

**Ecological Flows Science Advisory Board (EFSAB)**  
**Meeting Summary**                      **June 18, 2013**  
**Stan Adams Training Facility, Jordan Lake, Chapel Hill, NC**

**FINAL Approved for Distribution**

**Attendance**

**Members**

Hugh Barwick, Duke Energy  
Mark Cantrell, USFWS (online)  
Bob Christian, East Carolina University  
Tom Cuffney, US Geological Survey  
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  
Jay Sauber, NC Division of Water  
Quality  
Bill Swartley, NC Division of Forest  
Resources  
Fred Tarver, NC Division of Water  
Resources

**Division of Water Resources**

Tom Fransen  
Harold Brady

**Alternates**

Rebecca Benner, The Nature  
Conservancy  
Sarah McRae, US Fish & Wildlife  
Vann Stancil, NC Wildlife Resources Commission  
Tom Thompson, Duke Energy

**Guests:**

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)

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**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](http://www.nc-water.org/sab)

**WebinarResponse:** 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."

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**NOTE:** The EFSAB will meet **July 16-17, 2013, 9:00am until 4:15pm** at the Stan Adams Training Facility, Jordan Lake Educational State Forest Center Chapel Hill, NC (see page 54 for meeting agenda topics and directions to location).

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**June 18, 2013:**

## **Summary of Decisions/Recommendations and Proposed Actions**

### **Decisions and Recommendations:**

1. Distinguish in the Report (Draft 1) Outline from the EFSAB to DENR/DWR that the research assumptions are currently limited to the RTI and USGS research as well as some sections of the Recommendations like the protocol conclusions; that the Report will eventually include a comprehensive view of what has transpired and a more comprehensive set of recommendations..
2. **The EFSAB came to full consensus that the following recommendation should be included in their final report:**

*T&E subcommittee review suggests that flow-habitat relationships for these species are broadly addressed by the PHABSIM approach. Rather than further evaluate the developing research on T&E species' flow requirements, the SAB recommends that specific, potentially more limiting, flow needs for resident T&E species should be considered on a project specific basis by the DWR in addition to the more generic recommendations offered by the SAB. For planning purposes, portions of basins (e.g., nodes) that include listed species should be treated by DWR as needing additional analysis.*

### **Proposed Actions**

1. The EFSAB was asked to email any comments, questions, or proposed edits to Mary Lou Addor before the next EFSAB meeting scheduled for July 16.
2. The EFSAB has asked if the Coastal Ecological Flows Work Group can provide a trial balloon (a series of proposed recommendations) for the July 16 and 17 discussions.
3. Hugh Barwick and his subgroup will analyze PHABSIM data on 5 or 6 sites using 20, 30 and 40% of mean monthly flow by season.
  - a. See how that relates to flow-by.
4. EFSAB asked for RTI/USGS to conduct one or more examples of applying eco-deficit and benthos condition ranking using site specific data for a river and projecting out for 50 years (looking at how it impacts a current good-fair relationship was suggested).
5. EFSAB asked RTI/USGS to conduct a log-linear model for the benthos flow-biology relationship so it can be more comparable to fish, and so that the curve is not as flat
6. Based on their discussion, it appears that EFSAB members need to make a decision about whether they should recommend the approach or also determine the threshold that constitutes significant impact to ecological integrity. This has not been decided yet.
7. If our recommendation is based on PHABSIM results run using natural conditions, we need to understand what the implications are when it's used in a model with a SIMBASE current and SIMBASE future condition. This would need to be done on a basin-by-basin basis.

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## I. Executive Summary

**TITLE: Presentation: “Recommendations” Subcommittee’s “Preface” document**

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Presenter: Mary Lou Addor

Mary Lou Addor introduced the Preface (Draft 1) developed by subcommittee members Chris Goudreau, Amy Pickle, Fred Tarver, Sam Pearsall, Jim Mead, and Ian McMillian (and distributed to the EFSAB on June 10,2013). The subcommittee met twice to draft the Preface. In addition to the Preface (Draft 1), the subcommittee drafted a section titled Research Assumptions and Protocol Conclusions, followed with the subcommittees’ previous work on Recommendations, the Proposed Framework of Recommendations, Summary, and Conclusions. Reference Appendix for a copy of the latest copy of the Draft Report.

The preface was envisioned to introduce the Report that the EFSAB will submit to DENR. The Report will include research assumptions, recommendations, and conclusions that represent the EFSAB. Currently the Report and the outline is limited to a portion of what has been accomplished by the EFSAB.

**Major Discussion items/concerns/questions:** In the first paragraph of the Preface (which describes how the report to DENR will be organized), this section does not clearly state whose research assumptions and recommendations are listed. The section on the research assumptions does not include a comprehensive list of the organizations and groups that have advised the EFSAB but rather is limited to the RTI and USGS research. The recommendations section does clearly state whose recommendations are listed.

**Decisions Made:** Distinguish in the Report (Draft 1) that the research assumptions are currently limited to the RTI and USGS research as well as some sections of the Recommendations like the protocol conclusions and that the Report will eventually include a comprehensive view of what has transpired and a more comprehensive set of recommendations.

**Proposed Actions or Identified Decisions to be made:** The EFSAB was asked to email any comments, questions, or proposed edits to Mary Lou Addor before the next EFSAB meeting scheduled

for July 16.

**TITLE: Report on Work of Endangered Species Subcommittee**

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Presenter: Judy Ratcliffe

Presenter: Judy Ratcliffe

Judy provided the list of fish species that are host for various federally listed mussels, went through and lined up which fish species were riffle-run, pool species, then cross tabulated with the mussels to see which habitat guilds are being covered by the fish species. Chris G. helped develop a spreadsheet to display the results, which was shown to the group. Riffle run guild is very well represented (by fish hosts), as are pool run and riffle. The subcommittee believes the results suggest that using the guild approach could adequately address concerns for freshwater mussels, at least for their fish hosts. The exercise did not consider species that were petitioned for federal listing, which the subcommittee provided as a tab in their spreadsheet. They needed to know if the EFSAB wants them to do additional work to evaluate those species. After discussion, the EFSAB decided to develop and test consensus on a recommendation for their report rather than conducting additional analysis.

**Major Discussion items/concerns/questions:**

- If the BEC is not recommended or used, there would likely be additional work needed to determine if threatened and endangered species are being adequately addressed by a different method
- A lot of additional work would be required to crosswalk the petitioned species with the guilds, including determining which species are flow-dependant.
- The relevant species in the swamps and riparian systems shouldn't disappear from the petitioned list

**Decisions Made:**

**The EFSAB came to full consensus that the following recommendation should be included in their final report:**

*T&E subcommittee review suggests that flow-habitat relationships for these species are broadly addressed by the PHABSIM approach. Rather than further evaluate the developing research on T&E species' flow requirements, the SAB recommends that specific, potentially more limiting, flow needs for resident T&E species should be considered on a project specific basis by the DWR in addition to the more generic recommendations offered by the SAB. For planning purposes, portions of basins (e.g., nodes) that include listed species should be treated by DWR as needing additional analysis.*

**Proposed Actions or Identified Decisions to be made: NA**

**TITLE: Coastal Ecological Flows Work Group: Progress Report**

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Presenter: Bob Christian

Bob introduced the latest progress report of the Coastal Working Group and the results of the groups' second meeting. Comprised of 12 scientists, 3 are members of the EFSAB: Bob Christian, Fritz Rhode, and Judy Ratcliff. Six of the members attended the June 17 meeting. The group is focused on NC Coastal Waters downstream of DWR's OASIS Basin Models, an area well represented in the state in terms of the number of streams in the coastal plain. The second meeting of the coastal ecological flows working group included several learning objectives.

- Assess applicability of previous coastal work

- Other states
- Greenville
- Hone stream classification framework based on Scott's efforts and previous discussions
  - Identify key classes to consider based on importance of environmental factors and potential for flow modification by human activity
- Advance modeling effort
  - Consider maps of potential areas of concern
    - Other?

**Major Discussion items/concerns/questions:** The Coastal Ecological Flows Work Group is working on a three-pronged approach to link stream typology (origin with slope) to a potential Ecological Flows determinant such as discharge and habitat, downstream salinity, and overbank flow.

**Decisions Made:** None

**Proposed Actions or Identified Decisions to be made:** The EFSAB has asked if the Coastal Ecological Flows Work Group can provide a trial balloon (a series of proposed recommendations) for the July 16 and 17 discussions.

**TITLE: Presentation: Report Back on Comparison of SIMBASE and PHABSIM Unaltered Flows (to better inform modeling results of 80% flowby)**

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Presenter: Tom Fransen

During Tom Fransen's presentation at the May, 2013 meeting, the EFSAB had asked him to compare analyses using natural conditions (such as had been used in the PHABSIM work evaluated by the EFSAB previously) versus analyses using current conditions (SIMBASE) at PHABSIM sites and to compare 80% flow-by (using natural flows) with natural flows and SIMBASE. Tom presented these comparisons. His major conclusions for the PHABSIM comparison using one site were:

- The majority of reductions in habitat are associated with "Deep Fast" guilds where half or nearly half of months fall below 80% threshold.
- Deep Slow" guilds have 1 or 2 month breaches of 80% threshold.
- Another Deep species (Golden Redhorse Juvenile), with nearly half of months below threshold, had habitat values <500 by month.
- The SIMBASE and 2060 projection include wastewater treatment plant return flows, which tend to offset dam alterations.
- Seasonal calculations (Summer) tended to exclude breaches for marginal months when using Index B (mean of habitat events between 10 and 90% exceedance).
- Most of the impacts occurred between Natural and Current Conditions.
- Little to no addition impacts between Current Conditions and projected 2060 scenario conditions.

**Major Discussion items/concerns/questions:**

1. In the watershed evaluated, the difference between current and projected 2060 demands were not substantial, whereas in some areas, like the Triangle, the differences could be much more substantial.
2. If the EFSAB chooses to use an 80% flow-by approach based on PHABSIM results that used natural flows, it would be important for DWR to do this analysis within each basin. The

difference between natural and SIMBASE and between SIMBASE and SIM60 is going to vary basin to basin.

3. The question is still out there: if our recommendation is based on PHABSIM results run using natural conditions, even if it's not 80% flow-by, we need to understand what the implications are when it's used in a model with a SIMBASE current and SIMBASE future condition.
4. It's hard to capture what the impact is of using a different baseline flow if it's going to be different for each basin.
5. Do we have any idea how these deficit figures compare to the deficits that RTI calculates? Is an 80% flow-by equal to 20% deficit, or do we not have any idea of that yet? RESPONSE: It's a challenge because eco deficits are how big is the area under a curve, so that percent doesn't translate directly to these types of percentages.

**Proposed Actions or Identified Decisions to be made:**

1. The question is still out there: if our recommendation is based on PHABSIM results run using natural conditions, even if it's not 80% flow-by, we need to understand what the implications are when it's used in a model with a SIMBASE current and SIMBASE future condition. This would need to be done on a basin-by-basin basis.

**Decisions Made:** none

**TITLE: Biological-Environmental Classification (BEC) Project Update**

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Presenter: Jennifer Phelan, RTI & Thomas Cuffney, USGS

After continuing with the classification analyses as they said they would do at the last meeting, it was determined that nothing was gained by splitting rivers into pre-exiting classes (EDU for fish and Omernik Ecoregions for Benthos) - the most robust flow alteration – biological response models were statewide. Additional work was completed to create flow-biology relationship graphs. The ad hoc research group including: RTI, Tom Cuffney (USGS), Chris Goudreau, Fred Tarver, Jim Meade, Mary Davis and Sam Pearsall recommend: use state-wide flow-biology relationships for fish and benthos (based on RTI flow-biology methodology) to support determination of ecological flows. For biological response, use fish species richness of riffle-run guild, normalized by 90<sup>th</sup> percentile value for each basin and benthos EPT Richness, normalized by the 90<sup>th</sup> percentile value for each Omernik Level III ecoregion. For flow alteration, use change in eco-deficit based on a comparison of flows under Potential Natural Vegetation (PNV) condition and current (2006 NLCD land-cover + instream flow withdrawals, discharges and impoundments). Jennifer explained the methods and showed graphs to illustrate the relationships.

Tom shared with the group a method for how to equate percent change in benthic biological condition to DWQ benthic site condition (IBI) ratings of excellent, good, good-fair, and poor. A proposed way to determine a threshold for ecological integrity could be when an eco-deficit moves a site from one rating to a lower rating (for benthos). This method may not be as easily applied to fish due to concerns that fish NC IBI collection methods were more complex and less consistent than benthic IBI. In addition, the fish IBI would have to be adapted for the riffle-run fish guild. Benthic IBI is based on EPT.

**Major Discussion items/concerns/questions:**

- How to determine how long it takes species to recover- the lower you set the bar for the insult, the more likely it will recover. That information can be conveyed in the report.

- It would be good to have similar IBI-based biological condition classes for fish (same as benthic IBI classes) to provide the rankings for benthos to help provide a framework and thresholds for changes in biological condition. However, the complexity (fish IBI based on multiple factors) and inconsistency (fish IBI method varies by location within the state) makes the development of a fish IBI biological class system less feasible
- Trying to understand the relationship of PNV to unaltered flows and SIMBASE in OASIS
- Whether EFSAB should recommend the approach or also determine the threshold that constitutes significant impact
- In the legislation, there was a clear decision to use a definition different than DWQ's definition for biological integrity- EFSAB should keep that in mind while considering using DWQ ratings.
- How to highlight acute (extreme short term events that may highly impact benthos) as well as chronic eco-deficit impacts during planning
- How to express a level of comfort that changes are affected by flow and not other variables
- **Some questions were submitted to the ad hoc research group after the meeting- those questions and responses are at the end of the summary for this item**

**Proposed Actions or Identified Decisions to be made:**

- EFSAB asked for RTI/USGS to conduct one or more examples of applying eco-deficit and benthos condition ranking using site specific data for a river and projecting out for 50 years (looking at how it impacts a current good-fair relationship was suggested).
- EFSAB asked RTI/USGS to conduct a log-linear model for the benthos flow-biology relationship so it can be more comparable to fish, and so that the curve is not as flat
- Based on their discussion, it appears that EFSAB members need to a decision about whether they should recommend the approach or also determine the threshold that constitutes significant impact to ecological integrity. This has not been decided yet.

**Decisions Made: None**

**TITLE: Presentation of a Trial Balloon: 20,/30/40% or 30/40/50% of Annual Mean Flow or Monthly Mean Flow**

Presenter: Hugh Barwick

Hugh Barwick presented a trial balloon that he developed in cooperation with fellow Board members Jeff Hinshaw, Linda Dieboldt, Tom Thompson, and Jaime Robinson. They developed this trial balloon in response to concerns they have:

- Biological-Environmental Classifications (BEC) does not appear to be a viable tool for stream classification.
- Biological data used in the BEC were from wadeable streams.
- Potential for future water withdrawals appears greater for streams larger than those sampled and analyzed in the BEC.
- 80% flow-by appears overly protective.

Their objectives were:

- To present an alternative method of developing ecological flows somewhat based on a water-withdrawal permitting program currently used in SC.
- To suggest how these flows might be used by the NCDWR for planning purposes.

They divided the state into 4 physiographic regions: Lower Coastal Plain, Upper Coastal Plain,

Piedmont, and Mountains. They did not address the Lower Coastal Plain in their proposal, and made the following recommendations for the other physiographic regions:

**Upper Coastal Plain Streams (Anadromous fish)**

- High flow (Jan-April) – 50%\*
- Transition flow (May, June, and Dec) – 40%\*
- Low flow (July-Nov) – 30%\*

**Piedmont Streams (Cyprinids and Catostomids)**

- High flow (Feb-April) – 40%\*
- Transition flow (May, June, and Jan) – 30%\*
- Low flow (July-Dec) – 20%\*

**Mountain Streams (Trout)**

- High flow (Dec-April) – 40%\*
- Transition flow (May, Oct, and Nov) – 30%\*
- Low flow (June-Sep) – 20%\*

The asterisks indicate that the percentages would be of Annual Mean Flow (cfs) or of Monthly Mean Flows.

Hugh showed graphs for each physiographic region showing how the recommended flows would compare with the mean monthly flow and a drought of record at each site.

**Major Discussion items/concerns/questions:**

1. Although the biota might be able to survive equivalent flows during a drought, they would not be able to withstand those levels over multiple years.
2. Even if you set up a floor, you still have to come up with some way to say how often and how close do you have to get to that floor before some flag goes up.
3. Two of the gages you plotted here are below reservoirs that tend to make the average flows during wet times lower and average flows during dry times higher because that is the way they are supposed to operate. If you set your threshold or your floor based on monthly means and you are doing it off a gage record that has a big reservoir upstream, we need to be aware of that, and maybe think about do we want to use the regulated hydrograph, or do we want to use from the model an unaltered hydrograph.
4. I think philosophically, as a planning tool, what you want is something that raises flags earlier rather than later.
5. I think everybody in this room realizes that this planning tool may eventually morph into a permitting tool.
6. What South Carolina ended up with and those numbers were a policy decision. It was not really based on the science, solely. We need to be careful about understanding what those numbers are based on.
7. An approach like this has some value, has some merit because it is simple, it is straightforward, it is easily understood, but before I could endorse an approach like this, I have to be able to look at the graphs and say I see something there that reassures me that ecological integrity as defined in the Act will not be violated by using this approach.
8. You talked about balancing the needs for humans and aquatic resources and that is a good thing and DENR needs to do it. But our job is to figure out when ecological integrity is violated and when it is not.
9. How do we tie this to biological impact?
10. Part of the simplicity of this approach is the use of monthly mean flow as opposed to percent flow by. I think that, in and of itself, may be something the currently regulated entities are more

familiar with or are already used to thinking of usage in terms of that. Is that one aspect that makes this a simpler approach?

11. How much time would it take and is it feasible to re-run PHABSIM for a handful of Piedmont sites using 40, 30, 20 as a threshold and tell us what happens to our guild habitats?  
RESPONSE: They are already done, but not exactly like this. They were run with 30 all year, 20 all year, 40 all year. You have to pick from the different columns and recombine them.  
RESPONSE: You would have to do them by season.
12. The reports this was based on were from a minimum flow perspective, not from the perspective of maintaining ecological integrity.
13. If the goal is to not be at that minimum too frequently, then you are already taking a step towards just using a flow-by approach.
14. With an 80% flow by, drought years are worse [than a minimum flow].
15. It would be interesting to see how using this kind of approach would match up against the calculated impact of a flow-by. Just to use these kinds of numbers to set the level, and then see and calculate the percent deficit or whatever you want to call it at that point so we can get an idea of how it works. But it is a far simpler way to evaluate it, I think.
16. If we chose to recommend that our strategy should be to prevent increasing eco deficit by more than a certain percentage, minimum flow thresholds and flow-by targets are both viable tools for achieving that goal. These are not mutually incompatible strategies. It may be that minimum flow is not the best strategy for attempting to maintain eco deficit below some threshold, but it is a potential tool for doing that.
17. The reason why we moved away from these flows, these thresholds to begin with when we first evaluated them was that we were seeing impacts, in general, that we felt were not going to meet the ecological integrity objectives of the legislation.
18. The superficial simplicity of this actually leads to a greater complexity because you have to have a pretty complex system of if/then statements [to avoid being at too low a flow for too long]. We move quickly away from simplicity.

**Decisions Made: none**

**Proposed Actions or Identified Decisions to be made:**

1. Analyze PHABSIM data on 5 or 6 sites using 20, 30 and 40% of mean monthly flow by season.
  - a. See how that relates to flow-by.

## **II. June 18, 2013 Meeting Orientation and May 14, 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 May 14, 2013 meeting summary, and it has been posted to the NC Water.org website.

## **Presentation: Introduction of Preface Section of the EFSAB Report to DENR**

**Presenter:** Mary Lou Addor, NC State University

Mary Lou Addor introduced the Preface (Draft 1) developed by subcommittee members Chris Goudreau, Amy Pickle, Fred Tarver, Sam Pearsall, Jim Mead, and Ian McMillian (and distributed to the EFSAB on June 10, 2013). The subcommittee met twice to draft the Preface. In addition to the Preface (Draft 1), the subcommittee drafted a section titled Research Assumptions and Protocol Conclusions, followed with the subcommittees' previous work on Recommendations, the Proposed Framework of Recommendations, Summary, and Conclusions.

The subcommittee met May 30 to determine an outline for the Preface and to assign sections of the outline to the writing team; the subcommittee met again June 30 to review the drafted content and complete subsequent edits of the Preface (Draft 1) for incorporation into the EFSAB report.

The outline of the Preface (Draft 1) contains three primary sections:

1. How the report from the EFSAB to DENR is organized
2. DENR mandates in legislation
3. DENR's actions establishing the EFSAB

The first paragraph of the Preface describes the Report Outline from the EFSAB to DENR as follows:

The *Preface* describes the ecological flow provision contained in the basin modeling statute, the Department of Environment and Natural Resources' (DENR) effort -- with the Division of Water Resources (DWR) taking the lead role -- to establish the Ecological Flow Science Advisory Board (EFSAB), and the activities of the EFSAB. The *Research Assumptions* describes the guiding principles of the ad hoc work group that advised the analysis efforts of Research Triangle Institute (RTI), and the U.S. Geological Survey (USGS). The research was to assist the EFSAB in providing a foundation for their recommendations to DENR. The *Recommendations* includes the recommendations as well as supporting information. The *Summary and Conclusions* provides additional context for understanding the recommendations supported with maps, a flowchart, and insights from "lessons learned."

The EFSAB members asked additional questions about the Preface and offered specific comments.

**Comment:** In the first paragraph of the Preface (which describes how the report to DENR will be organized), it is not clear whose research assumptions and recommendations those are. Are you presenting the assumptions and recommendations on behalf of the subcommittee or are you presenting these assumptions and recommendations from RTI and USGS on behalf of the Advisory Board. As an Advisory Board, we've solicited specific input from a large number of different groups and organizations, not just RTI and USGS. I think we need to be very clear to distinguish whether the

recommendations that follow in our Report are coming from the subcommittee or from the entire EFSAB. However we put the REPORT together, we need to be clear where we're drawing our recommendations from and who they represent.

**Subcommittee Comment:** The preface was envisioned to introduce the Report that the EFSAB will submit to DENR. The Report should include research assumptions, recommendations, and conclusions that represent the EFSAB, not just the subcommittee. The subcommittee was offering the best effort of what we believe has been accomplished to date.

