreau, NC Wildlife Resources Commission
Jeff Hinshaw, North Carolina State University
Amy Pickle, EMC, Duke Nicholas School
Sam Pearsall, Environmental Defense Fund
Judy Ratcliffe, NC Natural Heritage Program
Jaime Robinson, NCAWWA-WEA
Fred Tarver, NC Division of Water Resources

Division of Water Resources
Harold Brady
Tom Fransen
Don Rayno

Alternates
Peter Caldwell, US Forest Service
Ian McMillan, NC Division of Water Resources
Sarah McRae, US Fish & Wildlife
Vann Stancil, NC Wildlife Resources Commission
Tom Thompson, Duke Energy

Guests:
Cindy Carr, NCWRC
Phillip Jones, RTI
Mark McIntire, Duke Energy
Jim Mead, Environmental Defense Fund
Kimberly Meitzen, The Nature Conservancy
Jennifer Phelan, RTI

NCSU Facilitation Team
Mary Lou Addor, Natural Resource Leadership Institute (NRLI)
Christy Perrin, NC State University
Nancy Sharpless (NRLI)

The purpose of the Ecological Flows Science Advisory Board: The Ecological Flows Science Advisory Board (EFSAB) will advise NC Department Environment and Natural Resources (NCDENR) on an approach to characterize the aquatic ecology of different river basins and methods to determine the flows needed to maintain ecological integrity.

Presentations, reports, and background information of the EFSAB are available at: www.nc-water.org/sab
Webinar: If you cannot attend the meeting in person but would like to join us via the webinar, you can watch the presentations and listen to the live streaming audio of the meeting by going to https://denr.ncgovconnect.com/sab/ and typing your name in the space labeled "guest."

NOTE: The EFSAB will meet **June 18, 2013, 9:00am until 4:15pm** at the Stan Adams Training Facility, Jordan Lake Educational State Forest Center Chapel Hill, NC
(see page 64 for meeting agenda topics and directions to location).

May 14, 2013: Summary of Decisions/Recommendations and Proposed Actions

Decisions and Recommendations

1. A subcommittee will draft a preface on May 30 and present the draft to the EFSAB at the June 18 meeting.
2. Table consideration of marine animals on endangered species list in recommendations.

Proposed Actions

1. Subcommittee produce list of species to address and cross-walk those with the guilds already established by the EFSAB, and then address any species or life stages not covered by those guilds.
2. Do not include in the list those species that are not flow dependent or marine species that not an integrated part of NC's fauna.
3. The ES subcommittee will report back in June or July.

Table of Contents

I. Executive Summary

TITLE: Biological-Environmental Classification (BEC) system and supporting flow–biology relationships in North Carolina – Project Update

Presenter: Phillip Jones, RTI
Phillip summarized results from Tom Cuffney's classification approaches using benthic macro invertebrate data, and his own results from classification approaches using fish data. They found that Omernik Level III and EDU were best performing ecoregions for invertebrates and fish.
Conclusions from invertebrate analyses:

- More complicated modeling may be necessary to understand the effects of flow alteration within the context of land-use changes.
- Models are most likely State-wide models incorporating elements of classification as a predictor variable (e.g, ERIII.DA).

    - Rather than using A priori top down partitioning, using ecoregion as a variable in the context of a larger modeling effort
- You tend to see a trade off between number of classes (spatial resolution) and significant biological differences.

Conclusions from fish analyses:

1. Statistical significance of classes frequently based on multivariate spread of biological data
2. Permutations based on EDU or Omernik III represent most promising options for eco-region variables
3. Additional fish metrics may need to be developed
4. Could re-examine most promising eco-regions with data of lower taxonomic resolution
5. Eco-region classifications alone unlikely to contain enough information to characterize variability of stream fish data at desired taxonomic resolution

They suggested some potential next steps:

1. Do a priori classifications improve (reduce variability, improve fit) flow-biology relations relative to analyses of all sites?
2. Do response models (invertebrate response = *f* (Elev + Landuse + Hydro) offer better prediction of biological responses?

Major Discussion items/concerns/questions:

- Using index and using only excellent- fair/good is already going to be capturing tolerance.
- It's important to look at flow differences in communities in drainage areas in NC.
- Tom thinks affect of land use will override flow.

Decisions Made: None

Proposed Actions or Identified Decisions to be made: None:

TITLE: Presentation: Flow Alteration – Biological Response Relationships: Proof of Concept of a Proposed Methodology

Presenter: Jennifer Phelan, RTI

Jennifer presented an update on the RTI internal project that had the objectives to develop and test a space-for-time/cross-sectional analysis approach to determine flow alteration – biological response relationships. She shared results of flow-alteration/biological response curves calculated for riffle-run and pool guilds, in particular for the metrics of eco-deficit and Annual Average Min 90-day flow. They found the riffle run guild is quite responsive to flow alteration. Pool guild is not as responsive to flow alteration as hypothesized.

Potential applications:

- Develop these relationships for each stream class
    - i.e., BEC system

- Adopt these relationships for all "monitorable" streams (i.e., stream classification may not be necessary):
    - Riffle-run guild:
    - Mountains and Piedmont
    - Pool guild:
    - Mountains, Piedmont, and Coastal Plain

Major Discussion items/concerns/questions:

- Regarding reference sites- how do values change when using 70s data rather than PNV? Much discussion occurred about reference sites, pros and cons of the different data.
- How to include nonwadeable streams? A suggestion was made, though while hydrology can be modeled anywhere, the limiting factor is the lack of biology data and difference in sampling methods.
- Much discussion occurred regarding the ecodeficit metric.

Decisions Made: None

Proposed Actions or Identified Decisions to be made: None:

TITLE: Report on Development of Subcommittee on Coastal Plain

Bob Christian

Bob Christian updated the EFSAB on the development of the subcommittee on the Coastal Plain. The Albemarle Pamlico National Estuary Program (APNEP) has identified ecological flows for the coast and for the Albemarle Pamlico sound as one of their priorities for their comprehensive conservation management plan. Water Resources Research Institute for North Carolina have identified ecological flows in the Coastal Plain among their research priorities. APNEP has had only the first staff meeting to discuss the issue, so it is in the nascent phase, but Bob sees them as being an organization that may help extend the work of the EFSAB. Bob had compiled a list of potential members of a coastal ecological flows working group, and about a half dozen people were going to be meeting that Friday in Little Washington. Bob invited EFSAB members to join the group. Bob hopes this group can provide recommendations for better ways to treat the Coastal Plain, other than just literature values, by the July EFSAB meeting.

Major Discussion items/concerns/questions:

- Bob sees opportunities with the Division of Marine Fisheries (DMF) and their information on the various fish species along the coast and flow needs of those fish species.
- He sees classification, hydrologic modeling, and availability of the biological information as the greatest issues/ challenges. He believes there are perhaps some classification schemes to bring in tidal/non-tidal influence of salinity, and there are some models that deal with overbank flow.

TITLE: Report on Work of Endangered Species Subcommittee

Presenter: Chris Goudreau and Judy Ratcliffe

The Endangered Species subcommittee had met once by phone.

Major Discussion items/concerns/questions:

- The subcommittee discussed whether listed species are going to be covered or not in the basin plan models and if so, do things like PHABSIM adequately cover those species, or does the BEC analysis adequately cover those species (things like mussels and fish and plants and other invertebrates).
- For any species not covered by BEC or PHabSIM or whatever approach taken, possibly produce a map that shows where those species occur that DWR could use to assess if endangered species need to be considered in planning future water withdrawals.
- Could have a post-processor for updating the approach as additions or changes are made to the list.

Proposed Actions or Identified Decisions to be made:

- Subcommittee produce list of species to address and cross-walk those with the guilds already established by the EFSAB, and then address any species or life stages not covered by those guilds.
- Do not include in the list those species that are not flow dependent or marine species that not an integrated part of NC's fauna.
- What lists should be used (state, federal, Center for Biological Diversity settlement species)?
- What recommendation will the EFSAB make for the finalized list?
- The ES subcommittee will report back in June or July.

Decisions Made:

- Table consideration of marine animals on endangered species list in recommendations.

TITLE: Presentation and Discussion: Subcommittee's Revision of the Framework of Recommendations

Presenter: Mary Lou Addor

A drafting subcommittee with EFSAB members, Amy Pickle, Chris Goudreau, Fred Tarver, Ian McMillian, Sam Pearsall, and Jim Mead, met May 1 and May 9. They were tasked with reviewing and reorganizing the list of recommendations generated in March (information located on pgs. 11-32 of the March 19,2013 meeting summary). At the April 16 meeting, the EFSAB members, in a review of the March session materials, requested not only a reduction of the 21 page document but also requested that the recommendations were separated from the dialogue and opinions located within the document.

Two resulted as a result of the subcommittee's review, a:

1. One page framework of recommendations - working document- Draft 1
2. Three page document that identified material for explanatory sections (e.g., preface and summary).

Both documents are located as an Appendix at the end of the May meeting summary document.

Major Discussion items/concerns/questions:

- Several editorial comments were received
- Overall, the framework is adequate to move forward to include additional edits and information, however, it does not include new materials or presentations since the April meeting, and thus the language is limiting.
- As a large group rather than a subcommittee, the EFSAB would like to discuss and write future changes to the framework of recommendations.

- The subcommittee was asked to meet again (May 30) and draft the preface section. Anyone from the EFSAB can join the drafting subcommittee.
- If anyone has comments on the two documents, particularly the outlines (items missing, too restrictive,….) please email your comments to Lou (Mary Lou Addor).

Decisions Made:

- The subcommittee was asked to meet again (May 30) and draft the preface section. Anyone from the EFSAB can join the drafting subcommittee.
- If anyone has comments on the two documents, particularly the outlines (items missing, too restrictive,….) please email your comments to Lou (Mary Lou Addor).

Proposed Actions or Identified Decisions to be made: None:

TITLE: Modeling of 80% Flow-by

Presenter: Tom Fransen

Tom modeled 80% flow-by as a demonstration of how DWR would use the EFSAB's recommendations as a post-processor to the model. He emphasized that 80% may not be the final recommendation, but it can be used as a demonstration. He was seeking an approach that would work for a single withdrawal, withdrawals near each other, potentially put up reservoir withdrawals, but what he was really looking at was releases from reservoirs, since you are not looking at the reservoir directly. He wanted to also have the ability to assess a cumulative upstream impact as he moved down. An important question is the baseline, which according to the statute are prevailing ecological conditions. Tom's analysis assumed that SIMBASE represents prevailing ecological conditions. SIMBASE is the model scenario that represents current conditions, withdrawals, discharges, reservoir operations, drought plans, etc. Tom used 80% of SIMBASE on the Broad River Basin, showing results for 3 nodes. He then graphed and showed in tabular form the results, showing SIMBASE, 80% on each day, and a run of projected use in 2060. Any time the 2060 value was below the 80% of SIMBASE indicated a potential adverse effect. For the tabular presentation, he also showed percent difference to get a feel for magnitude. Not surprisingly, the

potential adverse effects were associated with drought periods. Tom asked the following questions:

- If a flow-by approach is used, is the analysis on the right path?
- Is SIMBASE the correct starting point?
- Do all flows need to be ≥ 80% of SIMBASE?
- Are certain times of the year or specific flow ranges of more importance?

Major Discussion items/concerns/questions:

- The introduction of SIMBASE raised much discussion of what should be used to represent "prevailing conditions" and the consequences of using SIMBASE as prevailing conditions:
    - The PHABSIM work we did way back with all those various flow scenarios that were diagrammed for their habitat, the varying percentages of flow-by that were put in there were actually not percentage of flow-by SIMBASE, they were percentage of flow-by unregulated, or unaltered, or whatever you want to call it. So, that was for one purpose, this is a different way to look at it.
    - it will be important to understand what the naturalized flow would look like, as well, because it is that eco deficit piece that you would be illustrating then, the implications of 80% within that, because the difference between that naturalized flow and the SIMBASE, that is going to capture the change in the flow.
    - SIMBASE already reflects cumulative historic impacts.
    - if it is true that the statute requires SIMBASE to be prevailing conditions, then we are not able to change that denominator. We can change the numerator by saying well, 80% is not the right number. I do not think we can say, "Do not use SIMBASE, use natural flow."
    - If you are hanging your hat on 80% because of what PHABSIM said, you would have to re-run all that or somehow factor that amount back into that 80% flow-by instead of making 80%, it has got to be 90% or 84% or whatever, some other way.
        - But that is going to be much more dependent upon the individual reach of the river.
    - We have just been saying option two is so great and one of the reasons—and it is not that it is not, but one of the reasons I liked it, besides it having some mechanistic characteristics, is it was reference based. But the reference conditions were pre-settlement reference conditions which is different than the naturalized flow conditions, which is different than the SIMBASE conditions.
    - That is where the issue is; where is our baseline starting and the impacts, and we can partition where those impacts are coming, to the habitats, to the ecology. We can partition that out and demonstrate that it is what has already occurred in some basins, in others we may not be in that vulnerable stage yet.
    - This flow-by approach using SIMBASE lets me look at that cumulative impact as I go downstream. As I go downstream, I may have withdrawals. I may have some new discharges. I can see that cumulative impact as I go down. Lets me look at that

cumulative impact as I go downstream because you do not always know what is going on. As I go downstream, I may have withdrawals. I may have some new discharges. So I can kind of see that cumulative impact as I go down. I could actually come back and tell you, all things being held constant, how much more you could take out of it. With some of these other techniques, because of the wide range of statistics in them, I would have to do a trial and error method and I can probably back calculate this one directly.

- The engineer in me says by working this approach, I could actually come back and tell you all things being held constant, how much more you could take out of it. With some of these other techniques, because of the wide range of statistics in them, I would have to do a trial and error method and I can probably back calculate this one directly.

Proposed Actions or Identified Decisions to be made:

- So you have tripped it, but then the real questions are how many days or how many consecutive days or some other measure is really a problem?
- How to get understanding of how the biological effect of 80% flow-by using SIMBASE compares with the biological effect of 80% flow-by using unaltered.

Decisions Made:

- Tom will talk to his modelers about running a comparison of the flows produced by 80% of SIMBASE compared to 80% of unaltered.

TITLE: Options for RTI/USGS Work

Presenter: Jennifer Phelan

Jen came back and proposed two options for directions the EFSAB would like to see RTI take moving forward:

Option 1

a. A priori classifications and development/improvement of flow-biology relationships by a priori classifications: Omernik Level III or EDU
b. Determination of multi-factorial predictive model describing biological response location by location (not a stream classification)

Option 2

a. State level flow biology curves for fish and benthos
b. Biological condition thresholds and flow alteration
c. River classification based on degree of flow alteration
d. Recommendations of flows or process for ecological flow determination by stream class.

[Note: at the end of the meeting Ad Hoc Water Coordination Committee stated that they would use both option 1 and 2 in moving forward with an emphasis on 1b.]

Major Discussion items/concerns/questions:

- No one knows how these will turn out.

- Under option 1, if you reverse the order of those two steps, and go directly to a multifactorial predictive model of biological responses, location by location, level III and EDU values could be tested as useful but not exclusive variables in that location by location stuff. In other words, you could go directly to step B using the two a priori classifications as variables.
- RTI has run 2 guilds; there is not sufficient data for most of the other guilds. There was some discussion of using the most sensitive or of combining guilds.
- You are still limited to just wadeable streams.
- One of the appealing aspects of eco deficit is that it covers the full range of the flow duration curve, but using the deficit approach, which is just change in flow duration, it does not take into account whether that change is continuous days or scattered days, which something like that is very important to water users. Whether they come out the same or not, using those consecutive days of low flow can be important for a water user in their plan and in terms of setting a threshold, perhaps. But all that being said, when you look at the table that you initially came up with in your proof of concept, to me it did not make a huge amount of difference which metric you picked, it was roughly the same percentage of change in that metric to get roughly the same degree of biological alteration for the riffle run guild, which is the most sensitive guild.
- Do we need to validate the biological difference between points? I mean, that is "real data", using space for time.

Proposed Actions or Identified Decisions to be made:

- For option 2, decide what threshold values for reduction in biological condition and the associated changes flow alteration. Are the 10, 20, and 30% values demonstrated valid? How would you decide that and validate that?
- How would you propose ecological flows for each of those classes, and do you want to further divide? A suggestion was made that the EFSAB not make recommendations to DENR about what is acceptable, instead making recommendations to DENR that say something along the lines of, if you increase the eco deficit by less than such a percentage for these streams, this is the biological response you can expect. And it is up to DENR to decide what to do with that information.
- Something the SAB could do is come up with a recommendation for a proposed way forward to either further refine or test, validate some of these responses based upon measurements, a very, very well thought out, well planned schedule of proposed measurements

Revisiting the RTI/USGS Options

Presented by Sam Pearsall and Jennifer Phelan

Sam and Jennifer had had an opportunity to discuss the options further.

Proposed Actions or Identified Decisions to be made:

- RTI/USGS will run Option 1 and Option 2 presented, emphasizing b under option 1.
- They will not run option 2 immediately.

- Jennifer will develop questions to answer regarding option 2, and the EFSAB will supply to Jen a list of questions to resolve as a group before proceeding with option 2.
    - For example, do we agree that the riffle run guild is the most sensitive guild and, therefore, can be the arbiter for all guilds. Do we agree that eco deficits should be measured on mean annual flow, or should it be measured against some other variable, such as low season average flow or something like that?
- Do we need to make a decision on what the flow base will be?
- We may need to acknowledge that with prevailing conditions as the baseline, some stream reaches may be already over allocated, and the biota could already be suffering and ecological integrity threatened by those withdrawals.

Decisions Made:

- The facilitators will send out Jennifer's and Sam's proposal and a set of questions that Jennifer thinks need to be addressed about option 2 so that EFSAB members can start thinking about questions they think need to be answered about it. (editor's note- the ad hoc water coordination committee chose to proceed in a different manner, so this email was not sent)

II. May 14, 2013 - Meeting Orientation and April 16, 2013 - Meeting Summary Approval

Members and alternates of the Ecological Board Science Advisory Board introduced themselves and their affiliations. Guests in attendance and the facilitation team also introduced themselves. Everyone was reminded to sign-in who attended the meeting.

A brief orientation was conducted of the meeting facilities (restrooms, concession) and available technology (webinar). Members and alternates are encouraged to sit at the main meeting table and guests at tables away from the main meeting spaces. During discussions of the members and alternates, guests may comment once members and alternates have completed their comments and questions. During small group work, guests can also participate in small group discussions but may not dominate the time. Everyone is asked to ensure that space is created for others to engage. From time to time, the facilitators will conduct a straw poll to determine the current level of support for an idea or what additional information is needed, not necessarily for a final decision.

The EFSAB approved the April 16, 2013 meeting summary with a change requested to the Executive Summary of the SARP presentation.

III. Biological-Environmental Classification (BEC) system and supporting flow–biology relationships in North Carolina – Project Update

Presenter: Phillip Jones, RTI

(Note: this presentation is posted the ncwater.org website.)

Phillip presented the fish work and Tom's macrobenthic work.

Reminder, we looked at Priori classifications and subdivided as function of drainage area, and then looked at mapping those to biological attributes for benthos and fish community data.

- Omernik Level III Ecoregions (ERIII)
- Omernik Level IV Ecoregions (ERIV)
- Ecological Drainage Units (EDU)
- Classifications subdivided by drainage basin size (DA):
    - Headwater (hd): < 100 km2
    - Creek & small rivers (sm):100 >= X <518 km2
    - Medium rivers (md): >= 518 X < 2,590 km2
    - Mainstem rivers (lg): >= 2,590 >= X < 10,000 km2
    - Large rivers (vl): >=10,000 km2

Slide 4 shows the drainage area cutoff and number of basins with fish and invertebrate sampling sites. In practice, you may have level III, headwater, etc. A note, we wanted to remind people that sampling locations are heavily skewed towards small streams- most are headwaters, creeks, small rivers. The Benthos were a little more spread out, but mostly looking at headwaters and small rivers.

