Modeling Extreme Events at TVA with RiverWare

RiverWare User Group Meeting

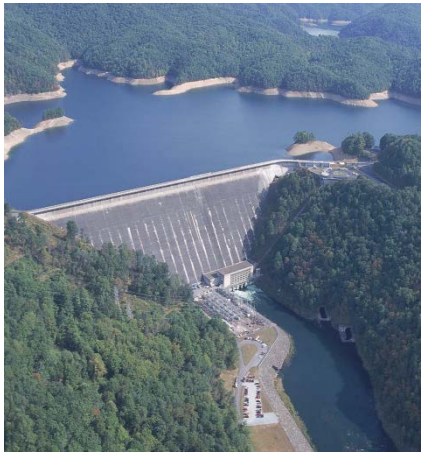
Boulder, Colorado Feb 1-2 2012

Outline

- A little TVA background
- TVA recalculation of PMF levels at 49 dams
- What is the role of RiverWare?
- What data are needed for RiverWare on TVA's main river projects?
- How well does RiverWare perform?

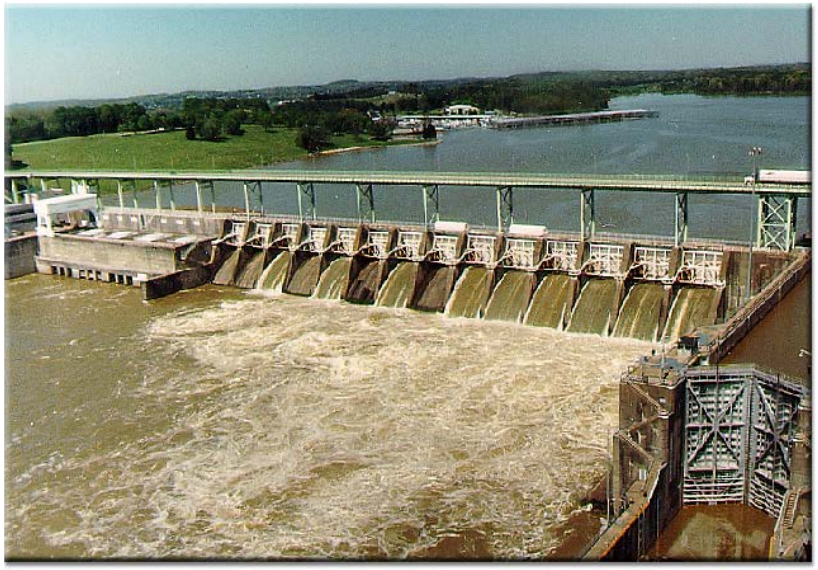
Modeling Extreme Events at TVA with RiverWare

49 Projects



LARGE

MEDIUM



Small

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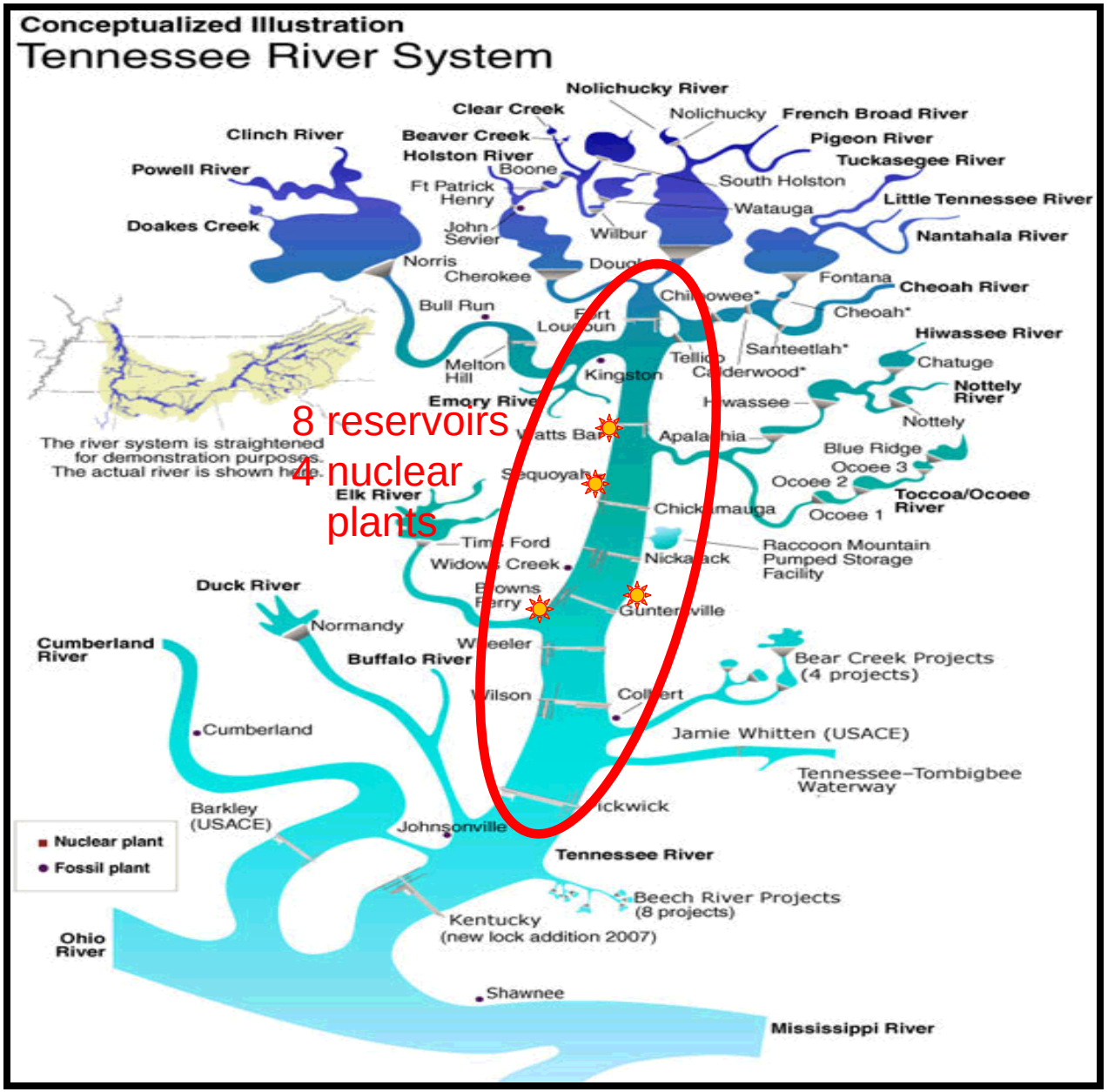

