TENNESSEE VALLEY AUTHORITY

TVA River Management & Hydropower Optimization

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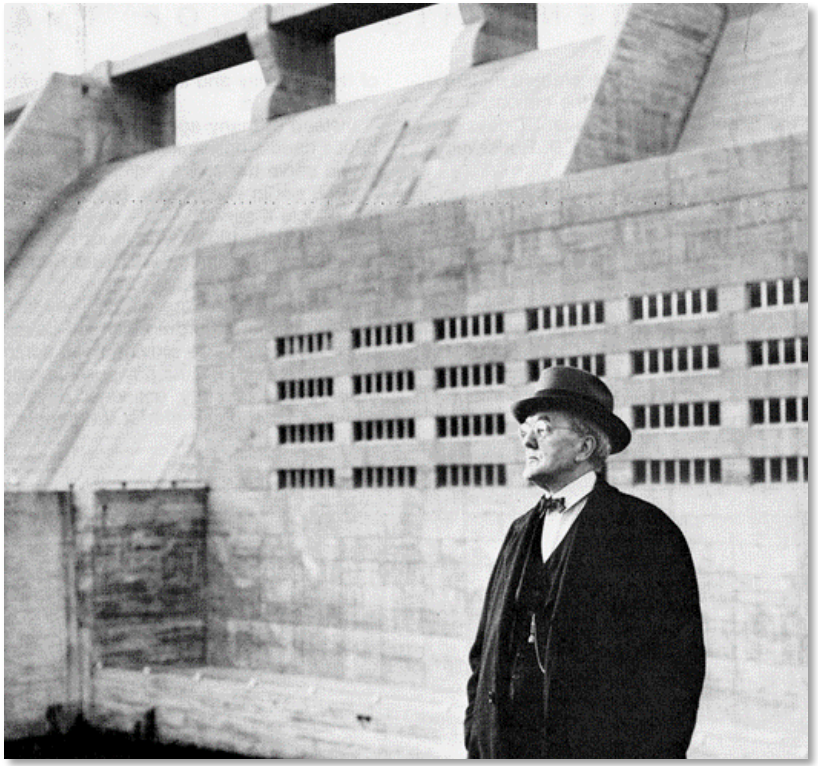
Hydrologist

The Tennessee Valley Authority Act

River system assigned multipurpose role through TVA Act in 1933.

(section 9a) …to regulate the stream flow primarily for the purposes of promoting navigation and controlling floods. So far as may be consistent with such purposes, …for the generation of electric energy…



