MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Operations RCG Meeting

January 30, 2014

Final KDM 03-27-14

ATTENDEES:

Vivianne Vejdani (SCDNR)
Dick Christie (SCDNR)
Scott Harder (SCDNR)
Steve Summer (SCANA)
Gerrit Jobsis (American Rivers)
Fritz Rohde (NOAA) via Conf. Call
Joseph Wojcicki (By-PAS) via Conf. Call
J. Hagood Hamilton, Jr. (SCANA)
Byron Hamstead (USFWS) via Conf. Call
Bill Stangler (Congaree Riverkeeper)
Bill Argentieri (SCE&G)
Ray Ammarell (SCE&G)
Kelly Miller (Kleinschmidt)
Henry Mealing (Kleinschmidt)
Bill Marshall (SCDNR)
Bruce Halverson (Kleinschmidt) via Conf. Call
Bret Hoffman (Kleinschmidt)

These notes serve to be a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Henry opened the meeting with introductions and a review of the agenda. Comments on the Operations Model Study Plan were submitted by SCDNR prior to the meeting on January 15, 2014 via email and these comments, in addition to review of the Study Plan, served as the basis for discussion throughout the meeting. Comments are provided below, along with a summary of the group's corresponding discussion. The original email in which comments were submitted is attached to the end of these notes.

1. In a prior Parr-FF operations committee meeting, there was a discussion about determining the effects of the Parr Hydro on the Congaree National Park. However, from the draft report, models will only be used to assess operations to approximately 20 miles downstream. Is the study component to address Congaree NP still on the table?

Ray said that he believes the Congaree National Park (CNP) is outside of the area of Project effects. However any effects to the CNP will come when SCE&G spills water over the dam. Gerrit said there will be project effects downstream, even if they are muted by the other projects in the area. The group agreed that input was needed from representatives at the CNP to determine what flows might harm or benefit the park. The group estimated that the Project is approximately 45 miles upstream of the CNP. Bret said that the confluence of the Saluda River and two hydro projects between the Parr dam and the CNP presented so many variables that it would be difficult to accurately model. He said a statistical evaluation of flows within a range of Project effects at the CNP would be possible.

Kleinschmidt

Ray pointed out that there is a storage limitation within Parr Reservoir, and so there is not much flexibility in terms of inundating the CNP. Additionally, through Article 39 of the current license, the Project cannot increase flow releases during a flood, which SCE&G has currently established as 40,000 cfs. Gerrit said there are incremental flooding levels that occur at CNP, starting at 8,000 cfs. Gerrit is concerned with how pulsing releases from Parr Shoals Dam may affect the park downstream. He also said effects to fish spawning near the confluence of the Broad and Saluda Rivers need to be examined.

Bret said that the Project Operations Model will include attenuation affects. He also said the operators of Columbia Hydro can absorb some of the smaller releases from Parr by fluctuating their storage reservoir, which is allowed in the current license for that project.

2. Refer to the discussion of metrics in section 2.4. Though we generally support the use of metrics to facilitate the reviews of various scenarios, metrics should be modified or added as needed during the scenario review process. As we have seen in other modeling efforts, defining initial metrics (or more appropriately when a given metric value denotes a significant change or impact) without reviewing the baseline and a few scenario outputs can be problematic. If metrics aren't defined carefully, then discerning the differences between two scenarios can be difficult.

Bret began discussion of this comment by saying that stakeholders can request specific metrics to be examined, and the model will be run to determine how these metrics may be affected by project operations. Scott asked if specific metrics can be identified initially with the option to go back and adjust those metrics for further or different analysis. Bret said that there will definitely be flexibility for adjustment to those requests.

Dick pointed out that information collected as part of the IFIM study, reservoir fluctuation study, navigational flows study, recreational flows study, and possibly others, will be used with the model. Gerrit said that the operations model will also be important for the Dual Flow analysis component of the IFIM study. He said that the compatibility of the Dual Flow analysis and the operations model output should be considered before the operations model is fully developed.

