Brookfield

Bear Swamp Project (FERC No. 2669)

Flow Regime Working Group Meeting

February 24, 2016

- Brookfield Renewable Energy Health & Safety Policy:

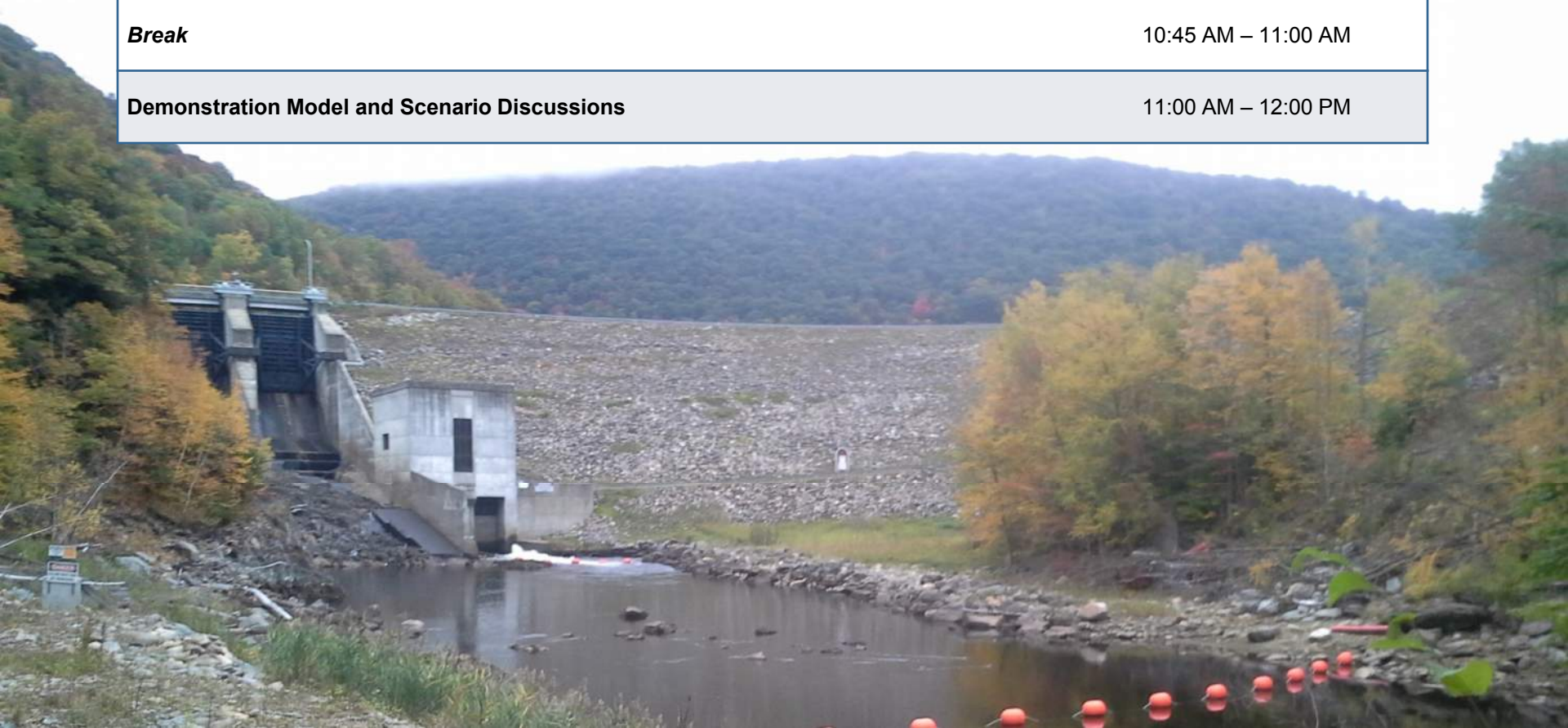
  We continuously strive to achieve excellence in safety performance and to be recognized as industry leaders in accident prevention.
- In case of emergency, we will dial 911
- Emergency exits and rally point outside
- Locations of emergency fire pulls
- Individuals trained in CPR
- Restrooms