“Father of TVA,” Senator George Norris

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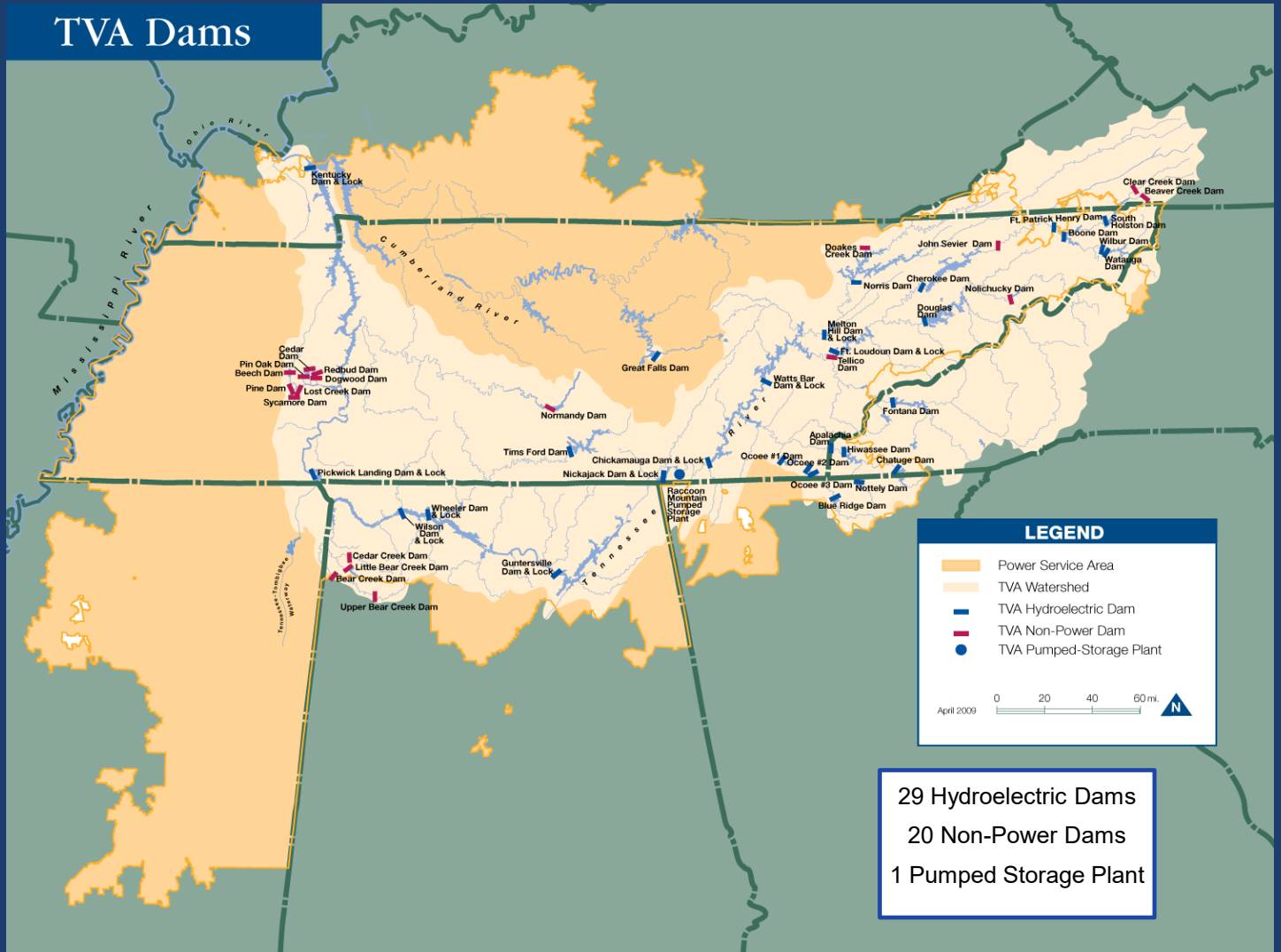
TVA Dams



29 Hydroelectric Dams

20 Non-Power Dams

1 Pumped Storage Plant

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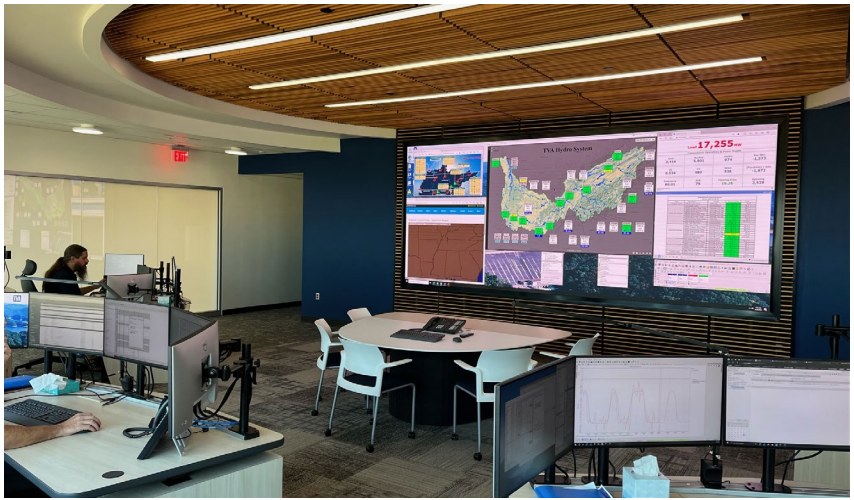
TVA River Forecast Center

Staffed 24x7 365 days a year – around the clock monitoring of the river system to respond to changing river conditions and weather as well as flooding and emergencies across the system.

TVA River Forecast Center – Knoxville, TN



Fort Loudoun Dam, Tennessee River

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Integrated River System Management

