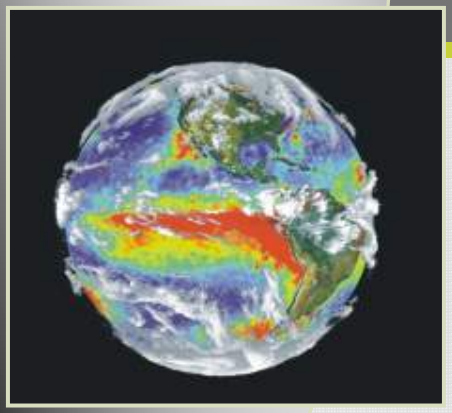

Clark Fork Hourly Operations

Marc Baldo and James VanShaar (RTi)
Heidi Heath (Avista Corp.)

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Introduction

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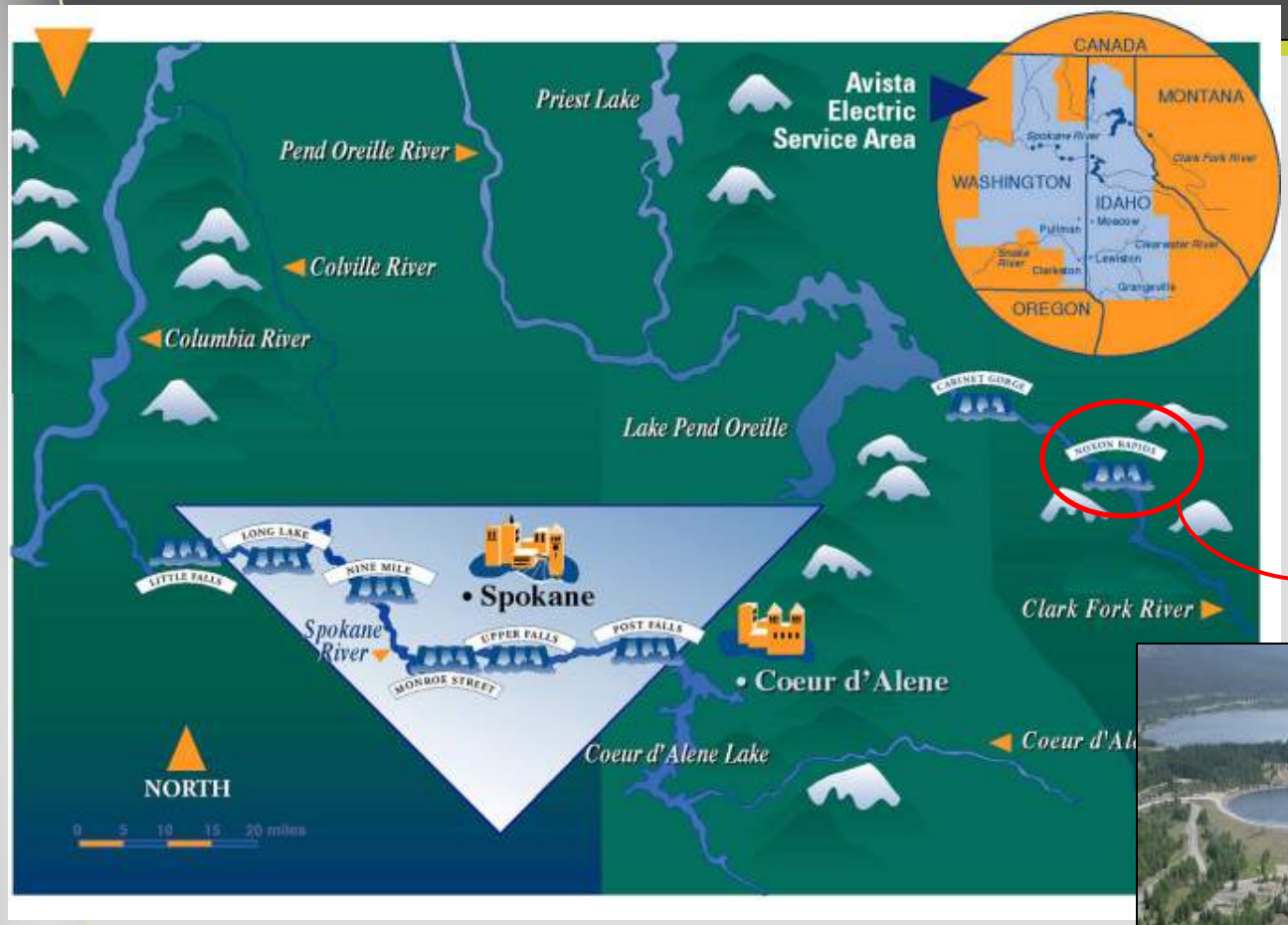
Introduction



