Ecological Flows Science Advisory Board (EFSAB)
Meeting Summary
August 28, 2012
Stan Adams Center at Jordan Lake, NC

X FINAL Approved for Distribution October 23, 2012

Attendance

Members

Mark Cantrell, US Fish & Wildlife
Bob Christian, East Carolina University
Tom Cuffney, US Geological Survey
Linda Diebolt, Local Governments
Chris Goudreau, NC Wildlife Resources Commission
Jeff Hinshaw, NC Cooperative Extension
Amy Pickle, Environmental Mgt. Commission
Judy Ratcliffe, NC Natural Heritage Program
Jaime Robinson (on-line), NCAWWA-WEA
Fritz Rohde, US National Marine Fisheries
Jay Sauber, NC Division of Water Quality
Fred Tarver, NC Division of Water Resources

Division of Water Resources

Don Rayno

Alternates

Peter Caldwell, USDA Forest Service
Vernon Cox, NC Department of Agriculture
Vann Stancil, NC Wildlife Resources Commission

NCSU Cooperative Extension Facilitation Team

Mary Lou Addor, Natural Resource Leadership Institute (NRLI)
Patrick Beggs, Watershed Education for Communities and Officials (WECO)
Christy Perrin (WECO)
Nancy Sharpless (NRLI)

Guests:

Michelle Cutrofello, RTI
Grey Flory
Lars Hanson, TJCOG
Jim Mead, Environmental Defense Fund
Jennifer Phelan, RTI

The purpose of the Ecological Flows Science Advisory Board:
The Ecological Flows Science Advisory Board 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 about the E-Flows SAB are available at:
www.ncwater.org/sab

NOTE: The next meeting of the EF SAB is **9:30am** at the Stan Adams Training Facility Jordan Lake Educational State Forest Center ground floor hearing room, Chapel Hill, NC
(see last two pages for meeting agenda topics and location).

AUGUST 28, 2012 QUICK SUMMARY:

I. Decisions Made

1. Assigning Fish Guilds for Flow Ecology

a. Put an asterisk next to those species that are non-native to the state or a basin, to flag for analysis.
b. Given that the sampling techniques used in gathering the data upon which the guilds are based defines the presence of species, document the assumptions and caveats of the current data and adapt as new data becomes available.
c. There will need to be some decision as to whether recommendations are going to be directly related to threatened and endangered species, whether satisfying the need of the guild satisfies the needs of the threatened and endangered species relative to flow.
d. With this also ask if there is a list of species that has requirements that are different from the guild list.

2. TNC Flow Study

a. Follow-up presentation on the results of the TNC project early 2013.
b. Examine/discuss the OASIS and WaterFALL models, how they differ, how they can enhance each other and EFSAB's quest to define ecological flows, and arrive at some decision about how the EFSAB wants to use them in their determination of ecological flows.
c. Review literature of freshwater fish or benthos studies conducted in NC for any data that might be included on the coastal plain.

3. Coastal Systems and Issues

a. review critical literature
b. work with Division of Marine Fisheries data
c. develop a screening threshold relative to the drainage area.
d. consider role of climate change and sea level rise, how it will influence the impact on the shifting of the salt-water wedge up the freshwater river networks rise and moving that wedge further inland (look at historical flows).
e. need to identify where the effects are occurring upstream and downstream.

4. Options for a Path Forward

a. review suggestions Fred Tarver offered, particularly for how to approach ecological flows and future studies
b. begin to work toward a screening tool for planning

II. Proposed Actions

- Develop consensus principles on why the EFSAB makes a recommendation or does not make a given recommendation

August 28, 2012Meeting Agenda

Executive Summary

III. ASSIGNING FISH GUILDS FOR FLOW-ECOLOGY ANALYSIS (CHRIS GOUDREAU)

Chris Goudreau presented a proposed fish guild structure, developed by Chris, Kimberly Meitzen and Jennifer Cutrofello, for North Carolina. The proposed structure divides species into six guilds, breaking them down into adult/juvenile and spawning. The guilds were developed to allow comparison of sites across basins and provinces. The guilds are based on the type of habitat in which the species spend the majority of their time or during a critical period of life. While the same species may not be present across basins or provinces, similar guilds will be present, which is why guilds are used in habitat-based models (e.g. PHabSim). The DWR guilds fit into the proposed flow-based guild structure, except for backwater.

Questions, Comments and Concerns raised:

- It would be relevant to look at it seasonally for the different life stages.
- Do you consider the non-native species?
- Whether you do or do not consider non-native species influences relative abundances.
- The data comes from wadeable streams.
- Where we see changes in species abundance or diversity, the cause may be changes in flow or other factors we cannot measure.
- Threatened and endangered species affected by flow may trump these analyses.

Proposed Actions or Identified Decisions to be made:

- Put an asterisk next to those species that are non-native to the state or a basin, to flag for analysis.
- Given that the sampling techniques used in gathering the data upon which the guilds are based defines the presence of species, document the assumptions, caveats of the current data, and adapt as new data becomes available.
- There will need to be some decision as to whether the regulation is going to be directly related to threatened and endangered species, whether satisfying the need of the guild satisfies the needs of the threatened and endangered species relative to flow.
- With this also ask if there is a list of species that has requirements that are different from this.

IV. THE NATURE CONSERVANCY'S ENVIRONMENTAL FLOWS PROJECT IN NORTH CAROLINA (KIMBERLY MEITZEN)

Kimberly presented a broad overview of a project that is in progress, emphasizing not results, but rather what TNC is doing and planning to do, and why. One goal of the project is to inform the EFSAB's work. They are looking at seasonal variability and inter-annual variability in flow and those effects on biology. They are using simulated baseline hydrology and altered hydrology to examine how flow alterations might be influencing biotic communities, using a modified ELOHA approach. The TNC project is focused on four basins, the Cape Fear, Tar Pamlico, Roanoke, and Little Tennessee. The six-step outline for the project is:

1. Conduct a literature review and analyze biological data to develop flow-ecology relationships
2. Model baseline unaltered and current altered flow scenarios
3. Analyze changes in flow metrics among simulation scenarios
4. Measure and predict species responses to flow alterations
5. Identify areas of resilience and vulnerability relative to flow alterations and environmental flow management
6. Provide flow recommendations to the EFSAB for NCDWR.

One of the primary goals is to look at biotic changes over time from the fish and benthos survey.

TNC will use the community level analysis, the hydrologic analysis and different environmental variables to determine flow/ecology relationships. The primary questions they want to answer are:

1. Can we make predictions regarding organism responses to different flow scenarios?
2. What are these predictions and how do they vary spatially?
3. Where do we have more confidence in them?
4. Where do we have less confidence?
5. Which flow metrics best inform these ecology relationships, and how are they further influenced by additional physiographic environmental variables?

The project has an 18-month time line, January 2012 through June 2013.

Questions, Comments, and Concerns Raised

- The EFSAB expressed significant interest in the project and the potential results.
- The importance of recognizing the purposes for which the data were collected (water quality conditions within a six-month population recruitment and grow out). If those sites are visited only once every five years, you are getting a snapshot of the conditions at one point in time, making it risky to discern trends or to extrapolate. Kimberly is hoping that the analysis using the USGS data will give an indication of extreme events that may have occurred between sampling.
- Many other factors affect biological abundance and diversity, not just flow. It is difficult to tease out what the flow contribution is. This is why Kimberly is analyzing environmental variables as part of this work.
- There was concern about how/whether to include non-native and invasive species in the analysis.
- The general sentiment appeared to be that this project will aid the EFSAB significantly is determining where gaps are and what questions to address.
- Most of the DWQ data are from "unaltered streams", but those streams may actually be altered by undocumented withdrawals.

- TNC indicated that they thought that EFSAB would find the low-flow information most helpful, to which there is some truth; however, it is also important to consider the potential effects of long-term withdrawals that, in some areas, might inhibit the ability to achieve the higher flows needed for spawning cues, for example.
- Are the methods being used transferable? Kimberly indicated that they would be.
- The EFSAB engaged in discussion about OASIS and WaterFALL: Are they are interchangeable, and if so, what the pros and cons of each? Or is WaterFALL most useful, for the purposes of the EFSAB's work, as a pre- or post-loader to OASIS? Don't the two models do different things?
- Tom Fransen is working up DWR software to validate any model, to see how OASIS and WaterFALL compare and how they compare to USGS data.
- OASIS is the model approved by the EMC, and it is unlikely that, for the overall river basin models, they will depart from use of OASIS. The question is whether WaterFALL can be useful in determining the ecological flow component of the OASIS models.

Proposed Actions or Identified Decisions to be made:

- Follow-up presentation on the results of the TNC project early 2013.
- Examine/discuss the OASIS and WaterFALL models, how they differ, how they can enhance each other and EFSAB's quest to define ecological flows, and arrive at some decision about how the EFSAB wants to use them in their determination of ecological flows.

V. COASTAL ISSUES PRESENTATION AND DISCUSSION (BOB CHRISTIAN)

Bob presented about coastal systems and three overarching concerns that challenge application of ecological flow approaches to the coastal plain are:

1. Hydrogeomorphological issues influencing modeling
2. Ecological issues influencing ecological integrity choices
3. Kinds of water withdrawals

In all three of these situations, what is happening in the stream on a daily basis, in a wetland or down in the stream, is that wetlands and their services are inextricably linked to waterways. Each major area contributes to the challenge of applying procedures used inland to the coastal plain. The EFSAB broke into two groups: hydrogeomorphological and ecological.

Recommendations generated as a result of the Ecological Small Group discussion included:

1. Need additional data that will be applicable to coastal issues and any model development that might be meaningful in terms of looking at impacts for coastal streams and water withdrawal impacts. A potential solution might be to include the Division of Marine Fisheries data, particularly if it has not been incorporated or considered.
2. Given older data sets, consider newer studies
3. Determination that these coastal systems are extremely complex and subject primarily to very large events. These large disturbances provide opportunities for measurements and meaningful data.
4. Consider some base point, one that might move (is not fixed) but a point on an upstream or downstream scale below which the models, Oasis or WaterFall, might not work. For example, there is probably a point in which these models are not the best approach. We do

not know where that point is but this suggestion may help NC DWR; draw that line and figure out where to go.

5. Consider other studies that other states are conducting other than research and modeling efforts for more upland freshwater systems. We have not reviewed the literature from other states on coastal systems such as Texas, California, southwest Florida and these might be reasonably predicted of what might go on in North Carolina.

Recommendations generated from Hydrogeomorphological Small Group Discussions:

1. Recognize the challenges in trying to model the other large controlling factors such as tides, wind, lunar, and astronomical controls. Thus, consider looking at salinity studies done in coastal plain areas (Pee-Dee River in South Carolina study).
2. It is important to identify where these effects are occurring. Get an idea of where the geography is and develop a better understanding of what is known about saltwater wedges and how far inland or upstream they are coming and trying to map those locations. Get a better view of that line where there is info from Oasis and where additional info is needed.
3. Consider where there are surface water withdrawals, depending on the drainage area and catchments that the surface waters are being withdrawn from, that might have a bigger influence on freshwater flows so that smaller basins and their catchments are going to be more sensitive to these surface water withdrawals than surface water withdrawal straight out of a main stem. That there should be a screening threshold relative to the drainage area.
4. Consider how climate change and sea level rise will influence the impact on the shifting of the salt-water wedge up the freshwater river networks rise and moving that wedge further inland (look at historical flows).
5. One area of agreement was the need to identify where those effects are occurring upstream and downstream.

Proposed Actions or Identified Decisions to be made: see above (and reference additional details in the main section)

VI. BIO-FIDELITY UPDATE (JENNIFER PHELAN – HANDOUT)

An update was provided on the Biofidelity Project a project to evaluate the fidelity of aquatic biota to stream classification systems in North Carolina. Since the Ecological Flows Science Advisory Board meeting on June 20th, 2012, the following have been achieved, modified, or are in progress:

1. Increase in the number of sites included in the analyses
2. Determination of Aquatic Biota and datasets that will be included in the analyses:
3. Comparison of EFS and McManamay river classifications using USGS gage and WaterFALL simulated hydrographs

Proposed Actions or Identified Decisions to be made: None

VII. NC DIVISION OF WATER RESOURCES: OPTIONS FOR A PATH FORWARD (FRED TARVER)

Fred presented options for a path forward to the EFSAB. He offered his perspective, that is, the group is "aiming to plug in the environmental flows for all the yellow dots presented here in the Oasis model." Some suggestions he made regarding options for moving forward:

1. Can the EFSAB approach environmental flows based on the River Basin timeline? Does the EFSAB pursue ecological flows as a statewide process or pursue the process, river by river.

2. Updating the Trial Balloon to support Round 1 of the habitat studies, looked at the responses in terms of habitat to various flows. Round 1 offered the opportunity to review information on the response of various habitats at the various study sites.

3. For Round 2, may choose to pursue additional in-stream flow analysis with stream study sites that do have classes associated with them but there's no Oasis model.

4. For Round 3, can choose additional study sites that are more confounded (no class or Oasis Model info, data format issues, and associated with alterations).

5. Presented a screening tool for planning (a conceptual framework) and ideas on how DWR would utilize the tool.

VIII. 2012 AGENDA DISCUSSION

The EFSAB has been engaged in an educative process, the development of shared understanding across its members. A complex process such as this one, can be lengthy and at times frustrating, as the board moves forward in developing a conceptual framework for recommendations. The EFSAB is charged with providing recommendations; the criteria for making those recommendations needs to be explicit and transparent. The EFSAB needs to be able to say what supported their recommendations and link their recommendations to the literature and professional expertise. The development of shared understanding will position the EFSAB to better grapple with the innate uncertainty in this process and, ultimately, with the tradeoffs that will need to be made in reaching recommendations.

The EFSAB developed agenda topics and activities for 2012 and early 2013 (reference this section for additional specifics).

Questions, Comments and Concerns Raised

- *Is this process going to take additional years*? Lou indicated that an advisory process such as this, is not linear; it takes a bit of time to develop shared understanding and generate a conceptual framework which will help achieve comprehensive recommendations. Lou does not anticipate multiple additional years. At the July planning meeting with Steve Reed and Fred Tarver, the group discussed moving toward recommendations in 2013. That said, there are many unknowns and until Fred has additional manpower, the process has been slowed a bit.
- There was discussion about how scientifically defensible the EFSAB's recommendations need to be, with the point being made that it is all defensible but that defensibility is a

matter of explicitly and transparently defining the uncertainties and the assumptions involved and linking was has been made explicit to the literature.
- Ultimately, it is up to DWR how to use the recommendations provided by the EFSAB

Proposed Actions or Identified Decisions to be made:

- Develop consensus principles on why the EFSAB makes a recommendation or does not make a given recommendation

I. Welcome, Agenda Review and introductions

Mary Lou Addor, facilitator, welcomed everyone to the fourteenth meeting of the Ecological Flows Science Advisory Board (EFSAB). She introduced herself and the facilitation team, reviewed the agenda for the meeting, and oriented everyone to the meeting facility. All attendees were invited to introduce themselves.

II. Review of June 19 , 2012 Meeting Summary

The EFSAB approved the June 19, 2012 meeting summary.

III. Assigning Fish to Guilds for Flow-Ecology Analysis

Presenter: Chris Goudreau
Team: Chris Goudreau, Jennifer Phelan, and Kimberly Meitzen

Chris reminded the EFSAB that RTI and TNC are investigating flow-ecology relationships by comparing flow metrics to fish metrics, such as abundance. The RTI study compares different locations across the state at different times. The TNC project compares the same locations over time in four river basins. Both are using Division of Water Quality's fish datasets, but those do not cover the state, particularly cold water streams and non-wadeable streams. To allow comparison of sites across basins and provinces the species are grouped into guilds based on the type of habitat where they spend the majority of their time or during a critical period of life. Some species like to hang out in pools, some in riffles, for example. While the same species may not be present across basins or provinces, similar guilds will be present; therefore, guilds are used in habitat-based models (e.g. PHabSim)

Chris, Jennifer Phelan (RTI) and Kimberly Meitzen (The Nature Conservancy) wanted to develop a guild framework to use in NC. They looked at five different guild structures that others had developed: NCDWR--14 guilds; ENTRIX, 2003--9 guilds; Aadland, 1993--6 guilds; Vadas & Orth, 2000--7 guilds; and Persinger 2010--4 guilds (Table 1). There is significant similarity among the various guild structures, but some are divided up more finely than others. What Chris, Kimberly and Jennifer wanted to do moving forward was to use a simpler framework with 4, 5 or 6 guilds, which: 1) are not so unwieldy to run through comparative statistical analyses as using 14 guilds would be; 2) you do not have to know the substrate or cover at the site; and 3) have names that are easy for the public to understand. They decided to restrict the guilds to habitats indicative of flow (i.e. ignore substrate/cover parameters such as the DWR guilds used). Chris, Kimberly and Jennifer

decided to use a structure similar to Persinger's, but to add guilds for stream margins and backwater.

