Yadkin Hydroelectric Project (FERC No. 2197)
Operations Modeling Issue Advisory Group Meeting
November 4, 2004

Alcoa Conference Center
Badin, North Carolina

Final Meeting Summary

Meeting Agenda

See Attachment 1.

Meeting Participants

See Attachment 2.

Welcome and Introductions

Wendy Bley, Long View Associates, initiated the meeting with introductions and a review of the revised agenda (distributed at meeting). Gene Ellis, APGI Yadkin Division, noted that based on discussions from the previous day's negotiations meeting he would like to add an item to the agenda to review the modeling provisions of the Negotiations Protocol. There was consensus to add the suggested item to the end of the agenda. Wendy then turned the meeting over to Paul Shiers and Mary Tibbetts of PB Power to review the OASIS model.

Model Development

Paul reviewed the agenda and gave an outline of the information that he and Mary would be covering at the meeting. Mary then began her presentation on model development, calibration and verification.

During her presentation Mary covered the following issues. Copies of Powerpoint slides containing information on each of these areas are provided in Attachment 3:

- Modeling approach
- Nodes
- Time Step
- Period of record
- System Map
- Schematic of Nodes
- Existing Conditions (operating rules)
- High Rock/Narrows Drawdown Schedule
- Turbine Performance Data
- PE Developments (how handled in model)

- Inflow dataset development – overview
    - Approach 1 – based on upstream USGS gages
    - Approach 2 – based on Rockingham Gage
    - Approach 3 – matches USGS at both Yadkin College and Rockingham
- Yadkin Historic Inflow Data
- Issues Related to Yadkin Historic Data
- Fill-in Program
- Daily Inflow Development at High Rock
- High Rock Inflow Comparison
- Developed inflows for Tuckertown, Narrows, Falls (drainage area based)
- Developed inflows for Tillery and Blewett Falls
- PE/DTA's Inflow development approach
- Compared Approach 1 with DTA at Tillery and Blewett Falls
- Approach 3 – benefits and methodology
    - Methodology behind Approach 3
    - Determine known gains between the Yadkin College and High Rock Gages and the High Rock and Rockingham Gages (1941 – 1962)
    - Estimate gains for remaining period (1929 – 1941 and 1962-2003) using Fillin
    - USGS Gages Used in Approach 3
    - Fill-in Adjustments
    - Examples of Fill-in Adjustments

During Mary's presentation several questions were raised by participants and answered. Don Seitz, Concerned Property Owners High Rock Lake, asked Mary why OASIS is a daily model, but utilizes weekly rule curves for High Rock. Mary explained the weekly-based rule curves are in the current FERC licenses and therefore represent existing operating conditions.

Regarding the simulation of PE's developments, Chris Goudreau, NC Wildlife Resources Commission, asked if PB used maximum capacity or maximum efficiency in the OASIS model for the PE developments. Mary explained that OASIS utilizes maximum capacity because that was the number that was available in PE's ICD.

Regarding the term "known gains", Darlene Kucken, NC Division of Water Quality, asked Mary to define "gain". Mary explained that "gains" are tributary flows to the reservoirs or the increase in water between two points. Robert Petree, SaveHighRockLake.org, asked if the proportion of gains to High Rock is skewed based on the how High Rock is operated as a storage reservoir. Mary noted that this was a good question. She explained that to eliminate any "bias" in the estimated tributary flows due to Project operations, the river flows were "unregulated" based on USGS flows. So gains or tributary inflows are based on unregulated flows. Gene Ellis added that the inflow dataset was developed as if the APGI and PE dams did not exist on the river.

Mary continued with her presentation covering the following areas:

- Annual Comparison of Approach 3 with Yadkin historic data (1-13% different, 8% average)
- Inflow data set conclusions
- Sending the inflow data set to USGS for review

Larry Jones, High Rock Lake Association, asked Mary if PB had been able to reconcile differences between the APGI and USGS flow data sets. Mary explained that she thought the differences were understandable and attributable to known changes in the system such as turbine efficiencies and the storage elevation curve. She noted that both the turbine efficiency curve and storage elevation curves for High Rock have been updated. She also noted that another source of the difference in the two data sets might be estimations of flow based on gate openings during spill events.

Paul Shiers noted that throughout the development of the inflow data set, PB has been working with PE and DTA, and that the final dataset includes flows recorded at both the Rockingham and Yadkin College USGS gages. Paul also noted that PB relied heavily on NC and SC for input and guidance as they used Approach 3 to develop the inflow dataset. Finally, Paul reminded the IAG that most of the work done on the inflow data set was done by Hydrologics, working in close coordination with the USGS.

Mary then discussed the Bennettsville USGS gage. She noted that when PB started working on the river flows, they tried to match 4 USGS gages, including the gage at Bennettsville, SC. But, she noted, the Bennettsville gage was a problem and they could never get a good match at that location. Accordingly, PB and Hydrologics met with USGS (South Carolina office) to discuss their findings. The USGS acknowledged that the Bennettsville gage is problematic due to the sandy river bottom at the location and, as a result, a constantly changing bottom contour and rating curve. Mary explained that for these reasons, the USGS considers data from the Bennettsville gage to be less reliable and the USGS suggested that PB not try to match flows at Bennettsville. Mary noted that Bud Badr (SC) agreed with the USGS recommendation.

Larry asked about 175 sq mi drainage area between High Rock and Falls reservoirs. He noted that the square mileage seemed low. Paul Shiers indicated that PB would double check on that drainage area. [Note: PB Power has since determined that the correct drainage area between High Rock and Falls Reservoirs is 217 square miles. The slide has been updated accordingly.]

Mary then continued her presentation, discussing model calibration and verification and related issues including:

- Calibration
- Verification (retest)
- Purpose of calibration and verification
- Calibration Years (1995 and 1998)
- Verification Years (1990, 1997, 2000, and 2001)
- Hydrologic characteristics of the calibration and verification years.

Don Seitz asked what formula was used to convert flows to generation. Mary explained that existing turbine performance data was used to estimate generation.

Eric Krueger, The Nature Conservancy, asked if PB was able to calculate some kind of standard statistical error for the calibrated model. He noted that his reason for asking, was his concern that, for example, scenarios being looked at during negotiations result in a 12% hit in APGI's revenue, whether this estimate is within the error of the model. He noted that some statistical rigor was needed to understand the potential error range of the model. Chris Goudreau reiterated Eric's question. He noted that at Tapoco, OASIS was used to look at very small differences in generation value between scenarios that may not have been real based on the statistical accuracy of the model. Paul Shiers noted that the calibration results of the OASIS model at Yadkin were very good, and that PB would look into producing error statistics for the model's estimates of generation.

Gerrit Jobsis, SC Coastal Conservation League and American Rivers, asked if 1998 and 1995 were the only years that PB looked at with the model. Mary explained that those two years were just selected as calibration years. She noted that additional years (1990, 1997, 2000, and 2001) were examined during the verification phase of model development and she showed the hydrologic characteristics of these years.

Chris Goudreau asked if PB had observed any consistencies in the larger percent deviations by development over the calibration and verification years examined. Mary indicated that they had seen no observable pattern.

Mary and Paul wrapped up the discussion of the model development by summarizing that calibration and verification of the model is complete. That the model was verified over a wide range of flow conditions, and that the model is ready to use.

Demonstration of Model

After a break, Mary did a run of OASIS under existing conditions for the period 1930-2003. She showed the IAG several of the options for viewing the model results. As an example of model output, she showed water surface elevations for High Rock. Then there was a general discussion of the accuracy of OASIS simulations of reservoir water levels. Mary answered several questions about difference between observed reservoir elevations and those simulated by OASIS.

Chris Goudreau asked about the way the model deals with evaporation and whether it is a function of water temperature and air temperature, as well as reservoir surface area. Mary explained that Hydrologics used measured evaporation for a lake in Durham, NC (Lake Michie) as representative of evaporation for the area and applied this measured amount proportionally to the surface areas of the Yadkin and PE reservoirs in the model. Mary noted that the model contained daily evaporation and precipitation data.

Complementary Models

Paul Shiers reviewed APGI's proposal for using the OASIS and CHEOPS models in a complementary fashion. He noted that the two models have their strengths and that each might be better suited to some types of simulations than others. He explained that while both models will include all six Yadkin River hydropower developments CHEOPS has been calibrated to the two Progress developments and that OASIS has been calibrated to the four Yadkin developments. He also reminded participants that OASIS uses a daily time step and therefore may be better for looking at the Yadkin Project developments and resulting downstream river flows on a daily basis, and for screening scenarios that involved both the Yadkin and Progress developments, while CHEOPS would be best used to simulate operation of the PE developments and to look at downstream river flows (below both Blewett and Tillery) on a more detailed basis. He noted that there may be times when both models are needed, and that when both are used, they could match flows at Falls, such that outflow from Falls simulated by OASIS could be used as inflow to Tillery to simulate hourly operations at the PE developments. He also noted that as a daily time step model, OASIS could be used as a screening tool to help narrow the range of alternatives that might be looked at in more detail using the CHEOPs model.

Chris Goudreau noted that the 3rd bullet of Paul's slide on complementary models suggests that the downstream areas are only in South Carolina. He asked that this slide be modified before being posted to the IAG that there are downstream areas in both North and South Carolina.

Larry Jones asked how the two models would be used in a complementary fashion in the negotiations process. This question led to much discussion about how the negotiations process would utilize the models. Many IAG members put forth suggestions on how the Negotiations Group might proceed with the models. Several suggested that a worksheet be developed that could be used by participants to start outlining model runs that they would like to see done. In the end, it was concluded that the negotiations Process Team would be responsible for determining how and at which meetings the models would be used in the negotiations.

Negotiations Protocol Modeling Language

Gene Ellis reviewed issues that had come up during the previous day's negotiations meeting regarding the added modeling language in the Negotiations Protocol. Gene noted that APGI had been asked to reconsider their decision about making the model available to all participants and to come back today with a response. Gene stepped through each paragraph of the language that had been inserted in the protocol so that participants would understand APGI's intent for each.

Paragraph 1 - APGI's versions of OASIS will be the primary tool for use in the Yadkin Project negotiations
Paragraphs 2 and 3 – Participants will be given full visual access to the model and results

Paragraph 4 – Participants will not bring results from other models into the negotiations
Paragraph 5 – Other models/results could be brought into the negotiations process with the consensus of the group.

Gene noted that based on all that APGI is offering, with respect to Yadkin's OASIS model, he didn't see the necessity of providing participants with the Yadkin model. He explained again that APGI's concern with giving other participants the model to run is that there would be multiple versions of the model in use, and that model results introduced from those other versions would be difficult, if not impossible, to verify. Gene also noted that the Yadkin version of OASIS is far more difficult to modify than the Tapoco version was because of the need to use the OCL language.