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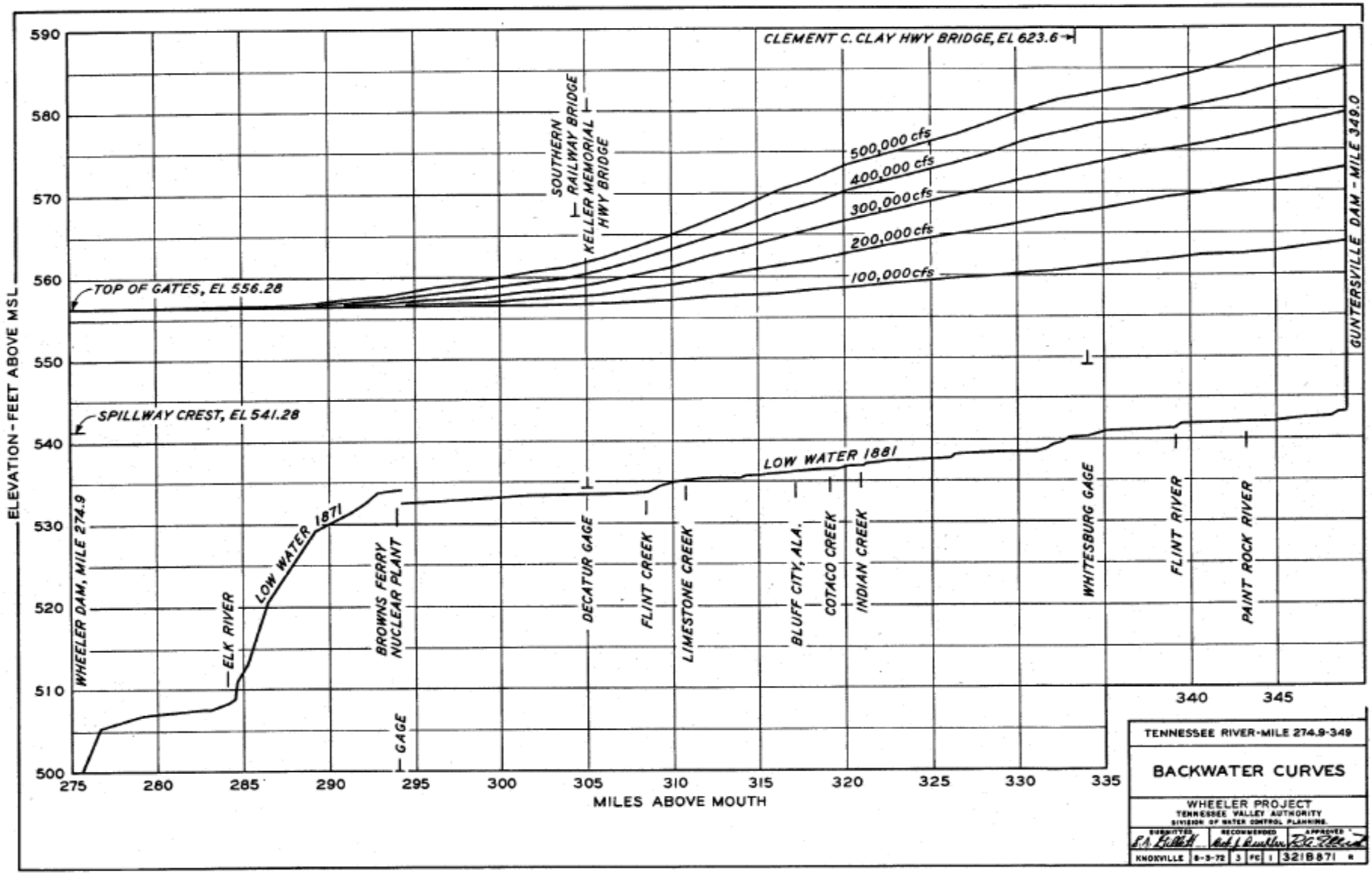

Backwater Profile for Wheeler Reservoir

Completing reassessment of PMF at 49 projects

- Team of TVA employees and contractors performed calculations
- Initially triggered by interest in getting license to resume construction on deferred nuclear plant
- New channel geometry and historic flood calibrations for many reservoirs
- Complete reevaluation of dam rating curves (DRC's) at all projects
- Deterministic analysis, using Weather Service HMR's for design rainfall
- For main river reservoirs, used TVA's SOCH model for reservoir routing (TVA's equivalent of HEC-RAS--may convert to HEC-RAS for future studies)
- RiverWare not used directly in these studies

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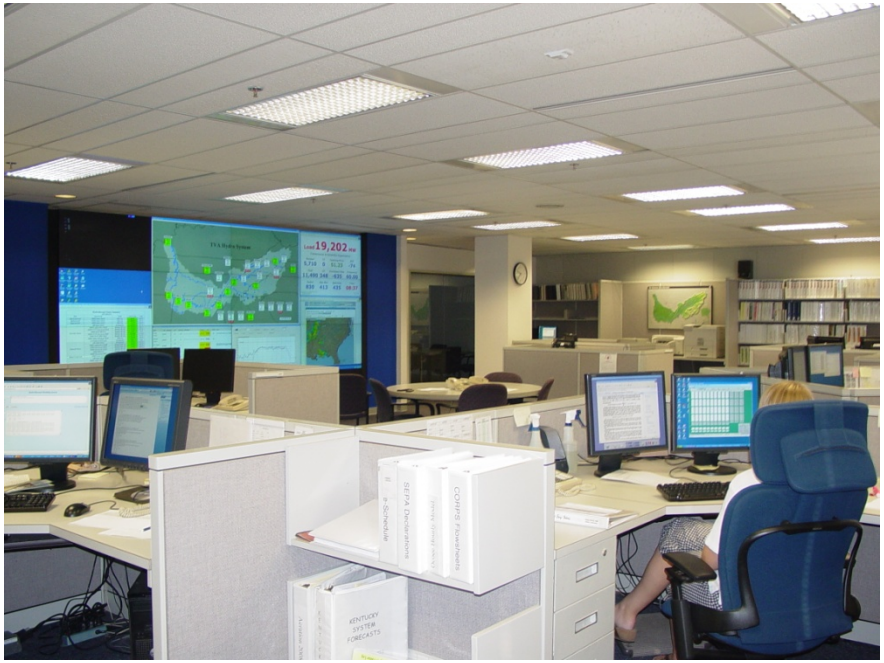
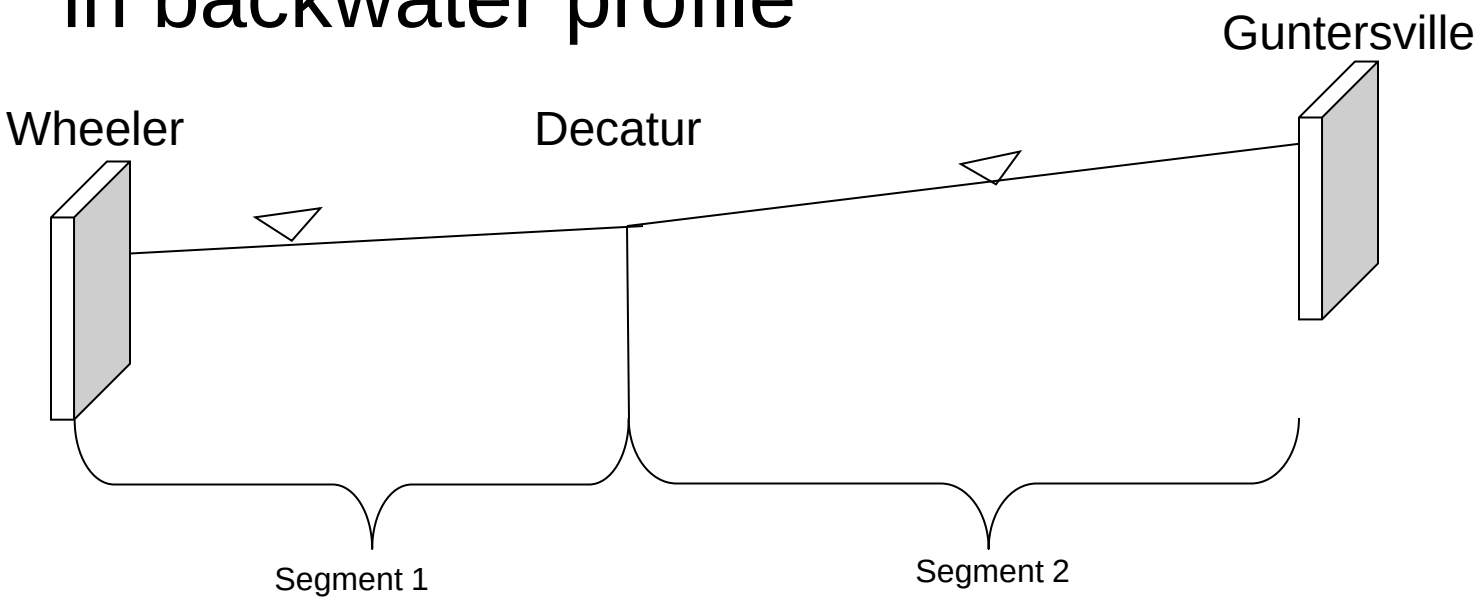
But it is the "tool of choice" for day to day scheduling of the reservoir system and for issuing river forecasts (since 1996)



