Ecological Flows Science Advisory Board (EFSAB)
Meeting Summary
January 18, 2011

NC Cooperative Extension – Wake County Center
Raleigh NC

__X__ APPROVED (For Distribution)

Attendance

Ecological Flows Science Advisory Board

Members

Donnie Brewer, EMC
John Crutchfield, Progress Energy
Tom Cuffney, U.S. Geological Survey
Linda Diebolt, Local Governments
Chris Goudreau, NC Wildlife Resources Commission
Jeff Hinshaw, NC Cooperative Extension
Jim Mead, NC Division of Water Resources
Sam Pearsall, Environmental Defense
Judy Ratcliffe, NC Natural Heritage Program
Jaime Robinson, NCAWWA-WEA
Jay Sauber, NC Division of Water Quality
Bill Swartley, NC Forestry Association

Alternates

Cat Burns, The Nature Conservancy
Peter Caldwell, USDA Forest Service
Scott Chapell, Division of Marine Fisheries
Vernon Cox, NCDA&CS
Sarah McRae, U.S. Fish and Wildlife Service (served in member role for Mark Cantrell)
Steven Reed, Division of Water Resources
Arlene Roman, Local Government (on phone)
Vann Stancil, Wildlife Resources Commission

Division of Water Resources Staff

Tom Fransen
Jucilene Hoffmann
Toya Ogalla,
Linwood Peele
Don Rayno
Sarah Young,

Facilitation Team

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

Guests:

Mary Davis, TNC/SARP
Jeri Gray, Water Resources Research Institute (WRRI)
Dan McLawhorn, City of Raleigh Attorney's Office
Betsy Pearce, Wake County
Haywood Phthisic, LNBA/NRCA
Sandra Wilbur
Henry Wicker, USACE

on phone:

Michelle Catrofello
Lisa Gordon
Lars Hanson
Kim Matthews
Steve McCutcheon
Forest Westall
Nancy White

The purpose of the Ecological Flows Science Advisory Board:

The Ecological Flows Science Advisory Board will advise DENR on approaches to characterize the aquatic ecology of different river basins and identify the flows necessary to maintain ecological integrity. The group will focus on methods of determining flows necessary to maintain ecological integrity.

Presentations, reports, and background information about the E-Flows SAB are available at:
www.ncwater.org/sab

Executive Summary: January 18, 2011: Decisions Made/Actions to be Taken

I. Future summary draft reports will be distributed as Word documents by e-mail for review. EFSAB Members and Alternates will review, track suggested changes, add comments and submit to the facilitator responsible for that report. Revised drafts will be distributed by e-mail for review prior to the next meeting.

II. Jim Mead clarified that the EFSAB will develop a recommended approach to characterizing the ecology of river basins and a recommended method to determine the flows necessary to maintain ecological health, in an advisory capacity, to NCDENR.

III. Handouts of power presentations will not be distributed at the meetings. All power point presentations will be available at: www.ncwater.org/sab

IV. The EFSAB needs to be able to share documents.

V. The EFSAB will meet at 12:30pm on the third Tuesday of the following months in 2011:

- March 15
- May 17
- June 21
- July 19
- August 16
- September 20
- October 18
- November 15

VI. In the Charter, the purpose shall read, "The EFSAB will advise DENR on approaches to characterize the aquatic ecology of different river basins and identify the flows necessary to maintain ecological integrity. The EFSAB will focus on methods of determining flows necessary to maintain ecological integrity."

VII. In the charter, under ***Decision Process***, Level 5 will read "Block (I cannot/will not support the recommendation or decision)"

January 18, 2011 Meeting Agenda

I. Executive Summary
II. Welcome
III. Agenda Review and Introductions
IV. Review of November 8, 2010 Meeting Summary
V. Future Meetings
VI. File Sharing
VII. E-Flows SAB Charter Review
VIII. Overview of Hydrologic Modeling, Presentation of Oasis Model and Discussion of other Models
IX. Presentation of Hydrologic Classification System Software for NC, formally known as *StreamFlow NC*
X. Recap and draft agenda for March 15, 2011 meeting

January 18, 2011 Meeting Handouts

1. EFSAB Charter (Draft)
2. Definitions of "instream flow", "ecological flow" and "ecological integrity"

I.Executive Summary (executive Summary added by facilitators)

Presentation on Hydrologic Modeling: An Overview and Specifics about OASIS model.