Q: What was basis for choosing basin size categories?
R: From Mary Davis' recommendations based on previous flow biology work.

This is Tom's work looking at invertebrates:
Examination of a priori classifications to understand invertebrate distributions and flow relations. Just as a reminder, slide 6 shows distribution of sampling sites, with Level III ecoregions shown.

To evaluate classifications, Tom looked at a couple different types of analyses:

- Indicator species: are there taxa that differentiate among classes (indicator species analysis, Dufrêne and Legendre, 1997)? Meaning Are there taxa you find in one ecoregion and not another?
- Invertebrate metrics: can invertebrate metrics differentiate among classes (CART analysis)?
    - Example metrics- % EPT, $ tolerant, may be broken down by functional groups like shredders, high flow taxa
- Hydrologic variables: can PNV hydrologic metrics differentiate among classes (CART analysis)?
    - PNV is potential natural vegetation (pre-settlement vegetation).

DATA used:

- Sites with Excellent, Good, or Good-Fair conditions: dropped down to 1,097 sites
    - Indicator species analysis
    - Invertebrate metrics in CART analysis
- All sites with PNV hydrologic information: 1,734 sites.
- Invertebrate metrics (168- some listed here):
    - Richness, % richness, abundance, % abundance
    - Tolerance metrics
    - Functional group metrics
    - Flow preference (fast/slow) metrics (Vieira et al. 2006)

Indicator Species Analysis- identifies taxa that have a high affinity for a class based on occurrence and abundance. If you have a species that occurs frequently in one class and no other classes, will have a high indicator score. Rare species occurs in multiple classes, and will have a low indicator score.

Tom looked at basically for all analyses, how many indicator species showed up as statistically significant in each of ecoregions. Here's an example - Mayflies in green, shows how many taxa came up as statistically significant in each of the 3 eco region III classes. Example- in the Blue ridge, of 151 total, 38 were statistical significant as indicator species. If you have a lot of taxa show up at one site and none came up as stat significant, the ecoregion was not good job of partitioning

	Blue Ridge	Piedmont	SE Plains	Coastal Plain
Mayflies	38	8	4	4
All taxa	151	40	60	96

Q: That's significant among sites, 38 that separate Blue Ridge form other regions?
R: Yes, they will occur mainly in Blue Ridge, and in significant abundance

Q: Coastal plain question-Is SE plain the inner coastal plain?
R: Inner. Mid Atlantic coastal plain is the outer coastal plain.

NO. TAXA ASSOCIATED WITH EDU CLASSES

Here is a similar table for other ecoregions. This is one for EDU class. Mayflies picked because they are the "E" in the EPT, one of the classic metrics for relatively low tolerance species. You get representation of one or more species in each of the EDU classes, a little lower than Omernik III.

	Albemarle/Pamlico		Cape Fear			Pee Dee
	Coastal Plain	Piedmont/ Fall Zone	Coastal Plain	Piedmont	New River	Coastal Plain
Mayflies	2	0	1	3	16	4
All	28	16	8	18	41	27

	Tennessee R Blue Ridge	Upper Pee Dee River	Upper Roanoke	Upper Santee	Upper Savannah
Mayflies	3	1	3	4	16
All	20	3	13	8	72

Based on the Indicator Values Benthic work- conclusions:

- Level III Ecoregions: suitable
- Level IV Ecoregions: unsuitable
- EDU: suitable
- Level III + Stream Size: unsuitable
- Level IV + Stream Size: unsuitable
- EUD + Stream Size: unsuitable

Level III and EDU have fairly good representation; the others have some zero values meaning no indicator species were found. They are not doing a good job of portioning species.

Q: Any effort to look at stream size?
R: In previous meeting we talked about it, will talk later. I think he's using drainage size but you'd have to ask him.

Invertebrate Metric CART analysis (next type of analysis used)- using it to see if invertebrate metrics, like % EPT, can predict levels of various ecoregion classes. Why? Rather than using multivariate analysis, you need one variable. Metrics are one way to condense the data.

Slide 14 shows example of what model looks like- it's basically a decision tree.

Example table- similar to other table, number of classes detected with CART. When you get these trees, they will go all the way to the bottom so every observation is its own class, and you have a massive chart. There are pruning methods to cut off bottom part based on statistical thresholds. What he wanted to find out was whether CART models recreated number of classes found in the original ecoregions. If the ecoregion had 4 classes, did the CART method come up with 4 classes?

NO. CLASSES DETECTED WITH CART

	Classifications			Drainage area classes (hd, sm, md, lg, vl)		
	Level III	Level IV	EDU	Level III	Level IV	EDU
No. classes	4	24	11	18	74	43
No. classes in CART model	4	7	8	7	8	5

You can see the 2 that were recreated using invertebrate metrics were Level III and EDU; that tells you that using metrics are good enough to characterize all the classes in the ecoregions. Level IV and Level II with drainage included, they are not sufficient for characterizing the classes in that ecoregion.

Omernik Level III and EDU were best performing ecoregions for invertebrates and fish.

Another analysis: PNV Flow Characteristics and CART Analysis: Can CART analysis of the flow

characteristics predict the various ecoregions. For each of the sample sites, gather the flow characteristics for that site. Can flow characteristics predict which class the sample site will be in? These will be monthly flows, median flows by months, etc. Similar table.

Results- In general Level III and EDU have better representations. This indicates, looking at flow metrics, the ecoregions that were characterized best by PNV flow metrics, Level III, EDU, and Level III with drainage area.

Conclusions:

- More complicated modeling may be necessary to understand the effects of flow alteration within the context of land-use changes.
- Models are most likely State-wide models incorporating elements of classification as a predictor variable (e.g, ERIII.DA).
    - Rather than using A priori top down partitioning, using ecoregion as a variable in the context of a larger modeling effort
- You tend to see a trade off between number of classes (spatial resolution) and significant biological differences.

So I think one reason you tend to see good results with Omernik III is there are only 4 classes, so you would expect biological differences between coastal plain, piedmont, etc.

You know you have differences within those though, so 4 classes will be inadequate. As you get into more classes you get into more difficulties characterizing based on the bio data we have, which is consistent with the fish analysis. It is a trade off.

Classification based on Fish Data- Finding predictive relationships between a priori classifications or biological metrics and stream fish community data

I did methodology comparable to Tom's but a little different. As reminder, here is a map of fish sampling sites (slide 21), general piedmont and mountain are represented well but the coastal plain less so. Almost all are small creeks, headwaters, wadeable streams.

Methodology

1. Determine which classification systems (a priori, species-based, etc.) explain the most variability in stream fish community composition.
2. Examine systems identified in Step 1 to determine whether differences in cluster assignment are due to fundamental biological characteristics (and not because you just happen to have a few more species show up at a site).
3. Using iterative 80/20 training/test random samples, fit models and predict unused observations to evaluate predictive power of classification systems (this is the difference from Tom's method
    - Used TREE models, but also used the 80/20 test, gives a sense of how well does this model actually predict the data, using data that wasn't used to build the model, which is important.

Can fish data predict any of the chosen a priori classification regions?

For each of the class regions, I had the assignment (level III piedmont) and all of the sample sites in those regions, can the biology predict where it would be.

INDICATOR SPECIES ANALYSIS

Classification System	No. of significant indicator species	No. of levels represented	% of levels represented
EDU	92	11/11	100
EDU DA	24	8/43	19
Omernick III	114	4/4	100
Omernick III DA	13	7/18	39
Omernick IV	16	8/24	33
Omernick IV DA	28	6/74	8

Bottom line: for EDU and Omernick III, all eco-region levels represented by significant indicator species

EDU is moderately to substantially predictive of the fish data. (ecological drainage unit) followed by EDU with drainage area, only one I consider decent is EDU with this process. The one where you're seeing significant differences in species composition of fish across classes is EDU.

I did an Indicator Species analysis- results different, similar process. Listed raw number of significant indicator species found, within each ecoregion, the number of levels represented by indicator species. EDU has 11 subdivisions, all 11 had representation by indicator species. Compared to other ecoregions, EDU and Omernik III does better job of partitioning out the biology so you can find the indicator species within the levels of the ecoregion. Indicator Species analysis with scores- the higher the score the more significant it is. I'm happy to email results to anyone who wants to take a closer look, you get a list of species by levels within particular ecoregion- higher the more likely fish has fidelity to that level in adequate abundances.

Q: Glancing through species list, including in the indicator species are there any endemic to only one region? Like New River. Seems like you wouldn't include those specific to one single drainage, since there is no power in finding it, you won't find it anywhere else.

C: American eel is predictive of Albemarle Pamlico, its predictive of undammed region.

C: It's predictive of the sampling set. It's not an easy thing to sample.

R: It's always good, you're not going to be analyzing the reality of the stream, but the data that was collected. Good to check the SOP for the data collection process. This is saying, based on most recent sampling site for this sampling program, based on that data set, these are the species that show up having the highest fidelity for these ecoregions. It's definitely a snapshot.

Q: Those are all the ecoregions?
R: This one is for EDU, there were 11, I chopped one or two off. Those areas with highest indicator

value, like New River, Upper Pee Dee,. Coastal plain, indicator species values may be lower, based on what you would expect.

Q: This is independent of whether there is hydro model with points associated with these samples? Coastal plain, hydrologic models don't take us as far you would find eel.
R: Depends on model. When Tom was looking at PNV, he had some drop down because they were in region of tidal influence. I didn't separate out by tidal, good point.

I then looked at ecoregions with fish metrics. Caveat, Tom has program that spits out 168 invertebrate metrics, I don't have that. Also, in my experience, invertebrate people love metrics, fish people not as much. I used basic ones. There are not as many available for fish. IF there's interest in pursuing this I could create more. Bottom line is no. I used common metrics, Shannon Weaver index, relative abundance a few others.

Fish conclusions

1. Statistical significance of classes frequently based on multivariate spread of biological data
    - May not be difference of average distance, but the spread of each of those clusters. Programs typically looking at where differences are, problem with looking at the spread is it may be related to sampling
2. Permutations based on EDU or Omernik III represent most promising options for eco-region variables
    - One thing you can do with #1, you can identify out of the 11 EDU classes, these have distinct centers, these don't. Does it make sense to put these without distinct centers together (ask fish biologist)
3. Additional fish metrics may need to be developed
4. Could re-examine most promising eco-regions with data of lower taxonomic resolution
    - Right now tom is using Genus for inverts. I was using species level. I could always repeat some of the analyses using genus, lose taxonomic resolution but may get better break out in differences.
5. Eco-region classifications alone unlikely to contain enough information to characterize variability of stream fish data at desired taxonomic resolution
    - just applying a top down approach probably is not going to give you good enough resolution.

Next steps

Best options if you want to move forward with this. When you start to incorporate ecoregion plus some other variables like land use.

1. Do a priori classifications improve (reduce variability, improve fit) flow-biology relations relative to analyses of all sites?

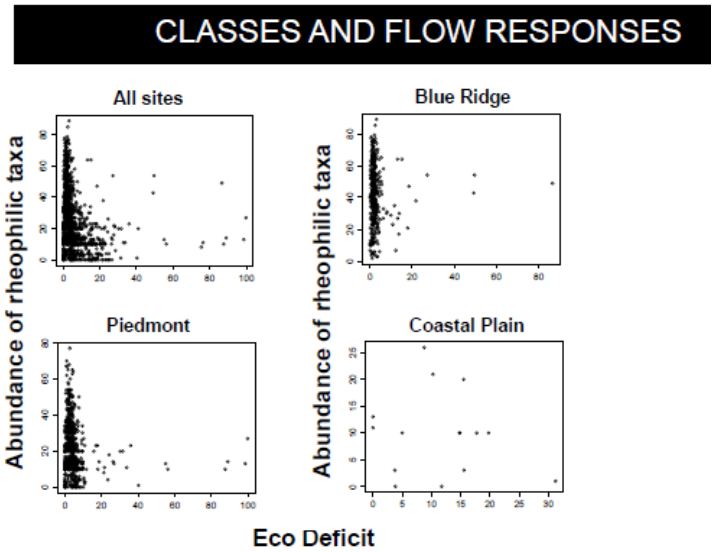
2. Do statewide response models (inverse response = (Elev + Landuse + Hydro) offer better prediction of biological responses?

Example slide- classes and flow responses- what we have is showing the abundance of rheophilic taxa (flow loving). In upper left, all data together that's what you see. What we suggest is to see if you see better relationships if data is partitioned out by ecoregion. If you look at Eco-deficit (x access on this slide).

Option 1.

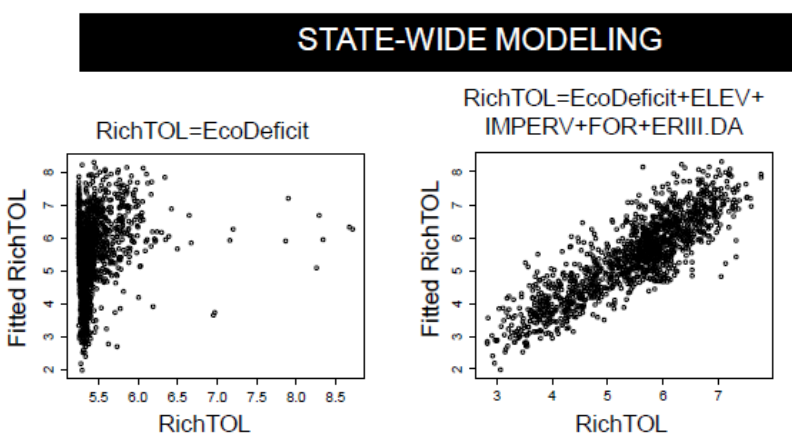
Potential outcomes of this "option 1" classes and flow responses:

1. Eco-region class used to improve fit of flow-biology model.
2. Classification used as grouping variable.
3. For a given biological response, magnitude of flow relationship may vary by class.
4. For a given biological response, important flow variable may vary by class.
5. To use: for a new site, identify eco-region, need biological response, and important hydrologic variable. Use fitted curve for those 2 things to identify thresholds that is acceptable. Confidence interval depends on modeling method.



Option 2.

An example of statewide modeling, where ecoregion used as predictor variable as well as other variables. This is species richness for tolerant taxa. He found when you compare the 2 you get value on left. By just ecoregion for ecodeficit, messy, when you add drainage area, other continuous variables, you get a better fit. Nice fit here.



$$RichTol = \frac{\sum_{i=1}^{n} TV_i}{n}$$ where: TV_i = tolerance value of taxon i, n = number of taxa

Potential outcomes of statewide modeling

1. Eco-region one of many predictor variables.
2. To predict how hydrologic change will influence biology at new site, need to have information for each variable in model (for a map-able system that drives variables selected such as elevation, eco-region class, land use, etc.)
3. To use: holding all else constant, how do changes in flow variable(s) impact biological response; confidence interval easy to calculate.

Caveat #2. You don't want to choose a predictor variable only available in one regions.

Questions (Q), Comments (C), Response (R):
Q: On previous slide- he changed x access on there. What happens if you present them without changing the scale.
R: Left is scatter plot with fitted model, tolerance and ecodeficit, plot fitted verses observed. The reason axis has changed, he may have limited it by one of the ecoregions.

C: Would be good to see it presented the same scale.
R: Typically scale is function of what variables you have in it. Good question to ask Tom.

Back to outcomes slide…so really the issues are making sure you have predictive variables available for all sites, this is dependent on using a model that can create hydrologic variables for sites without gages.

Q: is that something that can be done with fishes?
R: Yes. I looked at fish metrics some, there are quite a few. Could do it by guilds, functional groups, flow preferences, abundance, richness, IBI.

Next steps: which should be done?

3. Do a priori classifications improve (reduce variability, improve fit) flow-biology relations relative to analyses of all sites?
4. Do response models (invertebrate response = *f* (Elev + Landuse + Hydro) offer better prediction of biological responses?

Q: Using index and using only excellent- fair/good. That's already going to be capturing tolerance. Intolerant species will be higher. There are sites, flow related, in piedmont that will be naturally low O2, more naturally populated with more tolerant species that will be rated low. We're pushing out naturally low flow systems.
R: good point. Reason Tom had filtered was to try to reduce noise and find sites less disturbed.

C: may be better to use overlay like land use.
R: Good point. Reason we thought of these different responses, it's easy to imagine 2 sample sites in same stream, if one is forest and one is agriculture, you would likely get different species even if same drainage area and ecoregion. If you look at mountains and look at spread of classes, you can have classes that are elevations that are headwaters that are 3000 ft, or 1400 ft. may be in same ecoregion level but differences. That's our thinking for adding elevation, land use that does a better job to explain variability. I'm make sure to bring this up to Tom. Would be good if there were a map to identify areas where those areas likely to occur.

C: Ph may separate out the more acidic streams. You won't have shiners in the low ph, black water streams.

C: Even in piedmont there are low gradient sections in Little River, if sampled would probably be high % tolerant but is in relatively pristine condition. DWQ habitat ratings could maybe be matched up to the site.

R: there may be some alternative ways to filter out sites. Didn't do it for fish but maybe down the road could do it.

Q: About role that area is playing in stream size and how being used. As a simple factor of drainage area?
R: based on NHD+ catchment, high resolution hydrologic map. Used it 2 fold- to calculate drainage area upstream of site, then class them according to threshold shown earlier, either use as variable itself. But Tom used drainage area with Omernik level III, (ex O level III mountain headwater)

C: Raw drainage area will compound your flow considerable as you do east/west north south. I particular meteorology will confound it, geology will play a bigger role as you go across a drainage basin. Its an easy line to draw on a map with rainfall, average rainfall, or average rainfall runoff per square mile or unit of drainage area. It's important to look at flow differences in communities in drainage areas in NC.
R: We do have a couple sources for rainfall data we didn't use it for this analysis. Previously we looked at range of different variables like slope, elevation, average precipitation and other variables to see if it does a better job. In general it didn't do a better job. Tom meant this to be a quick example of what it would look like, hasn't been optimized using all the variables. It could be Ecoregion subdivided by precipitation class could be something we'll try.

C: Tom thinks affect of land use will override flow anyways. He started to add in other factors that improved the fit. Land use was driving it. Everything was good in III, then as he added in the other variables the land use was the overriding factor. He'll continue to look at that.

C: water quality as an important factor, duration…
R: Talking about state wide modeling, fitting variables within separate ecoregions or within 2 ecoregions together and based on whether it improves fit. Techniques can customize coefficients…a couple different ways to go with this.

Q: ecological drainage areas- doesn't it capture some precipitation?
R: A lot of these are proxy variables when you don't have a measure of what you'd like. So in the modeling context, need to be careful to not have highly correlated variables. Elevation is often a proxy for climate. Depending on where you are, elevation and temp could be highly correlated. Don't want to double dip or have same info in model twice, it makes model look better than it is.

Facilitator: reactions regarding implications? None.

IV. Presentation: Flow Alteration – Biological Response Relationships: Proof of Concept of a Proposed Methodology

Presenter: Jennifer Phelan, RTI

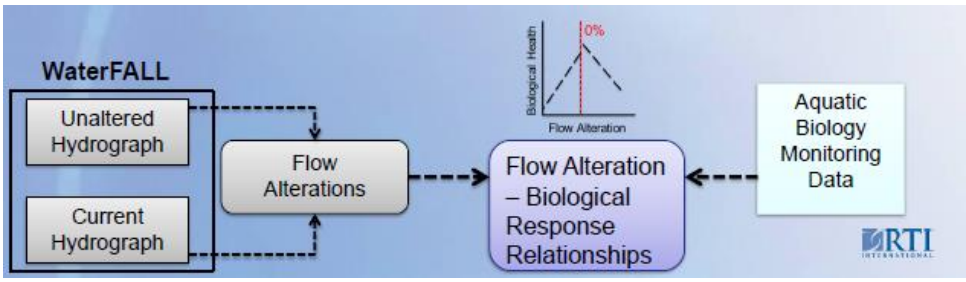
We thought it would be good to show the progress of internal RTI project. We have interesting results to share and hope it will assist you. We've done some of the modeling work that Phillip showed at the

end regarding multivariate predictors. We won't show that here today.