They propose the NC Guild Structure in Table 2, with the flow relationships depicted in Figure 1. The DWR PHabSim guilds can be grouped within the flow-based guilds, except for backwater.

Table 1. Guild Frameworks

NCDWR (14)	ENTRIX 2003 (9)	Aadland 1993 (6)	Vadas & Orth 2000 (7)	Persinger 2010 (4)
shallow fast higher velocity	Shallow Fast Coarse	Fast Riffle	Riffle	Riffle
shallow fast moderate velocity				
shallow fast lower velocity	Shallow Fast	Slow Riffle	Riffle Run	
deep fast, fine substrate				
deep fast, gravel/cobble substrate	Deep Fast	Raceway	Fast Generalist	Fast Generalist
deep fast, coarse substrate	Deep Fast Cover			
shallow slow, coarse substrate			Shallow Rheophilic	
shallow slow, young of year	Shallow Slow			
shallow slow, aquatic vegetation cover				
shallow slow, woody debris cover	Shallow Slow Cover			
shallow slow, fine substrate, no cover	Shallow Slow Fine	Shallow Pool	Pool Run	Pool Run
deep slow, no cover	Deep Slow	Medium Pool	Open Pool	
deep slow, cover	Deep Slow Cover	Deep Pool	Pool Cover	Pool Cover
deep slow, cover (version 2)				

Q: Are there PHabSim guilds equivalent to your proposed structure.
R: There is not for backwater, mostly because we have never done any studies in that kind of habitat.

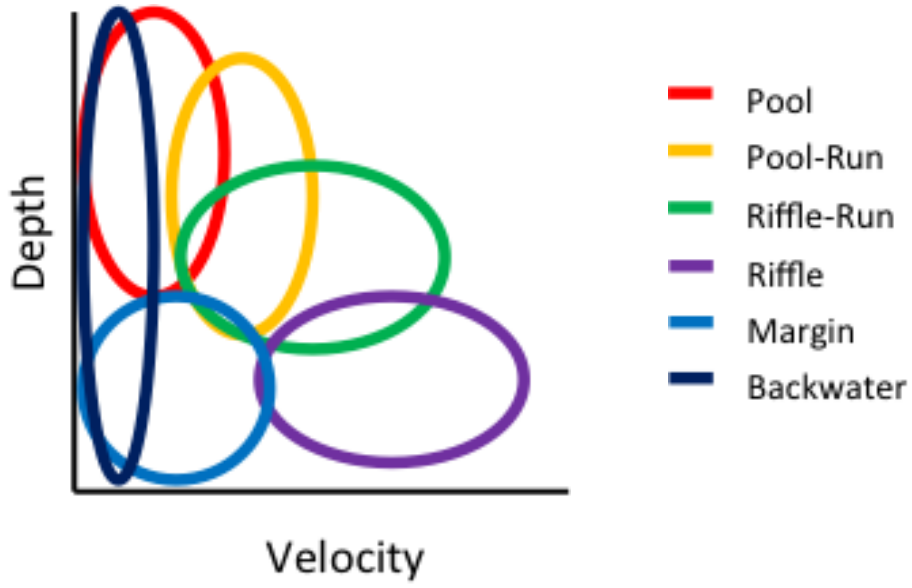
Chris then used "Fishes of" Books for Virginia, Tennessee, South Carolina, Mississippi and Alabama and tried to assign the list of species that is in the DWQ database to the six guilds in his proposed guild structure for NC. It's important to understand how those books describe habitat use. Some have accounts based on direct observation by the investigators. Others required some deciphering and cross-referencing between the literature. Some species go into more than one guild. Typically habitat was described for a given species for both spawning and adult/juvenile lifestages.

C: I think it would be relevant to look at it seasonally for the different life stages.
R: Jennifer, Kimberly and I felt that it would not be so important for the analyses that RTI and TNC are doing, but I think you make a good point.

Table 2. Proposed NC Guild Structure

Persinger	NC Study	Comment
Riffle	Riffle	
Fast-generalist	Riffle-run	Name change only
Pool-run	Pool-run	
Pool-cover	Pool	Name change; with or without cover
	Margin	Added; shallow-slow habitats
	Backwater	Added; mostly coastal

Figure 1. Proposed NC Guild Structure



So Chris divided the list of species into the 6 guilds, breaking them down into adult/juvenile and spawning. He sent those spread sheets to Fritz Rhode and Bryn Tracy for review.

After a couple of iterations to reach agreement, they developed the results shown in Table 3. Species using multiple guilds were assigned to their predominant guild. Going back to how these results would be used, Chris explained that RTI's analysis focuses on the riffle-run guild. These species are flow-sensitive; there is a high number of species and occurrences in the database. RTI uses this if either lifestage (adult or spawning) is in the guild, but the species must only use Riffle-Run. Initially the idea was to select five riffle-run species that we had good counts (on over 100 records) and that were well-distributed geographically. Since developing this list, there have been further discussions, and RTI will discuss this further when we get together next time.

Kimberly will talk today about how what TNC is doing is a bit different from what RTI is doing. TNC uses all guilds, addressing questions like what is percent occupancy by guild type at each site and date, and tracking those numbers to see how they change over time. TNC is essentially using the WaterFALL model to find out what the flow-ecology relationships are.

Chris had provided the EFSAB members at the meeting with a copy of the list of species and assigned guilds for their review.
Q: This is tying back to hydrology?
R: Yes, RTI is using these with WaterFall

Q: Do the macro-invertebrates fit in here somewhere?
R: That doesn't really fit in here, but presumably you could do this kind of thing with that data.

C: I'm conflicted on the native and non-native species. Do you consider the non-native species? I think our fish communities should focus on the native, but then I look at the list of non-natives species that

sometimes dominate. It influences relative abundances, so if there are species that come in and influence species and habitat, I think it might be important to consider where we have relationships of those species to flow.
R: Yes, red shiner is not native to this part of the country, but it is utilizing habitat. Do you use it or not? I had the same thought. I just want to note that some of those species are non-native.
C: Put an asterisk next to those species, whether non-native to the state or a basin. It may be important if a flow change proposal favors a non-native over a native species. My other thought, was on the estuarine species, like mullet. You see them 100 miles inland and in great numbers. Are they spawning inland? I wonder what they are up to.
R: No, I don't think so. Needlefish probably are.
R: That's the fuzziness. What are they doing, how long are they there? It made sense to me to not include them in the analysis.
C: Some of these issues will come up in Bob's discussion- where do you draw the line between coastal salt water. Sometimes we find hogchokers up in rivers.
R: There are some salinity issues that are flow-dependent, which is the reason it's important. The salt wedge can go further upstream if flow changes, and does change the distribution of fishes. Down on the Savannah River (Fritz was there), we saw schools of mullet 180 miles inland while snorkeling. We wonder what they are doing in such numbers.

C: Many years ago, on projects on the Neuse River, we sampled with a variety of deep-water gear (trawls included), and hog chokers were abundant, adults, not just juveniles. We were upstream mostly from salt wedge influence. White perch, for example, was a more abundant of species in the Roanoke River, but you only caught them with specific gear types (trawls), not wading. We saw the same thing with some of the other species. We need to be cautious with how this is applied. The dataset has the occurrence of these species. Grouping is appropriate, but with a caveat: the sampling technique defines the presence of species. Almost all of these data sets are wadeable.
R: If I had different data sets and took the same approach, I could refine.
R: What Chris is proposing is not the be all and end all; it can be adapted as we collect data and do site-specific studies; we have to assess the assumptions and caveats of the current data.

C: It seems like Bryn's data and site data includes the riffle, the habitat description. It also includes some other, at least instantaneous readings of turbidity, the kind of things that would affect side feeders and conductivity and those kinds of things that tend to influence the structure.
C: That's an interesting thing. But taking us back to what this is all about, is to try to develop flow-ecology relationships, at least for RTI and TNC, that's another whole kind of angle on it I guess.
R: I was thinking of it from the point of view of the ecological integrity issue. If that's where we're…maybe that's the place we can never get, and probably we can't. But we should keep it in the back of our minds somehow.

C: Well, and some of that just made me think, that is probably the source where you find each species to…

Q: I was thinking of the guilds that we use in our 8 or 9 sites, looking at relationship between sites we have and the classes we've run. Would you go back and run it using the guilds you have done?

R: The only difference is we…what we've got doesn't have specific depth/velocity criteria. You have curves, depth/velocity curves with that. That's not something we did with this.
C: Site-specific analysis. That's it too.
R:Yes.

Table 3. Results

	Adult/Juvenile	Spawning
Riffle	15	21
Riffle-run	25	47
Pool-run	49	41
Pool	60	33
Margin	6	7
Backwater	16	22

Note: Species using multiple guilds were assigned to predominant guild.

Q: Secondary question. If the metrics for invertebrates, trophic structure, function structure, habitat structure guilds remain the same but the species all change, does that meet the criteria of the law to protect ecological integrity?
R: What to do is to find envelopes for ecological integrity.
R: There's not really a relationship between flow management and whether or not there's bait bucket introductions. So if red shiner ends up being the dominant, it may still represent that the flow is okay but the actual types of other types of management questions are not being adequately addressed. I think that's true, even of tolerance for, say, pollutants that you don't necessarily have control of.

C: Threatened and endangered species affected by flow may trump these analyses. If we are under regulations for T&E, will that be in concert with this, or will it make this relatively unimportant?

Q: Are you talking about the state listing or the federal listing?
R: Yes. The real question is, is if we're under all sorts of laws, rules and regulations for protection of T&E, what's the distribution of our T&E species regardless of whose list you're using? Is that going to be in concert with this? And in which areas is that going to occur?

R: We have the distribution pretty well mapped, and I think that the species could plug into these guilds. Ultimately there would be some decision down the road as to whether the regulation is going to be directly related to T&E species, whether satisfying the need of the guild satisfies the needs of the T&E species relative to flow.
C: Yes. And I think that was me trying to pay homage to Tom's question on species-specific effects versus guild effects. Clearly we're going to be very concerned about T&E species, regardless of what the guild affects are. If they overlap then it becomes truly a non-issue.
C: In the habitat based approach, if we know that there is a list of information about it, we try to also run that in addition to the guild. If this is essentially a screening tool, then that would, in my mind, be another step in that screening process to ask that question. Okay, you have this, but is there a list of species that has requirements that are different than this. I'm thinking about how DWR would use this, how we structure this at the end of all this.
C: That's something that needs to be taken up by the broader stakeholder process.
C: One way to approach that though would be to look at the distribution. How many of these basins and at what level is that going to be the trump card because we might be able to reduce that number down.

C: And it might be that habitat requirements aren't really any different from what this would indicate anyway, so it may not essentially trump it. It'd just be…
R: Consistent.

Q: Potentially, it would throw it into question. Do we need to provide leadership there?
R: I think it's built into the process. There are more limiting factors that you have to consider.

Q: Is that on our agenda? I also want to go back to the guild selection a little bit. Kind of on a broader framework, I think collapsing the guilds might have some value. What it might do is help us identify where the holes are. Part of our charge is to go as far as we can go with the data and not try to stretch it beyond too much, and then identify the whole as a group.

IV. The Nature Conservancy's Environmental Flows Project in NC

Presenter: Dr. Kimberly Meitzen

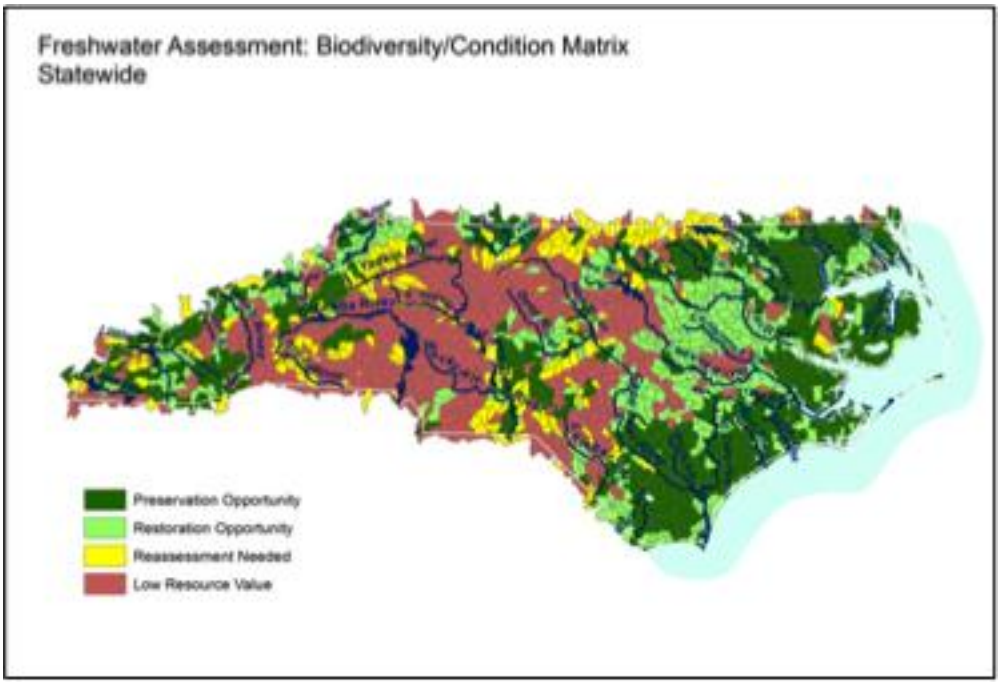
Kimberly started her presentation on The Nature Conservancy's Environmental Flows Project in NC by noting that she would be presenting a broad overview of the project objectives, what The Nature Conservancy (TNC) is doing and planning to do, and that she would not be presenting results.

TNC recently started doing freshwater work in the state. The product of this was the TNC Freshwater Assessment. One of the final outcomes of this assessment was a statewide distribution map (Figure 2). The dark green represents areas that are preservation opportunities for TNC. The light green areas represent restoration opportunities. The yellow ones represent places where there may be some sort of conflict with the data that requires further assessment. The pink represents areas of low resource value. Four basins stood out as having potential for resilience: Cape Fear, Tar-Pamlico, Roanoke, and Little Tennessee River Basins.

The second large component of TNC's Freshwater work is the Resilience Project. The primary components associated with resilience are: 1) linear connectivity; 2) lateral connectivity; 3)water quality and land use/cover; 4) access to groundwater; 5) diversity of geophysical settings in the area; and 6) naturally variable instream flow regime. The first five are being examined as part of the statewide assessment; the sixth, environmental flows, is geared toward analysis in the four basins.

TNC saw an opportunity to mesh TNC conservation goals with the EFSAB's and see what they can provide to the EFSAB's work. Our goal is to try to see what we can do to help assist this process for the Science Advisory Board. Part of the focus of the Science Advisory Board is to look for the low flows and areas of critical threatened habitats, so we're also building that in. Looking at a chart of daily discharge over time for the Tar-Pamlico, she notes that there's quite a bit of seasonal variability, but also inter-annual variability. All of those components are really important; we need to have a better understanding of that natural variability and how it's influencing different ecological communities.

Figure 2.



There is a popular four-step process that was developed by Poff and others, which examines the Ecological Limits of Hydrologic Alteration (ELOHA), and this process really starts with trying to define a sort of baseline hydrology and then simulate altered hydrology to look at the comparison between those. TNC is going to try to apply those to understanding how predicted flow alterations might be influencing biotic communities, and the biotic relationships are defined initially by flow ecology relationships, highly influenced by flow.