Robert Petree asked Gene if this meant that he could not buy his own copy of OASIS to run and APGI would give him the calibration data. Gene clarified that APGI would not furnish the calibration data to be put into any other version of OASIS. General discussion among the participants on the issue of model availability followed. Several participants noted that credibility and trust regarding the model and its use would take longer to be established if participants were not given the opportunity to have their own versions of the model to run. Several participants acknowledged that the Yadkin version of OASIS did look complicated and that it was probably best left to Mary to make runs that were requested.

Several participants asked what "output" would be made available for the model results, and in what format. Several indicated interest in having hard copies of model results made available that they could "take home" and review more carefully. Paul Shiers and Mary Tibbetts noted that they could work with the participants to develop a format for presenting model results that meet everyone's needs. It was agreed that hard copies of results would be made available, if desired. Chris Goudreau noted that it would be good to make model results (output) available electronically, as well. He suggested that model run results could somehow be "cataloged" on the Yadkin website.

Several participants asked if the value of generation would be included in the output that was made available. Gene Ellis noted that currently on peak and off peak generation (MWH) is available as output, but that APGI has not yet developed a "pricing function" to include in the model. Gene noted that APGI is working on coming up with a suitable pricing function that is representative of southeast region prices, but have not completed this work yet. He clarified that APGI will at some point in the process provide the participants with pricing information that can be used in OASIS to generate estimates of generation value.

It was asked if the model output would have total generation or, on-peak and off-peak generation. Paul Shiers explained that the model would have on-peak and off-peak generation, but not "shoulder" generation.

There was further discussion about why APGI was reluctant to give the model out for participants to use themselves. Gene Ellis reiterated APGI's concerns about multiple versions of the model being used by participants in the negotiations, and the general complexity of the Yadkin version of OASIS. Gerrit Jobsis again noted that giving participants the model would build trust between the parties.

Gene Ellis indicated that APGI is willing to hold an additional OASIS workshop that can be designed to meet the needs of the participants that still feel they would like to know more about how the model works, and how Mary will manipulate certain variables within the model to create simulations of alternative operations. Eric Krueger asked if a demonstration of an alternative model run could be made today at this meeting. After reviewing the files that she had available on her laptop computer, Mary concluded that she wasn't prepared to make such a demonstration today, but that such demonstration(s) could be made at a future workshop. Paul Shiers suggested that the workshop could be held in January or February of 2005.

Discussion returned to how model runs would be requested and results made available to the participants. Everyone agreed that to get started, PB would need to make a few runs of OASIS that could be used to bracket a range of scenarios, so that participants could begin to focus on certain aspects of Project operations. It was suggested that the best way to do this is to modify one variable at a time in model runs to see the "sensitivity" of the outputs (flows, elevations, generation) to changes in each variable. The idea of developing an "input" sheet for model runs was again raised. There was also further discussion on the idea of cataloging model results on the Yadkin website.

Several participants asked if the Interest Statements prepared for the negotiations could or would be used to frame some initial model runs. Wendy Bley noted that she assumed that was an issue that would be considered by the negotiations Process Team. Steve Reed concurred, noting that further discussion of how interest statements could be used to frame model runs should take place in the settlement negotiations. It was also noted that DTA has put together model input data sheet for the Duke's Catawba negotiations process. The suggestion was made that a similar sheet could be designed and used for the Yadkin process.

Darlene noted that neither OASIS nor CHEOPS has a water quality component that will allow simulation of water quality conditions under various operating scenarios. Paul Shiers concurred that OASIS does not have this capability.

At this point in the meeting Wendy Bley noted that the discussions had centered around two basic issues – 1) comfort with the model and the concept that APGI's version of the model would be the only version used in the negotiations and 2) concerns/questions about how the model would be integrated into the settlement negotiations and interest statements. Specific to the "comfort with the model" issue, Wendy noted that APGI had offered to have PB run an additional OASIS workshop after the first of the year, and that participants should let PB know if there were other aspects of the model or its use they would like PB to include in the workshop.

Larry Turner, SC Department of Health and Environmental Control, suggested that the workshop cover how weighting factors fit in. Eric Krueger suggested that the workshop include a sensitivity demonstration where PB would change one or two variables in the model at a time to see the explicit effect of that single change on model results. Larry Jones suggested that PB provide a glossary of model input parameters. It was also suggested that PB provide a list of output variables and display options that the participants could consider. Gerrit Jobsis suggested that PB get some of this information (glossary and output options list) out to interested participants in advance of the workshop. Chris Goudreau suggested that PB provide information on which model inputs and functions are in OCL language, versus those that could be modified directly in the other types of input tabs that Mary had shown earlier in the meeting. Don Seitz asked if PB could provide a definition of constraints versus targets, and how each could be handled in the model.

Gerrit Jobsis noted that prior to the workshop, the ability to manipulate target lake levels and to have downstream flow targets needed to be included in the model. Paul and Mary indicated that the model was already capable of simulating conditions with modified lake level targets and/or downstream flow targets. They also noted that the priority within the model to meet each of these targets could be changed. For example, Mary explained that under a particular operating scenario the model could be told that in situations where there wasn't enough water in High Rock to simultaneously stay on the target lake level and meet a downstream flow requirement, lake level parameter could be given the priority over flow, and the model could keep track of how many days the flow target would not be met. Conversely, the model could be revised such that flows were given priority over lake levels, and the model could track how many days that the lake level target was not met. It was asked if there were a "counter" in the model. Paul indicated that a counter could be added.

After wrapping up discussion on the proposed workshop, Gene Ellis made a final point regarding the OASIS model. He noted that while the model would not be made generally available to the participants, APGI would be providing a copy of the OASIS model to each of the states (NC and SC). He indicated that since the outset of the relicensing process both states had made it clear to APGI that they wanted to receive a version of the model that they could use in doing broader watershed planning for the Yadkin-Pee Dee River basin, and that APGI had agreed to this. Gene noted, however, that for purposes of the Yadkin Project relicensing negotiations, the states would be required to meet the same Negotiations Protocol terms for model use as everyone else.

The meeting adjourned at about 3:15 PM.

Attachment 1 – Meeting Agenda

Yadkin Project
FERC No. 2197
Communications Enhanced Three-Stage Relicensing Process

Operations Model Issue Advisory Group Meeting

Thursday, November 4, 2004
Alcoa Conference Center
Badin, North Carolina

10:00 AM

Agenda

1. Introductions, Review Agenda

2. OASIS Modeling Effort
   I. Model development
   II. Inflow dataset development
   III. Calibration and verification

3. Status of Model and Inflow Dataset

4. OASIS Demonstration

5. Complementary Models

Attachment 2 – Meeting Attendees

Name	Organization
Bob Warren	Uwharrie Point Community Association
Chip Conner	Uwharrie Point Community Association
Chris Goudreau	NC Wildlife Resources Commission
Coralyn Benhart	Alcoa
Darlene Kucken	NC Division of Water Quality
Don Cordell	Hazen and Sawyer
Don Rayno	NC Division of Water Resources
Don Seitz	Concerned Property Owners High Rock Lake
Eric Horner	NC Division of Water Resources
Eric Krueger	The Nature Conservancy
Frank Tiam	SC Department of Natural Resources
Fred Richardson	Pee Dee River Coalition
Gene Ellis	APGI, Yadkin Division
John Ellis	US Fish and Wildlife Service
Larry Jones	High Rock Lake Association
Larry Turner	SC Department of Health and Environmental Control
Mark Bowers	US Fish and Wildlife Service
Mary Tibbetts	PB Power
Mel Woffard	High Rock Lake Association
Nob Zalme	Duke Energy
Paul Shiers	PB Power
Phil Lucas	Progress Energy
Raymond Allen	City of Albemarle
Robert Brown	Fitzpatrick Communications
Robert Petree	SaveHighRockLake.org
Roy Rowe	Piedmont Boat Club
Steve Reed	NC Division of Water Resources
Todd Ewing	NC Wildlife Resources Commission
Wendy Bley	Long View Associates

Attachment 3 – Meeting Presentation

Operations Model
IAG Meeting
November 4, 2004

Today's Meeting

- Report on 2004 Activity:
  Inflow Dataset Development
- Model Reliability
- OASIS Demonstration
- Model will be used to show various operating scenarios during the negotiations process

Recent Activity

- Verification:

  2001 data set verification work complete

  (additional run requested at last IAG)

- 75-year Inflow Dataset:

  Inflow dataset development complete

- Model Development:

  Model has been constructed, calibrated and verified

Future Activity

- Inflow dataset to be reviewed by USGS
- OASIS model will be used to evaluate operating alternatives
- Complementary use of operating models with Progress Energy
- Negotiations process
  - Operations model protocol

Agenda

- Introduction
- OASIS modeling effort
  - Model development
  - Inflow development
  - Calibration and verification
- OASIS demonstration

Model Development

Operations Modeling Goal

Develop a computer model that will:

- Simulate operating alternatives
- Quantify impact of alternatives on:
  - Water levels
  - Stream flows
  - Energy generation

What is OASIS and How Does it Work?

- Generalized water resources simulation/optimization model
- LP formulation - operates with constraints and targets
- Uses the principle of mass balance to ensure that all the water in the system is accounted for
- Solves a set of linear equations for each time step to optimize benefits subject to user-defined constraints and targets

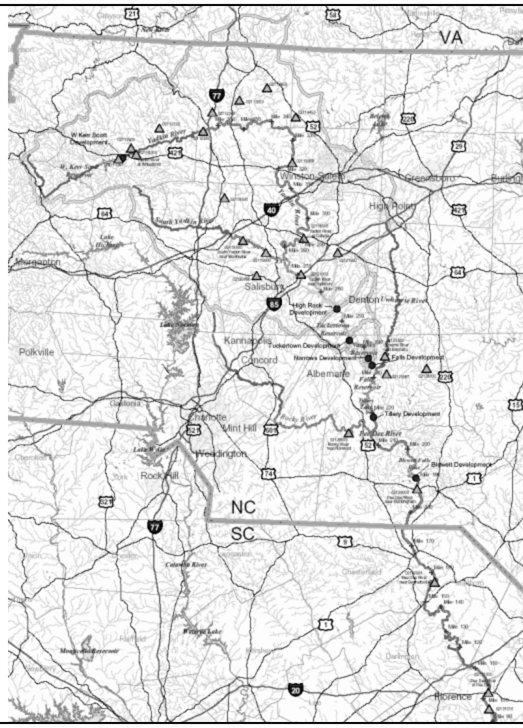
OASIS stands for Operational Analysis and Simulation of Integrated Systems

