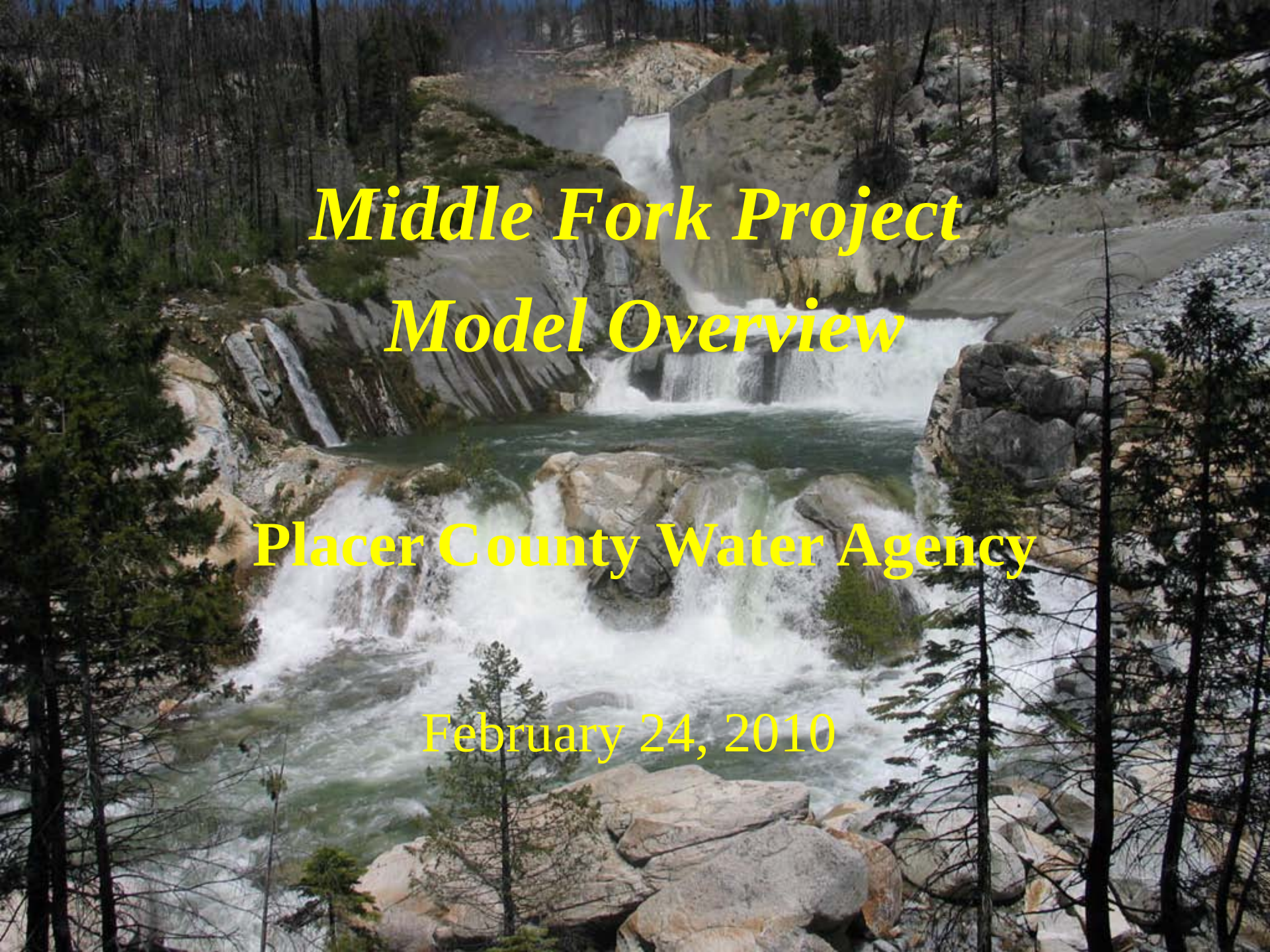


Middle Fork Project Model Overview

Placer County Water Agency

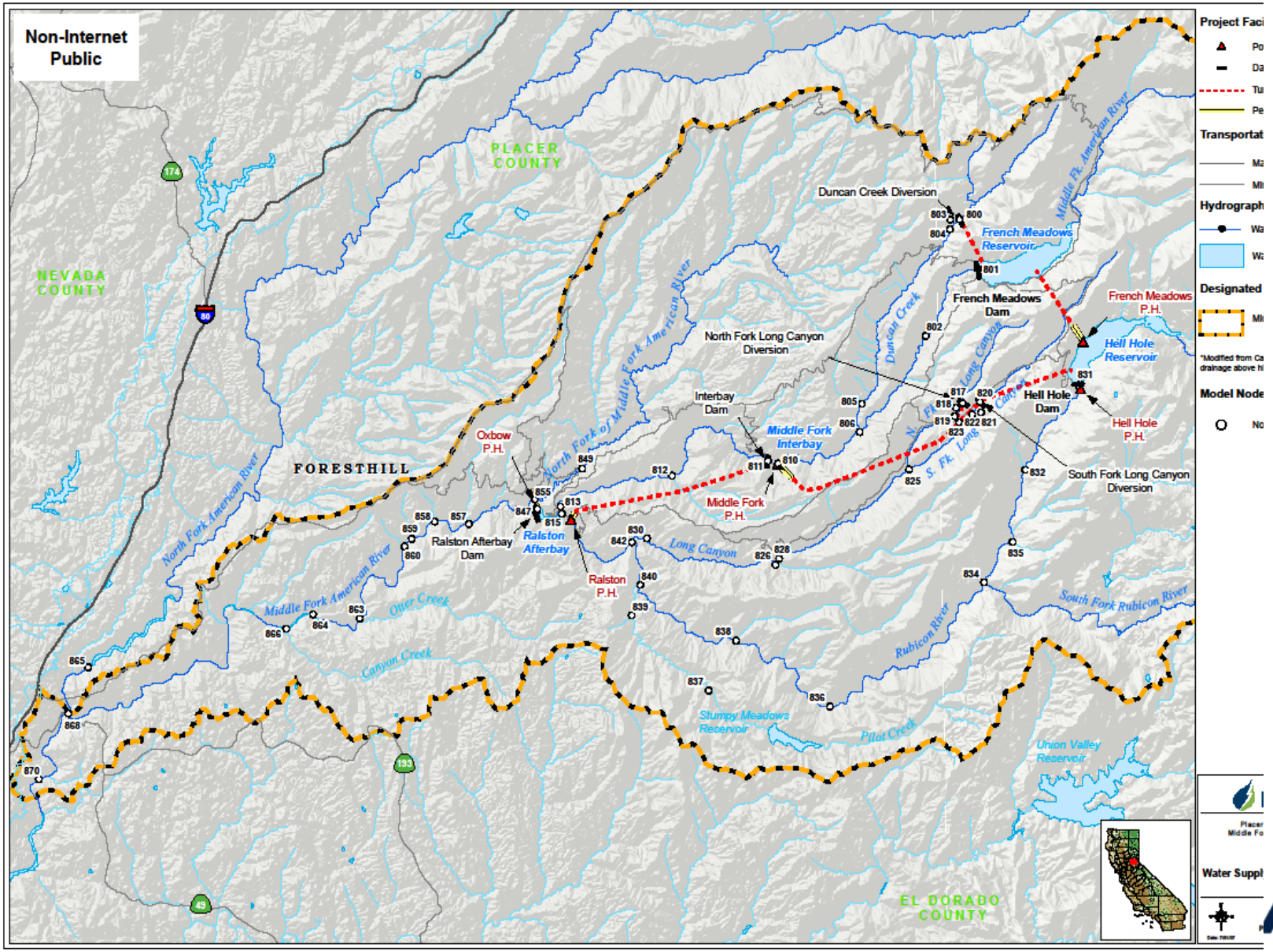
February 24, 2010

MFP Operations Model Overview

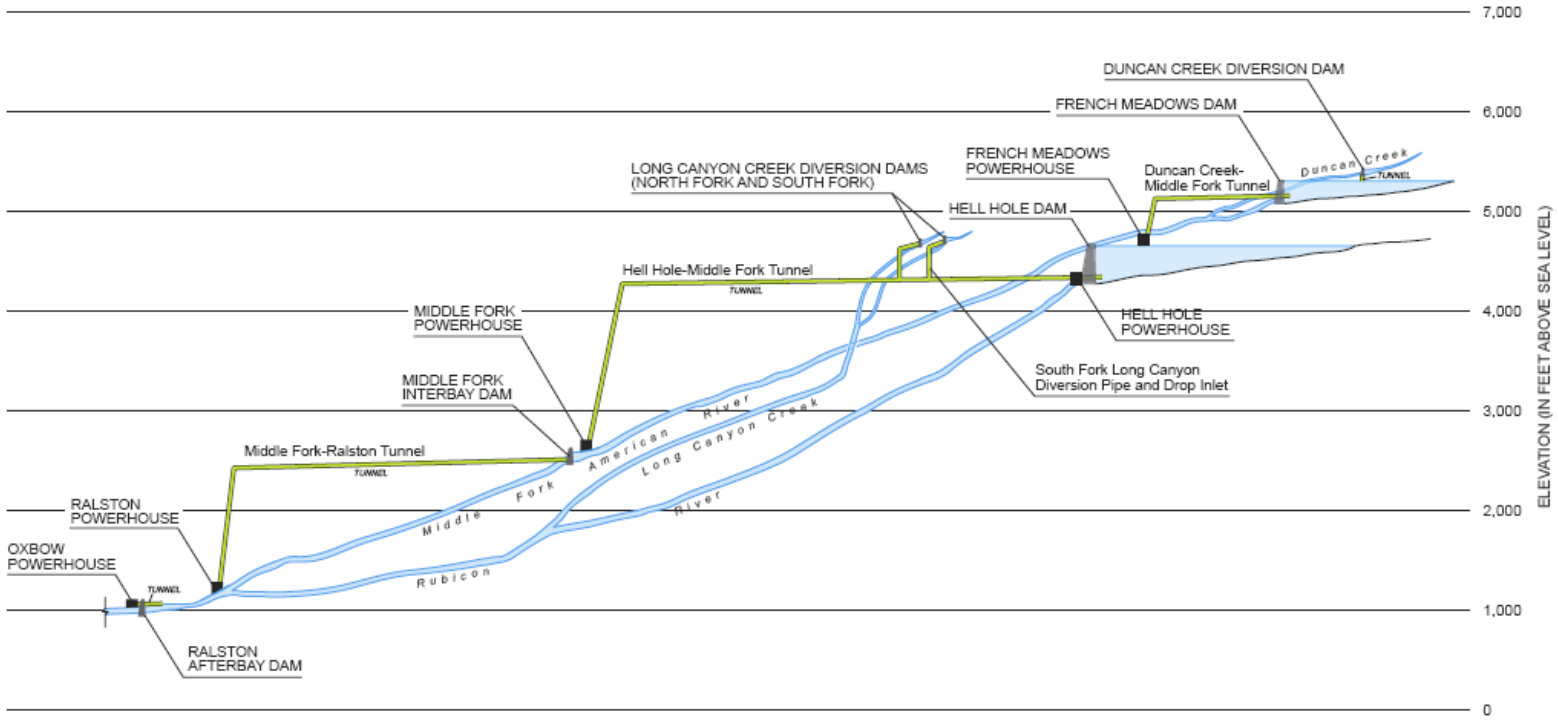
- Middle Fork Project Overview
- OASIS Model Introduction
- Hydrology
- Water Year Types
- Instream Flow Requirements
- Minimum Storage Requirements
- Consumptive Demand
- Hydro Generation Demand
- Storage Reservoir Operations
  - Small Diversion Operations
- Interbay / Afterbay Operations
- Maintenance Outages
- Betterments
- Hourly Model
- Post-processing Metrics

PCWA

Project Map


Non-Internet Public
PLACER COUNTY
NEVADA COUNTY
EL DORADO COUNTY
FORESTHILL
Duncan Creek Diversion
French Meadows Reservoir
French Meadows Dam
French Meadows P.H.
Hell Hole Reservoir
Hell Hole Dam
Hell Hole P.H.
North Fork Long Canyon Diversion
South Fork Long Canyon Diversion
Interbay Dam
Middle Fork Interbay
Middle Fork P.H.
Oxbow P.H.
Ralston Afterbay Dam
Ralston Afterbay
Ralston P.H.
Stumpy Meadows Reservoir
Union Valley Reservoir
Middle Fk. American River
North Fork of Middle Fork American River
North Fork American River
Middle Fork American River
Duncan Creek
N. Fk. Long Canyon
S. Fk. Long Canyon
Long Canyon
Otter Creek
Canyon Creek
Rubicon River
South Fork Rubicon River
Pilot Creek
Project Faci
Transportat
Hydrograph
Designated
Model Node
Water Suppl