Noxon Rapids Dam

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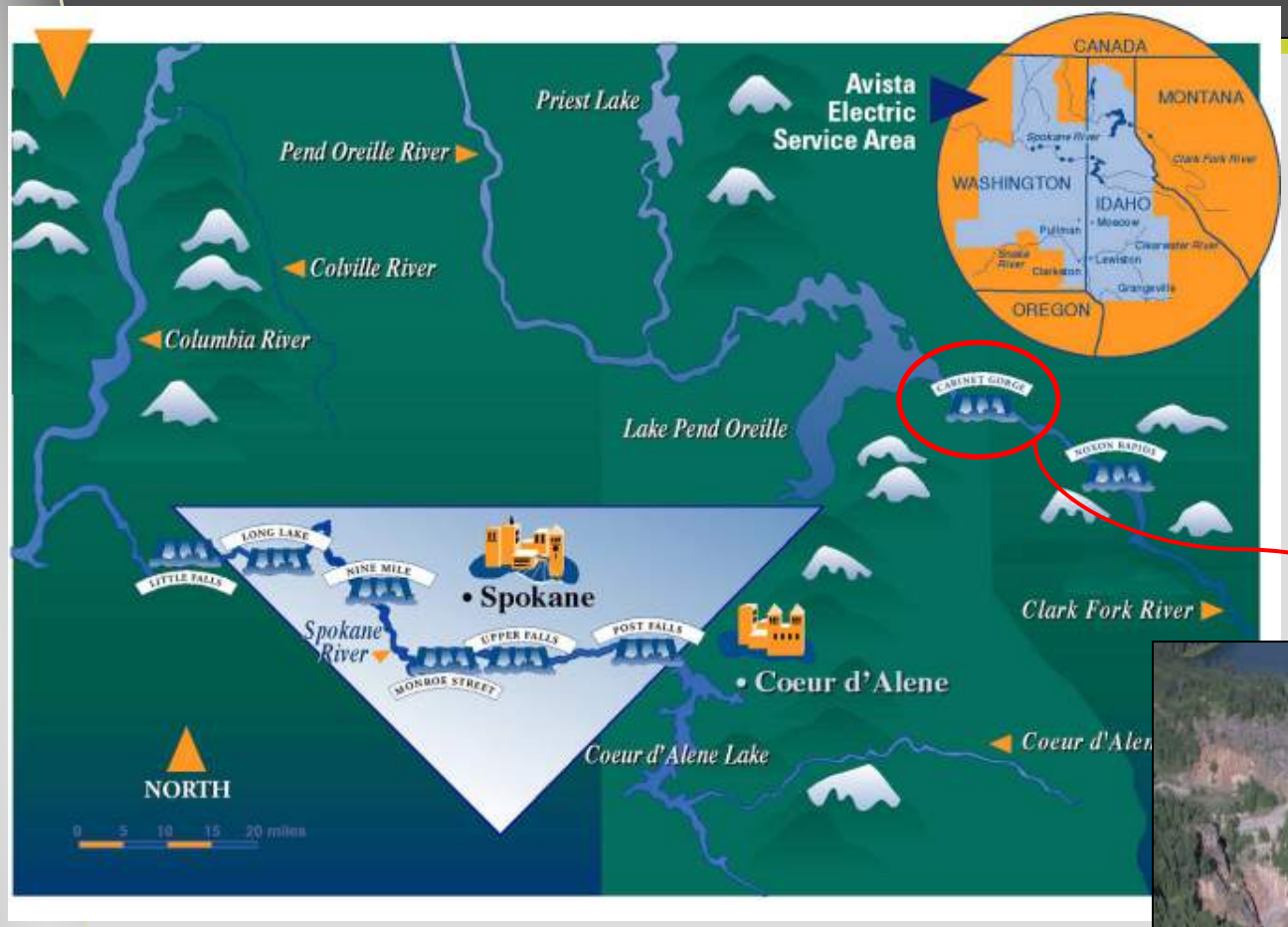