Flood Damage Reduction

Power Generation

Navigation

Water Supply

Recreation

Water Quality

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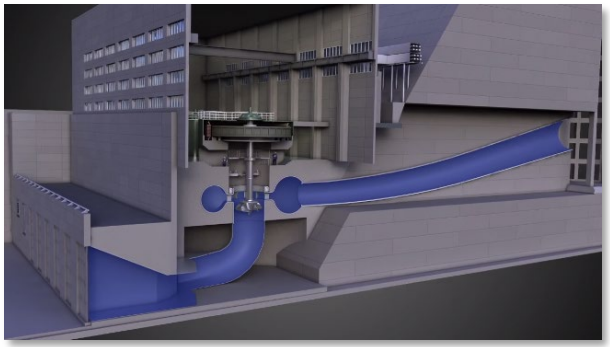
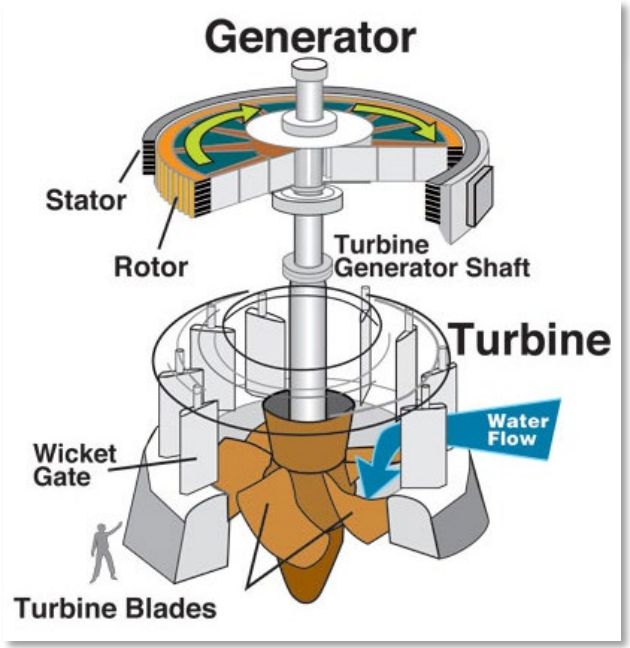
Hydro Power

- Approximately 9% of total TVA power portfolio
- 3,538 MW Conv. generating capacity (109 Units)
- 1,653 MW Pump-storage capacity (4 units)
- Load peaking demand and quick system response
- Clean, renewable, low cost energy source





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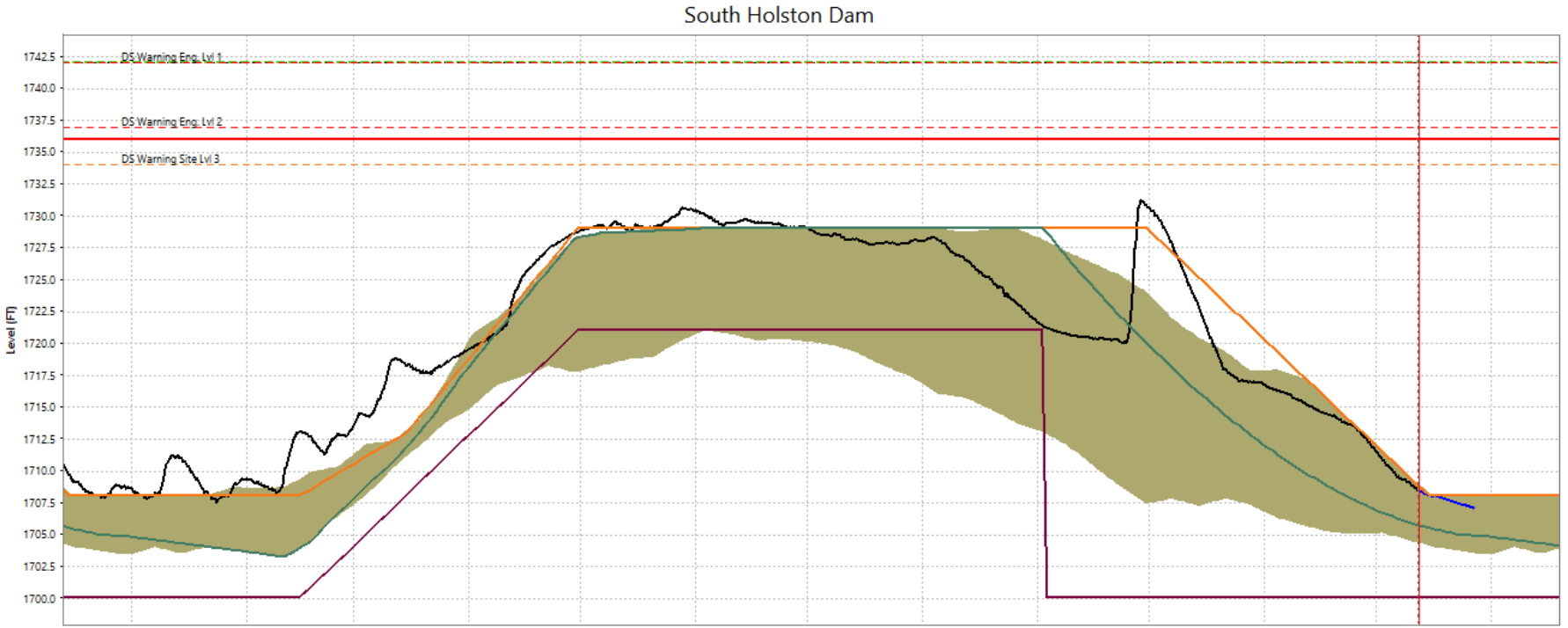
Seasonal Operating Guide Example