**Comment:** We need to indicate this in the first paragraph since it is not that clear. We looked at a whole range of research and recommendations that the EFSAB did not directly solicit, that provided us with research accomplished by other scientists and researchers. However, only the latest research is mentioned rather than presenting a comprehensive view of what has transpired. If we can make it clear that the recommendations will be put forward by the EFSAB and not simply two groups that recently conducted research, this will clear it up. It's still early in the deliberation process.

**Subcommittee Comment:** Agreed. As we move forward, the report will be expanded with additional comments and recommendations. In fact, the final version of this preface may not include research assumptions at all or it may include research assumptions that guided whatever the final recommendations are.

**Facilitator:** I will indicate this in the Draft 1 version.

**Question:** Can someone explain the last sentence of the third paragraph on page 2, which starts out, "Second, it was agreed that the EFSAB is recommending scientifically based methods or approaches of flow requirements which may be numerical but not site specific." I believe "site specific" in this case means specific for a project at a site but certainly the numbers we're getting are site-specific in the fact that we're trying to determine what flows might be at some node within Oasis or some position within a river or reach of a river. We're not setting up permitting requirements; what we are doing is setting up a planning tool that is certainly site specific from that perspective.

**Facilitator:** So it seems like project-specific is a better term. Is that right?

### **Research Assumptions Section from the Subcommittee's Report (this discussion occurred in the afternoon following the BEC update from RTI/USGS)**

Mary Lou Addor asked the EFSAB to turn their attention to the subcommittee's June 10 report. She reminded the EFSAB about the *Research Assumptions* section. This section describes the guiding principles of the ad hoc work group that advised the analysis efforts of Research Triangle Institute (RTI), and the U.S. Geological Survey (USGS).

The subcommittee had intended for the EFSAB to review this section as it related to June 18 RTI and USGS presentation. The ad hoc water research group plans to revise these assumptions given the results of today's presentation. Given this new development, the group would like to postpone the review and discussion. In the meantime, you have the original document that was submitted to you on June 10, and I have hard copies to provide to you today (if you would like a hard copy).

The EFSAB was fine with tabling this discussion until the ad hoc group had time to revise their *Research Assumptions* for a future presentation.

The subcommittee was thanked for their additional time and effort in developing sections of the report that the EFSAB can consider moving forward. The EFSAB was asked to email any comments, questions, or proposed edits to Mary Lou Addor before the next EFSAB meeting scheduled for July 16.

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## IV. Presentation: Report on Work of the Endangered Species Subcommittee

Presenter: Judy Ratcliffe

Judy reported on the work of the Endangered species subcommittee, which included Judy Ratcliffe, Chris Goudreau, Mark Cantrell, and Sarah McCrae. The group has worked mostly through email. Previously, Chris got help from Brynn Tracy and Fritz Rhode, went through textbooks and assigned habitat guilds to the list of species in the DWQ database. They assigned guilds to adult, juvenile and spawning stage. For this exercise, Judy provided the list of fish species that are host for various federally listed mussels (from an Ohio State publication), went through and lined up which fish species were riffle-run, pool species, then tried to cross tabulate with the mussels to see which habitat guilds are being covered by the fish species. That's what the boxes on the bottom are (referring to an Excel spreadsheet that is now posted online).

Species name of federally listed mussel is on far left. Riffle run guild is very well represented (by fish hosts), as are pool run and riffle. This goes forward with recommendation that if we go with the most flow sensitive guild species, try to establish if using the guild approach adequately addresses concerns for freshwater mussels, at least for their fish hosts.

The subcommittee didn't know how much further analysis the Board wants them to do. There is a petition list that may be included in the future (species that USFWS is or will be evaluating for endangered or threatened status). The list is included as a tab in the spreadsheet. It includes crayfish species, dragonflies, additional mussel species, fish, and amphibians. It would be possible to look into the literature and determine how well the species needs may be addressed by the current guild approach as well. The subcommittee needed guidance about if/how much more the Board wants done.

USFWS is currently considering these species in NC for listing. This requires species assessment and threat assessment before determining whether to list or not. Many if not all have some level of state recognition as threatened, special concern, significantly rare, etc., through the NCWRC or NC Natural Heritage Program.

QUESTION: How do you envision using the information? That would help us decide how far you should go.

RESPONSE: Listed fishes and mussel fish hosts- this crosswalk is directly related to whether or not we use the BEC, since BEC is using the guilds as part of their analysis. If the Board moves forward with using BEC, we could assess the confidence of the EFSAB in using the guilds as representatives of endangered and threatened species.

QUESTION: So you envision using it to put more or less emphasis on a particular habitat and how important it is?

RESPONSE: In the case of a lot of the mussel fish hosts- there are host species for across the board, across the guilds. But there is significant use in the riffle run and pool run. As we add species to this list it could spread out more, or it could become more apparent that riffle run is a critical guild for fish hosts. We have seen from a previous presentation that riffle run may be more sensitive to habitats. We're trying to help the Board determine if we may be able to address the endangered species of mussels with fish hosts through the guilds. It does seem like this suggests that we may be able to adequately address those needs through this approach. I'm not suggesting that BEC is the way to go, but if it is, then some of the federal species questions may be addressed.

QUESTION: Can you please send the Excel file for us to look at?

RESPONSE: Regarding the petitioned species list in the file, I got the list from Sarah, and took out terrestrial species. But I'm not sure if all the species are flow dependent. This is a draft; there may be species on the list that should be taken off, like some herptiles (amphibians and reptiles).

RESPONSE: Our committee has been away and has not thoroughly reviewed this draft. We'd like to

take a week to review it and then send it out to you as a draft.

COMMENT: Coastal group is in part focusing on overbank flows into swamp forests. I wouldn't want to see any of those relevant species in the swamps and riparian systems disappear from the list. Like crayfish- I see them there, but would want to see amphibians and plants.

RESPONSE: I can have our botanist check the plant list to look at habitat needs in riparian and flood plain areas.

COMMENT: If looking at overland swamps then ground-nesting birds and butterflies would be there.

COMMENT: They're waters of the United States, right?

COMMENT: We've determined that a lot of the petitioned species are flow dependant.

QUESTION: Would the petitioned species need to be cross-walked with the guilds?

RESPONSE: I don't think it would need to be done if the Board moved away from considering the BEC. Can we bring this up for questioning the Board at end of day? I haven't considered how the endangered species would be addressed with other scenarios.

QUESTION: I assume the habitat requirements for those that have been listed, are going to be proportional to the petitioned species habitat? We're considering expanding the list under consideration based on the presumption that the proposed species for listing will be protected through the same habitat. Is that represented there? If majority require riffle-run habitat, you'd like to know of those guilds' habitat...

RESPONSE: Not necessarily, if you look at species that wouldn't have been collected by DWQ or elosa species.

COMMENT: In your synoptic analysis at the bottom, you may need to put the % of each habitat type, to clarify. You have a huge list of petitioned species, then a smaller subset that already has protection...those that are currently protected- are they represented, or are their requirements proportionally represented by the habitat (riffle run habitat for example) there compared to those that are proposed to be listed? Before we draw conclusions on this information it would be good to look at proportionality. Are we putting too much emphasis on one thing when maybe we should be looking at something else?

RESPONSE: The first tab of this spreadsheet contains species collected by NCDWQ, and is what the guild data is build on. That represents habitat use for fishes in wadeable streams, it doesn't matter whether it's endangered or threatened.

QUESTION: To simplify the question, you could take the listed species, run through the analysis and look at the guilds, their requirements for habitat, just on the ones already listed (RESPONSE: that has been done). That does not include the petitioned species?

RESPONSE: no.

QUESTION: Then do proposed listed species require the same types of habitat as the listed species?

RESPONSE: We can only confidently tell if we run the petitioned species through the crosswalk.

COMMENT: That would be a lot of work.

COMMENT: If we go through the process and there is environmental flow that is established that is protective of the guild or habitat needs, we (USFWS) may not need to add them to the list because it is protected by the environmental flow. A lot of these critters are facing issues due to flows- not all but some.

QUESTION: How hard would it be to separate those that might require just that type of protection?

RESPONSE: Usually they are imperiled for multiple reasons. Aquatic systems are impaired for multiple reasons- impervious surfaces, many ubiquitous threats.

COMMENT: I'd like to see and spend time with it. But we only have 5 months left. I could see us debating whether endangered and threatened fits into "eco integrity". To move in a more expedient way, we could have a comment in our recommendation like "specific flow needs for resident T&E species should be considered in addition to the more generic recommendations...". We don't have time to deal with petitioned species. We should focus on the more generic targets for this group,

though I would consider it important to make reference in our recommendations.

COMMENT: Our cursory analysis shows we are addressing T&E species, but there are other considerations. We could add a second “flag tripper” that says if you have listed species then further analysis is needed. That could be a recommendation of the Board without getting into more work. The group discussed how to develop language, suggesting at first that the facilitators write it up as part of the meeting summary, but then deciding that they wanted to consider something for consensus in the June meeting.

The T&E subcommittee developed a proposal for the group to consider and test for consensus, then brought it back to the group later in the meeting:

***T&E subcommittee review suggests that flow-habitat relationships for these species are broadly addressed by the PHABSIM approach. Rather than further evaluate the developing research on T&E species' flow requirements, the EFSAB recommends that specific, potentially more limiting, flow needs for resident T&E species should be considered on a project specific basis by NCDENR, in addition to the more generic recommendations offered by the EFSAB. For planning purposes, portions of basins (e.g., nodes) that include listed species should be treated by NCDENR as needing additional analysis.***

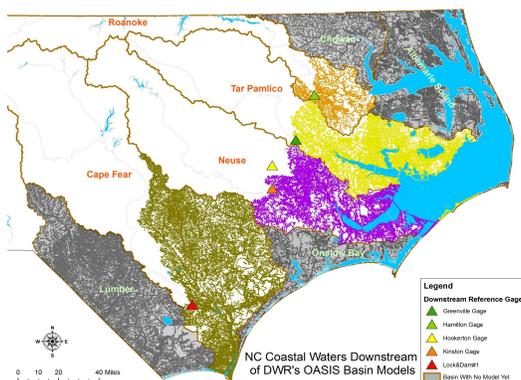
QUESTION: Regarding the last sentence, is that not covered automatically with SEPA (State Environmental Protection Act) regulations when a withdrawal is requested?

RESPONSE: The previous sentence covers that- project specific basis. What I was trying to get at was the planning phase- so when DENR runs OASIS, there would be an overlay of listed species in the basin. If there are listed species related to a node in the model, then that also raises a flag. I was trying to distinguish between the planning phase and site-specific analysis.

***Consensus to include this language in the draft EFSAB report was tested using the 5-finger scale- all 1s and 2s. The EFSAB was in consensus agreement.***

## V. Presentation: Coastal Ecological Flows Work Group: Progress Report

Presenter: Bob Christian, ECU University



Bob introduced the latest progress report of the Coastal Working Group and the results of the groups' second meeting. Comprised of 12 scientists, 3 are members of the EFSAB: Bob Christian, Fritz Rhode, and Judy Ratcliff. Six of the members attended yesterday's meeting. The group is focused on NC Coastal Waters downstream of DWR's OASIS Basin Models, an area well represented in the state in terms of the number of streams in the coastal plain. The second meeting of the coastal ecological flows working group included several learning objectives.

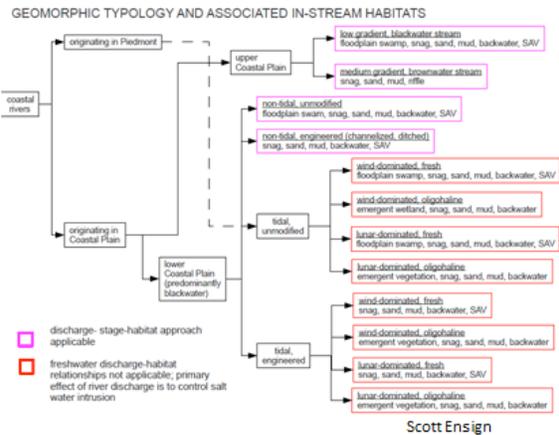
- Assess applicability of previous coastal work
  - Other states
  - Greenville
- Hone stream classification framework based on Scott's efforts and previous discussions
  - Identify key classes to consider based on importance of environmental factors and potential for flow modification by human activity

- Advance modeling effort
  - Consider maps of potential areas of concern
    - Other?

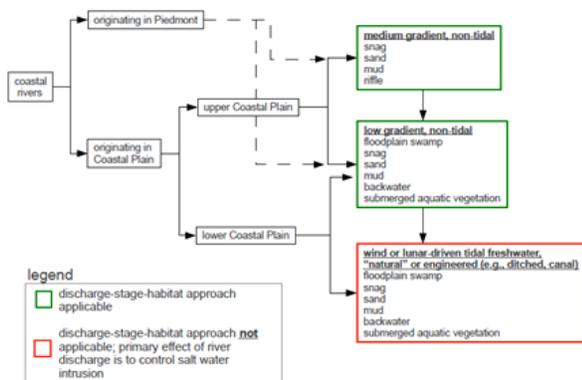
The working group was interested in the geomorphology and some of the hydrology of the system. Using Fred Tarver's October 2012 presentation, the working group looked at how Ecological Flows (EF) was addressed in different states and how they handled the coastal plain. The working group looked specifically at the City of Greenville and their planning work on the effects of what future withdrawals may do to the Tar.

A stream classification framework was introduced. Scott Ensign, a consultant from Morehead City with a lot of experience in the Coastal Plain streams came up with a typology of the streams and the coastal rivers. The working group has worked with the typology to figure out what would be valuable and useful to the working group.

The deliberations resulted in the following thinking: look at the origin of the streams and their location with respect to the upper and lower coastal plain, and then essentially looking at three stream types that would be freshwater streams – those with a medium gradient and non-tidal, low gradient non-tidal and those that were wind or lunar driven tidal freshwater systems in which essentially stage has nothing to do with discharge and it's stage is driven by the tide. This represents a situation that's quite different; one can think of these as not simply three blocks but really three Venn diagram circles where there's overlap.



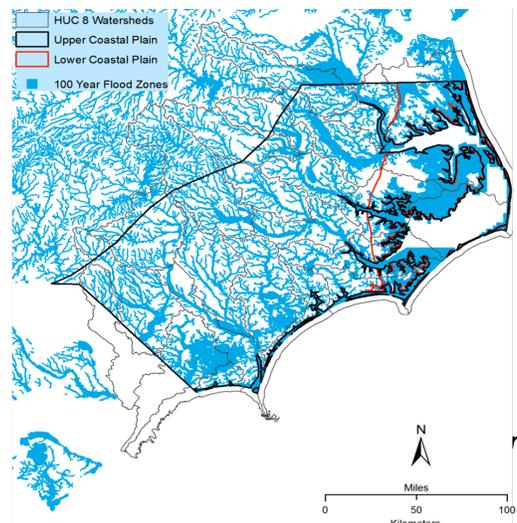
GEOMORPHIC TYPOLOGY AND ASSOCIATED IN-STREAM HABITATS



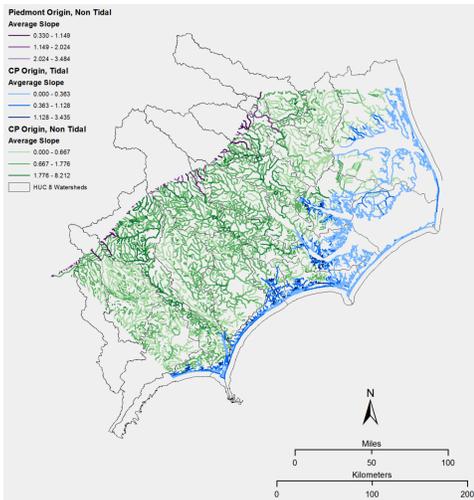
Scott Ensign

There are snags and mud too. There are riffles in the medium gradient streams, but they tend to disappear in the low gradient streams. There is development of swamp forest in the low gradient streams, which carry over into these lunar or tidal dominated streams. The working group focused on these three different classes as having enough differences in their hydrology, geomorphology, and potentially their ecology that they can and should be treated separately.

Eban Bean and a graduate student (Mike Griffin) in the Coastal Resources Management PhD program at ECU put together some maps largely based on state data and other data as a sort of a preliminary to the kinds of mapping the working group could do. The map demarcates the upper and lower coastal plain within the state. Next, the

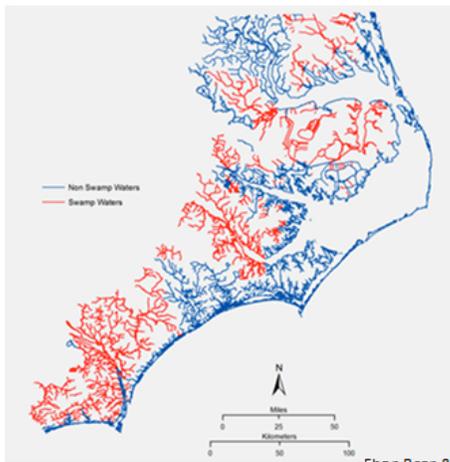


group looked at the slopes of these different types of streams in trying to start to characterize those that would have steeper slopes or at least median gradient streams versus lower gradient streams. The problem is, there isn't really a classification out there that identifies those tidally driven streams and the non-discharge driven streams that are freshwater. Thus, the state delineates tidal streams but they're all with salinity. What the working group is interested in is freshwater streams.



The working group has developed a trial balloon (a scheme) to address which of these areas may in fact have these freshwater tidally dominated streams. Basically there's a model that was developed for the coastal plain of North Carolina in which surface areas of the watershed have been related to the depth at bank full of these coastal streams. The working group is considering using Lidar to get the elevation of the surface of the flood plain and then use this model to figure out where the bottom of the stream is relative to sea level. If the bottom of the stream is at or below sea level, these should be tidally dominated. Thus the goal would be to go in and map those tidally dominated streams and then everything north of that or west of that would be either these low gradient or medium gradient streams, and the working group could define those non-tidal streams. The working group is headed in that direction to try to map out where one could delineate each of these three classes.

The working group also reviewed swamp and non-swamp waters versus swamp waters in the coastal plain. Thinking about how other states have handled coastal systems and what happened in the Greenville study, the working group believes that they can look at three different ways of characterizing



Eban Bean & Mike Gri

the ecology of these systems and relating it to flow change. For some of these, where there is a relationship between discharge, stage, and habitat, the working group should be able to develop some kind of discharge habitat or stage habitat relationship. What is more commonly used – what has actually turned out for Greenville – is looking at downstream salinity as a measure and looking for how change may affect the position of a certain salinity downstream of the withdrawal. And then finally, in some of these cases where there is a significant riparian system, we could look at

Link of Stream Typology & Potential EF Determination

overbank flow as an indicator of how flow changes might affect the ecology of the system and the ecological integrity.

The working group has this three-pronged approach that it has not addressed in any depth at this point. The working group plans to

Origin	Slope	EF determinant		
		Discharge & Habitat	Downstream Salinity	Overbank Flow
Piedmont	Medium gradient	X	X	
Upper Coastal Plain	Medium gradient	X	X	
Upper Coastal Plain	Low gradient	X	X	X
Lower Coastal Plain	Low gradient	X	X	X
Lower Coastal Plain	Wind or tidal driven flow		X	X

meet before the July meeting with scientists who study anadromous fish and begin to look at some of these issues by pulling from some of the Coastal Habitat Protection Plan (CHPP) work. Bob reported this is where the working group stood following two meetings.

A group discussion followed Bob's presentation:

**Comment:** I got the swamp/non-swamp but is that based on DWQ information? [Yes]. Then a caveat is to keep in mind that the DWQ classification system of swamp and non-swamp is based on the Environmental Management Commission actions, and not characteristics of the actual streams. For example, in the Chowan river basin, where the Great Dismal Swamp is located, those streams are not classified as swamp streams. The classifications are bureaucratic classifications and not ecological classifications.

**Question:** Where can the working group locate this definition? Is it on the DWQ website?

**Response:** The classification is neither a definition nor an ecological label; it's a process label. So depending on whether it's swamp or non-swamp, DWQ uses different strategies for determining water quality.

**Question:** Jay, does DWQ have a data set that would help map swamp ecological characteristics? Is there data that DWQ collects that would help collect that?

**Response:** Not that I'm aware of. The definition of swamp is generally along the lines of low velocities, and those sorts of things. I'm not aware of any legal definition that we've actually implemented that would also be consistent with our ecological definition for this particular group.

**Comment:** There are swamp waters on the Roanoke all the way up to Big Squash. They may not be classified as such.

**Bob:** The working group spent time talking about brown water versus black water and whether that was an important distinction to make. It may be when the working group gets into actually relating flow to ecology or stage to ecology.

**Comment:** Don't hang too many hats on that.

Bob: The group won't; maybe the National Wetlands Inventory would be a better map for this.

**Facilitator:** Any other questions about what you heard or that you would like Bob to bring forward to the coastal ecological flows working group?

**Comment:** Maybe a comment to bring back to the working group is the point of staging a habitat relationship for some and not for others. The question that comes to mind is the work that's been done by others and presented to this group up to this point (like the RTI and TNC work), it would be good to see if the working group has a feeling for whether those are applicable? could be expanded? how could they be expanded? And if so, could they be expanded to the medium gradient streams as an approach? There is an interest in the working groups' feedback.

**Bob:** That's a very good point. We may have the opportunity within the coastal working group to bring non-EFSAB members up to speed and thus could consider it.

**Comment:** I think something that would be helpful is to extrapolate work on the part of the coastal working group to develop a better idea of the actual slope or the sort of low gradient to medium gradient. I am not looking for a hard boundary dividing line but a range. Perhaps we could provide gradient classes that we're using and then you could determine if that is too steep or not.

**Bob:** That would be wonderful because the first time I saw these slopes was yesterday, and, in fact, they weren't really slopes. They were changes in elevation over the reach of the stream. We need to

develop that a little more and any advice that you would have, any contribution would be really appreciated.

**Comment:** I will contact Scott and ask for clarification about the cutoffs that we're looking at.

**Question:** Bob – do you believe that the Coastal Ecological Flows working group will have some type of draft recommendation for this group to consider by the July meeting?