Tom Fransen gave an overview of hydrologic modeling in North Carolina. The same statute that established the EFSAB (SL 2010-143) also mandated that DENR develop a basin wide hydrologic model for each of the 17 major river basins in NC. The legislation requires that the models include specific design components.

The models in the various river basins are in different states of development, with the Neuse model complete. The hydrologic models allow planners to vary uses, assuming that inflows stay constant, and predict availability for expected uses. DWR has selected OASIS as their preferred modeling program for simulating water supply systems in part because of its flexibility in simulating reservoir operations, although other models may be used in some basins.

There are several issues that arise in determining Inflow and critical assumptions of the OASIS model. The question then is How good is good enough? The goal is to get a reasonable representation of history. The data used does not have to match exactly. What is good enough will depend on the questions the model is used to answer.

Questions, Comments, and Concerns Raised
Several questions were raised and discussed about the operations of OASIS.

Proposed Actions or Identified Decisions to be made:
None

Presentation on Stream Classifications in NC

Sam Pearsall, Chris Goudreau, and Jim Mead presented on classifying NC rivers and streams describing how stream classification can assist in characterizing ecological flows.

Sam Pearsall gave an overview of why stream classification can be important to determining ecological flows given links between hydrology and ecology. The development of a class-based flow/response relationship might be possible if one could: (1) identify streams with similar hydrologic characteristics, which, according to ecological theory, explain major aspects of their organization and structure; and (2) identify unique hydro-ecological indices (indices that make the class different from the other classes) that best describe the hydrologic signature of the stream class and stream reaches by addressing the five major components of flow (magnitude, frequency, duration, timing, and rate of change,). This flow/response relationship could possibly characterize ecological flow.

Jim Mead then discussed how data were selected for the classification process. With input from DWR and USGS, the consultant (Environmental Flow Specialists) used data from 185 USGS gaging stations in North Carolina with at least 18 years of record. Two products developed from this work: (1) A software package to take any source of daily stream flow data and classify streams (NC StreamFlow), and (2) seven hydrologic classes of streams.

Chris Goudreau then provided an overview of the seven classes.

Questions, Comments, and Concerns Raised
A concern was raised about the data was manipulated and normalized.

Proposed Actions or Identified Decisions to be made:
Continue the discussion of the EFS Classification System at the next meeting.

II. Welcome

Jim Mead, Environmental Supervisor with the N.C. Division of Water Resources (NCDWR), welcomed everyone to the second meeting of the Ecological Flows Science Advisory Board (EFSAB). He reviewed the 3 primary objectives of the EFSAB:

1. **To recommend the best approach to grouping or classifying streams for determining ecological flows.** The possible approaches range from assuming that one size fits all to assuming that every stream is unique, with a site study everywhere. NCDWR expects that the answer lies somewhere in the middle.
2. **To review other states' approaches to determining ecological flows.** The EFSAB will review literature on others' approaches. Subject to any copyright restrictions, recommended literature will be posted on the EFSAB website at: www.ncwater.org/sab
3. **To advise the Department of Environment and Natural Resources (DENR) on developing an approach for identifying the flow necessary to maintain ecological integrity.** The EFSAB will be developing an approach in an advisory capacity. The DWR would like a partnership approach with the EFSAB to determine options, evaluate options, and package them. The DWR would like to complete the Eno River Demonstration Project after consideration by the EFSAB and determine if NCDWR should expand beyond Eno or whether they should come up with other approaches.

III. Agenda Review and introductions

Mary Lou Addor, facilitator, introduced herself and invited everyone to introduce themselves. She then reviewed the agenda.

IV. November 8, 2010 Meeting Summary Review

Nancy Sharpless, facilitator, presented the revised summary of the November 8, 2010 meeting of the EFSAB. Nancy indicated that, at the request of several EFSAB members and alternates, future draft summaries will be distributed in Word format to submit revisions using track changes until the summary is approved. Any substantive revisions and edits will be complied into a second draft of the meeting summary and distributed again, via e-mail for review prior to the next meeting.