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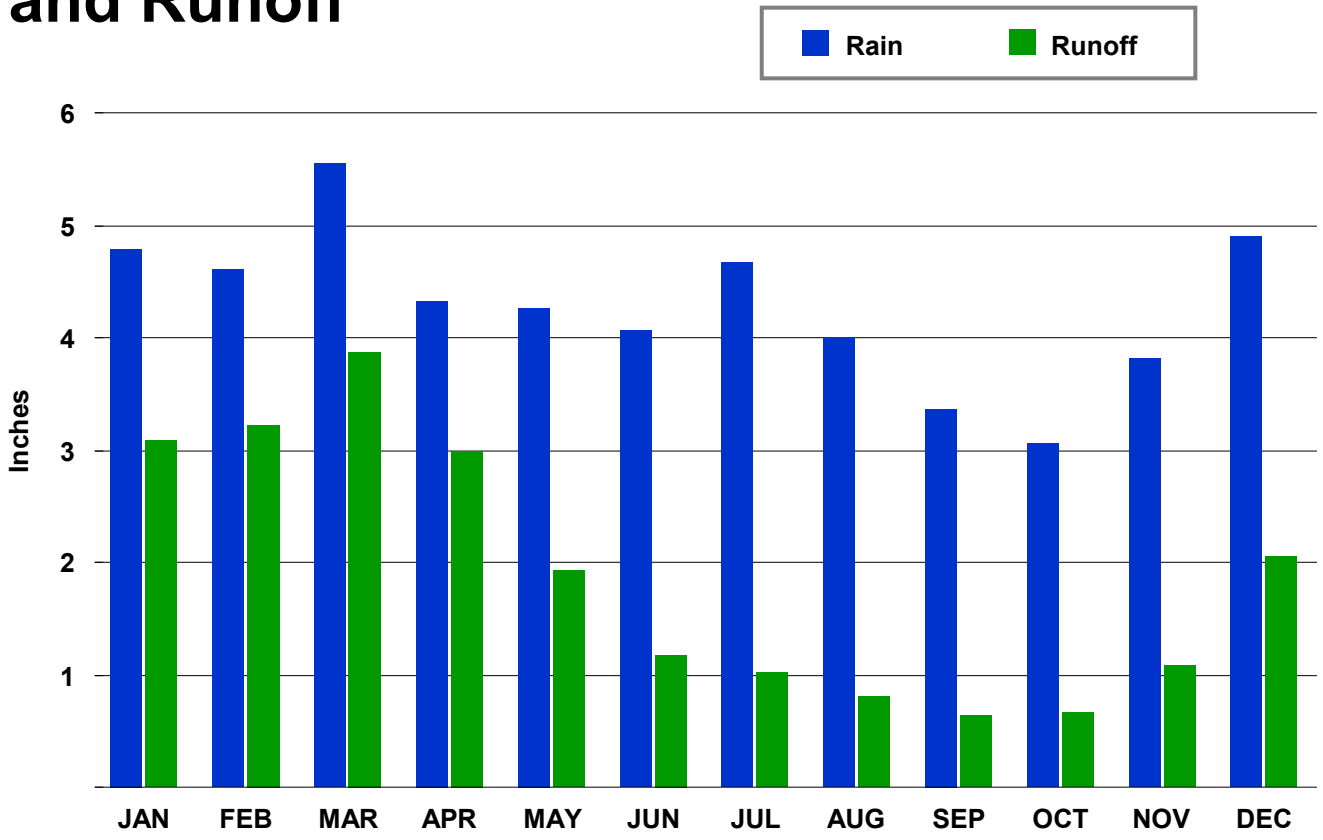
Rain and Runoff