Objectives

- To develop and test a space-for-time/cross-sectional analysis approach to determine flow alteration – biological response relationships:
    - to support determination of ecological flows
    - e.g., Step 2 of BEC project
- that are useful to water resource managers

As you probably all well know there are a variety of flow metrics available, many are eco relevant but challenging to interpret for managers. Want to narrow our focus to those that would be useful.



Graph depicts idea behind our approach. Using hydrologic data from WaterFALL pairing with data from bio programs, fish. Develop range of biological-response flow relationships.

Reviewing methods

Flow alteration

- Data:
    - WaterFALL hydrologic data at each biological monitoring station
    - unaltered (Potential Natural Vegetation - PNV) and current (2006 NLCD + instream flow alterations) hydrologic conditions – expressed as % change
    - 40-year climate period (1967-2006)to have stable record
- Metrics:
    - Based on TNC Indicators of Hydrologic Alteration (IHA) and Ecodeficit metrics (from VA, published in literature)
    - Focused on reductions/decreases in flow (management focus)
    - Originally 67 metrics, now 23 metrics due to high degree of correlation between metrics
        - magnitude, timing, and duration components of flow
        - If you'll recall we tried to represent magnitude of certain flows. We found them to be highly correlated, regardless of USGS or WaterFALL data, were highly correlated. Tailored them down to metrics that were not highly correlated.

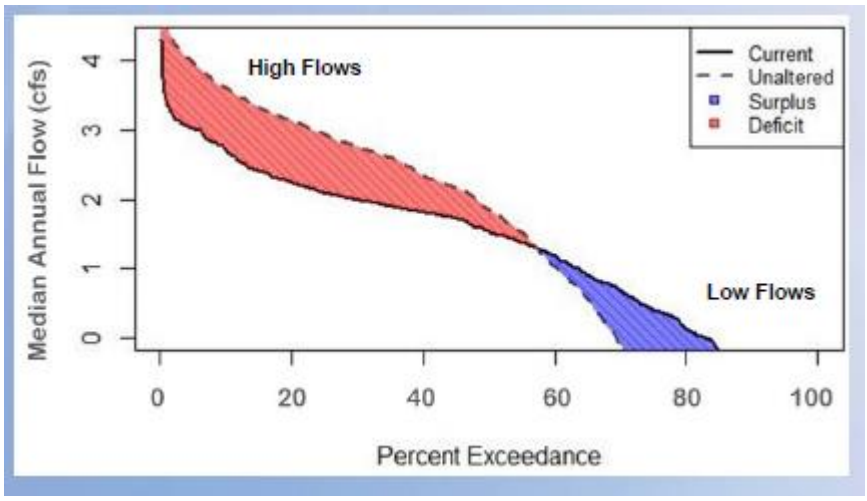
Table outlines flow metrics- grouped in 2 groups, by annual and seasonal time steps.

Metric Group	Time Step (months)	Description	Number of Metrics	Flow Regime Component
EcoDeficit	Annual Winter (12-3) Spring (4-6) Summer (7-9) Fall (10-11)	Deficit in flow duration curves between unaltered and altered conditions	5	Magnitude Timing
Minimum Flow Durations	Annual Winter (12-3) Spring (4-6) Summer (7-9) Fall (10-11)	3-, 7-, 30-, and 90-day average minimum flows (90 days not present in fall)	19	Magnitude Duration Timing
Total			**23**	

Seasons are same as for PHABSIM work. Minimum flow durations- IHA based metrics.

Ecodeficit metrics- are relationships between flow duration curves in the unaltered verses current condition and relationship between the two.

Methods: ecodeficit and ecosurplus graphs- you can see relationship between flow duration curves and PNV versus current condition. Tries to relate how flow has changed (red- deficit, reduction in flow in current verses unaltered: blue- increase in flow in current condition verses unaltered condition). Area under curve (red)/total area of unaltered conditions. It's through their research they showed its good way to integrate the magnitude metrics that have a single value and highly correlated with magnitude metrics. We felt comfortable using it as a surrogate to could capture variation.



Methods for Biological response metrics

- Biological response metrics
  - NC DWQ Fish community dataset:
  - Most recent record (1990-2011)
  - 858 monitoring stations
- Fish species (156) grouped by habitat guild:
  - *Pool (44 species / 675 stations)*
  - Pool-run
  - *Riffle-run (44 species / 650 stations)*
  - Riffle

    - Margin
    - Backwater
    - For our test of methods we chose 2, selected because they have the most abundant measurements, and wanted to hypothesize contrasting responses. Riffle run should be more responsive than pool.
- Metric
    - Species diversity
    - Abundance (total count)
    - Shannon Weaver Index

Something else we did to data prior to analyses, if you compare data by basin, there was quite a bit of interbasin variation. Table in slide 7 shows the 90th percentile values of each metric, see there is a lot of variation. This box in read, Neuse verses New, a similar number of monitoring stations but dramatic difference in abundance of species and Shannon Weaver index. In order to do larger scale comparison using a single analysis on a single scatter plot. we had to normalize by basin. Rather than normalize by median value, tried to capture maximal biological condition in each basin. Y access becomes a % value…difference from ideal – 100% condition is your reference condition, ideal, If it's 80% it's been reduced by 20, if it's 60% it's less than optimal.

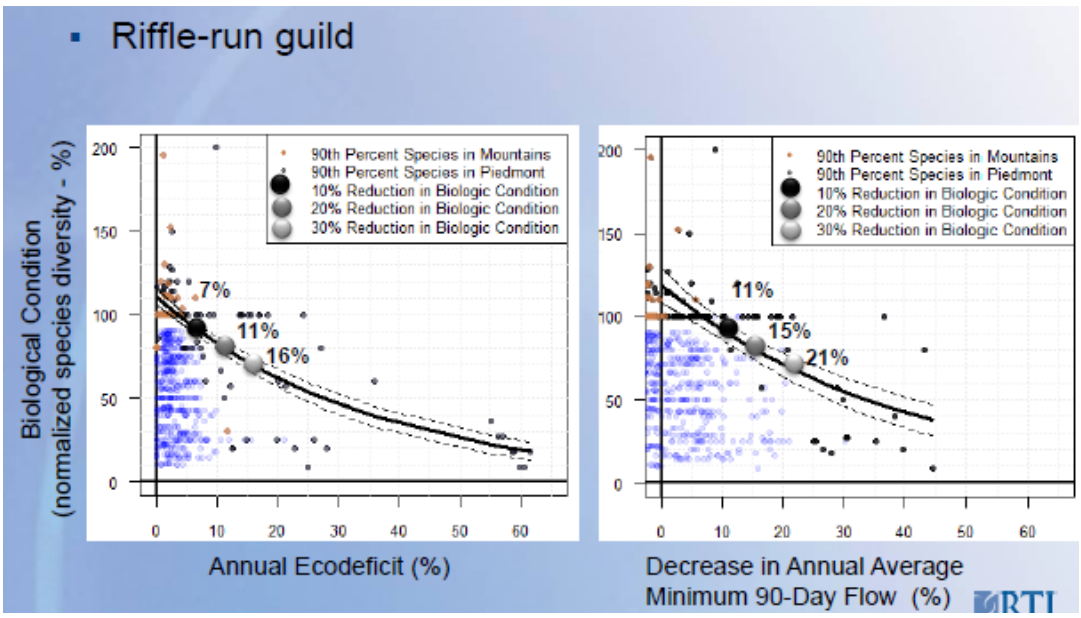
Q: Did you use any kind of transformation to account for the magnitude of that representative change - 90% of 4 is different than 90% of 59…
R: No. What does it mean if you apply it basin by basin. I agree, it highlights a concern we had …if you had a relationship based on absolute value….I want a 20% reduction so you can only go down by 8 species, but some may not have enough species. Why we wanted to normalize by basin…there are a lot of challenges we came up with and this is how we chose to deal with it. Feedback is helpful.

Methods- statistical analyses

- Statistical Analyses:
    - Focused on 90th percentile of data (to represent upper limit of response attributable to flow alteration)
    - Normalized data by basin
    - Analyzed at state level
    - Linear verses non-linear response function
    - best fit determined by residual deviance
- Thresholds of biological response:
    - Flow alteration associated with 10, 20 and 30% reduction in "biological condition"

This is not a new concept, used by Potomac. With 90th quartile regression approach, all the scatter underneath can be attributed to other variables. If you only want to see a single variable relationship… Analyzed at state level- did see if it made sense to separate riffle-run by region, but found we didn't gain anything in the analysis. Regarding pool guild, we found no distinctive difference by region.

Results:
Riffle –run guild- flow alteration/bio response relationships. Two of the 23 flow metrics. Annual ecodeficit, and decrease in Annual Average Min 90-day flow.



100% is reference condition of 90% value on both accesses. Before we try to model the response based on the 90th percentile of data, [points that are black are included in the best fit relationship]. The orange indicates the x sites verses sites in the coastal plain. The black, dark grey, light grey, are biological thresholds. Black is 10% reduction in biological condition and flow alteration- we can have 10% reduction in biological condition with a 7% change in flow, verses 30% being a 16% change. Riffle run guild is quite responsive to flow alteration.

Q: Your response variable in this prediction is exactly what?
R: Species diversity within riffle run guild.

Q: Data set is predicted or measured?
R: Measured, from DWQ data set. Restricted these analysis by riffle run guild

Q: Data points were taken with predicted level of ecodeficit?
R: Each location that had actual fish data, identified all members of riffle run guild and included them. This is the modeled hydrology with WaterFALL at that location. Change in flow under unaltered condition (PNV) verses current 2006 land cover with flow alterations. This is the change at that location where monitoring data collected.

Q: Do you have data that shows those 2 points? You're predicting what ecodeficit is based on a measure you currently have compared to a modeled value?
R: Yes. The waterfall model is calibrated with gage data.

Q: You don't have anything under PNV values for all sites?
R: There are some, not many. We have looked at the NC sites that have been termed as reference sites and seeing if the biology…(inaudible)

Q: Can you use that to validate predicted value of this approach?
R: Not easily, don't have representation from all basins. The biological response is not as clear at reference sites as you would hope.

Q: Did reference sites fall in the 90th percentile?
R: We did look at what 90th percentile represents, it did represent response mainly attributed to flow alterations. For Riffle run, had better water quality, higher DO, fragmentation was low, habitat score was higher. For pool guild it wasn't quite as clear.

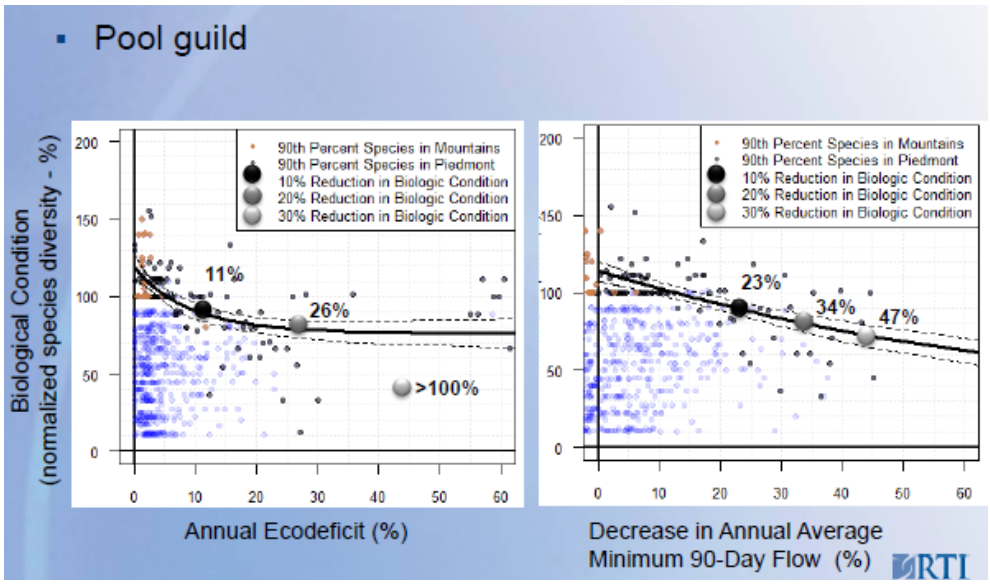
Q: Ecodeficit- it's a numeric value for area under curve, ecodeficit for high magnitude flow and low magnitude flow could be represented by same thing but are different…
R: relationships are very coarse, they include a lot of info, a lot of sites that are very different. It's hard for us to go there without more multivariate analysis. We can present those values. We found as far as ecodeficit…the riffle run was more influenced by flow metrics and less by other, pool guild found higher variation due to other variables like water quality, fragmentation.

C: Ecodeficit broken up by high magnitude and low magnitude values, ecologically it may be more important to understand how it influences.
C: We talked about that in our other meetings. One of Jim's suggestions was to split flow duration curve and look at half of it. Don't remember what came of it.
C: Take home is that with this guild, we're able to detect a relationship that will help us understand, but not so much with the pool guild.
R: what could you do with these? You could go into other approaches. You can develop these predictive relationships. If we could define how we want to do these relationships, we can further tailor to get more refined relationships. If you get finer and finer, you reduce the number of data that can go into the relationships.

Q: what type of curves are those?
R: Exponential decay for non-linear relationship or generalized linear model.

Q: is there an R2 value? Trying to get an idea of how well the curves really fit, what is level of variation acceptable.
R (Laura, RTI): because of distribution of data, they don't calculate. We have residual deviances we can compare. I can look at scale (for level of confidence) and get back to you

Back to presentation: Pool Guild results with same predictive flow metrics. Pool guild is not as responsive to flow alteration as hypothesized. Same axises are shown for pool guild.



Here are 2 tables (slides 11 and 12) with results for all 23 flow metrics calculated at each location where we had biological data using hydrologic modeling data using change in flow from unaltered verses current. They list the values associated for the 3 metrics. The grey cells represent the non-linear response functions, white is linear relationships. NS means non significant. Represent the 10% change in flow alteration…see from range of values here, riffle run guild appears to be very sensitive to flow alterations. If you look at there is not a lot of variation, average of all 3 metrics, 9-11% reduction of flow is related to 10% reduction in biological condition.

In contrast to pool guild, using same metrics. A lot more NS, the values are quite a bit higher, with respect to flow alteration associated with 10% reduction in biological condition. Looking at 9-11% reductions in flow to get 10% reduction in biological condition for riffle run verses 18-27% change in flow to get 10% reduction in pool.

Potential applications:

- Develop these relationships for each stream class
    - i.e., BEC system
- Adopt these relationships for all "monitorable" streams (i.e., stream classification may not be necessary):
    - Riffle-run guild:
    - Mountains and Piedmont
    - Pool guild:
    - Mountains, Piedmont, and Coastal Plain

Within each of the ecoregions you could do analyses by guild. We did not show we gained much by separating by region but….one method that could be used to develop relationships by stream classes. Given time frame and your objectives, it's possible that these relationships can be adopted as is.

Stream classes might not be necessary. Riffle run guild could be applied to all the monitoring sites with that guild present (map of sites on slide 14). Could apply the riffle run gild plots to each of these locations.

For Pool guild even greater coverage- (slide 15) blue dots have a member of pool guild present. Basically every site has one present. Could apply these pool guild relationships to each of these sites.

What does a monitorable stream look like? Areas with smaller drainage basins….we came up with this cutoff of what the drainage area would be. We found that the area corresponding to drainage area of <=137 km2 . (map on slide 16) Grey- has 137 km2 or less upstream. Red are drainage areas more than that- mostly main stream channels. As an area of calculation, 88% of entire state area in monitorable streams. With respect to eco flow determinations, there is very little biological data in larger streams, so something you'd have to deal with.

Questions (Q), Comments (C), Response (R):

Q: Regarding normalization, in using basins by default you're including eco regions because of way our drainages flow, the ones unique to mountains, you could normalize by ecoregion instead of basin. Species assemblages will be basically aligned with one another

C: Even mountain ecoregion is in both Atlantic and interior basins.
C: With EDU, it's not. If you use EDU as normalizing factor, wouldn't that tie you more closely to work being done with classification?
R: We did score EDU to see to what degree it could explain variation.

C: Example New and Neuse widely different, but some others have much closer numbers. Interior basin may be richer than coastal basin, I'm wondering if you can't do away with basin by basin and normalize by EDU.
R: You could potentially do that, split by physiographic region. BY normalizing basin you're per se classifying. Could confine relationships by ecoregion.

C: Seems like they would be correlated with one another in NC
R: Yes, are options to explore that depending on if you all think it's useful to pursue.

Q: If we have an area that we apply riffle run, if we were looking at proposal for water withdrawals that take a 10% reduction in flow, you would expect to see a 10% reduction in biological condition?
R: Yes, if you have a curve like this (reference to above curve for riffle run), biological condition verses ecodeficit, the dot is 10% change in biology, 20, 30. Thresholds of deficit here- can't be a blanket application because it depends where you are on the curve. You would need to tailor by basin- basin-specific starting point is needed. That may be where class system comes in- what is the condition of your basin now? Could have a pristine class, in general you have leveling out 0-5 pristine, 5- 30 is sensitive, over 30 is degraded/impaired.

C: This is important, understanding systems at this level.
R: You may want to divide into classes- for this class you allow x amount of change, etc. how much of alteration is due to land use, how much is due to hydrological alteration.

C: Seems like you have multiple classes. The response curve for riffle, then the other categories. Have you attempted to integrate as an overall group. Ex New River, 90% of species are in riffle run, only 10%

in pool. If you drop flow by 10% do you also have an impact on pool organisms and can you group those together…
R: Not yet, but important point. We have 22 other metrics besides ecodeficit.

C: But they all are showing a similar thing. All metrics are showing the same. How do we approach using this info? One approach, use the one more flow sensitive, because if you're protecting that you're protecting the other. That's a debate we can have.

C: What I'm getting at, in some basins that is right. In others, where riffle run only represents 3% of area?
R: We don't have enough data to characterize what degree of habitat is where. The habitat score represents diversity of habitat types but not abundance.

C: At the planning level scale, it's so much higher than that.
R: largely a foundation of this scale, crude and gross, we've already restricted analysis to understandable flow metrics. You can fine tune relationships further but then you lose significance. We've shown the methods appear to works and produces significant relationships, with riffle-run being more responsive than pool. The 90th percentile points are well represented across the state, and regard better quality of sites in general.

Q: Using waterfall flow metrics, how values change if you use 70s land cover rather than PNV to 2006. Some of the values may be exaggerated due to the extreme change. Did you look at that?
R: we started with using 70s data. There are 3 land covers we can use. 1970s, PNV, 2006. We didn't get as good a predictive capacity with 70s data. When talking about conversion of 1970s to 2000s change you assume you go from a better condition to an altered condition but that was not always the case.

Q: How would relationship change using reference sites truly as close to unaltered as possible verses current with land use changes? Sometimes drastic changes may be places with current alterations.
R: 1970s water quality was a lot worse than 2006. Population was heavily stressed, and have had a chance for recovery. We went through different iterations. This represented a lot of trial and error going through different approaches.

C: Yes, what was the amount of selection in the data to get to a curve.
R: Wasn't a purposeful selection other than choosing a range of dates. Organisms aren't representing 40 years of climate variation, example of imperfect data. We are finding a large portion of variation can be attributed to other sources.