The EFSAB's review of the first meeting's summary raised several questions regarding definitions of terms. In the revision of the summary, Jim Mead had elaborated on the definition of "instream flows" and "ecological flows", clarifying the distinction between the two. This elaboration satisfied earlier questions about the two terms. A definitions sheet, including the definition of those terms and of "ecological integrity" was made available at this meeting and will be available at all future meetings.

The EFSAB's review of the meeting summary illuminated confusion over the EFSAB's role. Two major questions arose:

1. Is the EFSAB's role to develop an approach to characterizing the ecology of river basins and a method to determine the flows necessary to maintain ecological health OR is the EFSAB to advise the NC Division of Water Resources on the development of these? Jim Mead clarified that the EFSAB will develop recommendations, in an advisory capacity, to DENR. He sees the DENR and EFSAB relationship as a partnership to evaluate options.
2. Where does the EFSAB fit into the structure of groups that will make recommendations to policy makers and groups that will determine policy regarding ecological flows? Jim Mead clarified that he anticipates the formation of another advisory group that will focus on the societal issues of flow management in order to develop policy to balance resource protection with flow-altering water uses, and human demands with ecosystem needs. The EFSAB will maintain its focus on the science and technical aspects of ecological flows. Policy makers will consider the output of both advisory bodies in developing policy.

The facilitators, in consultation with Jim Mead and Tom Reeder, clarified the language in the two sections of the November 8, 2010 EFSAB meeting summary. The November 8, 2010 meeting summary was approved and distributed Feb 8, 2011.

V. Future Meetings

Mary Lou Addor reviewed the revised schedule of meetings of the EFSAB in 2011, and the schedule was approved. The EFSAB will meet at 12:30pm on the third Tuesday of the following months in 2011:

Unless otherwise noted, all meetings begin at 12:30 PM and end at 4:30 PM.

March 15- Archdale Building Ground Floor Hearing room 512 North Salisbury Street, Raleigh

May 17- location TBA

June 21 - Archdale Building Ground Floor Hearing room

July 19 – Wake County Agriculture Services Building 4001-E Carya Drive, Raleigh

August 16 - Archdale Building Ground Floor Hearing room

September 20 – Archdale Building Ground Floor Hearing room

October 18 - Archdale Building Ground Floor Hearing room

November 15 - Wake County Agriculture Services Building

These dates include 3 meetings (June, August, and October) that have been added since the inception of the EFSAB.

At meetings, members and alternates will speak first, then if time allows, guests may comment and ask questions.

The EFSAB decided that hard copy handouts will generally not be provided at the meetings unless particularly warranted. Power Point presentations and other materials will be made available on the EFSAB website at: http://www.ncwater.org/sab

VI. File Sharing

The facilitator invited discussion on the best mechanism for the EFSAB to share documents. Sharepoint, Google Sites and FTP were suggested. The following points were made:

- The federal government blocks peer to peer file sharing.
- Something with limited access, not public, allows you to post copyrighted documents.
- FTP site meets those needs.
- MS Sharepoint is still likely considered public.
- The federal government allows use of FTP sites.

Patrick will investigate options for file sharing, including DENR's FTP site

VII. EFSAB Charter

The facilitator presented a revised draft of the EFSAB Charter. Points of discussion included:

1. Refer to Department of Environment and Natural Resources (DENR), rather than "the Department"
2. Under ***Purpose of the Board***, language needs to accurately reflect the language of the session law that created the EFSAB, which states, "The Department shall characterize the ecology in the different river basins and identify the flow necessary to maintain ecological integrity. The Department shall create a Science Advisory Board to assist the Department in characterizing the natural ecology and identifying the flow requirements." The EFSAB would also like to have a statement included that "the EFSAB will be focusing on the methods to determine the flows needed to maintain ecological integrity."
3. DENR is required to provide status reports, although DWR may have been given that responsibility.
4. Someone questioned the need for the section regarding representation under ***Responsibilities of Advisory Board Members.*** Comments made included:
    a. Isn't it our responsibility to just give our expertise?
    b. My constituent group and I do not believe that I represent them or their opinion, but rather the science. Also, I am to make sure that if they have scientific input, I contribute it.
    c. I see my role to see that my group's buy-in is considered (credibility).
5. Under ***Decision Process***, some questions were raised regarding the 5-fingers scale or gradient of agreement. The facilitators explained that the scale of agreement is used both as a straw vote to determine the level of agreement at a particular point or for members to weigh-in on final decisions or recommendations. If a member or alternate weighs in with 4 or 5 fingers, this indicates that more discussion is required to strive toward or achieve a more mutually satisfactory decision or recommendation. Some members expressed concerns with the description of Level 5, specifically the language of "acting outside the group to meet one's interest". The EFSAB employed the five finger scale of agreement to accept a new description for level 5, which will read: "Block (I cannot/will not support the recommendation or decision)." The language, "will act outside the group to meet my interests" was removed from the Charter.
6. Under the section <u>If Recommendations Cannot be Reached by Consensus</u>, which is under ***Decision Process***, a member suggested that the 5 levels of agreement be used in meeting summaries, rather

than qualitative terms to describe level of agreement. The meeting summaries will record the level of agreement reflected by using the 5 finger scale and qualitative terms with phrases like "substantial disagreement" or "minor disagreement".

7. Under ***Operating Principles for Interaction***, it was suggested that Kaner's Core Values of Facilitation (Full Participation, Mutual Understanding, Inclusive Solutions, and Shared Responsibility) be added to the list of operating principles and that the reference be removed.
8. The title, ***Changes to the Group Operating Principles",*** should read ***"Changes to the Charter"***.
9. Check for consistent capitalization of SAB, Advisory Board, etc.
10. Remove the language "House Bill 1743", as that refers to how the bill was tracked during the legislative session. Instead, use the session law designation of SL 2010-143.

VIII. Presentation on Hydrologic Modeling: An Overview, the OASIS Model, and Discussion of Other Models

The Power Point for the presentation is posted at:
http://www.ncwater.org/Data_and_Modeling/eflows/sab/presentations/20110118/01_River-Basin-Hydrologic-Modeling-Tom-Fransen.pdf

Tom Fransen gave an overview of hydrologic modeling in North Carolina. The same statute that established the EFSAB (SL 2010-143, which can be found at http://www.ncleg.net/Sessions/2009/Bills/House/PDF/H1743v6.pdf) also mandated that DENR develop a basin wide hydrologic model for each of the 17 major river basins in NC. The legislation requires that the models be designed to:

a. Include surface water resources within the river basin, groundwater resources within the river basin to the extent known by the Department, transfers into and out of the river basin that are required to be registered under G.S. 143-215.22H, other withdrawals, ecological flow, instream flow requirements, projections of future withdrawals, an estimate of return flows within the river basin, inflow data, local water supply plans, and other scientific and technical information the Department [DENR] deems relevant.

b. Be designed to simulate the flows of each surface water resource within the basin that is identified as a source of water for a withdrawal registered under G.S. 143-215.22H in response to different variables, conditions, and scenarios. The model shall specifically be designed to predict the places, times, frequencies, and intervals at which any of the following may occur:
   1. Yield may be inadequate to meet all needs.
   2. Yield may be inadequate to meet all essential water uses.
   3. Ecological flow may be adversely affected.

c. Be based solely on data that is of public record and open to public review and comment.

The models in the various river basins are in different states of development, with the Neuse model complete. The hydrologic models allow planners to vary uses, assuming that inflows stay constant, and predict availability for expected uses. DWR has selected OASIS as their preferred modeling program for simulating water supply systems in part because of its flexibility in simulating reservoir operations, although other models may be used in some basins because good models are already in use in those basins. The models are not water quality models, although the outputs can be used to define boundary conditions

to a water quality model. The OASIS model cannot be used for flood studies, and the model does not simulate ground water directly. The model inflow records are based on USGS streamflow gages. The gage data already includes the surface ground water interaction. The questions the models need to answer are: 1) "Is there enough water to sustain expected uses now and in the future (DWR does consider ecologic flows to be part of "expected uses")?" and 2) "Where, when and for how long could we expect to experience shortages?" The complexity lies in developing the data and equations to describe inflow, outflow, and storage of the hydrologic system.