Project Profile View



Horizontal dimension and size of facilities not to scale

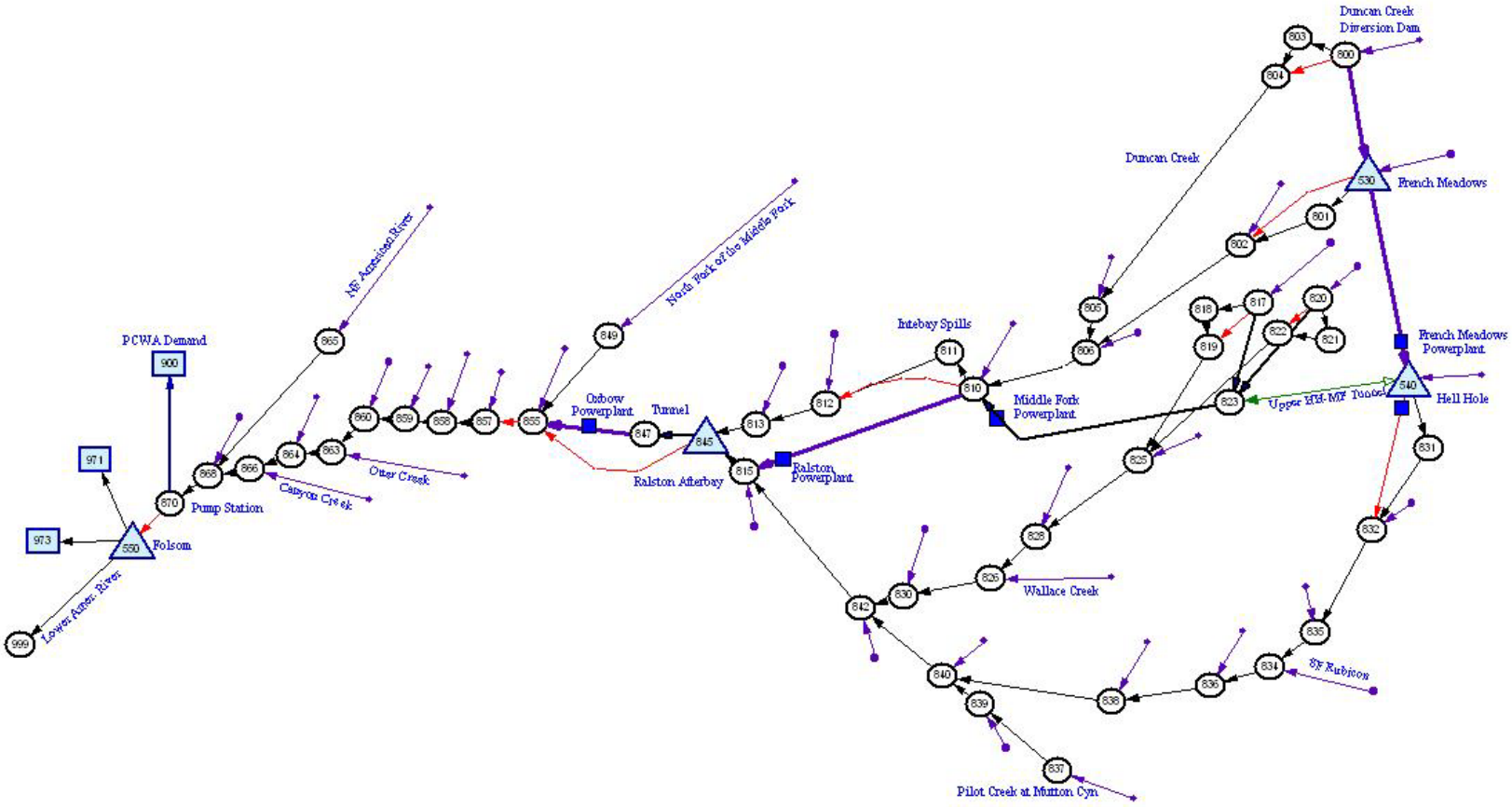
PCWA

Placer County Water Agency
Middle Fork American River Project

Figure SD B-1

MFP Facilities - Elevation Profile

Project Model Schematic



OASIS Simulation Model - Purpose

- Aid with analyzing the potential effects of proposed new license conditions on:
  - Streamflows
  - Reservoir conditions
  - Water supply
  - Hydro generation
- Support analyses associated with:
  - Water temperature
  - Instream/riparian habitat
  - Recreation
- Illustrate the hydrologic variability of the MFP watershed, and allows consideration of that variable hydrology for future operations

PCWA

OASIS Simulation Model - Structure

- Mass balance tracking tool
  - Daily time step according to a set of operational rules
  - Limited by the physical capacities of the Project facilities
  - Uses unimpaired inflow, which was calculated based on historic hydrology records
- Inflow into Project facilities is either:
  - Routed into storage
  - Released through MFP generation facilities
  - Bypassed to downstream reaches
  - Spilled
- Diversions to and from storage and generation change daily in response to a set of programmed priorities that include:
  - Meeting all minimum release requirements
  - Meeting consumptive water supply demands
  - Filling reservoirs without spilling
  - Arriving at an end of year carryover storage target
  - Generating electricity during periods of highest energy demand

PCWA

OASIS Simulation Model - Development

- Reverse-engineered to mimic historic operations to a large degree, in particular:
  - Balance between FM & HH reservoirs
  - Seasonal fill/dispatch pattern
- Benchmarks well against historic operations
- Flexible enough to undertake evaluation of future scenarios, including proposed betterment
- Developed and verified by PCWA in coordination with the Model Technical Team Subgroup participants

PCWA

Model Limitations and Use

- Developed to ensure that parameters and inputs were as realistic as possible
- However, numerous assumptions and simplifications were necessary, i.e.
  - Maintenance Outages
  - Carryover Storage Targets
  - Dispatch Routines
- Model allows the user to compare the relative effects of an alternative (such as changes to instream flow requirements) to a baseline condition
- Will not predict actual streamflows or reservoir elevations

PCWA

Hydrology

- Daily hydrology, 1975 - 2007
- Most of the hydrology that is used by the model is “unimpaired”
  - Inflow to Hell Hole, South Fork Rubicon, and Pilot Creek are impaired by upstream operators (SMUD, GDPUD)
- Historic releases from these operators are preserved in the hydrology

Unimpaired Hydrology Development

- Unimpaired Hydrology developed using existing gages and storage records
- Missing data was filled in using USGS fill-in program
- Monthly volumes were distributed based on unimpaired Duncan Creek and Pilot Creek daily patterns