Q: Going back to illustration of pristine, vulnerable, impaired. Number of pristine catchments will be small. The vulnerable will be perhaps larger, largest will be impaired.
R: We actually ran Upper Neuse, and can put it up there if you want to see what it looks like.

C: Wadeable streams are particularly vulnerable to withdrawal. Larger streams that we don't have data for may not be as vulnerable, but will have the most requests for withdrawals.

C: Ones being monitored are being affected by connectivity to larger streams, sometimes biota are moving back and forth.

C: Somehow we have to grab a hold of nonwadeable streams.

C: Getting a number on the area of the catchments in state that are wadeable (88%) that's helpful for us moving forward.

Q: 88% is by catchment area. They took the 127 km2 and found out how many catchments fit that.

Q: If using a space for time approach, you could (somehow extrapolate to larger rivers) relative to nearby wadeable streams that would be potentially influenced by changes in hydrology of nonwadeable streams. Would there be an advantage to that? Or too hard to show changes in biology of nonwadeable to wadeable?

C: In some places in piedmont, there is not that big of a difference at low flow.
Q: Sampling protocols will be so different that even the sample you have of biology is going to vary based on sampling protocol. It won't be comparable.

Q: Are you saying, can we expand the information into unwadeable streams based on relationship in flow changes in wadeable and unwadeable?
C: You can estimate changes in hydrology in nonwadeable streams but it's harder to do the biology. If there is an ecological connection between the nonwadeable and the contiguous wadeable then is there a relationship there…

C: Cumulative impacts would be the overwhelming factors in the larger system. It's possible to get 10% impact attributed to flow in wadeable, but then when you get to nonwadeable, the influence of flow would be less because of the cumulative.

C: What Bob's getting at, is not a cumulative affect, but accumulate affect. If you have ecodeficit of 10% in each wadeable stream, does that accumulate to 10% reduction in the larger stream?
R: Hydrology can be modeled anywhere. It's the biology that is the limiting factor.

C: Impacts of biology in a larger system may not be so much due to flow.

R: Map of upper Neuse- HUC in brown outline, based on flow alteration, annual ecodeficit is represented.

Q: Is it pristine, or is it masking plusses and minuses on the curve that are equaling out…
Jim: This is just deficit, not plus or minus.

C: Could be minuses in high flows, or minuses in low flows, which would be very different.
R: Right. It doesn't show that variation in the pattern. You have to resolve some of that by breaking it down by season.

Q: Is there a metric other than ecodeficit?
C: Would be flow duration, change in percentiles and looking at it as an ecodeficit or surplus.
R: We found those to be highly correlated in all our evaluations.

C: Something like this, whether ecodeficit or change, or seasonal, a map like this for the state would be extremely useful as a planning tool
R: Right, where to prioritize flow, if looking at management.

C: Where did you get the 5% number?
R: She drew a graph with annual ecodeficit on x, biological condition on y, showed 100%, some points above the 90th percentile. 100% was more or less around 5% ecodeficit, that is where you roughly maintain eco condition. Trying to determine where curve intersects 100%. As second criteria, of 30% value, this was roughly where curve flattened out. These are eyeballed values. If you are interested in something like this you would have to pick the metric, determine how many classes (of impairment). How do you map this across the state in another question?

C: Flow. That's what we're going to use, to be applicable in current models (DWR).
R: It is an integrated term that captures whole hydrographs…

Q: The next …amount of withdrawal, how is it predictive of ecodeficit. What quantity of withdrawal results in an ecodeficit?
R. You may start with the 3 levels of classes (pristine, vulnerable, impaired) you may need to further divide "vulnerable" into additional classes. Say you map it and can identify where management watershed falls on the curve- basically data driven but management decided…the finer your categories (the less accurate?)

C: I'm getting down to, how much change in cfs= how much change in ecodeficit. How do we build those curves?

R: Have to go by seasonal, annual, translate how it relates to flow duration curves… there are all these different steps, in ELOHA…

C: Can we also get at other alterations, discharges and such that alters hydrology.
R: We have modeled ecosurplus. You're talking variation which is masked in flow duration curves. The main goals of ecoflows is trying to deal with water withdrawals (e.g. DWR) which is why we concentrated on ecodeficits.

C: We found the # of statistically significant results were much less for ecosurpluses.
R: We've also only analyzed 2 guilds.
Q: what input is appropriate, on how to move forward on both of these efforts? Seems like there is some merging.
R: we've more or less completed our project due to funds. We aren't able to go much further than this. If you are interested, as a group you can discuss how it may be best to proceed. We did talk to Tom he said these kind of relationships could be developed for benthos.

C: This is an either or stage? This is in contrast to classifications by ecoregion
R: Not in contrast. You could do this after you develop stream class with BEC. But is there enough time? Will you lose significance if you got finer data? Don't know. Could figure it out in a year maybe but you don't have that time.

R: Ecoregion with highest explanatory power, second option statewide models would allow you to model elevation and other continuous variables, and see how it explains… incorporate hydrology and x as predictor variables. Need to have hydrologic data, only available through WaterFALL.

R: we'd use all the data, could use mappable data that is available for the state. Land cover, elevation. Could tease out sources of variation in the relationships. Have drainage area, elevation, water quality, that's another option.

Facilitator: sounds like were at a point to discuss choosing a direction. Perhaps let people think about this, and at next meeting maybe pull together and make decisions about where to go next. Reasonable approach?

The group decided to revisit it later in the meeting. Continued discussion with Jen Phelan enclosed.

So as a reminder, we left off with the two recommendations of Phillip's work and Tom's work was that there are two ways we could go with the stream classification approach, the BEC project. The first one would be adoption of an a priori classification system, either the Omernik level III physiographic region classification, or TOC's EDU classification as an a priori way to classify biology (because that seemed to be the best match for those two classification systems) and try to develop or refine flow-biology relationships using these physiographic regions. That is one option. The other option would be abandoning stream classification entirely and try to develop better descriptive models that predict biological response and multi-factorial biologic response models. So you build in not only a physiographic region like EDU level III and drainage class, or drainage area, but you also build in forest cover, impervious surface, and then the eco deficit, annual eco deficit, which is the flow alteration as one of the predictive variables. And this is something like what RTI has also explored using water quality, fragmentation, elevation, and a variety of other attributes in this predictive relationship as well. But that is not going to get you stream classification. That is just going to get you a more refined model that accounts for larger amounts of the variation in biological response. So those are the two options that were presented by Tom and Phillip. Okay. So you have to think about those within the context of your goals and your timeframe.

Q: Do you need recommendation from the Board—I mean before they proceed tonight, tomorrow, the very next day; they would like to have guidance on direction?
R: Right. These are two dramatically different approaches. Given resources and time, they want to know which one would be most useful for you guys with respect to helping to recommend ecological flows.
R: And we do not really want to wait until June to have that answer for them because that means we are here right now, and nothing will happen until June if we wait to make that call.
R: Exactly. And to be completely honest, too, Tom right now is in Costa Rica and he does not have his computer or his data with him because he was not able to take it with him because of USGS

restrictions. And he is not going to be back until June 3. So he is not going to be able to resume his work on the benthos side until his return. But Phillip could definitely get started on this from the fish side if we have some recommendations specific to which approach we would like him to pursue. Keep in mind that we do not know how these are going to turn out; they are not guaranteed paths so they are also going to need some evaluation. They will be able to provide updates in June and perhaps some final recommendations on what they found. So these are still not foolproof paths.
C: Under option one, if you reverse the order of those two steps, and go directly to a multifactorial predictive model of biological responses, location by location, level III and EDU values could be tested as useful but not exclusive variables in that location by location stuff. In other words, you could go directly to step B using the two a priori classifications as variables.
R: Yes, absolutely.
C: And if they are useful variables, great, they stay in the equation. If they are not useful variables, they come out. As it may turn out in some parts of the world, one of them will be a useful variable and in some parts of the world, the other one will be a useful variable. So it might be that in the mountains, it is EDUs and in the coastal plain or the whatever, it is level III.
R: Or for fish it is EDUs and for benthos it is Omernik level III.
C: So at some point, my recommendation under option one is to go to B and include level III and EDU a priori classes as variables.
R: Yes, both eco flow metrics, or flow metrics, and physiographic characteristics would be included as predictive variables within the model. But remember, when I say location by location, it means that the way the state would use this is they would have to go to each drainage basin, each catchment, and gather all of the data for that model relationship, plug it in to determine the relationship on biology and how much change they can have within flow within that relationship with an accepted level of biological response.
R: They can do that for a reach, and a reach could be defined using nodes in a model. And those nodes can be synthesized wherever they are needed.
R: Yes, true.
C: So I do not see that as a huge problem. It would be a process that could be illustrated on a flow chart, the result could be mapped, and it would be someone's job—Fred's maybe—to turn the crank on it, but presumably the data would be pre-loaded. If you compress those two steps under option one into that one step, then that is something for Phillip to work on furiously starting tomorrow afternoon and Tom to chip in on as soon as he is back. Meanwhile, I think we ought to see Option Two written up as something for this group to consider as a strategy to adopt.
R: Because Option 2 is kind of a multi-step process that lays out all of the pieces which ultimately, that is going to have to be done as well to some degree. I mean this is still getting at your flow biology relationship and how that's going to be determined within a stream classification or a geographical landscape context. This is what we have done with the internal research and development project. We have shown that based upon our method, we do not need to develop a stream classification. So it can be applied to all monitorable locations.
R: And you did that for two out of seven guilds.
R: Yes, right.
Q: And now that the process is complete and you know how to do it, how much trouble is it to do it for the other five?
R: I would have to get back to you on that. I have to talk to Lauren to see how much time it would take to do that.

C: Part of the problem is a lot of those other guilds do not have the biological data to probably give you a lot of good curve generations.
C: We do not necessarily have to have all of the guilds. What we are trying to find is a sensitive guild. Or perhaps a sensitive combination of guilds because if you combine riffle pool run as the most flow sensitive grouping and you find it is equally predictive, it will give you more power to have the guilds combined.
R: It will give you more strength.
Jen: Yes, we would analyze them separately to see if there are differences, and if there are not, then I guess you could combine them. But I guess—I do not see—you could just keep them as being distinct and just recognize the varying sensitivities of the different guilds.
R: I think we come down to the prescriptive part of which areas in the state have sufficient numbers of riffle and riffle run species.
R: And basically we found, much like for the riffle run species, 99% of the monitoring stations in the Piedmont and the mountains had a membership. For the pool, 99% of all the monitoring stations had membership.
C: But not a sensitive response—the response is not as sensitive.
R: With the pool.

Q: Just considering option two, you are still limited to just wadeable streams; you are not going to be able to apply that to larger streams. Is that correct?
R: That is true, but you meet the same limitation here.
R: But right, you have the same limitation there.
R: Yes, and that is basically recognizing the conversation within this group all along. We said there are challenges with the coastal plain and the tidal waters. And there are challenges with the large non-wadeable streams that do not have any biological monitoring data.
C: If I remember correctly from the presentation over on option one part b multifactorial, land use kind of overrode all of the other.
R: It did, but remember that that relationship is biological response as being Y, and then all the other predictive variables, so you are ultimately confined to your biological response that you can model.

Q: I was going to ask in terms of getting either one of these steps done, which one is going to put us in a position to go farther with more data in the future such as non-wadeable streams, the bigger river types of data. Is there any preference there?
R: No. There does not seem to be. Initially, when we set out with this, we had the idea that by having a classification system that was going to be physiographic, environmental attributes-based and biology-based, the idea was that we capture all of the streams that are wadeable and have biological data on this one arm, while at the same time also identifying additional stream types that do not have that data but have unique physiographic characteristics. We found out that that did not work. So we were not able to build in additional classes that are purely based upon physiographic or environmental attributes using that system. This one basically resides entirely upon biology data once again. So, even though we build in other variables, those are built in purely to try and tease up more variation in biological response. So we are still going to be limited.

C: I guess one thing I like about option two, even though both of the options are statistical, is that option two has a mechanistic base that seems more linked to what we were doing at the beginning of

our exploration in terms of habitat change than option one. Option one seems much more empirical. Option two is much more mechanistic. I tend to go more with the mechanistic when you are trying to explain why you want to do something.
R: Right. And I see option one as being a way to further refine some of these preliminary relationships that have been built upon empirical data outlined here in option one. So this is a way to refine those relationships and further tweak them and improve them, is this classification. Because the idea behind classification is it is taking out some of the variability in your response. You attribute to a stream classification process or in this case, a multifactorial analysis which is a variety of different stressors to biology. But the one thing here to keep in mind is you have these flow-biology relationships. Step two would be for the group to decide on which biological thresholds to use. We have shown you these biological threshold values of 10, 20, and 30% reduction in biological condition and the associated changes in flow alteration. I mean are you comfortable with those 10, 20, and 30% changes? Are those okay?
Q: What processes would you propose to validate such things? I mean that seems to be the one step that I am missing in both of these. Can one be used as a validating process for the other, or are there external measures or do you have enough pristine environments and/or modified environments that you can use to validate your predictions? Because it seems like we are taking a lot on faith by jumping in feet first with either of these processes. Like at the very end of what we have considered for the last two years, now we are sort of looking at switching gears and I am not going to be comfortable with picking a number like that without some means of validating what it is predictive of. You know, what is it really telling me?
C: In both cases we are building models on data and recommending to the department or to the state or to the scientific world at large, depending on how we frame it, that these are recommendations and based on our best evaluation of the data we had, but that they require future validation.
R: But one of these, at least earlier, at least option two I know and perhaps the other one, may have some at least limited amount of information that could be used to validate. Okay we made our projections, now we can pull these out that seem to fit this criterion. Where do they fit on the curve and this is some evidence that we are headed in the right direction—
C: Phillip and Tom are both withholding some of the data, building their models using some of the data and then testing it with the rest. You know, sort of saving up some of the data for validation.
R: Right but that is snapshot data. I understand how that works, that is just a means of evaluating whether or not your model fits the data you built the model with. And that is okay .That is not what I am talking about. What I am talking about is a little bit different.
R: The predictive value of what we do here will have to be tested over time, we cannot validate its predictive value using the data we used to build the model. To put a gestalt on this thing, when we were looking at the Potomac model a year or so ago, or the Potomac process, what people really liked was that we had individual species responses to flow alteration, and what we have over in option one a year and half later, roughly, is our continuing attempt to build something based on species response curves. So we basically start with species response and try to build up from there to a system that is predictive about how to protect ecological integrity. Over here in option two, we go in the opposite direction. We start with something that basically says we are going to define eco surplus and eco deficit more or less arbitrarily—
R: Right. And that is the reason for my discomfort is we are starting with an arbitrary classification. And unless we can come back and somehow—
C: I do not think it is arbitrary—

C: But what we are doing here under option two is building down. That is starting with a general concept and building biological responses under it as a way of validation. And all those curves you showed with all those scatter plots, which basically is the data that we are using to look at that whole eco surplus, eco deficit concept and see if it makes sense. And it may turn out that ecodeficit, eco surplus numbers of 10, 20, and 30 do not make any sense at all. Maybe it should be 12, 17, and 31. And my guess is that there will be places in the state where those numbers change. And obviously for guilds that would change.
R: But I think there is some information in there, at least from what you described earlier that could be used to at least attempt to plug it in.

Jen: Yes. I mean we have the options. Like I said before, these relationships can be expressed on the 25th, 50th, 75th percentiles which are hard values and not this integrated value like annual eco deficit. They are all flow metrics. They are all measures of flow alteration, so it is possible. And the reason we chose that was because we found the 10th, 25th, 50th, and 75th percentiles being highly correlated. Which one do you choose? So we this with Jim and with Fred, and they resonated with the idea of eco deficits as being these relationships, the entire flow duration curves. So we have that option as one thing and I think where you are going—I mean, there is also the way that sounds, you can do this predictive modeling where you can do a hundred runs and take 80% of the data, build your model and then see how well it predicts the other 20% of biological response. That is an option. The other option would be to basically, perhaps what you are saying, is to really come out and something the SAB could do is come up with a recommendation for a proposed way forward to either further refine or test, validate some of these responses based upon measurements, a very, very well thought out, well planned schedule of proposed measurements—of course, if there is money to actually validate these relationships. That is entirely possible and I think that would be a very good contribution to the process.

Facilitator: As a time check, have about five more minutes before Tom Fransen's presentation on 80% flow-by which will require 60 minutes. Let's go ahead and take one more question, and then I want to check back in to see where we are—where you all are regarding these options.
C: This is more of a comment than a question, but in looking at those flow metrics, a couple things I want to point out. One, eco deficit—one of the appeals of that was it covered the full range of the flow duration curve. You were not having to pick, did we use 50, 25, 10, are we looking at high flows, low flows, whatever. It is the whole range of change. The other sweep of metrics the 7, 30, 90-day low flows actually suggested, I think initially by Bryan McCrodden who works a lot with local water systems, and one of his things that he points out—his concern was that by using the deficit approach, which is just change in flow duration, it does not take into account whether that change is continuous days or scattered days, which something like that is very important to water users. Whether they come out the same or not, using consecutive days of low flow can be important for a water user in their plan and in terms of setting a threshold, perhaps. But all that being said, when you look at the table that you initially came up with in your proof of concept, to me it did not make a huge amount of difference which metric you picked, it was roughly the same percentage of change in that metric to get roughly the same degree of biological alteration, so--
Jen: By guild, each guild is different.
C: For the run riffle guild, which I would point out is probably the most sensitive guild. The rest are less sensitive, so my inclination is to pick the most sensitive one, and leave the rest to follow in their

dust. Now regarding validation, we have talked a lot about validation, and I just want to reinforce that the whole underpinning of everything that RTI has done is space for time. That biological difference between—is it 800 and whatever sampling sites—is not modeled, it is real. I mean that is based on DWQ samples. What we do not have is what did they sample 20 years ago, what is it at that exact same place today, and how would the flow change from 20 or however many years ago and today at that same place. That data does not exist. And so if, for the majority of—
Jen: Kimberly's found—she did some specific trend over time analysis but they were extremely challenging.
R: Right. So, again, what you have done is that space for time. You said, well okay, with this one, it has a certain type of biological metric and how altered is that flow. What is simulated, what is modeled, is that degree of flow alteration.
Jen: Yes.
R: So, I mean in terms of validating, do we need to validate the biological difference between points? I mean, that is quote unquote "real data." What is modeled is just the flow, as opposed to the PHABSIM approach, which we have talked about ad nauseam, where the flow is modeled, but then the response we are getting is habitat and what is not validated, again, it is challenging to do, is the link between habitat response and what actually happens to the biota themselves. We have kind of skipped over that with what RTI has done because you come straight to how is the biota different at these different locations and then how is the flow different at these different locations.
Jen: And try to capture that habitat component by grouping by guild, habitat-based guild.
R: True, yes.
Jen: And one point I just want to make with this that I think is really important with respect to your guys' task is the fact that this process of the kind of decisions you have to make with respect to your recommendations, this is just the first piece. You have these flow biology relationships, which that gets tied up in, but then how do you want to implement this with respect to what is an ecological flow using these continuous relationships. Do these biological thresholds make any sense with respect to 10%, 20%, 30% reductions in biological condition? Are those going to be good to use, or is it something like that? And then how are you going to put these on the landscape? I mean, and that is what was brought up, is this where the classification system, these three classes of pristine, vulnerable, and impaired a good approach to take, even though that language is probably not very good? And then, even within that, then how do you propose ecological flows for each of those classes and do you want to further divide, let's say that vulnerable class into 3 or 4 different classes, which you can assign. Okay you can accept a 10% change in this, a 15% change in that or a 20% change in that class. And I think, and I could be completely wrong here, but I think this is what needs to be included in your recommendations. Maybe, I do not know. So, what I want to encourage is to think about these in the context of recommendations you provide to us and also within the context of developing your outline and what you have to cover within your report.
C: I do not think we're going to make recommendations to DENR about what is acceptable. I do not think we are going to be making recommendations to DENR about how much change they should allow. I think instead we are going to be making recommendations to DENR that say something along the lines of, if you increase the eco deficit by less than such a percentage for these streams, this is the biological response you can expect. And it is up to DENR to decide what to do with that information. I really liked Jim's explanation of how this sort of all fits together, and I just want to add that whatever predictive model we provide to DENR at the end of this process will, by definition, require that DENR validate its predictive power in the future.