Cabinet Gorge Dam

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Project Goals

Planning tool to grade alternative operations

Avista plans big upgrade at Noxon dam

Four generators will get new turbine runners in $35 million project

Journal of Business, May 29, 2008 by Ripley, Richard

Project Goals

Planning tool to grade alternative operations

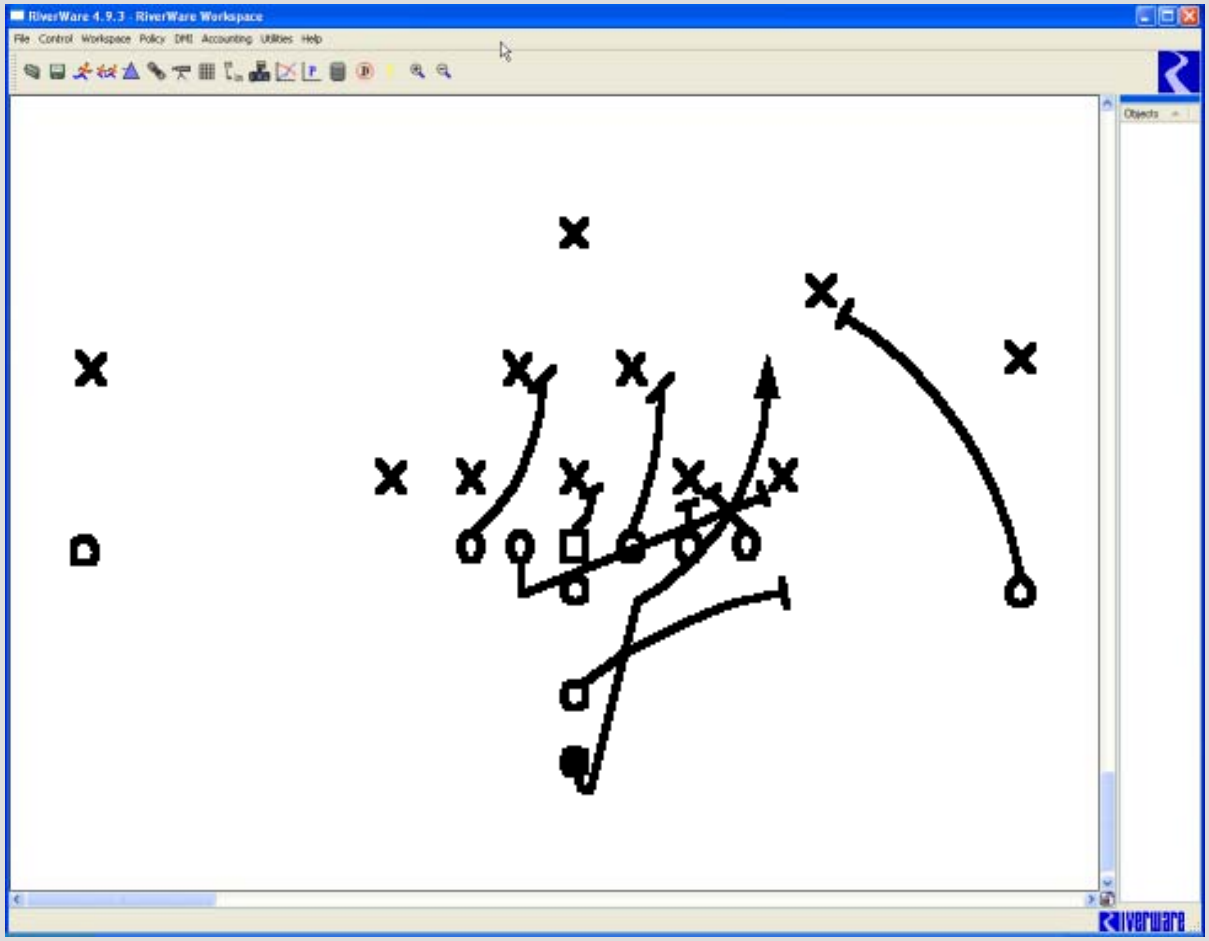
- Provide realistic hourly operation
- Model turbine capacity changes
- Construction times versus cost
- Model pool elevation changes
- Retain sufficient simplicity avoiding the need for ongoing consultant expertise
- Look forward to optimization