Fife Brook Development

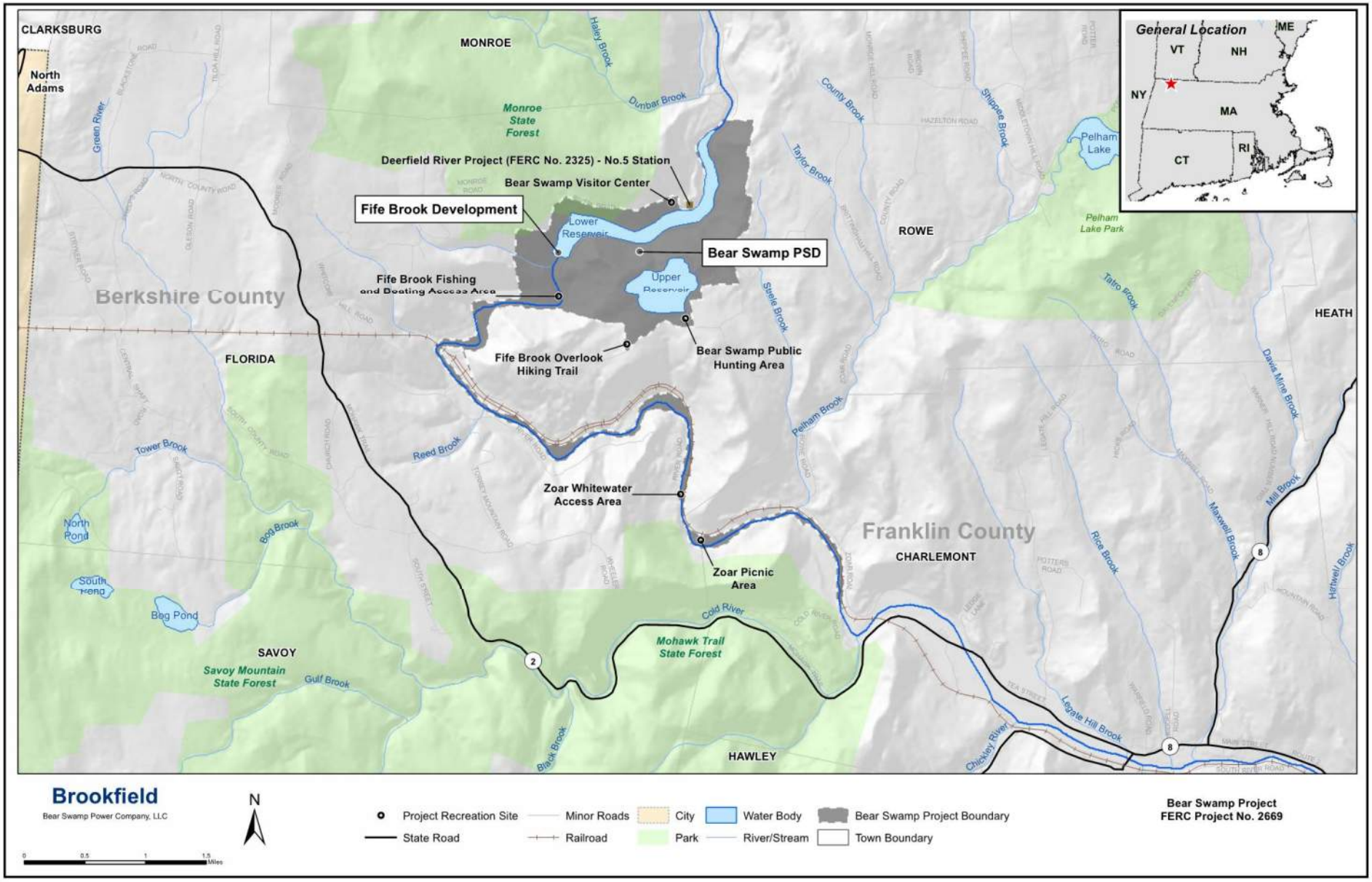
Overview, Meeting Objectives, and Agenda

Flow Regime Working Group Meeting: **Meeting Agenda**

Wednesday, February 24, 2016	Schedule
Introduction and Meeting Logistics	9:00 AM – 9:05 AM
Overview, Meeting Objectives, and Agenda	9:05 AM – 9:30 AM
CHEOPS Overview	9:30 AM – 10:45 AM
Break	10:45 AM – 11:00 AM
Demonstration Model and Scenario Discussions	11:00 AM – 12:00 PM

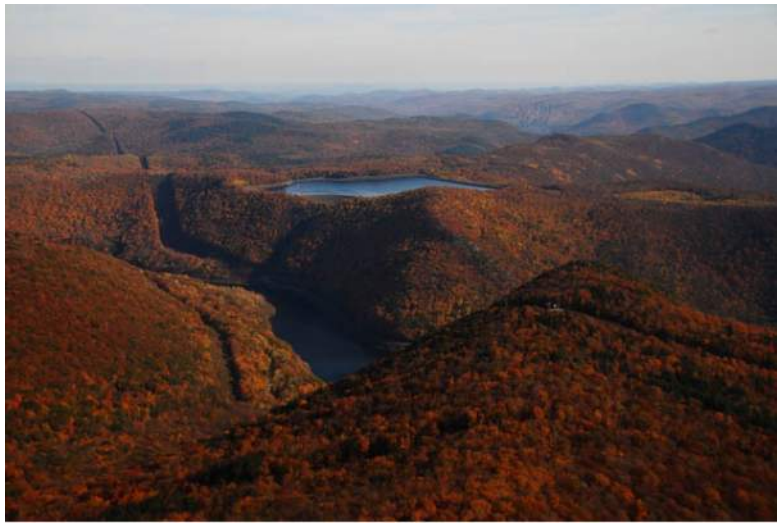


Project Location



Study Plan Development

- Bear Swamp Power Company, LLC (BSPC) is pursuing a new license for the Project from the Federal Energy Regulatory Commission (FERC or Commission) in accordance with FERC's Integrated Licensing Process (ILP) at 19 CFR Part 5.
- Pursuant to the ILP, BSPC developed a Proposed Study Plan (PSP) that was filed with the Commission on June 2, 2015.
- BSPC held PSP Meetings on June 29 and 30, 2015 and filed a Revised Study Plan (RSP) on September 30, 2015.
- FERC issued the Study Plan Determination (SPD) for the Project on October 30, 2015.