The inflow dataset for OASIS is based on "unimpaired" USGS stream flow gage data, in an attempt to establish a flow scenario as close as possible to the natural flow. "Impairments" are modifications of the natural stream flow caused by reservoir storage changes (including surface evaporation and precipitation) and consumptive withdrawals (including withdrawals and discharges from municipal, industrial, and/or agricultural uses).

Unimpaired flow = Measured Gage Flow + Upstream Withdrawals (municipal, industrial, agricultural) – Upstream Discharges (municipal, industrial) + Upstream Reservoir Storage (+ Increase / - Decrease) + Upstream Reservoir Surface Evaporation – Upstream Reservoir Surface Precipitation

Because the number of gaging sites is limited and not always at exactly the desired location, the USGS program *fillin* is used to extend short records and fill in missing flows. *Fillin* uses monthly streamflow records. The monthly data are disaggregated into daily values using the actual daily flows from a nearby gage; these unimpaired extended stream flow records are used (making upstream and drainage area adjustments) to create the local inflows for the nodes.

The issues that arise in determining Inflow are then:

- Lack of good long-term historical data to create the unimpaired flow record
- Lack of adequate long-term stream flow gages
- No adjustments for changes in land use
- No adjustments for changes in the surface water/ground water interactions.
- *Hydrologic Stationarity*--A key assumption in the OASIS model is that the future will be statistically indistinguishable from the past. Given current understanding of climate change and possible non-stationarity in water and ecosystem management, is this assumption valid?

Critical assumptions of the OASIS model include:

- Ground water/surface water relationships are reflected in stream flows
- Withdrawals will come from current intake locations
- Sellers will continue to meet buyers' needs
- Wastewater returns will continue at the same percent of withdrawals and same locations
- Agricultural withdrawals will not change significantly
- Stream flows will be within historical ranges
- Focus on normal and low-flow conditions
- Local water utilities are the best judges of distribution system growth
- Not a water quality model
- Not a ground water model

The question then is How good is good enough? The goal is to get a reasonable representation of history. The data used does not have to match exactly. What is good enough will depend on the questions the model is used to answer.

Request for clarification: Someone asked "What do you mean that sellers will continue to meet buyers' needs?

Response: Our projections include buying and selling of water. Unless we are told otherwise, we assume the seller will continue to meet the buyers' future needs.

To quantify water use, a map of water use is converted to a system of nodes and arcs, where nodes are locations of interest (reservoirs, demands, junctions) and arcs represent flow between nodes (stream reaches, canals, pipelines, groundwater seepage, etc.). Water use varies over the year, and OASIS allows variation by day, month or season, although for projection, monthly may be the best it can do.

How Well Does the Model Replicate Actual Conditions?
The question then becomes, "How well does the model replicate actual conditions and what conditions does the model not replicate well?" To test this, DWR ran simulations comparing historic data with computed data for specific years to validate a model.

Water Resources Policy Act of 2009
The DWR in 2009 used the Cape Fear River Basin Model as an example of one approach to implement the *Water Resources Policy Act of 2009* (note: this bill did not pass). A particular challenge identified in this example was what to use as baseline by which to determine if a basin is over allocated. DWR staff used their best professional judgment to develop a first cut at a simplified approach for the integrity criteria. They then ran four simulations using the Cape Fear River Basin model and concluded that the integrity criteria need further refinement.

The lessons learned from the simulations include:

- The basin model in combination with a decision support system could be a workable approach for basin wide allocation analysis.
- The current basin modeling approach will require adjustments after the integrity criteria are finalized.

Alternative Water Quality Approach
DWR's models do not model water quality. As a surrogate to modeling water quality, DWR considered the use of a stream flow statistic, such as 7Q10 (the driest seven-day period that has a probability of occurring every 10 years), as is currently used for water quality in National Pollutant Discharge Elimination System permitting. The 7Q10 is not constant, however, and DWR believes that 7Q10 should not be used because:

- The only time you should compare actual and model data is during the validation process.
- The inflows are calibrated at the monthly level. The users need to be careful using indicators with a time-frame step shorter than a month.
- This approach highlighted that (a) we will need to have a local inflow at all nodes, not just the key calibration points, and (b) the user needs to be careful about how the indicator is calculated (water quality is interested in what is flowing out of a node, whereas ecological flows are probably more interested in what is coming into a node).