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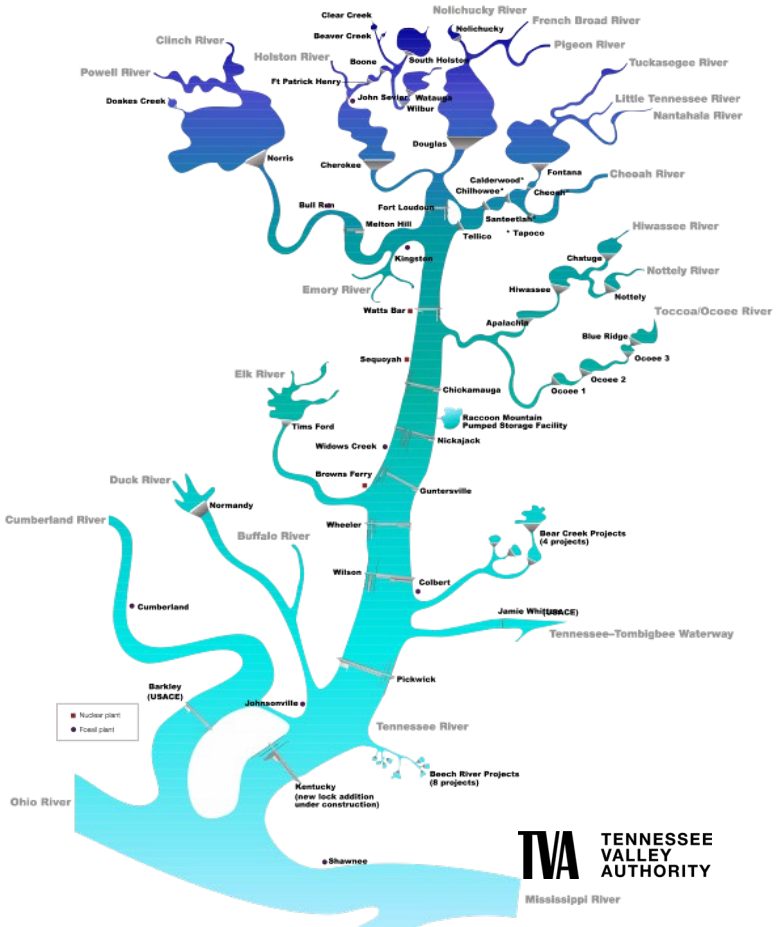
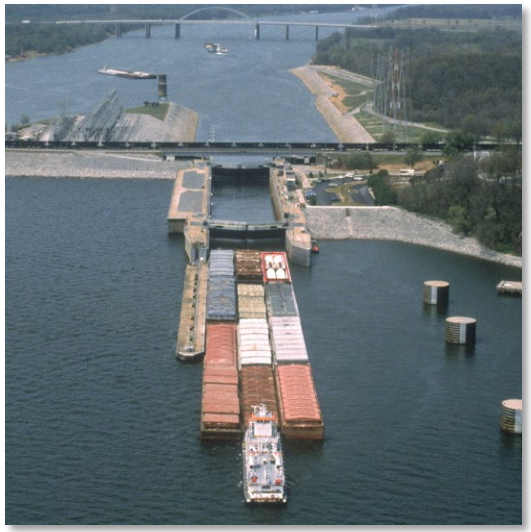
Flood Damage Reduction

Phases:

- Preparation
- Use Reservoir Storage
- Storage Recovery



Navigation



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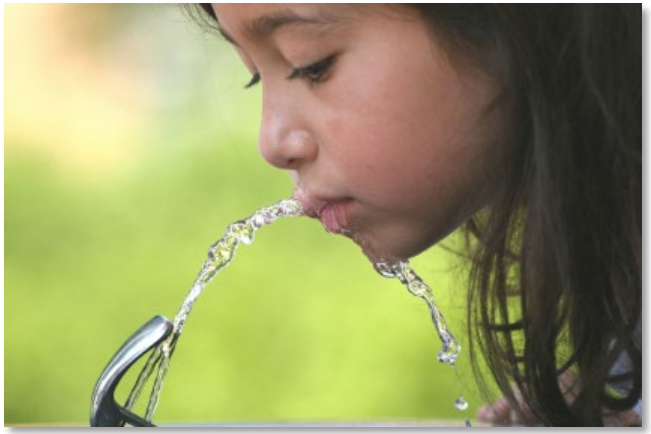
Water Supply

- Municipal, Industrial, and Thermoelectric permitted withdrawals
- TVA ensures that 700 water intakes across the Valley are adequately supplied with water
- The River Forecast Center is responsible for ensuring minimum depth for water intakes across the Valley