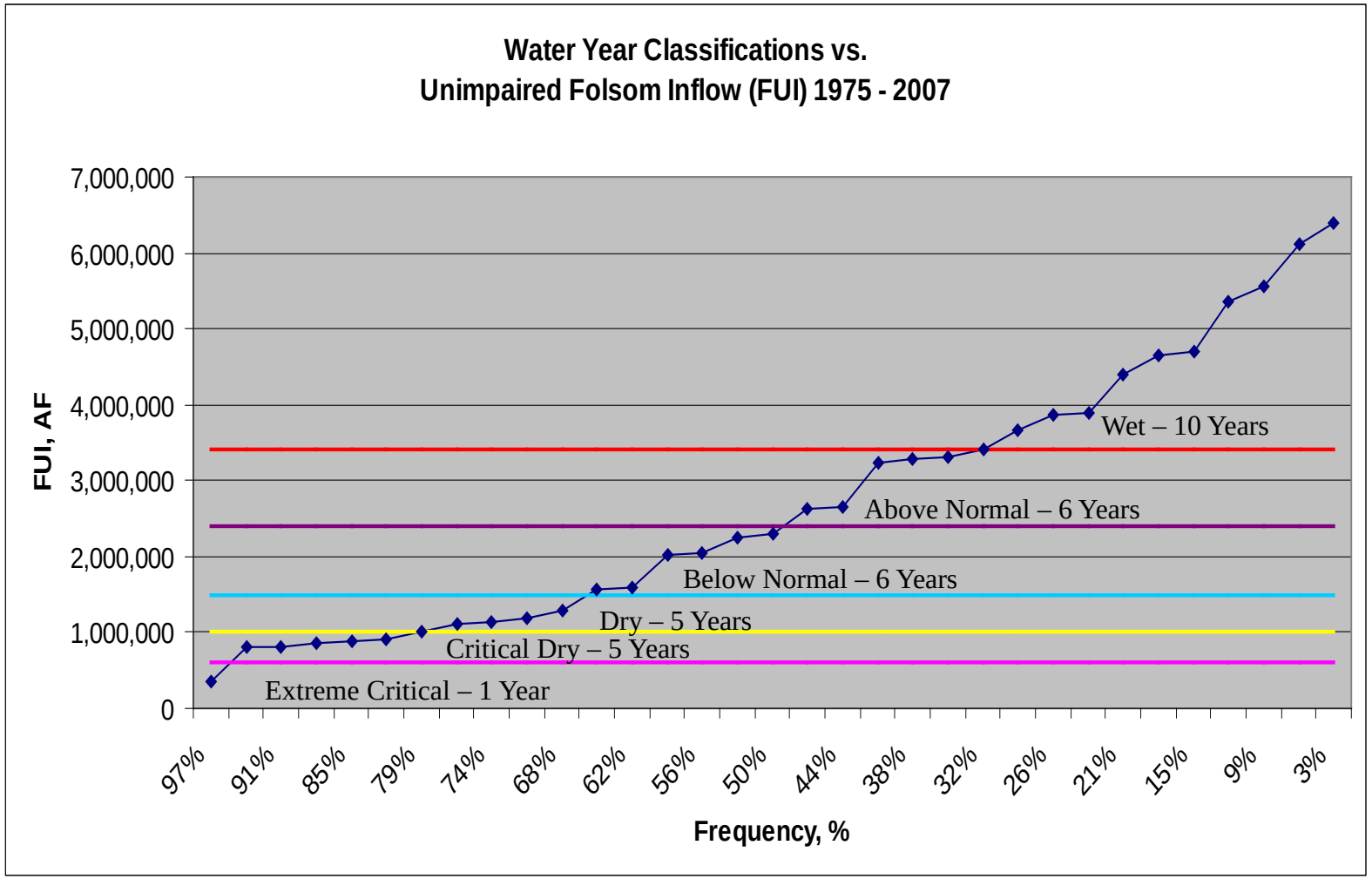
PCWA

Water Year Types

- Current FERC license
  - Reservoir storage requirements (Wet, Normal, Dry)
  - Minimum instream flows (Wet, Dry)
  - Utilizes April B120 FUI forecast to establish June 1 requirements
- Proposed Water Year Type Structure
  - Reservoir storage and instream flow
    - Six water year types (Wet, Above Normal, Below Normal, Dry, Critical, Extreme Critical)
    - Critical and Extreme Critical may be lumped
  - Monthly updates (February through May) based on DWR Bulletin 120 FUI forecast

PCWA

Water Year Types

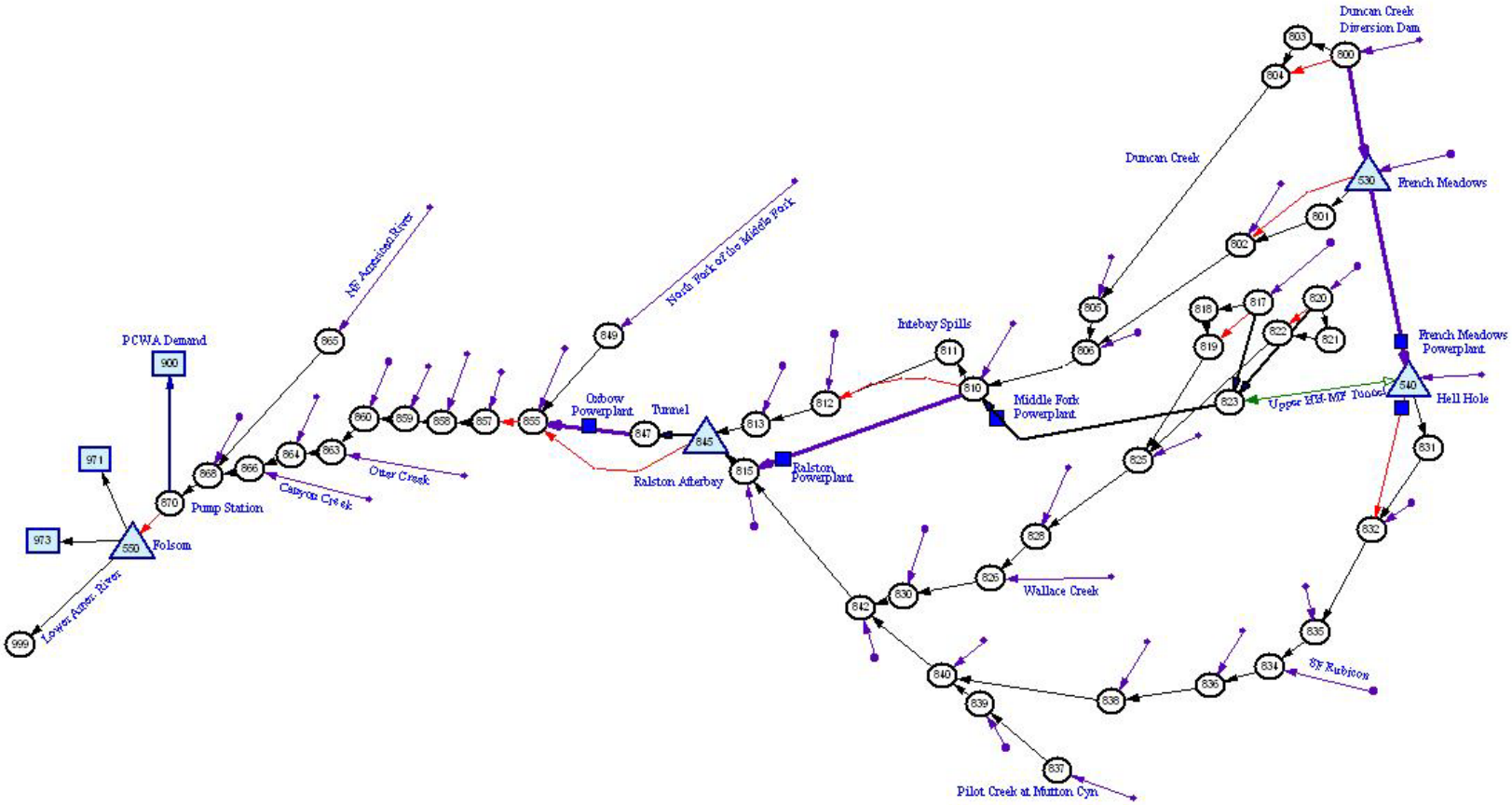


PCWA

Instream Flow Requirements

- The MFP is currently required to maintain minimum instream flow at seven sites as a condition of the MFP FERC license
- Currently required flows vary by water year type and, at one location, by time of year
- The Model user can specify different minimum instream flow requirements by the time period, the flow rate, and the water year type trigger

Instream Flow Requirements



Minimum Storage Requirements

- The current MFP FERC license contains minimum reservoir storage requirements for French Meadows and Hell Hole reservoirs

Location and Forecasted Runoff to Folsom Reservoir in Acre-feet

Minimum Pool in Acre-Feet	Jun - Sep	Oct - May
French Meadows Reservoir		
More than 2,000,000	60,000	50,000
Less than 2,000,000 but not less than 1,200,000	60,000	25,000
Less than 1,200,000	28,000	8,700
Hell Hole Reservoir		
More than 2,000,000	70,000	50,000
Less than 2,000,000 but not less than 1,200,000	70,000	25,000
Less than 1,200,000	26,000	5,500