TNC is following a similar ELOHA approach but they have restructured it for what their goals are. The following is a six-step outline for TNC's project : 1) conduct a literature review and analyze biological data to develop flow-ecology relationships; 2) model baseline unaltered, and current altered flow scenarios; 3) analyze changes in flow metrics among simulation scenarios; 4) measure and predict species responses to flow alterations; 5) identify areas of resilience and vulnerability relative to flow alterations and environmental flow management; and 6) provide flow recommendations to the EFSAB for NCDWR.

The literature review is almost complete. It focused on looking at environmental flow projects and ELOHA-specific applications, nationally and globally, and it also identified literature pertaining specifically to flow ecology relationships. TNC then looked at flow metrics, statistics that are used for environmental flows, and the different analyses that are used for measuring flow alterations. All of the resources for the literature review are set up in an Endnote library, and Kim offered to provide those to the group. It is not open sourced to be accessed. The other component was to look at the biological data evaluation (Table 4.).

Table 4. Biological Data Evaluation

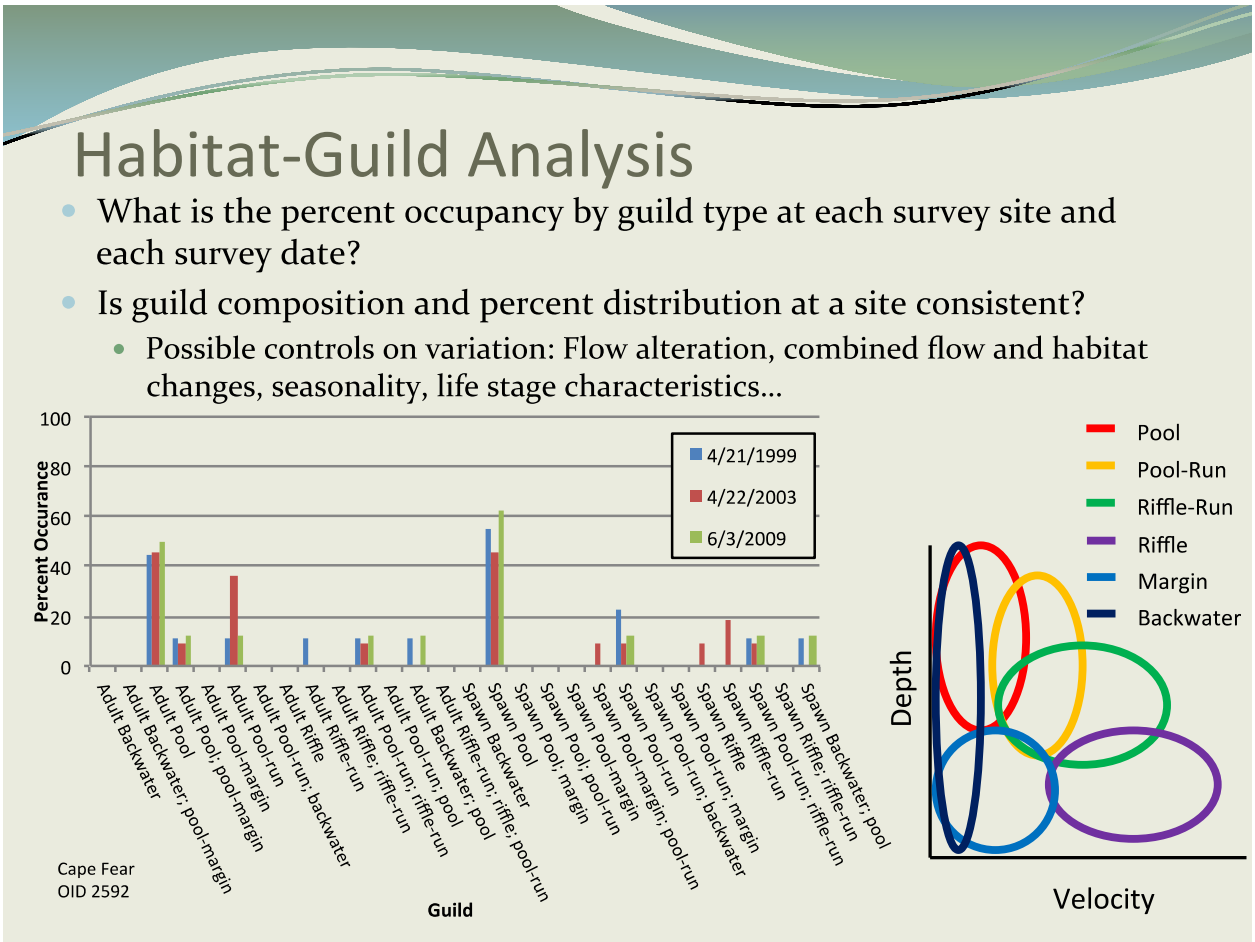
- **Fish data: sites with ≥ 2 survey samples**
- **Benthos data: sites with > 3 survey samples**

River Basin	Fish Sites	Fish Diversity	Fish Density	Benthos Sites	Benthos Diversity	Benthos Density
Roanoke	27	58	1,218	23	338	4,938
Cape Fear	69	68	2,650	136	464	28,032
Tar Pamlico	33	59	1,740	25	330	5,887
Little Tennessee	12	36	415	50	350	12,043

This was limited to the DWQ wadeable streams including fish sites and benthic macro-invertebrate sites. TNC identified sites that had been sampled at least twice in their history. Basically they looked at what the frequency of different samples were at all the different locations. They felt like they had a very robust sample size to work with, and there's very high biodiversity across all the basins as well. They got their benthos data set from Tom Cuffney, who had resolved taxonomic ambiguities. The data was reduced to abundance conversions where rare=1, common=3, and abundant =10.

One of TNC's primary goals is to look at biotic changes over time at these different sites, so for all of the fish and the benthos survey sites, they have gone in and looked at the data at every one of those sites and constructed graphs to look at the diversity changes over time and also changes in counter abundance. They have done this for all of the fish sites, and they have done this for all of the benthos sites. TNC has that data library right now, and they are going to be taking it to the next statistical step. Ultimately one of the goals is to try to look at whether declines in abundance or biodiversity over time at a given site are related to flow or is it related to something else. TNC has also taken all of the fish data for all of the sites and applied the habitat guild (guilds provided by WRC) associated with each fish for each of those sites and then looked at what the percent occupancy by each guild was at each site, and how that has changed over time. TNC put these together for all of the fish sites in all of those four basins. They discussed whether they have a very simple guild structure, but they concluded they do not. It is actually quite a complex guild structure. It has 28 different potential combinations (Figure 3).

Figure 3. Habitat Guild Analysis



They assessed what the representation was based on the original guild placement. In a lot of cases there is pretty good consistency, but there are changes. This first part of the analysis is complete for all of the sites, and TNC will be taking this to the next level with a more robust statistical approach. They were trying to get a visualization of what a snapshot looked like in using this approach. Primarily they sought to determine: 1)what was the occupancy by guild type at each site; 2) how is that changing; and 3) what might those changes be related to--alterations, inter-annual variability, oe the timing of when those species were surveyed relative to what their spawning seasonality. There are a lot of different things that might relate to that. TNC wanted to get an idea of what those patterns looked like and how they relate to geomorphology and possibly flow for those sites. One of the main questions in defining these flow ecology relationships is looking at how the biota, with regard to abundance and diversity, responds to different types of hydrologic analysis.
One analysis identifies USGS gages that are in closest proximity to the biological survey sites and looks at what the flow conditions were preceding the time of those survey sites These will then be compared to an overall pattern of flow relative to that gage, to get an idea if there is something going on with variability in flow that is influencing the different communities at the different sampling sites. The second analysis looks at simulated altered and unaltered flows using RTI's

WaterFALL model. That phase should begin soon. With the USGS gage data, they want to look at how hydrology in preceding years may compare with the longer term patterns and if that might be influencing the abundance and diversity. They also want to identify if there were specific flow patterns that supported higher abundance or higher diversity of communities, to identify what those optimal flow conditions might be. They are using 35 years of USGS data to do long-term pattern analysis and then at each survey site, depending on what the increments are with regard to when the surveys were taken, they are using one to four years of preceding data. For example, for the site with longer intervals between sampling, TNC can use a longer period of data prior to the sample. For the site with more closely spaced sample frequencies they can look at how those patterns in the preceding four years compared to that 35 year pattern, to see if it was an exceptionally wet year or an exceptionally dry year, to see if those might have control in what is seen in the biological communities.

The other component is the hydrologic model and the flow analysis that TNC is contracting with RTI. With RTI, TNC is modeling baseline and altered flows and then current altered flow scenarios. They will use TNC's Indicator of Hydrologic Alteration (IHA) model, to examine differences in pre- and post-altered flows. With IHA, they can look at different environmental flow components to ultimately look at what the difference is between a baseline and altered condition to get an idea of the degree of alteration, so that they can apply that to looking at relationships relative to the biological variables and the flow alteration. For example, if you look at those biological sites where there are multiple samples over time, if it's a site that is constantly declining and you also see a lot of hydrologic alteration associated with this site, we can be pretty confident with a hypothesis that flow is having some influence on those communities. But we might have other cases with a change in flow alteration in healthy sites, or there might also be conflict in what those patterns are.

A very important aspect with WaterFALL is that it's scalable. You can look at flows at any point within that NHD+ catchment in a water shed, so you can extract flows at the exact places that the biological surveys were taken, giving us a lot of resolution associated with the survey sites and the flows that we're looking at. Baseline flows, were modeled using mid 1970's land cover and absolutely no flow alterations--no dams, no withdrawals. For altered flows, we have a 2006 land cover and we're using scenarios with dams, withdrawals and returns or any information we have on alteration. We're doing two different approaches to the modeling: 1) we're going to model flows in all the locations of the biological surveys and 2) we're also going to look at a network approach through the whole system from the main stems down to the base level to look at what sort of network flow patterns emerge relative to the degree and locations of flow alterations. TNC is using IHA to compare unaltered and altered flows, and again the location of biological surveys but then also throughout the network. They are trying to identify metrics that are most representative, unique and useful for looking at these flow ecology relationships. They also really want to find indicators that are altered flows and that are most amenable to a management setting.

The IHA software is available to anybody. Kimberly showed the standard metrics and the environmental flow component metrics used for quantifying flow alteration between baseline and altered conditions. They calculate out for 2 different periods: 1) most hydrologically stressed,

which is the summer--July 1st through September 30th; and a higher low-flow, which would be from October 1st to June 30th, trying to use that split season to look at what the low flows are during that really stressed period of time. The Environmental Flow Components (EFC's) break the hydrologic record into five different components and categorize them based on extreme low flows, low flows, high flow pulses, small floods and large floods. Their metrics will allow them to look at percent change and then also counts in change from some of the metrics. There are other environmental variables that they are also using as part of their analysis. The community data will be used in a multi-dimensional analysis to look at the relationship of some of the different environmental variables to the different communities present.. They are looking at stream size, defined by the cumulative drainage area. They are also looking at stream gradient associated with the stream location for that biological survey site. They have those in categorical and continuous values. Most of these additional variables come from products that TNC developed for the SALCC. They will then also look at the percent natural land cover within the active river area proximal to the survey sites. The other environmental variable is connectivity and the amount of accessible river network relative to the different biological survey sites. TNC had an intern this summer who just graduated from Nicholas School of Environment at Duke. She did her master's project looking at connected habitat area and linear connected stream network habitat area in North Carolina using a barrier data set and TNC's Barrier Assessment Tool (BAT).. She looked at all the barrier locations in the state. She looked at the amount of connected habitat area upstream from the barrier on the stream network. This would give us an idea of the amount of connected habitats. So TNC can look at the biological survey sites to see if there is a connection between amount of habitat and diversity and abundance of species. That also might be a control on this community condition.

Ultimately, TNC is taking this analysis, to better understand species level and the community level flow-ecology and using the hydrologic analysis and different environmental variables to see if they can identify a flow/ecology relationship in the context of what they see from this other information. The main questions they want to answer: 1) Can we make predictions regarding organism responses to different flow scenarios? 2) What are these predictions and what are they spatially? 3) Where do we have more confidence in them? 4) Where do we have less confidence? 5) Which metrics best inform these ecology relationships, and what is an effect from the environmental variables? In some cases the environmental variables might be more a more important control than flow, or in other cases flow might be more important. Based on what TNC learns in those first three questions, how much confidence do we have in these and then extrapolating these to make recommendations for environmental flows that benefit ecological integrity. TNC's ultimate goal is to look at all components of the natural flow regime and also the environmental variables. For the Environmental Science Advisory Board they can restrict and target some of their analysis to the lower moderate flows for periods of time that might be more threatened relative to water consumption and water use by where some of those critical thresholds might be.

The project's timeline is 18 months, running January 2012 through June 2013. Kimberly is compiling a report on the literature review right now. The second part was to decide on the basins using the results from the freshwater component with the biological data evaluation. Kimberly is approaching completion of that. She has a lot of descriptive summary statistics done and a lot of

the tables set up to do analysis on what patterns were emerging. The next big step is looking at the flow/ecology relationships from the analysis between what is evident in the communities and what is evident in the flow analysis. USGS gage data flow analysis is in progress. Soon they will be working with the WaterFALL data. They will run that through IHA, and then they will go back to what was learned from the first steps to see what can be quantified relative to these flow ecology relationships with regards to what is seen in the biology, in the flow, and the environmental variables. There are a couple of big timelines for reporting milestones. One is this presentation, to get the EFSAB's feedback to evaluate how to best inform the group. TNC would like to distribute a report to this group sometime after December to get comments back then get the report out for distribution. Ultimately, this project will be completed June, 2013.

Q: What will be the scale that you are going to base that conclusion on? In other words, are you going to do it based on certain segments within the basin or an entire basin? What's the scale that we might look at?

R: It will be scaled out in different ways. There is a spatial component to scaling, but also we want to come to products that are also essentially maps looking at what some of these areas of alteration are, where areas of greatest resilience are, where areas of most vulnerability are, depending on what we find in this analysis. We are going to be looking at the WaterFALL data at a HUC12 scale, and then we can actually scale that up to HUC8 and also to the entire basin. It's interesting because for each basin that we're looking at, it's going to be a little bit different. For example, with the Roanoke, we're looking at sort of a different analysis. It's mostly focused to the coastal plain, and we're doing that in working with Chuck Peoples (TNC-Northeast Coastal Plain Director). That one is going to really be looking at flows from the entire basin scale network, but focusing on their influence to the lower coastal plain. But for the other component, the resiliency work, the Dan River popped out as being a very resilient system. So in terms of the headwaters in the Roanoke, we'll be looking at Dan River as a unit with a nested HUC-12 analysis. The biological data are just for the wadeable streams so evaluations are restricted to smaller streams and the headwater areas. But we want to be able extrapolate out what those flow alterations may imply throughout the river network. We'll provide site-specific evaluations but then also kind of larger HUC12 and HUC8 based evaluations. If there are particular sites that come out, say, for example, in the flow analysis and biological analysis and we know that there's a major withdrawal in close proximity to that site, then there might be a specific site recommendation for that location or the strategy behind it. We also want to get an idea of what's going on through the entire basins. It's not a very precise answer for you. A lot of that is going to depend on some of the patterns that we start seeing.

Q: To clarify the scope of your analyses. You are going to be looking at these four focal basins at different scales. Is that applied to all basins or just the four basins?
R: For the environmental flows work – yes, just the four basins. The other five components of the resilience analysis will be statewide, but for the flow analysis we're just doing that focused look at basins. We are doing just a flow alteration analysis that's statewide and we're also using WaterFALL for that. That's why I did the HUC12 and the HUC8. But it's not going to necessarily include direct biological data statewide. One of the reasons we chose those four basins is they

also…well there's a lot of reasons. They also represent a lot of diversity in the state, and those basins have a lot of species that are represented statewide, but then each of those basins also have a lot of endemic species. There is a possibility of looking at the results and then extrapolating it to some of the other areas of the state using a classification scheme to have understanding of what environmental flow implications might be and particularly relevant to what we see with the statewide flow alterations.

