Multipurpose Reservoir System Operations

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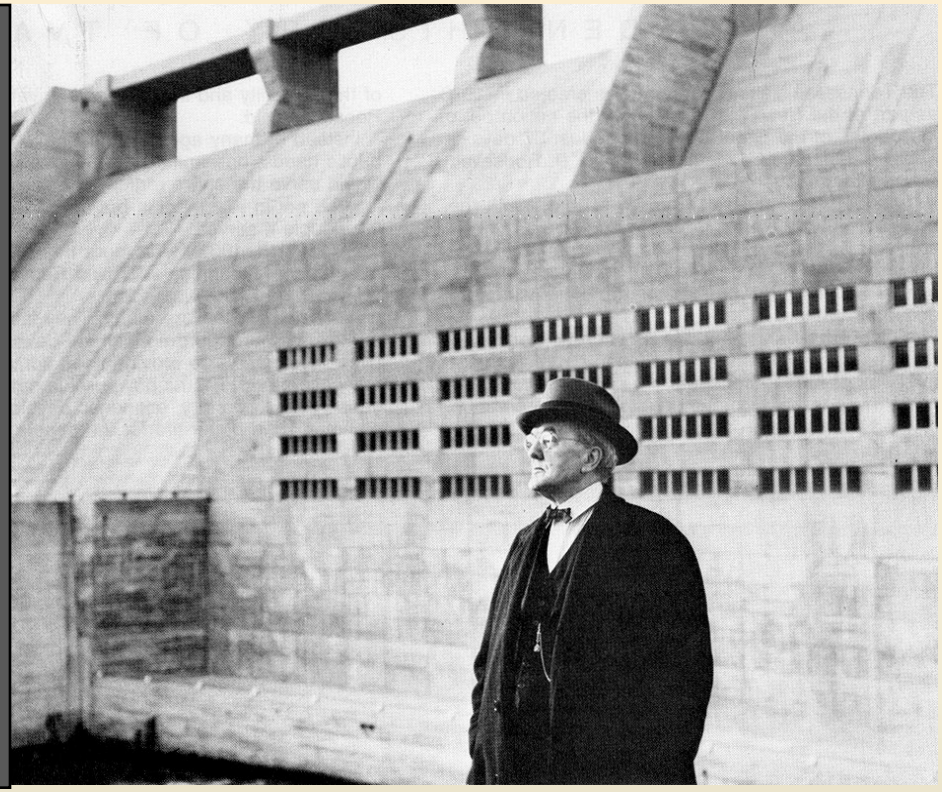
Operations Support

TVA

Tennessee Valley Authority

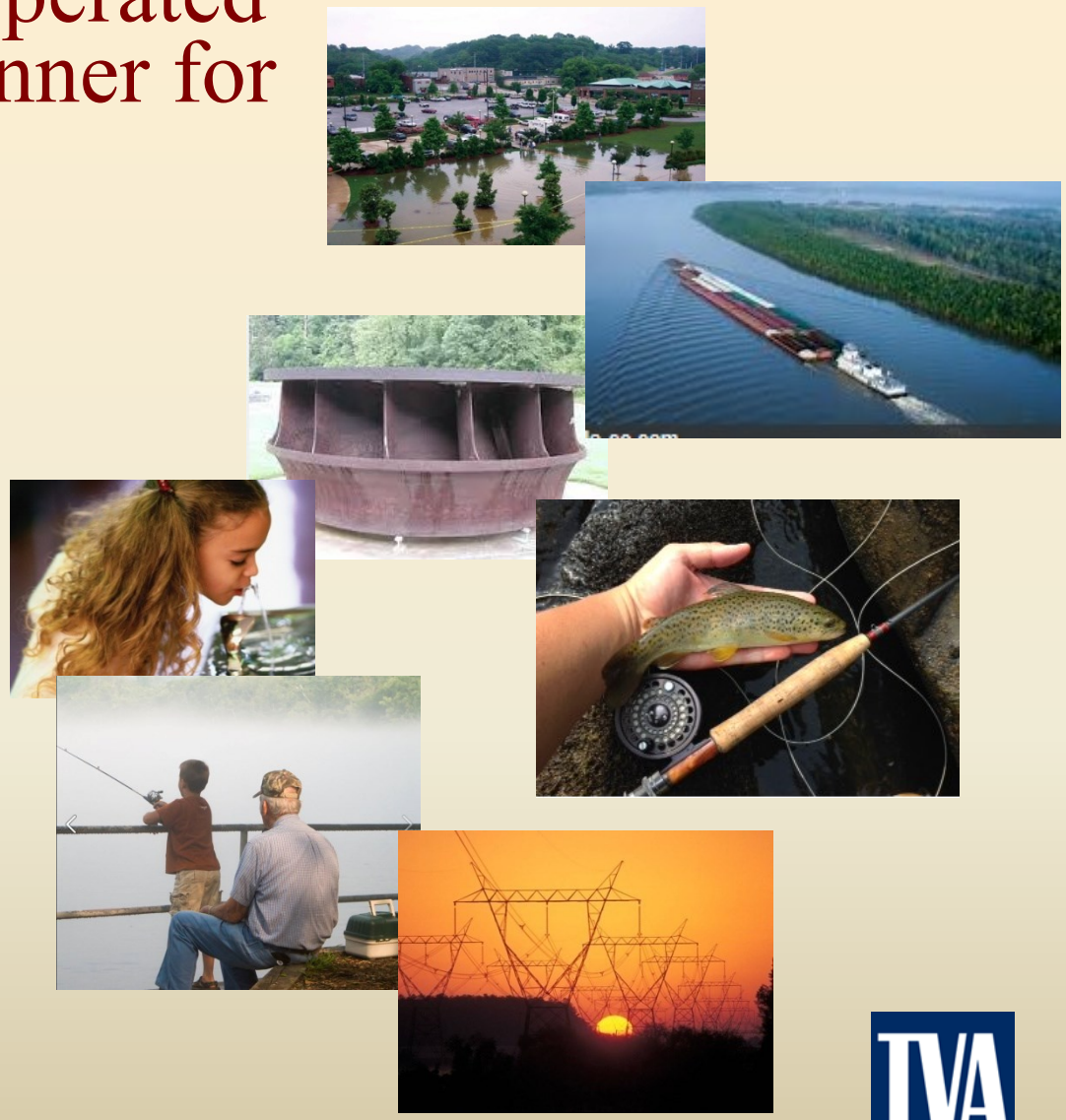
(section 9a) …to regulate the stream flow primarily for the purposes of promoting navigation and controlling floods. So far as may be consistent with such purposes, ...for the generation of electric energy...