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Recreation

- High summer lake levels for reservoir recreation
- Scheduled Tailwater Releases:
  - Norris
  - Apalachia
  - Ocoee No. 1
  - Ocoee No. 2
  - Ocoee No. 3
  - Tims Ford
  - Watauga/Wilbur
  - Upper Bear Creek
- Benefits include:
  - Economic Development
  - Quality of life
  - Lake Boating
  - Tailwater Floating
  - Wade Fishing
  - Whitewater rafting

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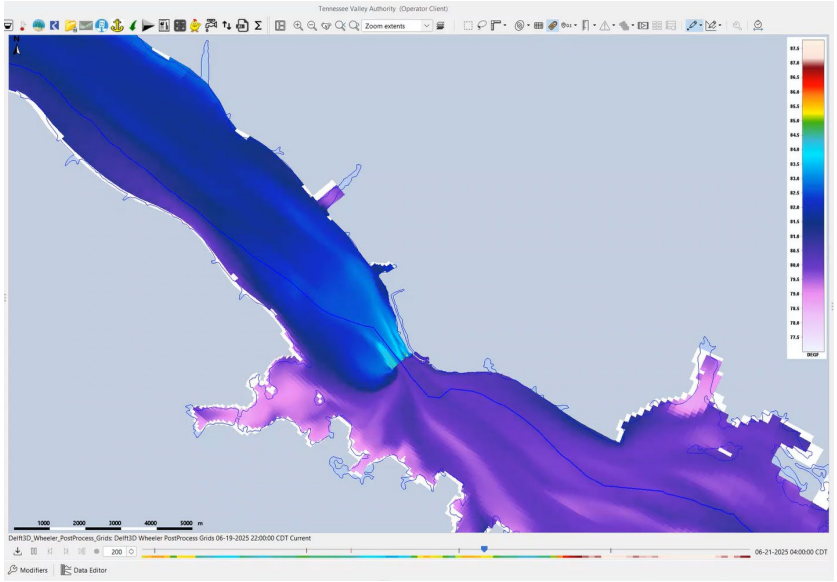
Water Quality

- Hydrothermal forecast modelling for NPDES permits at TVA coal and nuclear plants
- Aeration monitoring, operations, and structures for improving river dissolved oxygen (DO)



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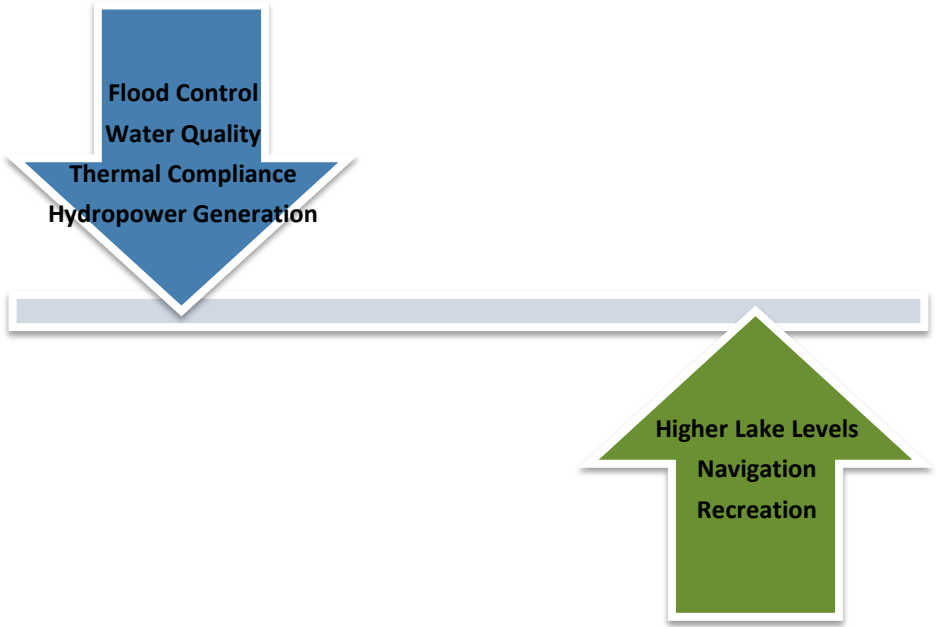
Challenges

- Balancing the competing demands on the system and the overall value to the public
- Understanding of the trade-offs associated with various scenarios
- Example: Can you keep my reservoir higher, longer?