Approach—Phases

- Review and Strategic Design

Approach—Phases

- Review and Strategic Design



Approach—Phases

- Review and Strategic Design
- Collaborative Development

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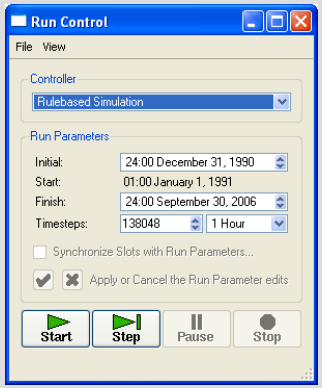
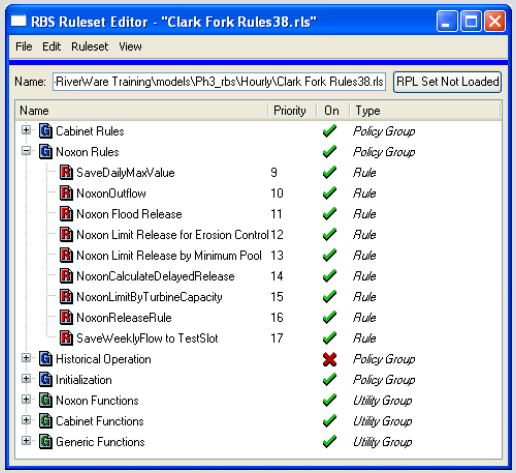
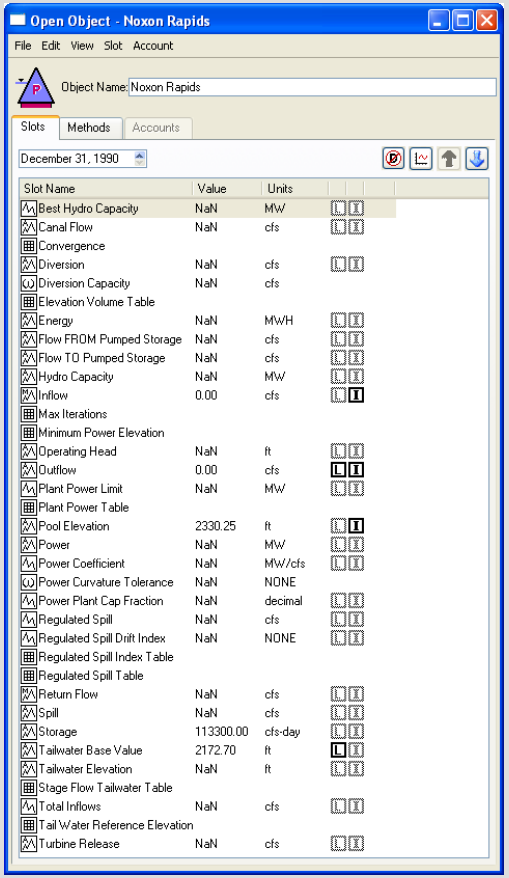
Approach—Phases

- Review and Strategic Design
- Collaborative Development
- Model Enhancement and Support







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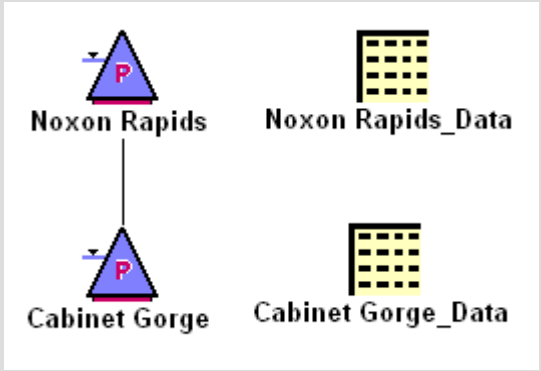
Model Design

- Simulation Model
- Physical and operational constraints
- Power market
- Rule development
- Model results

Simulation Model

- Match physical and historical operations
  - Hourly operation – 16 years of data
  - Cabinet pool elevation affects tailwater of Noxon Rapids
  - Power operation at both locations using plantEfficiencyCurve
  - Rulebased Simulation