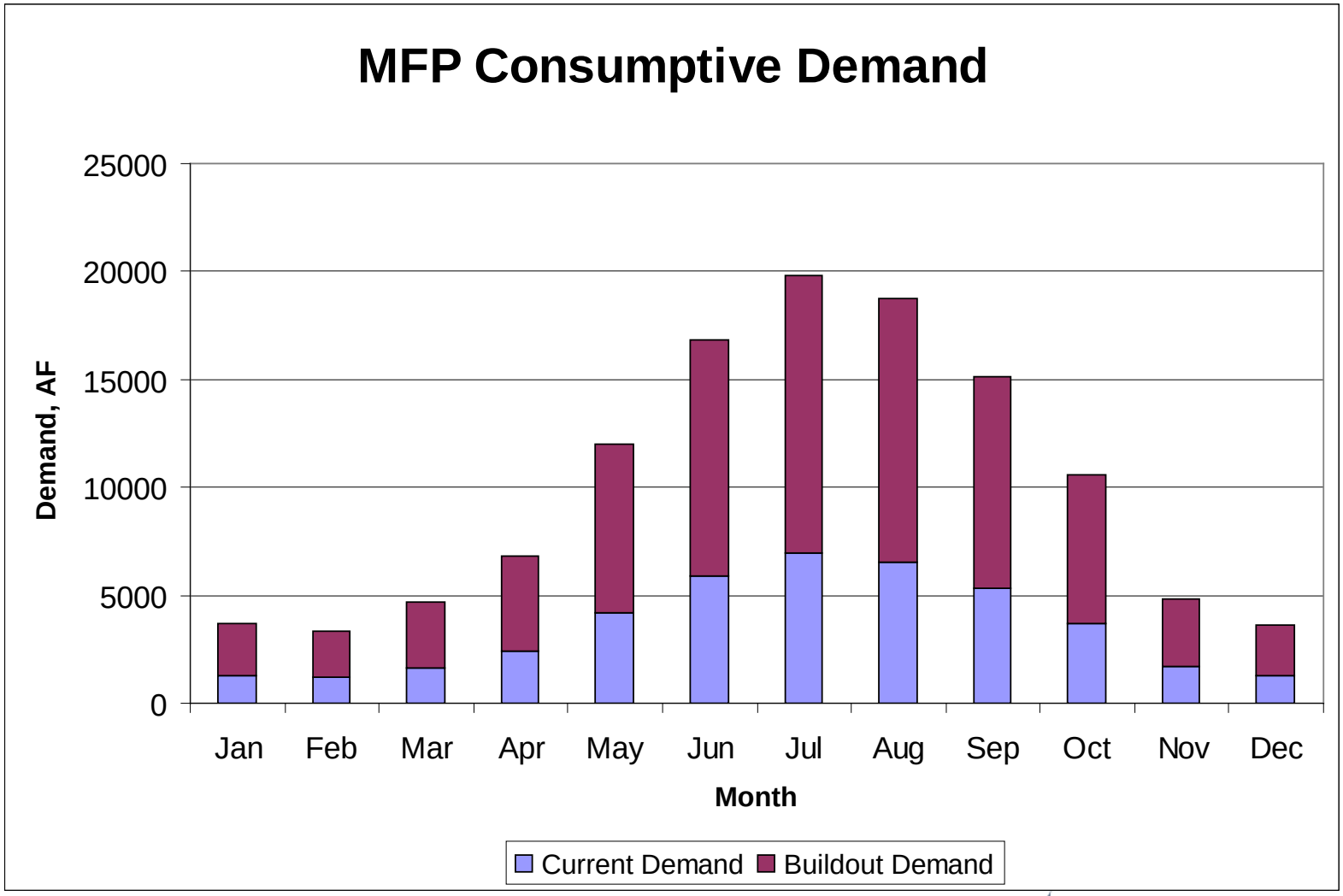
PCWA

Consumptive Demand

- PCWA has two points of diversion for consumptive water
  - American River Pump Station
  - Folsom Reservoir
- Monthly pattern based on recent observation
  - Daily pattern is represented by equally distributing the monthly demand
- Modeled current demand is based on recent actual consumptive demand (42 TAF)
- Recent actual demand has been as high as 64 TAF
- Build-out demand (120 TAF) is based on PCWA's Integrated Water Resources Plan (PCWA 2006)

PCWA

Consumptive Demand

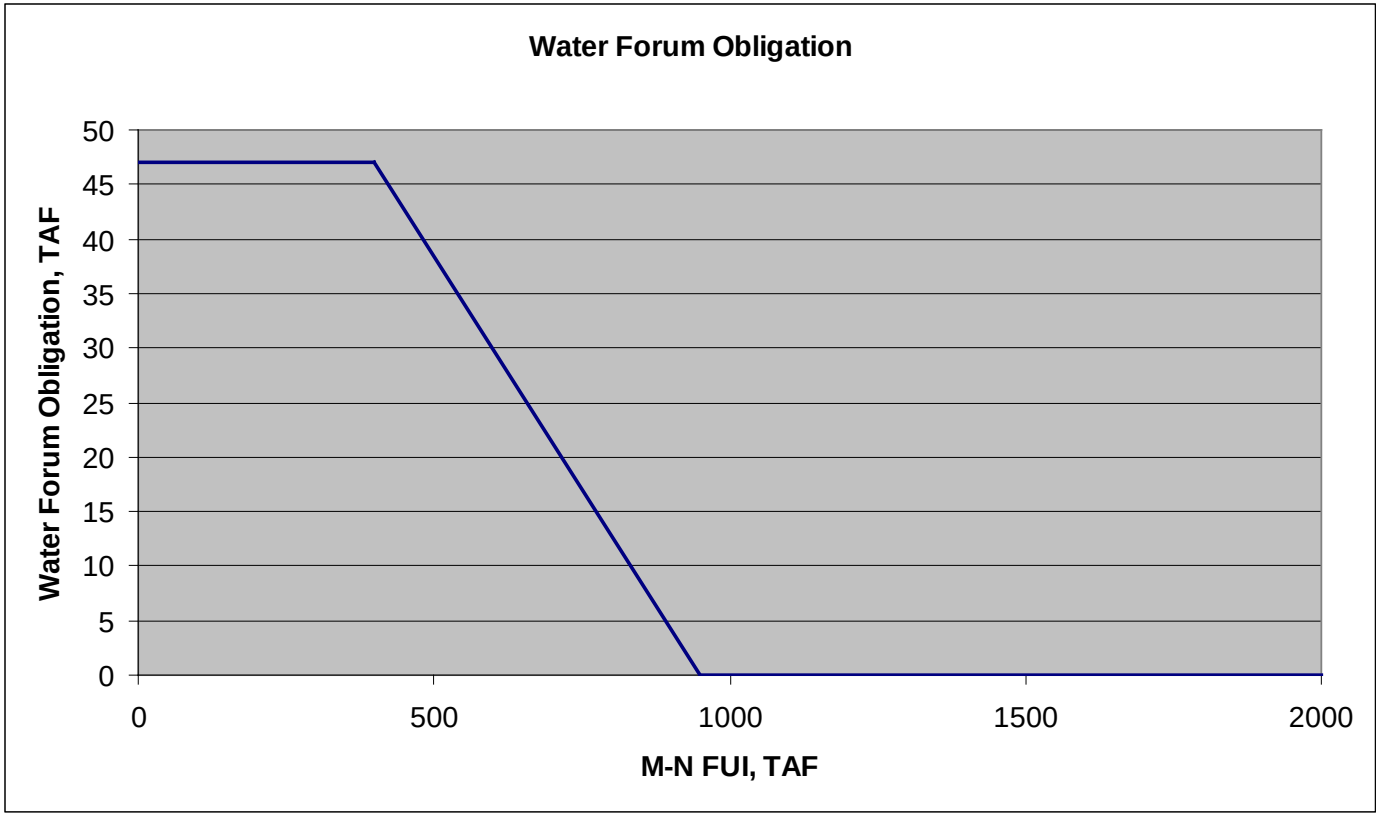


Consumptive Demand – Water Forum

- PCWA is a member of the Water Forum and a signatory to the Water Forum Agreement
- Under the Water Forum Agreement (Water Forum 2000), PCWA has committed to dry year actions to enhance flows in the Lower American River that affect current and future MFP operations