Following Tom Fransen's presentation, the EFSAB continued the discussion about the Option 1 and Option 2 presented by RTI. Rather than choose between Option 1 and Option 2, RTI will conduct research on both with an emphasis on 1b (in Option 1).

Facilitator: With a little bit of time left, let's re-visit how we might move forward with the RTI work. Prior to our presentation with Tom, Jennifer had introduced option one and option two as two different pathways for moving forward. Jennifer and Sam were able to develop a revised plan that they want to propose.
SAM: Well, we are going to do both. Option 1 is paid for. Phil and Tom can get back to work on it, Phil tomorrow, Tom when he gets back from Costa Rica with an emphasis on 1b. We are going to treat eco regional information as variables for input into this sort of suite of variables that are involved in the predictive model. So it may turn out that for bugs, one of these is more important and for fish the other one is more important, or it may turn out that in the Piedmont, one of these is more important, and in the Mountains, the other one is more important; we are going to go with the flow, so to speak, and basically treat these as variable inputs to this, and this becomes the focus of option one.
C: So both the physiographic attributes and the flow metrics will be considered as fact as we are doing that relationship.
R: Right.
C: And there might be multiple flow metrics within a single relationship.
Q: So, is that essentially a stepwise regression that you are going to see to build this model?
R: Yes. We have already done—this is something we are already using, a list of predictive factors, but we will know from land cover. You kind of shy away from that because it obviously also influences flow, so we have to determine to what degree land cover is correlated with flow metrics, as well. It is not just water quality, it is also flow.
R: So that paper that I just sent you, that Rodney Knight paper where they did this for the Cumberland and the Tennessee is essentially the same as what you are talking about doing?
R: I have not read it yet, but I believe—
C: He did a comparison of rain/runoff and statistical, but then this is a step beyond that, where I think they're actually doing what we are talking about here so there is one out there that they seem to like, I guess. I have not read through the whole paper yet but—same things about using province and using various other things like hydrologic statistics and so on.
Jen: Yes, I think what we will do is we will get together with Tom and list which predictive variables we want to do with the analysis. The main determinant would be eco region and then flow metrics and then, also, other characteristics, which they have stable data sets for and have it for the entire state and are based upon a monitoring station.

Sam: On option two, we are not going to proceed with option two immediately. Instead, I have asked Jen to collaborate with any of you who would like to collaborate with her and put together a list of questions that we have to resolve as a group before we can proceed with option two. For example, do we agree that the riffle run guild is the most sensitive guild and, therefore, can be the arbiter for all guilds? Do we agree that eco deficits should be measured on mean annual flow, or should it be measured against some other variable, such as low season average flow or something like that. And so she is going to be pulling a list of questions together. I am hoping it is not more than half a dozen, but it might be more. And we will debate those questions here and shape this option. At that point, it may

turn out, I kind of hope that it does turn out, that the results of B over there become the defining strategy for saying where the little dots fall in the scatter graph under this curve. In other words, that becomes the biological response data that drives this process. The two processes can merge. It may turn out that that will not work, but I think we can give it a month or two to percolate. At any rate, we are going to drive this to conclusion, and we will bring you questions about this one for the next meeting. That is the proposal.

Facilitator: What questions might you have this proposal to review both Option 1and Option 2.

Q: Do we need to make a decision on what the flow base will be? This gets back to the question that came up earlier with Tom Fransen. You are using a long-term average or the predicted pre-settlement condition flow, etcetera. I was just spending a few minutes trying to look at our charge and see how that might factor into it and, obviously, it is good to know it all. And we could do like Chris said, just run them both, but we need to provide a focus for this process to go forward and at least know what we are looking at.
R:That should be a question on your list for option two. Option one is based on the data that we have for the period of time that we have it.
C: So option one really only uses the flow record for the period of time that the data—
R: Well, it substitutes space for time—
C: So basically, one of the predictive variables will be the flow metrics and those are expressed as percent change.
C: From PNV.
R: Yes, we will need a current, so basically, like eco deficit, is a calculation of the change from the PNV to the current condition.
R: But that is in option two.
R: No it is in option one, also.
R: Eco deficit is in option two.
Jen: Well, no, in option one, of the 23 predictive variables, which will be included or could be included in those relationships will be flow metrics. Out of those flow metrics, eco deficit is a calculation of change between two conditions and we chose the PNV condition and the current condition. Same thing with like, 3, 30 9-day minimum flows, we express those as change as well. How much have they decreased in each location as a comparison of PNV condition and the current condition. So that would be the value that is plugged in in this modeled relationship for each location. So your variable is 30-day minimum average flow and for each day you include within this relationship you will calculate or plug in that percent change value for that variable into the relationship. Does that make sense?
C: I think that the way to deal with the issue that you are both talking about, or at least the way I understood Jen to talk about it with step 2 or 3, is when you figure out where you are on that curve, in implementation, the whole pristine vulnerable, impaired, whatever it was—is that if you are already in the impaired, then I guess that tells you whether or not there is anything left to worry about.
C: Right.
C: So that gets back to maintaining the ecological integrity—
C: In the current state.
Q: Can we put Tom's thing up just for one minute? When he first showed us what the SIMBASE was, the little gray line, the simplest graph that he showed us. I think you are right. There will be some that are impaired but there actually may be, in the Broad for example, like it is saying, relatively un-

impacted. Some days it might be pretty close to the PNV, and we need to know that, and that will be relevant to whether it is in the impaired. The larger un-wadeable streams fall into the impaired. Won't we know that based on the statistics, the flow statistics? Are the pristine, vulnerable, and impaired part related to the flow, or is it related to the biology? They are flow categories, right?
R: They are flow categories.
R: Right. So if the Broad is indeed relatively un-impacted then this line and the PNV line may be very close to one another and 80% of the PNV and 80% of the SIMBASE might not be a problem, but if you are in a seriously impacted watershed, your PNV flows may be up here, your SIMBASE is here, the 80% flow-by that we were choosing for its lack of causing impairment is related to the PNV. So we would model 80% of PNV, and you would see what the difference is related to SIMBASE, as well. You may be seriously impaired and that is where we would put it in the category. And maybe we would just shake our heads and say, take what you want, you know. I mean, I am assuming we would still say we do not think it is ecologically beneficial to go to zero flow anywhere because you still have to maintain the dilutions for your NPDS permits and all those others, so somewhere we have to make those recommendations, that even if we go with these criteria in the impaired systems, we are not going to recommend that they dry it down to zero because you would have legal obligations. But I think we have to see it on the model to understand how impacted the system is.

C: Getting back to your question, I am just reading literally from our charge defining ecological integrity and etcetera. It is all these factors comparable to prevailing ecological conditions. I am not suggesting that that is the best thing that we could do, but do we have to do that, at least as part of this exercise, and then maybe come back and say, we did not go this way because X? But is that something we have to do as part of our charge or at least tell the folks in the legislature, we did not do it this way because?
R: I can assure you that in the negotiations leading up to the passage of this bill, that this subject was discussed intensely and heatedly. And our charge is deliberately to essentially protect ecological integrity as it exists, to the extent that it exists, under prevailing conditions. And that is based on the period of record, which means that if there is 70 years of data, we do not have to base our charge on how bad things are today, we can look at how things have been over the last 70 years. But we do not get to go to pre-European, or pre-aboriginal, or pre-pleistocene conditions as a baseline. As much as I personally would like to look at least at pre-European conditions, that is removed from our charge and was a very deliberate decision made in Senator Clodfelter's conference room. I just can tell you it is not something that we can debate very much. As a scientific advisory board, we can say more than we were charged to say, but I am not sure how useful it would be.
C: Yes, so the point being when we approach either of these, I think we are bound to some extent to stick with the charge.
R: By the period of record.
C: By the period of record. And if we go and make assessments, recommendations, etcetera then it needs to be based on that. As you said, we might disagree with that philosophical or technical basis for some reason, but I think we are going to have to do it.
R: But that may be the time to acknowledge that with that prevailing conditions as the baseline, that some stream reaches may be already over allocated and the biota could already be suffering and ecological integrity threatened by those withdrawals.
R: I agree. I just think we have to be cautious in if we make a group or suite of recommendations—if we come up with one that says this one is already impaired because compared to pre-settlement

conditions, then that is not going to fly. I mean, I think we have to be cautious in how it is done.
C: There is no reason why we could not take the pre-settlement conditions as a reference condition, acknowledge then—what we do is acknowledge that there has been in current conditions some degradation, and then our decision then is from that point, how much further degradation we are willing to suggest is allowable. And that acknowledges that there is this pre-condition, this legacy of human activity, but still keeps true to the legislation that says from this point on, this is what we think should happen. So I think you can have your cake and eat it too in this.
C: Just very quickly, and really kind of building on what Bob said, just remember that what RTI did with the PNV was not to establish ecological flows, it was to develop a relationship between the change in biota and the change in flow and to do that, they had to look at a big change to be able to connect the dots. If they said, well we have to look at the change between 20 years ago and today, you are looking at the last two seconds on a 24 hour clock. And so I do not think there is a problem with using PNV for that purpose. I do not think that contradicts charge in the legislation, the fact that the legislation does also say using the period of record in prevailing conditions. I think that also, like Bob just said, gives us the leeway to at least see where we are now in deciding—with getting to RTI's idea of perhaps you have pristine, vulnerable, and impaired because that is factoring in the period of record while still looking at where we are now, going forward.
Jennifer: Basically exactly what Jim was saying. In no way are we trying to say that you have to try and manage to the PNV condition; it is more of just trying to represent degree of flow alteration that has occurred, and trying to use that as a way to see to what degree that accounts for biological response. It is to model biological response; that is the only intention of it.
C: It is just a yardstick.
Jennifer: Yes, it is just a yard stick.
C: And it may be as simple as moving your zero point on your x-axis in order to achieve it in such a way. What I am concerned about is if we put something together and present it to a particular Senator and they look at that and the zero point in their mind is something that has been created to try to simulate pre-habitation conditions, they are going to throw it out. That is all.
R: But there are data points that fall on that line. You can see the scatter plots. There are data points that fall on there, and then we get a range of zero to 5% that shows if you have this leeway within that range of flows.
R: So, I mean you have done that essentially by saying take the 90th percentile and do it; that is our new zero.
R: Right.
C: About that, I was going to try to come up with a better term, but can we come up with a better classification than pristine?
Jennifer: Oh, yes, definitely.
Q: Can we use unaltered or?
R: Yes.

Facilitator: Sam put a proposal in front of you, that RTI would put more effort in reviewing both option 1 and 2. Are you all okay moving forward with doing both?
Q: Has anyone talked with Phillip or Cuffney about their thoughts? About 1A or 1B?
Jennifer: They think that 1B is the most promising to describe the biological response to flow alteration considering that it is a multifactorial relationship. The only thing is, it will be challenging for managers to use across the landscape because you have to map all of these variables and realize that it

is not a pure relationship of flow alteration, biological response. That response is going to change its function among its other predictive variables.
Sam: Which is where we may process it through option 2—
C: I think the difficulty is going to be if the relationship shows that the pure flow piece is so minor in the description of all of the actual relationship, then where does that leave us. I mean, this is a nice assumption at the 90%. You know that—and it is a nice whole number, and it has been used in other basin assessments, and there is some background on that. Now I just feel like, this is such a fine and detailed assessment that we may—it is almost to the point where it is like, it may be so diffuse that it is not meaningful if we try to put it into option 2.
R: We will have to find out.
C: I'll send out that paper I was mentioning to everyone, you can all be experts on it for next time.

Facilitator: Regarding next steps: RTI will review option 1 and option 2 with emphasis on "b" in option 1. Please note, option 2 will not be presented in June. In the meantime, Jen will compose a list of questions as a way to think about option 2. Do you all have questions that you would like Jen to consider? And Jen, would this be helpful to you?
Jennifer: Yes, because we will not be doing anything additional to option 2 at this point in preparation for the June meeting. All we will do is in a very clear, kind of proposed path forward, with decision points that you guys are going to have to tell us in order to help better flush out the steps of option 2 to help provide you with the information that you need to include in your recommendations.

Facilitator: We'll email Jen's graphs to begin thinking about questions that can be posed to Jen.
C: If Jen was to draft a set of questions and send out to the SAB two weeks before the next meeting then one of the agenda items for the next meeting could be to actually test consensus on those questions so that RTI could potentially move forward with testing option 2.

Facilitator: The the SAB may have different questions they would like to raise that Jen might not think about.
R: My proposal is to get the questions out to you within a very few days so that you can mull them over before the next meeting. Much of the conversation we just had was about the questions that we need to address. If you have questions in mind that you think we should answer as a group before we pursue option 2, please get them to Jen as soon as possible. Because the sooner we compile them and get it back to you, the longer you will have time to think about them before the June meeting where we will have very little time to talk about them.

Outline enclosed: BEC Proposal for Next Steps: RTI is considering Option 1 and Option 2.
Following presentation of Option 1 and 2, RTI will use both option 1 and 2 in moving forward with an emphasis on 1b (in option 1).

Option 1: Tom/Phillip

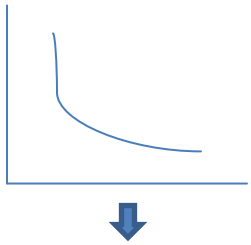
a) A priori classifications and development/improvement of flow – biology relationships by a priori classifications:

- Level III
- EDU

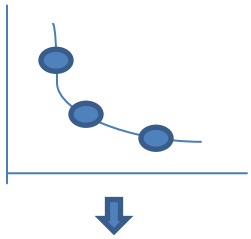
b) Determination of multi-factorial predictive model describing biological response location by location (not a stream classification).

Option 2: Jen/RTI

a) State level flow biology curves for fish and benthos



b). Biological condition thresholds and flow alteration



c. River Classification based on degree of flow alteration

d. Recommendations of ecological flows or process for ecological flow determination by stream class.

V. Presentation & Discussion: Subcommittee's Revision of the Framework of Recommendations

Presenter: Mary Lou Addor

A drafting subcommittee with EFSAB members, Amy Pickle, Chris Goudreau, Fred Tarver, Ian McMillian, Sam Pearsall, and Jim Mead, met May 1 and May 9. They were tasked with reviewing and reorganizing the list of recommendations generated in March (information located on pgs. 11-32 of the March 19,2013 meeting summary). At the April 16 meeting, the EFSAB members, in a review of the March session materials, requested not only a reduction of the 21 page document but also requested that the recommendations were separated from the dialogue and opinions located within the document.

The drafting committee reviewed the 21 page report line by line, including additional comments from the April session. The information was reviewed for repetition, overlap, and opinions and reorganized into two separate documents:

1. A one page framework of recommendations - working document- Draft 1
2. A three page document that identified material for explanatory sections (e.g., preface and summary). Both documents are located in Appendix A (page 65).

All input received from the March and April sessions to generate a framework for recommendations was incorporated into the two documents or it was not included, because, in the view of the drafting team, it was:

1. outside the charge of the EFSAB;
2. dialogue or comments that were not actual recommendations; or
3. on hold pending input from two committees (vulnerable species and coastal ecosystems).

Both documents were presented to the EFSAB during the May 14 meeting for the members to review. The following comments, concerns, and questions were offered by the EFSAB:

Comments, concerns and questions regarding the 1 page framework of recommendations.

1. Under characterization, item 1: What we heard today from RTI – indicated in part that there might be more of a statewide approach. Recommend changing the second sentence to read: That classification **may** include meaningful physiographic classes (remove very least).
2. Under characterization, item 2: What is a flat rate minimum? Items like 7Q10. Recommend changing the last sentence to say: This precludes **or goes further** than using a flat rate flow minimum strategies (e.g. 7Q10 or Sept medium).
3. Under characterization, item 1: Giese and Mason was being offered as way to classify the state not as flow strategy recommendation.
4. Under characterization, item 3: will need to identify the definition of class you are using if classes are used.
5. General comment: recommend targeting the recommendations to the Department as proposed in

the House Bill 1743 versus the Division.

6. Under ongoing validation, 2c: a member offered caution about using new data that was similar to "the flavor of the month" to modify classes, characterize target flows, …without a fairly strong review.

7. General comment: overall, the framework is adequate to move forward. However, it does not include new materials or presentations thus the language is limiting.

Comments, concerns and questions regarding the 3 page explanatory of information.

1. Question: Why was the section, "other aspects of the ecosystem to define ecological integrity" included in both the Preface and Summary section? Response: the subcommittee did not decide where this information should be located and thus listed tentatively in both sections.

2. Question: I thought we included just the last sentence regarding visual representation under the section on Necessity of Models? Response: the portion listed is accurate though any section can be edited.

The EFSAB thanked the subcommittee for their efforts in condensing the material generated in March and April. Rather than providing individual additional comments on the two documents, the EFSAB expressed that they would like to meet together to continue to draft the framework of recommendations and perhaps provide a visual of the recommendations. Any new material or presentation has not been included in the framework of recommendations –working document -1. What the EFSAB decided would be useful would be for the subcommittee to meet again and draft the preface section.

Next steps: the drafting committee will meet on May 30 to draft a preface section and distribute to the EFSAB prior to the June 18 meeting. The summary section would be written later. If anyone has comments on the outlines themselves – is anything missing? Is anything too restrictive?

VI. Presentation: Coastal Flows Workgroup

Presenter: Bob Christian

The Albemarle Pamlico National Estuary Program (APNEP) and their science and technology advisory committee had a meeting about a month and a half ago. I went to that meeting and presented some of our work and was very pleasantly surprised that they have ecological flows for the coast and for the Albemarle Pamlico sound as one of their priorities for their comprehensive conservation management plan. So we are not alone in that regard. Also, if any of you have not seen it or are interested in such things, the Water Resources Research Institute for North Carolina just put out their research priorities for their calls for proposals, and ecological flows are among their research priorities. So I think there are other activities going on in the state to supplement our work and also for us to supplement theirs.

Q: How far along is APNEP?

BOB: They had their first staff meeting to discuss the issue, so not very far. But I look at them as

being an organization that may help us extend the work that we might be able to begin through this group. At any rate, I got a list of names of people that might be useful in a coastal ecological flows working group. I sent out invitations and got maybe half a dozen replies, and we're having our first meeting on Friday at Little Washington, at the DENR office in Little Washington, starting at 10:00. If any of you are interested in coming, please take this as an invitation. I know this is short notice, but if you can come, I would love to have you. As I told Judy, it would be great to have one or two other people from this Board at this meeting so that they just do not hear the world according to Bob when I get this working group together. Our hope with this working group is that by the July meeting of this Board, we will have some recommendations as to better ways to treat the coastal plain other than just use literature values. I think there are some opportunities, especially through the Division of Marine Fisheries and their information on the various fish species along the coast and the flow needs of those fish species. The biggest challenge to me is probably the hydrologic modeling challenge and I do not know if we can make any advances there. I have some ideas; I think some others do, too. So, again, the invitation is to any of you to come on Friday, Little Washington, the DENR office, right next to the Belk shopping area. And if you want to let me know you are coming, that would be great; I will get an extra doughnut for you. If you do not let me know and you still want to come, please, come.