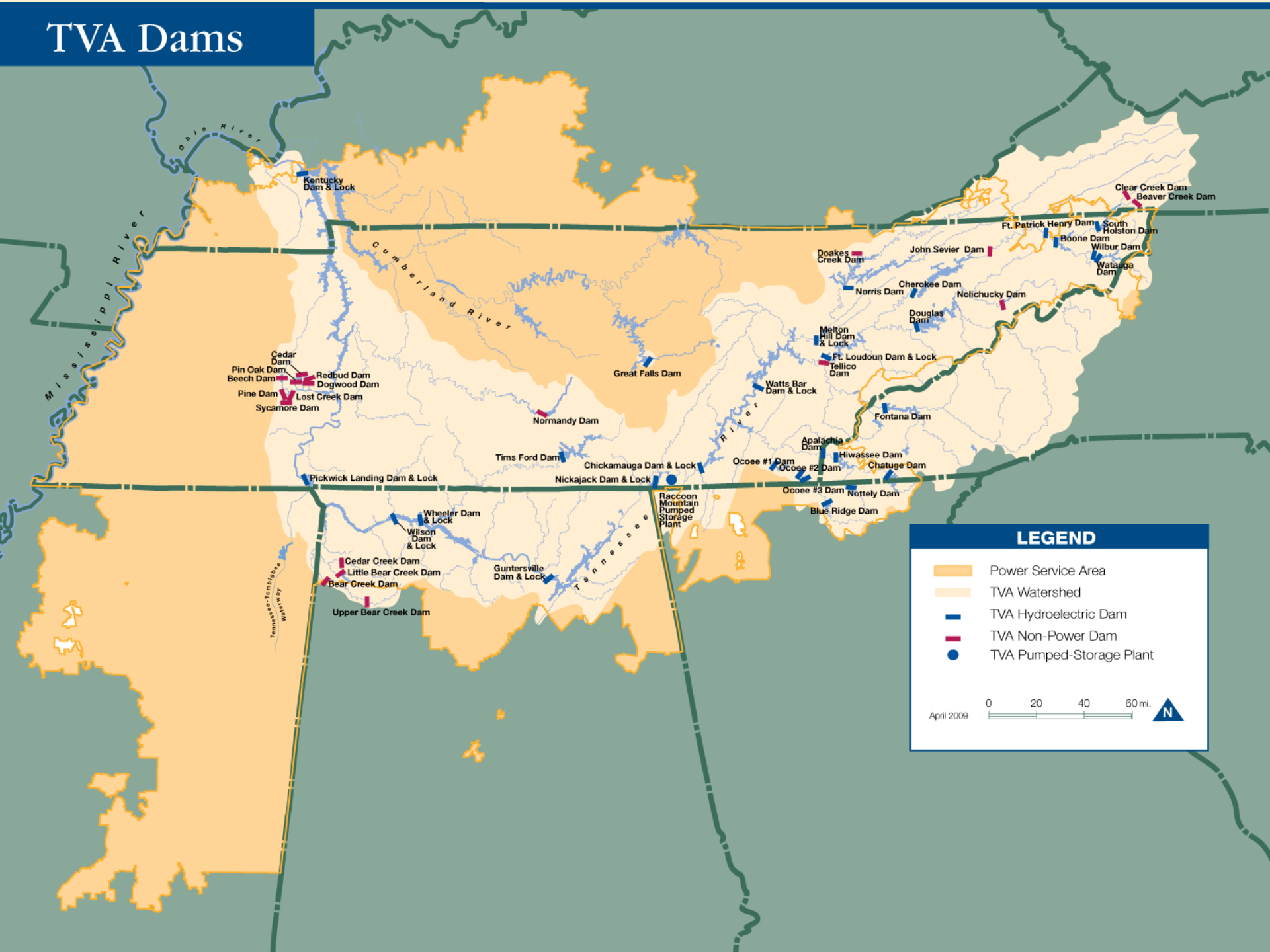
Senator George Norris, Norris Dam, TN

Reservoir System operated in an integrated manner for multiple benefits