3. We are was pleased to see the Enoree Gages will be used to evaluate regional relationships between runoff and drainage area, as we would recommend use of these gages to help develop an inflow data set. Appropriate error analysis should accompany the determination of the regional alpha and gamma coefficients presented in section 4.1.

Bruce said that sensitivity or uncertainty analysis, also known as error analysis, will definitely be a part of the process. Scott said that he would like to see a report on the development of the inflow data set added as an appendix to the final operations study report. He would like to have enough information on the inflow data set used so that he may reproduce the data set for independently running the model. Bruce said that the hydrology data set would be developed as a separate task early in the process. A report will be developed and distributed to the RCG describing how the inflow data set was prepared.

The group then discussed what time stamp will be used with the model. Scott said that an hourly interval should be considered. Ray said the model should use hourly data to provide a finer look at project effects, especially considering the fluctuation schedule of the project. Bruce said that hourly data can be used for specific events so that more information is available, however for long term

statistics, daily data would be sufficient. The time interval used could be determined based on the specific metric being examined. Scott said that data should be collected from the various sources as far back as possible. The most current data collected should be used to calibrate the longer period of record. Scott raised the idea of developing hourly inflow data from USGS gages. Data availability for this would be considered, in addition to the potential usefulness for hourly model time stamps.

4. In section 4.1.2, it is unclear whether or not the back calculation of the inflow hydrograph will be done or not.

Bruce said that an inflow data set will be developed based upon upstream gages. The group agreed to remove section 4.1.2 from the Operations Model Study Plan, as back calculation would be limited to only a few years and much more difficult than using upstream gages.

5. There is no mention of incorporating water use projections in the modeling process. We would recommend water use projections be included. It may be possible to build on previous projections done for the basin by Duke Energy (and any projections done by North Carolina, if available).
Note: If Duke's projections were used they would need to be carefully reviewed and likely modified because -- (1) the projections are somewhat dated (2006), (2) experience with projections by Duke energy in the Catawba basin within the past 10 years indicate they tend to overestimate water use projections, and (3) changes in energy sources (and perhaps demand) over the past several years in the energy industry could have a large impact on future water needs for energy in the basin that may not be accounted for the in the Duke projections.

Bill A. said that it only matters what water is coming into the Project because what is occurring above the Project is outside of SCE&G control. However, there have been requests for a municipal water supply withdrawal from Monticello Reservoir. This will need to be examined as part of the operations model. Ray said that there are no intervening withdrawals between the Project and the gages that will be used in the Operations model.

Scott asked if the model will take into account future energy demands and how that will affect flows. He mentioned that Duke Energy did a study on the projected water uses for the area surrounding their projects. He said this study should be examined to see if it is applicable to the Parr Fairfield Project as it may offer some important insight into future water demands and how that may affect the Project. However, since this information is considered speculative, SCE&G will not base the entire operations study on it; it may be used to run a specific scenario. Internally SCE&G will be looking at the expected energy needs for Parr and Monticello for the next several years.

6. We request the SCDNR (and other stakeholders) be provided with the baseline HEC Res Sim operations model and the HEC-RAS hydraulic model and have the ability to independently run the models and review outputs. Any proposed scenarios should be carefully documented so that SCDNR staff can independently make appropriate edits to the model (or alternatively, the consultants can provide updated models with loaded scenarios on a periodic basis). In addition, we would request a one day seminar or training session be scheduled for stakeholders to introduce the baseline models and provide limited training on use and running of the models.

Before discussion began on this comment, Scott said that instead of a training session, he would like for there to be an introduction to the model and a demonstration, for those who are interested. Scott

said this will help him and others to determine what scenarios they would like to be run. Bruce said that an introduction to the model and a demonstration can definitely be scheduled after the model is complete, however an actual training session is not feasible. Scott said he is mostly interested in learning more about the HEC-Res model in particular, but would like to see a demonstration of HEC-RAS as well. Byron, Fritz and others agreed that they would be interested in attending the model demonstration.

The group agreed that a preliminary report including model rules and parameters will be developed and submitted to stakeholders for comment, and adjustments will then be made based on comments received. After adjustments are made, there will be a demonstration of the model for any interested stakeholders. The baseline model will then be finalized. Following finalization of the model, the requested scenarios will be run and a final report summarizing the results will be issued.