Issues and Concerns for Modeling and Ecological Flows
Historically, the models have focused on water supply (municipal and industrial) reliability. Consequently, they have focused on larger streams and rivers that support the potential for withdrawals and discharges of 100,000 gallons per day or greater. Furthermore, calibration and validation has concentrated on normal and low flow periods, when the water supplies are stressed.

Modeling Issues that Need to be Reviewed for Modeling and Ecological Flows
We need to be sure the model scale works for the issue being evaluated. We need to review the validation process if the ecological flow requirements include one or more high flow statistic.

Question: Johnson County uses reclaimed water as a way of meeting nitrogen demands for the Neuse River rules. Is this factored in?
Response: If Johnson County can tell us as much as they can about amounts of reclaimed water, we can factor that in. It's not unlike adding in drought plans now that we have them.
Jim Mead offered clarification: There is an assumption on the percent consumptive. That will not change unless we have more information such as an increase in reclaimed water.

Comment: OASIS works well as a driver for any model that relies on flows. It delivers a time-series of flows that can be used for other models. If you can get storage and flow, it is amazing what else you can get with those two variables.

Question: Modeling usually represents the middle of the curve well, but not the high and low ends. You said that OASIS seems to work well in the low end?
Response: Since the inflows are based on the USGS streamflow gages, we feel pretty comfortable with the low flow calibration. This is different than rainfall-runoff models that you need to make assumptions about base flows.

Question: You commented that OASIS is not good for determining habitat needs for the Carolina heelsplitter [a mussel] in Goose Creek. Why?
Response: Goose Creek is too small. We do not include small creeks that did not have a withdrawal or discharge of 100,000 gpd or greater. *Added clarification:* It's not that OASIS cannot do it; it is just the way DWR set up the model.

Question: Modeling is sensitive to unimpaired flows. How do you do it?
Response: Tom went back to the equation for unimpaired flow (slide 12 in the Power Point and included in the discussion of Tom's presentation in this summary) and went on to say that DWR gathers all the data they can. DWR asks towns for data and gets good discharge information from DWQ. As an example, mills go out of business, changing the usage locally.

Question: Does OASIS look at bank storage?
Response: This is really about the surface water/ground water interaction. We assume this is being picked up in the gage record.

Question: How significant do you think unaccounted-for agricultural withdrawals are to your estimations?
Response: We may be over counting irrigation, being conservative, and therefore predicting our low flows are lower than they actually are.

Question: How close to real time do you run the model to add flow data?
Response: We would like to get in sync with the DWQ plans and do basin wide every five years. With current limited staff, we are doing every ten years for a full detailed update. During drought conditions we do weekly simplified monthly or weekly update.

Question: If OASIS is the model you have settled on, what other models have you looked at?
Response: We have looked at CHEOPS, but that model was designed for, and does a great job of, describing dispatch of hydropower. It is not so good for adding withdrawals, and it has a different level of detail. We have tried other models including writing our own from scratch. We have OASIS set up so that anyone can use it on DWR's server. This way anyone can use it without buying their own license and DWR can offer better support.

Question: From a biological standpoint, we may want to be looking at small streams. How is all this modeling going to help us if we don't look at those small sizes? At some point we need to know about these streams and this smaller scale. Is there a limit on minimum stream size with OASIS?
Question: What types of streams will be in our population?
Response: Good question. We do a better job of summarizing the streams in the model. The size stream is limited by available data and what makes practical sense for modeling done at a basin scale.

Question: Our biological assessment typically occurs in small streams, and that may be diametrically opposed to what we are trying to model with the hydrology. On small streams, how likely is it that man-made changes (withdrawals) will occur? Agricultural uses, yes, but we are not looking, for example, at land use changes?
Response: Our intent is to identify ecological flows that change from usage like withdrawals and discharges, not land use that may impact runoff, etc. At least that is my interpretation. If we don't have a node on a small stream, but at some point we feel we need to, we can prorate or estimate it from the nearest downstream node.