Slope storage calculations in RiverWare

- Slope storage reservoirs can be divided into segments
- The end of a segment denotes a break in backwater profile



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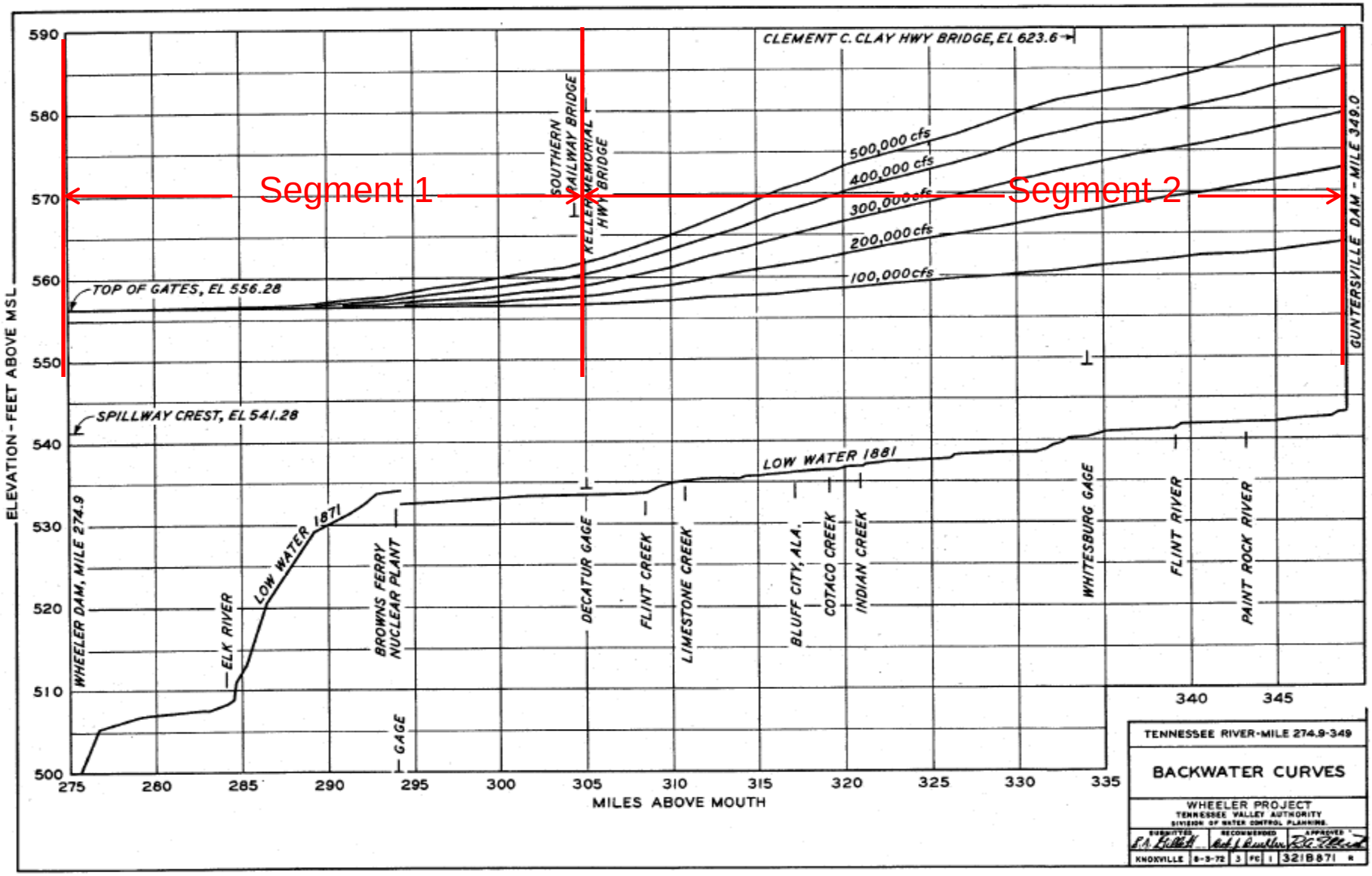

Backwater Profile for Wheeler Reservoir

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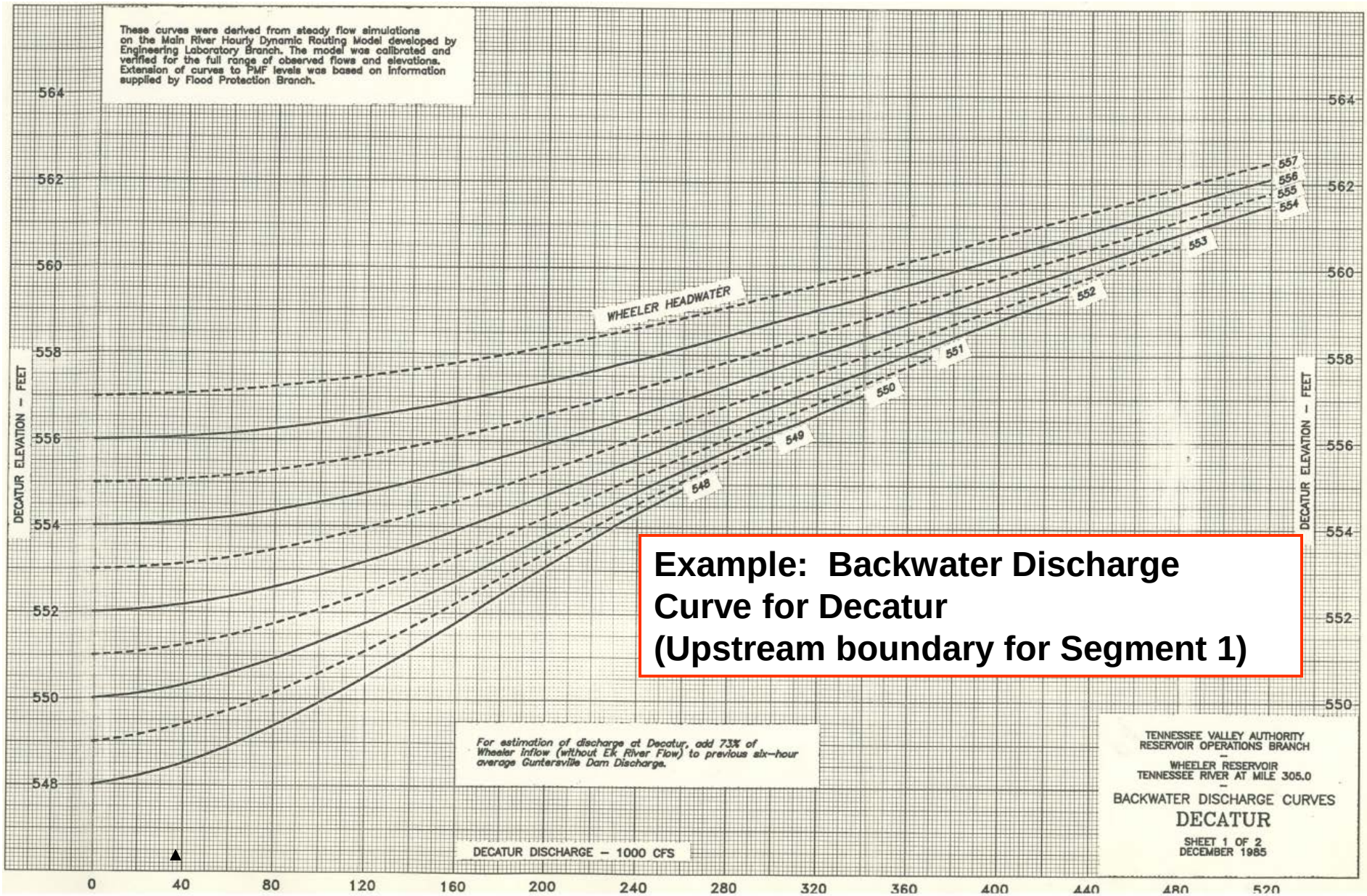