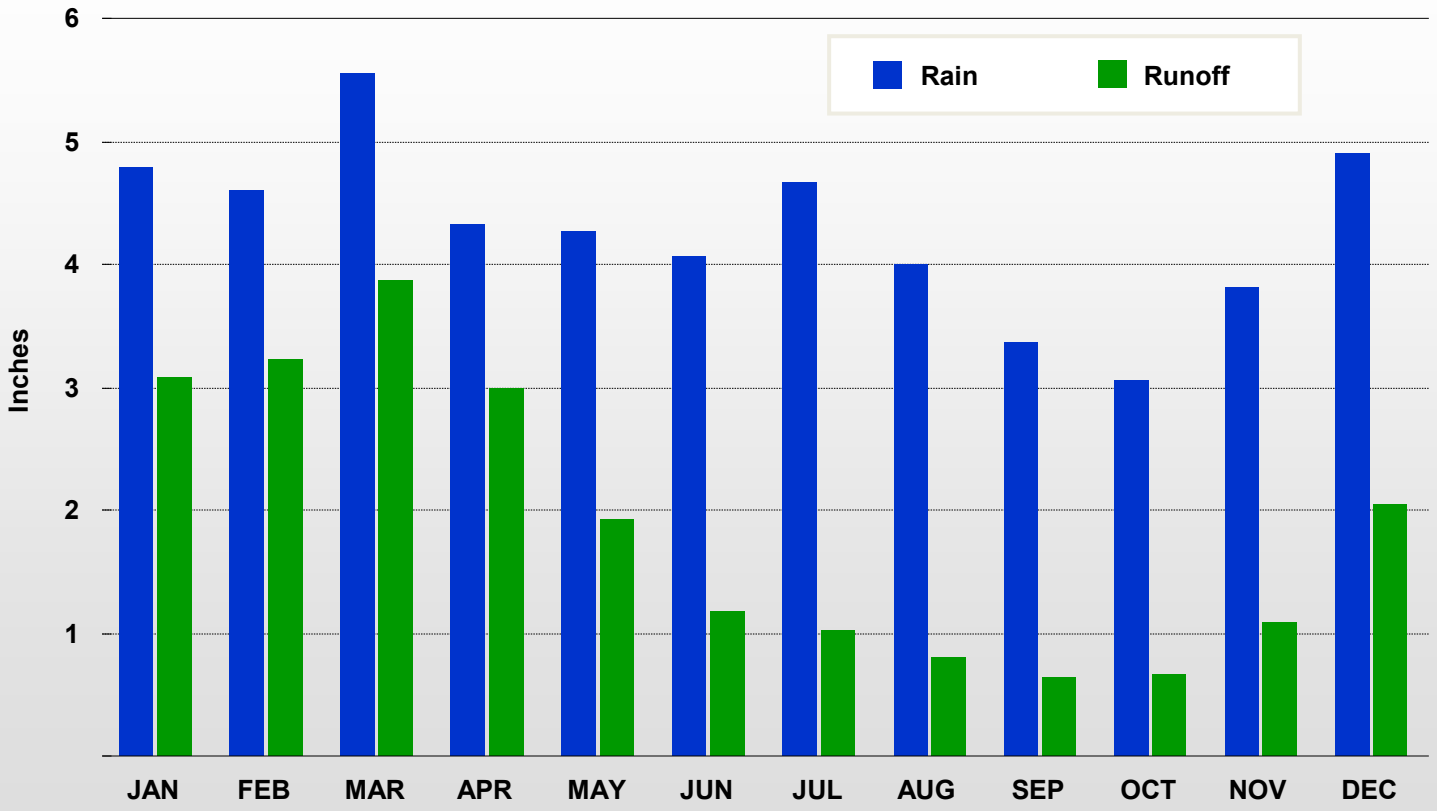
- Flood control
- Navigation
- Power
- Recreation
- Water quality
- Water supply