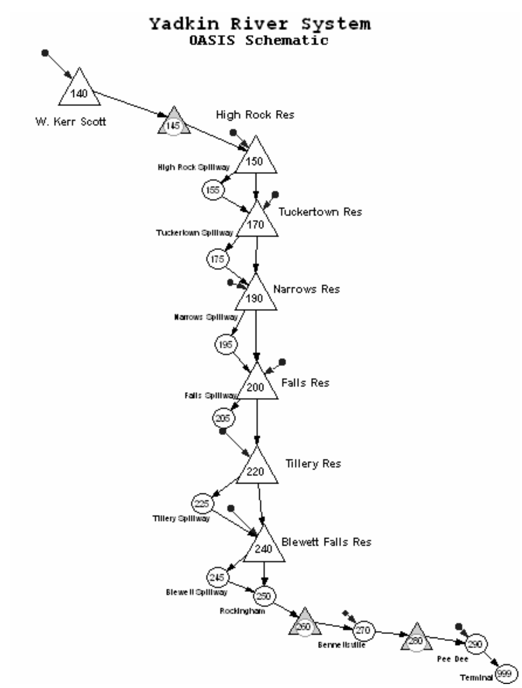
Modeling Approach

- Assemble data and construct model
- Calibrate model
  - Match historical stage and compare computed energy and discharges to historical
- Utilize model to investigate operational alternatives

Yadkin OASIS Model

- Nodes:
  - W. Kerr Scott
  - USGS gage at Yadkin College, NC
  - High Rock, Tuckertown, Narrows, and Falls Developments
  - Tillery and Blewett Falls Developments
  - USGS gage at Rockingham, NC
  - USGS gage at Bennettsville, SC
  - USGS gage at Pee Dee, SC
- Time step: Daily
- Period of record: 1929 to 2003

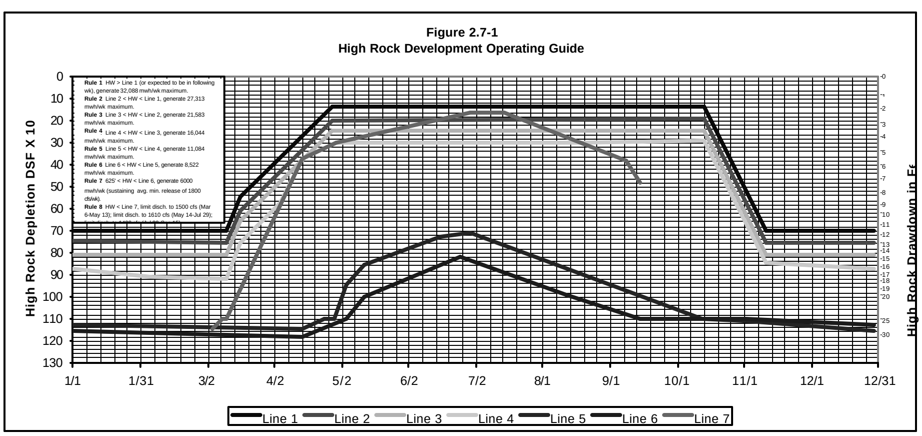

VA
NC
SC
Winston-Salem
Greensboro
High Point
Salisbury
Denton
Kannapolis
Concord
Albemarle
Charlotte
Mint Hill
Weddington
Rock Hill
Polkville
Morganton
Florence
High Rock Development
Tuckertown Development
Narrows Development
Falls Development
Tillery Development
Blewett Development


Yadkin River System
OASIS Schematic
140
W. Kerr Scott
145
High Rock Res
150
High Rock Spillway
155
170
Tuckertown Res
Tuckertown Spillway
175
190
Narrows Res
Narrows Spillway
195
200
Falls Res
Falls Spillway
205
220
Tillery Res
225
Tillery Spillway
240
Blewett Falls Res
245
Blewett Spillway
250
Rockingham
260
270
Bennettsville
280
290
Pee Dee
999
Terminal

Existing Conditions Operating Rules

- High Rock: follow existing guide curve, operate to maximize the value of generation
- Tuckertown and Falls: run of river
- Narrows: modified run of river, follow licensed drawdown schedule
- Tillery: run of river
- Blewett Falls: starts operating when Tillery starts, operates approximately 10 hours/day, daily drawdown of 2 to 3 ft
- Continuous releases
  - Tillery: 40 cfs
  - Blewett Falls: 140 cfs

High Rock Reservoir Guide Curve



High Rock Reservoir Rules

- Rule 1: HW > Line 1 (or expected to be in following week), generate 32,088 MWh/wk maximum
- Rule 2: Line 2 < HW < Line 1, generate 27,313 MWh/wk maximum
- Rule 3: Line 3 < HW < Line 2, generate 21,583 MWh/wk maximum
- Rule 4: Line 4 < HW < Line 3, generate 16,044 MWh/wk maximum
- Rule 5: Line 5 < HW < Line 4, generate 11,084 MWh/wk maximum
- Rule 6: Line 6 < HW < Line 5, generate 8,522 MWh/wk maximum
- Rule 7: 625' < HW < Line 6, generate 6,000 MWh/wk (sustaining avg. min. release of 1800 cfs/wk)
- Rule 8: HW < Line 7, limit disch. to 1500 cfs (Mar 6-May 13); limit disch. to 1610 cfs (May 14-Jul 29); limit disch. to 1400 cfs (Jul 30-Sep 15)

Note: Rule 8 governs over all other rules during applicable months

High Rock – Narrows Drawdown Schedule

High Rock Reservoir Elevation (ft, YD)	High Rock Reservoir Drawdown (ft)	Narrows Reservoir Elevation (ft, YD)	Narrows Reservoir Drawdown (ft)
655.0	0.0	541.1 - 539.0	0.0 - 2.1
654.0	1.0	539.5 - 534.5	1.6 - 6.6
631.0	24.0	539.5 - 534.5	1.6 - 6.6
631.0	24.0	534.0	7.1
629.0	26.0	525.0	16.1
625.0	30.0	510.0	31.1

Turbine Performance Data

- Turbine degradation at Yadkin Developments taken into account
- Narrows Unit 3 upgraded/refurbished 1995-1996
- Narrows Unit 4 upgraded/refurbished 2000-2001
- High Rock and Narrows have multiple curves for varying heads
- High Rock and Narrows have separate curves for with and without air injection
- Progress developments assumed to operate at maximum capacity

Model Development Conclusions

Yadkin has developed an accurate and reliable computer model that:

- Simulates existing conditions and operating alternatives
- Quantifies the impacts of alternatives on:
  - Water levels
  - Stream flows
  - Energy generation

Inflow Dataset Development

Inflow Dataset Development

- Yadkin historic dataset
- USGS based inflow dataset (Approach 1)
- Progress Energy inflow dataset
- USGS based inflow dataset (Approach 2)
- USGS based inflow dataset (Approach 3)

Yadkin Historic Inflow Data

- Historic operating data recorded by Yadkin
  - Measure: water levels, generation, and flood gate openings
  - Calculate: change in storage, turbine discharge, flood gate discharge, and inflows
- Daily data available electronically
  - High Rock: 1980 to 2003
  - Tuckertown, Narrows & Falls: 1986 to 2003
- Hourly data available electronically, all developments from 1997 to 2003

Issues Related to Yadkin Historic Data

- Data available electronically for relatively short period of record
- Each development's data is recorded independently of other developments
- Turbine efficiency changes affect calculated turbine discharges and inflows
- Storage – elevation relationship changes affect calculated change in storage volumes and inflows

USGS Based Inflow Data (Approach 1)

- Yadkin has opted to develop a USGS-based inflow dataset
  - Publicly available
  - Long-term record to assess hydrologic extremes
  - Unregulated to permit evaluation of alternative project operations
- Use available gage data at High Rock Dam
- Use *Fill-in* to complete missing record for inflows to High Rock Reservoir
- Add tributary inflows downstream of High Rock based on representative USGS gages

Fill-in Program

- Statistical regression and correlation using *Fillin*
  - Program developed by the USGS
  - Estimates monthly flows at gages with missing records
  - Useful when dealing with a large number of gages
  - Accuracy only as good as gage accuracy and the long-term average monthly correlation

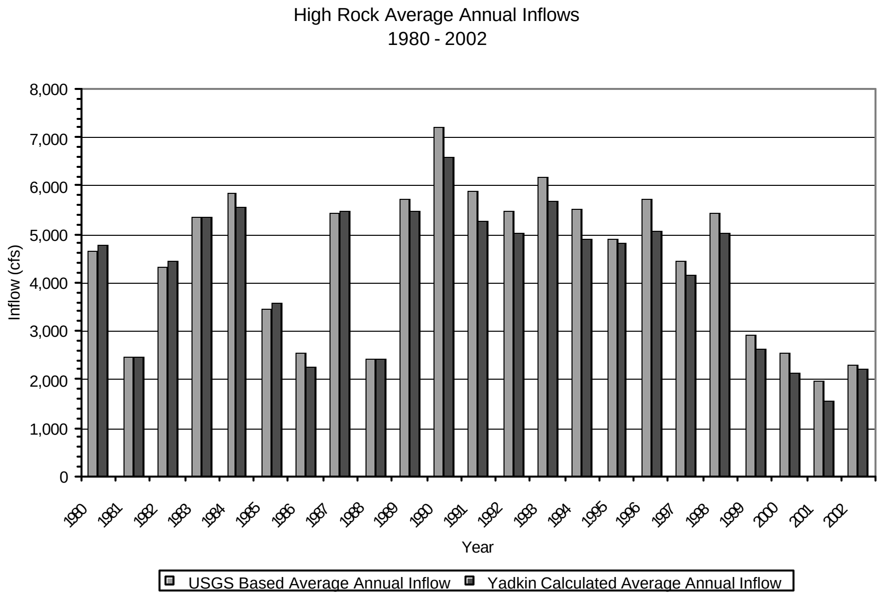
Daily Inflow Development at High Rock

- Daily inflow to High Rock Reservoir =

  (Daily flow at upstream gage(s) / monthly average flow at upstream gage(s)) * monthly Fill-in estimated flow at High Rock
- Yadkin College, South Yadkin tributary, and Abbott's Creek gages used to disaggregate to daily

High Rock Inflow Comparison

- USGS-based inflows ("Approach 1")
- Yadkin calculated inflows based on historic operating data



Comparison Conclusions

- Neither data set is "correct"
- On an average annual basis, the USGS based inflows are on average 6% higher than the Yadkin calculated inflows (1980 to 2002)
- Possible reasons include:
  - Accuracy of USGS gage data
  - Accuracy of Yadkin data
    - Turbine degradation
    - Changes in storage-elevation relationship
    - Net evaporation
    - Gate discharge calculations

Daily Inflow Development at Tuckertown, Narrows, and Falls

- Tributary inflow to downstream Yadkin Developments is ungaged
- Use Abbott's Creek gage flows, pro-rated for drainage area of each development
- When not available, use Rocky River gage flows pro-rated for drainage area
- Runoff coefficient (cfsm) for overlapping periods
  - Rocky River: 1.01, Abbott's Creek: 0.94
  - Drainage area between High Rock and Falls is 217 sq. mi.

Daily Inflow Development at Tillery and Blewett Falls

- *Fill-in* not used since Yadkin River down to Blewett Falls is ungaged
- Falls to Tillery (420 sq. mi.)
  - 1938 – 1971: Use Eldorado gage on the Uwharrie (360 sq. mi.)
  - For remainder of record, use Rocky River gage
  - Pro-rate gage flows by drainage areas
  - Cfsm for overlapping period
    - Eldorado: 0.95
    - Rocky River: 0.92

Daily Inflow Development at Tillery and Blewett Falls (cont.)