Example: Backwater Discharge Curve for Decatur (Upstream boundary for Segment 1)

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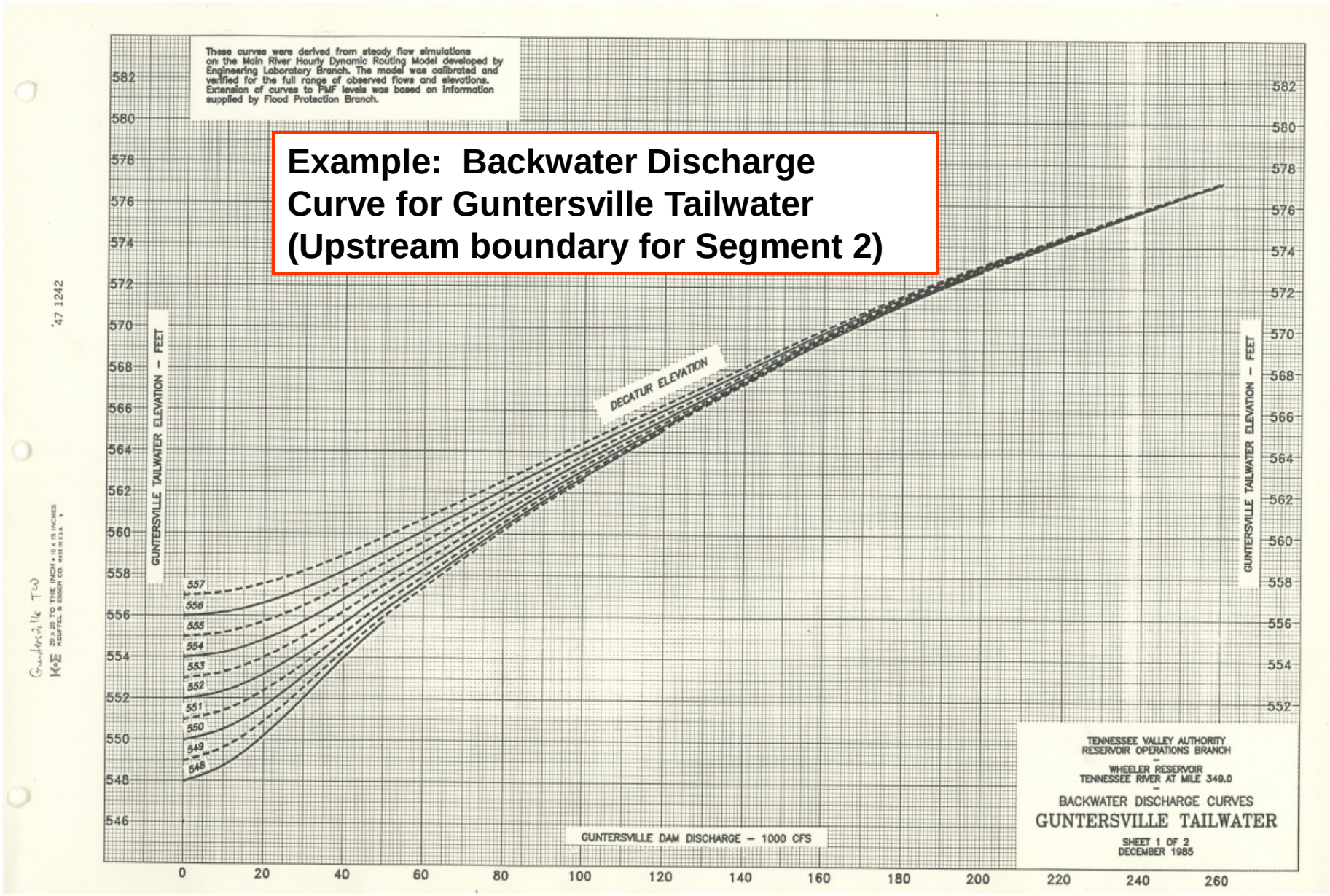
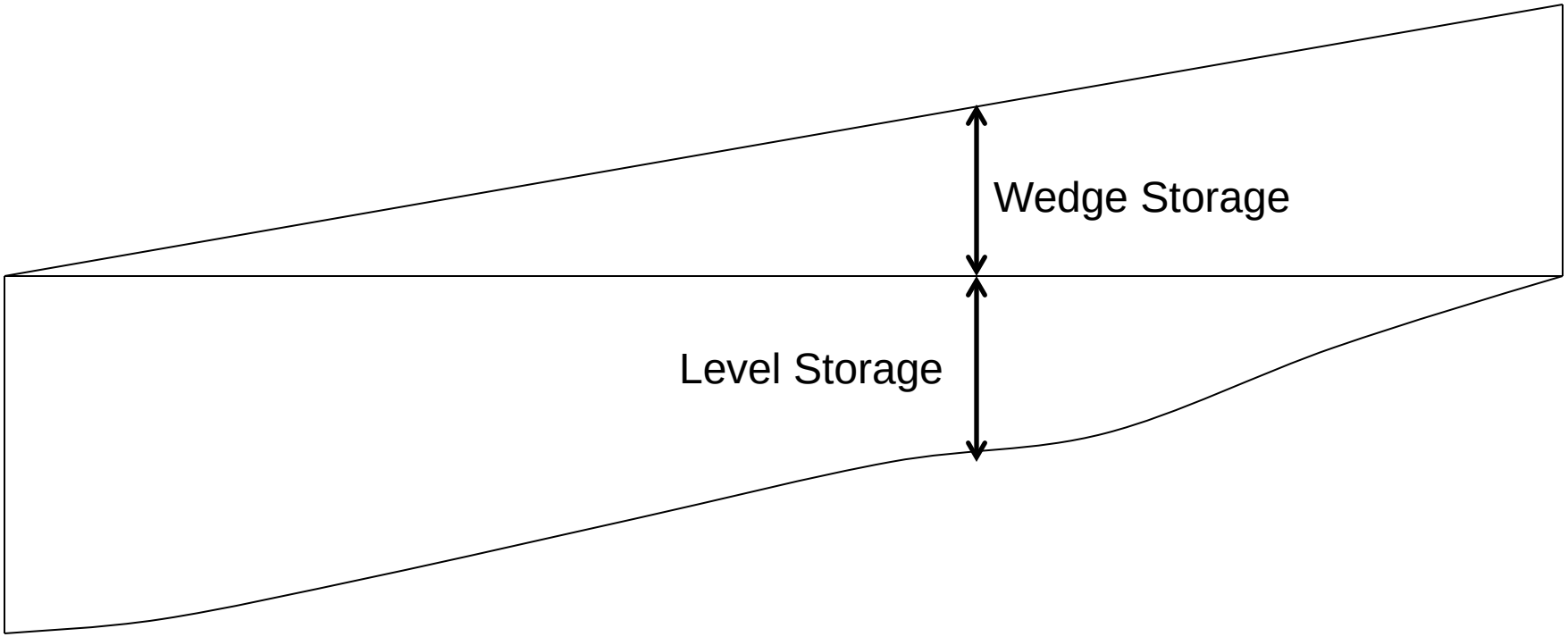
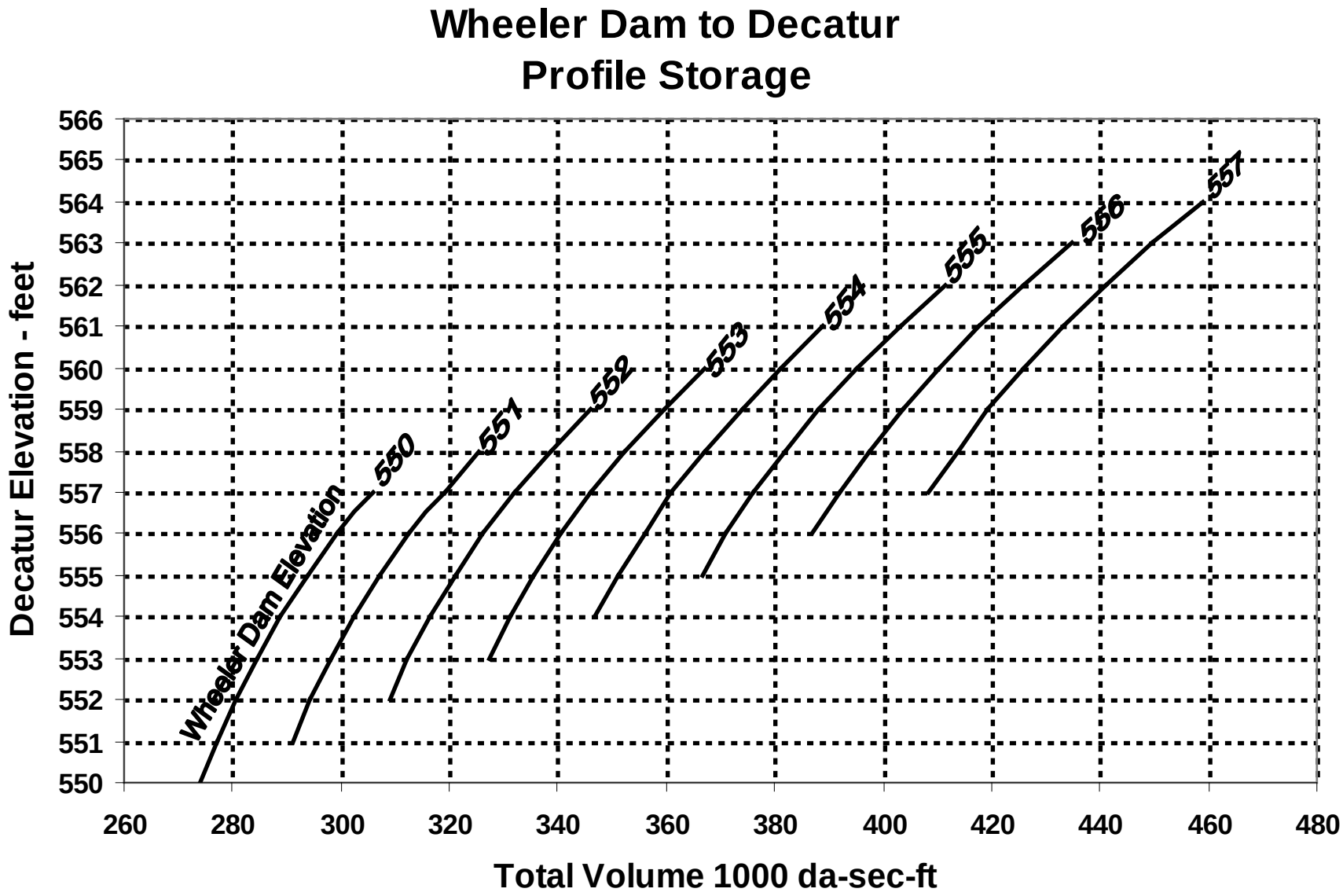
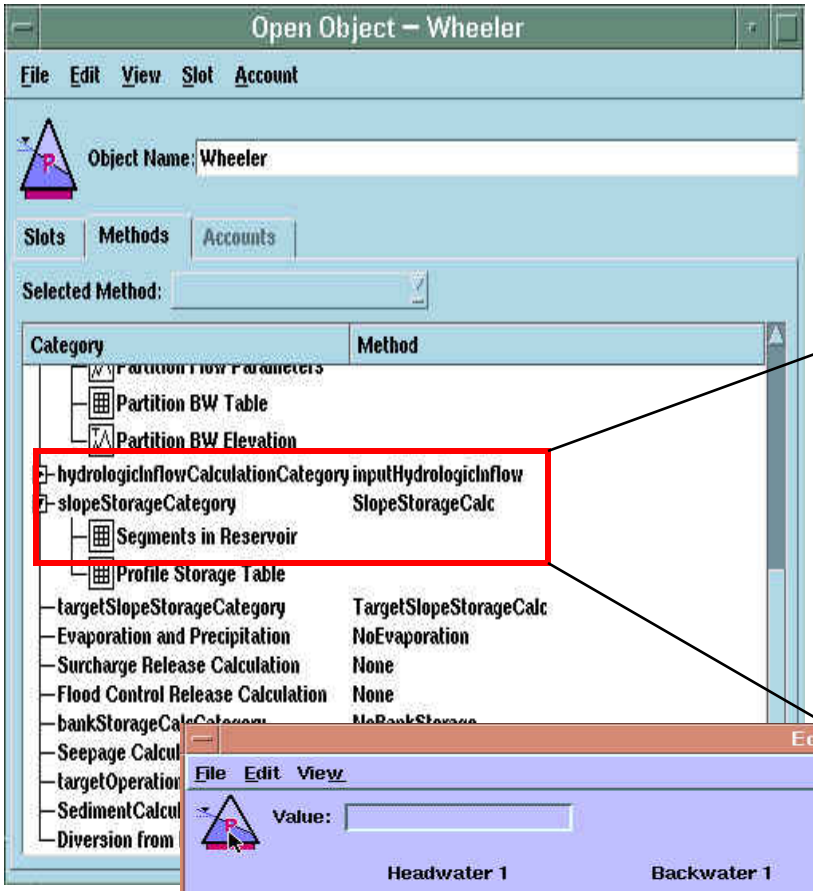