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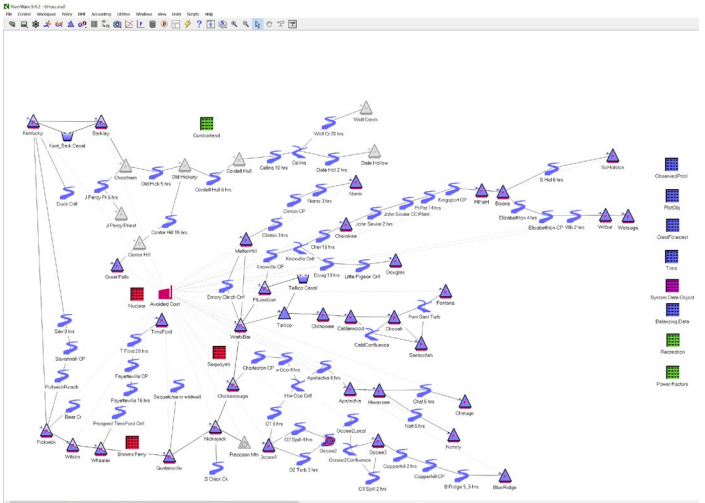
HydroPower Optimization at TVA

- Tennessee Valley Authority
  - ~9% Hydropower (29 power plants) + pumped storage
  - Remainder: nuclear, coal (decreasing), gas, solar (increasing)
- Models
  - RiverWare Model – hydropower ~ 2 weeks
    - Combined 6-hour and hourly timesteps
    - Water constraints → Goal programming
  - Production Cost Model: power and transmission (10 days)
    - Hourly timesteps
    - Mixed-Integer Program



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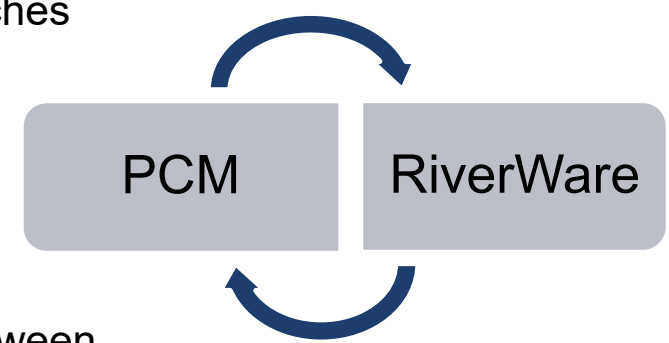
PCM/Hydropower Co-optimization

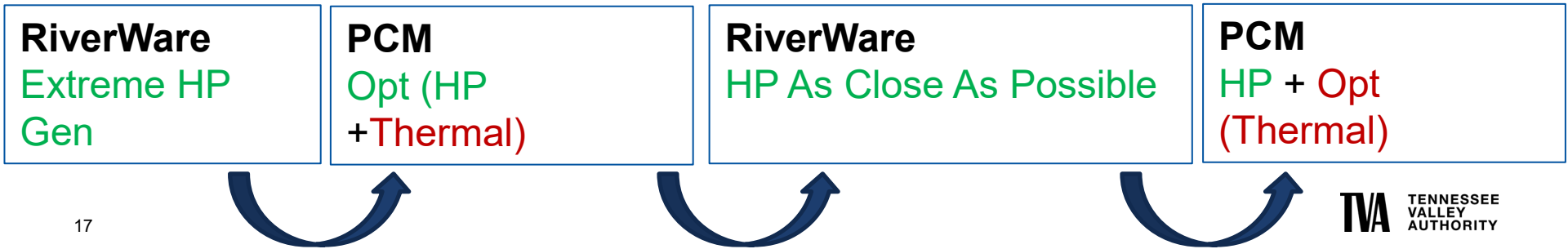
- Challenging
  - Ideally, all power in one model
  - Practically, impossible
- Traditional math programming decomposition approaches
  - Price decomposition
  - Resource decomposition
  - Master problem and subproblems
- Our approach
  - System constraints and ideal solutions passed between models



Co-Optimization at TVA - Basic Version

Iterating between RiverWare and PCM

1. RiverWare trial objectives → PCM constraints
   A. Min and max generation for each hour
   B. 10-day generation total
2. PCM: Ideal hydropower given constraints
3. RiverWare: As Close As Possible to the PCM solution
4. PCM: optimize given RiverWare hydropower solution