The group then discussed how the various scenarios will be compared to each other. Gerrit suggested that SCE&G could decide on a specific number of scenarios to be run and stakeholders and TWCs could request which scenarios they want to see. The information gathered from each scenario would then be distributed to the appropriate TWC and joint meetings may be scheduled to discuss the results.

7. Though we understand the challenges or producing an operations model that can mimic all historic operations, we would request the consultants to elaborate on any criteria used to determine whether the model is functioning adequately enough. For example, in section 4.3.1 at the end of the first paragraph, what is meant by the average expected system response?

The goal of the operations model is to establish rules that show how the Project is normally operated, and apply requests from stakeholders to determine how they can be balanced using the available resources. The model will be based on typical operating parameters, rather than unusual or emergency circumstances. Gerrit said that we should be most interested in the average, not necessarily outliers, such as outages. Scott said we need to make sure we have a baseline. He said that this Project is complex due to the pumpback operation and it will be difficult to match what is shown on the Alston gage. The best way to validate the model will be to look at a day when the Project is in a normal operating cycle so that information from the model and from Alston can be compared.

After the meeting, Gerrit submitted the following comments via email.

- In addition to project effects on the Park, it is important to understand the effects of project operations on sturgeon and striped bass spawning in the Columbia hydro project bypass reach and Congaree River. Shortnose sturgeon are known to occur and spawn in this vicinity.
- The operational model will be important for the Dual Flow analysis to be conducted under the IFIM study. How the Ops Model/output can be made compatible [to the] Dual Flow analysis should be determined before the model is fully developed.
- Existing and projected City of Columbia's water withdrawals and the same for any other downstream water withdrawals need to be taken into account in the Ops model and ultimately [in the] operational requirements.
- Future changes in upstream water use should be included in operational scenarios and adaptive management plans (i.e. low inflow protocol) for the new license.

Edits made to the Operations Model Study Plan were captured in track changes during the meeting and are attached to the end of these notes. Action items stemming from this meeting are included below.

ACTION ITEMS:

- SCE&G and Kleinschmidt will perform research to determine if there are any significant water withdraws planned for downstream of the Project.
- Kleinschmidt will make the requested changes to the Operations Model Study Plan and submit to the RCG for approval.
- Kleinschmidt will examine the availability of hourly USGS flow data for the upstream gages proposed in the Study Plan.

From: Bill Marshall
To: Kelly Miller
Cc: Scott Harder
Subject: Comments on Draft Hydraulic & Project Operations Model, Parr Hydro Project
Date: Wednesday, January 15, 2014 3:04:37 PM

Hi Kelly,

DNR hydrology staff have reviewed the draft operations model study plan and we are providing comments and questions for consideration as the RCG continues developing the plan and prepares for meeting on Jan 30. DNR comments and questions are as follows:

1. In a prior Parr-FF operations committee meeting, there was a discussion about determining the effects of the Parr Hydro on the Congaree National Park. However, from the draft report, models will only be used to assess operations to approximately 20 miles downstream. Is the study component to address Congaree NP still on the table?

2. Refer to the discussion of metrics in section 2.4. Though we generally support the use of metrics to facilitate the reviews of various scenarios, metrics should be modified or added as needed during the scenario review process. As we have seen in other modeling efforts, defining initial metrics (or more appropriately when a given metric value denotes a significant change or impact) without reviewing the baseline and a few scenario outputs can be problematic. If metrics aren't defined carefully, then discerning the differences between two scenarios can be difficult.

3. We are was pleased to see the Enoree Gages will be used to evaluate regional relationships between runoff and drainage area, as we would recommend use of these gages to help develop an inflow data set. Appropriate error analysis should accompany the determination of the regional alpha and gamma coefficients presented in section 4.1.

4. In section 4.1.2, it is unclear whether or not the back calculation of the inflow hydrograph will be done or not.

5. There is no mention of incorporating water use projections in the modeling process. We would recommend water use projections be included. It may be possible to build on previous projections done for the basin by Duke Energy (and any projections done by North Carolina, if available).