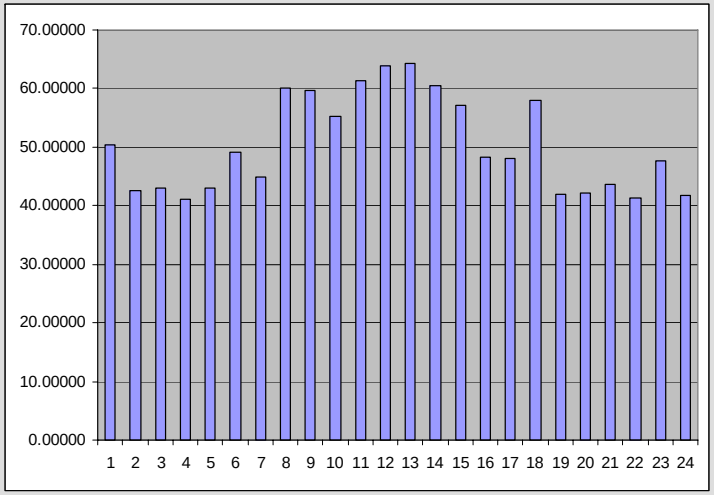
Constraints

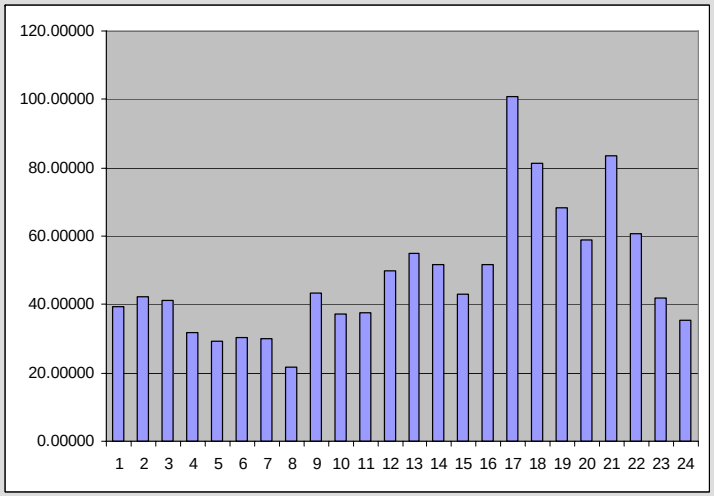
- Erosion control
  - Cannot decrease pool more than 2 ft / day or 5 ft / week
- Turbine capacity
  - Available capacity can change based on construction schedule
- Maximum/Minimum Pool Elevation
- Minimum stream flow below Cabinet

Power Market

- Hourly fluctuation in prices based on
  - Temperature
  - Day of week
  - Time of day
  - Season
  - External factors
- Operate to maximize benefit of hydropower
- Hourly prices could be used with optimization

Relative Prices per Hour
Spring and Summer Days





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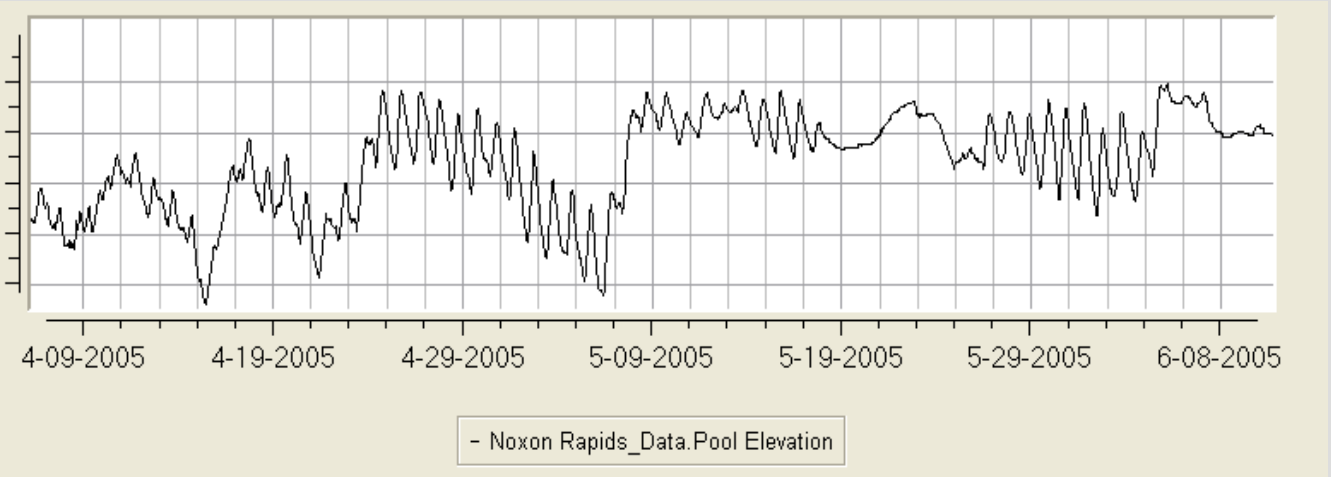
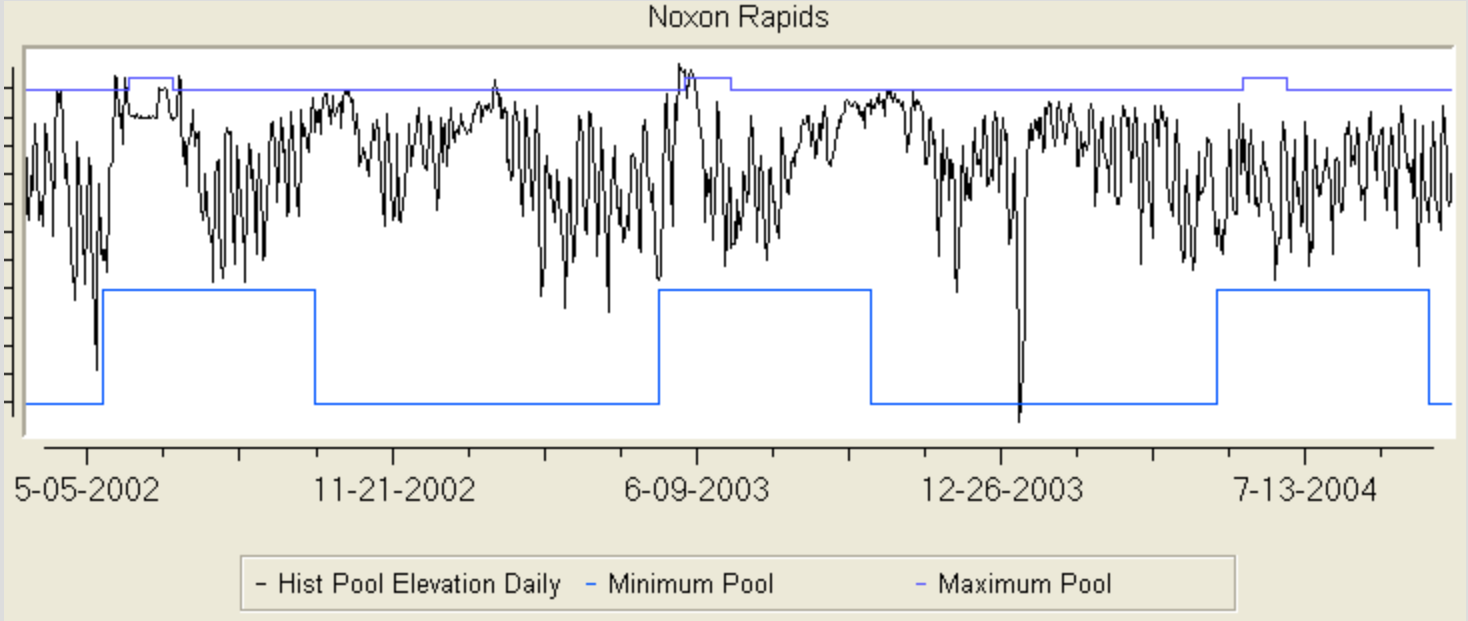
Power Releases