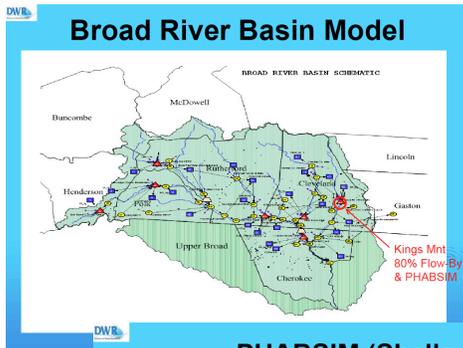
**Bob:** We are hoping but it will depend on whether we meet a week before the July meeting or the day before. Meeting a week before will provide time to advance something that can be formalized in some fashion. We are hoping that a few key points can be made to move us beyond, "Let's look at the literature," when it comes to the coastal plain. That's our goal.

So far we have discussed the physics of the coastal plain and expect to get into the biology of it. In the meantime, the Albemarle-Pamlico Nationally Estuary Program (APNEP) is committed to ecological flows for the region so they're going to continue our efforts beyond the EFSAB; they don't have the limitations of the legislation so they can really broaden their objectives.

## VI. Presentation: Report Back on Comparison of SIMBASE and PHABSIM Unaltered Flows

Presenter: Tom Fransen

This power point presentation can be found [here](#).

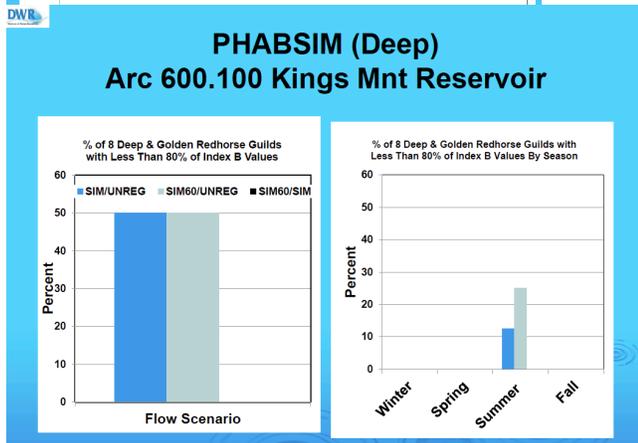


DWR had time to run only one comparison with the PHABSIM versus the 80% flow-by. They looked at the Kings Mountain node that they had used earlier.

They did three analyses: SIM (SIMBASE—which is basically current conditions) versus unregulated or natural, SIM60 (which is the projected 2060 scenario) versus the unregulated, and then what people were interested in was the SIM60 versus the current conditions.



DWR used the Index B approach (mean of habitat events between 10 and 90% exceedence). Interestingly, SIM/UNREG and SIM60/UNREG came out the same. Basically one guild out of eleven shallow guilds dropped below that 80% threshold. The 2060 versus current is not shown because it didn't have any guilds. When they ran this seasonally, all three analyses had zero guilds that were below the 80th percentile. If you look at the deep guilds [slide 4], it's showing a little bit more impact. Half of them were below the 80th percentile. The 2060 versus current was still zero. The only seasonal impacts were in the summer.



Fred had compiled a list of major conclusions from the analyses:

- Majority of reductions in habitat are associated with “Deep Fast” guilds where half or nearly half of months fall below 80% threshold.
- Deep Slow” guilds have 1 or 2 month breaches of 80% threshold.
- Another Deep species (Golden Redhorse Juvenile), with nearly half of months below threshold, had habitat values <500 by month.
- The Simbase and 2060 projection include wastewater treatment plant return flows, which tend to offset dam alterations.
- Seasonal calculations (Summer) tended to exclude breaches for marginal months when using Index B (mean of habitat events between 10 and 90% exceedence).

Fred added that he thought that for the deep/slow there were one or two months that were below. He went on to say that he had not created tables that Jim had included in earlier presentations of PHABSIM, indicating 1's and 0.1's where he was showing those that were greater than 1,000 weighted usable area versus those that were less than 1,000. Fred indicated that he could provide those if desired. He noted that some of these guilds like the Golden Red Horse had a fairly small amount of weighted usable area.

QUESTION: The over 120% isn't represented. What I would see there, if I could see that, is whether the deep fast is transitioning into an increase in the riffle habitats. Do you see what I'm saying--like a significant increase in the shallow fast or shallow slow--what became of the deep fast?

RESPONSE: My recollection is that none of the comparisons showed greater than 120%.

Tom: Part of the driver for doing this analysis was to compare—where I was doing everything on current conditions, looking forward, there was some concern how much potential degradation had occurred between the natural versus current. As one of the non-ecologists in the group here, my conclusions after taking a look at these were that what we saw with the PHABSIM is that most of the impacts occurred between the natural and the current conditions, and we were not really picking up, at least with PHABSIM on this one node, any additional impacts from current conditions up to the projected 2060 scenario.

Tom tried to do the same type of thing with the 80% flow-by. He modified what he did last time. He used the full record—the full hydrograph—last time. This time he used the index B approach where he

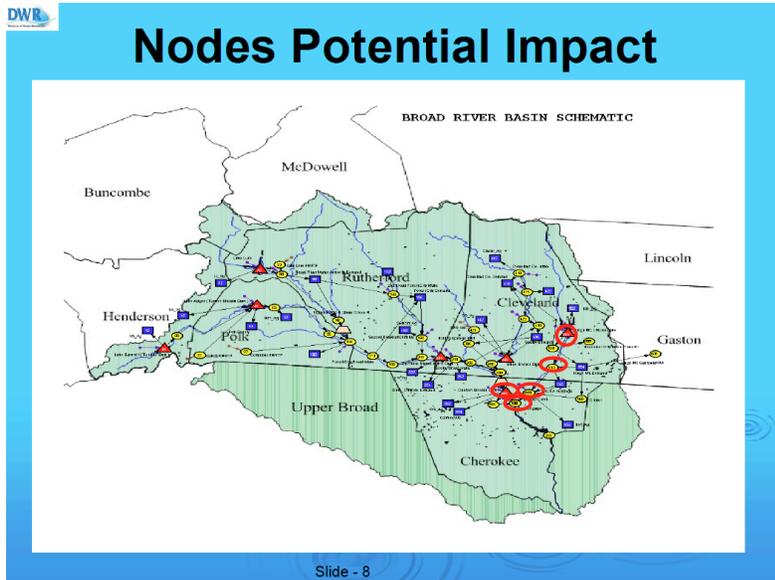


### 80% Flow-By Comparison

Arc Node	Broad River Basin - Simbase (Current Conditions) Scenario Baseline - Natural Flows		Broad River Basin - 2060 Scenario Baseline - Natural Flows		Broad River Basin - 2060 Scenario Baseline - Simbase (Current Conditions)	
	80% of Flow-By IndexB Approach (10% - 90%)		80% of Flow-By IndexB Approach (10% - 90%)		80% of Flow-By IndexB Approach (10% - 90%)	
	Number of days with potential adverse impacts	Percent of days	Number of days with potential adverse impacts	Percent of days	Number of days with potential adverse impacts	Percent of days
010.020	0	0.000%	0	0.000%	0	0.000%
020.040	0	0.000%	0	0.000%	0	0.000%
040.050	0	0.000%	0	0.000%	0	0.000%
050.060	0	0.000%	0	0.000%	0	0.000%
060.100	0	0.000%	0	0.000%	0	0.000%
070.080	0	0.000%	0	0.000%	0	0.000%
080.090	0	0.000%	0	0.000%	0	0.000%
090.100	0	0.000%	0	0.000%	0	0.000%
100.170	0	0.000%	0	0.000%	0	0.000%
150.190	0	0.000%	0	0.000%	0	0.000%
190.200	0	0.000%	0	0.000%	0	0.000%
170.180	0	0.000%	0	0.000%	0	0.000%
180.200	0	0.000%	0	0.000%	0	0.000%
200.220	0	0.000%	0	0.000%	0	0.000%
220.250	0	0.000%	0	0.000%	0	0.000%
250.260	0	0.000%	0	0.000%	0	0.000%
410.415 Cleveland Intake	0	0.000%	0	0.000%	0	0.000%
415.420	0	0.000%	0	0.000%	0	0.000%
420.440	0	0.000%	0	0.000%	0	0.000%
440.450	0	0.000%	0	0.000%	0	0.000%
450.500	0	0.000%	0	0.000%	0	0.000%
500.550	0	0.000%	0	0.000%	0	0.000%
550.700	35	0.148%	55	0.233%	2	0.008%
600.610 Kings Mnt Res	8,044	34.118%	9,763	41.409%	282	1.241%
610.650	4,807	20.389%	4,845	20.550%	154	0.656%
650.700	178	0.755%	192	0.814%	43	0.182%

was only looking at the flows between the 10th and 90th percentile, dropping off the extremes, which is comparable to what you do with the index B approach. Looking at slide 7, the first column shows natural flows as the baseline compared to current conditions or SIMBASE. The second column

shows natural flows and compares them to the 2060, and the last column is basically what Tom did last time, taking SIMBASE and current conditions and comparing them to the 2060. One interesting thing to note using this approach is that most of these nodes are coming out with zero days because most of them are actually looking at it during low flow range, usually less than 2nd percentile, so we're ending up with 12 nodes that were showing 1 or more days that are now zero days, dropping off the ends. It seems The Kings Mountain node is probably a worst-case scenario, at least based on this analysis. For the Kings Mountain node, which is what Fred did with the PHABSIM, we're showing quite a few days that are dropping below that 80% threshold for both, when you're using the natural flows. Before we were looking at impacts in the range of 1-2% as the highs; when you go back to natural, you're starting to see 34 to over 40%. So there is a difference—we are seeing some differences here. Of those 5 nodes that were showing 1 or more days, most of them are down at the lower end of the river system and below large reservoirs [slide 8].



Tom included slide 9 to help show what's occurring, why we're picking up so many days. It shows the duration curve for the natural flows then the duration curve for the 80% of that, of natural. Then it shows the duration curve for SIMBASE. He highlighted anytime the SIMBASE duration curve for a particular percentile was less than the 80%. So you're seeing for this node that it's in that 10 to 35% range or a good 15-35% range, which is showing why we're getting so many days. With most of the other nodes we were seeing the difference, when we had them, in usually less than 1%, 1-

2%. So they were not being picked up with this modified approach.

**Broad River Basin - Simbase (Current Conditions) Scenario**  
**Baseline - Natural Flows**  
**Kings Mountain Reservoir (600.610)**  
**Full Hydrograph**

	Natural Flows	80% Natural Flows	Simbase
0.5000%	1.97	1.58	12.00
1.0000%	4.45	3.56	12.00
2.0000%	8.15	6.52	12.00
5.0000%	14.67	11.74	12.00
10.0000%	21.36	17.09	12.00
15.0000%	26.15	20.92	14.79
20.0000%	30.16	24.13	20.25
25.0000%	34.07	27.26	25.03
30.0000%	37.96	30.37	29.26
35.0000%	41.30	33.04	33.70
40.0000%	45.49	36.40	38.26
45.0000%	49.67	39.74	42.85
50.0000%	54.57	43.66	48.26
55.0000%	59.47	47.58	53.81
60.0000%	64.62	51.70	60.19
65.0000%	71.17	56.94	67.07
70.0000%	77.99	62.39	74.76
75.0000%	86.16	68.92	83.96
80.0000%	96.69	77.36	96.45
85.0000%	113.17	90.54	115.94
90.0000%	141.36	113.09	148.30
95.0000%	217.60	174.08	234.08
98.0000%	419.13	335.30	461.28
99.0000%	657.43	525.94	710.88
99.5000%	966.98	773.59	1,035.70
99.997%	4,242.06	3,393.65	4,448.70

One of the questions that came up last time, since Tom just showed the full period of record, was how does the analysis break down by month or season. DWR modified the analysis approach so that you can now see the break down for a month [slide

**Broad River Basin - Simbase (Current Conditions) Scenario  
Baseline - Natural Flows  
Kings Mountain Reservoir (600.610)  
IndexB Approach (10% - 90%)**

Month/Period	Number of Days Flows < 80%	% of Days Flows < 80%	Average Deficit, cfs	Average Deficit, % Diff
1	96	4.647%	0.26	0.804%
2	109	5.867%	0.24	0.754%
3	106	5.389%	0.34	0.813%
4	506	23.947%	0.77	1.836%
5	1,015	45.011%	1.58	4.646%
6	1,176	58.247%	2.49	7.148%
7	1,189	61.992%	3.31	9.986%
8	1,184	66.071%	3.48	10.699%
9	1,121	67.612%	2.73	9.119%
10	948	52.872%	1.69	5.905%
11	472	23.529%	0.87	2.638%
12	122	5.722%	0.37	1.013%
Spring (4-6)	2,697	42.226%	1.60	4.507%
Summer (7-9)	3,494	65.089%	3.19	9.956%
Fall (10-11)	1,420	37.378%	1.26	4.180%
Winter (12-3)	433	5.397%	0.33	0.902%
P-O-R	8,044	34.118%	1.46	4.450%

10], using seasons the same way as defined in the PHABSIM analysis or the full period of record.

Tom did not think it is surprising that most of the impacts occur in the summer months. Your overall deficits are not real huge. Tom's conclusions about the 80% flow-by using an Index B approach were, 1) like the PHABSIM, most of the impacts occur

between the natural and current conditions; 2) this particular technique is picking up a few additional impacts between the current and the 2060 (Tom noted that he thinks that goes back to a question he has, in spite of having a lot of experience interpreting PHABSIM, about if you have one or two days, is that an impact or not—he's still trying to figure out how to interpret whether that really is an impact); and 3) using the Index B approach, 85% (22 out of 27) of the nodes in the model really weren't showing any impacts.

QUESTION: Tom, would you remind us what the 2060 projection was?

RESPONSE: The 2060 projections are our planners using the local water supply plans and other information to set up a scenario based on our best estimate of what conditions would be like in 2060. So we're putting our projected 2060 demands in if we know of new sources coming online, changes in reservoir operations, anything like that. That's our best guess of what the basin would look like in 2060.

QUESTION: So it's a projection of how management would change?

RESPONSE: Management, demands, and those types of things.

QUESTION: And in this watershed, were those 2060 projections substantial?

RESPONSE: There are some changes, but you're not going to see huge changes like you would over here in the Triangle. If you look at the Triangle region, you're going to see more changes than what we're seeing over in the Broad.

COMMENT: What I'm trying to figure out is when there's very little impact detectable between the current situation and the 2060 projection, whether that's an attribute of the sensitivity to the model, or if there just aren't any significant changes projected.

RESPONSE: There were a couple of municipalities that were projecting changes, but not many. Most of them were not much. That's probably something I should have pulled in here is to show what those were.

QUESTION: In following up on Sam's point, if I can jump in, I had the same question, but also noting that the PHABSIM site, on which fast and shallow, deep slow and shallow fast guilds were evaluated, is downstream of the Kings Mountain wastewater discharge. Is this due to the fact that the difference between unregulated and current is much more than between current and the projected 2060, and was that due to the fact that there's not much difference in the amount of water being taken out between current and projected 2060? Or is it because that wastewater discharge offsets more being taken out in 2060. Maybe it's a little of both.

RESPONSE: I think it's a little bit of both.

COMMENT: Yes, that's why I was kind of surprised when you compared natural to SIMBASE and the 60-year projection that you saw the 50% difference because I thought the wastewater return would sort of mitigate some of those impacts. But I guess the return wasn't enough to offset the impacts of the reservoir.

Tom: Well, I mean it is a little bit because this line here actually is the release from the dam, the one that shows the greatest. So you're seeing the impact from the dam. The next one down is the 610 to 650 where the wastewater gets added back in. So you're seeing that wastewater is mitigating some of what's gone on upstream, but not all of it.

RESPONSE: So instead of 34%, it's 20%.

Tom: 20%, yes. It hasn't mitigated all of it, but it did half of it. That's one of the things that I liked about this approach is that I can look at the upstream and downstream to see how things are kind of changing. You know, whether I've got a cumulative impact or—better or worse. This example does actually show it out. You expect something at the dam, and you would expect an improvement from the wastewater there.

QUESTION: I don't want to be repetitive, but can you give me a quick refresher on where the natural flows number came from in this case? What is that?

RESPONSE: When we create the model, we have to create an inflow record to drive it. The technique that we use is to start with USGS gage data, and we have collected the historical withdrawals and discharges and as much historical information about reservoirs as we can. So that we're not doing double counting in the modeling if we have a withdrawal, we add it back to the record. If we have a discharge, we subtract it out of the record, and we do the same type of thing depending on whether you're either gaining or losing storage in a reservoir. So by doing those additions and subtractions, to the best that we can find historical records, we come out with what we're calling an unregulated or natural or unencumbered flow. These are all terms that we use. It's not perfect, but it's better than doing no adjustment.

COMMENT: So bottom line, just trying to go back and look at the questions from last meeting, the question was, essentially, what's the difference between using SIMBASE versus unregulated as your denominator in your calculations for PHABSIM, for example. And the answer is...

COMMENT: About 50%.

Tom: I thought you were going to give me the answer.

RESPONSE: What's the take home message here?

COMMENT: Well you do have to temper it a little bit because in those percentages if the guild had one month versus 12, it was counted in or out. There might have been one month where it didn't meet the criteria. Whether you consider that a significant impact versus one that all 12 months doesn't meet the criteria, there does have to be a little bit of tempering. When you look at 50%, there's that.

Tom: I'll go back to the driver of this whole thing. I think part of this was the question of trying to figure out what's your baseline to use, and the statute says prevailing conditions. I think the question that came up was how has prevailing conditions already changed from natural. At least on the one node we looked at, which is the worst one by a couple of different measures here, there are significant alterations. But the statute still goes back to prevailing conditions so I'm not sure where that leaves you as a group to figure out what your final recommendation is going to be.

COMMENT: One clarification on that though: Your percentage reduction of flow, it seems like the largest one that I saw on your list was just under 11%. Is that correct? You have the average deficit percent difference; the largest number there is 10.7%. I know that if it's your habitat that's being lost, you're not that concerned if it's 10% that wipes you out. I just want to make sure I'm not misinterpreting what that deficit percent difference means. Can you explain to me?

Tom: The deficit—I was just looking at what we'll call the baseline, the 80%, and any time I drop below that 80%, I made it a positive, so that's saying, okay, in this case the average for those times that were below 80% are that many CFS. I also tried to put that number in context, and I also did it as a percentage over the natural flow. The three cfs deficit would translate back to the 10% of what the natural flow would have been. I know the magnitude by itself gets misleading because you don't know if that three is at a time when you only have six in a river, versus 500. So that's why I tried to normalize the data by using a percent difference.

QUESTION: So the natural flow would be about 35? Is that what that's saying?

RESPONSE: Yes.

QUESTION: CFS?

RESPONSE: When that occurred, yes.

COMMENT: Even though you have got a high percentage of just days that are below your 80% flow by, the habitat results were not as—correct me if I'm wrong here—the PHABSIM weighted usable area impacts were not that significant, not as much as just the day count. And one reason for that is that the deviation below that 80% is not very large.

Tom: Right. We were seeing that in the PHABSIM results, too where we went to seasonal, because a lot of those were just under the 80% and when we group the months together, we actually ended up with not having that trigger for us. Now is this a good basin to do this on? I don't know. We've had such small changes, but it's the one we had to use.

COMMENT: So I think this is an important assessment to do within each basin. Rather than try to make an assumption that there is a minimum impact based on this analysis. It seems that it would be heavily driven by the amount of anticipated change between SIMBASE and SIMBASE 60. So it's highly relevant within each basin that this type of analysis be run because the shift in natural to SIMBASE could be greater in other basins, as well. Or it might be less. And so without doing this type of analysis within each basin model, you wouldn't really be able to appreciate cumulative change and then characterize the additional withdrawal relative to its cumulative impact. It doesn't seem to be in this case that the SIMBASE to SIM 60 is going to be the straw that breaks the camel's back because we're fitting pretty well within the 80%. But there may be a scenario, there may be a basin in which even a small change that's represented in SIM 60 to SIMBASE could be a cumulative straw that breaks the camel's back if the cumulative change between natural and SIMBASE is so substantial, you see what I'm saying?

RESPONSE: Yes, I understand what you're saying.

COMMENT: The results here can't necessarily be applied in the Cape Fear, and you already made that point, or in the Chowan. But it's within each basin. If you conduct this analysis, it's very meaningful so that you can understand the cumulative flow change and then also add in your anticipated changes to see if that's really going to throw you into a lot of deficit.

RESPONSE: We've tried to set this up so that it would be easy to use as we move forward. As you can see, I have an analysis set up. I can do all of the nodes in the model, once I get that one script set up, in one shot. The interesting thing is that it takes longer to run the analysis than it does to run the model. But that's not uncommon doing these post-processors. Did you have any other questions that I could try to answer?

COMMENT: I was just trying to remember what we talked about a month ago.

Facilitator: You referenced this concern already but the concern was that if you go with one of these recommendations, for example that were in the trial balloon that Fred presented which was 80% flow by, if DWR uses SIMBASE instead of the baseline that was used in the habitat simulation that Jim did, are you really recommending 80% flow by or are you recommending something different because baseline has changed. Tom did these additional analyses to try and clarify if there was a big difference between the natural flows that Jim used and the SIMBASE that DWR's using moving forward with the basin planning. So I guess the question is, how much more do you need, or do you need more at all?

RESPONSE: Well I think Judy just said it; it's basin specific.

RESPONSE: So would we need to recommend that to DWR? Would that be a potential recommendation, that this type of analysis would be appropriate?

Tom: If 80% flow-by is what comes out in the end, and I'm not saying it is or isn't, what we're going to need from the Board whether it's 80% or something else, is here's our recommendation, this is how you implement it and how you interpret it. That would be ideal but the less you give me, the more flexibility I have to make up how I want to interpret it, too. Just going through this internally, we've had quite a bit of discussion. What does the 80% flow by mean, how could we implement it, what does it mean in terms of modeling and planning? And what you're seeing here is kind of what came out of those

discussions.

Facilitator: Are there any other reactions to this? Does this bring up any other thoughts for you or concerns?

Tom: I can do some follow-up summaries, if you need. Right now we only have the one PHABSIM, it's kind of hard to compare.

COMMENT: All I want to say is that I think there is something really profound in these results, and it is hard for me to even know, having just seen it, what exactly my response is going to be. But I think that question is still out there, if your PHABSIM recommendation, even if it's not 80% flow by, but if there's a recommendation that's based on the PHABSIM work that was done, and it was based on naturalized flow, or unregulated flow, we need to understand what the implications are when it's used in a model with a SIMBASE current and SIMBASE future condition.