Questions (Q), Comments (C), Response (R):

Q: What do you see are the issues in helping to define those ecological flows in the coastal plain, especially along the coast, as it were?
R: Well, I think there are several. One is, is there a classification scheme—the three issues: classification, hydrologic modeling, and availability of the biological information. That's what you have been dealing with. I think there are perhaps some classification schemes that we could use that are different to bring in tidal, non-tidal, influence of salinity, etcetera. I think the hydrologic modeling—there may be some models, in fact there are some models that deal with overbank flow that may be of interest to us to look into that we just have not dealt with here. And then thirdly, the Division of Marine Fisheries data set pretty much has been ignored by us and there are a couple of people that are coming that are very familiar with it so that they can bring that expertise, along with the ecology of those fish to the table.

Q: The other complication would be the aquifer and some of that area of the southeastern coastal plain?
R: Yes, the ground water, surface water issues become very close to one another, if not overlapping in the coastal plain, much more so than here. So, that is a good point.
C: So, same problems, just bigger and more.
R: Quantitatively different. That is right. And salinity--that's the qualitative difference.

Facilitator: So Bob, which organizations are represented on the coastal group so far?
R: There are a few people from ECU, DMF, Wildlife Commission, I guess. So far, there—oh, and APNEP.

Facilitator: Any other questions for Bob or any requests as he goes into this coordination group on Friday?
Q: How many meetings do you foresee?

R: Well we can knock this off in 2 or 3 meetings, that is no problem. I think that is all that we can expect from an ad hoc group, is maybe 2-3 meetings, especially by July, by the third week in July. And as with this group, we probably will not have the solutions, but we may have some directions.

VII. Presentation: Report on Work of Endangered Species Subcommittee

Presenter: Chris Goudreau and Judy Ratcliffe

Chris: Sarah McCrae, Mark Cantrell, Judy Ratcliffe and I had a call last week to try to get our heads around this again, and some of this has been on the outer edges of our discussions here--this whole issue of how are we going to deal with listed species and ensure that they are adequately covered in whatever recommendations we bring forward. So, I will just go down the list of talking points that we covered in our call and Judy is going to present the start of moving forward. So, just to remind folks, the issue of listed species was raised a couple of times. One, originally, was raised when wondering if waters containing listed species are going to be covered or not in the basin plan models and if so, do things like PHABSIM adequately cover those species, or does the BEC analysis adequately cover those species. And those are things like mussels and fish and plants and other invertebrates. Some of the species probably are covered with any analysis that we have done so far—PHABSIM or the flow biota relationships—but we are not sure whether all of them are. That is part of the reason for coming up with what species we should address. So the additional work that needs to be done is producing this list, cross walking those species with the guilds that we have already established, and establishing that we are confident that these things are covered by something we have already done. And then with whatever is still remaining, do additional work on those species or life stages to see how we can make sure that we are not forgetting them. So with that shortened list we could produce a map, for example, that shows where those species occur, which stream reaches hold those species. And then, if necessary, depending on how all this other stuff works, if you have something like what Jennifer presented as a recommendation, you might want to have another trial balloon that gets floated that says in regions that have listed species, particularly these that we are not sure are covered under the other analyses, we might want to have a more stringent approach that raises the flag earlier, for example, or is more sensitive in raising a flag, so that whatever recommendation that DWR moves forward, the species rise to the top of the list. And so, it is kind of just a cautionary principle approach to things, just make sure we are not forgetting them. Then, as additional information is gained over time of either additions or changes to the list or additional information about any of these species, then that would be part of an overall process for updating the approach that DWR uses. So that would be kind of a post-processing thing, or post-this-process-part of the recommendation.

JUDY: From our Natural Heritage data I generated a list of aquatic federally listed endangered and threatened species known from North Carolina.

Chris helped me with the organization of it, as well, and developed the evaluation of whether or not they are flow dependent and we put yes on all the blue ones. And then, the ones at the bottom are marine animals. The West Indian manatee, we did not want to not include these coastal species, because we have the coastal question. But I would raise it for general consensus that we would

probably want to drop these off of our list, as far as the species that we are going to focus on from this threatened &endangered (T&E) aspect because the manatee, for example, is just an intermittent visitor to North Carolina. It is not considered a part of our breeding fauna. It shows up sometimes, it might race up and down the coast. We track it because it is listed, but we do not consider it an integrated part of North Carolina's fauna.

C: But more importantly, where it occurs in North Carolina, it does not occur in any flow dependent systems, per se.
R: There are documented observations of it well within the Neuse River, pretty far up. But in this discussion about its flow needs, I do not think that this is the life stage where we would have implications for our work.

Scientific Name	Common Name	River Basins
Alasmidonta heterodon	Dwarf Wedgemussel	Tar, Neuse
Alasmidonta raveneliana	Appalachian Elktoe	Little Tennessee, French Broad
Elliptio steinstansana	Tar River Spinymussel	Tar, Neuse
Lasmigona decorata	Carolina Heelsplitter	Catawba, Yadkin-Pee Dee
Pegias fabula	Littlewing Pearlymussel	Little Tennessee
Pleurobema collina	James Spinymussel	Roanoke
Villosa trabalis	Cumberland Bean	Little Tennessee
Acipenser brevirostrum	Shortnose Sturgeon	Chowan, Roanoke, Tar, Neuse, Cape Fear, Yadkin-Pee Dee
Acipenser oxyrinchus	Atlantic Sturgeon	Chowan, Roanoke, Tar, Neuse, Cape Fear, Yadkin-Pee Dee
Notropis mekistocholas	Cape Fear Shiner	Cape Fear
Percina rex	Roanoke Logperch	Roanoke
Erimonax monachus	Spotfin Chub	Little Tennessee
Menidia extensa	Waccamaw Silverside	Waccamaw
Ptilimnium nodosum	Harperella	Tar, Cape Fear
Spiraea virginiana	Virginia Spiraea	French Broad, Little Tennessee
Trichechus manatus	West Indian Manatee	Marine
Dermochelys coriacea	Leatherback Seaturtle	Marine
Eretmochelys imbricata	Hawksbill Seaturtle	Marine
Lepidochelys kempii	Kemp's Ridley Seaturtle	Marine
Caretta caretta	Loggerhead Seaturtle	Marine
Chelonia mydas	Green Seaturtle	Marine

Q: These are federally listed species and you or Chris may have mentioned this, but why did you not include state listed species or Center for Biological Diversity settlement species which are required for evaluation as for potential listing?
C: I would start with the latter, and the latter is that we have been petitioned and continue to evaluate species on an ongoing basis. Until we are making the determination of whether a species will be listed as endangered, threatened, then it is not on the official list of federal species—
R: I know.

C: So this species list is somewhat dynamic. It could get additions or deletions as we have had in the past for federal species. As to state listed species, I guess I will defer back to Judy, but there are a number of additional species that are listed by the state as endangered or threatened.

Right, so the state does maintain a list of endangered, threatened, and special concern species. That is the jurisdiction of the Wildlife Resources Commission. They have legal responsibility for listing of those 3 categories of species. I can certainly present that list of species—without any hesitation, I can present that list. Part of the reason I am not presenting it at this time, is that we have the highest responsibility to the federal species. That is legally binding. The Division of Water Quality and every other state agency has responsibility for maintaining these species in North Carolina. The responsibilities that are related to the state listed species are not the same. Their level of protection is not robust.
C: They do not have the legal status that the federal species do for protection.
C: So there is that...
C: But in this room, we are not so much about legal status as we are about scientific condition.

I agree. So we can also go into that question. There is a listing process with the state. There are scientific councils for the state. There is an existing list, and there is quite an extensive list of proposals for changes to that list. Those proposals were made approximately 5 years ago and the Commission has not taken those up for consideration to change and amend the list of endangered, threatened, and special concern species. I would be happy to present the current list; however, there are significant pending changes that may be taken up by the Commission in the next couple of months, or it could be 2 years from now. So the legal list in North Carolina may or may not reflect accurately level of imperilment of the species. So there is that aspect. And then in eyeballing the data, as I do fairly often, many of these species are species associates of the state listed species. So by taking the federally endangered and threatened species into very, very serious consideration, they are acting as an umbrella to some extent for the state listed endangered, threatened, and special concern species. So as a first blush, this is what we are presenting to you. I am going to make the question about whether the marine species, by general consensus, could be dropped from consideration. And then I would take suggestions and recommendations from the Board as to whether or not we want to include state endangered, threatened, and special concern species, as well. And the Heritage Program also maintains a list, in addition to the special concern below that, as significantly rare and then we also have a watch list. So this can be narrow or it can be very broad. We will have to leave that to the Board.

C: Just another thing to point out is that as far as the federal listing goes, we also do not have the candidate species.

Right, there are candidate species. And there are petitions--

C: There are candidate species and we have a couple that are actually river aquatic.
Most of those will be covered by that state list, if we decide to go that route.

Right. I do not know if everybody got that, but that petition list in general was derived off of the state list of endangered species.

C: But again, the petition list was what I was referring to. Until we make a determination and review those, we do not know. Some of those, at the early blush, were some that we had already identified as candidates that we have been petitioned for and we get petitions every day. Some of those were species like red bellied slider, which are not particularly rare, though they may be flow dependent or probably will not make it to the endangered or threatened species list in North Carolina.
R: I was not actually asking about the petition species. I was asking about the settlement species, for which The Wildlife Service and Center for Biodiversity have signed the settlement in which the Service agreed to evaluate a list of species for listing. And that was as a result of a lawsuit that the—
R: And those are the same that I'm talking about. We [USFWS] did agree to review those. We agreed to a schedule to review those. But all the ones that we have been petitioned, we do review. So that is a given. If someone petitions us, we review. But we agreed to a schedule to make a determination. But we have not determined if it is warranted or not warranted yet.

Facilitator: So any general questions about what this group is doing before making decisions on a list that you will be looking at?

C: Depending on how broad the list is, the list really is not going to be as relevant as what we do with it. Are we just going to identify locations or habitats that are likely to be impacted, and, if they are, what kind of recommendations will come out? I think the list can be as broad or as narrow as anyone wants. But what we do with it seems to be the critical question. These are all listed as being flow-dependent. Some of them I can look at and can say they are dependent on relatively high flows or riffle type areas, like the more sensitive fish guilds might be. Some are not. Sturgeons, for example, might be a little different except in some parts of their reproductive strata. It looks like that is going to overlap a lot, with the more indications and sensitivity.
R: We kind of anticipated that that cross walk, where we would link the species that we had consensus on to look at, we would cross walk those to the guilds that are already being used and determine whether or not the modeling is adequate to capture the concern.
R: Well I guess what I would ask beyond that point: if someone were petitioning to do something to a stream--impound it, withdraw water—I am sure there are mechanisms already in place for dealing with the impact on endangered species that are known to occur in that particular reach. And how much do we need to duplicate that, other than identifying it as these are the areas and the broad categories that might have the most impact. Other than that, I do not know that we really have the time, energy, funds, etcetera to develop the criteria for regulating or suggesting approaches beyond what is already in place.
C: Yes, so back to something that maybe I did not make as clear as I needed to up front, is that there are those other processes for site specific issues that come up. In terms of a planning tool, it might just be that whatever list we come up with, included in our recommendation for use in the model might just be indicating the reaches that have endangered or a listed species in them and that trips the flag. That might be as simple as it gets, kind of along your lines, is that the other processes will deal with the specifics when and if those arise. Or we can just say no, everything we have done is already protective enough with this and we do not need a separate flag—
C: From a screening perspective. It is not that the flow, the specific flow would be met or if its needs would be met, but just from a screening tool, perhaps, recognizing that a changing riffle guild—that would trigger—would be sufficient.

R: I guess I am working under the assumption that such map identifiers, location identifiers already exist. I do not know if maybe they do. Maybe they do not.
R: They are mapped. That could be converted into the NHDPlus catchments, so you will have site-specific information. So that could be easily done.

That vein is why this is a small list, in part. Because if it were to be an overlay that was a trigger in and of itself, this is where the rubber meets the road with the federal law. But the state-listed species is a longer list. If you used that as the trigger for what happens next in the evaluation process, it would be a lot more geography.

Q: Is the geographic extent for the state-listed species defined? Is there a map of those?
R: Yes. It is all GIS available. And I can present that whenever.

This slide shows the basins that they occupy. So, Heterodon is found in the Tar and the Neuse. I did this quickly this morning, and I may have missed a basin or two. Elktoe is found in the Little Tennessee and the French Broad, and by these I mean basins. I am not getting down to the Little Tee River at this point, but we can get down to the catchment, NHD catchment, or we can get down to an 8 digit HUD, or a 12 digit HUD.

Q: So out of the 17 basins, probably every one of them is covered by riffle? Or just about?
R: Pretty much. Yes.
C: Spiraea is in the New.
R: Yes. Sorry about that.

Q: How is the spiraea flow dependent?
R: Well it can be found on rocky bars in the midst of river channels and thus its habitat is scoured—
C: Although it is a flowering plant, it depends on flow for a couple things. One is to knock back competing vegetation, native and non-native, but also for propagation and dispersing it downstream.
C: So that is more of a high flow.
R: Yes, it is a high flow dependency.
R: It is found in other habitats as well.

Q: I guess for mussel species, you would have to assume—you would also have to capture the needs of any suspected hosts, I guess, as well?
R: That's right. And again, it is within the realm of possibility that those species will be addressed within the guilds or within the fish assemblages that are being developed or that were developed from the DWQ data. If they were not, then we would hold them out separately to the group and say, okay we are not going to be able to just amalgamate these with our current understanding. We may have to address these independently, and that might be just the distribution triggering the next step from DWR.

Q: Are any of these non-wadeable, or found in non-wadeable streams?
R: Definitely. We can divide those wadeable, non-wadeable but all the mussels are found in wadeable and non-wadeable. They're both. For sturgeon current records are only in non-wadeable, I'm guessing.

R: I think there is a Roanoke record, by the way, for Atlantic sturgeon.
R: Isn't that on there? Yes, so Chowan, Roanoke, Tar, Neuse, Cape Fear. Yes, competing.
R: It is just the way the lines—the short nosed and the Atlantic sturgeon, pretty much the same. Cape Fear Shiner is wadeable, non-wadeable. Grouper is wadeable, non-wadeable, both. Waccamaw Silverside is only found in Lake Waccamaw and in a small portion of the Waccamaw River, so that has a really well-defined area. I do not think Waccamaw is even eligible for withdrawal, it is an ORW. Harperella is wadeable, non-wadeable. And Spiraea has both, as well. I do not know, Cumberland Bean, I would not call that wadeable, but the known distributions—
C: It is flow altered.
R: Yes. So that is really off the table, I mean, kind of like Waccamaw Silverside. Not probably an issue at this point. It has a FERC license above it.
C: TV license, yes.

C: So I guess we need direction from the group. How do you want us to—
C: Definitely regarding state listed species, I think we need some kind of direction.
C: So to summarize, you are suggesting that the list of species of concern are those that are federally listed and that if a federally listed species is known to occur in a reach under evaluation, that that evaluation should become more site specific and less modeled because of the presence of that vulnerable species.
R: Not necessarily—
R: Not more site specific, but in terms of the use of the planning model, that reach would have a more sensitive threshold--is more sensitive to further analysis by DWR in their process.
Q: Okay, what is the difference between further analysis as you just used it and more site specific work as I just used it.
R: Well, when I heard site specific, I maybe misinterpreted that to mean site specific in the sense of a site specific project, as opposed to a screening.
Q: Reach specific—rather than modeling the answer to the question, what constitutes an ecological flow, if there is a vulnerable species on the federal list flagging that reach, that reach should then be evaluated in the field. Is that what I hear?
R: I am going to turn to these guys (DWR), what are you going to do with anything when a flag goes up?

JUDY: I do not think that we were planning on making a recommendation as to whether that would trigger a site specific. That has come up in the past, but not necessarily in the recommendation that we were making.
C: You also referred to this requirement under the North Carolina statute for a site-specific management plan when there is any endangered aquatic wildlife that occurs in a water body in the state.
JUDY: Okay, so that again—that is beyond DWR's, but it is—
R: It is a DWQ.

JUDY: I do not think that our recommendation is necessarily that we would say that DWR needs to initiate a site-specific study as soon as it is recognized that a federal species is present. That may be what they decide to do, but that would probably be at their discretion. I was thinking that, when we did a cross walk, we will evaluate our confidence that the species' needs are being addressed by the

broader recommendation. And if a species that is on the federal list are not adequately met, or we do not know enough about the species' needs to say yes or no, then we pull that species and maybe some others from this list out, and those might need to be addressed with the distributional flag. I am overly optimistic perhaps, but I do think some of these species can be addressed with a broader recommendation because of the scale of this, because it is at this basin-wide, at a minimum, maybe, basin-wide scale. I could be wrong about that because we have not done the cross walk to the guilds or to the BEC assemblages. But that is a possibility. Rather than stating that all of these species distributions will automatically trigger the next step from DWR, and I am not prescribing what that next step is, or maybe we will, but at the moment I am not.
C: We definitely want your guidance. I would say the U.S. Fish and Wildlife Service would have a lot to say about that. Not necessarily, the Natural Heritage Program.
C: When that flag goes up, his phone rings.

Facilitator: So your process then would be to decide what your list is and then you all will meet again, cross walk that, come up with your list of those that you might want to have as flagging, or whatever. Will you develop some kind of language for a recommendation to propose to the group as well?
JUDY: We can maybe draft some language and then the group would have to rally around it, I guess.

Q: Just to ask a question to demonstrate my lack of knowledge in this area, what happens currently? When someone applies for a withdrawal permit in an area where one of the species is known to exist, what does that trigger? A contact—Mark or someone—and they make a decision? Or make a recommendation or review? And is that process sufficient where there is enough knowledge about the requirements of these species? And if that is the case, then really it is just a matter of mapping and identifying the geography, and then maybe the focus could be on which of the listed species, at least, are out there that we do not know what the requirements are. Maybe those could be recommended for further evaluation or something, a broad recommendation, I do not know.
R: Well, there is a usual process, and then I guess we could probably decide a couple of examples, at least, where there is withdrawal, or where at least a flow alteration proposed. Mostly the ones that involve endangered species that you see on this list are on the vertical axis, so that has been a lot of the experience with the flow alterations in which we have done in-stream flow studies specific to the mussels and considered their fish host, considered their habitat needs, and looked at the wading parameters and those kind of things that we could get at the constituent elements of their habitat and live fisheries. So that is usually what those things—in the case of Swift Creek, I do not know how it started, but--
C: That was a withdrawal.
C: That was a withdrawal, and we did an in stream flow study.
C: Any of those that trigger a NEPA analysis, then that is the process. So that is kind of the short answer of it.
Q: It is the 20% of 7Q10?
R: Yes. To me, the real question is what happens in those prior to site specific requests coming in, any planning discussions that are happening in DWR"s work, are there any steps that are taken in the screening process or whatever, or just any information sharing process, that say oh, by the way, there is something else to consider here besides the routine approach. To me, that is really the question.

C: I have two points. Thinking about 20% 7Q10, that is SEPA minimum criteria. In NEPA processes that

does not really hold any water. And the other issue I would have is those actions that do not require permits, like 10 different farmers putting in pipes in the river for irrigation.
R: We know that is not something that you guys are capturing, and it will not be captured in a basin plan, and it will not be captured in OASIS. I do not think DWR at the moment has the distribution data for endangered species to initiate a conversation immediately on receiving a request for withdrawal or impoundment or anything like that to say we are aware that there are endangered species and that needs to be an aspect of our conversation. I do not think that—
Q: You do not think they would have that information?
C: You guys do not.
R: I used to send it to you twice a year.
I used to send you that information. Twice a year, and you have access to it.