- Tillery to Blewett Falls (2230 sq. mi.)
  - Three tributary gages
    - 1929 – present: Rocky River (1372 sq. mi.)
    - 1954 – present: Little River (106 sq. mi.)
    - 1938 – 1971: Brown Creek (110 sq. mi.)
  - Total ungaged drainage area = 642 sq. mi.
  - Inflows to Blewett =

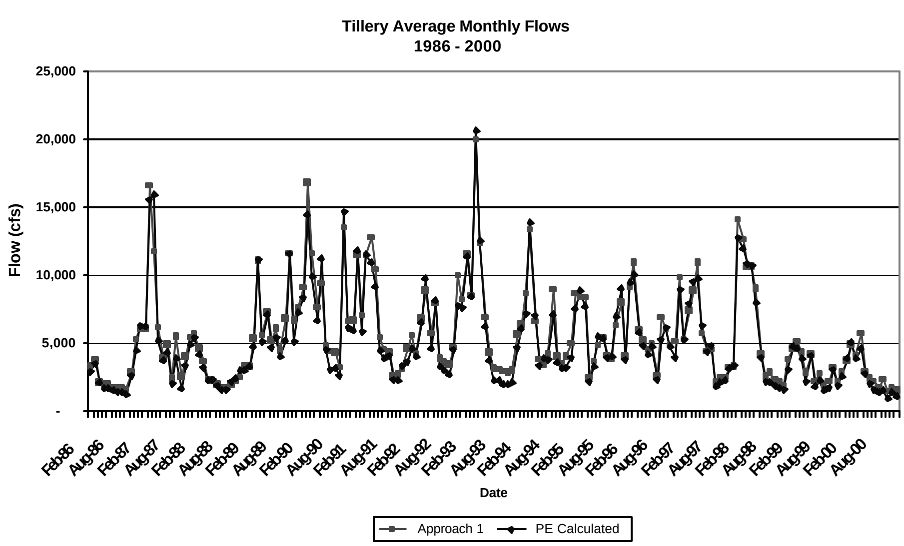
    Sum of tributary flows + weighted average cfsm * ungaged drainage area

DTA's Inflow Development Approach

- 20-year daily inflow record based on combination of operating data and USGS gage data
  - Tillery inflows: based on historic Progress Energy operating data
  - Blewett Falls inflows: based on USGS Rockingham gage data

Tillery Inflow Comparison

- "Approach 1" USGS-based inflows
- Progress Energy calculated inflows based on historic operating data

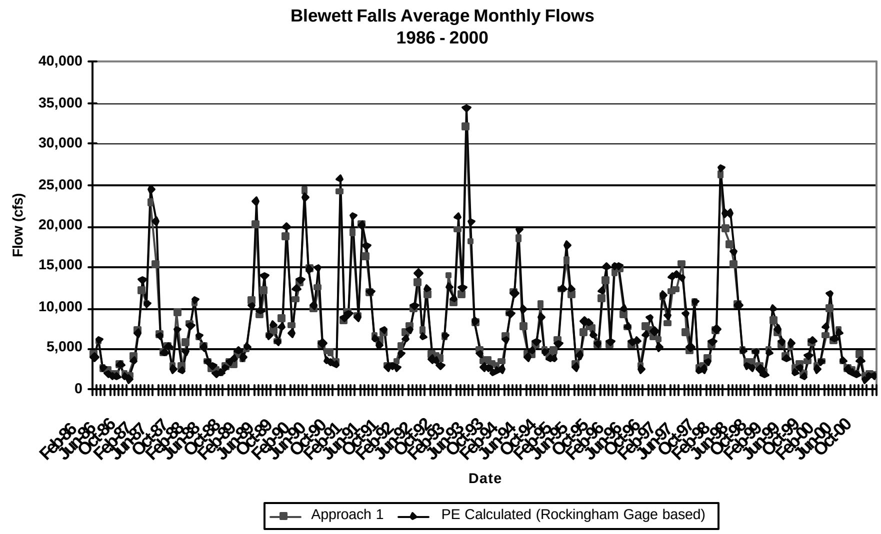


Comparison Conclusions

- 1986 to 2000: “Approach 1” USGS-based inflows 7% higher than Progress Energy calculated inflows
- The difference is 15 percent or higher in 63 of these months (36 percent of the time)

Blewett Falls Inflow Comparison

- “Approach 1” USGS-based inflows
- Progress Energy calculated inflows based on USGS Rockingham gage data

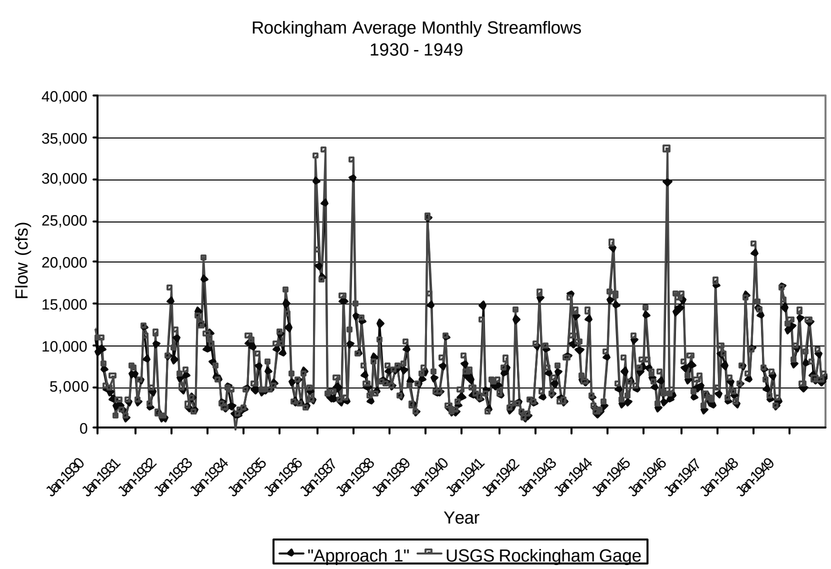


Comparison Conclusions

- 1986 to 2000: “Approach 1” inflows are 5% lower than Progress Energy calculated inflows

Comparison of Flows at Rockingham

- “Approach 1” USGS-based flows at Rockingham
- USGS gage measurements at Rockingham



Comparison Conclusions

- 1929 – 2002: Approach 1 flows are 5% lower than Rockingham measured flows

USGS Based Inflow Data (Approach 2)

- Develop inflows based on downstream Rockingham gage rather than upstream gages
- Determine known gains between High Rock and Rockingham gages
  - Applies to 1941-1962 when gage at High Rock gage existed
- Estimate gains for remaining period (1929-1941 and 1962-2003)
  - Use *Fillin* to estimate monthly gains using gages in watershed
  - *Fillin* uses gages that are most highly correlated

High Rock Inflow Comparison

- USGS-based inflows at High Rock ("Approach 2")
- Yadkin College Gage + South Yadkin Gage

Comparison Conclusions

- In 100 months out of 860 months total, Approach 2 inflows to High Rock are less than the combine Yadkin College and South Yadkin flows (11% of the time)
- Despite the fact that the High Rock drainage area is 1,000 sq. mi. larger

USGS Based Inflow Data (Approach 3)

- For nodes upstream of High Rock (W. Kerr Scott and Yadkin College), inflows based directly on gage flows
- For nodes downstream of Blewett Falls (Rockingham and Pee Dee), inflows based directly on gage flows
- From High Rock to Blewett Falls, flows based on *Fillin* using Approach 3
  - Statistical approach needed in this reach due to shortage of available gage records

Approach 3 (cont.)

- Adopted to ensure that monthly estimates of:
  - Gains between Yadkin College/High Rock and High Rock/Rockingham are realistic
  - Tributary inflows below High Rock are as accurate as possible
  - Flows at Yadkin College and Rockingham agree with actual flows (preserve mass)

Methodology behind Approach 3

- Determine known gains between Yadkin College/High Rock (High Rock gains) and High Rock/Rockingham (Rockingham gains)
  - Applies to 1941-1962 when gage at High Rock existed
- Estimate gains for remaining period (1929-1941 and 1962-2003)
  - Use *Fillin* to estimate monthly gains using gages in watershed
  - *Fillin* uses gages that are most highly correlated

USGS Gages Used In Approach 3

USGS gage (station number)	Drainage area (sq.mi.)	Period of record
Wilkesboro	504	1903 – 1909; 1920 – present
Yadkin College	2280	1928 – present
South Yadkin at Cooleemee *	569	1928 – 1965
South Yadkin at Mocksville	306	1938 – present
Hunting Creek **	155	1951 – present
Second Creek**	118	1979 - present
Abbott's Creek	174	1988 – 1991, 1992 - present
Eldorado, Uwharrie River	342	1938 – 1971
Rocky River	1372	1929 – present
Little River	106	1954 – present
Brown Creek	110	1937 – 1971
Rockingham	6863	1906 – 1911; 1927 - present

* Gages in red generally have highest correlations
** Used only for daily flow disaggregation

Fillin Adjustments

- *Fillin* produces estimates of High Rock gains and Rockingham gains
- Adjustments made to ensure that the sum of these gains matches the known gains between Yadkin College and Rockingham
- This method preserves the *Fillin*-estimated proportion of gains between Yadkin College/High Rock and High Rock/Rockingham while preserving the overall sum in this entire reach

Example of Fillin Adjustments

- Estimated High Rock gain = 1,000 cfs
- Estimated Rockingham gain = 2,500 cfs
- Estimated Yadkin College – Rockingham gain = 1,000 + 2,500
  = 3,500

- Known Yadkin College – Rockingham gain = 4,000 cfs

- Adjusted High Rock gain = 4,000 * (1,000 / (1,000 + 2,500))
  = 1,140 cfs
- Adjusted Rockingham gain= 4,000 * (2,500 / (1,000 + 2,500))
  = 2,860 cfs

Monthly Inflow Estimation

- High Rock inflows = Yadkin College gage flows + adjusted High Rock gains
- Blewett Falls inflows = drainage-area corrected local gage flows (principally Rocky River)
- Remaining inflows to Tuckertown, Narrows, Falls, and Tillery = adjusted Rockingham gains – Blewett Falls inflows and allocated by project drainage area