Note: If Duke's projections were used they would need to be carefully reviewed and likely modified because -- (1) the projections are somewhat dated (2006), (2) experience with projections by Duke energy in the Catawba basin within the past 10 years indicate they tend to overestimate water use projections, and (3) changes in energy sources (and perhaps demand) over the past several years in the energy industry could have a large impact on future water needs for energy in the basin that may not be accounted for the in the Duke projections.

6. We request the SCDNR (and other stakeholders) be provided with the baseline HEC Res Sim operations model and the HEC-RAS hydraulic model and have the ability to independently run the models and review outputs. Any proposed scenarios should be carefully documented so that SCDNR

staff can independently make appropriate edits to the model (or alternatively, the consultants can provide updated models with loaded scenarios on a periodic basis). In addition, we would request a one day seminar or training session be scheduled for stakeholders to introduce the baseline models and provide limited training on use and running of the models.

7. Though we understand the challenges or producing an operations model that can mimic all historic operations, we would request the consultants to elaborate on any criteria used to determine whether the model is functioning adequately enough. For example, in section 4.3.1 at the end of the first paragraph, what is meant by the average expected system response?

Thank you for consideration of our comments and questions.

Bill Marshall
SCDNR

From: Kelly Miller [mailto:Kelly.Miller@KleinschmidtUSA.com]
Sent: Monday, December 16, 2013 8:56 AM
To: Alison Jakupca; BARGENTIERI@scana.com; Bill Marshall; Bill Stangler (CRK@congareeriverkeeper.org); Bret Hoffman; Byron Hamstead (Byron_hamstead@fws.gov); Dick Christie (dchristie@comporium.net); Frank_Henning@nps.gov; Gerrit Jobsis (gjobsis@americanrivers.org); Henry Mealing; J. Hagood Hamilton Jr. (jhamilton@scana.com); Jay Maher; Joe Wojcicki; Kelly Miller; Malcolm Leaphart (mwleapjr@att.net); Pace Wilber (Pace.Wilber@noaa.gov); rammarell@scana.com; Randy Mahan (randolph.mahan@scana.com); Scott Harder; Steve Summer; Terri Hogan (terri_hogan@nps.gov); Tom McCoy (thomas_mccoy@fws.gov); Vivianne Vejdani; Wayne and Ginny Boland (wayneboland@bellsouth.net)
Subject: draft Project Operations Model Study Plan

All,

Attached for your review is the draft Project Operations Model Study Plan for the Parr/Fairfield Project. Please have any comments or edits back to me by Wednesday, January 15th. We will discuss this study plan at the upcoming Operations RCG meeting, scheduled for Thursday, January 30th.

Thanks,
Kelly

Kelly Miller
Regulatory Coordinator
Kleinschmidt
Office: 803.462.5633
www.KleinschmidtUSA.com

DRAFT
HYDRAULIC & PROJECT OPERATIONS MODEL

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtUSA.com

December 2013

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SOUTH CAROLINA ELECTRIC & GAS COMPANY

TABLE OF CONTENTS

1.0 INTRODUCTION ..... 1~~2~~

2.0 STUDY OBJECTIVES ..... 1~~2~~
- 2.1 HISTORIC INFLOW HYDROGRAPH DEVELOPMENT ..... 1~~2~~
- 2.2 HYDRAULIC MODELING ..... 2~~3~~
- 2.3 OPERATIONS MODEL ..... 2~~3~~
- 2.4 SCENARIO COMPARISON ..... 3~~4~~
  - 2.4.1 SUMMARY STATISTICS ..... 3~~4~~

3.0 STUDY DOMAIN ..... 3~~4~~

4.0 METHODOLOGY 4
- 4.1 INFLOW HYDROGRAPH DEVELOPMENT 4
  - 4.1.1 UPSTREAM GAGE PRORATION ..... 4~~5~~
  - 4.1.2 DOWNSTREAM GAGE WITH OPERATIONAL INFORMATION 5
- 4.2 HYDRAULIC MODELING ..... 5~~6~~
- 4.3 OPERATIONS MODEL 6
  - 4.3.1 OPERATION RULES & REGULATIONS ..... 6~~7~~
  - 4.3.2 OPERATIONS MODEL FRAMEWORK ..... 7~~8~~
- 4.4 SCENARIO COMPARISON ..... 8~~9~~
  - 4.4.1 STATISTICS ..... 8~~9~~