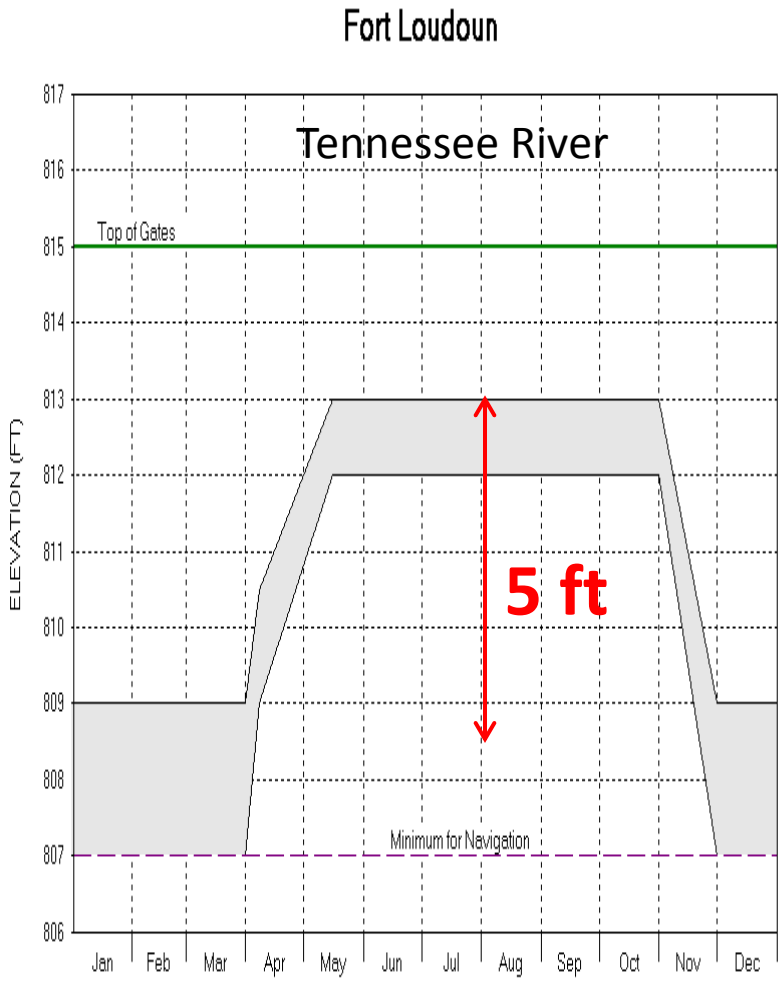
TVA Dams

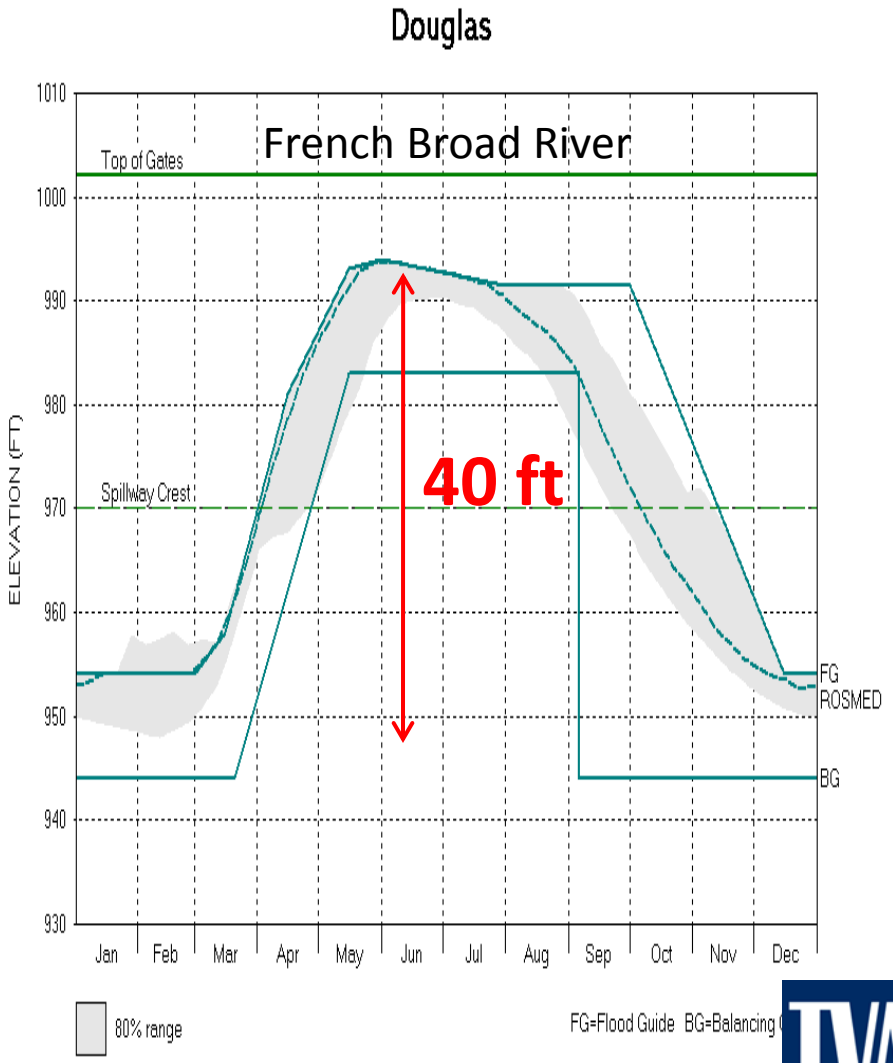

Ohio River
Mississippi River
Cumberland River
Tennessee River
Tennessee-Tombigbee Waterway
Kentucky Dam & Lock
Cedar Dam
Pin Oak Dam
Beech Dam
Redbud Dam
Dogwood Dam
Pine Dam
Lost Creek Dam
Sycamore Dam
Great Falls Dam
Normandy Dam
Tims Ford Dam
Pickwick Landing Dam & Lock
Chickamauga Dam & Lock
Nickajack Dam & Lock
Raccoon Mountain Pumped Storage Plant
Wheeler Dam & Lock
Wilson Dam & Lock
Cedar Creek Dam
Little Bear Creek Dam
Bear Creek Dam
Upper Bear Creek Dam
Guntersville Dam & Lock
Watts Bar Dam & Lock
Fontana Dam
Apalachia Dam
Hiwassee Dam
Ocoee #1 Dam
Ocoee #2 Dam
Chatuge Dam
Ocoee #3 Dam
Nottely Dam
Blue Ridge Dam
Melton Hill Dam & Lock
Ft. Loudoun Dam & Lock
Tellico Dam
Douglas Dam
Norris Dam
Cherokee Dam
Nolichucky Dam
Doakes Creek Dam
John Sevier Dam
Ft. Patrick Henry Dam
South Holston Dam
Boone Dam
Wilbur Dam
Watauga Dam
Clear Creek Dam
Beaver Creek Dam
LEGEND
Power Service Area
TVA Watershed
TVA Hydroelectric Dam
TVA Non-Power Dam
TVA Pumped-Storage Plant
0 20 40 60 mi.
April 2009
N

Valley Rainfall and Runoff



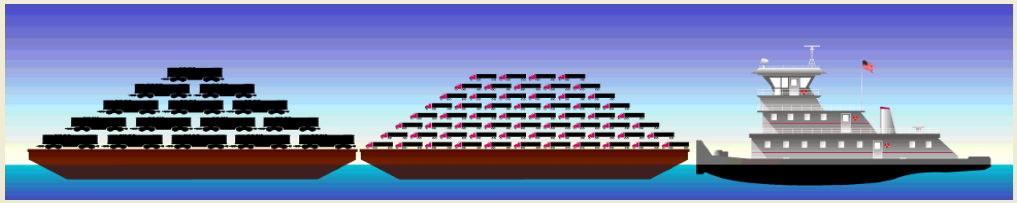