Daily Inflow Estimation

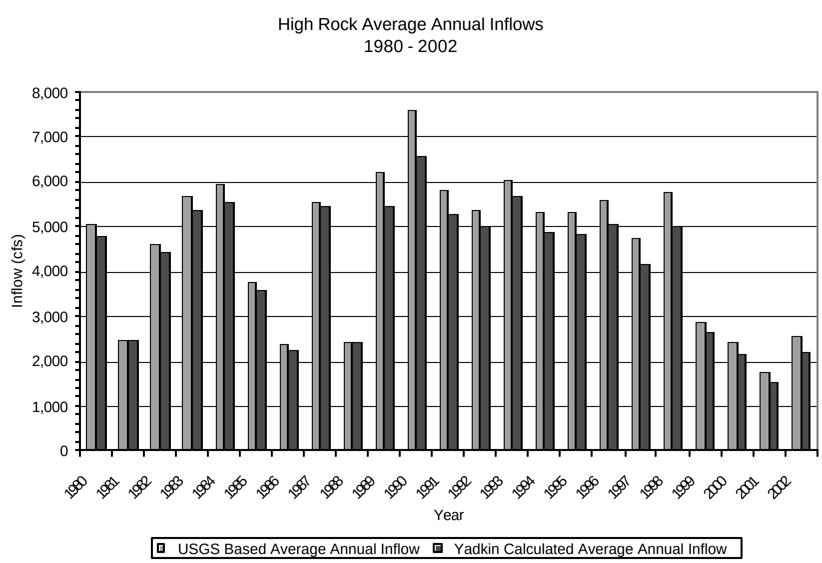
- Using High Rock as an example:

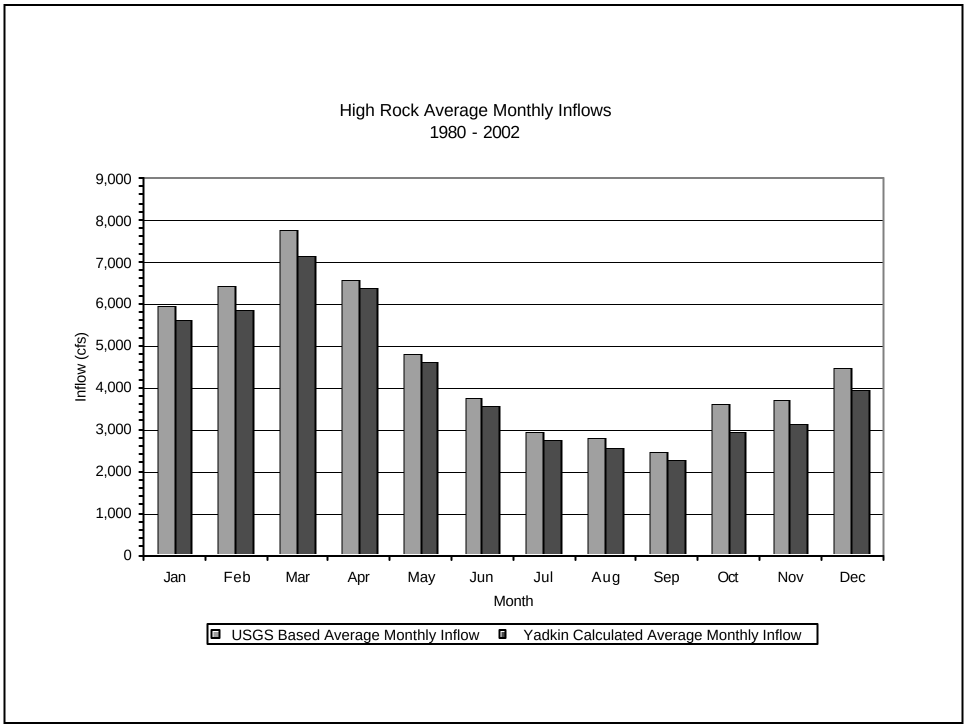
  Daily flow =

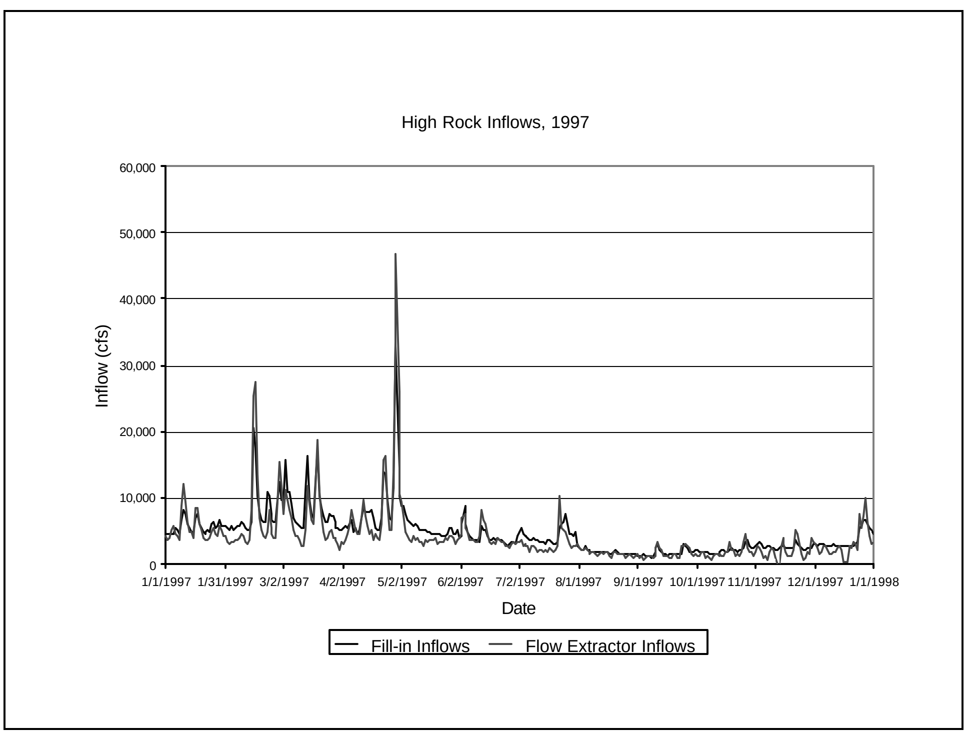
  (daily flow at upstream gage(s) / monthly average flow at upstream gage(s)) * monthly *Fillin* estimate

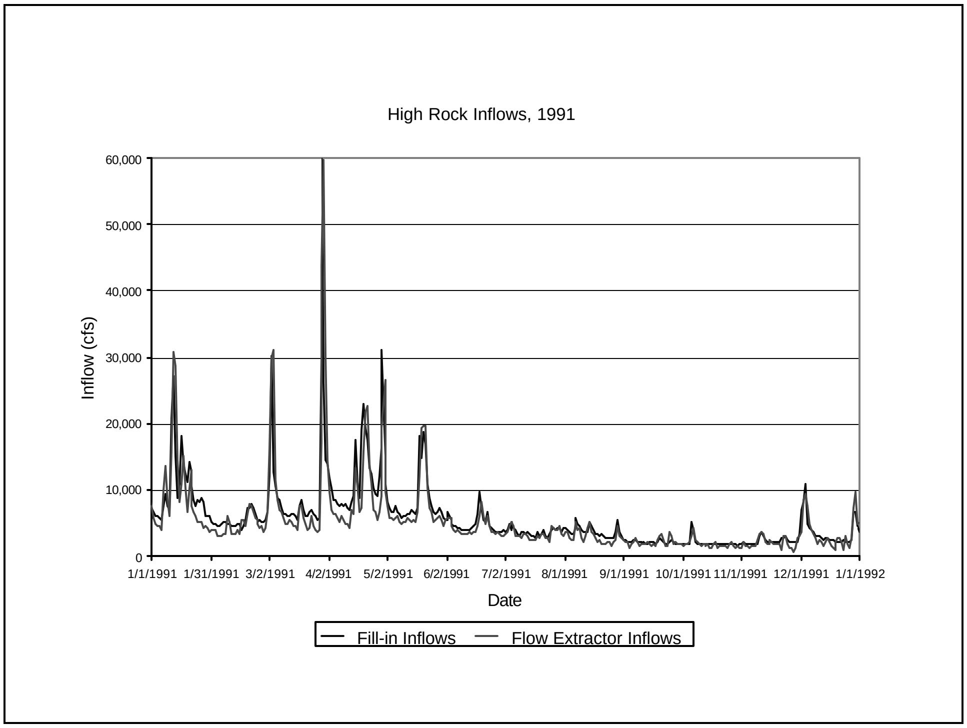
High Rock Inflow Comparison

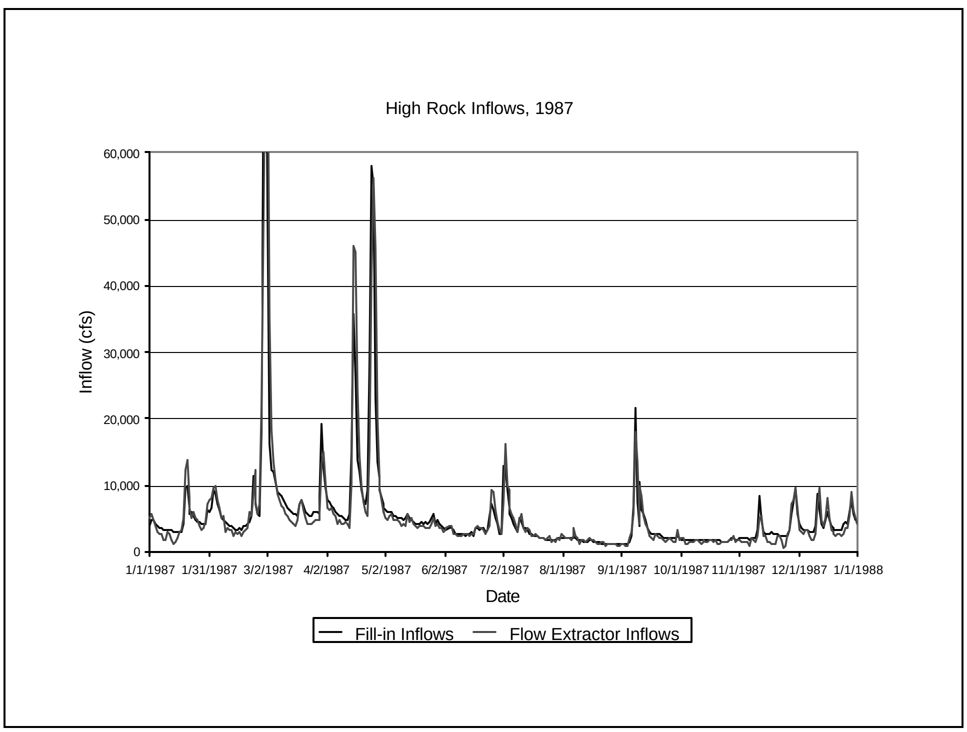
- USGS-based inflows ("Approach 3")
- Yadkin calculated inflows based on historic operating data