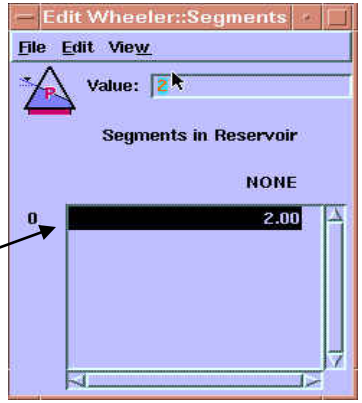
Profile Storage

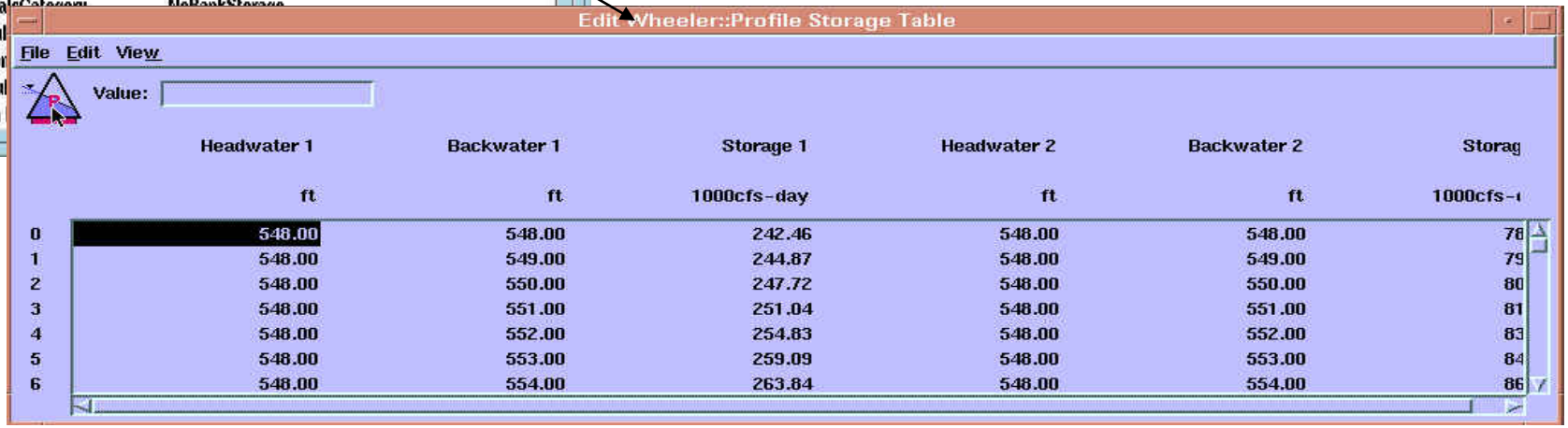



Wheeler Dam to Decatur
Profile Storage
Decatur Elevation - feet
566
565
564
563
562
561
560
559
558
557
556
555
554
553
552
551
550
Wheeler Dam Elevation
550
551
552
553
554
555
556
557
260
280
300
320
340
360
380
400
420
440
460
480
Total Volume 1000 da-sec-ft

Let's look at the relevant tables in RiverWare







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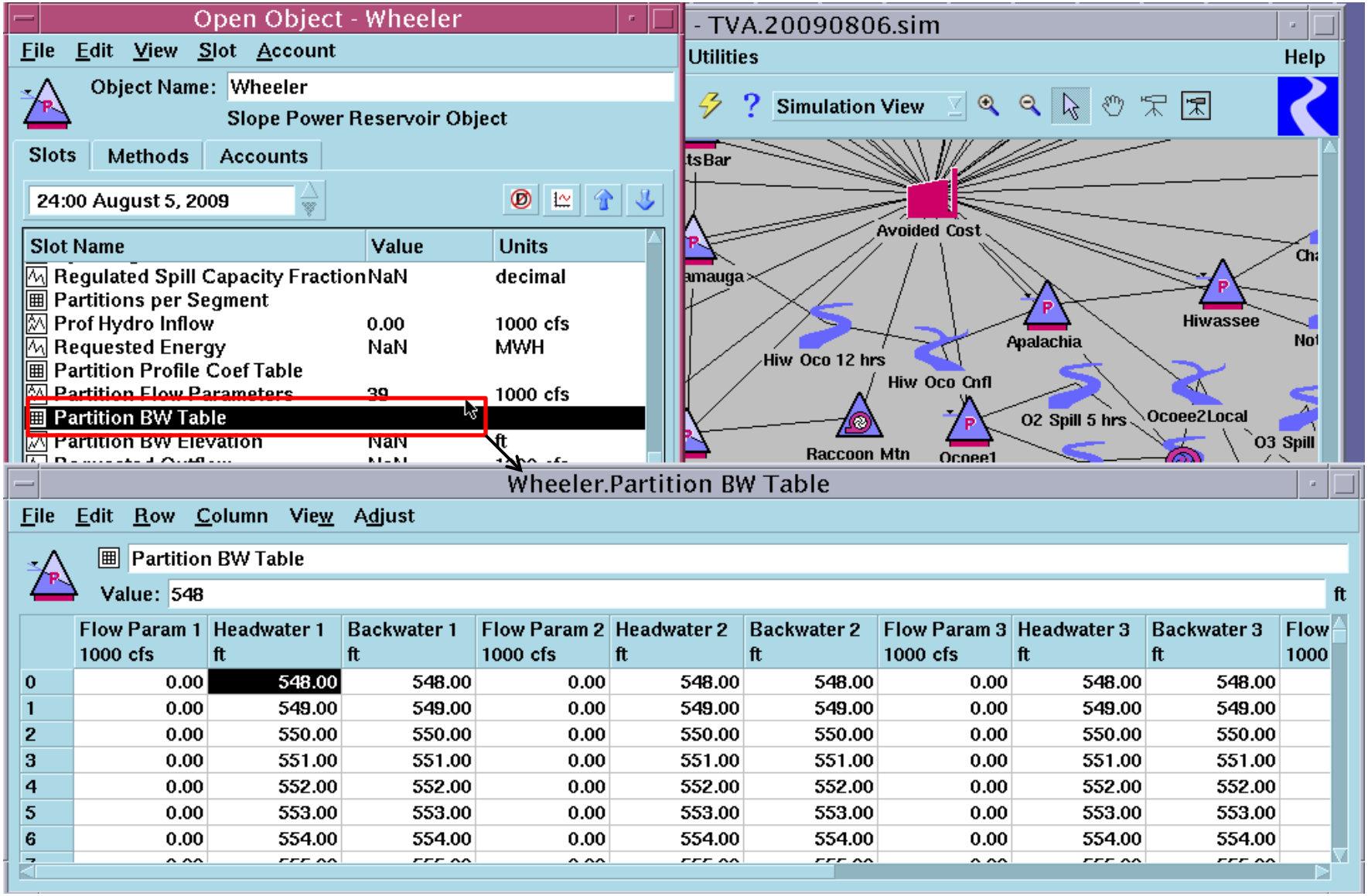

	Flow Param 1 1000 cfs	Headwater 1 ft	Backwater 1 ft	Flow Param 2 1000 cfs	Headwater 2 ft	Backwater 2 ft	Flow Param 3 1000 cfs	Headwater 3 ft	Backwater 3 ft	Flow 1000
0	0.00	548.00	548.00	0.00	548.00	548.00	0.00	548.00	548.00	
1	0.00	549.00	549.00	0.00	549.00	549.00	0.00	549.00	549.00	
2	0.00	550.00	550.00	0.00	550.00	550.00	0.00	550.00	550.00	
3	0.00	551.00	551.00	0.00	551.00	551.00	0.00	551.00	551.00	
4	0.00	552.00	552.00	0.00	552.00	552.00	0.00	552.00	552.00	
5	0.00	553.00	553.00	0.00	553.00	553.00	0.00	553.00	553.00	
6	0.00	554.00	554.00	0.00	554.00	554.00	0.00	554.00	554.00	

Estimating Flow Parameters

Flow in the Main River reservoirs is gradually varying. However, because we use steady flow models, we use “flow parameters”. The flow parameter is the estimate of a steady flow, when the actual flow is gradually varying.

How are flow parameters computed in RiverWare?

$$P(t) = a_1 I(t) + a_2 I(t-1) + \ldots a_n I(t-n) + b_1 H(t) + b_2 H(t-1) + \ldots + b_n H(t-n) + c_1 I2(t) + c_2 I2(t-1) + \ldots + c_n I2(t-n) + d_2 P(t-1) + d_3 P(t-2) + \ldots + d_n P(t-n) + e_1 O(t) + e_2 O(t-1) + \ldots + e_n O(t-n)$$

Where…

- I = Inflow from upstream dam
- H = Hydrologic inflow
- I2 = Inflow 2 (side inflows)
- P = Flow parameter
- O = Outflow

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What is a Dam Rating Curve?

A Dam Rating Curve shows the **maximum** amount of water that can be released at the dam as a function of pool elevation

A DRC will include one or more of the following components:

- Turbine discharge (regulated)
- Spillway discharge (regulated)
- Sluice (bypass) discharge (regulated)
- Emergency spillway discharge (unregulated)
- Flow over spillway deck (unregulated)
- Flow over top of raised spillway gates (unregulated)
- Flow over top of “non-overflow” portions of dam (unregulated)
- Flow over the top of lock gates and appurtenant lock structures (unregulated)
- Flow through failed portions of dams and saddle dams (unregulated)

DRC’s are not static and may change throughout the storm event!