5.0 REPORTING ..... 9~~10~~

6.0 SCHEDULE 10

LIST OF TABLES

TABLE 1 SUMMARY OF AVAILABLE HYDROLOGIC DATA 5

DRAFT
HYDRAULIC & PROJECT OPERATIONS MODEL

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS COMPANY

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) is the Licensee of the Parr Hydroelectric Project (FERC No. 1894)(Project). The Project consists of the Parr Hydro Development and the Fairfield Pumped Storage Development. Both developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina.

This document provides a detailed outline of the process proposed to complete a Hydrologic and Project Operations Model as part of the Parr and Fairfield relicensing project. These models will be used to assess ability to provide potential changes to project operations, and the resulting effects of potential modifications to operations of the projects. These models will primarily focus on the effects that may result from proposed changes in project operation on energy, capacity, water budget, and flood control. The intent of this effort is to develop a series of high-level fully functional modeling tools, which can be used to incorporate stakeholder requests as parameters to provide outputs and results that can be easily interpreted.

2.0 STUDY OBJECTIVES

2.1 HISTORIC INFLOW HYDROGRAPH DEVELOPMENT

Critical to the operations of hydroelectric projects is the hydrology, which generally requires using the best available gage data to determine local contributing flows. Unless there is a gage immediately upstream of the project headpond, the inflows can be derived by pro-rating available gages, to account for any ungaged drainage area between the respective gages and the site, and then summing the values. Alternatively, a downstream gage can be used to back-calculate inflow using the respective daily reservoir level and evaporation estimates. The goal of

this task is to create the best available historic inflow series, which will form the input to the operations models, energy models, and habit and recreational studies.

2.2 HYDRAULIC MODELING

The operations of Parr and Fairfield may affect recreational or habitat interests on the downstream reach of the river. Rapid changes in flow result in a wave (either positive or negative) that propagates downstream, potentially affecting habitat, stream channel stability, and recreational opportunities. The hydraulics of this wave are affected by both translation and attenuation as it progresses downstream. The impacts of existing and proposed modifications to operations (if any) can best be evaluated with a 1-D hydraulic model, which will allow the evaluation of the unsteady flow wave along the downstream reach under several different operating conditions. The goal of this study is to either construct a model (or utilize an existing model) that will evaluate stage (water level), discharge, and velocity with time, along the Broad River downstream of the Parr Dam.

2.3 OPERATIONS MODEL

The Parr-Fairfield project includes several components that need to be included in an operational model. These include the Parr Dam and powerhouse hydraulic capacities, the Fairfield Pumped Storage project operational parameters (for both pumping and generating), the Monticello Reservoir, and the Parr Reservoir. The operations of this system have historically been closely coordinated for the primary purpose of supporting the electrical grid (both demand and stability). SCE&G will need to maintain this coordination during future operating conditions. Additionally, any potential changes to operations in the future will need to be evaluated for effects on dam safety, and operating rules or limitations. This is best accomplished by developing a comprehensive operation model. The goal of this task is to assess and quantify historic operations and limits, and to incorporate these rules into a comprehensive and flexible operations model that can be easily modified to simulate proposed future operations. We propose using the HEC Res Sim model to investigate headpond fluctuations and associated hydro generation hours that SCE&G could have.

2.4 SCENARIO COMPARISON

2.4.1 A process will be developed through which TWCs/RCGs and various stakeholders will submit scenarios to be run and compared to evaluate potential future operations and their effects.

~~2.4~~

2.4.2 ~~Once models are constructed,~~ The operations model will be used to run scenarios proposed by various stakeholders and submitted through TWC's or RCG's. Results will be reviewed by the RCGs/TWCs during a series of meetings. Model results will be summarized and integrated into the final recommendations presented in the license application.