Milestones for Study Implementation and Development of License Application

Activity	Schedule
Conduct Field Studies	In accordance with the SPD
File Initial Study Report (18 C.F.R. §5.15(c))	October 30, 2016
Hold Initial Study Results Meeting (18 C.F.R. §5.15(c))	November 14, 2016
File Updated Study Report (18 C.F.R. §5.15(f))	October 30, 2017
Hold Updated Study Results Meeting, if necessary (18 C.F.R. §5.15(f))	November 14, 2017
File Preliminary Licensing Proposal or Draft License Application	November 1, 2017
File Final License Application	March 31, 2018

Project Operations Model

- The SPD describes 19 approved and modified studies to be conducted in support of relicensing the Project, including an Operations Model
- Pursuant to the SPD, BSPC intends to model:
  - Existing conditions;
  - Alternative minimum flows from Fife Brook dam ranging from 125 cfs to 275 cfs in increments of 50 cfs;
  - Alternative whitewater flows ranging from 800 cfs to 1,400 cfs in increments of 100 cfs;
  - Operating scenarios that demonstrate the physical limitations of the Bear Swamp Project;
  - Operating scenarios based on the current and upgraded turbine-generator configuration for the Bear Swamp Project; and
  - A scenario where scheduled whitewater releases from Fife Brook Dam and a drawdown of the Fife Brook impoundment are coordinated with the 32 scheduled whitewater releases from Deerfield Station No. 5.

Meeting Objectives

- As described in the RSP, BSPC is establishing a Flow Regime Working Group to serve as a forum to discuss model development, scenario development, findings and on-going efforts by BSPC.

- The objectives of this meeting are to:
  - Provide the Flow Regime Working Group with an overview of the CHEOPS model, including the model framework, capabilities, input, and output
  - Demonstrate the abilities and output of the CHEOPS model using example input data
  - Initiate discussions of scenario runs