Annual Reservoir Pool Cycle





Flood Control & Navigation

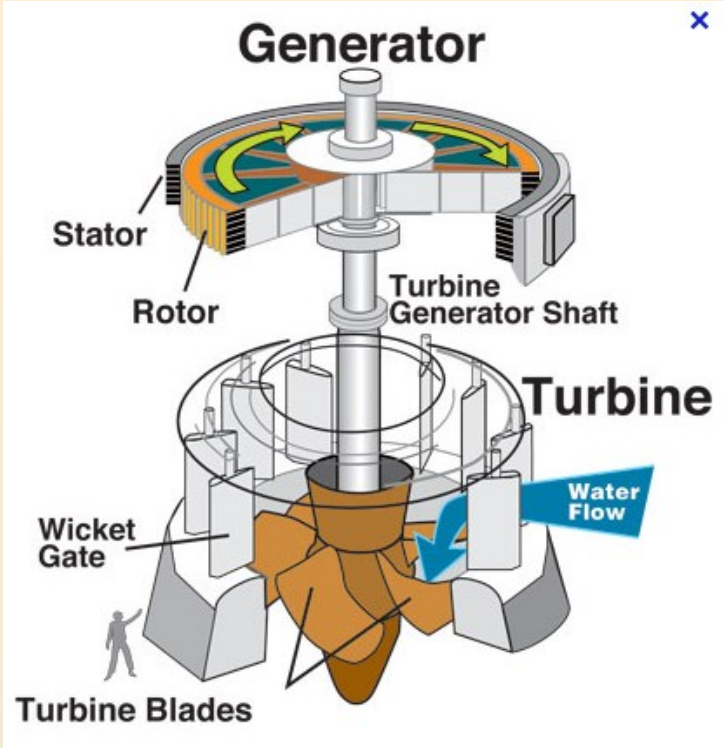
- Store water during flood to reduce crest
- Issue flood forecasts for regulated system
- Release water at non-flood rate after crest
- Annual average flood damages averted are $260 million ($6.8 billion to date)



- Cost-effective transportation
- Raw Materials, Coal, Grains, Aggregates, Iron, Steel, Petroleum
- ~ $1B/year in shipper savings
- 652 Miles of Navigable Waterways
- Partners the U.S. Corps of Engineers

Hydropower

- 3,538 MW Conv. generating capacity (109 Units)
- 1,653 MW Pump-storage capacity (4 units)
- Peaking power demand
- Rapid Dispatch and Flexibility
- ~ 10% of TVA's energy portfolio
- Low O&M Costs
- Used to displace more expensive fuels
- Water temperature support at thermal generating plants



http://water.usgs.gov/edu/hyhowworks.html

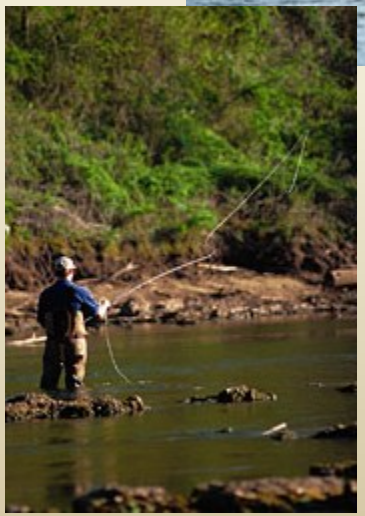
Water Supply and Quality

- 700 Water Intakes
- Process water for industry, thermal-electric cooling, municipal, irrigation
- Drinking water for nearly 5 million people
- Provide minimum depths for intakes
- Manage inter-basin transfers