Q: You covered a huge amount of information in a very concise and quick fashion. I've got a couple of clarifying questions for you. The first comment to you is, wow. It's just a great presentation and I'm looking forward to the results. Part of me wants to suspend the EFSAB to receive your results. The other part of me wants to continue to funnel our questions out there for work on clarifying whys. My understanding is that you used our [DWQ's] biological data and evaluated relationships of that to the gages. Can you elaborate on that a little bit more for me? Our biological data is located at very small sites for the most part. Available sites are typically small drainage areas, and we have thousands of those sites. Yet we know we only have very few gages in this state, most of which are located on large water bodies. So your flow, IHA metrics, were they run off the WaterFALL products that use those gages or were they actually run off the gage information in terms of frequency, duration, magnitude and ??? Can you help me understand that a little bit, in terms of clarifying? I'll just stop there and give you a moment to respond.

R: There are two different hydrologic analyses. One uses just the USGS gages and another one that just uses WaterFALL. The WaterFALL data is developed and calibrated off of USGS gages, so inherently the WaterFALL model has that information in it. TNC first looked at what USGS gages were available in the state in at least a 35 year record that also spanned the biological survey dates. So we looked at that for the four basins we were working in and then basically just downloaded all of the data for those USGS gages that met that 35 year period of record for each of these. A lot of the basins are mostly on large rivers. There are some that are on smaller ones. So for the USGS analysis, what I was doing was looking at the gages' proximity to those biological survey sites. In a lot of cases it was downstream from the biological survey site, but what was happening at that gage would give us an indication of what's also happening in that watershed. The main thing with the USGS gauge data was trying to look at, what are the differences with regard to inter-annual variability? Multiple sites are often included within analysis for one USGS gage, that one gauge that is a proximal downstream location from those biological survey sites. We get a snapshot of what annual flows, how they might be influencing the biological surveys. When I went through and looked at the biological data to see how the diversity and abundance were changing at a station over time, there were a lot of cases where…say for example, abundance and diversity would be really low one year and then four years later it would be really high. Then four years later it would drop back down again. Immediately I was interested in, "What's creating this spike?" That got me thinking maybe it's entering a specific high or low flow pattern. Those other events might have been preceded by a drought year. We might have had a series of high flow years, then there is a recovery response in the community, and then there is some sort of connection with the flow variability. I'm in the process of doing the USGS analysis right now. The next step will be looking at what those relationships are. The one thing that is complete is the biological analysis for all the survey sites. That was a really large step because I've been working on over 100 locations for fish, 250 for the benthos. Some of those sites were visited at least twice, some were visited up to 10 times. That data helped inform some of these questions that I've begun pursuing. Then for the

WaterFALL data, we'll be able to simulate the unaltered and altered conditions at the site of the biological survey. With WaterFALL, we can look at a simulation anywhere within the river network so that's going to be a much higher resolution analysis. My hypothesis with that is, if we have this station that in the last twenty years has seen a decline in diversity and a decline in abundance and the WaterFALL simulation shows that this is a site that's highly altered in terms of its flow, we anticipate there is some sort of connection there. There are also examples where TNC has seen increase in diversity and an increase in abundance. I want to mention I did take out the exotic invasives. For this data, I'm just working with the native communities. The diversity and abundance do not include the natives. There are other cases where at a site there's an increase in the diversity and the abundance; it's going to be interesting to answer the question there – what is happening to the flow there? Is that a site that is very unaltered? There the communities have a healthy growing response. Are there situations where we might have an increase in diversity and abundance, but it's an really altered site? Increasing alteration might be influencing the change. The WaterFALL analysis will do very close assessment for those sites. Those are based off of 30 year records. For the WaterFALL analysis, our unaltered data is based off of 30 years of records. We're looking at really large patterns in change. And then going back to the USGS one, it's just looking at what inter-annual variability is.

C: I'm very eager to see how your waterfall analysis works with the other metadata. DWQ's database, as you are well aware, has much besides the species presence or absence information, habitat assessment and time. So that's a very key component.
R: I didn't mention that. I showed you quite a bit of my presentation. There was also an environmental variable slide that had the variables for the different sites that were done during these surveys. I also have that data.
C: Take us through that a little bit.
R: We just started looking into that because we just recently got that data set. It's basically some of the habitat variables associated with the sites. One of our challenges is it's not completely comprehensive so we don't have the same variables collected at every site. We're still in the process of actually going through and seeing which one is representative and used across all of our sites, that we have a robust amount of data for. Some of those include the substrate information. Again, that's a challenging one. A lot of it, is subjective, and it varies relative to the other chemistry parameters. Again, they're not consistent between all those sites. We want to try to pick out which ones are. Those we would also include as part of the environmental variable analysis to try to look at sort of a third gradient or multi-dimensional approach to see what are the relationships of those with different survey locations and also the biological communities at those locations.

C: I think that is incredibly important, especially given the purposes and the reasons for those original biological data sets. It's been consistent over the past 30 years that biological data collections were done to assess the water quality conditions within a six-month population recruitment and grow out. If we only visit those sites routinely once every five years, we're looking at a time range of assessment of approximately 1825 days, of which we collect data once. Consequently, where do you draw the line for antecedent conditions in hydrologic assessment versus biological assessment? The thing that I always wrestle with, as does any researcher, are those words that make me nervous: trends and

extrapolation, when you've got a one-day assessment out of 1825 days. A hurricane that came through a year before and destroyed the channel morphology, unbeknownst to us, and then we go in there a year and a half later and get a big difference. I have difficulty gluing those five-year windows of assessments, whether it's one or ten of them, together to call it a trend because we really don't know what happened.
R: That's what I'm hoping the USGS analysis will give us--an indication of some of that. A very large precipitation event, for example, is going to be a thing that we pick up with the metrics.

C: Extreme events.
R: So if we see that in a year preceding a certain condition, that might be an indicator of what was different between that year and previous years. Again, it just gives us something to hypothesize on.

C: I would also direct you to our water quality assessment documents where we've summarized our anecdotal and local knowledge information. We may have particular sites in your database that you're going to look at more intensively, and we may have reported out in those situations whether or not there was a massive fish kill the year before or whether or not there was a big environmental event. All that anecdotal information is documented in those reports. It doesn't lend itself very well to spreadsheet tracking, but if you get further down your analysis in the site-specific work or try to do some validation on any of these sites, hopefully they may be of service to you.
R: Definitely at these sites where I see a lot of these extreme changes I am going to start asking questions. I was quite surprised at the number of sites that are increasing biodiversity.

C: Also, like you say, all of these other environmental attributing issues are something that's pretty prevalent in this state. Across the state, land use is changing quite a bit. A lot of farmland is going out of service. We're also consolidating an awful lot of small wastewater treatment plants into large regional facilities. There are a number of reasons why we could be improving biological diversity in the state.
R: There's a lot of work that we're doing and a lot of work that has been done. One of my goals was to look at what data is available or what else can we reveal from that data that is available. It has been revealed in some of this initial analysis.

Q: You mentioned excluding invasives, but are you using non-native and invasive interchangeably?
R: I did not exclude inter-basin invasives. I just removed invasives that would be invasive to the state.
Q: I guess the question is, are you considering any non-natives to be invasive?
R: I haven't started looking at that yet. I am doing an indicator species analysis within the different communities. I want to see certain species that are very indicative and have a presence associated with the different conditions. If I start looking at that and there's a certain species that comes up, that appears to be native but invasive in that habitat, it will get looked at further.
C: I think non-native might be a better term for what you're removing, when it's from outside the basin. I think this was covered a little bit earlier, though--the fact that those non-natives may be just as dependent on the flow regime as a native, and are you at risk of skewing the results by excluding

those? I know it's important in terms of looking at, for example, the hydrologic parameters. But in terms of evaluating flow regime impacts, excluding those you might be…
R: There is. If there are sites where they were present and then I removed them, it's going to have an effect on what the diversity and abundance of that site is so that might reveal itself as a lower diversity or lower abundance. How that's going to translate out, if that invasive were still in there, I don't know. My suggestion would be to present both.

Q: The other thing is, are there specific fish species--what are the red flags I should be looking for?
R: It might be that Fish & Wildlife or Wildlife Resources saturated the river with a predatory species that is migratory; that in itself may have an impact. If you look at native, non-native, invasives and human practices such as stocking, I do not know how you would account for it.
R: I was just looking at the list. Some of those might not be picked up in the sampling; it might be in an area that would affect the community. But at some sites it might not have been collected.

Q: I agree with everyone else. Great presentation. Can you elaborate on how you are going to use IHA?
R: We're going to use IHA as a tool to inform where we see the most flow alteration. TNC is using it to graphically look at where the most altered flows are and what is causing those flow alterations. Is there something proximal to that location (such as a withdrawal) that might be causing the flow alteration? The IHA analysis will really be used to look at alteration. We might be looking at how it changes low flow duration time periods. Are they increasing or are low flow events and the duration of those events increasing and it's causing a lot of negative flow alteration? Graphically we look at where this location is proximal to a large withdrawal. What strategy or management regulation affects the amount of water that shouldn't be withdrawn? It's going to be site specific, but then it might be by water shed. There is definitely a very strong geographic component.

Q: Has anyone, going through this process, sat down and said, "Okay, the major independent variable is flow; the major dependent variable is blank, and then start putting in all those other independent variables, like the fact that we only had information on one out of five years on any one site and that's not linked to the flow data, etc., and build a sort of flow diagram, or at least a list, of why we're not going to get to a correlation of one.
R: I don't think that we will. I don't even think with a great analysis we're going to get to that correlation. There are so many causal factors.
C: Land disturbance rate, for example.
R: Right. And that's why we're looking at the percent of change in the active river area. I didn't have it in this one, but for the upper Cape Fear that's a really large concern. There's been a lot of development in the Upper Cape Fear. When we did a very small analysis, looking at 2006 and then looking at USGS flow in two 15 year periods, you could see patterns that are potentially more indicative of those land use changes patterns. They may have a large influence on flow, but that's something that we want to be able to try to account for with the land use cover analysis and also with WaterFALL between altered and unaltered.
Q: I'm wondering whether it's flow alteration due to increase in cover and flashiness versus withdrawal or return to operation of a dam?

R: Right. I don't think we're ever going to be able to say this flow alteration is from this cause. This flow alteration is from all these causes. But most likely most of the alteration is caused by this factor. So we want to see which factors at different locations have the greatest influence. It's going to vary spatially. At some locations, that alteration might be more because of landuse/cover change. In another location, an alteration might be because of a withdrawal. There is a very strong spatial component. That is something we are hoping to be able to pick out in some of the different environmental variables associated with a site.

C: But you should be pretty clear cut because that's built into the models.
R: Right. That one's built into the models so we'll know…
C: Altered versus unaltered.
R: Yes. Unaltered condition has no withdrawals, no returns, no dams. The altered has those. RTI has worked all of those withdrawal return points into WaterFALL and then worked out an equation to extrapolate what those withdrawals are over the course of a year and how that's influencing. That is something that is part of water quality. We have those point locations so we know if there's withdrawal at this location and this amount of alteration, and we go back and look at what those relative withdrawals are. Does that account for this observation? I think there's going to be a big spatial control on this. In some cases we might have absolutely no flow alteration and changed biological communities. That might be where we see that there's dams that are actually influencing habitat productivity. But maybe not flow or…
C: It sounds to me like you all are just doing an amazing job of doing this analysis and today we only know what we do know. But expect that most of our biological monitoring sites, being wadeable, will be unaltered streams. It is common for us to go out in the field conducting these studies and find out Farmer Jones does indeed have a pipe in the creek upstream and has sucked out ¾ of the creek. Clearly those are unpermitted withdrawals, but in North Carolina you don't have to have a permit for those kinds of withdrawals. Those are not the kinds of things that we have insight on, but I would predict at the end of the day, not only is there not going to be a one to one, but you will have done a very, very marvelous job of pulling together all of the reasons why the challenges to this SAB are so great.
R: My hope is that we are going to see patterns revealed from which we can develop strategies for management objectives. There are two components of this. One is the TNC side of the agenda , which is to identify the priority areas for conservation. There's also the question of which areas are most vulnerable, which is important from this group's perspective. There are different large questions that we're answering with this project. The ultimate goal is just to try to determine, to the best of our abilities, some of the things that are happening with freshwater systems in North Carolina. We are developing a starting point that more studies can be built off of. I would like to try to inform how often biological surveys should be done. I hope that it reveals something that can be applied to strategy.

R: Also, for some of those questions it might be a little premature. I'm not providing a lot of results now because we're still in the phase of looking at analysis. It might be that in November or December we have a follow-up on what TNC has done as I'm finishing up a report, before disseminating it. Once we find out what information from those can help, it might be that we need a follow-up. We're looking

at a really wide suite of metrics. Those metrics will be more relevant to the Science Advisory Board than others. I really wanted today to let you know what TNC is doing, what we have done and where we're going. But I am also interested, within this meeting, to also continue small group discussions and one-on-one. A number of people in this room have been really helpful so far to get where we are.

Facilitator: Would some discussion of what the Board anticipates be useful? That segues nicely into a broader discussion of the implications for the EFSAB.

R: That would. From what TNC is proposing, are there certain elements or components the EFSAB can use...
Q: The question I would have is; how much information is going to be available?
R: All of it, as far as I'm concerned.
C: Kimberly, it's hard for me to really respond to that because I think I have a good idea of all of the dominoes you guys are playing with, but I'm not exactly sure how they're going to line up yet. I think it's a little premature for me to provide any more assistance to you until you all get done with some of your work.
C: One comment is that a few times you mentioned that we might find the low flow information most helpful. I think that's true. But I am also hopeful that IHA will be helpful in determining whether or not a highly altered system is able to achieve high flows, appropriate levels of high flows, for ecological community health. I think it is not only important for our Board to focus on the implications of the low flows, which are arguably very, very important and probably may be very defining, particularly in systems that have a lot of riffle habitats that are particularly vulnerable habitat low flows. But it is also important to look at the systems that are, perhaps, these moderate size rivers where we don't have a lot of hydropower on them. Withdrawal in the long-term might inhibit the ability to achieve higher flow needed for spawning cues, for example. I just don't want to limit ourselves, at least limit our expectation to something that's relevant only to low flow.
R: I think that that's a really good comment. In the end I envision having this suite of information, and we are looking at the higher components of the flows.

C: One thing I think is important is your focus on other factors. I don't know if you're looking at permitted discharges, presence or absence or...
R: Yes. We have the point locations for discharges.

Q: Regardless of the conclusion, what are some of the other factors that we are not looking at? My question is around that this is going to be great data, great analyses for results. We can't wait. In terms of transferability, how about methods? Will we be able to use these methods and transfer it to other basins that you all didn't focus on? How difficult is that going to be for us? Is this just plug in some of these same data into a spreadsheet and crank it out?
R: So far, all of the methods that I'm using will be transferrable to all the other basins in the state. There's no data specific to those four basins. Part of our limiting it to the four basins was that we wanted to be able to do more of a detailed assessment. Ideally, I think it would be neat to see some of these methods extrapolated out to other basins in the state. The reason we're not doing it statewide is time. Now that WaterFALL is available statewide, the conductivity analysis was done

statewide. Those other data layers for the environmental variables are available statewide. You could just go through the same method of filtering out the sites that are used for the analysis. All of this could easily be transferred to another basin.
C: I think it would be helpful for this group to be able to do that.
R: Areas where we have don't have methods that are suitable would probably be impacted. We have fairly recently-developed benthic methods for swamp data that's being collected now. There are areas that are limited for methodology but I wouldn't…The one limitation would be the use of WaterFALL, to be worked out with RTI. For our purposes, we are trying to scale up a bit. In some cases there are higher resolution programs.

Q: Is that very basin specific?
R: I'll let Tom answer that.
Q:: The question is, in terms of other possible next steps that apply in this and something besides those four basins, WaterFALL would be something that the Board would definitely need for the macro-invertebrate...
R: All the taxonomic ambiguities. Within the data there are a lot of samples that have genus and species; there are a lot of samples that just have genus. There are a lot of questions as to how to be able to use that data. Tom would be able to answer that question much better. But as far as it being available for the state, it's running the DWQ benthos data. I was fortunate to be able to get data that had already been gone through, and I just pulled up for the four basins.
R: That step's already been done, that real hard part.
R: A lot of that's also resolvable using Store net.