Alright, with that being said, looking forward, it does seem, whether it raises a flag or not, that level of mapping could be included in OASIS so that people would see it no matter what. No matter what action would follow from that, people can see it. That can easily happen. It can be part of the planning approach, the location and distribution data.

C: Don, I would say this is your world.
R: Yes, that would be incredibly helpful. If we had that mapped out so that when we were looking at a river basin, looking at changes in flows based on projected increases in water withdrawals out 20-30 years, knowing whether there is an endangered species in one of those drainage areas would be very helpful.
R: Fantastic. So I can provide that data. I mean, Heritage Program can.
C: I will continue to provide it to them.

Facilitator: Is there an immediate action coming out of today's meeting?
R: I do think we need to answer the question about the broader list.
Facilitator: Do you want to start with the marine animals first?

Judy: The mapping for the sea turtles, by and large, is handled by WRC and the federal government and we have some broad mapping done for it, but I would just say that these are nesting on the beaches and so it is not really going to be within the habitats that would be flow included by our discussions.
R: I think it is somewhat along what Bob is going to be struggling with. Those early life stages are in estuarine and tidally dependent habitats for some part of their life cycle. I do not know. That is not my understanding of their biology, but—
R: I do not think so.
C: Sea turtles do.
R: Then if that is the case then I would agree.
C: Yes, I was just thinking about some of the sections to that at the mouths of the Cape Fear River and in some of those areas where you get some interaction with flows and in the beaches and the nesting areas. So, for the most part I do not think that those species are going to be a big factor in those determinants. Most of that happens way upstream. It would probably be good to have a better conversation about the sturgeon that are diadromous.
R: Oh absolutely.

C: I think that is where we are going to be having to drill into some of their habitat needs and life history--seasonality of their life history requirements related to flow, but yes, the turtles we might get down in the weeds that far later on.

Facilitator: So Jeff are you talking about the marine animals, dropping it? How does everybody feel about dropping the marine animals?
[all 1's and 2's]

C: or are you saying table them?
R: Put them aside for now—
R: Put them aside. I do not think we're going to have to spend time on them, but they are still federally listed—
R: Right. And we will still need some of the criteria.

Facilitator: So language would be tabling them for now. Does that change anybody's—
C: When we try to match those, that will be real interesting.
C: Well you will see where they are, so--

Faciitator: I am assuming the next step is cross walk? Does everybody agree with this list as is with the marine animals tabled?

I heard Sam's concerns over the state listed species and does this list or the list that we cross walk need to be expanded to include those that receive legal protection within the state of North Carolina even though that might be limited; there is not a legal protection for those species. And then it could even be broadened to the Heritage--
C: Let me just modify that a little bit. I am not persuaded that vulnerable species are an essential part of our recommendation, but if they are, I am not persuaded that their bureaucratic status is necessarily the most important thing for us to take into consideration. It seems to me that a more important thing to take into consideration is whether those individual species are actually vulnerable to alterations in flow. So there may be federally listed species that are not vulnerable to flow alterations, and there may be federal candidate species that are vulnerable to flow alterations. I am not at all sure that we should draw the line according to listing status rather than vulnerability status. I understand that represents a huge job for someone to go do, go through all those species and figure it out.
R: Using the guilds to define a group of species, or a habitat, or a guild that is vulnerable to flow, should preclude the need to do that.
R: Which takes me back to my first point. I am not at all sure that's species specific--
R: So it goes back to the bureaucratic question of do we have a legal responsibility or does DWR have some legal responsibility to address these species uniquely or not.
R: It sounded to me like Don would be okay with having that list, or that map, or whatever it is for those discussions for planning purposes.
R: Yes.
JUDY: So Heritage can provide mapping for both the federal and the state listed species to DWR. No question, we can do that. It will be by reach or it will be by habitat. We can talk about that.
C: I am good.

Facilitator: So was that resolved by providing that data or is there a suggestion to change this list for cross walking? I am not clear. I need some clarification on what you just agreed to.
JUDY: I mean I agree to definitely provide that data, and I think that is not necessarily related to this program. It is going to be helpful to DWR to be aware specifically of where these species are. That is not necessarily related to eco flows. It is just related to their—

Facilitator: Sure. So I am just checking to make sure—does that mean you all are comfortable. We can do a consensus vote of whether you are comfortable with this list. Amy, you look like you are about to say something on this.
R: I am.
C: I have to say something, too.
C: I think that the cross walk would be useful if what we are interested in determining is whether or not, on a few assumptions: 1) that endangered species' needs are possibly not matched by the more gross evaluation that we are doing for guilds or for anything else. So that is me saying yes to cross walk. I am not sure that looking at federally listed T and E species is the only list of species that may not have high fidelity to whatever demarcation we are going to do for overall recommendations on management. So I think this is a great place to start; I think it is a logical first step. I do not know that we will necessarily capture it all, and so I would propose doing this, seeing what happens from a cross walk and then perhaps leaving it open to reevaluate whether or not it is doing what we need it to do, which is figure out whether or not species that are particularly sensitive are being protected with whatever flow management we are proposing.

C: So I did not want the idea to slide past that Sam brought up about whether and at what level we should consider endangered species, and I wanted emphasize the point that in terms of the list of endangered species, and threatened species, the purpose of the Endangered Species Act is to protect the eco systems on which those species depend. So if we are looking at truly the reason we listed those species is not to make life difficult for people, but it is to actually protect the eco systems and the functions therein, including flow functions for those flow dependent species. Theoretically, if we protect the flows, then we are protecting the eco system, the aquatic systems that these species occur in. So that, I think, is part of that—the tie-in for having endangered species at least considered when we are looking at ecological flows in those eco systems that we are focused on here that are mostly those flowing waters of the state.

Facilitator: So unless there are any other proposals, it sounds like I am hearing Judy and her group can move forward with the cross walk in this list. If there is another proposal, now is the time to put it up. Okay. So do you plan on bringing this back in June or July?
C: I think June.
Q: Who said June?
JUDY: Okay so I need to direct that to the subcommittee because Mark I know is aware of a lot of literature that would be relevant to this and I do not know if it can be crunched through by June.
C: I think we can come up with an annotated bibliography of sorts for each species.
JUDY: Sure. We'll let you know.

VIII. Presentation: Modeling of 80% Flowby

Presenter: Tom Fransen, NCDWR

The Powerpoint presentation can be found here .

I appreciate having a few minutes at the end of your long day here. I know I have talked to you about modeling in the past and how we would use your recommendations as a post-processor to the model. As we have been moving forward here, I have been thinking about what that post-processor might look like. For those that have worked with me before, I do these types of trial runs all the time. The 80% flow-by that was thrown out as one possibility was a fairly easy one for me to test. And we are not assuming that that is what is going to be your final recommendation. It is just a way for us to start thinking in-house how to utilize what comes out of the group and maybe give you some feedback on how we would go about actually developing some type of post-processor to answer some of the questions that I have heard discussed this afternoon. So, like I said, this is just one approach. It may not be the right approach; it is just a matter of us trying to do a testing here, not make any assumptions about where the final recommendation will be. Originally I was going to do this on both 20% of 7Q10 and 80% flow-by. Especially after talking with Jim, we kind of realized 20% of the 7Q10 has really been a minimum criteria for when you need to do additional studies. It has been assumed that as long as your withdrawal is less than that, and you are not in something like special waters, you would not have to do additional studies. Consultants have somehow morphed that into a safe yield number. It was never that. It was just kind of a trigger for when you do and do not have to do a study. It has worked well as a minimum criterion. It really works probably best when you have an isolated withdrawal out in the river somewhere. Of course it does not work for reservoirs. There is no such thing as 20% of 7Q10 in a reservoir. If you have multiple withdrawals near each other, we have always had the problem with having to use best professional judgment. How close is too close? It does not really give me a metric for assessing kind of the cumulative impact as you move downstream. I cannot answer the question, if everybody is using 20% of 7Q10 up and down the river, is that too much? It has really been designed to kind of look at one node in one spot. I think the other thing that is lost in this discussion is 7Q10's are not a constant number. As we get droughts and that record gets extended, that 7Q10 changes. We have had some bad droughts. In a lot of parts of the state right now, our 7Q10's are lower than they were even 10 years ago. We start getting into the discussion when we talk about how do you calculate 7Q10, what is the period of record you should use? So those are some of the issues that we have had with that. This group is hopefully going to help us move past that. For this trial implementation of 80% flow-by, I was looking for an approach that would work for a single withdrawal, withdrawals near each other, potentially put up reservoir withdrawals, but what I was really looking at was releases from reservoirs, since you are not looking at the reservoir directly. I wanted to also have the ability to assess a cumulative upstream impact as I moved down. So that was my goal, sitting in my little cubicle doing this one afternoon. One of the starting points is the baseline. Where are we starting from is the statue:

- **"Ecological integrity"** means the ability of an aquatic system to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity,

and functional organization **comparable to prevailing ecological conditions** and, when subject to disruption, to recover and continue to provide the natural goods and services that normally accrue from the system.

- **"Prevailing ecological conditions"** means the ecological conditions determined by reference to the applicable period of record of the United States Geological Survey stream gauge data, **including data reflecting the ecological conditions that exist after the construction and operation of existing flow modification devices, such as dams**, but excluding data collected when stream flow is temporarily affected by in-stream construction activity.

An analysis assumption is that the **SIMBASE** modeling scenario represents "Prevailing ecological conditions". SIMBASE is the model scenario that represents current conditions, withdrawals, discharges, reservoir operations, drought plans, etc.

I used 80% of SIMBASE. I have done it. I will show you some of the issues here that I came out with. We are going to need some guidance if we move forward with this, how do you interpret in terms of seasonality, number of days, that type of thing. What I tried to show here [slide 7] was kind of the graphical presentation of what I put into words. The light black line is SIMBASE, the red line is 80% on each day, and the green line in this case is the 2060 run. Based on at least my criteria to start with, any time the green line is below the red line, that is a day that has a potential adverse impact. This is what we want to see, the green line above the red line. That is kind of what you would expect; it should probably be somewhere in between. To really look at this you have to kind of really look real tight on it. But that is the methodology graphically. I used for this trial balloon the Broad River Basin. That is the only basin for which we have a certified model. It is probably one of the simpler basins to deal with. It has some reservoirs, no hydropower, not large complex like some of them. There were 27 nodes on which I did the analysis, basically the all the river reaches in the model. It has a record right now of 1930 through 2009, so we pick up these latter droughts. Before I did the analysis I said, okay, you remember when I said to look at withdrawals, reservoirs, and kind of the cumulative impacts. I am going to focus on the Cleveland County intake, the releases from Kings Mountain, and then the Gaffney Gage down here in South Carolina is kind of a cumulative impact one, near the end of the model [slide 10]. We will see how it works out. I tried doing the whole hydrograph and as you can imagine, you cannot read anything, it just is all on top of each other. This is the only one I am going to show the whole network of gages for [slide 14]. The yellow ones are the ones that we actually focus on. The color code here means the red ones are where we have at least one or more days that the green line was below the red line, and as you can see, 74% of the nodes, 20 out of 27, I had some potential adverse impact. But if you notice, all of these are less than 1% of the days although Kings Mountain here, if you run it up, is probably 1%. So the question becomes, would you call that basin having an ecological impact based on our predicted 2060 withdrawals and management strategies. Kind of zooming in a little bit on those three nodes [slide 15], you can see the ranges of absolute differences here. Also expressed is a percent difference. After talking to Jim, he suggested I try to normalize that so we can get a feel for the magnitude. The absolute difference up there of 5 in a flood is going to be a lot different than the 5 in a drought, so this kind of helps you portray that a little bit, in terms of the ranges. What I tried to do here [slide 16] was expand that out so you can see where the differences are occurring. The black here relates to the absolute, the red reads off the other side, so that is the percent. It really comes out not too surprising, where the 30s drought, the 40s, the 50s, the late 80s and then the 2002, 2007 droughts are where you are seeing these potential days of impact. Kings

Mountain [slide 17], I am not surprised, with the reservoir, its being a little bit more than just a run a river intake. So we are seeing a little bit more. It is kind of breaking out along drought patterns again. Gaffney [slide 18], I was actually surprised with that downstream node. I was expecting to see more there. Apparently there is stuff going on upstream that is kind of off-setting some of the other impacts that are going on. I know with Chris, looking at your work, we have used duration curves as one way to express this. I plotted the duration curves, but the lines were on top of each other, so you really could not read them. So I represented them in the table [slide 19]. If you take from the tabular, kind of a duration of frequency analysis, we only got 3 points up here: two in the Cleveland and one down at Gaffney, at the very bottom, that you are actually seeing that the duration curves would be below the 80% duration curve, and not by that much. If this approach is used, did the way I did this analysis make sense? Is this the right way to do a flow-by requirement? Do you agree that SIMBASE is the correct starting point? Do all the flows need to be above that 80%? Can a certain number of them be below? Is the time of year more important? So there is just a whole host of questions here we could ask on how to interpret it. Remember, like I said, this was not me telling you we are going to go ahead with 80%, it is just to help you understand how we are going to use something like a flow-by approach if that is the recommendation or something similar, how we might approach putting it in a model. I am sure there are questions. When I presented it to staff, they did not grasp it right away. I had to explain it a couple of different times. I can go back to any of the previous slides or whatever.

Questions (Q), Comments (C), Response (R):

Q: SIMBASE, how would that compare to this PNV that was discussed earlier for WaterFALL?

R: I am not sure—

C: SIMBASE is the existing conditions with all the withdrawals, discharges, dams. It is the human-altered, under current condition hydrograph.

C: It would probably be more representative of that 2006 data.

C: Okay. Alright. So from the point of view of our objectives, SIMBASE is really, from the legislative point of view, SIMBASE is the current conditions from which we are supposed to make decisions about changes to ecological integrity rather than the pristine conditions. Is that correct? So our reference really should be these current conditions, rather than pre-settlement conditions.

C: Sure. And if my understanding is right of Jennifer's work that the difference between the 1976 land cover information and the 2006 shows what the change had been over that period to give an indication of what change might be in the future beyond her prevailing conditions--what changes in prevailing conditions we might see.

Tom: Like I said, whether I picked the right scenario—it was just a way to get the discussion started. I know you are not at the step of a recommendation yet, let alone how to implement that recommendation, but I thought it would be helpful as a group for you to see at least a way to start as things formulate. Because I know that it looks good on paper until you actually try it. Sometimes then you might be surprised that it may be more difficult to implement or give you results you hadn't counted on.

Q: Do you want to go back to one of those days where you just said, look, it is not surprising that here are the droughts that stand out.

R: Gaffney Gage is not too bad. We know we have some severe droughts in the mid 50s. We have that late 80s drought, but we basically know that really the 2002 drought was really a 4-year drought ending in 2007. Whether this is going to be representative of all basins or not, this just happened to be the way three of the nodes in this one came out. So since all three came out

similar, I am expecting that if I did this for all of them, it would be something like that. There may be other ways to graph this or present it. I mean, this is just my first shot at trying to get a handle on what the data is telling me.

Q: I apologize, Tom, because it did not really hit me until just now thinking about Bob's question about what is SIMBASE and so on. The PHABSIM work we did way back with all those various flow scenarios that were diagrammed for their habitat, the varying percentages of flow-by that were put in there were actually not percentage of flow-by SIMBASE, they were percentage of flow-by unregulated, or unaltered, or whatever you want to call it. So, that was for one purpose, this is a different way to look at it. I just wanted to point that out. For the scenario you ran, I do not know, but if the water users in the Broad Basin are not projected to grow very much, in with their 2060 projection, you would not expect a lot of days to be less than 80% of SIMBASE, but what are they in terms of 80% of unregulated? I recently picked that 80% of unregulated when we were doing the PHABSIM scenarios because we were treating it kind of as new withdrawals. What flow do you need to maintain ecology if you have a proposed withdrawal, well 80% of what is there before the withdrawal, does that seem reasonable, but there is a difference there. That just struck me just now, thinking of it then.
R: Since we have already got that natural flow run done, it is about a 20 minute answer because we have been able to write a script that will do that whole table of all the nodes, but to generate that full analysis takes the model about 20 minutes to run to do the post processor, which is not bad since it is doing everything in one shot and I do not have to keep hitting the button over and over, 27 times. So we could do that to find out. Like I said, for this exercise I was starting from what was in the statute as a starting point. I had to make an assumption, and I am not guaranteeing my assumptions are the correct ones. It is just, like I said, me sitting in the office one afternoon trying think through what this would look like.
C: So I think it was a good assumption based on the legislation. I think it will be important to understand what the naturalized flow would look like, as well, because it is that eco deficit piece that you would be illustrating then, the implications of 80% within that, because the difference between that naturalized flow and the SIMBASE, that is going to capture the change in the flow.
R: Yes, but eco deficit that RTI was using, their base line is—it does remove all withdrawals, discharges, dams and in addition to that, which OASIS cannot do, it adds a more undeveloped land cover.
R: Right so it is not going to be truly the same, but it will be closer, a closer comparison. I think it would be helpful to understand what the Broad's net flow, what the cumulative impacts that is already reflected in SIMBASE. There are already cumulative impacts.
R: Yes, I understand there are already cumulative impacts. It is easy enough to do it now, since we have the script set up. It is just trying to—if it is going to help you make a decision, we would be glad to do it.
C: But there is a difference, though. You would have to run the model based on what this says.
R: Well I can run the model on anything I want, but at the end of the day I have to kind of rely on the statute.
R: So, to me, the other stuff was done in order to get to understand what the flow biology relationship is. So it is not tied to this. So it is two different things. I think Judy was saying the same thing earlier. I mean this makes sense for what you did and I would not get too hung up on that. To me, the bigger question is your other bullet about do all flows need to be greater or equal

to 80% of SIMBASE, in other words, you have tripped it, but then how many days or how many consecutive days or some other measure of what is really a problem.
C: And that is one of the key questions for this group, regardless of what metric you do.
R: Right.
R: Yes.
C: Maybe more than any other question.
C: Right.
Q: Well, but 80% of SIMBASE as far as impacts, impacts to the biology, 80% of the naturalized flow, when you take an 80%, if you allow 80% flow-by of a naturalized flow, that is x amount of CFS, right?
R: Yes.
C: That is not the same amount as what 80% of the SIMBASE CFS—
R: I know they are not.
C: So, if using PHabSIM, you are saying that 80% is the percentage of naturalized flow that causes the least amount of change in habitat, and if you use SIMBASE and 80% of flow-by for SIMBASE, that could actually be 75% of naturalized flow, and the impacts to the habitat are huge.
R: Right. What I am saying though is if it is true that the statute requires SIMBASE to be prevailing conditions, then we are not able to change that denominator. We can change the numerator by saying well, 80% is not the right number. I do not think we can say, "Do not use SIMBASE, use natural flow."
R: No, no. I am not saying that you want to test where is SIMBASE relative to the naturalized flow.
R: Well it is easy enough to do that test.
R: Right. I mean there might not be 80% there.
R: That is fine but all that does is lead you to the next question is how do you change your flow recommendation. It does not say you can go back and change what SIMBASE is.
R: But what I am saying what your analysis then of PHABSIM would be okay, not naturalized flow, it would be the SIMBASE flow. If you run SIMBASE through all the PHABSIM work and you say, what percentage of flow-by do we need to cause the least amount of environmental damage—
R: That is a different analysis.
R: It is a totally different analysis. But you cannot say if that is already—if SIMBASE is already at 50% of naturalized flow.
R: I understand what you are saying.
R: Add 20% more withdrawal to that, it is apples and oranges.
R: I understand.
R: So I just do not see how it would not be the flow. I do not see how you could use the 80% flow-by.
R: So where it really goes is like I just said, if you are hanging your hat on 80% because of what PHABSIM said, you would have to re-run all that or somehow factor that amount back into that 80% flow-by instead of making 80%, it has got to be 90% or 84% or whatever, some other way.
R: Which I thought you would get at that by finding the difference between the naturalized flow and you would see—
R: No. It is not going to be—
C: But that is going to be much more dependent upon the individual reach of the river.
R: That is what I am saying.
C: And not just on soil type, etcetera. So I think that the thing that I come back to is we have just

been saying option two is so great and one of the reasons—and it is not that it is not, but one of the reasons I liked it, besides it having some mechanistic characteristics, is it was reference based. But the reference conditions were pre-settlement reference conditions which is different than the naturalized flow conditions, which is different than the SIMBASE conditions. And it seems to me that this is a whole new component to what we have been talking about. It is awfully late in the game to start worrying about this, but I do not know how you not worry about it.
R: But I think it does maybe highlight exactly where the biggest impacts to our aquatic biota may come, and it may not come from the next withdrawal, it may come from the last 10 withdrawals. That is where the issue is; where is our baseline starting and the impacts, and we can partition where those impacts are coming, to the habitats, to the ecology. We can partition that out and demonstrate that it is what has already occurred in some basins, in others we may not be in that vulnerable stage yet.
R: Well with that, any place you have a reservoir, or downstream of that reservoir, you are going to have significant alterations from the naturalized state.
Q: When you ran SIMBASE, just trying to understand what the inputs were to it for the 60 year time frame, do you use the historic hydrology?
R: Okay, for SIMBASE we have that whole synthetic record that we created at all the nodes that go back to 1930 through 2009. We are using current demands, current demand patterns, and it also includes the current drought operation points.
C: But not projected.
R: And any operation rules for any of the reservoirs. So that is SIMBASE. The difference between SIMBASE and the 50 year and the 2060 runs is we now have replaced current demands with our projected 2060 demands, and if we also know of any new water plants coming online, any changes in operation, any new waste water plants, plants going offline, all that—our best guess of what 50 years in the future might look like. So that is the difference between—
Q: So that was the 2060?
R: That is the 2060.
Q: When you run SIMBASE on a period of record, you are basically running current management rules, whatever they are. But the flow inputs over the period of record are influenced by the evolution of land use.
R: They cannot filter out—
R: You cannot filter that out. You can filter out all human modifications. You can take dams out of the stream and all that. You can take intakes and outfalls out, but the topoedaphic with land cover context you cannot really mess with. Now when you are looking into the future, from now to 2060, you are basically projecting future management rules, new withdrawals, new outfalls, new modifications, flow in some way or another, but you are using current land use and inflows, right?
R: Well the current and historical, yes.
C: It would be that same pattern, though—
R: It is the same pattern.
C: 80 years of evolving land use—
R: But what you are using are average values. You are not taking the projected. If inflows have changed gradually over the last 70 years as a result of climate change, and they have, or land use evolution or whatever, you are basically just taking the average of those values and projecting them forward?
R: It is the same exact pattern.