- Temperature and Dissolved Oxygen monitoring
- Adaptive Management for T&E species
- Minimum flow for downstream habitat
- Thermal compliance at TVA fossil and nuclear sites

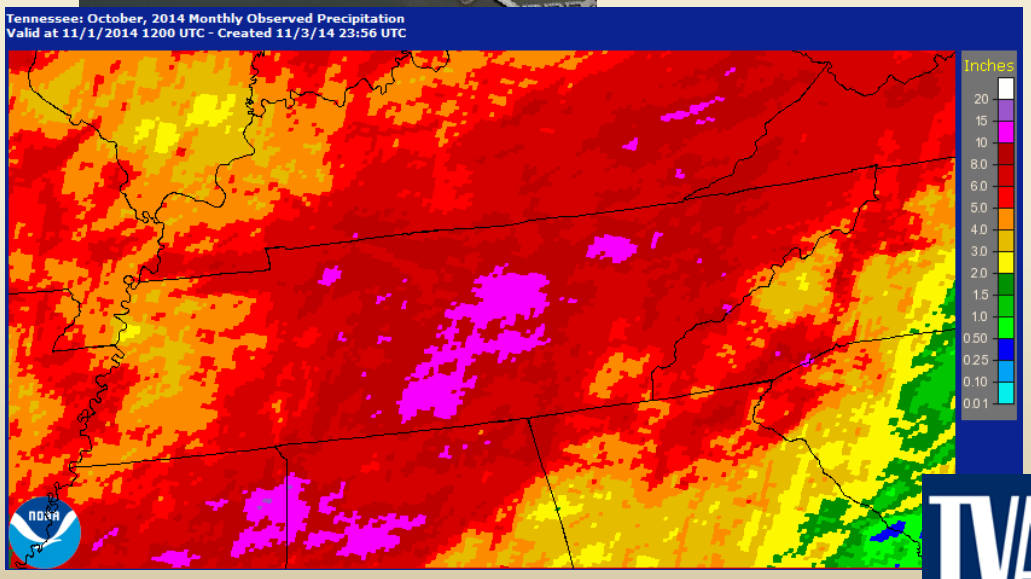
Recreation

- 230 Commercial Marinas
- 260 Campgrounds
- Drawdown restricted June 1 – Labor to provide higher summer lake levels
- Numerous tailwater releases to support trout fishing, whitewater rafting and drift-boating
- Economic Boost
- Stakeholder Involvement
- Special flows and elevations to support community events

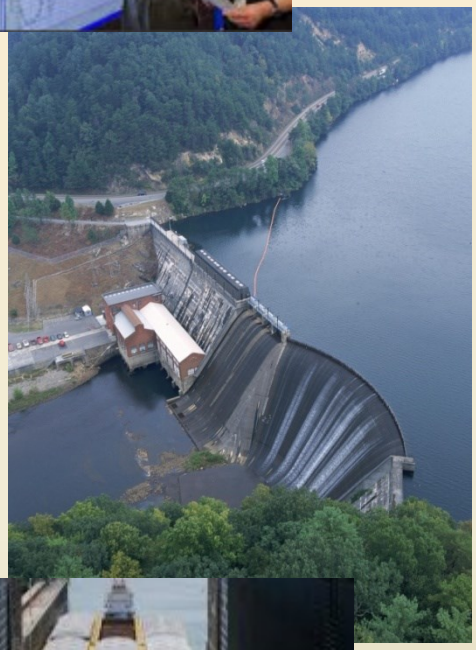


Forecasting and Decision Support

- 240 Rain Gages
- 60 Stream Gages
- Inflow and Runoff Modeling
- Reservoir Release Routing and Simulation
- Hydropower Optimization
- Hydrothermal modeling
- Liquid Oxygen System Operations
- Reservoir Release dispatch and scheduling
- Dissemination of Information to stakeholders and partners