~~and different operating scenarios have been run, we will summarize the results into easily compared and intelligible metrics. Without this step, the results of a given scenario or study may be lost in the details and vast quantity of data.~~

2.4.1 2.4.3 SUMMARY STATISTICS

With several integrated modeling efforts, each including possibly several different scenarios, it is critical to develop summary tables and/or summary metrics for each scenario. The goal of this task is to consider each of the studies, and the potential set of results, and develop a standardized means of summarizing and quantifying the results. As an example, it may include the number or percent of flood days changed from baseline conditions, the change in habitat area, the change in streamflow variance, or the increase/decrease in potential MWh. Using the summary statistics, stakeholders and TWC members can prioritize their requests and work to minimize the negative aspects of operational changes.

3.0 STUDY DOMAIN

The focus of this study includes the Parr Reservoir (defined as the elevation of the top of the crest gates, or El. 266.0'), the Fairfield Pumped Storage facility and the Monticello Reservoir, and the Broad River downstream of Parr Shoals Dam extending to and including Frost Shoals, near Boatwright Island.

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4.0 METHODOLOGY

4.1 INFLOW HYDROGRAPH DEVELOPMENT

Development of the inflow hydrograph can be accomplished by two methods: the use of upstream gages prorated to the dam's drainage area, or the use of the gage immediately downstream with detailed information of the project's past operations. In the case of the Parr model, the upstream gage proration method will be used, due to the limited availability of detailed Project operation data. Historic data will be reviewed to determine the period of record and time increment to be used to represent project inflow. The proposed inflow data will be reviewed by the Operations RCG for agreement.

4.1.1 UPSTREAM GAGE PRORATION

Proration of streamflow gages, in order to account for ungaged drainage area, is not necessarily a linear relationship. In order to evaluate the regional relationship between runoff and drainage area, two unregulated stream gages on the same river with overlapping records is required. The only gages that meet this in the immediate Parr Dam watershed are two gages on the Enoree River. These two gages will be used to assess an appropriate proration coefficient (α) and exponent (γ), which may be used to regionally prorate all of the gages required in construction of an historic inflow series.

An equation that may be used with the fitted regional coefficients to determine inflow to Parr is below, where the values are the ratios of the total area to gaged area for each gage location. Additionally, these gages are at different distances from the Parr Reservoir, and drain through different channels, thus the arrival times should be adjusted accordingly. The angled brackets denote a routed hydrograph series.

$$Parr\ Inflow = \langle \alpha * BRC \left(\frac{3250.8}{2790}\right)^{\gamma} \rangle + \langle \alpha * TRD \left(\frac{807.9}{759}\right)^{\gamma} \rangle + \langle \alpha * ERW \left(\frac{731.3}{444}\right)^{\gamma} \rangle$$

where,

BRC – Broad River at Carlisle
TRD – Tyger River near Delta
ERW – Enoree River at Whitmire
α – Fitted Regional Coefficient
γ – Fitted Regional Exponent
⟨...⟩ - Routed Translation

Routing will be completed using a simplified Muskingum approach, and will allow for wave attenuation and travel time, which are more critical for shorter period flows. Daily flow rates would not require this routing, as the average daily flows can simply be summed.

~~4.1.2 Downstream Gage with Operational Information~~

~~Using the USGS gage at Alston, which is immediately below the dam, provides the simplest means of determining project releases. However, back-calculating an inflow hydrograph would require data from project operations, including releases and spills from Parr, generation and pumping information from the pumped storage (or Monticello Reservoir elevations), a stage-storage curve for the Parr Reservoir, and estimates for evaporation from the reservoir. Alternatively to the pumped storage generation and pumping information, Monticello Reservoir elevations could be used, but would also require a stage-storage curve and evaporation estimates.~~