C: In general, have WaterFALL and OASIS being compared, and what are the pros and cons?
R: WaterFALL is like a front loader. Rather than just using actual gage data, you have that generated data to get plugged in.
C: Like she said, WaterFALL is trying to mimic the gage sites that are out there. You have to look at the gage within reason. With OASIS, you're trying to incorporate all of the various water uses and have the nodes along the stream. OASIS you try use the water to hit the gages. Sam said you can't compare the two as far as products since they look at different things.
R: Using WaterFALL just means that we can have data to load into Oasis for streams that don't have gages.
C: I envision you create virtual gauges.

C: I know that Tom Fransen was working up DWR software to compare any model to do validation, for both OASIS and WaterFALL to see how the two compared and how they compared to USGS data. OASIS and WaterFALL have different purposes. OASIS is a mass balance water management tool--big picture, safe yields. WaterFALL is aimed more at land cover. It can deal with small catchments and land cover, climate change what ifs, etc. I think the comparison of the 2 is still ongoing. There is not expectation that they will line up exactly. The question is whether they will be close enough for what we want to do.

C: There is a paper that just came out this year by USGS comparing ecological flows in two ways, looking at a regression analysis and so it kind of gets to Bob's question. It really depends on what you want to use it for.

C: It seems to me that one of the decisions or recommendations this board could make or it doesn't matter, and that is a potential solid recommendation from this board on how they interact with respect to determining ecological…

C: DWR is pretty much committed to Oasis. It's not going to depart from its use…it's kind of a question of whether the information that goes into it can be tweaked. The models are approved by EMC. It is unlikely for the overall river basin models to depart from use of OASIS. The question here is whether WaterFALL function as a pre- or post-processor. EMC approves the river basin models with the understanding that we will add in the ecological flow component. The process for approving river basin models is ongoing. There is the technical discussion comparing the models, and there is the approval process for river basin models. That is unlikely to change.

C: With OASIS the nodes are trying to hit the gages. You could use WaterFALL to create virtual gages to eliminate some of the scatter downstream.
R: In all this analysis, I am looking at the spatial component--their position relative to another. One of the things I am trying to look at is, within a basin, is there an area where we might see a threshold where upstream of this location biology looks great, flow looks great and when we look downstream from here, things start falling apart. So that might be kind of what you were asking – how does this relate back to that. I really want to look at these, the alterations and also the biological response from that. Right now all the data that we're working with [inaudible 1:56:03] Again, Tom, that's something that data would absolutely have meaning for this group, whatever we derive or produce during this process. A lot of it's exploratory. That would be available. So we're looking at what…1) what are hydrology changes through the network? 2) Are there certain thresholds relative to those changes, or are there certain metrics that are better for revealing those changes than other metrics?

If anybody is interested in seeing more of what TNC has been doing and seeing some of the data and seeing some of the preliminary analysis, Kimberly is willing,, either in small groups or individually, to sit down with people that have more concerns about how the biological data is being used. She is very willing to set up meetings with people so they can see what some of the data looks like.

V. Coastal Systems & Issues: Presentation and Discussion

Presenter: Dr. Bob Christian

Bob presented about coastal systems and three overarching concerns that challenge application of ecological flow approaches to the coastal plain:

a. Hydrogeomorphological issues influencing modeling
b. Ecological issues influencing ecological integrity choices

c. Kinds of water withdrawals

Hydrogeomorphological

With respect to hydrogeomorphology issues influencing modeling, the area is flat. Topographic relief or lack thereof makes watershed designations very difficult. The slope is low and therefore water generally does not move very quickly or sometimes does not move at all – hence flow is often not high enough to move heavy material and scour. These are different kinds of streams than we have discussed. The riffle and pool structure with rocks is less common, and the stream bottoms are often muddier.

Because an area is flat and low, reverse flow is common during tidal action and backflow from larger rivers during high flows. During tidal action, there are significant differences in tidal influence:

- from the Northeast, within and behind sounds – tides are wind dominated. This means there are low frequencies, irregular and long durations.
- from the Southeast – tides are astronomically dominated. They have high frequencies and are more regular.
- there is a spectrum of possibilities between end-members

Hurricane Irene or Hurricane Floyd at the coastal plain, come to mind as cases of backflow from larger rivers during high flows. The flooding that occurred with these storm systems was not a result of within watershed or local watershed rains but rather from large rivers coming down and then back flooding into our area.

In terms of tidal action, these (i.e., in image) are two areas about fifty miles apart – the Pamlico Sound and Bogue Banks. They each show a bit of difference in the tidal picture that might occur. In the case of Bogue Banks, which is more open to the ocean, astronomical influences explain about 50% of the variance and the winds explained less than 40%. With the few inlets and the barrier islands of Pamlico Sound, we have a much different picture of the tide in which tidal signal is driven largely by wind and therefore the flooding or non-flooding of an area can occur over time scales that might be weeks or months long.

Where geomorphology is flat, there is also high connectivity with adjacent wetlands. This is an important point – where overbank flow can increase cross sectional area and volume significantly. The lidar map (slide 7), is analyzed by region names. What I want to point out is the Roanoke River. The river itself is right in here and although the dark blue area represents minus nine feet, this is 0 to 5 feet, and what you see is, essentially all wetlands around the stream. Therefore, it does not take much of overbank flow to flood the wetland, and in so doing dramatically change the volume associated with it. As a result, it is also changing the ecology dramatically. This is something that we have not heard much of before.

Gauging stations are limited and unevenly distributed in areas where the elevations are low. Because the coastal plain is low and flat, salinity for the first time, presents a problem for us in the mixing of flow characteristics and water quality characteristics. Salinity may range from 0 to >30 and may be affected by water use. In addition, with projected sea-level rise, this is expected to exacerbate salinity concerns. It is very difficult to separate out salinity with other water quality characteristics in the coastal plains.

Another item to consider in the planning equation is having models that deal with how humans alter the waterways throughout the state. This is one coastal factor that I believe occurs more

frequently in the process of trying to get water from "a point A to a point B." Agricultural ditching and/or roadside ditching, navigational dredging, desnagging/snagging, and dams and culverts that block fish passage alter flows and are all prevalent in the coastal plain.

The management of the coastal area is regulated by the coastal habitat protection plan (CHPP). The plan recognizes several different types of habitats.

Ecology:
With respect to ecological issues influencing choices of ecological integrity, the water column is the medium through which all other aquatic habitats are connected. Habitats germane to the EFSAB are part of the foundation through the Coastal Habitat Protection Plan (CHPP) was developed by NC Division of Marine Fisheries (DMF).

Coastal fish species are often different than those found in inland waters or they have different ecology from that of the inland species. Some examples include:

a. *Anadromous fish* (upstream spawning)
- Blueback herring and alewife (under consideration for endangered status)
- American shad
- Atlantic sturgeon (endangered)
- Shortnose sturgeon (endangered)
- Striped bass (stock status – concern)

b. *Catadromous fish* (marine spawning) eel – (stock status - depleted)

c. *Estuarine species* – some of the common low-salinity species that occur in river systems: southern flounder, Atlantic croaker, spot, menhaden, bay anchovy, blue crab, white shrimp, striped mullet.

In terms of how coastal species of fish may differ from inland species, there are spawning issues, specifically where certain species spawn, e.g., whether they are spawning up river. That's critical here since spawning location and timing are major factors in categorizing species. A number of fish species are of particular importance to the Division of Marine Fisheries that require a Fisheries Management Plans involving flows.

In addition, in terms of importance to coastal waterways and coastal fishers of North Carolina, there is an abundance of nursery areas at the coast. Some portions of coastal rivers (oligo-mesohaline) support greater species richness than polyhaline and freshwater due to overlapping ranges, seasonal variations in salinity. Ranges will vary naturally due to environmental conditions and seasonality, as these species move back and forth. This comes back to the point about such species as striped bass and blueback herring. Flows are associated with stock status. We've heard a lot about this kind of work. There is a lot of interest in coastal plain and how it differs from inland, the nuances in scientific processes, and how the management community has to interpret data from their monitoring efforts.

The coastal plain is broken into five different areas in which methodology is needed of the biotic index. The NC Division of Water Quality has different programs for Index of Biotic Integrity for coastal plain streams (and I defer to Jay and Tom on details). The two index methods include:

a. Hydrogeomorphology (Very low flows, channel modifications, riparian zones, depth)
b. Biota (fish and benthic macroinvertebrates (swamp method)

There is no estuarine Index of Biotic Integrity for coastal waters.

Kinds of water withdrawals
Water withdrawal issues include community water supply and non-community water supply; all which are obviously important. Community water supply issues increase with demands due to coastal population growth. These issues are not necessarily based on surface withdrawal and reservoir use (ground water withdrawal and desalinization play a factor). Major mining operations, agriculture, and industry (power plants) represent a different aspect of water use.

In closing, coastal plain waterways are potentially different in numerous ways, though three major areas help define those differences:

a. Hydrogeomorphological issues influencing modeling
b. Ecological issues influencing ecological integrity choices
c. Kinds of water withdrawals

Each major area contributes to the challenge of applying procedures from inland to the coastal plain. I've described some of the problems. Can we find solutions to address these problems? What I'd like for us to do with this information is to be more specific about what the issues are related to hydrogeomorphological issues influencing modeling and the ecological issues that influence ecological integrity choices. We should then provide potential solutions to address these issues. We are going to break into two small groups: hydrogeomorphological and ecological. You can self-select into the group of your choosing. There will be a report out in about an hour.

Small Group Discussion and Report Out

The Ecological Issues Report Out
Our group concentrated on identifying additional problems and solutions for exploration. The first issue we addressed is the lack of ecological data. Most of what had been used in the various models has come from the NC Division of Water Quality Division; there needs to be additional data that will be applicable to coastal issues and any model development that might be meaningful in terms of looking at impacts for coastal streams and water withdrawal impacts. A potential solution might be to include the Division of Marine Fisheries data, particularly if it has not been incorporated or considered.

The data sets used are fairly old; some of the studies are limited in sampling frequency and/or sample locations/stations. UNC-Wilmington has completed some recent studies on the lower Cape Fear that might be of value.

If we had the opportunity to view all the data on coastal systems, what might be achieved as a possible outcome? Given the noise or the background influences present in many of these coastal systems, probably one of the best outcomes we may hope for is the reset button. A reset button is an event, after which you start over with your population assessment and use the number of available data points. For example, consider that you are assessing biological diversity, and a massive hurricane and flooding event comes through. That extreme event is almost going wipe out any effects of the withdrawal that have been occurring on a smaller scale up to the extreme weather influence, particularly in terms of impacts on the population and data sets that were available. So

we need to define what these large altering events might be (i.e., hurricanes, wind events, building of a large reservoir,….).

Another item that came up as an issue is how to identify sensitivities. That is what are those things that seem to matter in terms of a measureable criteria or quality event such as low DO in an estuarine system following an extreme large event like a hurricane, change in runoff, or very dry year/drought season. Salinity intrusion, if there is some wind event that pushes the salt wedge far up into the estuarine system – this something that will have a measurable impact and that the system could be relatively sensitive. A recent example of this is an ongoing study of the Savannah system. Here researchers are considering things that would show up in a data set as something measurable like a change in a biological index of some sort of population (spawning was affected and thus population was reduced), or oxygen depletion that wiped out a species.

In general, our determination was that these coastal systems are extremely complex and subject primarily to very large events. These large disturbances provide opportunities for measurements and can give us meaningful data.

Other conclusions are associated with freshwater withdrawals; they may be cumulative and they may exacerbate some of these large events like hurricanes, sea level rise, etc. In general, the signal to noise ratio is very low so it's going to be hard to make predictions or assessments of the impacts of freshwater withdrawals, in light of the fact that these large events make detecting the impacts of these withdrawals difficult (not that they do not occur – just difficult to locate or what the impacts are).

Another suggestion is to consider some base point, one that might move (is not fixed). This may be a point on an upstream or downstream scale below which the models that we've been looking at so far, Oasis or WaterFall, might not work. For example, there is probably a point in which these models are not the best approach. We do not know where that point is but this suggestion may help NC DWR; draw that line and figure out where to go. Below that, base point we recommend site-specific models may be necessary. These areas, given our previous statement, only produce measurable impacts when you have very large events. Probably the projects that would have a measurable impact would large projects and subject to a site specific review/evaluation. At this point, groundwater and surface water would be more likely to intermingle. Groundwater withdrawals might have just as much effect as surface water withdrawals but they would probably offset one another pretty much.

Finally, suggestions for the NC Division of Water Resources are to look at other studies other states are conducting. We believe what has been presented to the EFSAB has focused on research and modeling efforts for more upland freshwater systems. We have not reviewed the literature from other states on coastal systems such as Texas, California, southwest Florida – these might be reasonably predicted of what might go on in North Carolina. These are some items that NC DWR may want to take into consideration when working with coastal systems from our perspective.
Q: My question is for Kim. In your analysis of the Environmental Flows Project in North Carolina, it appears you set aside the coastal plain to some extent. But did you find any references that would shed some light on the extent to how other researchers handled the coastal plain?
R: I didn't get into the coastal plain yet because I've mostly been focusing on wadeable streams. There are a couple study sites that are part of the coastal plain. Unfortunately, we did not get far in the analysis because of the mixing issues with the salinity and freshwater brackish areas. And we've been intentionally trying to target the study to just the freshwater components of the

systems. So, for example, even in the Tar, we've really limited the geographic scope to fresh water flow issues. In terms of the coastal plain, we are addressing the big river issues but from a freshwater context (one exception to this, is the Roanoke and the Albemarle Sound, our focus here is meant to inform a whole management system strategy).

C: What I was hoping, that in your literature search, you discovered information on coastal plain that might be useful for us to consider (something you have come across and the EFSAB would not have to search for this data). .
R: I will review the literature I've gathered. I never specifically made a literature search for those very low land, coastal plain issues. However, a freshwater or fish or benthos study conducted in NC might include the coastal plain.

Ecological Issues	
Issues to Be Addressed	**Potential Solution to Address the Issues**
Less biological data exists for coastal plain.	• Convert NCSU shad and fish data to appropriate database format for analysis • Use NC DWQ swamp data • Promote/launch biological monitoring in coastal plain • Incorporate Division of Marine Fisheries data
Only (15-20%) of 180 fish community sites are located in coastal plains (RTI)	
Will take long time (up to 10 years) to have coastal biological data for sufficient analysis (lack of data (DWQ)	• Division of Marine Fisheries data sets o Much of the data is older o Not many stations o Limited samples o UNC- Wilmington o Lower Cape Fear River o Define "reset" button (-CG-)
How to ID Sensitivities	EMC still underway with Savannah River
Time scale needs definition	
System very complex	• Only very large perturbations measurable • FW withdrawals may exacerbate salinity rise, impacts of hurricanes, etc.
Point below which models we have examined do not work	• Site specific methods needed • Groundwater and surface water combine
Review other studies from states with similar flow studies relevant to coastal river flows	• Texas • CAL • SWFL
Additional Comments/Issues	
Climate Change/sea level rise	Influences of upstream migration
In-stream flow study was conducted in Greenville,	Evidence of ecological integrity sacrificed due to flow? • Yes, Roanoke – big reservoir

example of tidally influenced (DWR)	Pumping from mine (Castle Hayne) Accumulation of withdrawals likely
Other states studies include ecological flows for tidally influenced areas (Potomac, others?) (Mary Davis)	

Hydrogeomorphological Issues Influencing Modeling: Report Out

Our group focused on modeling issues in the coastal plain and the concerns of low elevations, the mixing of freshwater and salt water in the brackish areas. We were trying to come up with some different controls that would influence the freshwater component of flows. One of the things we considered is not just the flows, not just what's coming down the stream. Other large controlling factors are tides and the controls on them such as wind, lunar, and astronomical control (Bob introduced earlier that there are two significant geographic differences in tidal influence: the northeast within and behind the sounds that is wind dominated - with its slow frequencies and irregular and long durations; and the southeast, with its astronomically dominated -short frequencies and regular durations). Whatever that sort of salt-water wedge is coming in, there are many different controls on where that saltwater wedge is within the river channel. So those controls are not just flow but the other major controls. It is really challenging to model these kinds of controls. In part because we do not have any data for them. Thus, we may want to look at what salinity studies have been done in coastal plain areas. We think a study has been conducted on the Pee-Dee River in South Carolina so it might be look at what they have learned from their analysis and see how those results might be applicable to what is going on in our coastal plain system.