Facilitator: It's almost like you could have a caveat to a recommendation saying the equivalent of SIMBASE, right? If it's a difference? That would be something they would have to look at in the other basins, it sounds like. Is that kind of what you were thinking?

Tom: Well, like I said I apologize we didn't get it out so you could look at it and think about it before so when you get working on your next agenda, if somebody feels like they need a follow-up discussion to clarify something that either Fred or myself have done, we would be glad to come back and do that.

COMMENT: I think one of the issues that Judy brought up though is that we're looking at one basin, and in a way, it's hard to capture what the impact is of using a different baseline flow if it's going to be different for each basin. You've got some basins that already have a lot of water use development, and others that don't—some that are projecting to have a lot more than others in the future, so without seeing this kind of scenario on different basins, to me it would be a little difficult to move ahead and say okay this is the impact of using SIMBASE versus the naturalized flow. Okay, if we've only seen one basin, I accept your estimate that it's going to be different in others makes a lot of sense, but how much different.

Tom: That's really going to vary from one to the other, because I can tell you some basins we're working on right now and we're having dramatically different wastewater discharge scenarios and different water supply alternatives with what the current condition is. So I would expect that you're not going to see 22 out of 27 of the nodes showing 0 change.

QUESTION: Do we have any idea how these deficit figures compare to the deficits that RTI calculates? I mean is a 80% flow by equal to 20% deficit or do we not have any idea of that yet?

QUESTION: Are you talking about eco deficits?

RESPONSE: Yes.

RESPONSE: I think we have had that discussion.

RESPONSE: It's a challenge because eco deficits are how big is the area under a curve, so that percent doesn't translate directly to these types of percentages.

COMMENT: Yes. This is a daily, an instantaneous, in a sense, issue versus a summation.

Tom: Right. I mean they're slightly different approaches to this. I think that's part of the problem of all this. We talk about percentages, but we're talking about percentages of different things. So it's kind of hard sometimes to compare them. If you think about it, and somebody feels that they need us to come back and summarize this slightly differently or have a follow-up discussion, we'd be glad to come back at the next meeting.

QUESTION: So, Tom, just for my own understanding, if you were to run the other basins, how much time would that take?

RESPONSE: I don't think for me to run some of the other basins is meaningful unless we've also got a

PHABSIM site for comparison. I can run the numbers and see, probably the Neuse and the Tar I could do—probably would take me maybe a day, maybe a couple of days to set up the initial analysis, and I'm probably talking maybe for both of those maybe 3 or 4 days' work, total. But like I said, I'm not sure it's going to help you if I don't have some PHABSIM sites in there to compare against.

QUESTION: Tom, I have a question for you and Jim. Would that work we did in association with the Harris coal application be applicable for comparison, where we used PHABSIM?

RESPONSE: That was on Buckhorn Creek, and that was one of the nine PHABSIM sites.

RESPONSE: Yes, and we did Cape Fear River as well.

RESPONSE: Cape Fear would not work probably because remember we had side channels, and it doesn't really represent. At Buckhorn Creek, that was one of the nine PHABSIM sites. There, the difference between unregulated and existing is phenomenal because of the creation of Harris Lake. Even if the additional units were put in and the reservoir were raised, and I'm not sure that the 2060 projection would include that or not but even if it did, it would be, I suspect, a lot smaller than the difference between no Harris lake and Harris Lake.

RESPONSE: You probably will see some there because if you actually go with the scenario of the new units and changing the size of the lake, you're going to see some changes.

RESPONSE: But as part of that would be adding a minimum release to Buckhorn Creek, which the current situation does not have.

Tom: Right. So add all of those together—that's why we have the models because there are too many variables to get a good handle on what would be the final answer.

COMMENT: I guess, again, the use of the river stations just wouldn't be applicable because we were restricted to that small two-mile study area.

RESPONSE: I think so, yes. I mean it had a very specific aim, and all but a couple of the transects there were off on little side channels because that's where we thought most of the impact would be. And also just workability, too.

COMMENT: That's where the most diverse habitat was.

Right.

COMMENT: But thinking about the Buckhorn Creek thing, that's another reason where when for the nine sites that we did the PHABSIM analysis for, over the course of this group's meeting, we used unregulated as a baseline and then some flow regime, whether it was flow-by, percent average flow, 7Q10, etcetera. None of those included the presence or the operation of a reservoir because each reservoir is different. Trying to come up with some sort of approach that could be applied broadly, and we've talked about this before, we're looking more at just withdrawal types of changes in flow and not big reservoirs, or even smallish reservoirs and how they change flows because each reservoir has its own unique characteristics in terms of how much storage, how big of a stream is it on, how is it operated. Plus every reservoir has to go through its own separate permitting and environmental study process that we didn't want to try to replicate or shortcut. So even though Buckhorn Creek has reservoirs sitting upstream on it, we treat it as if someone just had a lower spot withdrawal on Buckhorn Creek that was letting some amount or more go downstream.

RESPONSE: Right.

## **VII. Presentation: Biological-Environmental Classification (BEC) Project Update**

Presenter: Jennifer Phelan (RTI) and Tom Cuffney

Jennifer provided an update on the BEC work, followed by Tom providing an update on the fish classification portion of the work. This has been a joint effort between RTI and USGS. We acknowledge funding sources of EDF, NCDENR, and NC WRC. They provided feedback to make it a strong collaborative effort.

At the last meeting, 2 main presentations were given, one by Philip Jones on stream classification. Then I did one to share products of our RTI Internal research development project, specifically a method to test on developing flow- biology relationships. As a reminder, we presented that there was no obvious winner with respect to stream classification associated with biological assemblages. No stream classes...we suggested 2 approaches (see slide Last meeting for the 2 options)

- 1) Do multifactor response models offer better predictions of biological response? (other attributes besides flow metrics)
- 2) Do a priori regional classifications improve strength of flow-biology relationships? (Like Omernick ecoregion or EDU)

Since then we've pursued the 2 options of the BEC classification system pairing those results with RTI IRD work. We've come up with recommendations for flow-biology curves. Recommendations are based on going as far as we can with the class approach and given time and resources, best available data for flow-biology curves.

Before jumping to curves, I'll give a brief overview of methods. Similar models were developed by Tom and presented by him. We did similar analyses with fish. Response metric- species richness of riffle-run since it is most responsive so far for flow changes.

Muti- factor response models?

- NC fish (species richness of riffle-run guild)
- Flow metrics:
  - Summer Eco-deficit - chosen because summer eco-deficit represents magnitude
  - decreases in Annual 30-day Minimum Flow- chosen because it represents both magnitude and duration
- Best model fit- We included a variety of predictive variables based on Tom's recommendations, and could be applied across the state (mapped):
  - Flow metric
  - Ecological Drainage Unit (EDU) regions- a strong predictor variable
  - Slope
  - % Forest Cover (highly correlated with flow metrics)
  - Average Temperature -only a good predictor for annual 30 day min flow

These results we found for fish were similar to results for benthos (forest cover/flow metrics, Ecoregion(Omernick) worked best for benthos, EDU for fish, which makes sense since EDU was developed for fish.

A priori regional classification improve strength of flow-biology relationship?

- NC fish (species richness of riffle-run guild; RTI flow-biology methodology – normalized by basin; response of 90th percentile data)
- Flow-biology relationships developed for each EDU
- Results:
  - Flow-biology relationships were not consistently strengthened by splitting up by EDU
  - only 4 of 10 EDUs had significant flow-biology relationships
  - only 1 EDU had a better model fit than the state-wide model (Albemarle Pamlico Piedmont EDU)

We didn't gain much by splitting up by EDU. There weren't always a lot of observations within each EDU, some had 4, 2, 9. If there were more monitoring data results it could change but can't do that. Normalizing by EDU, found only 1 EDU had a stronger model fit than statewide model. We're not gaining anything by splitting by EDU. Best approach is a statewide model.

**Recommendation** (from the ad hoc research group including RTI, Tom(USGS), Chris, Fred)  
 Use state-wide flow-biology relationships for fish and benthos (based on RTI flow-biology methodology) to support determination of ecological flows

- Biological response:
  - Fish
    - Species richness of Riffle-run guild
    - Normalized by basin by 90<sup>th</sup> percentile value for each basin
  - Benthos
    - EPT Richness
    - Normalized by Omernik Level III
- Flow metric:
  - Eco-deficit

QUESTION: Remind us what EPT is?

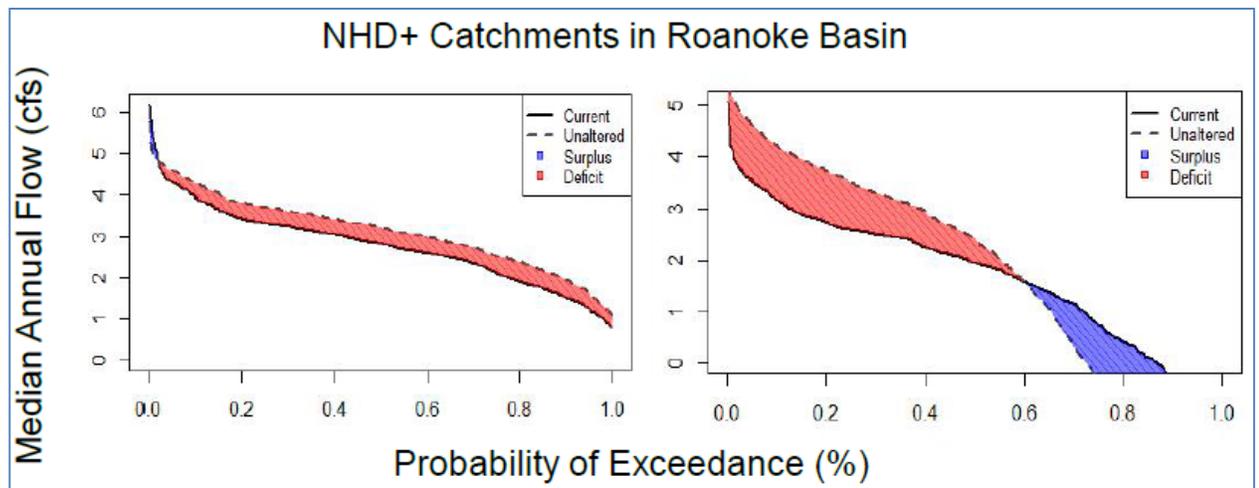
RESPONSE: Includes mayflies, stoneflies, caddisflies (insect orders Ephemeroptera, Plecoptera, and Trichoptera). It has for a long time been a very sensitive method, and one that DWQ uses as procedures for establishing site condition.

QUESTION: Summer or annual eco-deficit? Both.

*Eco-deficit definition:* It's a calculation not as simple as a daily flow value. Eco-deficit is a measure of the reduction in volumetric water availability

20% eco-deficit = 20% reduction in volumetric water availability (over a defined period of time)

It can be expressed daily, monthly, seasonal, or annual basis. A relationship between flow duration curve during baseline condition (can choose



that (and current condition, and looking at difference under the curve. Results in a calculation of either a surplus- increased flows, or a deficit, meaning flow is reduced. Red is decrease, blue is surplus. These graphs (above) show the rate of how the deficit or surplus will change based on amount of flow per second. These are NHD catchments in Roanoke. We find more often than not that this is what the relationship looks like. You have a consistent decrease in flows, but a little bit of surplus in the higher magnitude of flows. Occasionally you have something like this happen; sometimes you have an increase in flows. You have a whole variety of what these look like when you examine on a catchment-by-catchment basis, which makes sense when you think of the changes. This one, when I scroll down the plots you'd see this was a common trend (the one on left).

QUESTION: The expectation for slide on right, where current exceeds unaltered, that's expected to

occur where you have a low flow requirement, or changes in land use where you have flashiness of a discharge?

COMMENT: A dam, or wastewater discharge could cause that.

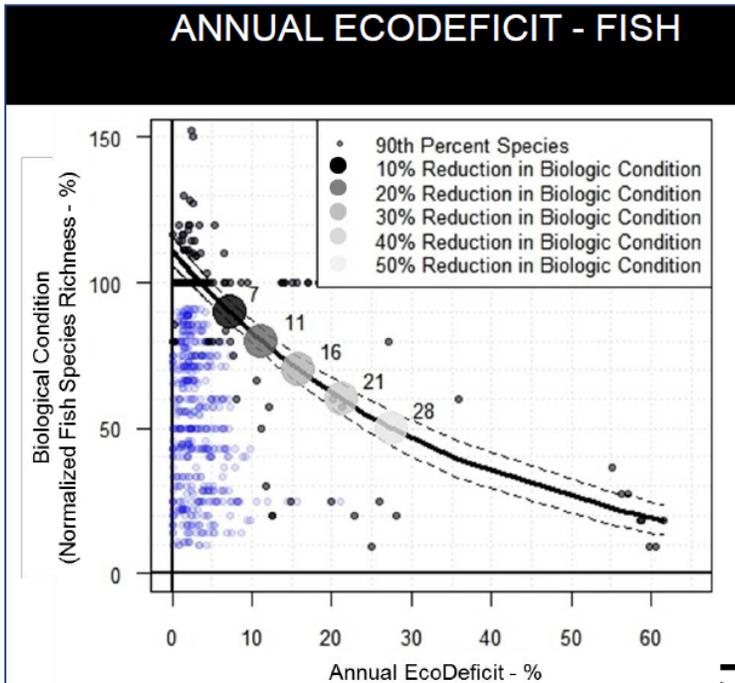
QUESTION: For the graph on right, if calculating eco-deficit for that one, you're taking the eco-deficit you have right now, subtracting surplus from it and that would be your eco-deficit?

RESPONSE: No, just taking the eco-deficit. Only calculating this value, not doing net change...

QUESTION: When calculating eco-deficit over time is it a cumulative calculation or is it an average for that time period?

RESPONSE: These flow duration curves are done over a time period, so you determine what period you want to do eco-deficit for based on what period of record.

QUESTION: 20% measurement over entire



period, summed?

RESPONSE: Yes, so keep in mind whether it is annual, seasonal, daily or monthly. It doesn't make a lot of difference in results.

Now we're getting to the curves themselves. This graph shows annual exceedence for fish. As a reminder, normalized fish species richness is normalized by 90<sup>th</sup> percentile value as denominator for all monitoring (max biological condition). So you take the 90<sup>th</sup> percentile value of species richness for the basin, use that as denominator for all monitoring stations in that basin. Anything less than that is less than your maximum biological condition. These are a best-fit curve to the upper 10% of the data, either linear or non-linear based on the best model fit.

Q Why did you choose upper quantile?

RESPONSE: Potomac did ground breaking work; they used upper quantile approach. They found that there was so much variability in the data, there seemed to be an upper response limit. They used quantile regression approach to hypothesize that the top 10%, the upper quartile, of data was showing the upper response, the ceiling of response that could be attributed to flow alteration.

COMMENT: If you look at the dot that says 16, what it tells me is that a 16 percent increase in annual eco-deficit will result in a 30% reduction in biologic condition.

QUESTION: I understand the 90<sup>th</sup> percentile decision though it seems arbitrary. Equate that to definition of ecological integrity put forth by legislation.

RESPONSE: We haven't done that. That is up to EFSAB. Argument could be made (by biologists) that a reduction of any number of species, any species loss in the system violates integrity. We're not saying that. We're saying EFSAB needs to determine where that violation occurs, where to draw the vertical line. We'll have to have that debate here.

COMMENT: The point I'm wrestling with, when legislation was enacted and DWR negotiated, there was a crystal clear decision to use a definition different than DWQ's definition for biological integrity. I'm hoping EFSAB can avoid making the judgment decisions, and make our recommendations so that

allows a lot of flexibility. I'll hold off until Tom makes his recommendations.

Jennifer continued her explanation of the graph- This is the bio-flow response relationship with best fit curve based upon data. All we've done here is to put into context of changes in biology we've plotted a 10, 20, 30, 40, and 50% reduction in biological condition, saying for this incremental change of biological condition, it is associated with the 7,11,16, 21, and 28% eco-deficit for fish.

QUESTION: Specific for riffle run guild? If you're looking at riffle run guild, and the site you're looking at is on a riffle, you will already have much higher amount of riffle run guild than if it were sampled at a pool. Have you accounted for the habitat at the site? One might show up as low in a riffle run guild, it may be because of the individual habitat site...

COMMENT: Regarding how they were sampled, it's a 600 foot length of stream. The question is pertinent since it is a site-specific assessment, hopefully we'll capture a diversified habitat for the reach we're trying to evaluate. We can provide the SOPs but in actuality there is variation in the sampling. It's a good reason for why to use the entire database rather than narrowing it down.

RESPONSE: Right. The hope would be because of the sheer volume and number of data points, that would help reduce error.

COMMENT: Because of DWQ program and resource constraints, the entire data set for fish is not very big. Not as big as the benthos.

RESPONSE: Riffle run guild is 858 sites, then take into account tidal zone, restricted sites- we got 600 sites for riffle run, ~650 for pool guild collected between 1990-2010, the most recent measurements for each site.

COMMENT: If riffle run guild was not present in sample, site was not included in analysis (

RESPONSE: correct). Not a determinant; won't see a lower value of sites simply because of sites without riffle run.

RESPONSE: Right. 90-95% of sites that have riffle run guild present were almost exclusively in piedmont and mountains, and had at least one observation of riffle run guild species, whereas Pool had representation in coastal, piedmont and mountains.

COMMENT: Calculation of species richness when predicting effects of eco-deficit on richness, is that accomplished by using either sequential observations on the same site with different flow patterns, or is it calculated based on an estimate of reduction versus natural flow conditions?

RESPONSE: The latter. All the data points here represent single time measurements, most recent at a biological monitoring station (even though measured every 5 years). Kimberly did more of a time series analysis which she'll present next time. As far as flow alteration was concerned, it was comparison of flow under PNV, no flow alteration, vs current condition (2006 NLCD with current withdrawals, discharges). We used same climate period (1967-2006) for both land cover conditions to isolate effect of human influences.

COMMENT: Every site has a current eco-deficit, which is the baseline.

COMMENT: Your numbers are based on you calculate natural flow versus current flow at most recent sample.

COMMENT: We have to treat current condition as baseline. If you add additional eco-deficit, how many additional species do you expect to lose?

RESPONSE: Some sites have had a lot of alterations based on current land use, where some have had relatively little alteration.

Q; When you enter data, take species richness data from a site and it has categorization as riffle run or pool, it seems logical that at some point if it has significant eco-deficit (20% or more) then that the site may have been a pool site.

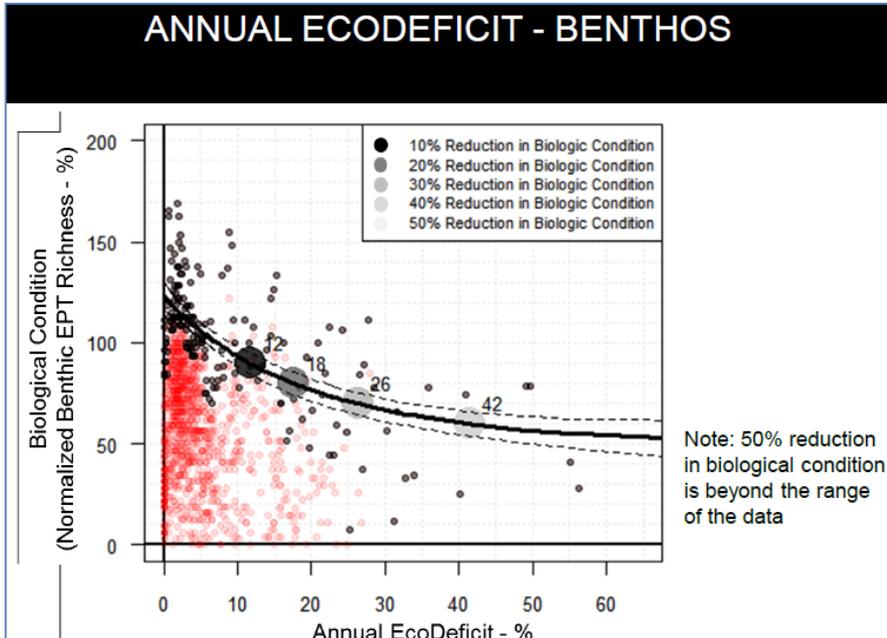
COMMENT: No, each site includes multiple habitats.

COMMENT: But Jen used current guild species...

RESPONSE: In last meeting I showed a map of NC with fish monitoring sites, it showed overlap of which ones had riffle run species- the majority in mountains and piedmont.

COMMENT: The site description is from guild species present at sampling, not from looking at the site.

RESPONSE: correct.



Moving on to Benthos- we did the same analysis. Benthos in response to eco-deficit normalized by EPT richness. 50% reduction is not on this curve.

Then look at them on the same graph- the blue is benthic, black is fish. Confidence interval is shown.

COMMENT: A stronger response demonstrated in fishes

RESPONSE: yes, as according to best fit curve normalized with 90<sup>th</sup> percentile

COMMENT: with the best we could do with data we could find, these 2 graphs based on

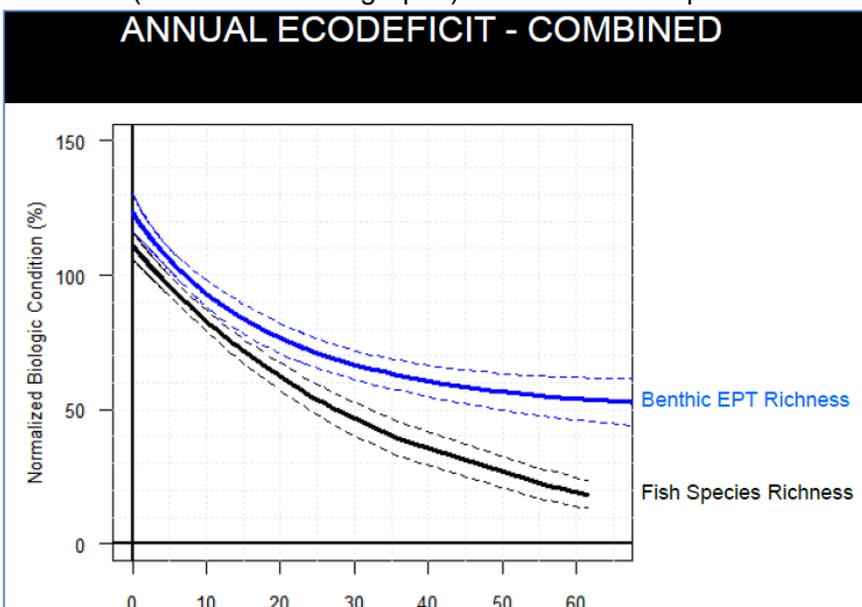
fish and bugs, tell us how biological condition reacts to increases in eco-deficit. We used the most sensitive/most representative guild, second most sensitive guild, came up with these 2 curves. One option is to give the 2 curves to DENR and say it is up to DENR to decide how much degradation is tolerable. Other possibility, charge in legislation prefers this, I think we can in this room on the basis of science, only on science, try to decide where the state should declare ecological integrity exists on the graph. There is no regulatory function reflected in this graph. We don't need to think about balancing needs of stakeholders, we need to think as scientists, where does eco integrity fall apart. Ecological integrity is defined in act as species richness and ability to recover species richness and disturbance, and ecosystem services. I think we're at the point where we need to consult colleagues, literature, each other, to make science based decision about where on this graph eco-integrity probably lives. I don't think it will be easy.