Consumptive Demand – Water Forum

- Water Forum release obligation increases linearly as Folsom Mar-Nov Inflow decreases from 950 TAF to 400 TAF

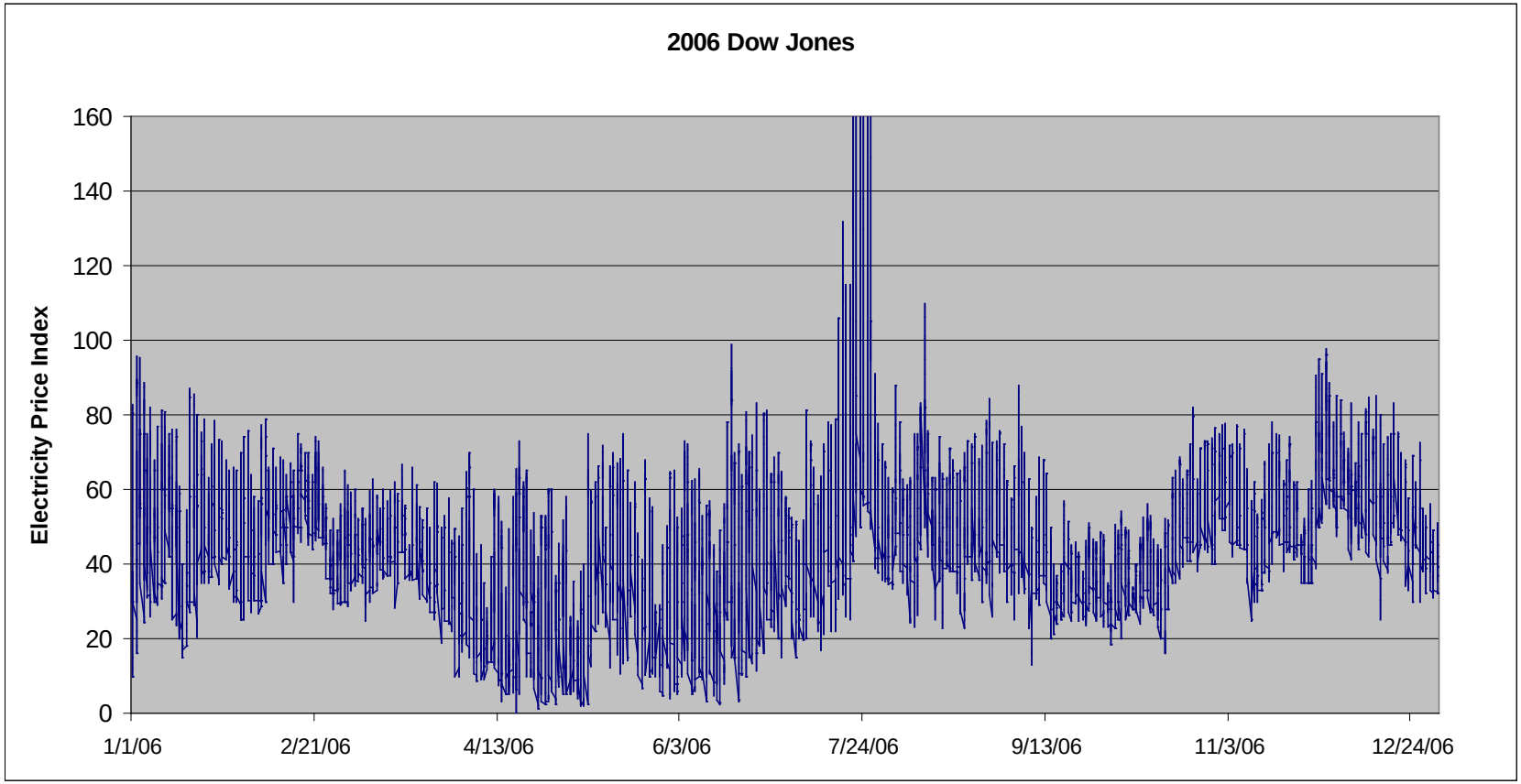


Hydro Generation Demand

- The Model uses generation dispatch curves to determine the hours per day of generation given a volume of water available
  - Based on 2006 Dow Jones Electricity Price Index as a proxy for electricity demand
- The dispatch curve shapes seasonal generation releases to days with higher overall energy demand
- The Model operates the powerhouses during days that have the highest value

PCWA

Hydro Generation Demand



PCWA

Runoff Forecasts

- To avoid using perfect knowledge of inflow, the model uses B120 Apr-Jul runoff forecasts
- Updates to the historic B120 forecasts are implemented on the 15th of the month, shortly after they historically became available
  - B120 forecasts are provided February, March, April, and May
- The Model interpolates between the current and next month's B120 forecast to simulate the updates that are currently available (but not historically available) and updates the runoff forecast

PCWA

Precipitation Records

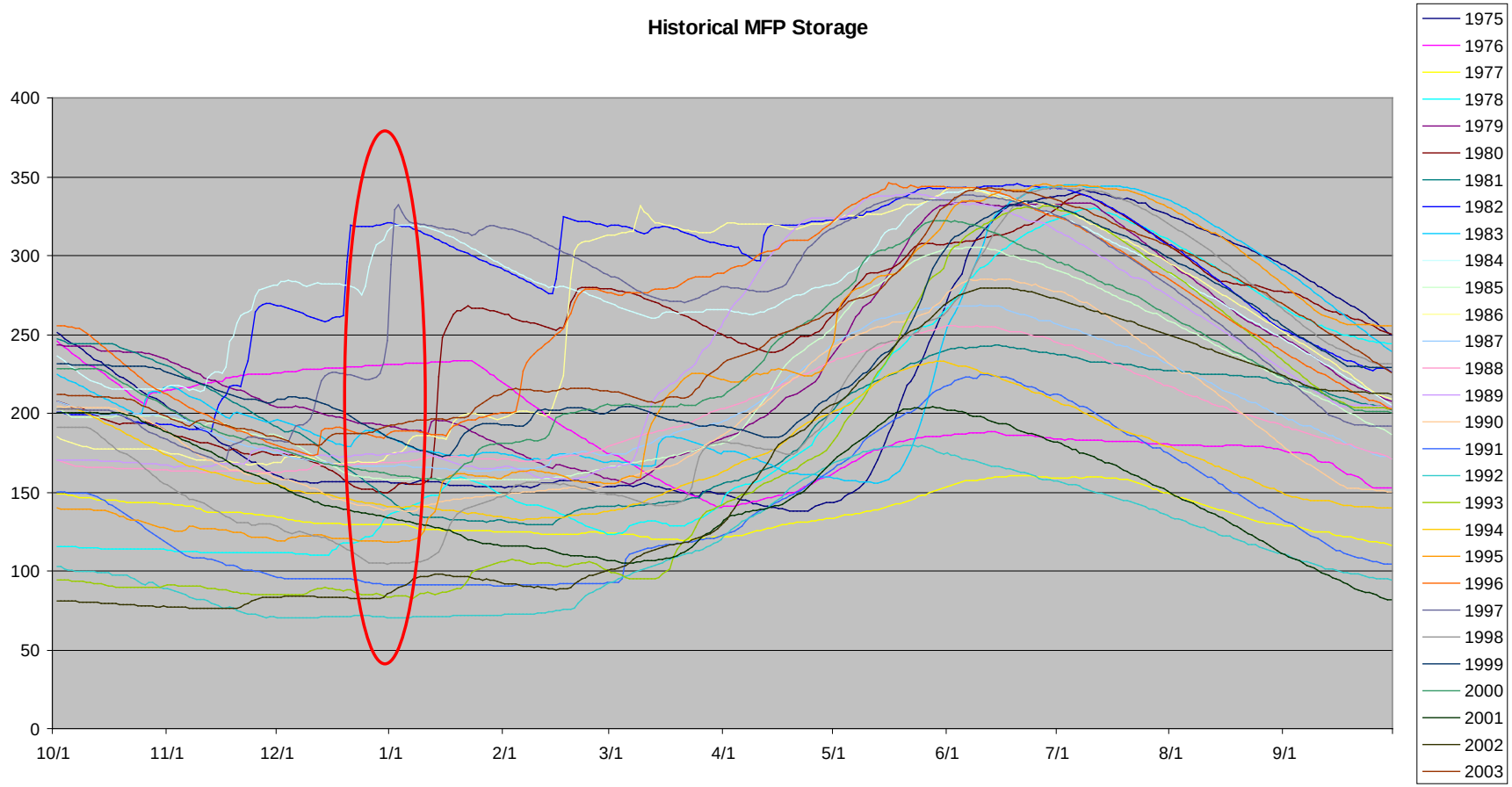
- The Model uses precipitation records from the Blue Canyon gage as a weather forecast
  - Used to simulate real-world conditions in which a Project operator would use real-time weather to slightly modify Project operations between B120 forecasts