There is a question of whether there is any evidence of ecological integrity being sacrificed due to flows. We believe there is from large reservoir operations but it is hard to say if there are areas that are not impacted by large reservoir operations and more of a result of fluctuations of the salt-water wedge.

If we cannot point to a big problem then it probably does not make sense to devote a ton of resources to the issue. For most obvious cases where there was ecological integrity issues seemed to be big projects with major regulations on hydrology with the exception of cumulative effects of many upstream withdrawals or changes in flow or if you've got the small stream that goes directly into the sound and has withdrawals.

We are in agreement with the first group in that we thought it was important to identify where these effects are occurring. We thought mapping out the lower nodes and where our current models don't give us accurate information – getting an idea of where that geography is and having a better understanding of what we know now about saltwater wedges and how far inland or upstream they are coming and trying to map those locations. Getting a better view of that line where we have information from Oasis and where we need additional information.

C: This is similar to what the Ecology group had to offer- determine what the point or line is in which the modeling effort switches gears.

The next item we discussed was groundwater, acknowledging that the direct effect on surface water flows from these deep withdrawals is tenuous at best. The shallow withdrawals can

definitely have an effect on surface water; what is happening with the deep water withdrawals where they are being regulated to try to reduce these cones of depressions and adverse effects from salinity intrusions in the deep ground water – what you're getting is users are shifting to either shallow groundwater or surface water. Therefore, they are balled up together into a potential effect on surface water from indirectly managing the deep ground. One additional important point to consider here is that where there are surface water withdrawals, depending on the drainage area and catchments that the surface waters are being withdrawn from, that might have a bigger influence on freshwater flows so that smaller basins and their catchments are going to be more sensitive to these surface water withdrawals than surface water withdrawal straight out of a main stem. That there should be a screening threshold relative to the drainage area. Some sites might have very specific management associated with them or others might have more strict regulations on the smaller drainage areas than catchments with larger drainage areas.

The hydrogeomorphology of the coastal plain is that it has this big buffering and attenuating capacity for continuing flow modifications, particularly if it is a large big drainage system. This connects to a point made earlier that the screening tool is scaled by drainage area.

Other points we addressed was how climate change and sea level rise will influence the impact on the shifting of the salt-water wedge up the freshwater river networks rise and moving that wedge further inland. We thought there might be value looking at historical flows (tree ring analysis of 500-1000 years), to give us some indication of what those historical flows looked like and how those flows might be changing given sea level rise; to see if there is a relationship between freshwater flows in that area to the tree growth and health, and if that might be changing as a result of the saltwater wedge moving further inland.

We need to have a better understanding of where the saltwater wedges are, what factors are controlling those wedges, can we model those factors and what models might be available for that, and what is the geography of the coastal plain that we need the models to focus on, and for the specific water withdrawals that might be very important for site specific studies in the coastal area.

F: It sounds like one area of agreement was the need to identify where those effects are occurring upstream and downstream. Are there any other areas you would like to highlight from the two report outs?
C: Site-specific needs for analysis are another thing. The other is the overriding possibility of how climate change and sea level rise might have dramatic effect on the coastal plain and thus changes in freshwater hydrology might just be a small influence given the larger effects of sea level rise.

There is thinking the Oasis models are completed or on their way for the Roanoke, the Neuse, the Tar, the Café Fear, the Chowan, and the Pasquotank so contacting the modelers for those models, they could quickly tell you what's the downstream boundaries and why that boundary was determined.

In some cases the boundary may be set because of lack of data to calibrate; or there may be actual data to set the boundary.

C: The research that Greenville did used 2% salinity as criteria for looking at the biological line. They used certain organisms indicted of coastal habitats so this may be another line that can be drawn. How can you deal with the fact that it is a wedge - by focusing on the bottom. They used benthos species as their indicators which are right at the bottom.

C: The way that I'm doing it is measuring at multiple points up the river, at multiple levels. You look at the bottom, it flows to the bottom and the up to the surface, and tells something but not as much as…
C: Well especially if your end is species disturbance and stuff, because it's not just the concentration magnitude, it's also the speed at which that sets up.
C: Yes, and you get some residual stuff that sets up, you get these pools and that salt will sit in the pools…

Q: Does anyone know if there is a map that shows those salinity lines on the coastal river basin groups; to match them up with the terminal node locations to find out what the span is and how they relate to each other?
C: There is probably pretty good mapping on the Neuse system because that's probably the one system where we've got the most data. But just because we had maps for the days that we were out there mapping doesn't necessarily reflect all the complexity of the issues we're talking about here. We had decent maps for something on the order of two days a month.
C: And UNC Willington may have maps of the Cape Fear similar to those. They did map during the drought year to see how close it was to the data.
C: The is a general salinity map in Bob's power point from the Coastal Management.

F: Sounds like mapping those areas are important to most of you. What are some of the ecological issues to consider?
C: We make a lot of suggestions here but with the recent departure of DWR staff, is Fred going to be able to analyze all of these? Our charge is to advise Water Resources on possible directions to go. It seems that the plate is fairly full at this point. Fred's very capable but Fred, can you carry out this analysis by yourself at this point, given limited capacity issues. What additional assistance is NCDWR providing to the group? (segue into next discussion item to address this question).

Coastal Hydrogeographical Issues Influencing Modeling Process

Issues	Potential Actions to Address Issues

A Model that works for the coastal plain is needed to develop ecological flows (Oasis model stops working where tidal influence begins)	• Mark where tidal influence begins on map
	• Explore WaterFALL as a modeling option
	• Explore NCSU's model *(someone needs to identify this model)*
	• Floodplain mapping by NC Flood Mapping Program (use their GIS layers) for stream channel maps
	• Oasis does have data on past flows
	  ○ Control for a flow that has existed in past
	• Limitations of Oasis Model include:
	  ○ Lowest nodes in OASIS
	  ○ Oasis does not capture salinity and DO variability around node
	• Rather than eco-target, have a flow target related to historical flow
	  ○ Tree ring analysis a possibility to identify historical flows
	  ▪ Drought & inundation
	  ▪ Roanoke study – cores to be analyzed
	• Screening threshold relative to drainage area (smaller – site

	specific) • Need to lasso the word "historical"
Locating tidal influence: marking where tidal influence begins is difficult because of so many variations in coast and shorelines patterns (RTI)	
USGS gauges not as evenly distribute in coastal plain	• Work with the data we have; best possible for now. • Mapping to ID most effects from tides (most upstream effect) • Determine limitations of gauge data ○ If there are not tight flow/ecology relationships, why spend resources
Tidal wedge lines may creep over time due to development	

Elements a model may need to incorporate:
 	
• Salinity
• DO
• Groundwater
	Salinity
	• Salinity – not just flow but tides (lunar and wind driven)
	• Oasis does not capture salinity
	• Look into Salinity model done in South Carolina for PeeDee FERC. Does critical flow adversely affect salt wedge? (no). TNC's Eric Krueger has the studies and Tom Franzen was involved.
	• Salinity modeling can be expensive
	
	DO
	• Oasis does not capture DO variability around node
	• DOs- do not received a dramatic response to Dos in flow
	• Use groundwater monitoring wells (do they have necessary responsiveness)
	
	Groundwater
	• DWR can address groundwater in model(s)
	• Use of groundwater monitoring wells (do they have necessary responsiveness)
	• Account for ground water to best of EFSABs ability to be responsive to legislation.
	• Groundwater withdrawal impacts may be more important
	  ○ Shallow withdrawals
	  ○ Municipal (CCCUA -capacity use area) required to use less deep aquifer H20)
	• Explore: how do a model incorporate wind factors

Additional Comments/Issues	
Climate Change/sea level rise	Influences of upstream migration
In-stream flow study on tidal influence	Evidence of ecological integrity sacrificed due to flow? • Yes, Roanoke – big reservoir • Pumping from mine (Castle Hayne) ○ Accumulation of withdrawals likely • Instream flow study was conducted in Grenville, example of

	tidally influenced (DWR)
Other states studies	• Australia • Include ecological flows for tidally influenced areas (Potomac, others?) (Mary Davis) • References on what happens upstream

VI. Biofidelity Analysis of Stream Classes in NC: Brief Update

Mary Lou Addor presented an update of the Biofidelity Project using a handout (information enclosed below) that Jennifer Phelan (RTI) prepared for the Ecological Flows Science Advisory Board.

The Biofidelity Analysis is a project to evaluate the fidelity of aquatic biota to stream classification systems in North Carolina. Since the Ecological Flows Science Advisory Board meeting on June 20th, 2012, the following have been achieved, modified, or are in progress:

1. Increase in the number of sites included in the analyses:

Based on the results of the preliminary biofidelity analyses (analyses of the fidelity of benthic macroinvertebrates in 106 NHD+ catchments that were presented at the June 20th meeting), it became apparent that the number of records per stream type and the number of records per species are likely to confound or reduce the strength of the analyses. Therefore, the number of NHD+ catchments that will be included in the final analyses will be increased to a maximum of 1,073. This number represents the total number of catchments that meet "minimally altered" (1. benthic water quality condition is excellent, good, and good-fair and 2. drainage area between monitoring station and upstream source of flow alteration is twice the drainage area upstream of the alteration) criteria outlined during the June 20th meeting. The distribution of the 1,073 NHD+ catchments is presented in Table 1.

Table 1. Distribution of NHD+ catchments that will be included in the biofidelity analyses.

Physiographic Region	Number of NHD+ Catchments
Mountains	520
Piedmont	429
Coastal Plain	124
TOTAL	1073

2. Aquatic Biota and datasets that will be included in the analyses:

The analyses will only examine the fidelity of benthic macroinvertebrates (NCDENR DWQ Benthic Macroinvertebrate dataset) and fish (NCDENR DWQ Fish Community, USGS NAQWA, WRC Trout, and WRC Diversity (Gameland Surveys) datasets). The Natural Heritage Program

Inventory of aquatic biota will not be included in the analyses. This decision was made based on additional review of the dataset and concerns regarding:

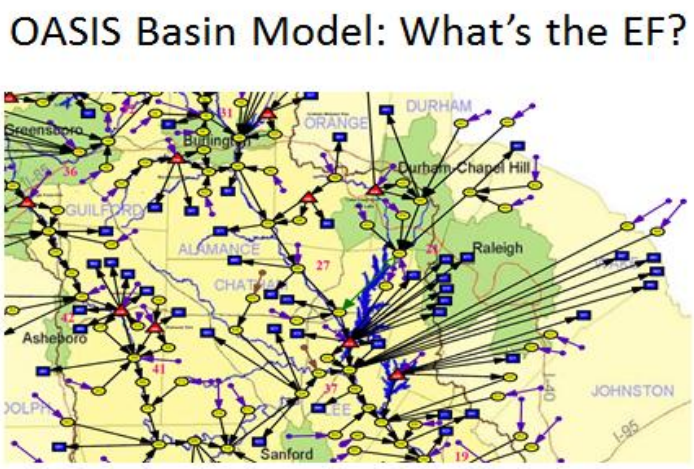
i. The dataset consists of observations from a large variety of sources, each with a different methodology and different set of objectives.
ii. Records consist of single species observations, and therefore do not allow for community-based analyses.
iii. Samples were not collected using a stratified or random sampling methodology throughout the state. Therefore, the physical distribution and apparent fidelity of a species may be a result of sampling being restricted to a single river or stream.

3. Comparison of EFS and McManamay river classifications using USGS gage and WaterFALL simulated hydrographs

We are currently in the process of determining the EFS and McManamay stream classes at each of the185 catchments with USGS gages (gages used to produce the EFS classification system). These classes will be based on USGS gage and WaterFALL simulated data. Following the completion of the classifications, we will compare the USGS gage- and WaterFALL-based classes and the EFS and McManamay classification systems.

VII. NC Division of Water Resources: Options for a Path Forward

Presenter: Fred Tarver (NC Division of Water Resources)



I want to provide a thumbnail sketch of where we've been, where we are, and hopefully where we're going. The charge of the NC Ecological Flows Science Advisory Board is to provide recommendations that identify flows and ecological integrity of river systems. This is the ultimate product. Using the snapshot of the Oasis Basin Model: What's the Ecological Flows?

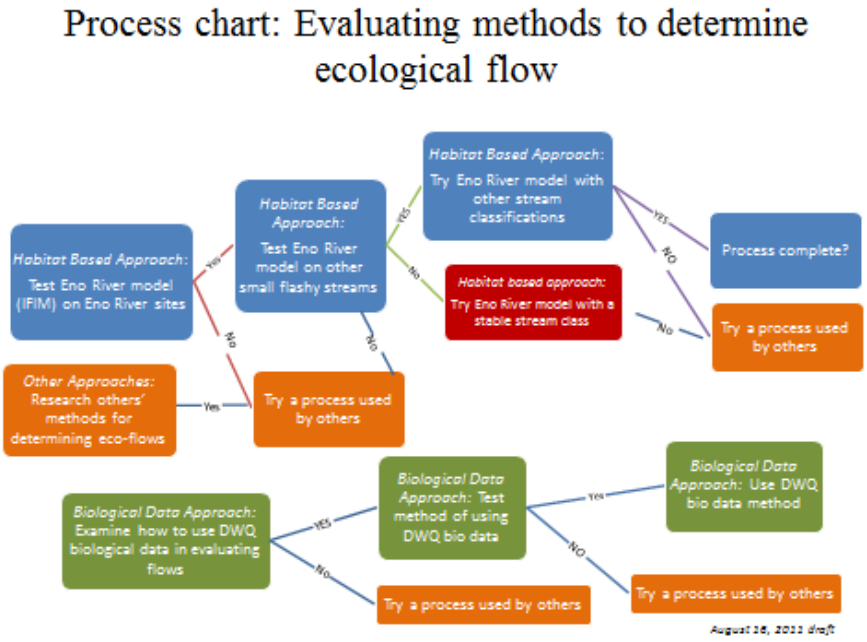
From my perspective, what we are trying to accomplish, is to plug in the environmental flows for all the yellow dots presented here in the model itself. Steve Reed talked before about environmental flows and the role of Oasis Modeling in helping to determine Ecological Flows (attached to this segment). He talked about the importance of including environmental flows in the River Basin Hydrologic Modeling that is progressing onward.

The River Basin Models are under a schedule so they progress whether we have the environmental flows or not. The schedule for the River Basin Models lists some near completion, such as the Tar-Pam and Broad, and the Cape Fear/Neuse is close to being done. Initially, the Neuse and Cape Fear were separate but now are combined. The Roanoke just kicked off. Over time, the remaining River Basins will be completed.

A discussion we might want to consider: if we're trying to determine what the environmental flows are for example - the Savannah- and the hydrologic model is not due until 2016, do we need to concern ourselves with this river system now or can we reconvene at a future date, based on what we've learned over time, to come up with those environmental flows? The session law says we need to determine the ecological flows associated with the modeling but does not convey a timeline. Therefore, we can pursue it now as a statewide process or pursue the process, river by river. Another example, the Albemarle Sound and the Chowan are not due until 2018, so that there is time to get our heads around the coastal issue.

Completion Year	River Basin Hydrologic Models
2011	Tar and Broad
2012	Cape Fear, Roanoke and Neuse Updates
2013	Hiwassee and Little Tennessee
2014	French Broad and Lumber
2015	New and Watauga
2016	Catawba and Savannah
2018	Albemarle Sound, Chowan and Onslow Bay
2019*	Yadkin-Pee Dee

*The Yadkin-Pee Dee is scheduled for completion in 2019, but if the Federal Energy Regulatory Commission issues new licenses for the Yadkin and Yadkin-Pee Dee Hydroelectric Projects in that basin, priority for model development for the Yadkin-Pee Dee would be elevated and the basin model completed



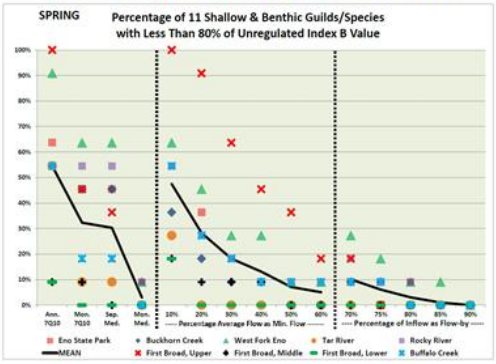
A process flow we introduced earlier indicated that we use a habitat approach initially (reference Jim Mead's Eno River site, a rerun of older DWR study). We took that study and compared it to other sites. Yet, maintain a parallel process by keeping the door open for other approaches such as other researcher's methods and findings, and the biological approach.