- Correlation between releases and the hourly power price was low
  - Total water available
  - Physical constraints, such as starting or stopping individual units



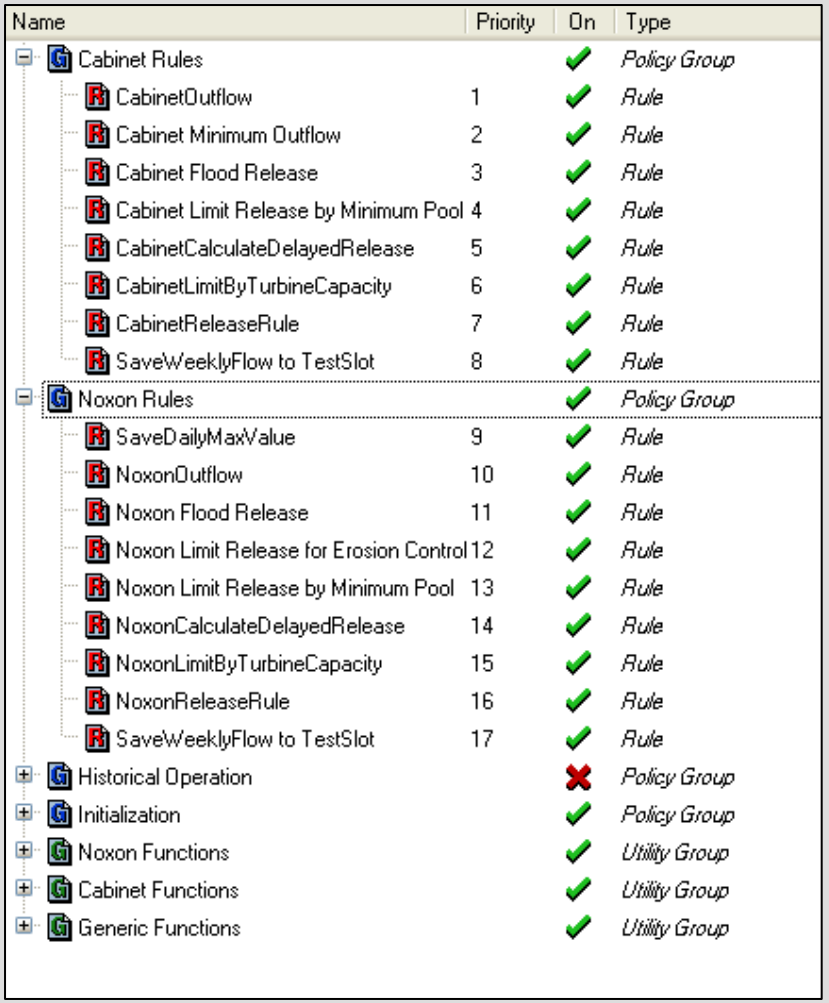
Pool Limits

- Maximum / Minimum
  - Provided as a seasonal pattern (periodic)
  - Particularly helpful for maximum storage
  - Provided limits for the release rule