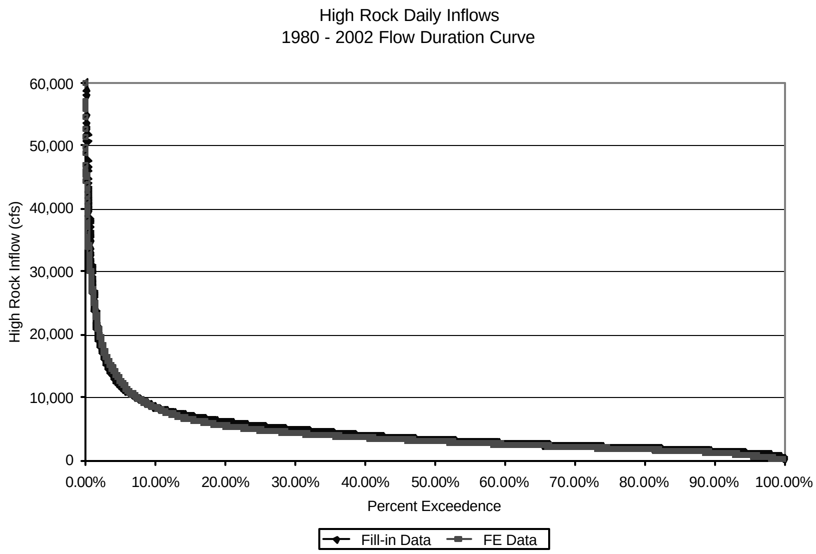



High Rock Average Monthly Inflows
1980 - 2002
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Inflow (cfs)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
USGS Based Average Monthly Inflow
Yadkin Calculated Average Monthly Inflow


High Rock Inflows, 1997
60,000
50,000
40,000
30,000
20,000
10,000
0
Inflow (cfs)
1/1/1997
1/31/1997
3/2/1997
4/2/1997
5/2/1997
6/2/1997
7/2/1997
8/1/1997
9/1/1997
10/1/1997
11/1/1997
12/1/1997
1/1/1998
Date
Fill-in Inflows
Flow Extractor Inflows


High Rock Inflows, 1991
Inflow (cfs)
60,000
50,000
40,000
30,000
20,000
10,000
0
1/1/1991 1/31/1991 3/2/1991 4/2/1991 5/2/1991 6/2/1991 7/2/1991 8/1/1991 9/1/1991 10/1/1991 11/1/1991 12/1/1991 1/1/1992
Date
Fill-in Inflows
Flow Extractor Inflows


High Rock Inflows, 1987
Inflow (cfs)
60,000
50,000
40,000
30,000
20,000
10,000
0
1/1/1987 1/31/1987 3/2/1987 4/2/1987 5/2/1987 6/2/1987 7/2/1987 8/1/1987 9/1/1987 10/1/1987 11/1/1987 12/1/1987 1/1/1988
Date
Fill-in Inflows
Flow Extractor Inflows



Comparison Conclusions

- Neither data set is “correct”
- On an average annual basis, the USGS based inflows are on average 8% higher than the Yadkin calculated inflows (1980 to 2002)

Yadkin College, Rockingham, and Pee Dee Gage Flow Comparisons

- USGS-based flows (“Approach 3”)
- USGS measured flows at gage locations

- Complete agreement between the datasets

Inflow Dataset Development Conclusions

- Utilizing inflow dataset Approach 3
- Dataset development is complete
- High level of confidence in dataset
- Data to be reviewed the USGS

Calibration and Verification

Calibration

- Calibration:
  - Use the model to reproduce Project operations (water levels, stream flows, and generation) that were measured over a certain time interval
  - Model parameters are adjusted, or calibrated, until the model is able to reproduce historical conditions

Verification

- Verification:
  - Apply the calibrated model to reproduce Project operations measured over a time interval different from the calibration interval

Purpose of Calibration / Verification

- Purpose:
  - To show that for a range of inflow and headwater conditions, the model can accurately reproduce historic operations
  - Once the model can accurately predict historical operations, it can be used with confidence to analyze future operating scenarios

Calibration / Verification

- Performed using revised Yadkin measured data
  - Data adjusted to balance flow between developments
  - Turbine performance curves adjusted
  - High Rock storage elevation relationship adjusted
- Match historical stage and compare computed energy and discharges to historical

Calibration / Verification Years

- Calibration Years:
  - 1995
  - 1998
- Verification Years:
  - 1990 (Wet Year)
  - 1997 (Average Year)
  - 2000 (Dry Year)

  - 2001 (Additional Dry Year at Request of IAG)

Selection of Calibration Years

AVERAGE ANNUAL INFLOW		
Rank	Flow (cfs)	Year
1	6,591	1990
2	5,692	1993
3	5,573	1984
4	5,467	1989
5	5,464	1987
6	5,349	1983
7	5,282	1991
8	5,075	1996
9	5,026	1998
10	5,022	1992
11	4,888	1994
12	4,827	1995
13	4,774	1980
14	4,431	1982
15	4,154	1997
16	3,554	1985
17	2,614	1999
18	2,466	1981
19	2,417	1988
20	2,250	1986
21	2,213	2002
22	2,150	2000
23	1,547	2001
Average	4,210	

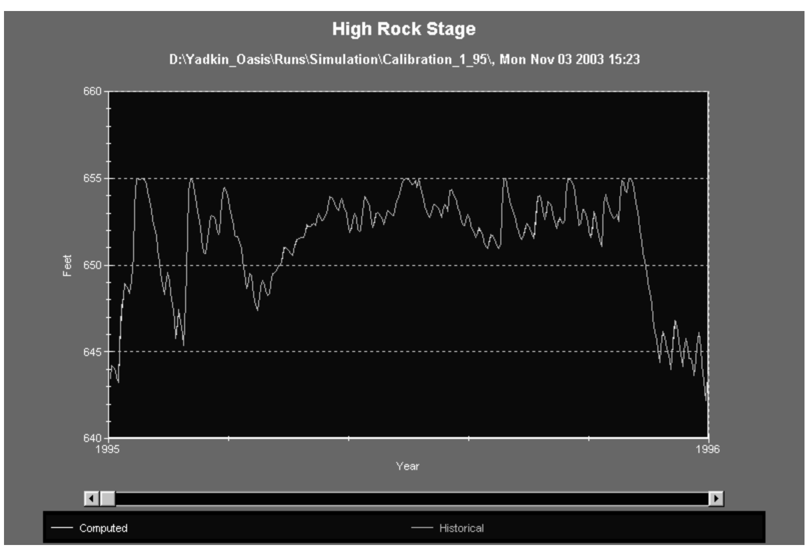
Selection of Calibration Year - 1995

AVERAGE QUARTERLY INFLOW							
Year	Average Inflow 1st QTR	Year	Average Inflow 2nd QTR	Year	Average Inflow 3rd QTR	Year	Average Inflow 4th QTR
1993	12,238	1987	7,737	1989	4,558	1990	7,751
1990	9,416	1983	7,638	1984	4,349	1989	6,673
1998	9,372	1991	7,569	1994	4,338	1992	5,841
1994	8,593	1984	7,522	1996	4,053	1995	5,013
1991	8,374	1998	7,281	1995	3,808	1996	4,683
1984	8,264	1980	7,133	1987	3,166	1983	4,658
1987	8,235	1992	6,836	1985	2,986	2002	4,586
1980	7,557	1990	6,607	1992	2,893	1985	4,061
1983	7,292	1993	6,158	1991	2,863	1982	3,711
1996	7,218	1997	5,903	1990	2,650	1987	2,804
1995	6,652	1982	5,433	1982	2,531	1994	2,768
1997	6,332	1989	5,053	1980	2,256	1986	2,758
1982	6,097	1996	4,363	1997	2,160	1991	2,413
1989	5,583	1994	3,922	1993	2,128	1993	2,392
1992	4,532	1995	3,862	1983	1,876	1997	2,289
1985	4,461	1981	3,071	1981	1,812	1988	2,210
1999	4,105	1999	2,915	1998	1,747	1984	2,209
1988	3,615	1985	2,720	1999	1,714	1980	2,208
2000	3,504	2000	2,684	1988	1,545	1981	2,086
1986	3,187	1988	2,312	2000	1,432	1999	1,919
1981	2,913	1986	1,702	1986	1,368	1998	1,824
2001	2,610	2001	1,687	2001	1,078	2000	1,001
2002	2,464	2002	945	2002	848	2001	837
Average	6,201		4,828		2,529		3,335

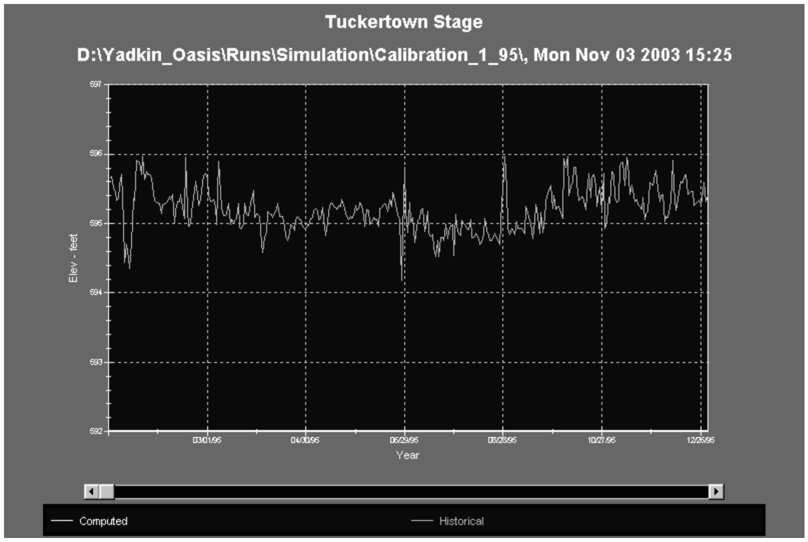
Selection of Calibration Year - 1998

AVERAGE QUARTERLY INFLOW							
Year	Average Inflow 1st QTR	Year	Average Inflow 2nd QTR	Year	Average Inflow 3rd QTR	Year	Average Inflow 4th QTR
1993	12,238	1987	7,737	1989	4,558	1990	7,751
1990	9,416	1983	7,638	1984	4,349	1989	6,673
1998	9,372	1991	7,569	1994	4,338	1992	5,841
1994	8,593	1984	7,522	1996	4,053	1995	5,013
1991	8,374	1998	7,281	1995	3,808	1996	4,683
1984	8,264	1980	7,133	1987	3,166	1983	4,658
1987	8,235	1992	6,836	1985	2,986	2002	4,586
1980	7,557	1990	6,607	1992	2,893	1985	4,061
1983	7,292	1993	6,158	1991	2,863	1982	3,711
1996	7,218	1997	5,903	1990	2,650	1987	2,804
1995	6,652	1982	5,433	1982	2,531	1994	2,768
1997	6,332	1989	5,053	1980	2,256	1986	2,758
1982	6,097	1996	4,363	1997	2,160	1991	2,413
1989	5,583	1994	3,922	1993	2,128	1993	2,392
1992	4,532	1995	3,862	1983	1,876	1997	2,289
1985	4,461	1981	3,071	1981	1,812	1988	2,210
1999	4,105	1999	2,915	1998	1,747	1984	2,209
1988	3,615	1985	2,720	1999	1,714	1980	2,208
2000	3,504	2000	2,684	1988	1,545	1981	2,086
1986	3,187	1988	2,312	2000	1,432	1999	1,919
1981	2,913	1986	1,702	1986	1,368	1998	1,824
2001	2,610	2001	1,687	2001	1,078	2000	1,001
2002	2,464	2002	945	2002	848	2001	837
Average	6,201		4,828		2,529		3,335