Carryover Storage Targets

- The Model is operated to an end-of-year (December 31) combined storage target
- The combined storage target is intended to ensure that the MFP carries over sufficient water to meet the following year's demands in the event of a dry year, but also ensure sufficient vacant reservoir capacity to allow runoff to be captured in the event of a wet year
- Historic combined carryover storage targets have ranged from over 165 TAF to less than 100 TAF
- Based on historical average, the combined storage target is set at 142 TAF in the model

PCWA

Carryover Storage Targets



PCWA

Reservoir Fill Logic

- Operating goal is to fill MFP reservoirs without spilling
- Runoff forecasts are incorporated in estimate of inflow
- Drier year fill date is May 31, wetter year fill date is June 30
- Model will generate electricity during the spring (fill period) when projections indicate that there is more water available than needed to fill the reservoir and meet downstream obligations

PCWA

Reservoir Fill Logic - Small Diversion Operations

- Small diversions are open all year
- Passive systems that divert flows in excess of the minimum flow requirements
  - Duncan = 400 cfs
  - SF Long Canyon = 200 cfs
  - NF Long Canyon = 100 cfs

PCWA

Reservoir Dispatch Logic

- During the dispatch cycle, the Model looks ahead to the end-of-year carryover storage target to assign a volume of water to be used to meet requirements, demands, and to generate electricity
- Volume is updated bi-monthly

Interbay / Afterbay Operations

- Ralston and Middle Fork powerhouses are operated synchronously
  - Middle Fork Interbay modeled with no storage capacity
  - Middle Fork Powerhouse is occasionally curtailed to take advantage of accretion flows into Interbay
- In the Daily Model, generally there is no net change in Afterbay storage
- Detailed Afterbay operations are captured in the hourly model

PCWA

Maintenance Outages

- For modeling purposes the maintenance outage at French Meadows Powerhouse is assumed to begin the first Monday in May and lasts nine days
- The maintenance outages at Middle Fork, Ralston, and Oxbow powerhouses have historically varied from two weeks to 12 weeks or more
- The maintenance outages at Middle Fork, Ralston, and Oxbow powerhouses are assumed to begin the first Tuesday in October and last 28 days
- During outages, no flow goes through the affected powerhouses
- During the fall outage, Ralston Afterbay is drawn down to an elevation of 1149 ft, and releases from Hell Hole Reservoir are increased to ensure minimum instream flow compliance downstream of Ralston Afterbay

PCWA

Betterments

- PCWA is considering one betterment for the MFP relicensing: the Hell Hole Seasonal Storage Increase
  - The Model can simulate project operations, including this betterment
  - This betterment increases active storage in Hell Hole Reservoir by 7,600 ac-ft, raising the maximum reservoir elevation by six feet
  - The storage increase is seasonal and occurs when the gates would be in place, April through November 15 (similar to current gate operations at French Meadows Reservoir)
  - The water captured with this betterment would be utilized the year that it is captured and dispatched to meet instream flow requirements, consumptive demand, and electricity demand

PCWA

Hourly Model

- Used to evaluate effects of Oxbow Powerhouse and Ralston Afterbay operations on the peaking reach
- Daily and Hourly models run sequentially, changes to the Hourly Model can require changes to daily model
- Redistributes the Daily Model output, using an hourly power demand index
- Includes travel time in the peaking reach

PCWA

Hourly Model

- Peak hour categories identify most valuable generation
- Ralston Powerhouse and Oxbow Powerhouse may not operate synchronously
  - Afterbay storage fluctuations allow disconnected operations