QUESTION: Based on this graph, is there any way in which this can reflect on recovery?

COMMENT: if you go to literature and ask how much can species richness decline before it can recover you may find answers. That's the only way to answer that question.

Jennifer continued with the rest of her presentation.

Annual eco-deficit combined slide: With respect to duration, here it presents the metric by annual, seasonal (annual shown in graphs). Seasons correspond with PHABSIM months in seasons. These values correspond to 10, 20, 30% reduction in condition. Values correspond to changes in flow. You can see in comparison of annual to seasonal there is not much change. You could adopt season-by-season or annual.



QUESTION: To interpret the table, an 18% increase in annual eco-deficit gives you a 20% reduction in EPT richness?

RESPONSE: yes. These

thresholds have been calculated for all 23 flow metrics. They all show a similar trend, there's not much variation between metrics.

COMMENT: The big issue for me is because the benthic curve is so much flatter than fish curve, you're looking at making decisions that could be skewed in either direction, the difference between 20 and 30 depending on which curve you use.

RESPONSE: Last time we showed pool as well, pool guild showed a similar response to benthos. We only analyzed 2 of the 6 guilds determined by fish biologists. We chose contrasting guilds. The data supported our hypothesis that riffle-run guild is more responsive (sensitive), the pool guild less so.

COMMENT: There are a lot of things going on. Benthic ecologists would indicate that community structure of fish is much more related to habitat. Benthic incorporate water quality and other things more so than fish. The

difference between the 2 is not as wide as I thought.

RESPONSE: Remember these are 2 different models. Invertebrates do not use a log-linear model. It may be worthwhile to do this, even if it is not the best fit, it may be a more comparable and better model. That's why it's flattening out.

COMMENT: EPT are not necessarily categorized by their guild. There may be some that may not be so flow sensitive, some will be. They are bound together right?

RESPONSE: Right. Usually EPT is used because a large amount of them are sensitive. In doing this we looked at 140 some metrics. We used this one because of response and because it's applicable to things that have been going on for a long time.

QUESTION: Can you guess what the log-linear relationship would look like?

COMMENT: It may be worthwhile to do that, because of the fact we don't have many samples out at the other end, that place where it is flattening out is not well defined.

QUESTION: For comparison purpose, how does your PNV flow compare with the unaltered flows showed this morning? They use different method of calculating unaltered flows. It would be good to see comparison.

RESPONSE: It may be good to compare.

COMMENT: Not sure that comparison can be made. OASIS strategy is to remove all human alterations of flow, and OASIS ignores land use change over period of record. WaterFALL compared PNV flows with current flows and avoided all human modification of flows in baseline condition.

RESPONSE: PNV flows in comparison with current condition which is 2006 land use cover and instream alterations (in 2006).

COMMENT: What you started with in 2006 would be more comparable to the unaltered flow that was presented this morning (SIMBASE).

RESPONSE: In WaterFALL you could start with 1970s and use it as baseline and compare with 2006 as another option.

QUESTION: Your current condition model we'd hope it is similar to SIMBASE. The question is, is PNV similar enough to their unaltered flow so eco-deficit could be a part of the conversation of how it goes into OASIS. If PNV were very different from unaltered regime, we'd need clarification moving forward

<b>ANNUAL ECODEFICIT - COMBINED</b>						
	<ul style="list-style-type: none"> <li>Annual versus seasonal ecodeficit – biological responses relationships and associated “biological condition” thresholds</li> </ul>					
Metric	Fish: Species Richness			Benthos: EPTR		
	10%	20%	30%	10%	20%	30%
Annual EcoDeficit	7	11	16	12	18	26
Winter Deficit	7	11	16	11	16	24
Spring Deficit	7	11	15	11	17	25
Summer Deficit	9	13	18	13	20	31
Fall Deficit	10	15	20	14	21	30
Average	8	12	17	12	18	27
Standard Deviation	1	2	2	1	2	3

with a recommendation about eco-deficit.

COMMENT: SIMBASE in OASIS is the current state of affairs. Take SIMBASE and remove all human alterations of flows-outfalls, withdrawals, dams. If you have 100 years of data in OASIS, every year represents the land cover that year. There is no PNV point in an OASIS model.

COMMENT: Right, in order to use the eco-deficit in relationship to model DWR has, we need to understand relationship between PNV and what DWR uses as unaltered flows.

COMMENT: To rephrase, what we've done with waterFALL is characterize current rate of affairs as how much eco-deficit already exists. Then DENR with OASIS can calculate future eco-deficits based on future management and can determine future additional eco-deficits, then we can look at how that may affect species richness.

QUESTION: That relationship is there when comparing difference in flow. Whether it's due to vegetation, climate change, human use is beside the point.

COMMENT: Your denominator is based on current flow and difference you've projected between natural flow and current condition. Magnitude is what is used to calculate effect on species richness and where that fits on the curve, correct?

RESPONSE: Yes, but it is that change starting from today into the future. You don't have to go back to model PNV.

COMMENT: DWR will use model using SIMBASE regardless.

RESPONSE: As long as you are calculating deficit in the same way, same area under the curve calculation.

COMMENT: You're saying its not the difference, its where your starting point is.

RESPONSE: Yes, PNV has only been used to develop this relationship, it does not have to be used in putting this into management.

COMMENT: Oasis can be used to calculate future eco-deficit. That's the point.

RESPONSE: Depending on where you fall on the curve, how much further degradation are you willing to accept? Your prescription may be different if you are on one part of the curve as opposed to the other, maybe.

QUESTION: I have concerns with eco-deficit metric, think its important to look at guild that you're using. Hypothetically since calculating eco-deficit with high and low ends of flow range, you're saying with a riffle run guild it will respond the same to changes in a 75<sup>th</sup> percentile flow as to a 25<sup>th</sup> percentile flow, but in reality literature says riffle run guild is most likely to change in response to the 50<sup>th</sup> down to the ) or 10<sup>th</sup> percentile, which is when they will be sensitive to the metric. I feel like the result of eco-deficit could be artificially exaggerated by putting an eco-deficit at that higher end. I think it's important to have a better link between the flow metric and the guild that is used.

RESPONSE: Good point...that's a concern when you see a bias of a deficit or surplus in one part of your curve vs another. But more often and not we found the graph on the left as a trend- an even spread, a general reduction in the curve. It's not quite as biasing. You also have to be concerned that this is an annual thing that gets rid of your periodicity. Versus if you want to do it on a seasonal or monthly basis. You have to be cognizant of these when looking at the results.

COMMENT: Also important in the difference of how the fish and benthics respond.

### **Tom Cuffney presented the rest of the slides.**

As Sam alluded, when you start looking at plotting the 10, 20, 30% reduction, we're faced with issue of putting in relevant context to interpret it.

Depending on the current condition of a stream, how much degradation in the biological condition is EF-SAB (NCDENR) willing to tolerate?

To make this work relevant: Need to link ecological responses (e.g., EPT richness) and flow deficits (i.e., quantile regressions) to ecological condition.

DWQ has established invertebrate condition classes based on EPT taxa richness. DWQ uses EPT richness as one means of establishing condition classes:

	Mountain	Piedmont	Coastal Plain
Excellent	>35	>27	>23
Good	28-35	21-27	18-23
Good-Fair	19-27	14-20	12-17
Fair	11-18	7-13	6-11
Poor	0-10	0-6	0-5

DWQ has condition rankings for most sites and dates used in EF-SAB analyses.

Therefore, we can:

- Calculate 90th Percentile for Condition classes in each ecoREGION
- Standardize for 90th percentile Condition in each condition class within each ecoREGION
- Derive state-wide Condition classes based on average standardized values

It gives us some context as how much change has occurred. From the invertebrate perspective, we have advantage that DWQ has

used them to rank sites by condition. The numbers aren't important but the concept is what is important. With DWQ data we have condition data, rankings, for the sites.

Because quantile is dealing with 90<sup>th</sup> percentile, we can calculate 90<sup>th</sup> percentile for each category of condition class for piedmont, coastal plain (atlantic and southeastern plains combined), mountains (see graph).

Based on EPT taxa richness the curves are different, particularly for coastal plain. We can normalize those dividing by excellent condition, from 1 to 0. The excellent condition reflects reference. We can get average curve for state- we've got one curve to deal with. Could also take midpoint between classes and develop table (see table above).

EPT richness classes are based on proportion rather than percentage. We can go back to the quantile regression and plot where the excellent condition would be, good, good-fair. WE can go to eco-deficit and see it may be fair, not excellent. If you change it, maybe it goes to poor. So we can use it as a screening criteria to see if a planned water withdrawal will result in a flow deficit that it pushes site into a lower condition class. Then if that occurs you could go into site specific flow study. This takes advantage of what state has done for condition classes and in order to get a feel for whether the change is significant, this is significant if it jumps into a different condition class.

Graph shows statewide condition classes based on 90<sup>th</sup> percentile. Advantages of approach- takes advantage of best data we have. A

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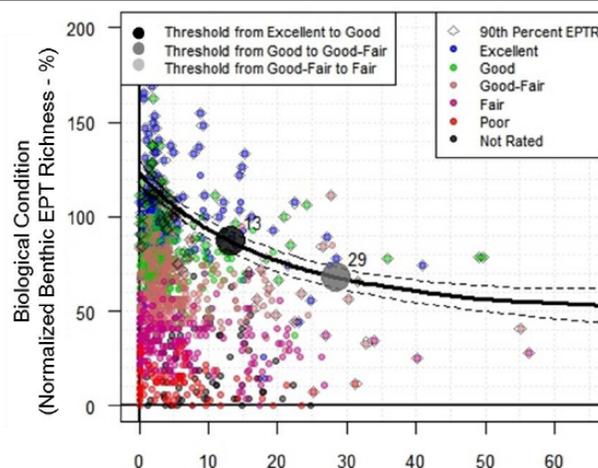
### STATE-WIDE CONDITION CLASSES BASED ON 90<sup>TH</sup> PERCENTILE

	EPT richness <sup>1</sup>
Excellent	≥ 0.868
Good	0.868 - 0.675
Good-Fair	0.675 - 0.469
Fair	0.469 - 0.249
Poor	< 0.249

<sup>1</sup>EPT taxa richness scaled by 90<sup>th</sup> percentile in mountains, Piedmont, and Coastal Plain

Screening criteria: if a planned water withdrawal results in a flow deficit (annual, summer, winter, etc.) that pushes the site into a lower condition class then a site-specific flow-ecology study is warranted (e.g., PHABSim).

### STATE-WIDE CONDITION CLASSES BASED ON 90<sup>TH</sup> PERCENTILE



Note: Thresholds for Good-Fair to Fair and Fair to Poor are not reached within 100% decrease in Annual EcoDeficit

data-driven approach for establishing ecological flows.

- Relates back to NC DWQ concept of biological condition classes
- Uses state-wide flow-biology relationships for fish and benthos (based on RTI flow-biology methodology) to support determination of ecological flows
- Guards against further degradation, while taking into account of current conditions
- On-going process (adaptive management)

COMMENT: Remember that DWQ's definition of biological integrity is based on reference condition and not on prevailing condition. It's unimpacted comparison, not prevailing comparison.

QUESTION: how many sites?

RESPONSE: ~900 sites. There were 1700 invertebrate sites but RTI couldn't model them all for flow. We did not restrict sites used to certain conditions (good-fair etc)

We don't have expectation a fair site to be good or excellent. It's an ongoing process, the invertebrate model is an exponential decay model, we need to decide if we want to use a different model even if not as good a fit. It may be good for us to say "here is a way to proceed in the future", we won't get to a final end point during the EFSAB process.

**Tom ended his presentation. Questions, comments, responses:**

QUESTION: Most of this data is based on wadeable streams. What are pros and cons of trying to use this data to say anything about larger rivers where most of your withdrawals will come from?

RESPONSE: I think there is overlap with streams where there are water withdrawals, the Eno for example. These are percents of flow, if you're saying it is not related to large rivers, and large rivers are responding to flow differently than other river systems, I'd say it's not true. Some large rivers may be more sensitive to it, particularly ones where benthos are dependent upon snag habitat (coastal plains streams). I wouldn't throw it out, I'd say this is the best we have to deal with. If we don't try to incorporate this, then what other basis are we standing on? I like data.

QUESTION: About fishes, because IBI (index of biotic integrity) also has excellent, fair, good, will that be run along same concept?

RESPONSE: It would take additional work to see if riffle guild info and IBI coordinate.

COMMENT: We (DWQ) continue to work on refinements to IBI to address issues. The IBI is an adaptive process itself. In some places it's not working well- small mountain, sandhill streams for ex. Fish uses more metrics used than EPT, which makes it more challenging.

QUESTION: Using riffle-run guild, you'd have different one for fish and for benthos based on different sensitivities.

RESPONSE: Instead of using 10, 20, 30 % reduction arbitrarily, he's equating it with an existing condition classification scheme to enable you to use a framework to determine when you are crossing an ecological flow threshold.

COMMENT: DWQ draws line in sand between fair, and good to fair, calls fair to poor waters impaired. That is a threshold we use.

QUESTION: How much of the difference in richness indicator here would you attribute strictly to flow as opposed to other factors?

RESPONSE: It's a small portion looking at the entire state. That's one of the reasons for going with the quantile regression. The 90<sup>th</sup> percentile is a statistical estimate of upper ceiling based is on flow.

RESPONSE: Data points are color coded based on site condition ranking of benthos. More or less the excellent provides the excellent data (blue) followed by the good (green), then good-fair (mauve)...it's a nice gradient, doing what you would expect with your site conditions.

COMMENT: If good-fair is acceptable condition, than your eco-deficit is pretty far out there.

COMMENT: We haven't made the call that good-fair constitutes acceptable condition. Lots of variables influence species richness in stream, flow is without question the most difficult of those to characterize because flow changes a lot seasonally and inter-annually. What I think RTI and USGS

team has done is close to best job humans can do in figuring out how species richness responds to flow variation, filtering out other variables and giving us something close to the truth. I don't know what we'll do with this, but I feel strongly that it is a powerful tool for us to consider using.

COMMENT: At a bare bones minimum it will provide us with some educational tools to share with folks who have not been sitting at the table. I also think it provides us an opportunity to talk about other issues, impacts on ecology, biology, flow durations, frequency and magnitudes. Another way to express annual eco-deficit in terms of a recommendation, it could be changed to our comfort level or confidence in making a recommendation. I need time to digest this and think about it. I like making decisions based on data.

QUESTION: For sake of argument, could you take this relationship, using good-fair rating, establish eco-deficit with that. Take projections for a river basin and look at it in 50 years to see as an example?

RESPONSE: Right, and not just look at magnitude, also whether it changes water quality rating class. It would be a good screening tool. To get to hard facts PHABSIM would probably need to put site specific data in it.

QUESTION: A math question, it seems that if the denominator were at 90<sup>th</sup> percentile, than the intercept would be about 111% but it seems to be around 120%?

RESPONSE: I don't have the equation here, it is a non-linear relationship. Lauren would be more familiar with the statistical model.

COMMENT: I think she used 90<sup>th</sup> percentile for excellent rather than 90<sup>th</sup> for maximum biological condition. That may be why it's low.

RESPONSE: We'll look at that together with the log linear model to see how that changes it.

QUESTION: This is interesting. Jay hit on the difference between fish and EPT, if you could establish this sort of relationship/graph with fish it would be interesting how it compares.

RESPONSE: A graph with both fish and invertebrates were shown in this presentation, but fish does not have the site condition classification. We would have to do the same thing with fish with IBI, rather than arbitrarily using 10, 20, 30% etc. reduction in biological condition.

Facilitator: The facilitators think we're still in information gathering phase today and we're winding that down. Sam brought up that we need to address frequency, duration, magnitude, and the need to discuss the threshold and whether to set them. We think it would be best to complete the information gathering. We have another trial balloon today, and the TNC report in July, then let's start assessing the various trial balloons and questions to answer. What I've taken from today's discussion- there's some desire to do log-linear model for benthos to finish fleshing out this work, comparison of unaltered by Tom Fransen, crank through some examples with site specific data to see if condition switches, and to look at fish condition similar to benthos method. Other suggestions?

RESPONSE: RTI can do log-linear model.

COMMENT: I think it can wait until we decide if we may make decision about eco-deficit, then we'd want to see if it is transferable to OASIS (regarding the comparison of unaltered).

Facilitator: What about doing site-specific examples? Is that something that could be done?

COMMENT: Using projections of one of the rivers to project out and see what it would show us, using the benthos with DWQ site rankings, see if it jumps class.

COMMENT: Keep in mind that good-fair class is not the way the legislation is done. It is a comparison to reference condition not to prevailing conditions.

COMMENT: But it's a characterization of the prevailing condition relative to the reference condition, it's not making a judgment call about impairment. You could still use it to anticipate whether there will be a change.

COMMENT: Right.

COMMENT: It's just an exercise to better understand the impact of this model.

COMMENT: I find the classification from fair-good to fair, whatever, misleading in that it is strictly flow related. If you are saying you are only going from good to fair good, when in reality you may be going to poor conditions due to water quality. It's misleading to characterize using these terms to define the system. I think you will confuse people like me.

COMMENT: In the end, legislation says tell us what changes in flow produce reductions in ecological integrity. All changes in flow produce changes in eco integrity- there is not point on the lines where it is flat. The question for this group becomes what constitutes a significant change. What Tom did by using the DWQ classes is handy, something that many people understand. When we started I dreamed that we would find stream classes, and they would be sensitive to flow changes but that didn't work. So now I think we have the challenge of looking at curves that relate flow and richness (these worked the best), and determine what constitutes a significant change from current to future condition. I want to say any loss of species is significant, but I imagine not everyone will agree so I think at some point we'll have to decide what is significant.

COMMENT: Legislature doesn't require that.

COMMENT: Is that a policy decision?

COMMENT: For DWR, we're developing planning tools. In terms of a planning tool, annual eco-deficit is something you can work with. If I want to suck all the water out of a creek, I could still have a darn good annual eco-deficit. What is your minimum duration and frequency elements you'd need to work with to do the kind of planning you would normally do? In acute situations, planning is not very good.

C(DWR): If you talk about drought, if I have a run of river scenario I'll look at worst case scenario, worst day. If a reservoir I've got more flexibility. That's what we're hoping you can help us define the time frame we should look at. I've got daily data- we can look at by day, group by month, by season. Tell me how I have to group it, we can figure out how to analyze it. We're it looking for you to tell us what is significant from an ecological viewpoint.

COMMENT: If it is an acute (one day no flow- invertebrates may be toast, fish may be able to hang out in a pool and come back), if it's a chronic situation, like eco-deficit looks at, it could be a similar or maybe worse effect. There are 2 times to deal with. Extreme one day changes in flow are very important.

C : Eco-deficit is a kind of average, it gets at tendency. If DENR was in regulatory mode (though they won't be) if they said to a municipality that they couldn't increase eco-deficit by >10%, the municipality has flexibility for when it takes water, etc to meet that over a year. The other point is that suppose DENR does say that 5% additional eco-deficit is threshold, question is how often and how long can you violate that. If annual eco-deficit is violated once every 4 years, DENR would probably use that as prevailing condition.

COMMENT: If you suggest natural cycle of drought is an acceptable prevailing condition, I would say that for an example drought in the mountains, trout were not recoverable in a reasonable span of time. They only through stocking and rehabilitation and some have not returned.

COMMENT: If we or DENR picked a number of acceptable degradation (example 10% loss of bio condition), you see what the corresponding eco-deficit is, you can look at period of record to see what happened around that number. If species were there during that number, then you know the eco-deficit is not going to cause significant degradation.

COMMENT: I'm with you but the question is we haven't defined how long it takes to recover.

COMMENT: Would we even be able to get to that point? Seems like we're wrapping our predictions into this eco-deficit. Resiliency, recovery are related more its position in landscape than to how flow relates to resiliency and recovery. As long as flows address eco-deficit question, the flow part, assuming it will be taken care of, then the resiliency and recovery will vary by site. I don't see how to tie recovery and resiliency to flow.

COMMENT: I wish legislation had included your opinion, it's in the definition.

COMMENT: Wherever we set the eco-deficit reduction point, it could be conservative to reflect the recovery ability. If we set 50% then it would be less likely to recover than 10% reduction.

COMMENT: Right, we could express if we are less confident, more confident that recovery will occur at different points.

COMMENT: We'll have to do the best we can given definition given in law. Definition in law does not give us a way to report back on the variable given. We can report back on species richness based on data.

COMMENT: The lower you set the bar for the insult, the more likely it will recover. We can relate that even if not related to a parameter.

Facilitator: It sounds like there is an inclination by some to use these curves to answer some questions in the legislation. Is there additional work that would provide more comfort in using these. If so, the researchers need to know this now.

RESPONSE: We won't come up with additional data. If there are additional analytical methods or presentation strategies that RTI can do to help this group, we can discuss this tomorrow when ad hoc group meets and we'll see if we can get them done.

COMMENT: Would it be more productive for us to provide that there is a way to proceed in general terms, and here is an example using annual eco-deficit. Or are we saying we want to pick a number (for example maximum 10% annual eco-deficit)? Do we have the time and ability to get that level of resolution?

COMMENT: The more refined our recommendation, the easier for DWR to implement it. The broader, the longer it will take them to get a workable solution. If we have capacity we should try to get a refined recommendation.

COMMENT: I think the legislation says we need to tell how biology responds to flow. I think we need to give DWR more than an example.