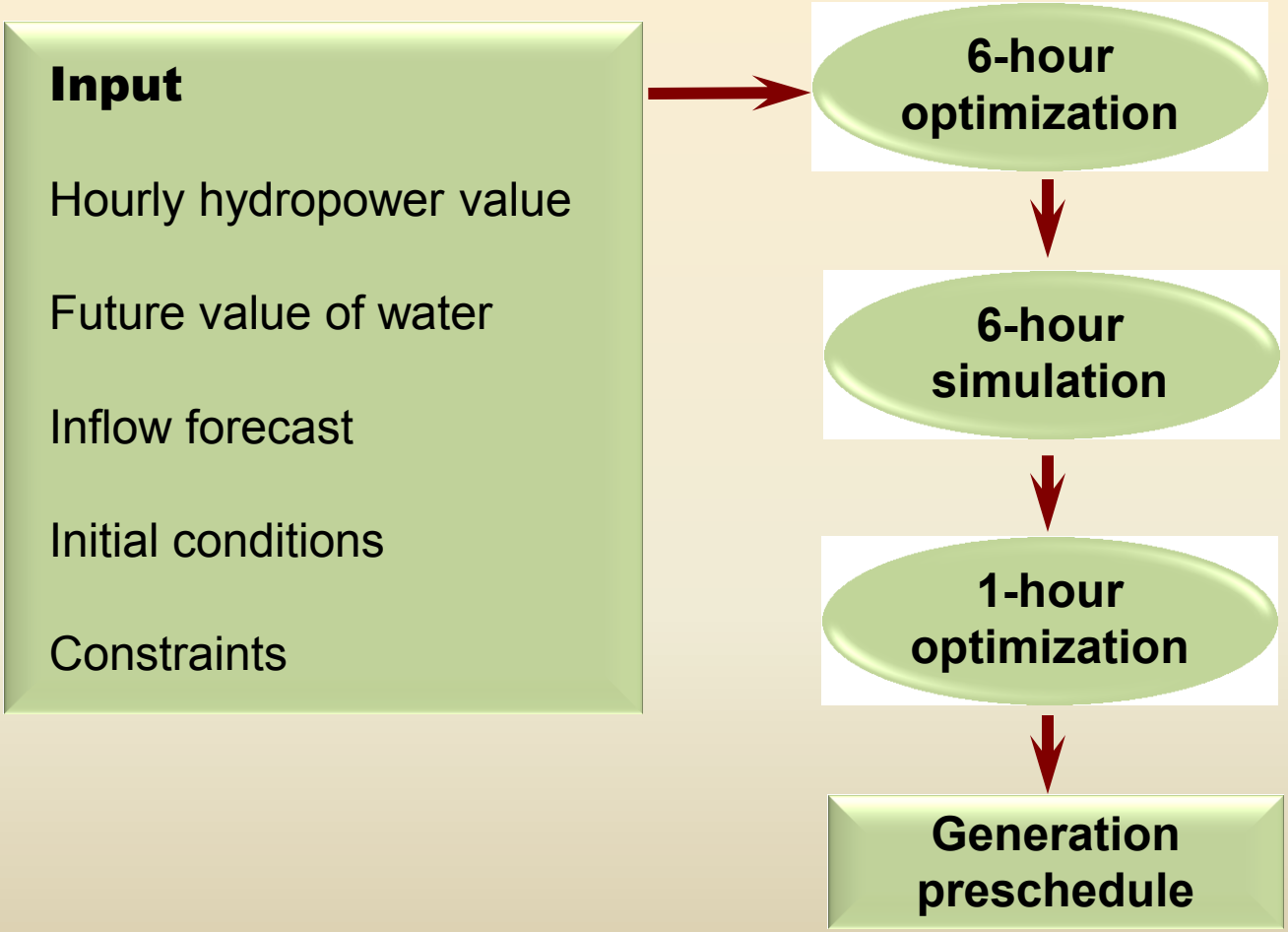
http://water.weather.gov/ahps/



Using RiverWare to Optimize the TVA Reservoir System

- TVA's RFC is staffed 24/7/365
- Teams issue 2 - 4 river forecasts per day
- Precipitation & Inflow Input
- 14 day elevation/outflow/power - simulated operations
- Day ahead and next day hourly hydropower releases for 109 power assets – optimized to offset higher cost thermal asset use
- 14 day optimization routine used to maximize hydro value with given constraint set

Optimization Process



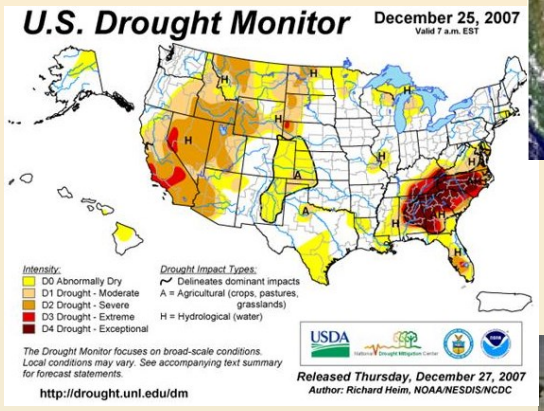
Decision Horizons and Tools

Historic

Observed Values 3 - 14 Days

Today

Real-time Reservoir Data, Real-time radar data, Real-time Decisions



2 Days

Hourly Economic Modeling, Reservoir Simulation, Power System Planning, Reservoir Release Dispatch, Quantitative Precip

14 Days

Reservoir Simulations, Reservoir Optimization, Economic Forecasts, Load Forecasts, Weather Forecast, Planned Constraints

Months - Years

Planning Models, Long-term power studies, Capacity Constraints, Resource Strategy

Data Dissemination

Model Results

- Hourly Hydropower Schedule (next 48 hours)
- Daily Avg. Flows & Daily Total Power (next 1-30 days)
- Forecasted Reservoir Elevations