Peak Hours Designation

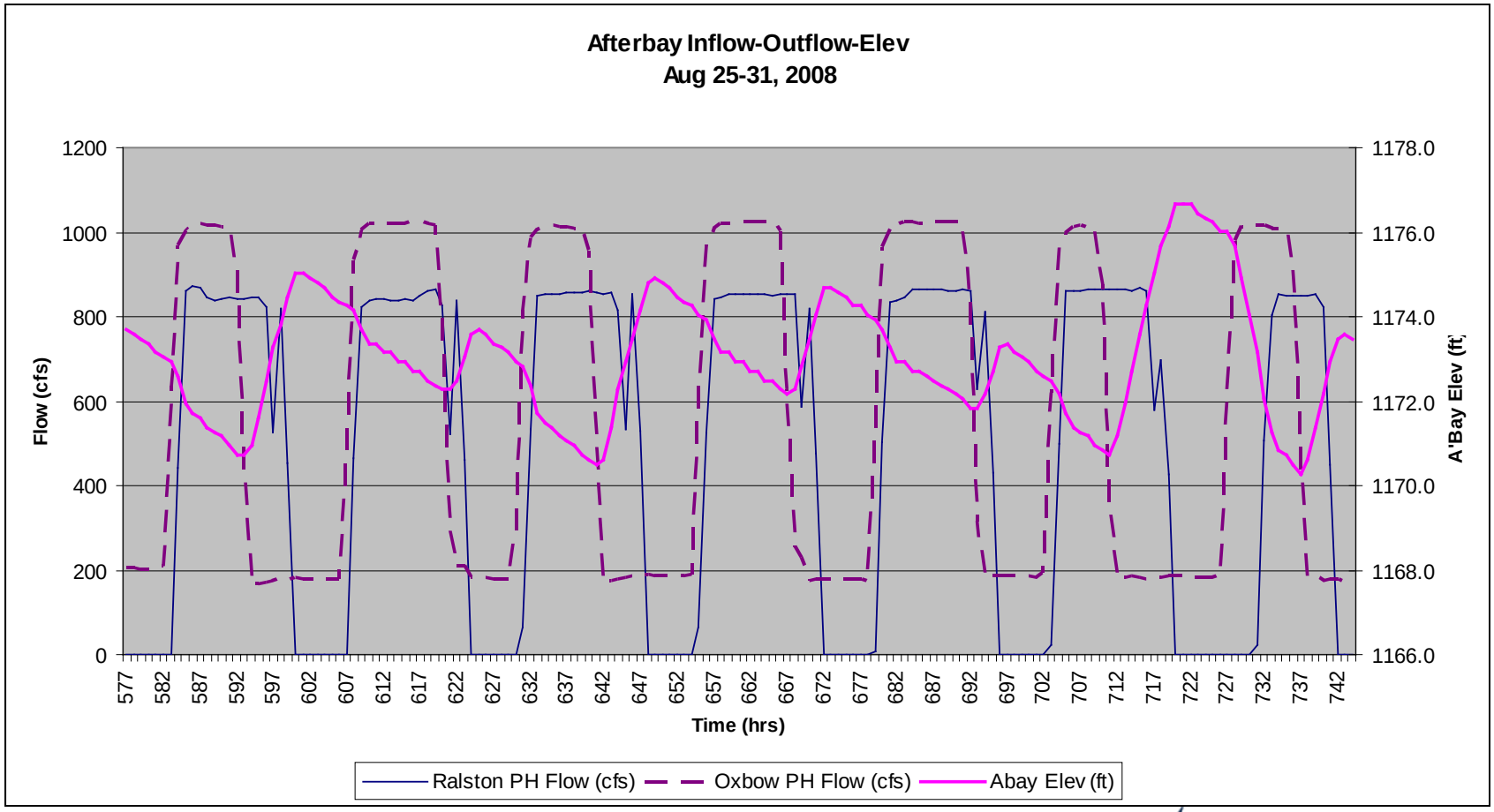
Hour of day	Weekdays Jul - Aug	Weekdays Jun, Sep	Weekdays Nov - Feb	Weekends Jun - Sep	Weekdays Mar - May & Oct	Weekends Oct - May
0	Off Peak	Off Peak	Off Peak	Off Peak	Off Peak	Off Peak
1	Super Off Peak	Super Off Peak	Super Off Peak	Super Off Peak	Super Off Peak	Super Off Peak
2						
3						
4						
5	Off Peak	Off Peak	Off Peak	Off Peak	Off Peak	Off Peak
6						
7						
8	Low Partial Peak	Low Partial Peak	Low Partial Peak	Low Partial Peak	Low Partial Peak	
9						
10	High Partial Peak	High Partial Peak				
11						
12	Peak	Peak	High Partial Peak	High Partial Peak		
13						
14	Crit Peak					
15						
16						
17						
18	Peak	High Partial Peak				
19						
20	High Partial Peak	Low Partial Peak		Low Partial Peak		
21			Low Part Pk			
22	Off Peak	Off Peak	Off Peak	Off Peak	Off Peak	
23						

Hours in 2006	
Critical Peak	176
Peak	434
High Partial Peak	1393
Low Partial Peak	2127
Off Peak	3170
Super Off Peak	1460
Total	8760

PCWA

Hourly Model

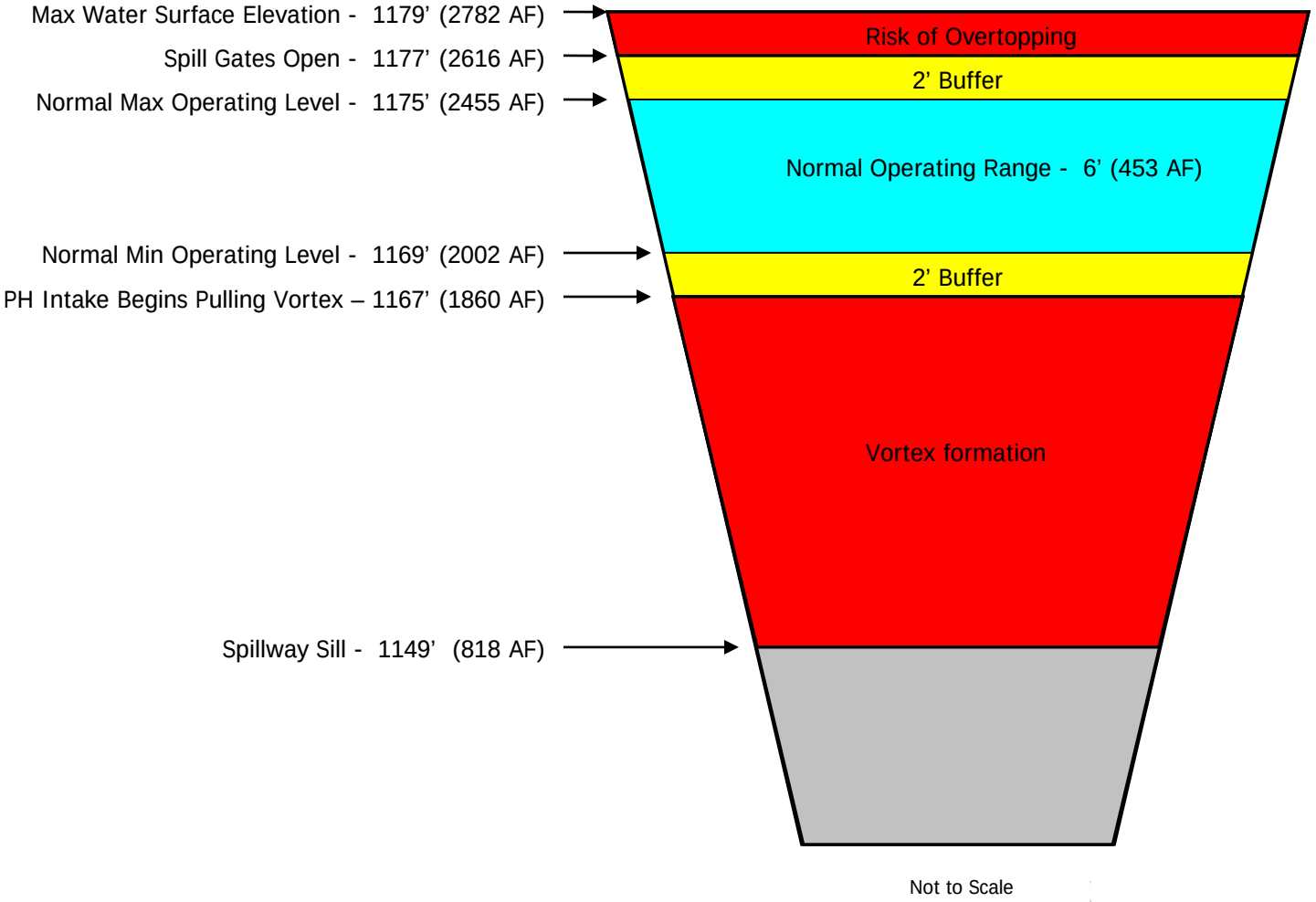
- Ralston and Oxbow powerhouses operate asynchronously
  - The difference is made up using Afterbay storage



Afterbay Constraints

- Afterbay has limited usable storage volume
- “Buffer” at top of active storage prevents overtopping
- “Buffer” at bottom of active storage prevents vortex formation

Afterbay Constraints



Output Metrics

- The Daily and Hourly models produce both built-in graphical flow, storage, and generation metrics and comma delimited data for import to external spreadsheets
- Comparative Flow Metrics
  - By node
  - Flow/elevation exceedance plots by month, year type
  - Daily, monthly time series plots
  - Spill magnitude and duration
  - Days exceeding thresholds

PCWA

Output Metrics

- Comparative Generation Metrics
  - By station
  - By year type
  - By peak hour designation
  - By throughput
- Daily and hourly model output is basis for environmental and recreational analysis

PCWA