Fife Brook Development

CHEOPS Overview

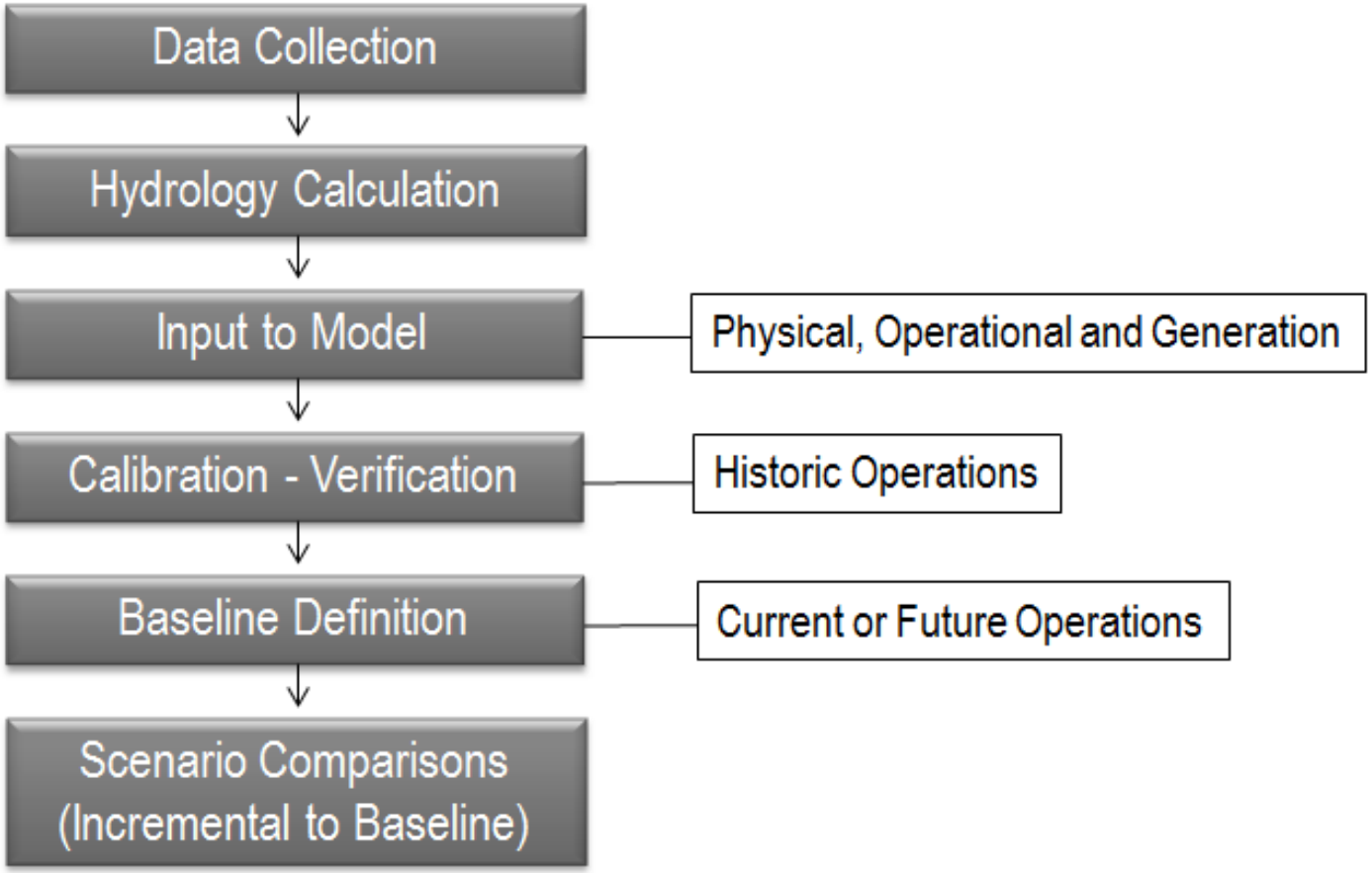
CHEOPS Overview

- An operations model/software tool for evaluating a wide range of physical and operational constraints on a hydroelectric facility
- Typically used to compare:
  - Impacts from varying operational protocols
  - Physical modifications
  - Feasibility of potential upgrades
  - Changes considered during operations negotiations

CHEOPS™
Operations and Planning Model

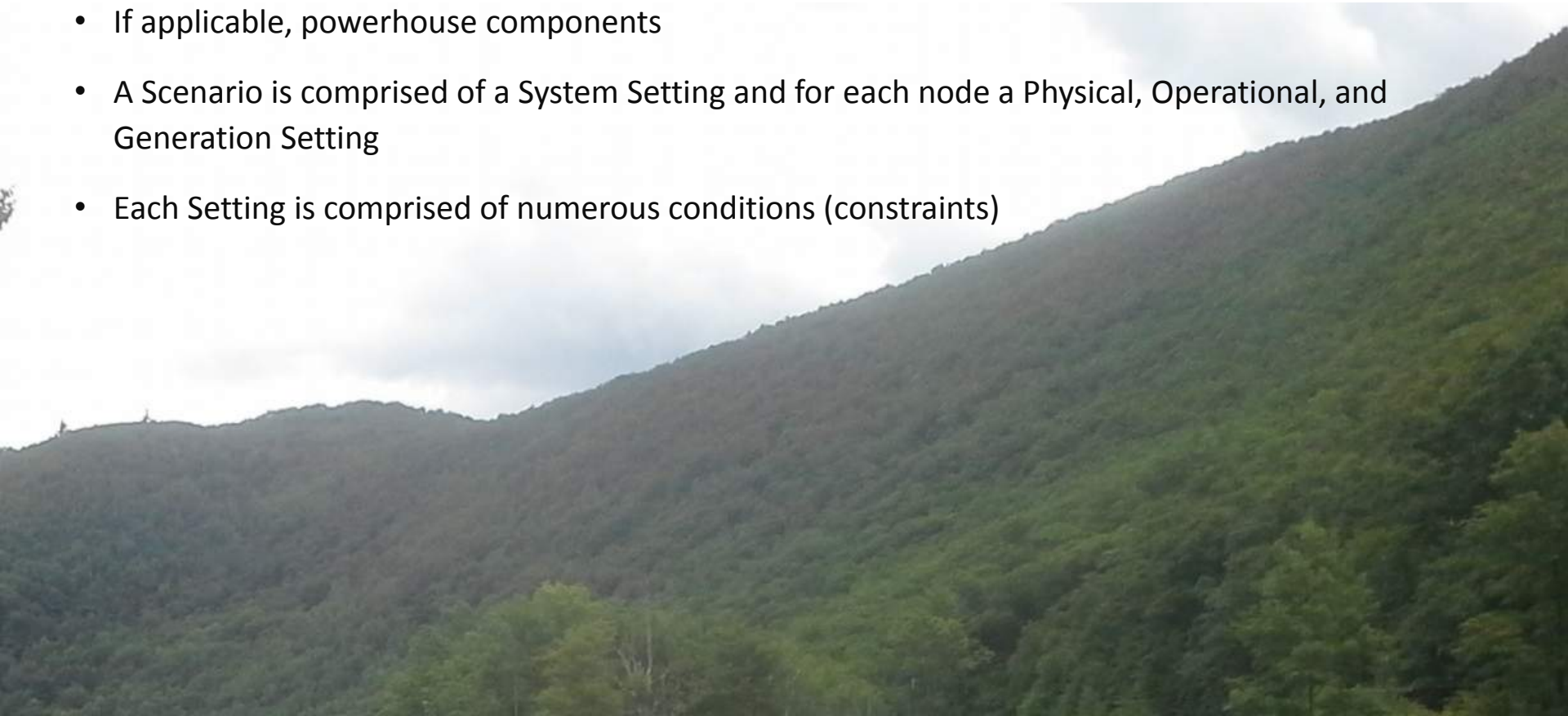
CHEOPS Model Development

Typical Sequence



Model Input

- Hydrology data sets – Typically USGS and/or plant records
- System-wide requirements/conditions
- Physical descriptors of each reservoir/dam/diversion
- Operational conditions/requirements
- If applicable, powerhouse components
- A Scenario is comprised of a System Setting and for each node a Physical, Operational, and Generation Setting
- Each Setting is comprised of numerous conditions (constraints)