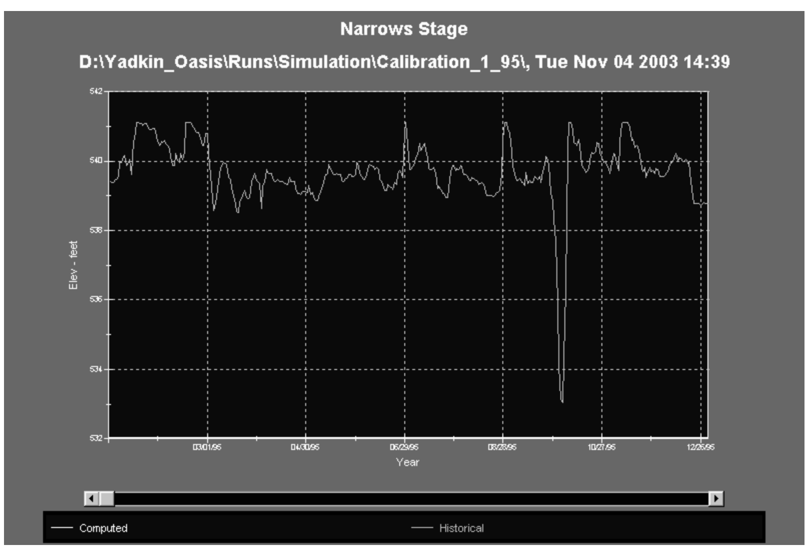
1995 – High Rock Headwater Elevations



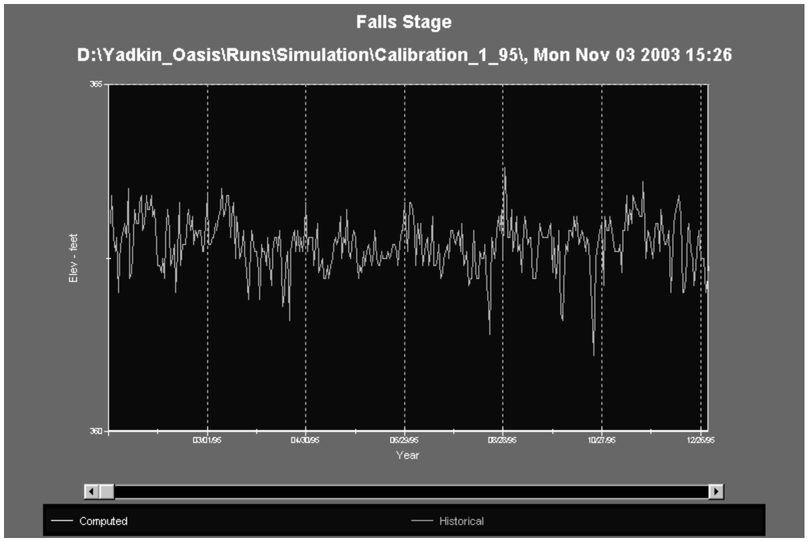
1995 – Tuckertown Headwater Elevations



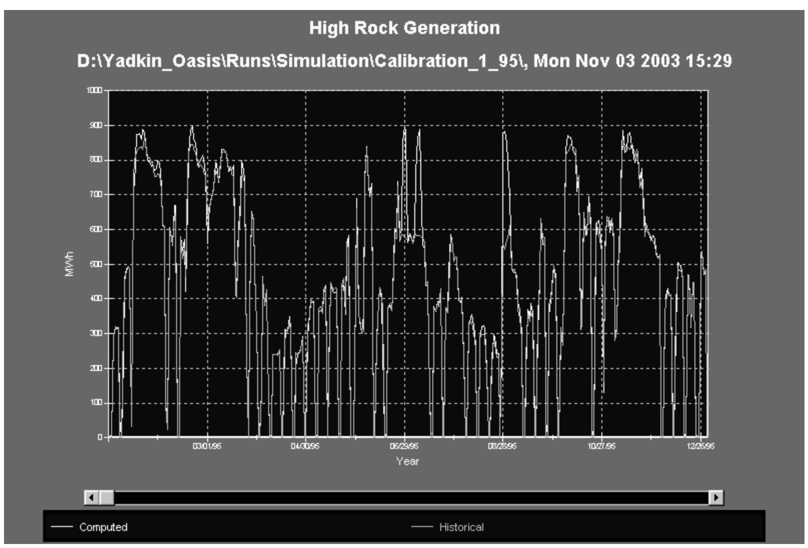
1995 – Narrows Headwater Elevations



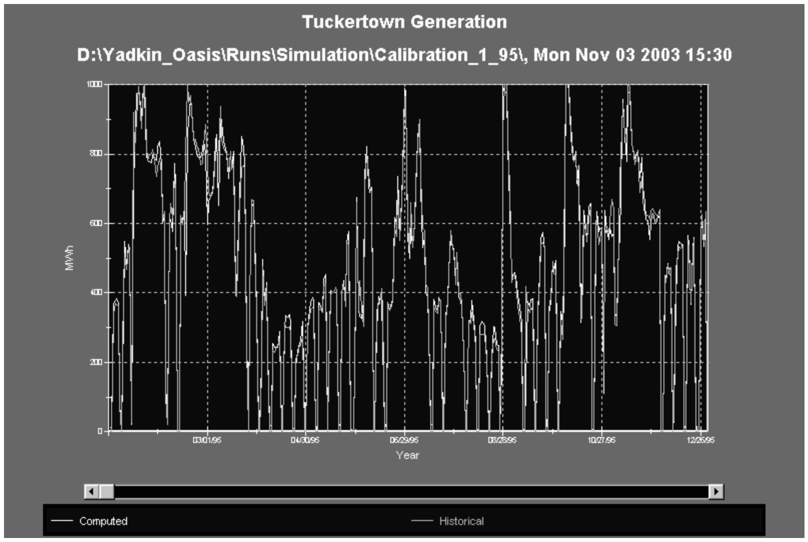
1995 – Falls Headwater Elevations



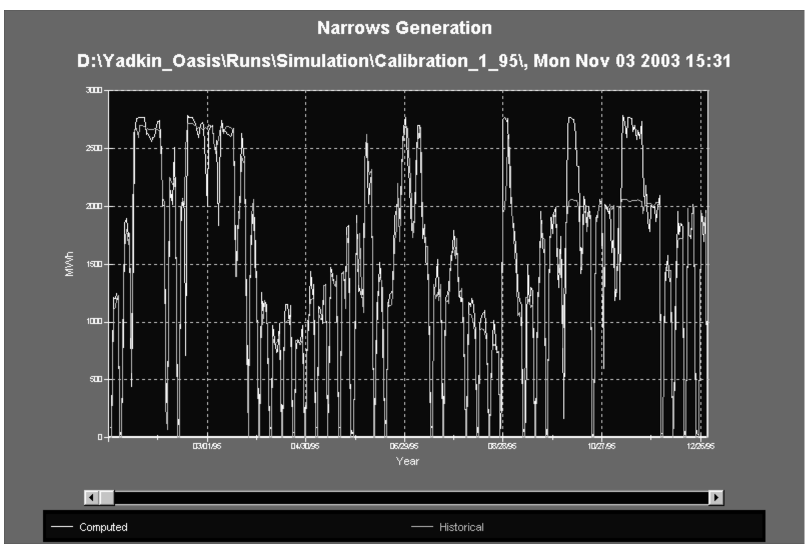
1995 – High Rock Generation



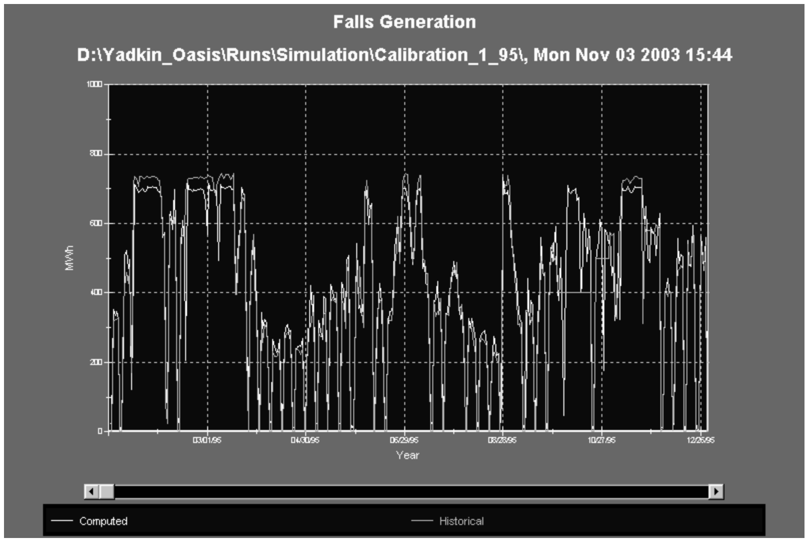
1995 – Tuckertown Generation



1995 – Narrows Generation



1995 – Falls Generation



Calibration Results - 1995

1995	Simulated (MWh)	Historical (MWh)	Deviation (%)
High Rock	164,000	159,000	2.6%
Tuckertown	168,000	168,000	0.1%
Narrows	550,000	537,000	2.4%
Falls	151,000	149,000	1.7%
Total	1,033,000	1,013,000	2.0%

Calibration Results - 1998

1998	Simulated (MWh)	Historical (MWh)	Deviation (%)
High Rock	153,000	154,000	-0.7%
Tuckertown	159,000	149,000	6.6%
Narrows	500,000	488,000	2.4%
Falls	128,000	135,000	-5.2%
Total	940,000	926,000	1.5%

Selection of Verification Years

AVERAGE ANNUAL INFLOW		
Rank	Flow (cfs)	Year
1	6,591	1990
2	5,692	1993
3	5,573	1984
4	5,467	1989
5	5,464	1987
6	5,349	1983
7	5,282	1991
8	5,075	1996
9	5,026	1998
10	5,022	1992
11	4,888	1994
12	4,827	1995
13	4,774	1980
14	4,431	1982
15	4,154	1997
16	3,554	1985
17	2,614	1999
18	2,466	1981
19	2,417	1988
20	2,250	1986
21	2,213	2002
22	2,150	2000
23	1,547	2001
Average	4,210	