TVA uses these slots to define the DRC for a project as needed:

- Unreg Flow 3 Spill Table
- Unreg Flow 2 Spill Table
- Unregulated Spill Table
- Regulated Spill Table
- Bypass Table
- Max Turbine Q

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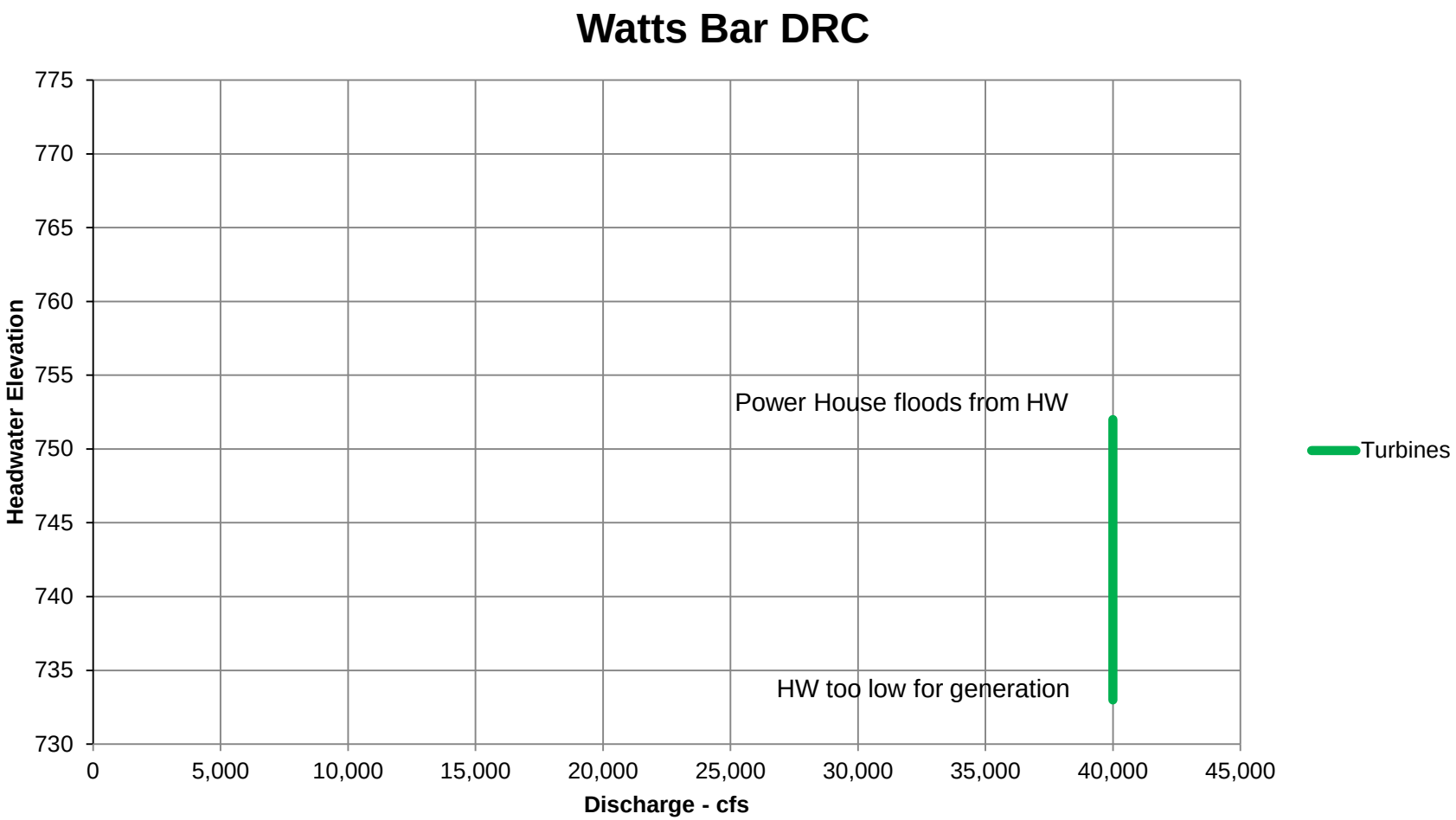

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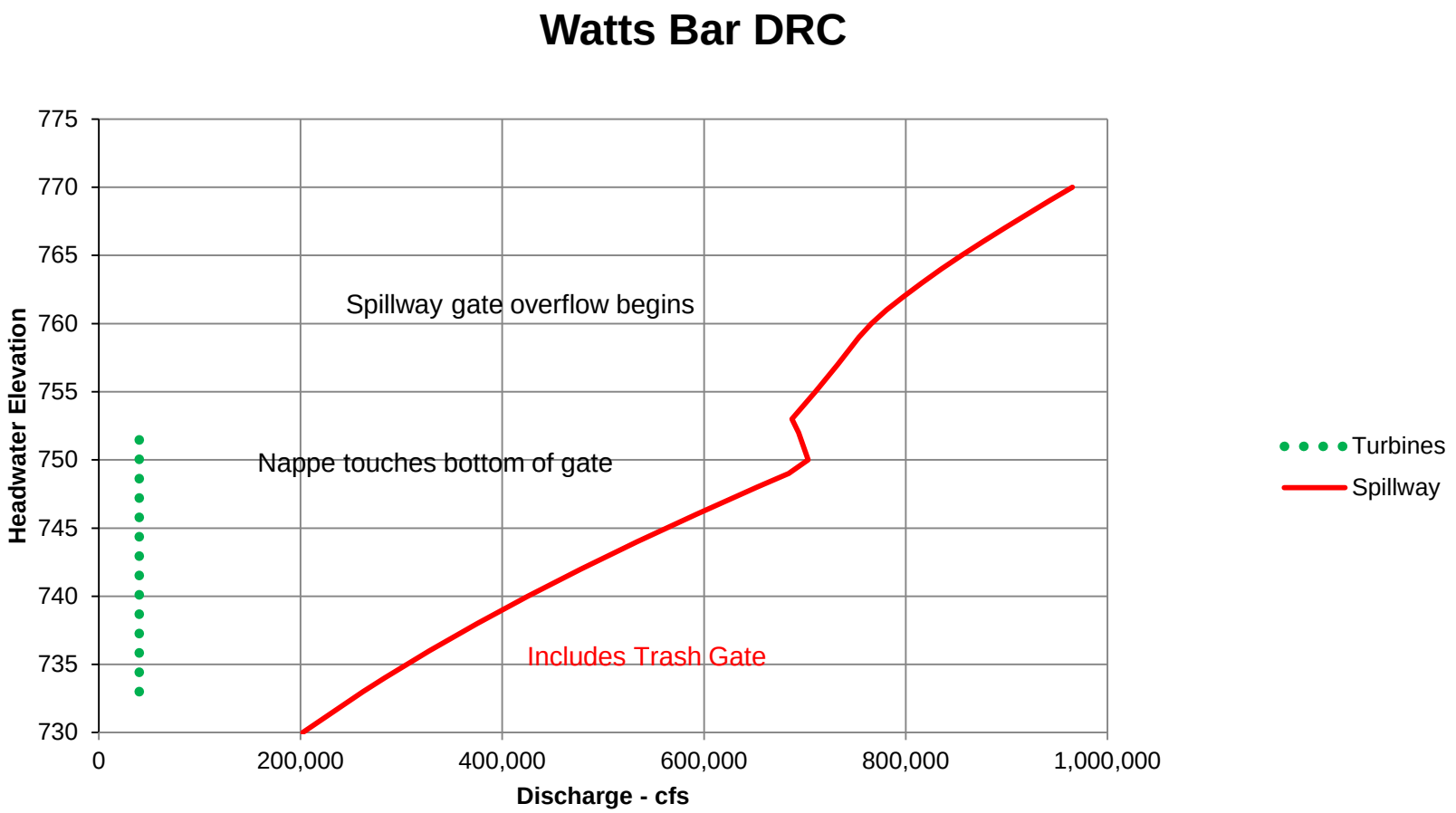