Table 1 Summary of Available Hydrologic Data

Data Source	Period of Record	Data Type
Parr Reservoir (#02160990)	10-1-1984 to Current	Stage
Broad R. at Alston (#02161000)	10-1-1896 to Current	Stage & Discharge
Congaree R. at Congaree NP (#02169625)	10-1-1984 to 8-9-2013	Stage
Broad River at Blair (#02160750)	9-11-2010 to 3-7-2013	Discharge
Broad River near Carlisle (#02156500)	10-1-1938 to Current	Stage & Discharge
Broad River below Neal Shoals (#021564493)	3-27-2012 to 9-26-2013	Stage & Discharge
Broad River at Diversion Dam (#02162100)	10-1-1987 to 9-24-2012	Stage
Enoree River at Whitmire (#02160700)	10-1-1973 to Current	Stage & Discharge
Enoree River near Woodruff (#02160390)	2-9-1993 to Current	Stage & Discharge
Tyger River near Delta (#02160105)	10-1-1973 to Current	Stage & Discharge
Fairfield Pumped Storage Generation/Flow	TBD	Discharge
Monticello Reservoir	TBD	Stage

4.2 Hydraulic Modeling

The downstream reach of the Broad River below Parr Shoals Dam will be modeled using the Army Corps of Engineers' HEC-RAS v4.1, which is a 1-dimensional model that will allow correlation between flow releases from Parr Reservoir and resulting water level stage in the river downstream. Wave travel times, rates of rise, and stage recession times will also be available from this model. Readily available data will be used for developing the model. The model will

be developed to include the hydraulic affects of flow releases down to the Frost Shoals area near Boatwright Island (approximately 20 miles downstream of the Parr Shoals Dam). The results of the model will be used to determine flow estimates for other interests in the project, such as navigation, recreation, or habitat benefits.

4.3 OPERATIONS MODEL

Development of the operations model includes two major tasks: develop the rules and patterns from historical operations, and secondly use these rules to construct a model for testing alternative scenarios. Success of this task can be measured by the ability of the model to replicate historical operations, but can also be measured by the ease and flexibility of testing future scenarios that produce easily interpreted results by stakeholders and TWC members (i.e. important information is not lost in modeling details). The operations model can become quite complicated very quickly, thus to successfully accomplish both of these goals, an appropriate model framework using the best available data is required early in the process.

4.3.1 OPERATION RULES & REGULATIONS

Not only is hydrology a stochastic process, but operating history and generation (pumping/generating) can also be stochastic as a response to weather patterns, random outages, increased grid demand, changes to grid support via addition of other generators, low flow periods, or even differences in decisions between operators using forecast data. Therefore, it is impossible to state explicit rules that define the operating regime for any of the projects, but both extreme limits (i.e. minimum/maximum pond levels, or minimum/maximum flow rates, rates of change, etc.) may be extracted from specified rules, curves, or observations of the system. Additionally, subjective operational patterns may be inferred from historic operations (i.e. typical pumping volumes in June are a certain amount, generating is typically highest during a given period of the week, etc.). Both the hard and soft rules are important for developing an understanding of conjunctive project operations. Although the rules may not exactly depict the operations at any given point in time, from either the past or the future, they should be able to depict the ~~average~~ expected system response.

Several key components of data will be concurrently analyzed:

- Pond Operating Levels (Parr Dam & Monticello Reservoir)

- Spillway gate operating guidelines
- Pumping Rates (Fairfield)
- Generation Rates (Parr & Fairfield)
- Rates of Change from Generation Flows
- Typical Generation Periods (time of day, weekday, months)
- Seasonal Influences
- Influence of low river flow conditions boundary
- Influence of high river flow conditions boundary
- Influence of water withdrawals from Monticello Reservoir
- Potential impacts of future upstream and downstream water withdrawals on Project inflow and downstream effects.

In order to appropriately define typical system responses, detailed historic information is required. This includes as available:

- Hourly (or finer) generation records for Parr & Fairfield
- Parr and Monticello Reservoir stage records
- Meteorological Data (precipitation, temperature)
- River Flow gage records

These records will be reviewed, plotted, regressed and inferred upon to develop an understanding of 'typical' system responses. Again, exact operations for a complicated system are impossible due to the stochastic nature of all influences, but typical rules may be inferred.