Typical Release

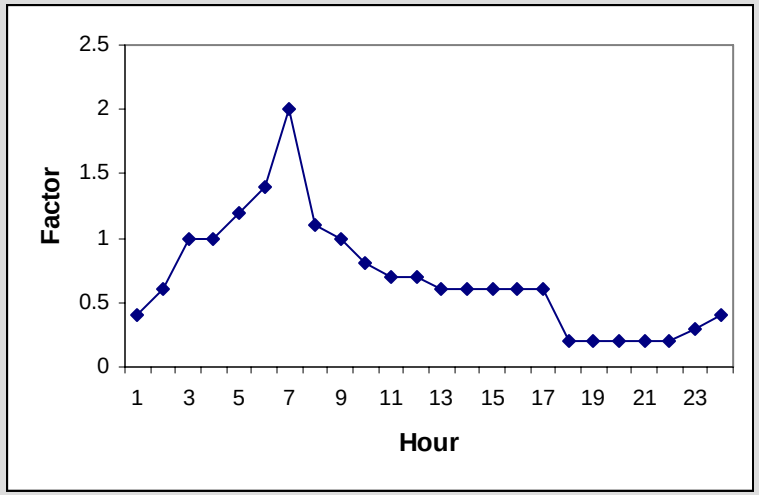
- Release is a function of:
  - Weekly inflow
  - Date
  - Turbine capacity
  - Minimum pool
  - Maximum pool
  - Erosion limits
  - Minimum release

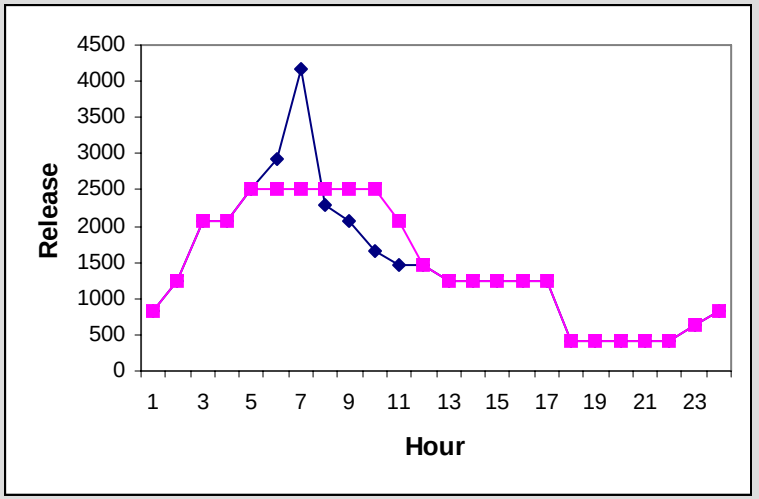


Name	Priority	On	Type
Cabinet Rules		✓	*Policy Group*
CabinetOutflow	1	✓	*Rule*
Cabinet Minimum Outflow	2	✓	*Rule*
Cabinet Flood Release	3	✓	*Rule*
Cabinet Limit Release by Minimum Pool	4	✓	*Rule*
CabinetCalculateDelayedRelease	5	✓	*Rule*
CabinetLimitByTurbineCapacity	6	✓	*Rule*
CabinetReleaseRule	7	✓	*Rule*
SaveWeeklyFlow to TestSlot	8	✓	*Rule*
Noxon Rules		✓	*Policy Group*
SaveDailyMaxValue	9	✓	*Rule*
NoxonOutflow	10	✓	*Rule*
Noxon Flood Release	11	✓	*Rule*
Noxon Limit Release for Erosion Control	12	✓	*Rule*
Noxon Limit Release by Minimum Pool	13	✓	*Rule*
NoxonCalculateDelayedRelease	14	✓	*Rule*
NoxonLimitByTurbineCapacity	15	✓	*Rule*
NoxonReleaseRule	16	✓	*Rule*
SaveWeeklyFlow to TestSlot	17	✓	*Rule*
Historical Operation		✗	*Policy Group*
Initialization		✓	*Policy Group*
Noxon Functions		✓	*Utility Group*
Cabinet Functions		✓	*Utility Group*
Generic Functions		✓	*Utility Group*