COMMENT: Are we going to tell them how to use it? Or let them know how we think they should use it?

Facilitator: I don't think you can decide that today. There is some question about level of comfort with using this method. Do people have questions about this, or do they want to see it analyzed a different way? Sam would need those today.

COMMENT: My question- I like the way benthic EPT proposal was laid out and how we could make recommendations. I don't have as equal a grip on how the fish curve could be implemented. It would be helpful to see some scenarios of how fishes and the riffle guild piece could be implemented.

RESPONSE: Do you feel comfortable choosing like how much biological condition are you willing to accept a reduction in (5%, 10%, 15%, etc)? If group feels comfortable coming up with a threshold value associated with change in riffle run guild, you could.

COMMENT: So it would be a change in the riffle run guild? (RESPONSE: yes) So for every reach/node analyzed that does not have riffle run guild, how would we apply this? There is a subset that is not, coastal?

RESPONSE: You could potentially apply riffle run guild to every wadeable monitorable stream. Then you might do something like pool guilds or other guilds for coast. Then have to think how do you deal with benthos vs fish? Do you go with the more sensitive of the species in an area? Again, the question is how do you mark the threshold condition for your comfort zone. Benthos could use a preexisting condition. We don't have an equivalent in fish but could choose a % reduction in biological condition as an option. This was presented as a strawman as a way to start talking about fish.

QUESTION: Is this going to be sent to us in hard format for us to consider?

COMMENT: We need time to review this before sending thoughtful questions. Until Friday.

RESPONSE: Ad hoc committee meets tomorrow, we can see if they can meet again.

COMMENT: Maybe you don't need to meet, but the question could go directly to the person in the group. It doesn't necessarily be a new analysis, but answer questions.

RESPONSE: A lot of time and energy went into producing these. We're presenting the jewels at the

end of these roads. Its not that we don't want to further meet your needs but we have to keep time in mind.

COMMENT: It would be interesting to run a couple examples through the Cuffney method, looking at projected changes in 2060.

C (ad hoc team member): we can do that.

COMMENT: Slide- state-wide condition classes- that shows the only -2 classes represented due to data available. It could not do a jump from class based on this data

QUESTION: Somebody mentioned the chronic vs acute issue, that eco-deficit represents chronic conditions, (inaudible) seemed to be intercorrelated. Is there any acute metric that would be inherently different than this?

COMMENT: The metric wouldn't be any different. Even if you had daily values.

RESPONSE: the metric we used as the smallest time step was...and correlation between 30 day...found a high correlation between...(inaudible- not recorded)

COMMENT: Those are all magnitude. In my mind you get to acute by dealing with a duration type of variable.

RESPONSE: Have we done that with the 1, 3, 7, 30, 90 day flows

COMMENT: That's an average one day flow. Duration is how long a certain flow lasts- number days below certain flow.

COMMENT: We've looked at IHA stats and others, to our surprise some of the stats we thought would be most powerful weren't. Eco-deficit turns out to be most powerful statistic. You can vary flow quite a bit as long as you maintain the ecoedficit.

COMMENT: One of the issues is perhaps the correlation between flow and other variables that results in measures, such as land use, other factors. It's not that we're saying were looking at another indicator, how can we reach a point where we can say this is a result of flow reduction. How do we tease that out?

COMMENT: I believe that's included in our charge. If flow causes variations in temp and DO, and biology is responding to flow, and some is related to temp, DO, I think all we need to know is that flow changed and biology responded. If flow is caused by a suite of other variables. Our charge is flow-biology. The place where we have to worry about is where changes in biology have nothing to do with flow. I think we've done good job of isolating flow and response.

COMMENT: I think some of it is integrated in there, but getting back to where the numbers came from. Perhaps the change in biological condition is due to flow change. If we can assign a proportion of likelihood change due to flow. I'd like a comfort level that it is flow primarily.

COMMENT: I'm open to suggestions about how to do this.

COMMENT: If you can restate the use of the 90<sup>th</sup> percentile and how it helps us focus on flow?

RESPONSE: Take for example 30 on eco-deficit. That value represents the best condition of all those sites. If you say what is the best condition, everything else is not affecting that flow parameter. It's not a partial regression, what your doing is saying here is my very best if everything else except flow does not change. If it were 50<sup>th</sup> percentile, you're saying other things affecting it.

COMMENT: What that indicates to me is that we can spend a lot of time refining, but perhaps a more appropriate use would be if these were the trends, pick a comfort level with where the steep part of curve is, etc. without redoing the calculations.

COMMENT: Depends on your recommendation, if you have enough confidence in these curves today, the EFSAB could say "don't increase annual eco-deficit more than 10%" for ex. I feel like we've beat it to death. I'd Like to hear Hugh's pitch.

**The following questions of clarification for the ad hoc research group were submitted and answered after the meeting:**

**QUESTION: Slide 3:** How did the annual 30-day minimum flow statistic results turn out? Can these be circulated to the group? What led the research team's preference for eco-deficit as the recommendation?

RESPONSE: We decided not to use annual eco-deficit, because it was disguising important seasonal differences. We will now compare seasonal eco-deficits and 30-day minimum flows to see how they effect biological condition. We should have the results of that comparison for the July meeting.

**QUESTION: Slide 5:** Recommendation is to use statewide flow-biology relationships...with this recommendation where can we to meet the legislative directive for a classification of streams? Would we instead "classify" the streams by the current eco-deficit? Group streams by their current condition annual 30-day minimum flow statistics?

RESPONSE: We tried several different strategies for stream classification, and none was robust, meaning none of the classes could be counted on to be ecologically distinct from their nearest neighbors in multivariate space. The clusters were too close together and too fuzzy. So now we are using a statewide, unclassified approach, with the important distinction that fish data are normalized by basin and benthos data are normalized by Omernick region. These a priori "classes" seem to be doing the trick for making it possible to compare one basin or ecoregion with another. Species in the mountains and species in the piedmont tend to respond about the same to eco-deficits and 30-day low flows, even though these are different species and they are responding to changes in wadable streams of different sizes.

As I recall, the legislation does not require classification, but does require characterization. But even if it does require classification, our normalization strategies qualify. We're still on target.

**QUESTION: Slide 6:** What change in flow (cfs) results in a change in the eco-deficit from 10% to 20%. Slide 6 indicates that 20% eco-deficit = 20% reduction in volumetric water availability; will the reduction in flow (cfs) be relative, depending on basin characteristics? I want to better understand how "significant" a shift in eco-deficit could be to habitat availability as described with the concepts of the PHABSIM models where we are presented with % change in habitat availability in relation to change in flow (cfs). Is it possible to cross-walk these concepts?

RESPONSE: Eco-deficit is kind of hard to understand. Increasing the eco-deficit from 10% to 20% does not mean reducing flow by 10% overall or at any given time. Eco-deficit is a kind-of-average (cool term, huh?) value that represents the gross (not net) negative area between the stream in undisturbed condition without management and with natural vegetation and the measured flow today or at some future time. So essentially every stream has a current eco-deficit, and we would measure the percent change in the eco-deficit from that baseline if flow is changed in some way(s) by management or climate.

In a general sense, eco-deficit is the difference between two scenarios – baseline and managed. The baseline is not necessarily natural vegetation, but in our instance comparing current to natural vegetation gives us a sense of how much things are already altered.

PHabSim investigations determine the reduction in a guild's habitat based on changes in flow. They remain the investigation technology of choice for individual sites. But we're trying to use a statewide database to develop ecological condition response curves for actual organisms, based on actual data. That is, not local reduction in habitat, but local reduction in species, based on a statewide model without a local PHabSim study everywhere to lean on.

Meanwhile, remember, habitat area is not necessarily the same thing as species presence, and species presence varies differently per area for all species. This is the standard criticism of PHabSim.

**QUESTION: Slide 7:** What is the range of riffle-run guild species richness included in this analysis...what is the maximum richness? In the piedmont? in the mountains?

RESPONSE: Riffle Run species were chosen because they are the most representative species, found in the most samples, and they are the second most sensitive species guild, after riffle species. However, there are never very many of them at one site, a problem we're struggling with all the time. The most at any one site in the Neuse is 4, and the most in the mountains is 14. The total number is 18. {I think these numbers are correct; if not, someone please correct me}

In the DWQ database of species collected in their samples, there are 51 species in NC we classified as riffle-run. RTI used all the riffle-run species classified that were in the latest NC samples at sites with repeated sampling. That number ended up being 42 species. The drop from 51 species is not too surprising since some of the riffle-run classified fish were pretty rare in the data (0 to 1 occurrences at a sample location since 1990).

We are exploring the Shannon-Weaver index which takes into account both species richness and abundance, but the SW index is also hard to explain to non-specialists, and the legislation does explicitly refer to species presence as relevant to ecological integrity. I would say that the choice between species richness and the SW index is the most thorny problem we currently face.

**QUESTION: Slide 18:** Does a 100% change in eco-deficit translate to 100% reduction in volumetric water availability(as described in Slide 6)...if so that sounds like a catastrophic change, yet, this 100% reduction does not result in the good-fair to fair reduction in Benthos condition pointed out in the slide and also by Tom and Jennifer...does this suggests that the Benthos may not be "sensitive" enough to the eco-deficit metric. Perhaps the log-linear fit will demonstrate a greater sensitivity?

RESPONSE: The DWQ condition classes are wide enough that a large change in benthic species present does not necessarily force a class change. It's like the class boundaries are 20 units apart, and sometimes a change of 15 units is entirely inside a class. We are considering an alternative approach in which, rather than looking at class changes, we look instead at the total change in ecological condition, such that a change of 15 units will always be more important than a change of 10 units, and so on. I predict we will come out with that approach, but then the question is, how many units of change does it take to raise the flag?

The RTI and USGS team members have been losing sleep and missing meals to come up with some way we can use real data to tell the story of how aquatic ecosystems, the second most ephemeral (after aeolian) of all kinds of ecosystems to my knowledge, respond to flow variation, the second most capricious and highly variable of all the physical parameters (after weather) that define aquatic ecosystems. And amazingly, they've done it. All the species x flow response curves look about the same. They all have about the same shape. We're struggling with two things, basically: Which curve tells the story best, in language that others will understand; and given whatever our favorite curve is, what change(s) in the y-axis variable (ecological condition) can be said to violate ecological integrity.

I have more confidence now than I ever have that we will have cogent recommendations for x-axis and y-axis variables and acceptable values for y-axis deltas. We were hoping to have an official trial balloon at the July meeting, but I am not at all sure we will. August is more likely.

I am also absolutely confident that our answers will only be approximate, and we will have to

recommend strongly to DENR that more data be collected, with the specific aim, and format required, to make our recommendations better.

## **VIII. Presentation: A Trial Balloon—20/30/40% or 30/40/50% of Annual Mean Flow or Monthly Mean Flow**

Presenter: Hugh Barwick

For this power point presentation go [here](#).

Hugh Barwick presented a trial balloon developed in cooperation with Jeff Hinshaw, Linda Dieboldt, Tom Thompson, and Jamie Robinson. Hugh noted that this subgroup represents on the Board those that use water. They wanted to make this presentation because they have some reservations about the BEC as a viable tool. The data that were used in the BEC were from wadeable streams. These EFSAB members are concerned that you cannot take the information for wadeable streams and just transfer it completely over to non-wadeable streams. They think that is important because a lot of the future withdrawals in this state are going to be from streams that are larger than those sampled to produce the data analyzed in the BEC. The 80% flow-by approach proposed is a big concern to this subgroup of the EFSAB. They think it is overly protective; it will restrict a lot of things that the water users in this state might need to do in the future. Hugh expressed that he wanted to walk the EFSAB through this subgroup's trial balloon objectives and to present an alternative method of developing ecological flows, somewhat based on a withdrawal-permitting program that is currently used in South Carolina. That program was developed back in the 1980s and was put into permitting mode in South Carolina in 2011. It took them a long while to go from developing an ecological flow, and they do not necessarily call it an ecological flow. They use more of a minimal flow there. Hugh indicated that his group wanted to offer a few suggestions of how DWR might use some of this for planning purposes.

Hugh noted that he has listened a lot to what is needed for a desirable ecological-flow planning tool. The EFSAB has talked about specific physiographic regions. The EFSAB has said it needed to account in some way for the needs of the aquatic resources; the ecological flow needs to be somewhat based on specific stream biota, although he noted that maybe in some of the information heard today, that may not be quite as important an issue as it was. He noted that the EFSAB's recommendation should be relatively easy to understand and to use and provide some balance between the needs of humans and aquatic resources. So those are the things that this subgroup thought about when they were developing this tool. The physiographic regions are pretty simple. The state breaks out into the lower Coastal Plain, upper Coastal Plain, Piedmont, and Mountain streams. This subgroup did not address lower Coastal Plain streams. They are going to leave that to Bob and his group. This subgroup focused on the upper Coastal Plain, Piedmont, and Mountain streams.

In Upper Coastal Plain streams, anadromous fish are the species of importance: sturgeon, river herring, hickory shad, American shad, and striped bass. The importance of these upper Coastal Plain streams is primarily for spawning in the spring of the year. We need higher flows during those periods of the year when they would be using these streams to get them easily upstream. Hugh proposed:

- High flow (Jan-April) – 50%\*
- Transition flow (May, June, and Dec) – 40%\*
- Low flow (July-Nov) – 30%\*

The asterisks indicate using either [percentage of annual mean flow \(cfs\)](#) or [percentage of monthly mean flows](#).

QUESTION: You are saying these are minimum flows or how much could be taken out?

RESPONSE: No. It is just a percentage of the mean annual flow, and I will elaborate on that a little further, or a percentage of the monthly mean flow.

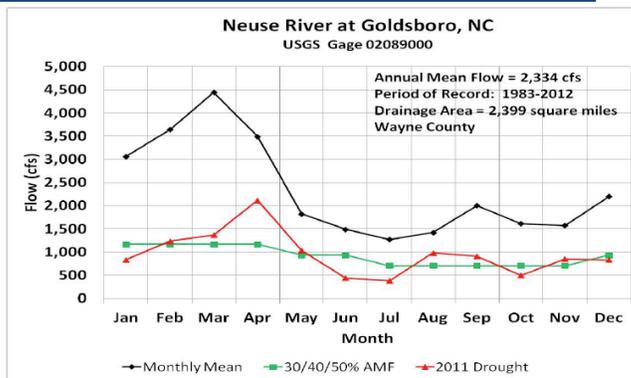
QUESTION: Well you are suggesting that for the months of January to April, 50% of the annual mean flow should be considered a minimum flow?

RESPONSE: Yes.

COMMENT: So they are minimum flow figures.

What does that really look like when you go to the river? Hugh picked Neuse River in Goldsboro [slide 7 in the power point, shown on next page]. South Carolina uses 20%, 30%, and 40% of annual mean flow; they proposed 20, 40, 60. Hugh took the difference between 40 and 60 and made it 50. In slide 7, the green line represents those percentages (20, 30, and 50, depending on season) of the annual mean flow. That is kind of a flat line. The black line indicates monthly mean. Hugh also wanted to know what it did during a drought year. How close was this planning flow or ecological flow, depending on what you want to call it, to drought conditions? At this site, Hugh used the 2011 drought. You can see that it represents this 30, 40, 50 percent annual flow relatively well. There are some periods when it is below, some that are at it, some at above, but it is not too bad a fit. Slide 8 shows percentages of the mean annual monthly flow. They took a 30, 40, 50% of that flow and plotted it here, looking at somewhat the minimum that we would allow during those seasons, based on what we have seen historically for this period of record. Hugh noted that it is not a very long period of record there for a lot

## Neuse River Flows

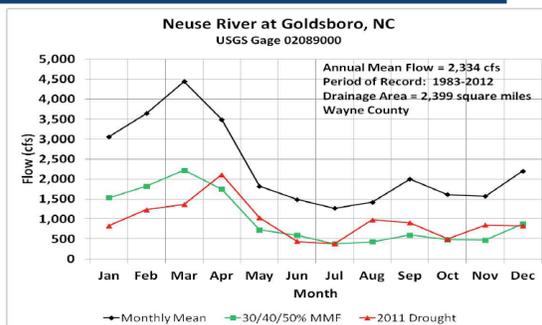


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of these stations but that is what they had and that is what they used. Again, he superimposed the drought of 2011 on there just to see how this minimum flow or ecological flow might compare. This group is proposing that DWR, if they get a request for a withdrawal, take their models and predict what this would look like at that particular location. They would calculate the 30, 40, 50% monthly mean flows for that, then they would do their model predictions, and hopefully that flow would be between the green line and the black line. If it was, then maybe for planning purposes, you could say okay we

have sufficient water over the next 50 years for them to have that withdrawal, and you do not have to

## Neuse River Flows



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go any further. If, however, it starts to look like its getting closer to that line, you might say well that is a red flag. This group is not proposing that these are absolute numbers here by any means. They are saying this just for example purposes. This is for

planning purposes. These are planning flows. What they are trying to do is preserve sufficient water in the river to allow anadromous fish to complete their life cycles in freshwater and to preserve the other species of fish in the river. If we maintain that for them during these periods of the year, the young are adapted to this period and other fish as well to these lower flows. This group is calling that their ecological flow, and they would not think that the ecological integrity of the Neuse River at that station would be impacted as long as flows stayed above this minimum.

QUESTION: So if anadromous fish experienced the drought of 2011 every year, would they do okay?

RESPONSE: Well I think they always recover from previous droughts.

QUESTION: But they recover from previous droughts by having non-drought years, right?

RESPONSE: Well, yes, that is right. But this does not mean that this is going to be the flows every year. Flow is going to be dependent on the rainfall that occurs. Through the modeling, I think—and you correct me if I am wrong, Fred—that you would be able to predict how frequently flows approaching this level might occur, and then you would look at the duration, the frequency of that before you made a determination as to whether a site specific study was needed there or not.

QUESTION: So you are not proposing those metrics of what actually is the frequency of excursions into that realm there? In other words, what you just said was you can model that, but how often you go into that is not...

RESPONSE: I am not presenting—I am not making a recommendation for that.

RESPONSE: Okay.

Hugh: That is something either this group or Division of Water Resources would have to decide.

COMMENT: Hugh, I think what you want to say is do you want to look at that in terms of how often and frequent are those flows going to approach that lower end of that range.

Hugh: That is right.

COMMENT: And if it looks like they are going to be approaching the lower end of that range outside of what you would see normally, then that is your warning flag, that is your—that is where you need to worry.

Hugh: That is right. Other questions?

QUESTION: I have a question; it may not be for you; it may be for DWR. If withdrawals are permitted, are you able to change them year-to-year? If you were going to assess that this is sort of what you are left with, or sort of this excess capacity, and you are going to look at it and say it seems to me like over time that you are going to be sort of pushing that lower threshold and then you get to the question of is there ever a chance then for it to get to some sort of a natural, or a more...

Hugh: It would, but then there are other things that would have to be considered. There would have to be low inflow protocols. And I think that is something that might be required. Offsite storage or off stream storage might be a way, or withdrawals from the groundwater for makeup water if you were getting down into this level. So you may have to require, or industry may have to impose on themselves, a way to moderate their impact on this flow. Those are just some ways to do it. The other option is that that intake does not go in at the location they prefer; maybe it would have to go into an existing reservoir.

COMMENT: This conversation seems to be about a regulatory program.

Hugh: No, sir.

RESPONSE: Well you are talking about—let me revise my question. How can I look at that graph and tell what the effect of flow moderation is on ecological integrity?

RESPONSE: Well based on the science that went behind producing these flows, based on what they did in South Carolina and what I have seen in some other studies in North Carolina, that 30% is going to generally protect the fishery resources; 40 will, and 50 will.

QUESTION: Is that based on the Tennant method?

RESPONSE: Yes. Well, that is one method they use.

RESPONSE: Which was known originally as the Montana method?

Hugh: That is it.

QUESTION: Why don't we let Hugh continue before we get too far,,,

RESPONSE: Oh, I am sorry. Okay.

Hugh: Yes, you are going to see similar proposals for other streams. Okay. Piedmont streams. Here again we are targeting your riffle run dwellers primarily, with the high flow period right at February and April where we are looking at 40% of the flow, transition flows in May and June, possibly January gearing up for this higher flow period of 30, and low flows in July to December of 20%.

QUESTION: For us non-fish squeezers, that is sun fish and—

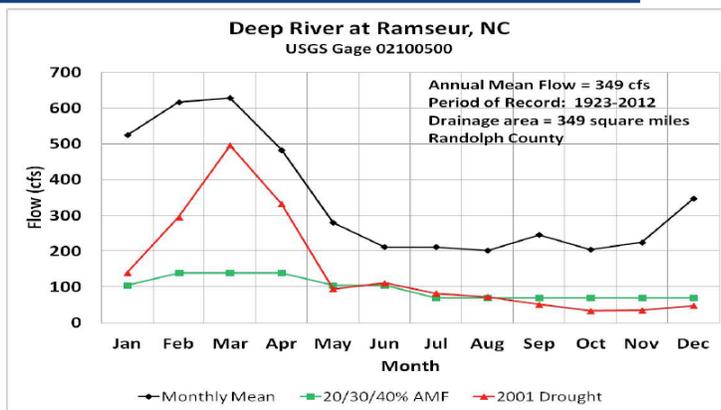
RESPONSE: That is shiners and suckers.

RESPONSE: Thank you.

COMMENT: Not sun fish.

RESPONSE: Not sun fish, but shiners.