Model Input

Typical Sequence

- Loadshape and inputs that apply to the whole system
- Hydrology Input

Physical

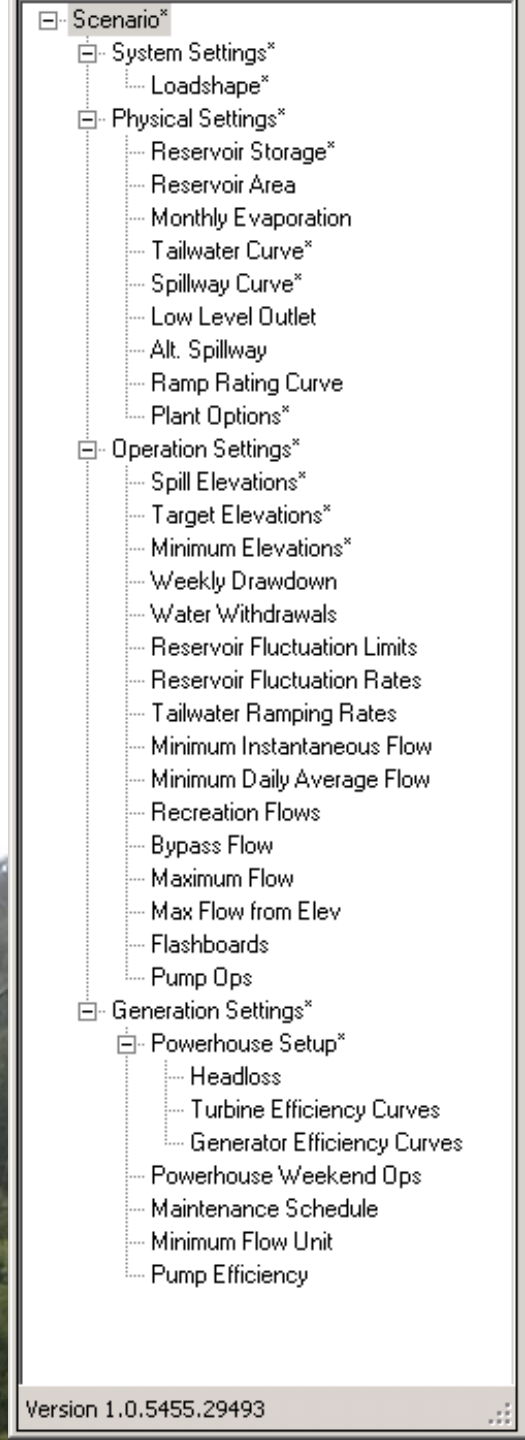
- Concrete or earthen relationships

Operational

- Operating rules, agreements, license requirements

Generation

- Powerhouse configurations and operating options




Scenario
System Setting (1 per Scenario)
Physical Setting (1 per Plant)
Operational Setting (1 per Plant)
Generation Setting (1 per Plant)
Loadshape
Carry Over
Forecast Length
Reservoir Storage
Reservoir Area
Daily Evaporation
Tailwater Curve
Spillway Curve
Ramping Rate Curve
Plant Options
Spill Elevation
Target Elevation
Minimum Elevation
Withdrawals
Fluctuation Limits
Fluctuation Rates
Min Inst Flows
Min Daily Flows
Ramping Rates
Bypass Flows
Powerhouse
Headloss
Turbines
Generators
Gate Leakage
Maintenance
Minimum Flow Unit

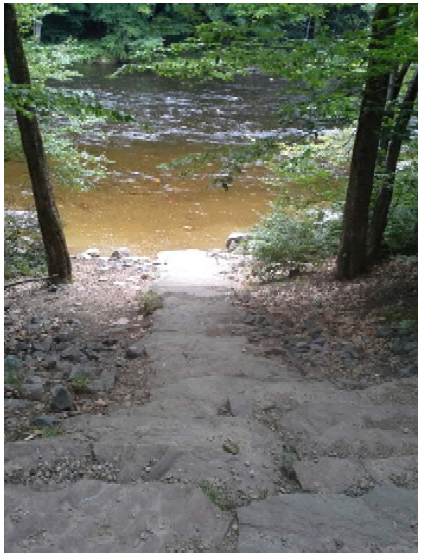
Model Input: **Physical Setting**

- Reservoir storage/elevation relationship
- Reservoir elevation/surface area relationship
- Monthly evaporation coefficients
- Ramp rating curves (flow/stage relationship at point of constraint)
- Spillway capacities
- Tailwater flow/elevation relationship
- Powerhouse operation type (peaking, run of river, etc.).