Selection of Verification Year - 1990

AVERAGE QUARTERLY INFLOW										
Year	Average Inflow 1st QTR		Year	Average Inflow 2nd QTR		Year	Average Inflow 3rd QTR		Year	Average Inflow 4th QTR
1993	12,238		1987	7,737		1989	4,558		1990	7,751
1990	9,416		1983	7,638		1984	4,349		1989	6,673
1998	9,372		1991	7,569		1994	4,338		1992	5,841
1994	8,593		1984	7,522		1996	4,053		1995	5,013
1991	8,374		1998	7,281		1995	3,808		1996	4,683
1984	8,264		1980	7,133		1987	3,166		1983	4,658
1987	8,235		1992	6,836		1985	2,986		2002	4,586
1980	7,557		1990	6,607		1992	2,893		1985	4,061
1983	7,292		1993	6,158		1991	2,863		1982	3,711
1996	7,218		1997	5,903		1990	2,650		1987	2,804
1995	6,652		1982	5,433		1982	2,531		1994	2,768
1997	6,332		1989	5,053		1980	2,256		1986	2,758
1982	6,097		1996	4,363		1997	2,160		1991	2,413
1989	5,583		1994	3,922		1993	2,128		1993	2,392
1992	4,532		1995	3,862		1983	1,876		1997	2,289
1985	4,461		1981	3,071		1981	1,812		1988	2,210
1999	4,105		1999	2,915		1998	1,747		1984	2,209
1988	3,615		1985	2,720		1999	1,714		1980	2,208
2000	3,504		2000	2,684		1988	1,545		1981	2,086
1986	3,187		1988	2,312		2000	1,432		1999	1,919
1981	2,913		1986	1,702		1986	1,368		1998	1,824
2001	2,610		2001	1,687		2001	1,078		2000	1,001
2002	2,464		2002	945		2002	848		2001	837
Average	6,201			4,828			2,529			3,335

Selection of Verification Year - 1997

AVERAGE QUARTERLY INFLOW										
Year	Average Inflow 1st QTR		Year	Average Inflow 2nd QTR		Year	Average Inflow 3rd QTR		Year	Average Inflow 4th QTR
1993	12,238		1987	7,737		1989	4,558		1990	7,751
1990	9,416		1983	7,638		1984	4,349		1989	6,673
1998	9,372		1991	7,569		1994	4,338		1992	5,841
1994	8,593		1984	7,522		1996	4,053		1995	5,013
1991	8,374		1998	7,281		1995	3,808		1996	4,683
1984	8,264		1980	7,133		1987	3,166		1983	4,658
1987	8,235		1992	6,836		1985	2,986		2002	4,586
1980	7,557		1990	6,607		1992	2,893		1985	4,061
1983	7,292		1993	6,158		1991	2,863		1982	3,711
1996	7,218		1997	5,903		1990	2,650		1987	2,804
1995	6,652		1982	5,433		1982	2,531		1994	2,768
1997	6,332		1989	5,053		1980	2,256		1986	2,758
1982	6,097		1996	4,363		1997	2,160		1991	2,413
1989	5,583		1994	3,922		1993	2,128		1993	2,392
1992	4,532		1995	3,862		1983	1,876		1997	2,289
1985	4,461		1981	3,071		1981	1,812		1988	2,210
1999	4,105		1999	2,915		1998	1,747		1984	2,209
1988	3,615		1985	2,720		1999	1,714		1980	2,208
2000	3,504		2000	2,684		1988	1,545		1981	2,086
1986	3,187		1988	2,312		2000	1,432		1999	1,919
1981	2,913		1986	1,702		1986	1,368		1998	1,824
2001	2,610		2001	1,687		2001	1,078		2000	1,001
2002	2,464		2002	945		2002	848		2001	837
Average	6,201			4,828			2,529			3,335

Selection of Verification Year - 2000

AVERAGE QUARTERLY INFLOW										
Year	Average Inflow 1st QTR		Year	Average Inflow 2nd QTR		Year	Average Inflow 3rd QTR		Year	Average Inflow 4th QTR
1993	12,238		1987	7,737		1989	4,558		1990	7,751
1990	9,416		1983	7,638		1984	4,349		1989	6,673
1998	9,372		1991	7,569		1994	4,338		1992	5,841
1994	8,593		1984	7,522		1996	4,053		1995	5,013
1991	8,374		1998	7,281		1995	3,808		1996	4,683
1984	8,264		1980	7,133		1987	3,166		1983	4,658
1987	8,235		1992	6,836		1985	2,986		2002	4,586
1980	7,557		1990	6,607		1992	2,893		1985	4,061
1983	7,292		1993	6,158		1991	2,863		1982	3,711
1996	7,218		1997	5,903		1990	2,650		1987	2,804
1995	6,652		1982	5,433		1982	2,531		1994	2,768
1997	6,332		1989	5,053		1980	2,256		1986	2,758
1982	6,097		1996	4,363		1997	2,160		1991	2,413
1989	5,583		1994	3,922		1993	2,128		1993	2,392
1992	4,532		1995	3,862		1983	1,876		1997	2,289
1985	4,461		1981	3,071		1981	1,812		1988	2,210
1999	4,105		1999	2,915		1998	1,747		1984	2,209
1988	3,615		1985	2,720		1999	1,714		1980	2,208
2000	3,504		2000	2,684		1988	1,545		1981	2,086
1986	3,187		1988	2,312		2000	1,432		1999	1,919
1981	2,913		1986	1,702		1986	1,368		1998	1,824
2001	2,610		2001	1,687		2001	1,078		2000	1,001
2002	2,464		2002	945		2002	848		2001	837
Average	6,201			4,828			2,529			3,335

Selection of Verification Year - 2001

AVERAGE QUARTERLY INFLOW										
Year	Average Inflow 1st QTR		Year	Average Inflow 2nd QTR		Year	Average Inflow 3rd QTR		Year	Average Inflow 4th QTR
1993	12,238		1987	7,737		1989	4,558		1990	7,751
1990	9,416		1983	7,638		1984	4,349		1989	6,673
1998	9,372		1991	7,569		1994	4,338		1992	5,841
1994	8,593		1984	7,522		1996	4,053		1995	5,013
1991	8,374		1998	7,281		1995	3,808		1996	4,683
1984	8,264		1980	7,133		1987	3,166		1983	4,658
1987	8,235		1992	6,836		1985	2,986		2002	4,586
1980	7,557		1990	6,607		1992	2,893		1985	4,061
1983	7,292		1993	6,158		1991	2,863		1982	3,711
1996	7,218		1997	5,903		1990	2,650		1987	2,804
1995	6,652		1982	5,433		1982	2,531		1994	2,768
1997	6,332		1989	5,053		1980	2,256		1986	2,758
1982	6,097		1996	4,363		1997	2,160		1991	2,413
1989	5,583		1994	3,922		1993	2,128		1993	2,392
1992	4,532		1995	3,862		1983	1,876		1997	2,289
1985	4,461		1981	3,071		1981	1,812		1988	2,210
1999	4,105		1999	2,915		1998	1,747		1984	2,209
1988	3,615		1985	2,720		1999	1,714		1980	2,208
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1981	2,913		1986	1,702		1986	1,368		1998	1,824
2001	2,610		2001	1,687		2001	1,078		2000	1,001
2002	2,464		2002	945		2002	848		2001	837
Average	6,201			4,828			2,529			3,335

Verification Results - 1990

1990	Simulated (MWh)	Historical (MWh)	Deviation (%)
High Rock	199,000	192,000	3.9%
Tuckertown	202,000	204,000	-1.2%
Narrows	652,000	651,000	0.2%
Falls	177,000	178,000	-0.8%
Total	1,230,000	1,225,000	0.4%

Verification Results - 1997

1997	Simulated (MWh)	Historical (MWh)	Deviation (%)
High Rock	134,000	131,000	2.0%
Tuckertown	139,000	142,000	-1.8%
Narrows	445,000	427,000	4.2%
Falls	122,000	127,000	-3.8%
Total	840,000	827,000	1.6%

Verification Results - 2000

2000	Simulated (MWh)	Historical (MWh)	Deviation (%)
High Rock	71,000	69,000	2.5%
Tuckertown	76,000	78,000	-2.9%
Narrows	246,000	252,000	-2.6%
Falls	68,000	65,000	4.8%
Total	461,000	464,000	-0.8%

Verification Results - 2001

2001	Simulated (MWh)	Historical (MWh)	Deviation (%)
High Rock	51,000	49,000	4.6%
Tuckertown	54,000	53,000	1.6%
Narrows	183,000	180,000	2.0%
Falls	49,000	47,000	4.3%
Total	337,000	329,000	2.6%

Calibration and Verification Conclusions

- Calibration and verification completed for a wide range of inflow conditions
- Calibration and verification complete
- Model ready for use

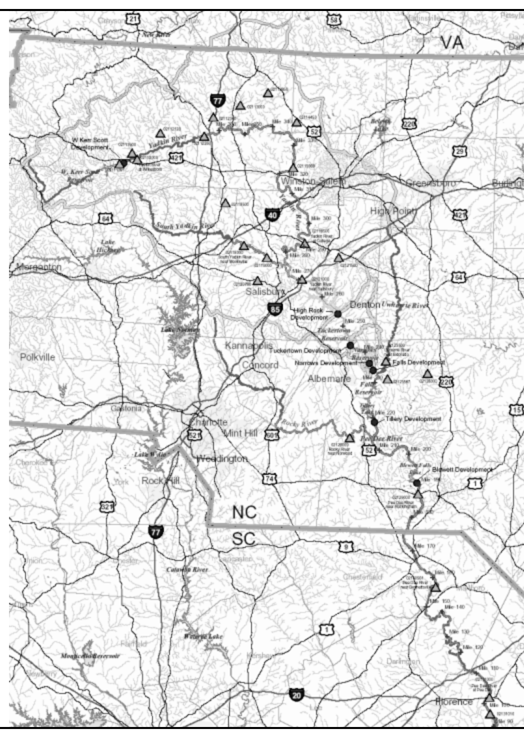
Status of Model and Inflow Dataset

- Model
  - Constructed
  - Calibrated and verified

- Inflow dataset
  - Development complete (Approach 3)
  - Reviewed by Progress Energy and DTA
  - Awaiting review by USGS

Complementary Models

- APGI using the OASIS model
  - Model includes nodes upstream to the W. Kerr Scott Reservoir and downstream to the USGS gage at Pee Dee, SC
  - Model includes detailed information upstream of High Rock Reservoir
  - Model will be used to perform detailed analysis of Yadkin development flows, reservoir elevations, and generation
  - Model will utilize the 75-year daily inflow dataset
- Progress Energy using CHEOPS and RMS4 models
  - Model includes detailed information downstream of Blewett Falls
  - Model includes detailed analysis of Progress Energy generation
  - PE will develop hourly flow data, as needed, for analysis of its facilities and downstream releases



Proposed Complementary Models Use

- As alternatives are more clearly defined/narrowed, complementary modeling would be used
- OASIS would determine impacts at APGI developments, including generation impacts
- CHEOPS and RMS4 would be used to determine impact on PE facilities and downstream area in NC and SC
- APGI would run OASIS and provide computed Falls discharge data to PE
- PE would use this daily flow data set as input to CHEOPS and continue the run downstream