The suite of Habitat Response to Flow Regimes that Jim provided were primarily restricted to Cleveland County for the First Broad and then in the eastern part of the state with the Tar River/Rocky River/Eno and the West Fork Eno. These were some studies where we had the ability to cherry pick some sites; we had gauge data that was available so they were easy to run.

Round 1: DWR PHabSim Sites in Basins with OASIS Model – Habitat Response x EFS Class

Round 1, of the habitat studies, looked at the responses in terms of habitat to various flows. In addition, we have spent several meetings looking at a number of graphs to obtain information on the response of various habitats at the various study sites. Looking at our old traditional flow requirements from back in the day of the – the 7Q10, the September Medium, the monthly median, and then we looked at average flow, inflow, and the percent of flow-by. Our goal was to see what the responses were, if there was a correlation among some of the study sites, and of the scenarios presented, which are more protective to meet the charge of determining environmental flows.

Habitat Response To Flow Regimes Based on DWR PHabSim Sites

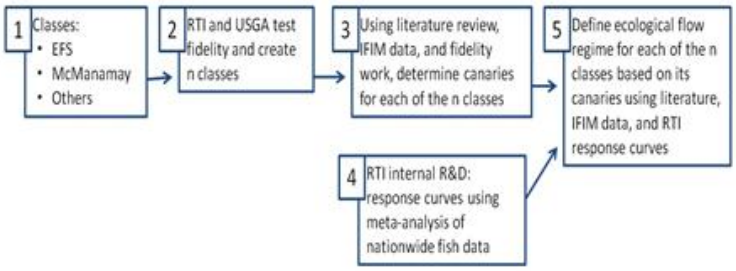


We followed the habitat scenarios by introducing the Trial Balloon *(reference the April 24, 2012 Meeting Summary)*. We put forth the trial balloon in terms of all the various considerations for the flow-by scenarios. The scenarios were then subdivided by various seasons. Some general conclusions were offered to revise the trial balloon such that to have the same set of flow alternatives for all seasons and at some point, ensure 7Q10 is included (in the final summation) because it has institutional standing. An updated version of the Trial Balloon will be provided at a later date particularly if we include any future instream flow study sites.

	BIO-FIDELITY TEST HYDROLOGIC STREAM CLASSIFICATION	RTI INTERNAL RESEARCH & DEVELOPMENT PROJECT	THE NATURE CONSERVANCY'S FOUR-BASIN ENVIRONMENTAL FLOW PROJECT
Results	• How well do the stream classes describe the spatial distribution of aquatic biota (i.e., a higher probability of a species or community being present in one stream class over another) • Does the classification system need revision?	• Ecological response curves: x-axis =% flow alteration y-axis = fish metric based on species level count • Uses space (multitude of sites with varying amounts of flow alteration) as surrogate for change in flow in (same site)over time	• Ecological response curves: x-axis = % flow alteration y-axis = fish metric based on species level count • Uses flow changes over time from multiple samples • Also will include descriptive analysis of basin conditions

Other efforts we are taking into consideration include what Kimberly mentioned in her presentation, such as efforts being undertaken by TNC, RTI and EDF, all who are looking at these similar sorts of things.

A new flow chart was introduced by Jim Mead. It is a process flow chart for how you take the classes and do the analysis of those classes and try to see how the classes fit, in terms of the relationship of the bugs and the fish to the classes. Are they a good fit or not, and if not, then what needs tweaking?

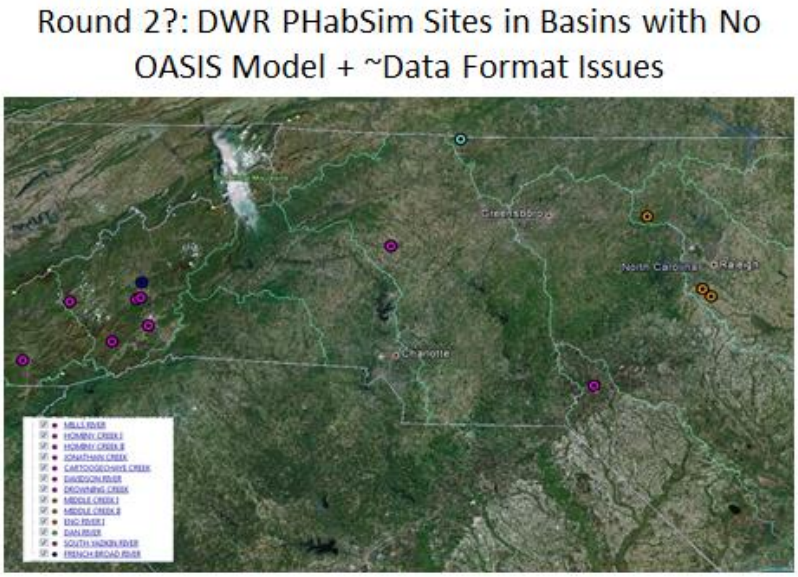


Process flow chart:

Box 2 is the multi step process we are talking about, including all of the RTI work and Tom's work.

Box 3 and 4 begin the convergence of all the work

Box 5 is when we take all this and make decisions.



For Round 2, I envision that if we choose to pursue additional instream flow analysis we do have other instream study sites out there that we can resurrect and manipulate to come up with flow scenarios and do what Jim did in previous efforts. They do have classes associated with them but there's no Oasis model. I suspect we need to use some other method to come up with a flow record. If WaterFALL were available, that might be used as a surrogate or some other method.

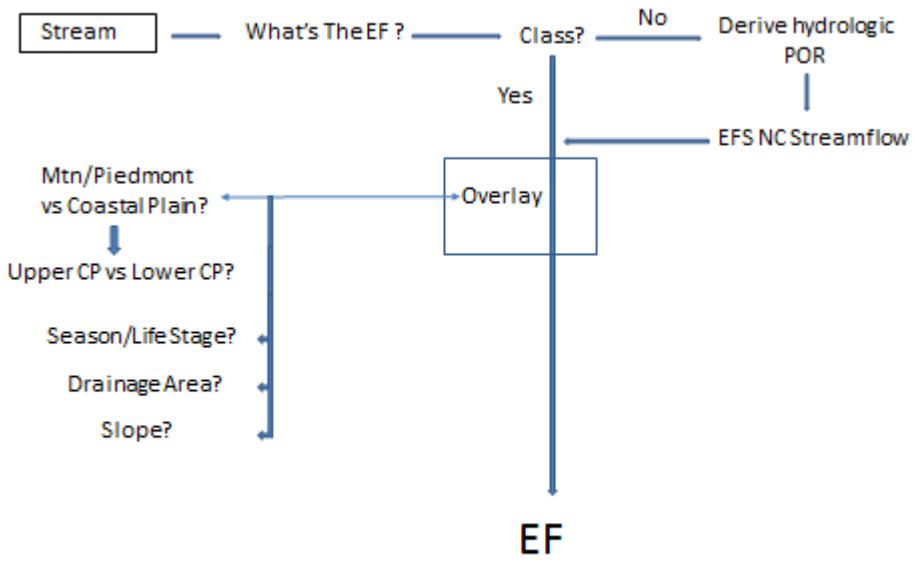
There are some data format issues to consider. Some of these were done many years ago and are perhaps in hard copy so it would require time and effort to return these to electronic format. They do cover a more geographic scope and there is some more diversity in terms of the classifications out there. Not a whole lot of replication but they are more diverse; some out in the mountains that are associated with water supply issues and trout farms. If the Science Advisory Board feels that there is value in resurrecting some additional in flow study sites and wants to do some further comparisons like Jim did, that's something for us to talk about and consider.

For Round 3, we have additional study sites that are even more confounded because we don't have an Oasis model or a class, and there are data format issues; and these are associated with dams so there is some alteration. Because some of this data is associated with some of the licensing efforts that took place up in the mountains, there are probably gauge records that were used for this modeling. Therefore, in terms of a flow record, there might be advantage to that. I do not recall the exact wording in the legislation but in terms of alterations, a dam is an existing feature in the watershed or on the river so that alteration will be present. Whether or not it's a similar alteration in the future as it is now is something to consider – it will not be baseline but it is a flow scenario. If there is wording in the legislation about current conditions and the existence of dams. There is a multitude of instream studies out there that we can pursue if it's of worth to the EFSAB and there's manpower.

In thinking about the end product for the NC Division of Water Resources, I was envisioning myself in my office when one of the basin modelers came in and asked, "What's the environmental flow for so and so basin?" and I said, "Well, that's a good question. I don't know." I can come up with the easy ones. If we have hydropower dams, we have flows from those; if we have dams that are under dam safety, we have flow requirements for those. If we have water projects and we have done a study out there, we have environmental flows for those. For these other streams out there, we have yet to determine what the ecological flows are.

Therefore, ten years from now after this process is complete, what will I have on my desk so that I can respond to that question? From my perspective, it would be nice to have some sort of spreadsheet or something to list all these various rivers in the basin and cite it's environmental flow.

Another approach I envisioned is that if we have the established class and yet we are still trying to determine whether the biological data fits into a particular class to show a correlation between various streams in our classification system (if there is not a good fit), perhaps we need some sort of overlay to break apart these classifications into more refined groupings. These overlays might include it's physiographic region, whether its mountain or piedmont or whether it's coastal plain. Alternatively, as Bob mentioned earlier in his talk about upper coastal plain versus lower coastal plain: the season, life stage, drainage area, or slope. There could be many other characteristics of physiographic regions. I have provided a conceptual framework illustrating what I mean.



If we do have streams that are not classed, then somehow we need to derive a virtual gauge or an existing gauge. Some sort of flow record that we could put through our software – the EFS Stream Flow package – to come up with that classification and then run that

through the overlay if that's the method we have to come up with the environmental flow.

This is my brainstorming of the kind of products that could be helpful to me. It has to be something that I, working in my office, have the ability to pull up to make these determinations about what the flow is. Whether it's a number or whether it's some sort of graphic on one of these clickable tables where you can look up tables and drainage area, and other items using these overlays.

Questions (Q), Response (R), and Comments (C): *F (denotes Facilitator)

F: Are there any questions for Fred?

C: If DWR/EFSAB goes forward in conducting a next round of habitat flow studies (Round 2), and we look at the western parts of the state, we came up with a # of guilds for the Piedmont sites (Broad and Neuse Basin). Think it was 8 shallow and 6 deep guilds, including a few additional bugs and such, there were 19 items in total - there needs to be similar thinking for western streams to determine a common yardstick. The western part of the state has a different fish community; need to update this information on various sites like the Davidson River and Jonah Creek. Are you going to do individual species or guilds or a mix of both? Are they going to be the same species as in the Piedmont or will they be different?
Q: I'm trying to figure out whether we're doing the ecological flows that are site specific or class specific? Are we coming up with one set of ecological flow recommendations that represent the seven or nine classes that we have? Or, are we coming up with a number of classes within the basin? Given the discussion about development in the Oasis models and wanting to have River Basin Hydrologic models as the Oasis model comes on board - it seems to me if we are focused on classes that basins are no longer material.
R: To some degree. Right now what we are pursuing is the Biofidelity to determine whether there is a correlation between the classes and fish or aquatic insects. If the classes do not hold, then you have to reconsider those classifications based on some partitioning aspects.

Once we come up with a classification system, I can visualize that all streams that are in that class have this particular stream flow requirement, *the question is how do you determine if that particular stream is in that class?* From my perspective, there may be a need to generate that flow scenario and run it through the environmental flow software to produce the class information and make that determination. If that stream is in A, B, or C class, it has those certain characteristics that meet that determination for ecological flows. So yes, I think it would be that classification system – meaning if someone came and asked, "What's the flow for that particular stream?" it would be based on that classification determination. However, I'm still a little fuzzy about how some of these overlays will affect the refining of the classes. My hope is the classification system will hold so that we do not need to determine e-flows for every stream in a basin.

C: Agree; we may move from 9 to 19 classes or a geographic or slope component.

Q: What plans does DWR have to support Fred in moving forward? Fred, can you provide the kind of data to move forward? If not, what resources do you need to make this happen?
R: I could do it, although I'm not sure what kind of timeframe we need. It can be done though it may take awhile. We do not want to be here another 3 years but yes, it can be done. For example, those instream flow sites, if we choose some that are a bit easier, it might be more manageable. NC DWR will be employing new staff soon.

Q: Is it true that the Oasis model can only realistically model streams that are large enough to have gauge sites in proximity to the area that you're modeling? In talking about western sites, for example, how reliable is that model going to be without input from another source?
R: I'm not an Oasis expert, but my understanding is that it goes back to yellow node, there is a gauge associated with that node, that you're trying to gather flow statistics at the gauge. If you're off at that node in the relation to the gauge, you have to offset that discrepancy upstream – whether its flow manipulations or something else. I don't know if you can partition the flow to the tributaries.
C: Oasis is calibrated to USGS data and the idea is to use every scrap of USGS data available. If there is no USGS gauge at a site, then the modelers will go downstream to the next closest spot and prorate it for the most part by drainage area. Unless you have some other information, it will just be a straight drainage area ratio from a known node that is calibrated to real data to these smaller watersheds. WaterFALL tries to insert some more watershed specific information about using land cover and so on. So it might do a better job for those places that are smaller. Remember, those old study sites in the western part of the state, none of them are microscopically small because the study sites were put in because there was some sort of water withdrawal going on. Although some of them are still pretty small and there has never been a gauge on them, WaterFall data might be a better fit over straight drainage area ratio. Plus WaterFall data might conceivably be online and ready to use for these western sites.

From Nov 15, 2011 Meeting Summary: How Ecological Flows Would be Applied to NC River Basin Models

Steve Reed of the NC Division of Water Resources presented slides that are available on the website at : www.ncwater.org/sab

Much of this presentation comes from the session law, which requires river basin models that include ecological flows and pace times, and instances when ecological flows may be affected. Currently, NC doesn't have ecological flows included in our river basin models. If not included, models assume any and ALL water can be withdrawn to meet demands.

This instream flow model would be used as a screening tool for river basin models & plans. It would flag locations where offstream demands and instream ecological flow needs cannot be met under existing or projected conditions. It needs to be quantified at ALL nodes of interest throughout each basin. We may need to go back to discuss what the law says about prevailing conditions and how we will interpret that.

River basin models include:

- Unaltered Hydrology
- Flow Alterations – withdrawals, discharges, reservoirs
- Withdrawals include existing, 20- and 50-year projections
- Nodes – specific locations where records of flows are simulated

Nodes are places where the model is going to be making the calculation and where flow calculations will be determined, where an ecological flow may be adversely affected. Anywhere water is coming out or going back into the stream, we have a node (anywhere it is over 100,000 gallons). Each node has data for:

- Drainage Area

- Daily Flows for 80 years – unaltered, existing, 20-year, & 50-year projections
- But, not data for ecological flow

For example, when the model is run and the ecological flow is added in, it might raise a red flag at a particular node, which would tell you to go in and check it out in order to further evaluate what is going on.

Q: this makes sense to me if there is minimum flow, but how does it work when you have more of a natural range of variability, such as being sure there are high range events and low range events, all of which are natural.

Current number of nodes:
- Neuse = 84
- Cape Fear = 164
- Tar = 21
- Broad = 40
- Plus 13 more basins, eventually

Q: Is the model dynamic enough, for example in the Neuse, if a third of the nodes may be one type of classification and another 3rd, another type. Is the model going to be able to handle that?
R: Short answer is yes.
The Task:
- How will the ecological flow be quantified at each node?
- Is the approach for determining the ecological flow the same for all nodes?
- If not, how are we subdividing nodes?
- What are the stream classifications?
- How many different approaches or classifications are there?

C: We need to consider having minimum flows versus having correct ecological flows.

Q: Some things happening at some nodes are 30 years old, so they may actually represent a violation, so do we put all the onus on the new withdrawal or do we decide to look at prior users?
R: Basically, it's a flag that will go up, and then after gathering additional information, we make decisions at that point.