Model Input: **Operational Setting**

- Spill elevation
- Target elevation
- Minimum elevation
- Water withdrawals/returns
- Reservoir fluctuation limits
- Reservoir fluctuation rate
- Minimum instantaneous discharge
- Minimum daily average discharge
- Bypass flow
- Ramping rates



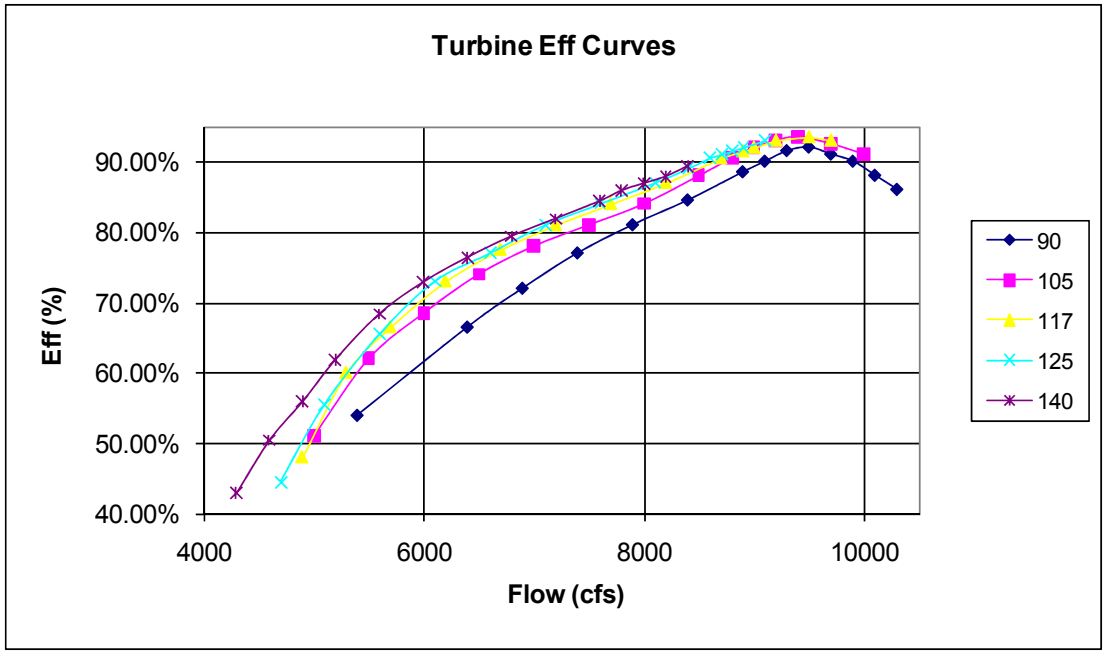
Model Input: **Generation Setting**

Powerhouse components

- Headloss
- Turbine efficiency curves
- Generator efficiency curves
- Turbine wicket gate leakage
- Pump turbine efficiency

Minimum flow unit

Maintenance outage schedule








Model Output

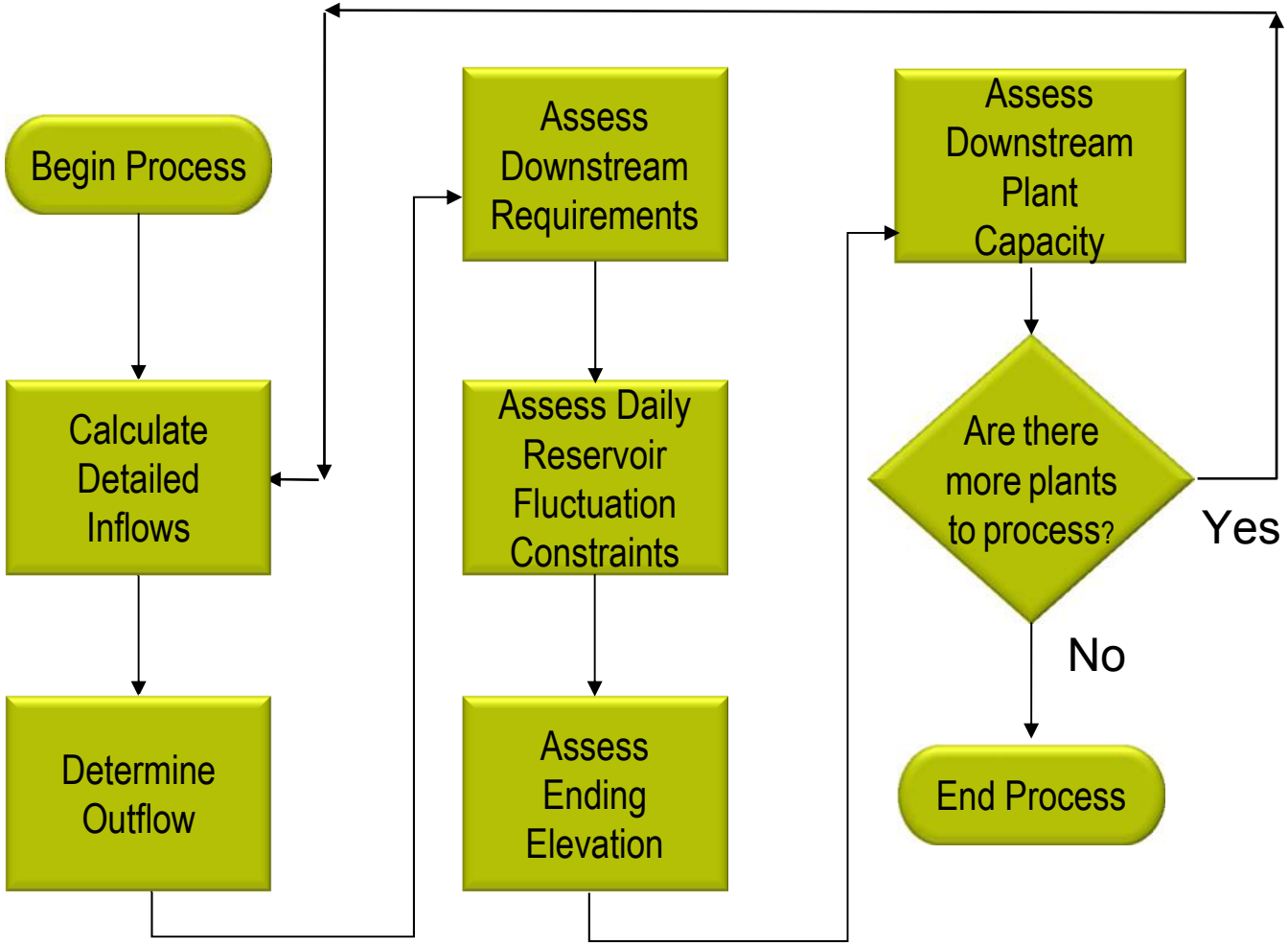
- Detailed reservoir, powerhouse and stream flow metrics
- Multiple detail levels: annual/monthly/hourly/15-Minute