4.3.2 OPERATIONS MODEL FRAMEWORK

Once a comprehensive understanding and documentation of typical operating rules has been developed, they may be used within a modeling framework to replicate historic operations (validation process), and then test future or altered operating conditions.

The model will be constructed at hourly time steps to allow testing of different release rates and spilling events from the Parr Dam, and/or operating conditions at Fairfield. Longer durations may miss critical operating responses, and unnecessarily short time steps would be excessive and not add additional value. The duration of the validation period will vary based on the available data, but should cover as many sequential years as manageable.

The operations model will be developed using the Army Corps of Engineers HEC-ResSIM software package. This package is freely available, easily integrates with other models (such as

HEC-RAS), and has the capacity to model multiple projects (including the Fairfield pumped-storage) with a range of complex and even contradictory operating rules. Results of the model are easily viewed either within HEC-ResSIM, or externally using the HEC-DSSVue software package.

4.4 SCENARIO COMPARISON

From the early development of the study plan, model runs should be sufficiently detailed to outline how the projects' operations will be tested. For example, what river flows are critical (low flows to high flows) and should be emphasized? What rates of generation are important, and how quickly can they be changed? A matrix defining each scenario, and how each component of the project is being operated, should be developed. This will naturally confine modeling efforts, and maintain focused efforts for comparison by the TWC members and stakeholders.

4.4.1 STATISTICS

Statistics are valuable for concisely summarizing the nature or property of a random or stochastic variable. For example, the sample mean is commonly used to describe a set of data, but additional information may be obtained from higher order moments (variance, skew, kurtosis). The critical statistic (metric) should be determined early in the study process for each study or model output. For example, the total habitat area may be critical, the average generating rate, the 1% exceedance flow rate, the variance in water levels during a critical period, the maximum headpond level, the 7Q10 flow rate, etc. are all examples of summary statistics. These should be discussed early, and concurrence with working groups or stakeholders should be achieved early in the process to determine what is considered critical.

Additional examples of potential flow statistics include:

- Rise-Fall Rates
- Mean, Median, Quartile Flow Rates
- Variance, skew, kurtosis
- Autocorrelation Function & Partial Autocorrelation Function lags
- Flow-Duration Curves
- Excess Distribution Functions and Conditional Excess Distribution Functions
- 7Q10 flow
- 5,10,50,100-year peak flows
- Stage-Duration Curves (Parr Reservoir)

5.0 REPORTING

A preliminary report documenting the development of the operations model will be provided to the TWC for review prior to the completion of the model. This preliminary report will include the methods and information as follows:

- Discussion of model data acquisition
- Inflow hydrograph development
- Development of future inflow hydrograph(s)
- Hydraulic 1D Model Development & Calibration
- Operations Model Development & Verification
  - Parr Operations
  - Fairfield Pumping/Generating

Following a comment period, a demonstration session will be conducted to familiarize interested stakeholders with the implementation of the HEC-RES SIM and HEC RAS models for this Project. During this session, the input data and Project parameters will be reviewed, and a "hands-on" session can be conducted to allow stakeholders to learn how to run the model. After the demonstration session is conducted, the final model will be ~~development~~developed and used to analyze operations scenarios. ~~will conclude, and the implementation of the model will be conducted~~.

~~Scenarios proposed by various stakeholders and submitted through TWC's or RCG's will be incorporated into the model to determine the statistical implications of each set of parameters.~~

A final report will document methods and results as encountered in the modeling effort, including:

- Scenario Results
- Hydraulic Routing Model
- Operations Model
- Energy Modeling
- Scenario Comparison Matrices & Statistics

6.0 SCHEDULE

Data collection and model development will begin no later than the spring of 2015, with a preliminary report documenting the development of the model completed by the end of 2015. The methodology for this modeling effort may be revised or supplemented based on consultation with TWCs and other interested stakeholders. Model results will be used as an information resource during discussion of relicensing issues and developing potential Protection, Mitigation and Enhancement measures with the SCDNR, USFWS, RT&E TWC and other relicensing stakeholders. The final report, which will include the scenario results, will be completed for filing with the final license application.