## Deep River Flows

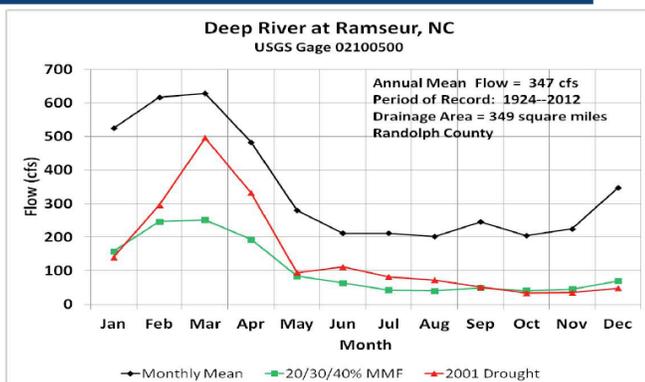


Hugh: And these are the ones that we think are most sensitive, and we talked about that. These are the riffle dwellers that are most sensitive to changes in flow in these Piedmont streams. The Deep River was one of the sites I selected. If you look at the annual mean, 20, 30, 40% of the annual mean, based on this flow at this Deep River site, it is flat-lined primarily [slide 10]. This slide also shows the mean monthly and compares this to the 2001 drought. This is what they use in South Carolina, and in some respects, Hugh's group did not think that this method produced a planning flow or an ecological flow

that was similar to what we normally see on our mean monthly flows at these stations. So, again, that is why they tend to go to the mean monthly flows [slide 11] and then that gives a little more simulation of what the monthly mean flows look

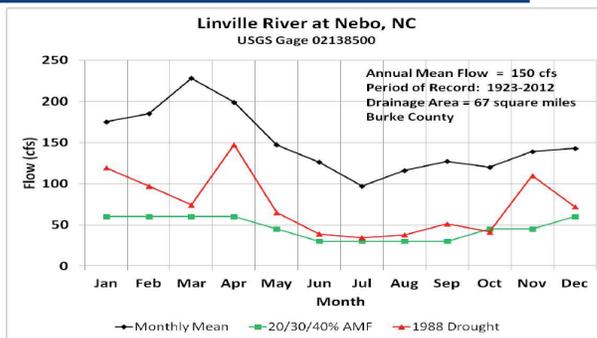
like there. Again, here we are looking at the drought and you can see that protects the period of the year when those fish would traditionally be spawning there and then as lower flows the rest of the year, which we think those species are readily adapted to enduring. So we are looking at this as being the ecological flow and again, Fred would use that similarly in his modeling and for flows that were approaching this, would certainly raise a red flag in the predictions of the 2060.

## Deep River Flows



In Mountain streams, we are primarily focusing on trout. There are some mountain streams that probably should not even be considered for any withdrawals, some of the higher elevation streams. There is probably no need for withdrawals from some of those streams. This trial balloon concentrates on high flows during the spawning season for trout, and depending on the species, they would be spawning in this December to April period and we are looking at a 40% flow there. Transitional flow period, November getting them into the riffles where they spawn in December and allowing those young to hatch and move out of the riffle areas in May going into the low flow period in June and September. This trial balloon would suggest maybe 20% was appropriate there. We looked at Linville River flows [slide 13]. You have the annual mean of 150, and this is what South Carolina uses. This slide shows the monthly mean—and a 1988 drought. The flows for the annual mean flows were lower than what were noted for the drought. That appears to be maybe too low. If we look at the mean monthly flows [slide 14], again, it simulates what we normally see at this particular location on a seasonal basis is 20, 30, 40 and again it is a little lower than what we saw in the drought. So there may be some tweaking

## Linville River Flows

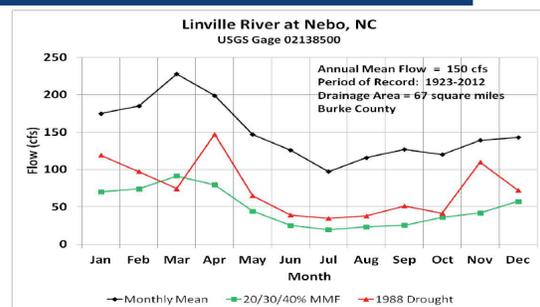


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that is necessary here in some of these mountain streams. I do not know, we would have to look more closely at that. But that is what it would look like at the Linville River site. Hugh closed by saying that these percentage-based ecological flows presented here appear to provide adequate protection for aquatic resources when compared to drought flows, which we see naturally. Hugh acknowledged that we do not want those every year for the fish to respond to. Hugh noted that this approach appears to somewhat balance the needs for humans and the aquatic resources, and he thinks it might be easy to incorporate it into the models that DWR currently uses. He does not think it will preclude

any site-specific studies.

## Linville River Flows



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QUESTION: You chose three different drought years, 2011, 2001, and 1988; is that because those were the droughts of record for those—  
Hugh: Well they were pretty close to the lowest I could find in say the last 10 or 15 years.

RESPONSE: So those were the droughts of recent record for those three systems.

RESPONSE: Yes.

RESPONSE: Okay.

QUESTION: I guess what I am trying to get my head around is you refer to not being at those minimums all the time; you do not want to do that every year.

Hugh: Right.

QUESTION: I guess for me the \$64,000 question then becomes well, if you set up a safety net or a

floor—

Hugh: Basically, that is it. That is what we are talking about.

QUESTION: You still have to come up with some way then to say how often and how close do you have to get to that floor before some flag goes up and that is where I am a little shaky. In terms of what do we do there and do you set it as some sort of naturally occurring frequency that you do not want to get down to that floor or... and that is certainly preferable then saying well, this is a minimum and whether it is that way in one year in five or five years in five, it does not matter because that is just the flat minimum. Because that is not what I am hearing you say.

Hugh: Right. To be honest with you, I do not know. I thought about it, but I really do not know what that frequency should be. If you look at the flow record, is that a way to determine how frequently it has occurred historically and maybe that is what you would shoot for going forward? I do not know, I really do not. You are right, that is the hard—

COMMENT: I think what you talked about earlier was looking at maybe modeling those drought years when they occur based upon your period of record, how often they occur and try to model how often flows get down in that range and is it significantly different in some statistical fashion from what you would normally see naturally.

QUESTION: So the question—is there a predictable drought cycle in the period of record and does adding in withdrawal drive the system to that drought condition more frequently?

RESPONSE: That I do not know.

Hugh: Yes. I am sorry, we do not know. But it is something to look at.

COMMENT: Then just another observation: with two of the three gages you have plotted there, the Deep River and the Neuse River, those are—well, the one at the Deep River is pretty recent and they have Randleman Reservoir now. And Neuse obviously has Falls Reservoir since the early 1970s. So the effects on those reservoirs tends to be, on an annual basis, there may not be a whole lot of change in terms of average annual flow. But they tend, just because they are built to operate that way, to make the average flows during wet times lower and the average flows during dry times higher, just because that is the way they are supposed to operate. So if you set your threshold, your target, your floor—whatever you want to call it—based on monthly means, and you are doing it off a gage record that has a big reservoir upstream, we need to be aware of that, and maybe think about do we want to use the regulated hydrograph, or do we want to use from the model an unaltered hydrograph. I think the Tennant method, forgetting for a moment that it was started out in the Western part of the country, but I think they used unregulated gages when they were first developing their percentages and deciding what level of protection each percentage provided. It was based on gages that had no reservoirs or alterations to hydrology.

Hugh: But it is awful hard to find gages that do not have reservoirs upstream.

RESPONSE: Well, on big rivers—

Hugh: On big rivers, it is hard to find those, and I did not want to go into great detail here before I presented it in case you thought it was a terrible idea and we just toss it out and go home. If it has some merit potentially, it is an option we want to explore further, we can certainly do that. But we did not want to spend a tremendous amount of time and effort trying to work out the details on this if this concept was not something that was even worth considering by the Board. So we are presenting it simply as a concept, simply to be used for planning and it is what it is. That is where we are.

QUESTION: Hugh, how long has this been in place in South Carolina?

RESPONSE: Since 2011. So it is fairly recent.

COMMENT: So that is not a lot of time, but what is the perception of business and industry?

Hugh: Well, business and industry like it, obviously. Some of the resource agency people fought going down to the 20, 30, 40. But in the end they were able to kind of resolve their differences and agree on 20, 30, 40. And that is for Coastal streams and Piedmont streams. They do not have anything

proposed for mountain streams simply because there are not that many mountain streams.

QUESTION: Was there heavy input from the South Carolina Chamber of Commerce technical committee on this?

RESPONSE: That I do not know.

COMMENT: A couple of responses: one of your earlier slides talked about the other approach that we have been talking about for a number of months, the 80% flow-by, is overly protective. Whatever the numbers are, I think philosophically, as a planning tool, what you want is something that raises flags earlier than later, so I think we need to deal with that.

RESPONSE: I think everybody in this room realizes that this planning tool may eventually morph into a permitting tool.

RESPONSE: Well, that is the elephant in the room. On the other hand, what South Carolina ended up with and those numbers were that policy decision. It was not really based on the science, solely, and I think that is where we need to be careful here and not jump right to the end and say well this is all we will be able to get through. As far as the specific numbers about using mean monthly flows, we did talk about that early on with all of Jim's zillions of graphs and tables and so on. If we want to talk about that and the specific numbers, I think that is certainly viable and open for discussion. What I think we need to be careful about is understanding what those numbers are based on. I am trying to go through the South Carolina report now, but it has been years since I looked at it. But it seems like it is a combination of Tennant stuff, wetted perimeter stuff, and maybe some PHABSIM stuff. We have, at least for several streams here, and I guess Fred is going to have some more to bring forward to us next month, that whole suite of numbers, of percentages for North Carolina streams. And so to me, if we were going to go with that kind of approach, we would want to make sure that it is grounded with some data that is—you know, what is going on in North Carolina not—some generic kind of stuff so I just wanted to throw those ideas out there.

QUESTION: My question is an easy one. Didn't you state at the beginning of the presentation that South Carolina has been using this for a number of years prior to its going to a permitting program, is that correct?

RESPONSE: Not that I know of.

COMMENT: Their surveys are from the 1980s is what you said.

RESPONSE: The concept was developed in the 1980s. It did not reach the permitting level until 2011. But I do not know that they were using it for planning purposes between then and 2011.

COMMENT: I think I am going to restate what Chris said in my own unique way. An approach like this has some value, has some merit because it is simple, it is straightforward, it is easily understood, but before I could endorse an approach like this, I have to be able to look at the graphs and say I see something there that reassures me that ecological integrity as defined in the Act will not be violated by using this approach.

RESPONSE: I fully endorse that.

COMMENT: Because our question is not how do we balance water use requirements—

RESPONSE: That is right, that is right.

COMMENT: --between fish and people. That is not our job, That is DENR's job. Our job is to answer the question how much water does it take to maintain ecological integrity in rivers and streams, explicitly in North Carolina rivers and streams? And if we could answer that question and come up with something as simple and straightforward as this, I would be partying all night.

RESPONSE: And I will go with you.

COMMENT: And I am buying. Getting to that question is where we have to go. What does it take, how much water do we need to leave in rivers and streams, or maintain our rivers and streams, to maintain ecological integrity in North Carolina, as well as we can figure it out from the data available.

RESPONSE: That is right. And that is what you and Jennifer and Kimberly and Tom have been—I mean you have been beating that stuff; I mean you turned it inside out looking for that silver bullet and

that is the elusive part in all this. What is that silver bullet?

COMMENT: In several places in your presentation you talked about balancing water usage between, it appears to balance the needs for humans and aquatic resources, and that is a good thing and DENR needs to do it. But our job is to figure out when ecological integrity is violated and when it is not. And if you guys are looking for next steps, for me, it is how do we do that with this approach.

RESPONSE: Well we are just asking is there an interest in going to the next step? Does this approach have merit for any of you? What do you think?

QUESTION: Just a question. This is not an area of my primary expertise in terms of the water management, what South Carolina and other places have done, but how do we link this to the biological impact? I do not want to be a broken record but what information is out there that is either from South Carolina or other places that will give us some indication of the level of impact or protection—

RESPONSE: Well there were the two reports that I sent out with the draft of this and that is primarily what they used to develop these. And is there more information out there than that?

COMMENT: I think we discussed maybe a study or some evaluations that were done for permitting in North Carolina. Is there anything we can draw on?

RESPONSE: Well I had looked at and questioned that and based upon a question I had for Jim earlier today, I do not really think that has happened because it was a very small study area, about a two mile stretch, that we did look at those instream flows and we looked at it for the Lillington gage and this is for the Harris Cole project. Based upon Jim's comments this morning, it may not really be applicable to what we are doing here because it was a small study area. Basically, it did show that at the flows down to about 600 CFS that you maintained about 80% of your area under the curve for most species, 80% or better; however, again that was restricted from a small study area, and to the small side channel. So it may not be applicable to the larger water bodies as a whole.

QUESTION: Jim—do you, Fred—know of PHABSIM work that would have any application to what we are talking about here where we could look at flows or—

RESPONSE: Well all nine sites we have done so far you could do and there is Catawba and Pee Dee if you wanted to look at big rivers, and Fred is going to be grinding away on the mountain ones.

COMMENT: So some of these numbers were run as part of that.

RESPONSE: Yes.

COMMENT: Now they tended to be—the biggest one was the Tar near Lewisburg, drainage area-wise, and that was about 500 and some square miles. We do not have any on the Neuse other than a really old one that would be impossible to resurrect.

COMMENT: And so we could actually look at these percentages of mean monthly flow and see. We have been working out that 80% flow-by just because that seemed to show a minimal amount of impact to most of the guilds. We can actually see what level of impact and compare apples to apples and say this is the level of impact we see to the guilds, assuming that everybody on the Board is still interested in the results of the PHABSIM, that those have merit. Part of the simplicity of this approach is the use of monthly mean flow as opposed to percent flow by. I think that, in and of itself, may be something some of the currently regulated entities are more familiar with or are already used to thinking of usage in terms of that. Is that one aspect that makes this a simpler approach?

RESPONSE: I think so.

COMMENT: So again I just go back to the PHABSIM and look at these numbers relative to what we have been looking at and see if the potential for impact seems to be greater. I think many of us on the Board would think that the potential for impact is greater with these numbers because they are representing minimums rather than some kind of optimal threshold.

QUESTION: So how much time would it take and is it feasible to re-run PHABSIM for a handful of Piedmont sites using 40, 30, 20 as a threshold and tell us what happens to our guild habitats.

RESPONSE: They are already done.

QUESTION: We did 40, 30, 20?

RESPONSE: Yes.

QUESTION: Like this?

RESPONSE: No. Not exactly. What we did is we did 30 all year, 20 all year, 40 all year. You have to pick from the different columns and recombine them.

RESPONSE: Yes but we have to do them by season.

[inaudible]

RESPONSE: No more new running, just rearranging results.

COMMENT: You have results by season so if, for example, I have Eno State Park and Buckhorn here from work he did before and if you look at the 20-50% range as a minimum flow, there are some seasons where there was very little effect. Maybe 10-20% of the guilds or species were affected. But there are other seasons—spring and winter—where anywhere up to 70% of the guilds were affected in a different way. I think that is one of the reasons why we stayed away from—we started looking at that 80% flow by was that that was in an area from these graphs that had relatively little effect compared to these 20, 30, 40, 50 as minimum flows. But it is worth revisiting, I think.

COMMENT: I would like to see—I mean I am delighted to hear—to be reminded that all we have to do is pick some columns off of the spreadsheets and combine them. But I would love to see for a handful of Piedmont sites, what 40, 30, 20 arranged in this way does to guild habitat. And if the answer is positive then I am a happy guy.

COMMENT: I think one other thing that we need to take the time to go back and look at these underlying reports that you seem to have to support this. Like I said it has been many years since I did look at them, but my recollection is that it was from a—what is the minimum flow perspective.

RESPONSE: That is right.

COMMENT: So it was not trying to maintain ecological integrity. Whether the approach of mean monthly flows, I said this before, is any better than percent flow by, it may not be if the numbers are high enough where the habitat response is not crashed. I think that is kind of what Bob was saying, so again, we just need to go do a little bit more homework on this if someone wants to continue to carry this ball forward.

COMMENT: I was just going to offer a comment and I think I have said before that minimum flows work when withdrawals are not large in the context of how much water is out there to withdraw from. It is when the withdrawals grow to be a larger proportion of the flow going by that you end up spending more and more time, more frequently and for longer durations of time, at or near the minimum. If you start building in conditions to say well, we are going to try not to get down to the target minimum more frequently or much more frequently than you would naturally, at some point if you build in enough little clauses about well, here is our minimum but we do not want to get there more than x percentage of time or for x length of time, at some point you are kind of tip-toeing up to a flow-by type flow regime where you are saying well, we have this minimum but we are still trying to mimic so that during wet years we have more than just the minimum and yet during dry years we do not go below minimum. I just wanted to throw that out. If the goal is to not be at that minimum too frequently, then you are already taking a step towards just using a flow-by approach.

COMMENT: Well and if the minimum flow is approximately drought flow, and you only go to the minimum flow as often as you would experience a normal drought, then you cannot take any water out of the stream because you are going to get that flow naturally anyway. The one thing I learned working on the Roanoke all those years is that droughts are going to happen whatever you plan and whatever their natural frequency is, they will occur.

RESPONSE: On the other side of that is, with an 80% flow-by, even during the drought years, you are still withdrawing water.

RESPONSE: Oh, yes.

RESPONSE: Oh, yes.

COMMENT: With an 80% flow by, drought years are worse.

QUESTION: A question and a comment—I think you started out by suggesting the context that this would be used in and predominantly be used in those streams that were larger, that were likely to be the sources of withdrawal. So there may be some boundaries that you might want to put on this. This approach may not work well in small mountain streams. I think you have made that clear. It may work fine in the Piedmont, upper Piedmont, for example, or certain lower Piedmont streams. That is one; the other is looking at the context of how we interpret the impact, the ecological impact of withdrawals comparing this approach to the calculation of impact using the flow-by approach, which, frankly, I do not think it is a good way to make an estimate of an average impact. But it does not reflect the reality of how people are going to use water. I think most facilities that do not have capacity for large offline storage are going to want the ability to withdraw water on a reasonably broad range that is fixed. They are not going to know what is the flow out there today, I mean, frankly from what I have heard, Water Resources cannot tell us in most locations what the flow is today, tomorrow, the next day—you have to do some estimates of your own to get to that point. Most facilities are not going to have that capability, except the very largest ones in municipalities and those that might be capable of having large off stream, or offline storage reservoirs. It would be interesting to see how using this kind of approach would match up against the calculated impact of a flow-by. Just to use these kinds of numbers to set the level, and then see and calculate the percent deficit or whatever you want to call it at that point so we can get an idea of how it works. But it is a far simpler way to evaluate it, I think.

COMMENT: One last observation: if we chose to recommend that our strategy should be to prevent increasing eco deficit by more than a certain percentage, minimum flow thresholds and flow-by targets are both viable tools for achieving that goal`. These are not mutually incompatible strategies. It may be that minimum flow is not the best strategy for attempting to maintain eco deficit below some threshold, but it is a potential tool for doing that.

RESPONSE: But the number for that potential minimum would be derived from the data rather than from your suggestion, from South Carolina's recommendations.

COMMENT: I think South Carolina's policy is instructive, but what we have to have in North Carolina is science about North Carolina rivers and streams. Having that science on the table, there is nothing wrong with having several different tools available to achieve whatever goal we decide to set. Did I respond to what you said?

RESPONSE: I think so, to my satisfaction.

RESPONSE: Good.

Facilitator: Other questions or comments? Hugh what is our next direction, then, based on what you find.

RESPONSE: I do not know. I think maybe we need to look at the PHABSIM data, like Sam suggested. 5 or 6 sites plotted similar to what we have plotted here and see how that compares and what do you think, Chris, look at how that relates to a flow-by?

RESPONSE: Well, again, I think it has all been run; it is just a matter of rearranging a bunch of numbers so it is spit out in another format.

Facilitator: And who is going to be doing that and by when?

RESPONSE: If I can get my hands on the information, I will be happy to—

COMMENT: It's public information. You just have to find it.

Facilitator: So, Fred, you would be working with Hugh to provide him with that information so Hugh could do that.

COMMENT: Be careful when you provide that because there is a lot of look ups that refer to external files so you have to make sure the external files stay together or it will be looking in the wrong place.

Facilitator: So do you think that this is readily something that could be produced by July? I am looking

at Fred and Hugh and I think that—

RESPONSE: I can do my best. You know, if I can get it I will certainly try.

Facilitator: Okay. Any other questions or comments for Hugh?

QUESTION: Just in general, is there any way we can kind of reduce some of these scenarios down to eco deficit type stuff? Put a common footing on it? Compared to what we have done with the RTI work?

COMMENT: If you have a baseline, unregulated or SIMBASE, just run 20, 30, 40 or one of these through and calculate your eco deficit.

COMMENT: It would be interesting to see which one, what they come out to be.

COMMENT: It is just basically the area under the curve and this is just another curve superimposed to see the eco deficit. Now RTI has been one to calculate the eco deficits so far.

COMMENT: Calculating the eco deficit using this strategy presumes that the minimum flow is the constant.

RESPONSE: Yes. What is the real world flow going to be under this strategy? That is something different.

COMMENT: Basically what we got was comparisons between these strategies and the drought of record, and in each case, the proposed strategy put less water in the river than the drought of recent record for half or more of the year. But we are not going to take this to that level on a constant basis. What we do not know is how often we are going to approach that level and how close we are going to get. Those are questions that need to be answered relative to ecological integrity in North Carolina. I think the PHABSIM data will help.

C; What Tom asked about maybe is a second step after you take a look at the PHABSIM stuff.

COMMENT: The reason why we moved away from these flows, these thresholds to begin with when we first evaluated them was that we were seeing impacts, in general, that we felt were not going to meet the ecological integrity objectives of the legislation. I think in order to honor your work to this point, I am willing to look at the PHABSIM data that represents the 40, 20, 50 mean monthly flows but I will say—and maybe I am the only one who is stupid enough to say it that I do think the implication—what we had already seen, did not lead us in the direction of these due to the level of impacts that we were perceiving. Before we go too far with people's time and money, presumably, I do think that was the general direction, why we moved away from this early on.

COMMENT: And those were with those levels being there; that was it. It was not a safety net with some unknown frequency of being well above minimum. We have no way of really saying well what does that really mean.

RESPONSE: I think that, though, is where the surficial simplicity of this actually leads to a greater complexity because you have to have a pretty complex system of if/then statements. We move quickly away from simplicity, so again, I might be the only person—

RESPONSE: That is a really good point. Again, for planning purposes, even if you used a mean monthly flow series of numbers that vary by physiographic province and so on, in a planning tool, if you set those high enough, it is simple for them to run and raise the flags that need to be raised. If and when a permitting program ever comes around, there would be a whole other bunch of discussion of whether or not those numbers get changed and to what and then what all the other complexities get involved into the frequency and duration of excursions outside of that. I think we really need to keep our eye on the ball as Jay has said earlier about what it is we are trying to do right now with this process. If it is really giving Tom Fransen's bunch something he can stick in a model, let's keep that in mind and not overly complicate things because we could spend another three years talking about what all those other metrics are for how to interpret everything.

RESPONSE: That was a big deal in South Carolina going to the permitting; I can assure you that. It was complicated; it was complex; it did not have any fistfights but there were plenty of verbal fights.

RESPONSE: Well the fistfights can come after our work is done.