Reservoir Data	Powerhouse Data	Stream Flow Data
Ending Elevation	Powerhouse Discharge	Powerhouse Discharge
Ending Storage	Gross Head	Spill
Gross Inflow	Peak Generation	Bypass flows
Accretions	Shoulder Peak Generation	
Gross Outflow	Offpeak Generation	
Evaporation loss	No-Generation Flow	
Withdrawals		

Model Algorithm

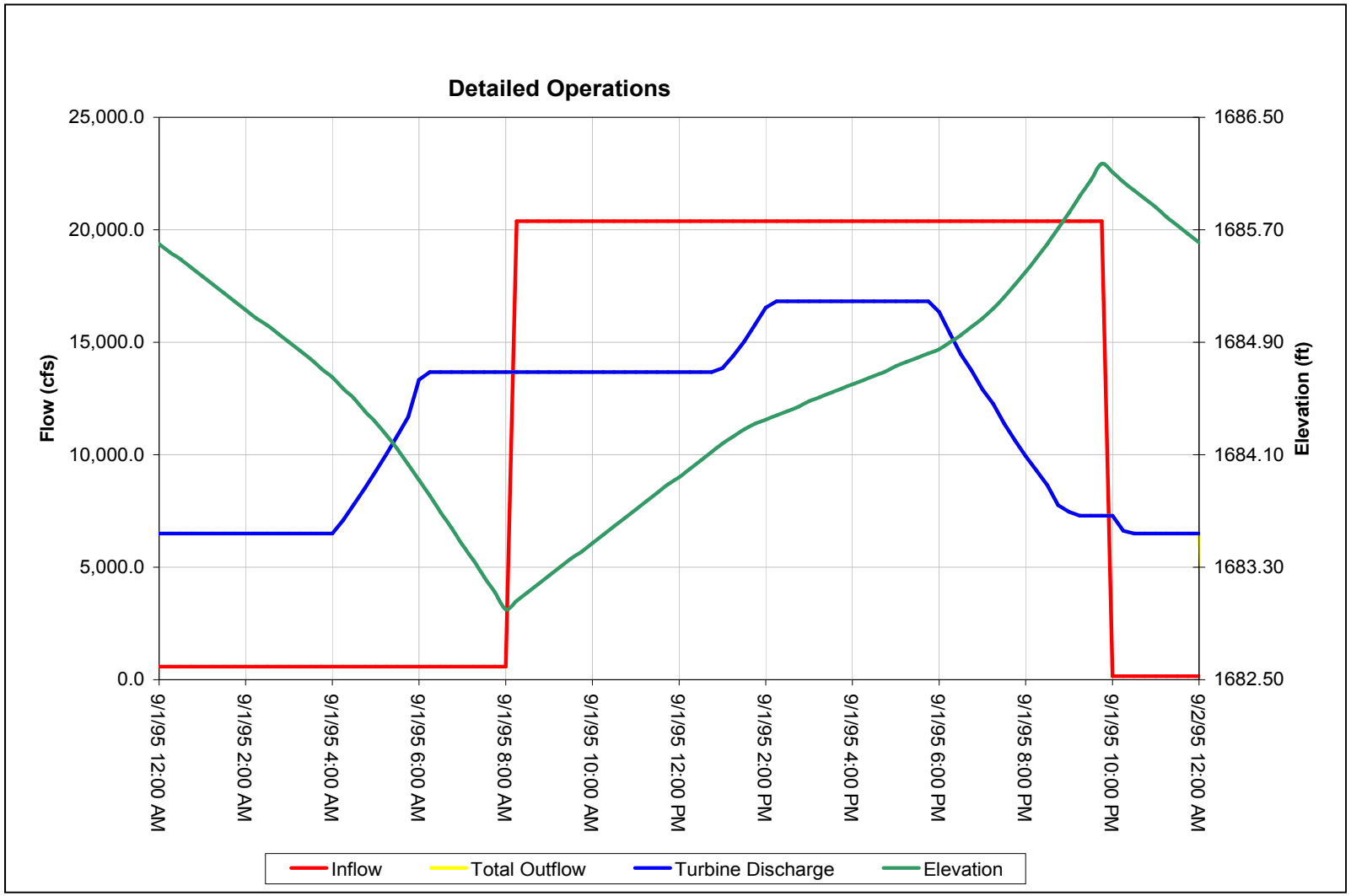
- For each day, starting at top of system to bottom of system, for each reservoir/node, Outflow = Inflow - change-in-storage
- Operation conditions (non-generation) given priority over generation concerns (withdrawals and bypass reach flows accounted for before powerhouse/diversion flows)
- Outflow determined to support the downstream reach flow requirements