Turbine Capacities

- Reduction in turbine capacity
  - Daily release variation is maintained
  - Excess release is stored
  - Pool elevation limits are enforced





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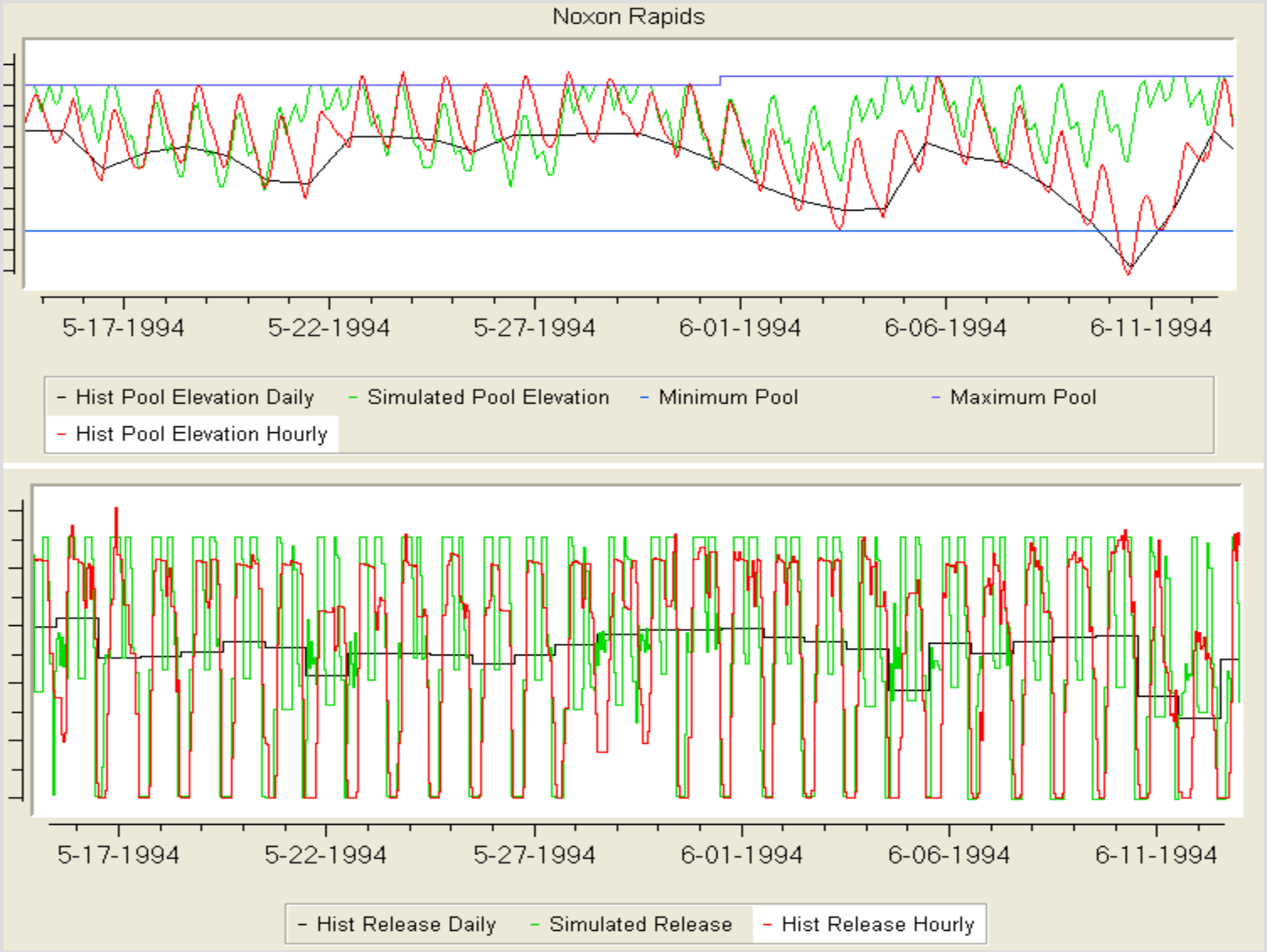
Results



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Conclusion

- The model and training were successfully delivered with project objectives fully met
- Avista currently runs the model
- Modeling results used for:
  - Construction / Maintenance timing
  - Estimating the benefits of planned improvements


Spokane River,
Downtown Spokane, WA
Questions?