Question: There is a node anywhere anyone does something with water (from a permitted or known-about point of view), right? If it's necessary to show an action, we add a node, right?
Response: Yes.

Question: Going back to small stream agricultural withdrawals, what about land use and these small streams?
Comment: We do capture some of the unreported agricultural withdrawals, so some those are factored into the scenarios. An assumption for irrigation is that if there is not enough precipitation for agricultural use, it will come from irrigation. The Agricultural Survey reports withdrawals greater than or equal to 10,000 gallons per day. This is three years old; more data in the future will help.
Comment: Larry Band has a model for yield based on land use that works better at smaller scales than larger scales. We may need to look at that.

Question: Where does the ecological flow measurement fit into this modeling?
Response: The current modeling approach is model how the system is currently being operated. If an ecological flow is part of a permit it is included in the model. For ecological flows not in a permit or part of an operation plan it is analyzed as a post processor function.

IX. Presentation on Classifying NC Rivers and Streams

Sam Pearsall, Chris Goudreau, and Jim Mead presented on classifying NC rivers and streams [See the referenced papers at http://www.ncwater.org/Data_and_Modeling/eflows/files/]. Jim prefaced the presentation by saying that stream classification can assist in characterizing ecological flows.

Sam Pearsall gave an overview of why stream classification can be important to determining ecological flows. Hydrology and ecology are linked. According to the literature, the structure and function of a riverine ecosystem and the adaptations of its species/communities are dictated by the temporal variation in a river's flow regime. Variability of the flow regime determines species abundance and diversity, and habitat availability, and drives disturbance and geomorphic processes. Magnitude, frequency, seasonal timing, duration and rate-of-change of flow conditions are controlling aspects of the flow regime. Thus, the development of a class-based flow/response relationship might be possible if we could: (1) identify streams with similar hydrologic characteristics, which, according to ecological theory, explain major aspects of their organization and structure; and (2) identify unique hydro-ecological indices (indices that make the class different from the other classes) that best describe the hydrologic signature of the stream

class and stream reaches by addressing the five major components of flow (magnitude, frequency, duration, timing, and rate of change,). This flow/response relationship could possibly characterize ecological flow.

Jim Mead then discussed how data were selected for the classification process. With input from DWR and USGS, the consultant (Environmental Flow Specialists) used data from 185 USGS gaging stations in North Carolina with at least 18 years of record. Initially, they used only records from gaging stations on unaltered streams (streams whose flow had not been significantly altered by some human activity). Then a test classification was conducted including 46 gages with altered records. The results of this test yielded the same number of classes (7) as the classification using only gages with unaltered periods of record. The altered gages did not fall into a new, separate class; furthermore, they were not clustered within any of the unaltered classes. This was interpreted to mean that although an altered gage might have a changed classification, it is still hydrologically similar to one of the unaltered classes and not distinctly different. Therefore, the classification proceeded using only gages with unaltered periods of record.

Sam Pearsall continued with a description of statistical analysis that used 108 variables. Of these, 22 were found to be most deterministic and yielded 9 compound vectors. In the space defined by these vectors, the gages clustered to define seven classes characterized as the clusters with the smallest diameters and the largest distances between them. Two products developed from this work: (1) A software package to take any source of daily stream flow data and classify streams (NC StreamFlow), and (2) seven hydrologic classes of streams.

Chris Goudreau then provided an overview of the seven classes, initially labeled A-G, with common names that were deemed accurate but not helpful for public discussion. Chris described a workshop convened with fifteen biologists, hydrologists and ecologists with the following objectives:

- To determine whether the classes make sense hydrologically and ecologically
- To describe geomorphic and ecological characteristics of classes
- To adjust classes and class names, if appropriate
- To discuss strategies to use classes in developing ecological flows

Go to http://www.ncwater.org/Data_and_Modeling/eflows/files/ for complete notes from the workshop, including characteristics of all stream classes.