Process Overview

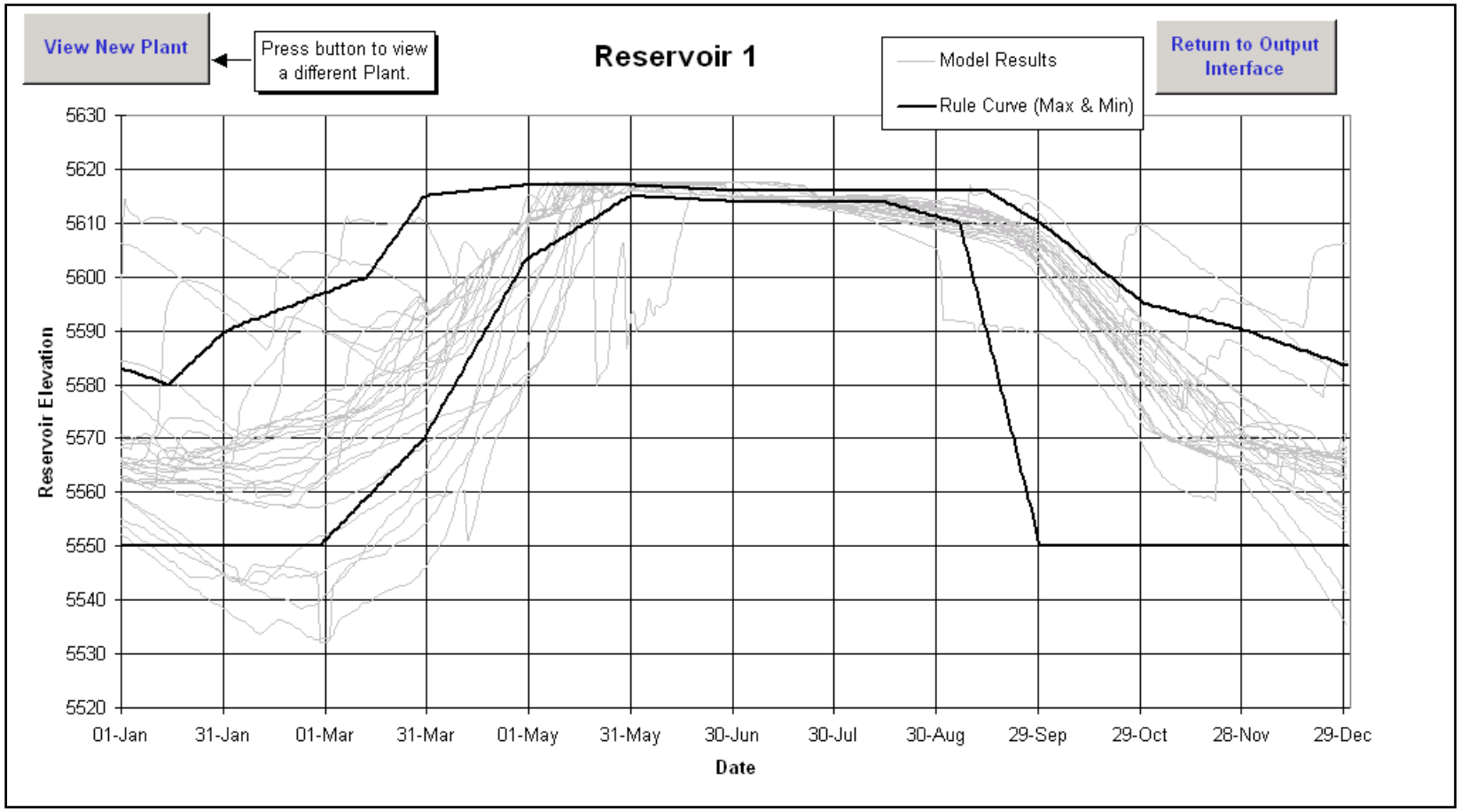


	Average Week Day MWh			Average Weekend MWh		Average Annual (MWh)
Scenario	**Peak**	**Secondary**	**Off-Peak**	**Peak**	**Off-Peak**	
Basecase - Existing Conditions						
Variant						
Incremental MWh change from Basecase						
Percent change from Basecase						

Sample Model Outputs: **Detailed Powerhouse Operations**



Haze Chart of impact to reservoir recreation season elevations due to competing high stream flow requirements below reservoir




Fife Brook Development

Model Scenario Discussion and Questions