Transmission Operations & Balancing

Hydro-automation and Dispatched Releases

Partnering Agencies

Industry & Public

Forecasting System Modernization

- Majority of current systems are in-house developed and custom tailored to TVA needs, expensive to maintain
- TVA is recognizing a shift to broader user base and platforms by partnering with similar agencies, NWS, USBR, BPA, etc.
- Adapting more modern tools and decision support systems
- Improved visualization of results to aid in decision process
- Recognizing importance of ensemble forecasting and communication of forecasts to stakeholders
- Regulatory impact – Post Fukushima and Nuclear Licensing

Forecasting System Modernization

Data Collection and QC

- Consolidate processing into a uniform automated system

Rainfall

- Thiessen polygon method to MPE, NSSL Q2
- Use NWS QPF, move to QPF ensemble

Inflows

- Event-based API to Continuous SAC-SMA with data assimilation

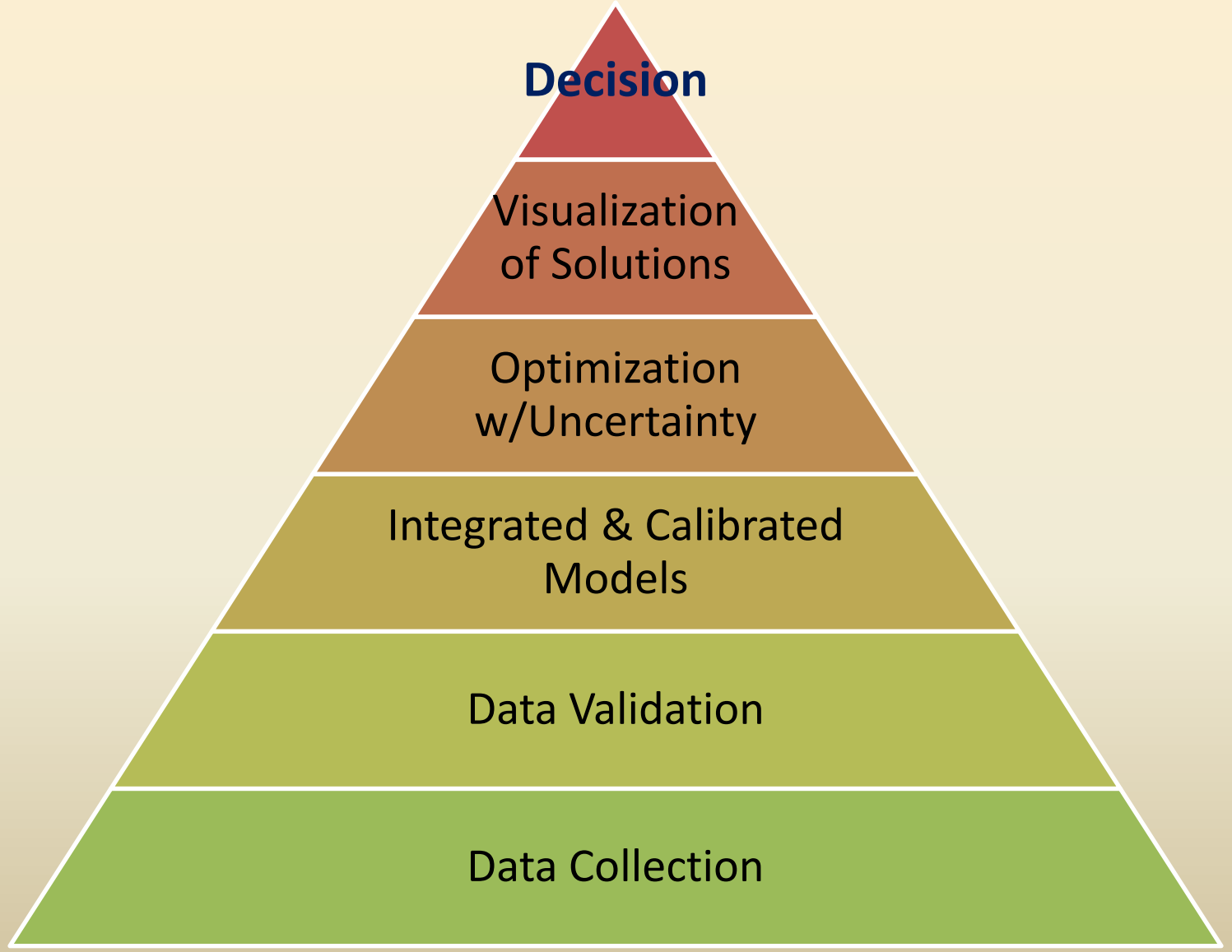
Decision making

- Riverware optimization improvements

Decision evaluation

- Hydraulics to HEC-RAS
- Explore using HEC-RAS and Delft-3D for temperature simulation

Value Chain


Decision
Visualization of Solutions
Optimization w/Uncertainty
Integrated & Calibrated Models
Data Validation
Data Collection

Summary

- TVA has a long history that began with its river management mission
- Operations are driven by rainfall and runoff as guided by Reservoir Operations Policy
- Integrated operation allows TVA to balance river system benefits:
  - Navigation
  - Flood-damage reduction
  - Affordable and reliable electricity
  - Improved water quality
  - Dependable water supply
  - Recreation
- Decision Support Tools as well as reliable real-time data are vital to meeting these objectives
- As technology continues to advance, TVA has chosen to modernize tool-set

River Forecast Center

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