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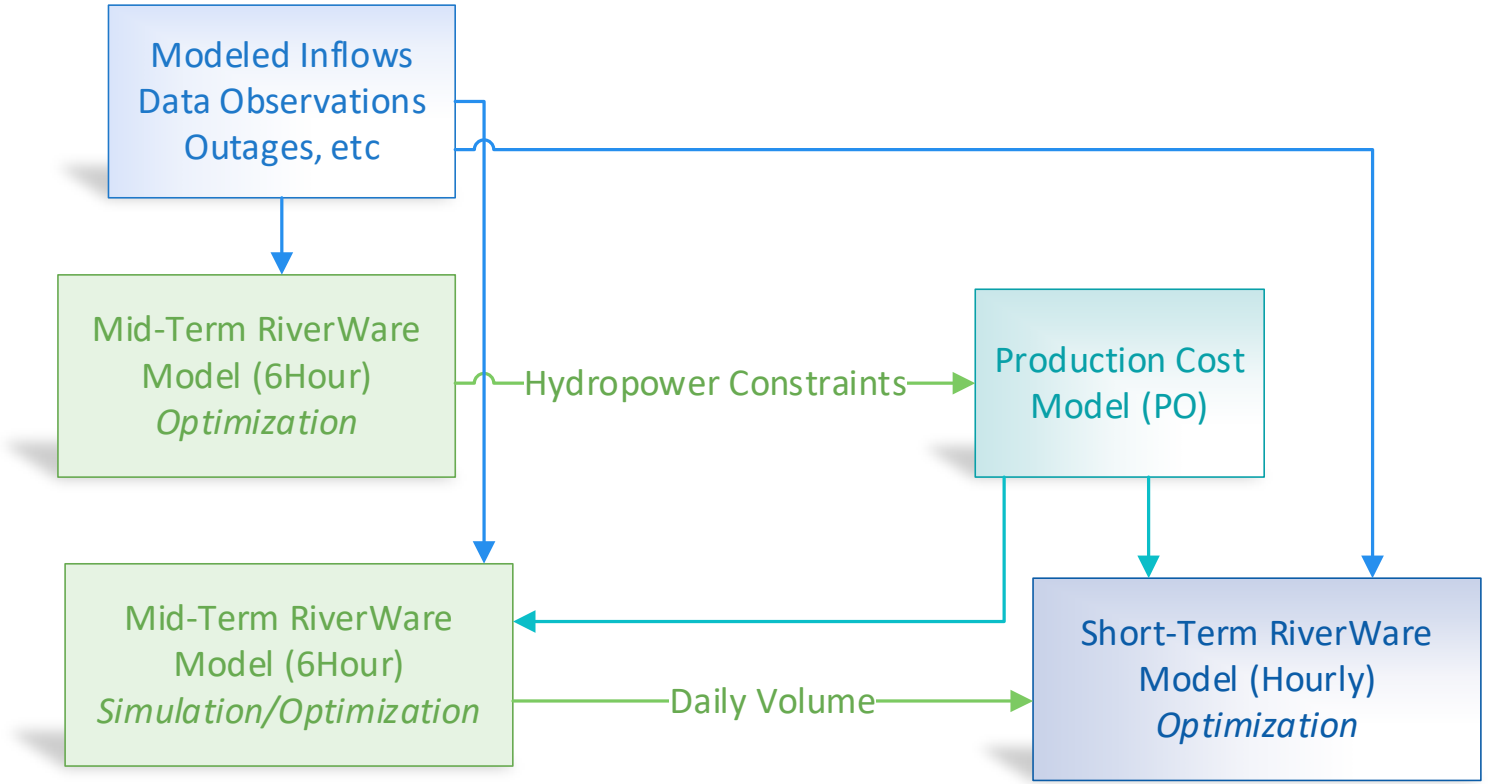

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Portfolio Optimization at TVA - Enhanced Version

Iterating between a Hydropower Model and a PCM

1. RiverWare trial objectives → PCM constraints
   A. Min and max generation for each hour
   B. 10-day generation total
2. **Create more "realistic" A' constraints**
3. 2 PCM solutions
   A. Ideal hydropower with A & B constraints?
   B. Realistic hydropower with A' & B constraints?
4. RiverWare: 2 sets of soft constraints:

   Priority 1: Within the range of the 2 PCM solutions
   Priority 2: As Close As Possible to the ideal PCM solution
5. PCM: optimize given RiverWare hydropower solution

Portfolio Optimization at TVA - Results

- RiverWare hydropower mostly between the PCM solutions
  - By design
  - When outside the PCM solutions: usually close
- Some hours: hydropower is near the ideal PCM solution
  - By design
- Operational tools
  - Run several times per day

Portfolio Optimization: Potential Enhancements

- Add more RiverWare policy into PCM
  - Good example - ramping constraints
  - Will generate more realistic PCM solutions
- Add ideas from other approaches


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