C: It has been helpful to hear this presentation because it gets us back to thinking about what we are supposed to be doing.

C: DWR suggested a 2 year mission and I think we need a midcourse identification to see if we are on the right path. Currently it has been an internal education process, which has been good, but now maybe we need to know what the division needs to move us forward.

C: Until something comes from the board, there is nothing to put into the models. So the sooner we can get something in, the sooner we may all be happy.

R: Whatever you come up with, we can put it into a model.

C: If a municipality or an industry is withdrawing water, that is difficult to change. But what we need to do is come up with a range of flows for those streams.

Q: Can we put in a presumptive standard, go for it, and check back with us in 2 years?
R: The legislation seems to say that would be OK to put in a stopgap measure.

C: I don't want to move to far without having the DENR input.

C: Looking at Mary Davis' handout, those are multiyear projects, and I don't see the board doing all that. Do we need to have something in place now? Or do we have the flexibility to look at multi-year approaches that other states are using. I don't know what the pressure is on DWR.

C: The Nature Conservancy is working with RTI and starting a one year project to do a study like the Potomac project for 3 watersheds in NC in this coming calendar year, basically the ELOHA approach. NC is doing the Michigan approach basically. So we will have a lot more data soon, almost within the 2 year schedule for this group. There's nothing that says our schedule can't be extended.

Q: It seems the idea of putting in a presumptive standard got raised eyebrows from the DWR staff. What would DWR do with a presumptive standard if we decided on one now? Would it help us to move forward? What does DWR think about it?

C: What I am hearing is there is a lot of work for the SAB, with not a lot of funding, so we need to balance expectations with what we are likely able to achieve. Can you get back to us at the next meeting about what DWR needs?

DWR: DWR can report back on this in January.

C: EMC has to approve all models

C: We can get it nailed down, it is thorny, but we can do it. We need some firm objectives.

C: 3 things may occur that the model is supposed to produce:

1. To identify the yield inadequate to meet all needs
2. To identify the yield inadequate to meet all essential water uses
3. To identify the yield when ecological flow may be adversely affected.

Q: I think I understand 1 and 3, but I want to know what the essential uses are. How is that being defined? Can we run this scenario through one or more of these basin models to see when these things occur so we can better understand all of this.

C: I was there when those 3 identifiers above were written. The goal was to find all needs, pollution dilution, and ecological integrity. Pollution dilution was converted to 'essential needs" to meet legal requirements. It is important to remember – the legislature doesn't work with models, and they don't have a requirement that it be one model, it could be a number of models working in tandem. It may be easier to solve this problem that looks at output from OASIS instead of input. We can be totally flexible. I don't think we have to test ecological integrity at every node in every model. Maybe we can look at the lowpoint node along a stream. We don't need to make this more complicated than it has to be. We should strive to make this more straightforward instead of more complex.

C: Whatever algorithm we come up with, it will apply to all the nodes.

R: I'm not talking about how it applies, what I'm saying is that you may not have to run the model at every node. Maybe we can just run the model where you have change in classification. I think

you want to do it at each of these nodes, to determine which node or which withdrawal it stems from or is it the culmination of all the withdrawals.

C: But you then transfer the responsibility to someone down the line to make a decision

C: It sounds like there is already a presumptive standard, which is 7Q10 – is that true?

R: Well, that is the water quality standard.

C: We need to get some presumptive standard into the model and then move up from there.

C: I'm trying to understand what the House bill expects each basin wide model to determine and what output is required. Those 3 categories above (essential water uses, etc) seem to overlap.

C: All uses is all encompassing. When that was decided there were champions for each number or category, but rather than try to find something that satisfied all 3 interests, it was decided to come up with those 3 overlapping categories.

C: We have the Cape Fear and the Neuse model. The Tar and the Broad are close to being done. They are ready to run, but they haven't been run yet.

C: Can we stick in a place holder, for example, 15%, to help us understand the output of the model.

R: Currently we don't have those 3 categories in the models -we don't have any flow put in there (eco flows), we are waiting on you, the EFSAB to tell us something. It does not have 7Q10. If you tell us to test it with a protective standard we will. Essential uses is the first thing defined, we don't have it yet, neither have we taken it to EMC.

C: We've already experienced people using water during drought where we've gone below the 7Q10.

C: It would be easy to plug 7Q10 or 10% of inflow as a presumptive standard, into OASIS and test a new node by taking some water out. That seems pretty straight forward. That will get us some temporary info, but at some point we need to be much better than that. That's the reason we are here, isn't it?

C: Ecological integrity is somewhere in between the 3 categories, and 7Q 10 is probably the lowest.

VIII. 2012 Agenda Discussion

Mary Lou Addor, facilitator, presented a process overview. She noted that sometimes the data-gathering stage of a process can seem long and drawn out. In a large process like this one, there is a lot of shared understanding to be developed; it is not unusual for the first two years to focus on defining the problems and issues, in educating one other about the perspectives each individual brings and then determining how to use the knowledge that has been brought forth. The facilitation team recognizes this can be frustrating. People start asking, "When will we get there?", though the group is still defining what "there" is. There is a lot of divergent and convergent thought at one time, which adds to the level of frustration given the different perspectives among Board members and highly complex subject matter. At some point, you will grapple with tradeoffs given the level of uncertainty in this process.

Looking forward to February, the facilitation team is going back through all the meeting summaries and pulling together an overview of what was discussed, what decisions were made, what questions does the group still have, and what substantive concerns remain. That will take some time, but our goal is to provide a package that presents an overview and timeline of the progress the EFSAB has made, and identify the gaps that remain. This product will allow the EFSAB to search the information more readily to achieve both objectives.

Fred proposed, not only options for moving forward but also provided an initial draft of a screening/planning tool (a conceptual framework for how some of the pieces might fit together). Hopefully, it is evident to the EFSAB that recommendations have been provided all along, that you are working toward decision points where the EFSAB can start weighing in and providing recommendations as you have been tasked to do.

Referring back to Tom Reeder's visit with the EFSAB, he said the EFSAB needed to come up with something scientifically defensible. Whatever the EFSAB proposes: recommendations, criteria for making those recommendations, the EFSAB will need to be clear about what is being proposed and why.

Given the constraints on Fred's time, we need your help determining what the next steps in our process might be. We have three more meetings in 2012: Sept 25, October 23 and November 27. The facilitation team, in consult with DWR, is thinking that its best use of everyone's time to cancel the September meeting with the idea of having a longer meeting in October. (The EFSAB supported cancelling the September meeting).

For the October 23 meeting (Stan Adams Educational Center), several agenda items for consideration:

- Guest Speaker, Thomas Payne, to present about the pros and cons of habitat modeling, the topic of transferability, and use of guilds from his expertise (will be a guest of Duke University later in the afternoon).
- Presentation and discussion about the results of the BioFidelity study from RTI and where to go from here.

For the November 27 Meeting (located in Raleigh at Archdale), several agenda items for consideration:

- Potential for discussion of how OASIS and WaterFALL interact as models and whether WaterFALL can serve as a pre-loader for OASIS (include RTI, Fransen, Hydrologics). Include Fransen validation tool (smaller watersheds/ WaterFall; larger watershed Oasis).Can WaterFall improve Oasis, a Mass Ballistic Model?
- Status update of RTI internal RnD project
- Implications of state and federal policies on e-flows, threatened and endangered species and coastal issues, and locations (Mark, Judy, and Dan).
- Several suggestions about the need for maps: review maps for tide, wetlands, and endangered species, whatever it might be.
- An overview of coastal studies was also requested. What other guidelines for the coast are needed? What ecological concerns are present for the EFSAB coastal work?

For a February Meeting

- Originally, there was a plan for additional habitat modeling runs in November. Those will not be ready in Nov but may available by February (once additional manpower is available at DWR and assuming the EFSAB is interested in these additional inflow studies).
- Final results of TNC Study. What's different between (Kimberly agreed to present Feb, 2013).
- Refining a screening/planning tool (conceptual framework)

Q: Can you just give us your gut feeling, along with what you have discussed with DWR, on where we are and what you expect in the months to come.
R: When Steve Reed, Fred Tarver, and the facilitation team met for our planning meeting in July, we believed the EFSAB would converge on some kind of conceptual framework in late 2013. We now have to pull back a bit for obvious reasons, regroup, and deliberate how to do that. When Tom Reeder met with you all, he said the project did not have a deadline. However, we are hoping to achieve some results in 2013. And perhaps, as someone mentioned earlier, there would be opportunities to reconvene the EFSAB several years out. Remember, right now we are talking about a screening/planning tool that will assist DWR in determining ecological flows. What do others think at this point?
C: As I go through this process and continue to learn (and it has been a wonderful education, no question), I think further out about the level of education I still need. Scientifically defensible is a very high level of confidence and many of the decisions that we have deliberated so far about looking at this or looking at that, are not scientifically defensible decisions. They have been experimental decisions. Eventually, in order to reach a level of scientific defensibility, some of these things are going to have to be tested and that will take decision-making and time. I think it would be much easier for the group to come up with some "consensus principles", come up with why we did something as opposed to trying to defend it. That might be part of our uncertainty discussions. But it seems to me that consensus principles are different from scientifically defensible. I think we can come up with consensus principles here, that what we do and offer can be explainable, but we may not be able to defend them.
C: Two comments: 1) If our initial goal here is to come up with a screening tool for planning, then the level of scientific defensibility may not be at the same degree as it would need to be if the recommendations would support permitting decisions and affect people's wallets. 2) It may be that after the October meeting we will have a much better picture of the time line going forward because of the bio-fidelity testing--there is a lot riding on that. With the RTI internal research and development project, whether we hear about that in October or November, if that ends up providing a useful tool, that could accelerate our timetable. It may be that we will have a much clearer view of what lies ahead.
C: I reviewed the session law; it doesn't say anything about "scientifically defensible", those words are not there but it does say we are advising DWR. It's up to DWR to take whatever of that information that they choose to take and use that to their benefit.
C: In terms of data integrity; it does say that for basin wide models that those basin models be based solely on data that is of public record and open to the public. Therefore, in terms of data integrity, it just says it needs to be open to the public. It's all defensible; it's a matter of explicitly defining the uncertainties and the assumptions involved, making those clear and transparent and linking them to the literature. Being explicit depends on the literature; the literature reflects the science; there has to be a link there somewhere.
R: Great discussion and points raised by Chris, Jay, and others, particularly about the possibility of reaching consensus in principle and what can be achieved with and explained by scientific integrity.

You all are providing a very needed service and it is greatly appreciated. Thanks to all of you, a highly complex process has been made that much easier. We have a plan for moving forward through 2012 and into early 2013. Part of the path forward depends on what we hear about the Bio-Fidelity study in October. We hope this discussion has been helpful, and if there are any questions or concerns that you all have, please let us know so we can work through them.

IX. Next Meeting: Agenda Topics & Meeting Location/Directions

Remaining Meetings in 2012:
The remaining 2012 meeting dates and meeting locations are posted online at: www.ncwater.org/SAB. We have one more meeting in 2012:

November 27, 2012 - Archdale Building, Raleigh, NC

Next EFSAB Meeting and Agenda Topics:
The next meeting of the EFSAB is scheduled for October 23, 2012 at the Stan Adams Educational Center from 9:30 until 4:15pm.

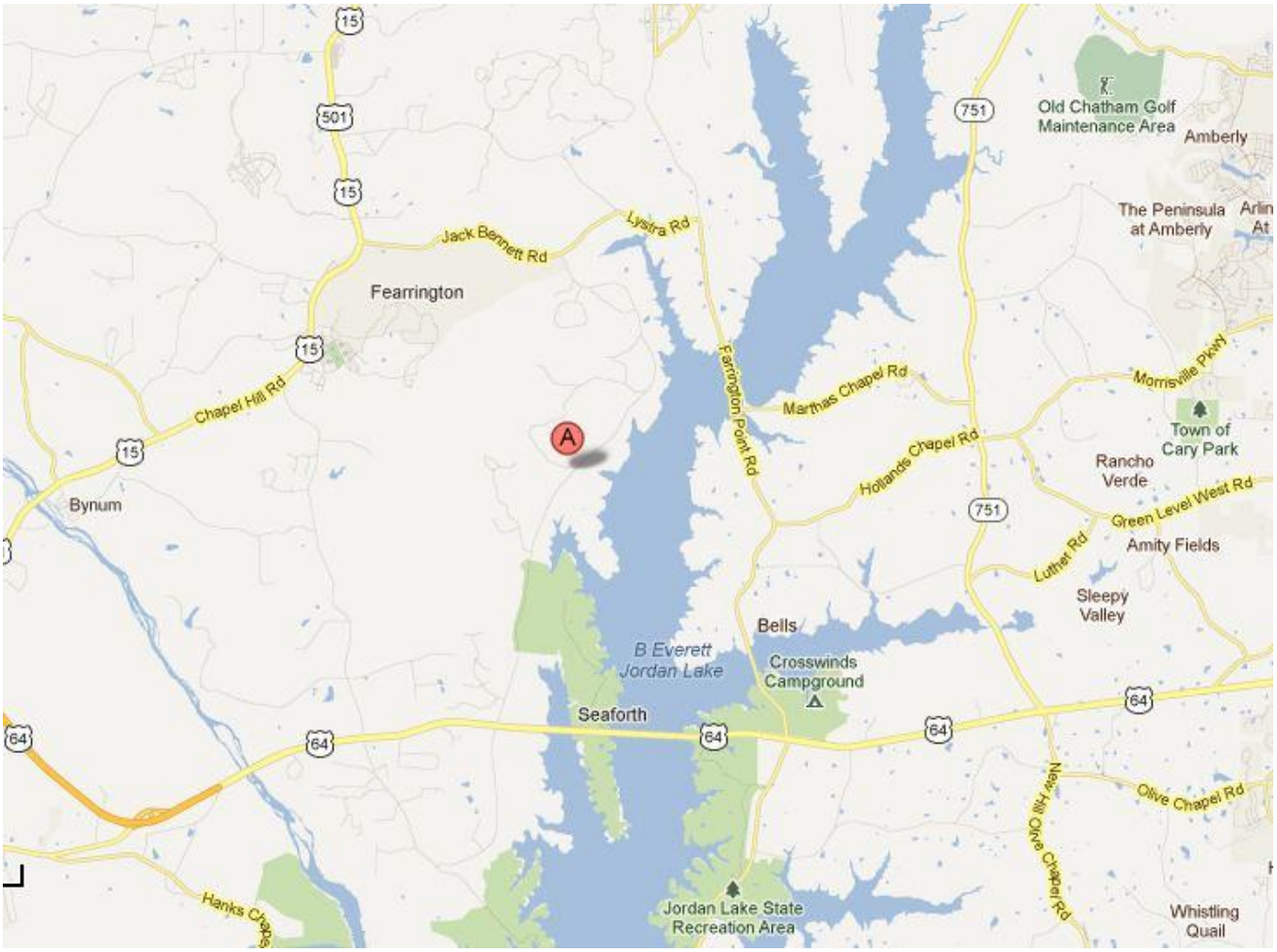
The discussion items for the agenda include:

- Biofidelity Analysis of Stream Classes in NC: Presentation and Update
- Thomas Payne. DWR will request him to review EFSAB plan of action and habitat modeling results so far.
- DWR Concept Paper For Next Steps
- Coastal Studies Presentation

Please remember to bring lunch and refreshments with you. Coffee will be available on site and soft drinks ($1).

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
Map link: http://go.ncsu.edu/stanadams
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.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Jack Bennett Rd
Lystra Rd
Fearrington
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Chapel Hill Rd
15
Bynum
A
Farrington Point Rd
Marthas Chapel Rd
Hollands Chapel Rd
751
Old Chatham Golf Maintenance Area
Amberly
The Peninsula at Amberly
Morrisville Pkwy
Town of Cary Park
Rancho Verde
Green Level West Rd
Amity Fields
Luther Rd
Sleepy Valley
Bells
B Everett Jordan Lake
Crosswinds Campground
Seaforth
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New Hill Olive Chapel Rd
Olive Chapel Rd
Hanks Chapel
Jordan Lake State Recreation Area
Whistling Quail