The workshop participants decided to subdivide two of the seven classes (B and F) that had wide geographic distribution because temperature variance might require different approaches for flow management. They also decided that classes D and G should be subdivided because these classifications can reflect hydrologic characteristics influenced by particular underlying geology (most notably the Carolina slate belt formation), but they can also reflect hydrology affected by land use, impervious surfaces, numerous small impoundments and other alterations. As a result Classes D and G were each divided into “natural” and “accidental” sub-classifications. The final stream classes are:

Class A	Coastal Streams
Class B1	Small Stable Streams, Cool
Class B2	Small Stable Streams, Cold
Class C	Large Stable Streams

Class D1	Small Flashy Streams, Natural
Class D2	Small Flashy Streams, Accidental
Class E	Large Piedmont Rivers
Class F1	Medium Stable Streams, Warm
Class F2	Medium Stable Streams, Cool
Class G1	Small Seasonal Streams, Natural
Class G2	Small Seasonal Streams, Accidental

To view currently classified streams (those with sufficient gage data) overlaid on other data layers (only geology at this time) go to: http://www.ncwater.org/Data_and_Modeling/eflows/kml/

Jim Mead then described how the classifications determined from gage data for the Neuse River Basin compared with classifications determined from flows simulated by OASIS at the same locations. This analysis was done by DWR and Environmental Flow Specialists as a follow-up to the workshop – to address questions raised about the use of widely varying periods of record for the 185 gages used to develop the classification software.

Eight gages out of 31 had different classifications for flow data simulated by OASIS, and eight of the 31 OASIS flow records had different classifications depending on the period of record selected. Explanations were determined for these discrepancies resulting in: further refinement of the StreamFlow model; and better understanding of the limitations of the OASIS model regarding the period of record used. The analysis concluded:

- OASIS has the capability to simulate flow records for Neuse River Basin locations for up to 79 years. The longer the period of record, the more likely the stream will be classified correctly.
- The period of record should be entirely unaltered or entirely altered. There should be no trend inflections or long-term perturbations.
- Future hydrologic models for other river basins should include nodes at all USGS stations to allow additional comparisons and checking of simulated versus measured flow data.
- Simulated daily flows are sometimes less comparable to measured data in the very low and low flow range, and the high and very high flow range. A significant number of simulated zero flow days can result in a seasonal stream classification. Abnormally high simulation flows should be verified, since they can sometimes result in a class change. A longer analysis interval (30 or 40 years) usually resolves this issue.
- The initial year in the simulation record should not be included in the classification analysis.

Debrief: Questions and Responses

Question: Do reservoirs have an eco-flow need? They were dropped from OASIS.
Response: We decided not to classify lakes, reservoirs, streams controlled by reservoirs. We are looking at streams not lakes. Also, in most cases, releases from dams are regulated by Federal agencies.

Question: My read of the legislation is that those excluded by the model are to be done by this group.

Response: Any flow record can be included in OASIS, even downstream of reservoirs. We can categorize it, but the model did not use the data from these in the baseline. Impounded reservoirs are not flow dependent systems. We are not denying that reservoirs have ecosystems, but we set out to look at eco-flows for streams. Perhaps looking at reservoir eco-health is a separate process.

Comment: Others have done similar work and came up with the same classification. The results were replicated.

Question: I have issues since methods were not explained in detail. How were data manipulated before going into the model. Normalizing data, for example, needs to be done. We need statements of exactly how things were done.

Response: Please put your statements in writing so that we can give them to Environmental Flow Specialists, Inc. (developers of NC StreamFlow).

Time for discussion ran out, and EFSAB Members and Alternates were encouraged to ask additional questions and continue discussion on the EFSAB listerv.

X. Agenda for March 15, 2011

The following items were proposed for the agenda for the March meeting:

- Presentation by a consultant for Progress Energy on what's involved in habitat modeling—another pillar behind Eno River modeling.
- Follow-up on classification presentation with time for a debrief
- Review and add to information needs discussed at the Nov 8, 2010 meeting.

A participant suggested that the group would welcome homework assignments provided ahead of time to prepare the EFSAB for substantive discussions at the upcoming meetings. There is general agreement from the EFSAB for homework assignments.