R: It is the same, yes.
R: The only change in that withdrawal or discharge number, everything else—
R: Or operational or whatever.
Q: Are you running future rules on past performance?
R: No, on past flow record.
R: On past flow records, that is right. Okay, never mind.
C: So we get the whole spectrum of flows that have occurred over 80 years, and when we describe that situation to water withdrawers, you use the language of if we get a recurrence of flow conditions like we saw here, where they were low, you could expect to see a shortage in your supply for this many days, this many times.
R: I should have known that. You are basically taking a future set of management conditions and applying them to the period of record.
R: Yes.
R:Okay.
Tom: If you are expecting answers from me today, I am sorry I was probably in charge of some more questions.
R: No but you bring up good thoughts for where we need to go with our final recommendations, more than what we were thinking. At least that is what I think.

Q: So on your little red spikes, just trying to understand what that looks like in the river itself in each one of those nodes. Can you—
R: Okay, the red spike here, you can look at both nodes, in this particular case, you are about 23 CFS below the 80% line, which is roughly 15% of the flow for that day. So I was trying to look at magnitude as well as percent so that way if you had a—say if that was 20% or 20 CFS of flow, my percent here would be small.
Q: That is a daily?
R: That is a daily. This is done at each day.
Q: So if you ran both the 2060 and the 2010 data through IHA, which statistics would show up here as being affected?
R: No clue. Without doing it, I really cannot—I mean, I had changed it as a whole suite of statistics, so I cannot answer the question, which one is—
Q: Is it just going to be the single, you know the single low flow days? You know, like you are very low percentage?
Q: Because you do not have one just of the 2000s, do you? Alright that one will work. Since this a frequency curve, I would expect that maybe some of the low flow statistics might be slightly impacted, but—
C: The one day or the three day low flow or the seasonal—
R: For this particular basin because of, I mean there is growth, but not a lot of growth, I am not seeing a lot of change. I would not expect a lot of change in that variety of statistics. I guess from my viewpoint, I like simple and that is what I kind of liked about that 80% flow-by. I had a very simple number to work with, rather than try to understand the impact. I can explain that to somebody. I know over the years of working with you all on different projects, you worry about things like the shape of the hydrograph. Since I am looking at each day, I know I am keeping the shape and I am trying to preserve the shape of that hydrograph and short-term droughts and long-term droughts, floods, droughts—all across the whole board, so, I am not—

C: So that is what I was thinking because I am trying to think in terms of the way we have analyzed, you know, pre and post-withdrawal in sorts of hydrographs in the past, but this one does not look like it would even show up in IHA statistics, really in comparison.
R: For probably those three, the one I would expect the most impact from would be if you did something with a natural flow over here at the dam. Of course you are going to have a big difference just by the fact that you have that storage there. The Cleveland intake is probably not going to see much. Gaffney is the one that kind of surprised me the most, to be honest. But that is why we run models. We cannot always know what the answer is going to be.

Q: Does that have anything to do with where it is positioned, that it is in South Carolina, that there may be withdrawals and—
R: We have tried to work with South Carolina to capture what is going on within the scope of the model that we have. It may not be as accurate as we have in North Carolina, but we have tried to capture it, too. You may be losing water down there on some of these, you may be below major tributaries.
C: So really, then, we can look at what that does to people like Great American who want to build intakes at Cleveland County and withdraw water, so it looks like they are not going to meet their demand for a couple of days, or that they need to have some volume of storage in reserve.
R: I am not ready to apply this to an actual project.
C: So we could probably do that, but we could really look at that and see what it does to the physical habitat for the biota.
R: Yes. And I think what I kind of liked about it the more I worked on it is this now also lets me look at that cumulative impact as I go downstream because you do not always know what is going on. As I go downstream, I may have withdrawals. I may have some new discharges. So I can kind of see that cumulative impact as I go down. The engineer in me says by working this approach, I could actually come back and tell you all things being held constant, how much more you could take out of it. With some of these other techniques, because of the wide range of statistics in them, I would have to do a trial and error method and I can probably back calculate this one directly.
C: But the SIMBASE has that flow in between nodes built in so you are seeing those accumulations.
C: This is the one that has gone through the EMC's approval process, that we have gone through a model certification and shown the whole thing about how it's been built and how it compares to the historical flows out there. It has been signed off on by the Environmental Management Commission as being a reasonable representation of the Broad and kind of met their stamp of approval.
C: I think I appreciate the cumulative piece. I think that is really a great piece of this, but I guess I would step back and just say where did we get the 80% flow-by number if we did not get it from the PHABSIM work? I do not currently know what the biological implications of that are. That is not something that we have data for.
C: And as Chris pointed out, if we tried to use something like SIMBASE as our baseline in PHABSIM, we would have a moving target as a baseline because each site would have a different—some of them may have had upstream intakes, and other things affecting their SIMBASE flow. Others had very little if anything affecting whatever flow was arriving at that location or PHABSIM study site so there would not be any difference between SIMBASE or—hardly any difference—between SIMBASE and unaltered baseline. So it had something that was a consistent denominator using unregulated, unaltered, natural, whatever you want to call it—at least we had a consistent

denominator for all—what was it 9 sites—
R: I do understand that. So 80% flow-by of a natural flow means that very little habitat is altered. I would have confidence in that, but that to me, has almost no relation to 80% of flow-by of SIMBASE because, again, that is a moving target; SIMBASE for the Broad is going to be different than SIMBASE for the Neuse, and it encompasses all of the current withdrawal scenarios that presumably have impact to them. And so I just do not think that 80% is going to be the number against SIMBASE. It would be against the naturalized, and then show me SIMBASE against that and the new scenario, and we will talk about where the deviations are. You see what I am saying?
C: We wrestle with this all the time during hydropower licensing. What do you use as your baseline in current conditions or unregulated conditions, and you decide by how much change you want to have: where are you now before you decide where you want to go in the future.
Tom: Well if there is something else that some of the modelers can run for you to help you as you work through this, let us know, we will be glad to at least take attempt at it. Hopefully this did not confuse things, but help give you some ideas to think about.
C: One thing that would be really nice to know then is the difference between, at least some examples, of the difference between naturalized flow and the SIMBASE flow, if we can get some kind of metrics on that, maybe for some of the sites that you have done for the PHABSIM.
C: That can be done, but it is really hard to tease out.
R: Everything we have done has been hard to tease out.
C: If you have done a record of climate change, a record of land use, and a record of management, it is easy enough to separate the record of management out, but the other two are really hard. I think the period of record foundation is going to become decreasingly useful as the world changes ever more rapidly, and I am fairly worried about that. I mean, we are struggling in here about natural flows and unaltered systems and not only are there no such things anymore, but we are rapidly approaching the point where we don't know what they are.
R: So rather than basing 7Q10 on a longer period of record, it is going to be more accurate on a shorter period of record.
R: Yes.
C: The new extremes are—
R: Increasingly we are going to be thinking about how we want things to be, rather than how they were.

Q: Tom, is the 10% non-exceedance roughly equivalent to a 7Q10?
R: No, because that is using daily flows. 7Q10 you are using a 7-day average. They are calculated dramatically differently, so you cannot correlate that to a 7Q10.
C: Well I noticed that the current release from Kings Mountain is 12 which is the 7Q10 and I noticed that--12 up to 10% that it goes up from there. I did not know if that means anything.
R: Well I mean that just tells you the minimum release on Kings Mountain is 12—that they are able to meet the minimum release out of Kings Mountain for the whole time.

Q: Did the height of those bars, did that have anything to do with cumulative days or is that just …
R: That is just a daily.
C: That is a single day.

Facilitator: So would you be able to do that comparison for us, and what about timeline, is that

something they could get back in June?
R: I will not be able to do it myself. I will check with my modelers. They may not be able to run it as fast as I did. Like I said it takes about 20 minutes to run the script, and then it is just a matter of summary.
Facilitator: Okay, thank you.

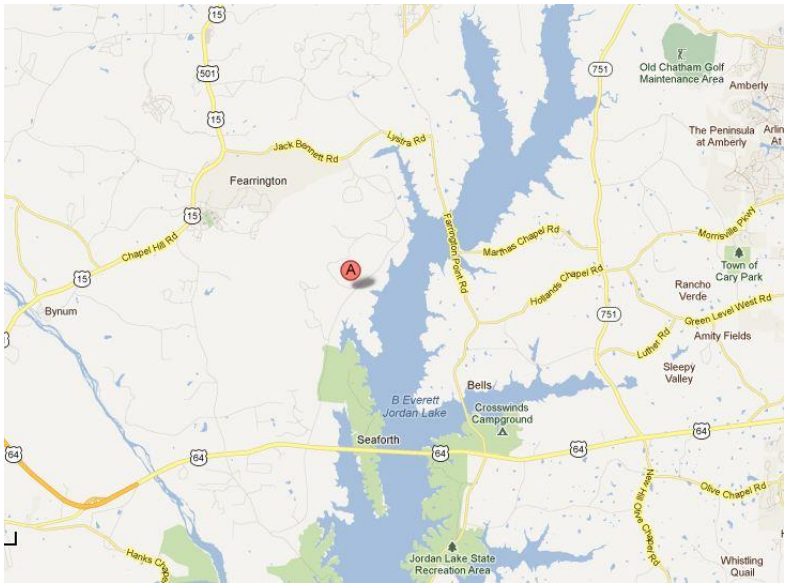
IX. Next Steps and June 18 Meeting Agenda and the Timeline

The draft agenda for the June 18, 2013 meeting includes:

- An endangered species subcommittee report on a crosswalk between T&E species and guilds;
- A presentation of the subcommittee's revised framework of recommendations and "Preface" document;
- A DWR report on the comparison of SIMBASE and PHABSIM unaltered flows (to better inform modeling results of 80% Flowby);
- The final results of the Biological-Environmental Classification (BEC) Project and discussion of classification; and
- A presentation of a trial balloon from some EFSAB members.

The next meeting of the EFSAB is scheduled for **June 18, 2013** at the Stan Adams Educational Center from 9:0oam until 4:15pm. Please remember to bring lunch and refreshments with you. Coffee will be available on site and soft drinks are ($1). **Webinar:** If you cannot attend the meeting in person but would like to join us via the webinar, you can watch the presentations and listen to the live streaming audio of the meeting by accessing the link and typing your name in the space labeled "guest": https://denr.ncgovconnect.com/sab/

Meeting Location & Directions: The meeting location is the Stanford M. Adams Training Facility at Jordan Lake Educational State Forest. Directions are: 2832 Big Woods Road, Chapel Hill, NC 27517. From Rt 64 and Big Woods Road, it will be the first Forest Service sign on the right. Pass the office building and continue on through the gate to the education center. For Map link: http://go.ncsu.edu/stanadams



Appendix A: Framework of Recommendations and Explanatory Document – Working Documents

A. EFSAB Framework of Recommendations – WORKING DOCUMENT – DRAFT 1

Three sections: Characterization, Treatment of Coastal Areas, and Approaches to Determining Ecological Flows

Characterization—What and How

1. A classification of streams is required. That classification **may** not be based solely on flows but should be based on biological data and physical characteristics of the stream. Classification at the very least **may** include meaningful physiographic classes. Options include Giese and Mason, 1993; Omernik, Level IV, 2001; SALCC, 2013.
2. Characterize each class according to the record of flows and the biological or habitat response curves for the biota most sensitive to changes in flow. This precludes **or goes further** than using a flat rate flow minimum strategies (e.g. 7Q10 or Sept medium).
3. For each class identify reference reaches.

Treatment of Coastal Areas [pending input from Bob's working group]

1. Recommendations for Coastal Plain:
    a. DWR should emphasize new data collection in the coastal plain
    b. Use the management strategies, models, and data of other agencies (e.g., Division of Marine Fisheries, Division of Water Quality)
    c. Use literature

Approaches to Determining Ecological Flows

1. A framework for DWR to use in determining Ecological flows for stream reaches should incorporate:
    a. Seasonality - perhaps differently for each class
    b. Target flow regimes for each season based on available data for:
        i. the biota most sensitive to changes in flow
        ii. habitat for the biota most sensitive to changes in flow
        iii. the prevailing flow regime and the Sustainability Boundary and the Eco-Deficit approaches (Richter, et al, 2011; Vogel, et al, 2007).
    c. Thresholds for each season depending on class flow characteristics which may be either:
        i. acceptable deviations from target flow regimes in terms of magnitude, frequency and duration; or,
        ii. a band of acceptable variation around the target flow.
    d. A procedure for situations where there is uncertainty regarding whether the threshold is crossed (e.g., site specific evaluations).
2. Ongoing Validation - DWR should adopt/design/develop strategies for:
    a. validating class characterizations and ecological thresholds. Strategies should be informed by new data or research.
    b. tracking the impact of flow changes when they occur.
    c. modifying classes, characterizations, target flows, and thresholds based on new data, changing conditions, and lessons learned.

EFSAB Subcommittee Proposed Explanatory Document WORKING DOCUMENT – DRAFT 1

(provides context on how to make sense of the process)

Preface Section:

Parameters for the EFSAB Project

1. Our job to advise and recommend when possible. Need to make readers aware of the uncertainty we have wrestled with. We may not be able to provide an answer to the question that was posed to us.
2. This is scale dependent. We are talking about ecological flows for the entire state. We use fish and bugs because that is what is available. For site-specific can use other data as available.
3. Acknowledge the EFSAB used models to respond to charge – but is not advising DWR on which models to use nor that DWR has to use models.
4. Charge/parameters – place in a preamble/preface to the report (examples: flow requirements and other aspects of the legislation that must be made explicit)
5. Refined charge – a report will read by a larger audience other than DWR. Convey context about the report so that it is not misinterpretative or raised unnecessary flags for constituents, planners, etc.
6. Include the EFSAB's reactions and concerns regarding the original charge (ex: defining and characterizing the ecology)

Characterization—What and How

1. Characterizing ecology is a just means to an end, not an end in itself.
2. Have a number of good classifications we can try to use that could be useful.

Other Aspects of the Ecosystem to Define Ecological Integrity (concerns over taxa and a biotic interactions that may not be considered such as nitrate fixation, for example).

1. Our classification is fish and benthic-based**, but there may be other approaches that could be pursued as data becomes available.**
2. Our definition of ecology and ecological integrity is based on fish and invertebrates primarily and doesn't explicitly include other aspects of the ecosystem (nitrogen fixation at a certain rate, for example). We have essentially **("rejected" was edited out by EFSAB member)** put aside looking at ecological integrity from the point of view of some other processes.
3. Corollary to that we should consider other ecological functions where they may ultimately end up impairing fish and benthos, such as low-flow withdrawals that will exacerbate longer retention time that could trigger algal blooms that would then in turn affect fish and benthos.[outside of charge]
4. We did not reject some approaches (such as those addressing nitrogen fixation or other processes in the coastal plain) by choice, but rather because the data is not available.
5. We have not discussed in detail other elements of ecological communities or processes, but we could. Thus far, we have used fish and benthos as indicators, but even though data is not available, we could incorporate into the recommendations including that data as it becomes available.
6. We are working with fish and benthos because that is our best data, but there could be data that could be gathered, just not in time for this process. I think this is where are going with the nitrogen retention, threatened and endangered species, and the coastal question.

Approaches to Determining Ecological Flows

1. Some flow recommendations are incompatible with maintaining ecological integrity [7Q10].

Summary Section

Other Aspects of the Ecosystem to Define Ecological Integrity (concerns over taxa and biotic interactions that may not be considered such as nitrogen fixation). Include in both Preface and Summary

1. Our classification is fish and benthic-based**, but there may be other approaches that could be pursued as data becomes available.**
2. Our definition of ecology and ecological integrity is based on fish and invertebrates primarily and doesn't explicitly include other aspects of the ecosystem (nitrogen fixation at a certain rate, for example). We have essentially **("rejected" was edited out by EFSAB member)** put aside looking at ecological integrity from the point of view of some other processes.
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6. We are working with fish and benthos because that is our best data, but there could be data that could be gathered, just not in time for this process. I think this is where are going with the nitrogen retention, threatened and endangered species, and the coastal question.

Necessity of Models

1. In absence of that black box, we need to capture the process that we hope DWR goes through in the form of a flowchart of the steps DWR needs to go through, as specific as science allows. That kind of graphic representation of our work would be very helpful for explaining it to EMC and others and may help to get to these other questions of whether we are providing an actual number. **[Visual representation should**

include a map of the classes and some visual flowchart of the planning process]

Recommendations for Report

1. Allow the EFSAB to include value added recommendations, insights, concerns as a result of 3 years of work to share with the broader audience. [**In preface or the summary, capture how the EFSAB delved into the process in much more detail than other states or regions and therefore had more opportunity to investigate and evaluate the science. Example: others states are using flow based stream classifications. The NC EFSAB tested a hydrologic classification system and determined there was not the level of confidence in using this approach].**