Facilitator: Hugh, thank you very much and yes, I think you and Fred are going to be working together so hopefully you can get us something in July so thank you and your team for doing that.

## IX. July 16-17 Meeting Agenda and the Timeline

Nancy Sharpless initiated a planning discussion to determine the agenda for the July 16 and 17 meeting. She pointed out to the EFSAB that scheduled for July 16 were several agenda items:

1. PHABSim mountain sites and recommendations
2. TNC Final Report and recommendations
3. Coastal Study update and recommendations
4. Barwick Updates of 20/30/40% & 30/40/50% and recommendations
5. BEC/RTI
  - a. Log-linear model
  - b. Revised research assumptions of the RTI/USGS study & recommendations

For the July meeting, the focus will be on closing the loop on presentations and to hear recommendations from the presenters on how their presentation addresses the charge to the EFSAB. Although trial balloons may continue to be developed (as well as new information) – where are we now?

Several members asked questions about the July meeting:

**Question:** Have we seen trial balloons related to the BEC and eco deficit? I mean we've seen the presentations but are we anticipating trial balloons that are directly built out from that?

**Comment:** What we will have from the RTI and USGS work at the next meeting is revised research assumptions and conclusions, responses to address the questions we heard today during the RTI/USGS presentation (this includes questions that may be submitted later this week), and recommendations for recommendations. This will be our trial balloon.

**Facilitator:** Hugh – will you return with results from the additional work requested today? [Yes]. Once we review the trial balloons, our plan was to begin to discuss remaining questions we had. For instance, how do we deal with questions like duration and magnitude? What kind of criteria will you all develop to help select options or recommendations for moving forward?

For July, we will have a two-day meeting. Given you will hear new presentations (TNC, Coastal, the 20/30/40 Presentation) and information on July 16, does a back-to-back meeting make sense? Will this give you enough time to start processing and assessing what you heard?

**Comment:** If we were presented with new information on day one and then had a structured decision-making process day two about how to use the cumulative information that we've seen so far, would that not work? Even though day two may end up being a little bit nebulous, our time constraints encourage us to move forward. Moreover, if the presenters send all proposals ahead of the meeting, then we could review the material prior to the meeting. Postponing any additional work until August is not moving us forward.

**Facilitator:** Given the month-to-month meetings, presenters try very hard to provide information ahead of the meeting as best they can.

**Question:** Do the two meetings have to be on consecutive days?

**Facilitator:** One reason for scheduling back to back meetings is that this allows those who travel to reduce their travel time overall and it helps with consistency. If we split up the meetings now, some folks might not be able to attend.

**Comment:** Since we don't know what's coming for the July 16, it's hard to say how much we need to digest. Perhaps you all could factor in time on the July 16 agenda to work with the materials and/or raise additional questions. It's hard to know how much time will be needed for digestion.

**Comment:** It would be helpful if presenters would package their presentations with specific recommendations for the EFSAB to digest and deliberate in order to determine our options. If we could get something like this for presentation – in part or mostly drafted, then we might be able to have structured discussions. Kimberly, for example your presentation – will you offer recommendations in part or whole?

**Kimberly:** That's my goal; to have something to provide you guys with so that you can hopefully pick out pieces or ideas from it that you think would be useful. My recommendations will be those that Nature Conservancy is supporting.

**Comment:** Since the EFSAB is somewhat familiar with Kimberly's methodology, it will not be startlingly new.

**Comment:** I think we've been a little bit reluctant to suggest our recommendations during our presentations, "Here it is and now react to it." We've kind of beat around the bush, which lends itself to more questions than deliberation on how to move forward. Using this method might finally get us to a point where we know what the gaps are and areas of agreement. Regarding the two days - if we have them before us then it will be useful. We need packages of information/recommendations to help us make sense of how to move forward.

**Comment:** RTI and USGS will produce responses to your questions, a revised set of assumptions, a revised set of recommendations which would constitute our trial balloon at least a week in advance of the meeting.

**Facilitators:** Our proposal to you all would be to review each presentation with the recommendations and assess strengths and limitations of each, how each presentation addresses the charge based on specific criteria, and then let those settle unless something clearly rises to the top. We may take a straw poll but the idea is not to settle on a trial balloon- it is still too early and you all may want to create a new trial balloon (or hybrid) (something that incorporates aspects from each trial balloon you all agree on).

**Comment:** I think we have to come a lot closer to a decision about which approach we're going to recommend. We're getting very close even with what was presented by the 20/30/40 subcommittee. I don't think it's going to be helpful to DWR if we say there's five trial balloons and we don't want to hurt anybody's feelings, and we think there's something good in each one of these. I would rather see trial balloons that are more fully fleshed out as opposed to saying, "I like 80% flow by and I like eco-deficit." I don't think that that's the type of recommendations that DWR is going to be able to operate.

**Comment:** That is not what the facilitators are suggesting. It might be, for example, we take a wadeable stream approach from this presentation and non-wadeable from this approach and create a whole different package from what we have learned.

**Question:** When is the concept mapping going to occur of where we apply and test each package of ideas?

**Facilitator:** We need to determine what you want to move forward with before tackling the next stage of mapping and using a situational approach.

**Comment:** It will take several iterations and that's when the surprises hopefully start popping out, "Oh that thing we didn't think was going to work has use."

**Comment:** That's when we have to be careful that we don't accidentally design a camel while trying to design a horse.

**Facilitator:** Ok, it sounds like we will move forward with two meeting days in July. Next, are we missing any agenda items for July?

**Comment:** Can I get clarification on what people want to see from the 20/30/40 subcommittee? I believe we are not going to do any reruns but rather use previous results and rejigger the results by these designated months. Is that correct?

**Comment:** Tom made a comment about the eco deficit. This is tough to address because without assuming it's a flat flow all the time what do you model?

**Comment:** The suggestion was to table this approach for now.

**Question:** Can the second meeting not be a consecutive day, that it's maybe the following Tuesday the 23<sup>rd</sup>? Or sometime that week?

**Response:** It's a matter of expense for those who have to stay in a motel unless you're willing to pay me for my travel.

**Facilitator:** So you're actually suggesting that it's easier for the people traveling to do it on two separate days? Suggestion – can we keep the July meeting dates as it may be difficult to choose another meeting day now in July (especially for the facilitation team) and then consider how to deal with the expense or move to non-consecutive meeting dates.

**Question:** I have a procedural question. If we're all not here at the meeting, can we still make decisions? I'm not sure how the charter works.

**Facilitator:** Each member should have an alternate to attend the meetings when he or she cannot attend or find a way to have someone else weigh in from them during the meetings. The other option is to participate by webinar during the discussions.

Note: For the following meeting dates:

- Dec 3 will be held at the Stan Adams Center (the Archdale is not available).
- Have added October 23 as a second meeting day
- We will evaluate the consecutive meeting structure on July 17.

Thank you everyone!

## X. Information on Next Meeting

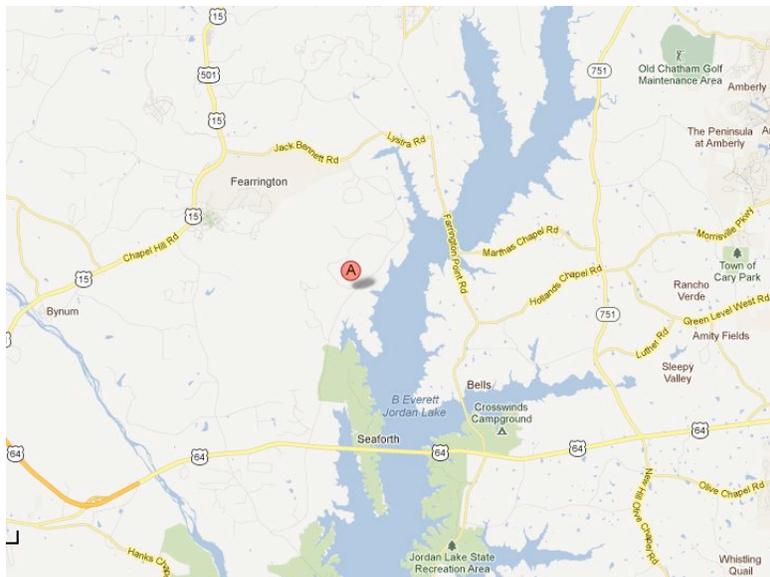
The draft agenda for the July 16-17, 2013 meeting includes:

- PHABSIM using mountain sites
- Report back from the coastal group and recommendations
- The results of the TNC study and Recommendations
- The RTI/USGS response to the questions asked today, the research assumptions and recommendations
- Report back from Hugh Barwick and others with PHABSIM results for 20/30/40 and 30/40/50 and Recommendations
- Discussion of Report

- Begin assessing proposed recommendations (trial balloons)

The next meeting of the EFSAB is scheduled for **July 16-17, 2013** at the Stan Adams Educational Center from 9:00am 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: Report Outline (DRAFT 1) from the EFSAB to DENR/DWR

{All working documents into this document except the guidelines to aid recommendations source document}

**Note:** The research assumptions enclosed are currently limited to the RTI and USGS research as well as some sections of the Recommendations like the protocol conclusions; the Report will eventually include a comprehensive view of what has transpired and a more comprehensive set of recommendations.

## PREFACE

1. How this report is organized

This report is organized into a preface, research assumptions, recommendations, and summary and conclusions. The Preface describes the ecological flow provision contained in the basin modeling statute, the Department of Environment and Natural Resources' (DENR) effort—with the Division of Water Resources (DWR) taking the lead role—to establish the Ecological Flow Science Advisory Board (EFSAB), and the activities of the EFSAB. Research Assumptions describes the guiding principles of the ad hoc work group that advised the analysis efforts of Research Triangle Institute (RTI), and the U.S. Geological Survey (USGS). The research was to assist the EFSAB in providing a foundation for their recommendations to DENR. The Recommendations includes the recommendations as well as supporting information. The Summary and Conclusions provides additional context for understanding the recommendations supported with maps, a flowchart, and insights from “lessons learned.”

## 2. DENR mandates in legislation

[Session Law 2010-143](#) amended portions of [General Statute 143, Article 38](#) (Water Resources). Specifically, the Session Law added language to G.S. 143-355 requiring DENR to develop basinwide hydrologic models for each of the 17 major river basins in North Carolina. The models are to be used to simulate flows for determining if adequate water is available in the future to meet all needs, including essential water uses and ecological flows. Basinwide models are considered a practical approach to water planning because site- and project-specific evaluations require considerable time and money. However, the planning method used by DENR will not replace site specific studies needed for a specific environmental assessment or permit review.

The statute defines ecological flow as “the stream flow necessary to protect ecological integrity.” Ecological integrity is defined as “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.”

The statute directs DENR to “characterize the ecology in the different river basins and identify the flow necessary to maintain ecological integrity” and to “create a Science Advisory Board to assist the Department in characterizing the natural ecology and identifying the flow requirements.” The EFSAB shall include representatives from: the Division of Water Resources; the Division of Water Quality (DWQ); the North Carolina Wildlife Resources Commission (WRC); the North Carolina Marine Fisheries Commission (MFC); and the Natural Heritage Program (NHP). The statute also directs DENR to invite participation by: the United States Fish and Wildlife Service (USFWS); the National Marine Fisheries Service (NMFS); individuals with expertise in aquatic ecology and habitat from organizations representing: agriculture; forestry; manufacturing; electric public utilities; and local governments; and other individuals or organizations with expertise in aquatic ecology and habitat.

Finally, the statute directs DENR to ask the EFSAB “to review any report or study submitted to the Department for consideration that is relevant to characterizing the ecology of the different river basins and identifying flow requirements for maintenance of ecological integrity.”

DENR is required to provide status reports to the NC Environmental Review Commission (EMC) on the development of basinwide hydrologic models no later than November 1 of each year, beginning in 2011.

While the role of the EFSAB appears rather clear from the statutory language, at times there was confusion on several issues. First, after discussion and review of the statute, it was agreed that EFSAB recommendations regarding ecological flows are made for the purpose of water resource planning, not water use permitting. Second, it was agreed that the EFSAB is recommending scientifically-based methods or approaches and flow requirements, which may be numerical but not **[removed site]**

### project specific.

The EFSAB is not responsible for recommending how DENR responds to a water-availability issue nor advising DENR on how to use the EFSAB recommendations and research products.

### 3. DENR's actions establishing EFSAB

DWR created and hosts an ecological flow website with pages defining ecological flow and discussing its importance. DWR also hosts pages for all activities of the EFSAB, including presentations, literature, audio of meetings and meeting minutes.

DWR contracted with the N.C. State University's Natural Resources Leadership Institute and program for Watershed Education for Communities and Local Officials to assist in the development of the EFSAB charter, lead development and organization of the agenda for each EFSAB meeting, facilitate each EFSAB meeting, and produce written minutes for each meeting.

DWR extended 16 invitations to members of the NC scientific and technical community with expertise in aquatic ecology and habitat to serve on the EFSAB. The EFSAB has a total of 15 primary members, as well as alternates, from the following agencies or organizations: DWR, DWQ, WRC, NHP, MFC, EMC, USFWS, NMFS, USGS, American Water Works Association, the N.C. Department of Agricultural and Consumer Services, the North Carolina Forest Service, electric public utilities, local governments, and environmental non-governmental organizations.

The EFSAB met 24 times; the first meeting was convened November 8, 2010 and the last meeting December 3, 2013. During the initial meetings the EFSAB established a charter that included the purpose, goals, procedural rules, and responsibilities for the EFSAB members, DWR and the facilitation team. Decision-making by the EFSAB was based on consensus. The EFSAB used small-group break-out sessions, brainstorming, and trial balloon techniques to discuss and clarify topics, capture individual member's concerns, and put forth potential methods to achieve the EFSAB's ultimate goal of advising DENR on its charge of characterizing the ecology in each of the river basins and identifying the flow necessary to maintain ecological integrity.

Experts on the EFSAB and from other organizations gave presentations to the EFSAB on the early efforts to characterize and classify NC streams based on flow patterns, evaluating aquatic habitat using physical habitat simulation models (PHABSIM), and the history of establishing ecological flows in various other states and in major river basins. Other presentations focused on DWR's basin modeling using OASIS and the vision of how ecological flows would be incorporated into the modeling effort. Later presentations focused on coastal waters and alternative approaches for determining ecological flows.

The EFSAB relied on copious analyses and presentations by its members as well research of outside organizations. DWR worked closely with Environmental Flow Specialists Inc. (EFS) on the early efforts to characterize and classify NC streams based on flow characteristics from USGS gage data. DWR also updated nine study sites from the NC piedmont as a test for characterization and classification similarities. RTI undertook a biofidelity analysis to verify the EFS characterization/classification strategy. USGS also performed statistical analyses of aquatic insect samples as an initial test of the EFS characterization/classification strategy. RTI and USGS performed statistical analyses of fish and aquatic insect samples to examine relationships to flow variables. {next sentence is anticipated} In the end, the EFSAB developed a framework for determining ecological flows based on available fish and aquatic insect data without using a stream classification system.

## **RESEARCH ASSUMPTIONS**

All of the original research done to date supporting the EFSAB mandate, whether by RTI for an internal research and development project or the Environmental Defense Fund (EDF), DWR, and WRC funded investigations, has been based on the following assumptions:

- In accordance with the statute and the operating principles of the EFSAB, any approaches recommended for the determination of ecological flows will be made for the purpose of understanding the flow requirements of stream ecosystems and not for water use permitting.
- While it would be desirable to evaluate what happens at sites over time as flows are altered, biological sampling data for pre- and post-flow alteration conditions is very limited. The strategy selected substitutes evaluation of a very large number of sampling sites (649) reflecting various levels of flow alteration and compares the results to estimate the effects of flow alteration.
- All of the consistently collected and comparable fish data came from DWQ Wadeable Stream sampling sites. We acknowledge that this leaves a significant gap in our knowledge about how the largest streams may react to flow alterations, but aside from the fact that there was no alternative data set readily available, there are two reasons why this approach may be adequate. RTI determined that Wadeable Streams make up 88% of the [National Hydrography Dataset Plus](#) (NHD+) catchments in NC, so they do represent most of the state, and especially, most of the mountain, piedmont, and sandhill regions. Also, Wadeable Streams are assumed to be more sensitive to flow alterations, so flow-based strategies developed for protecting ecological integrity in them will be adequate for larger streams.
- For the purposes of evaluating the level of flow alteration and determining biological responses in the RTI analyses, landcover for the baseline was assumed to be [Küchler's Potential Natural Vegetation](#) (PNV). This does not commit us to using a PNV condition to describe the current baseline for the purposes of our final recommendations. It does provide a useful metric for knowing the degree to which the current baseline includes prior human influence. Using the PNV to determine biological response curves also results in a larger amount of flow alteration when compared to the existing conditions under which the biological data was collected. In turn this improves the resolution and range of those curves.
- The EFSAB is charged with developing a statewide approach, but this does not substitute for site-specific evaluation when that is needed.
- With respect to stream classification schemes, these are always scale dependent, so the set of variables and the thresholds of those variables typically change when designing a classification system at a national, regional, state, or local scale. Again, the EFSAB focus was at the state level.
- Research could only use available data that met certain criteria (sufficiency, consistency, validity). Thus, the research product is limited and does not include all possible indicators of ecological integrity, especially those based on measures of ecosystem function (e.g., nitrogen fixation) as opposed to composition.

## **RECOMMENDATIONS**

1. Consider how to include/weave in a lit review (how to demonstrate credibility/context with the research)
2. Describe what the EFSAB considered and why
3. Describe how the research that did not “work” taught/informed the EFSAB about how to move forward and in what directions.
4. Describe areas of uncertainty
5. EFSAB did both analysis of current research and conducted research

- a. Experts who presented on their research
- b. Experts' publications that were reviewed/referenced by the EFSAB
- c. Ad-Hoc Water Research Coordination Group
- d. EFSAB members commissioned research to support/inform the effort.

### Procedural Conclusions

Flow Metrics: RTI evaluated several flow metrics in their proof-of-concept evaluation of biological response curves. These included ecological deficit and the 3-, 7-, 30-, and 90- day low flows – all evaluated on annual and seasonal bases. Ecological deficit is the total difference between the altered and unaltered flow duration curves, whenever the altered curve falls below the unaltered curve – also calculated on annual and seasonal bases. The proof of concept investigation developed a relationship between the change in biota in the run/riffle guild in response to the change in each of these flow metrics. The response was very similar regardless of the flow metric used.

We propose to use two flow metrics **[note:could change based on RTI analysis]** as the work of the EFSAB moves forward:

1. summer (July through September) ecological deficit
2. annual 30-day low flow

We also recommend that biological response curves be developed using the spring (April through June) and fall (October & November) ecological deficits at a later time.

Our reasoning is as follows. It is desirable to retain the seasonal analysis because the seasons identified are different from the standpoint of hydrology, water use, and life cycles of biota. Ecological deficit does a good job of evaluating changes in flow magnitude and frequency over the entire range of the seasonal hydrograph. The annual 30-day low flow also captures the duration of low flow events that could be affected by withdrawals, and is a metric familiar to hydrologists/modelers and water users. The annual 30-day low flow will fall mostly within the summer months, but calculating it on an annual basis eliminates calculation problems with low flow events that extend into other adjacent seasons.

Guild Representation:**[note: not sure how this will apply to bugs]** RTI evaluated two habitat guilds (riffle-run and pool) in their proof-of-concept research of biological response to flow alteration. We propose using the riffle-run guild for two reasons: 1) it shows a significant response to flow changes; and 2) it is more flow sensitive than the pool guild. The riffle-run guild showed significant relationships whether the biological metric was fish abundance (number of individuals), species richness (number of species), or diversity (Shannon-Weaver index).

We do not believe it is necessary to investigate the biological response of the other guilds (pool-run, riffle, margin, backwater) for the following reasons: 1) time and funding constraints; 2) of the four remaining guilds, three (pool-run, margin, backwater) are expected to be less flow sensitive than the riffle-run guild; and 3) the number of riffle species and the number of sample sites containing riffle species is lower than that found for the riffle-run guild, thus the power to detect significant relationships is likely lower.

Biological Response Metric:**[note: not sure how this will apply to bugs]** RTI evaluated three biological response metrics. These were:

- Abundance: The total number of fish present at the sampling site
- Richness: The total number of fish species present at the sampling site
- Diversity: Using the Shannon-Weaver Diversity Index which combines abundance and richness through a complex formula

As with flow metrics, there was little difference in how these three metrics responded to flow alterations.

We propose to use richness as the biological response metric. Our reasons are as follows.

- Ecological: Species richness is a much better indicator of the ecological health of an aquatic ecosystem than is organism abundance. A system with a very large number of one or very few species may be and in fact probably is seriously degraded. Abundance and richness tracked each other in RTI results because very few seriously degraded sites were evaluated.
- Legal: The legislation mandates that we evaluate ecological integrity in terms of the ability to sustain existing species diversity.
- Ease of interpretation/explanation: Affecting the number of fish species is easier for people outside the SAB process to understand and interpret than an index of diversity. Since the two metrics respond very similarly to changes in flow, we recommend using the simpler one.

The EFSAB relied upon the historical fish and aquatic insect collection records of DWQ and WRC, which was fundamental to the Biological-Ecological Classification (BEC) research performed by RTI. The EFSAB benefited from the availability of DWR's PHABSIM data sets in the piedmont and mountain regions as a tool to judge various flow scenarios. The availability of real and synthesized flow records from the USGS, DWR's OASIS basin models, and RTI's WaterFALL model were essential for PHABSIM and BEC. The research performed by primary authors such as LeRoy Poff and Brian Richter; the research undertaken in large river basins—e.g. Potomac, Susquehanna, Savannah; and the efforts by other states, like Michigan, Texas, New Jersey, have all provided a foundation for the decisions of the EFSAB.

## **EFSAB Subcommittee Proposed Framework of Recommendations**

### **Characterization—What and How**

1. A classification of streams is required. That classification **may** be based solely on flows but should be based on biological data and physical characteristics of the stream. Classification at the very least should 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. **[will need to identify the definition of class being used if classes are used].**

### **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 foResponse:

- 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.

## **SUMMARY AND CONCLUSIONS**

- Includes visual representation of recommendations
- Includes a map of classes (if there can be a map of classes)
- Includes value-added recommendations, insights, concerns  
(example: other states are using flow based stream classifications. NC EFSAB tested this and determined the paradigm was flawed, thus came up with a different approach that addressed those flaws)