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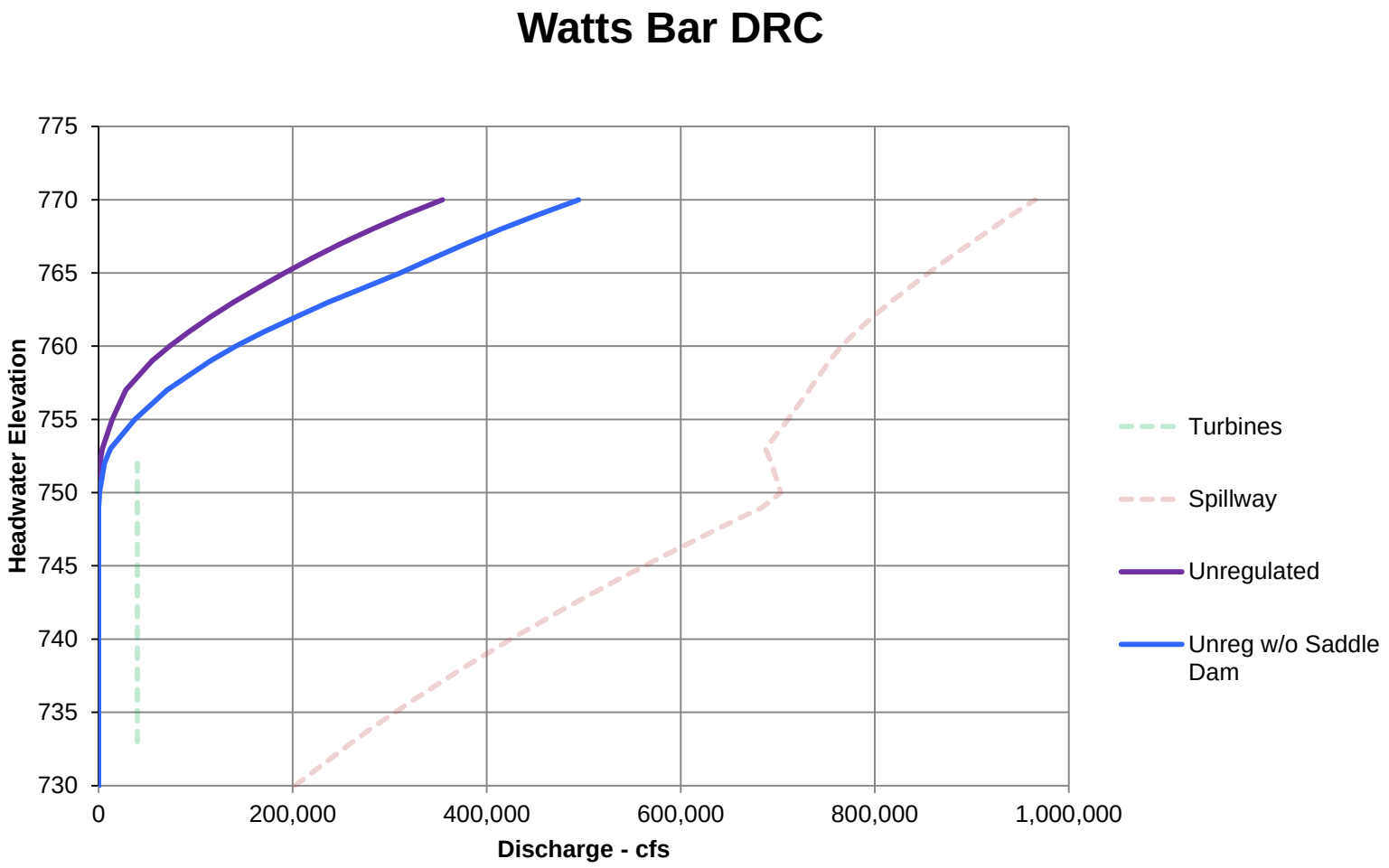

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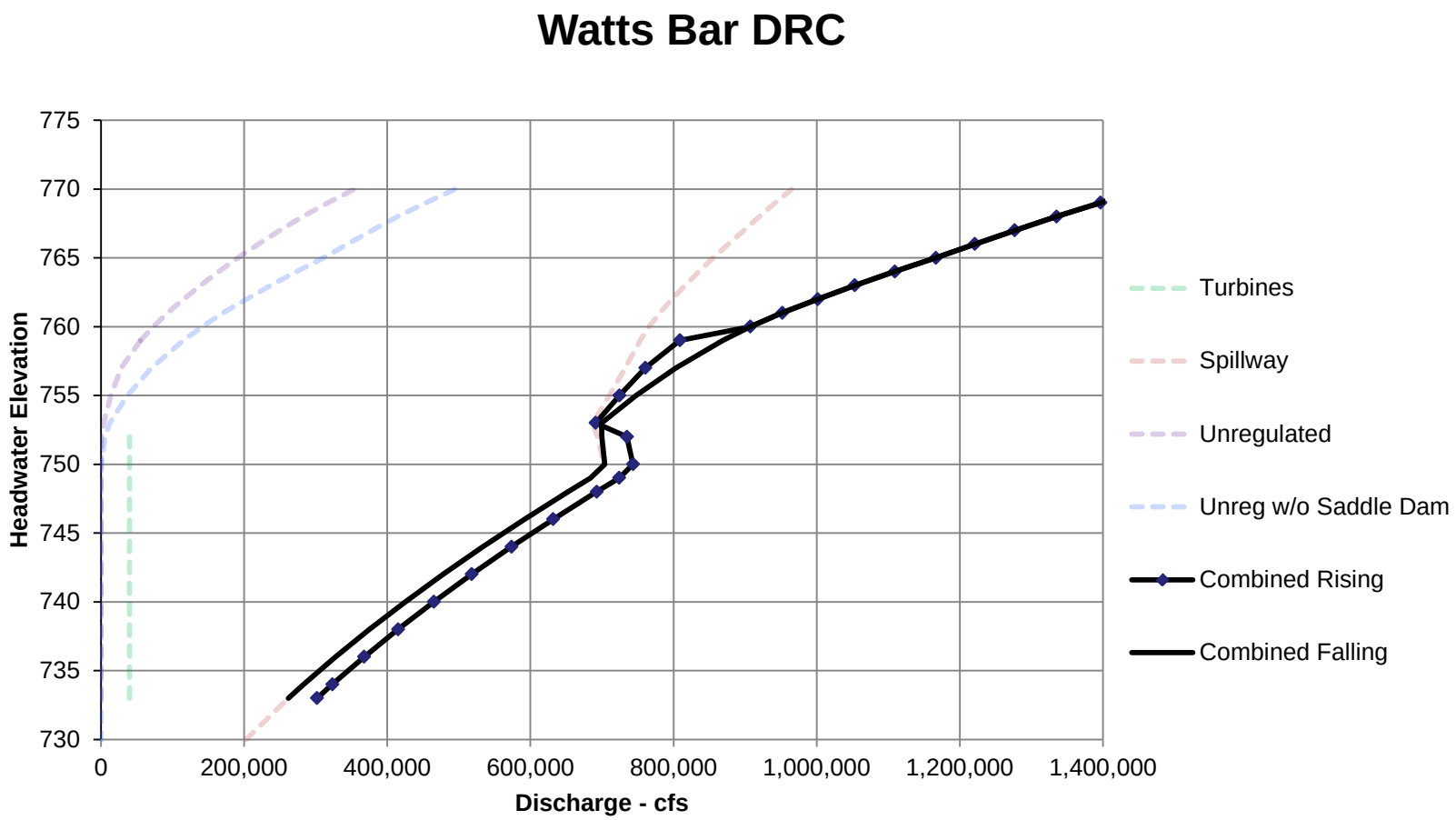

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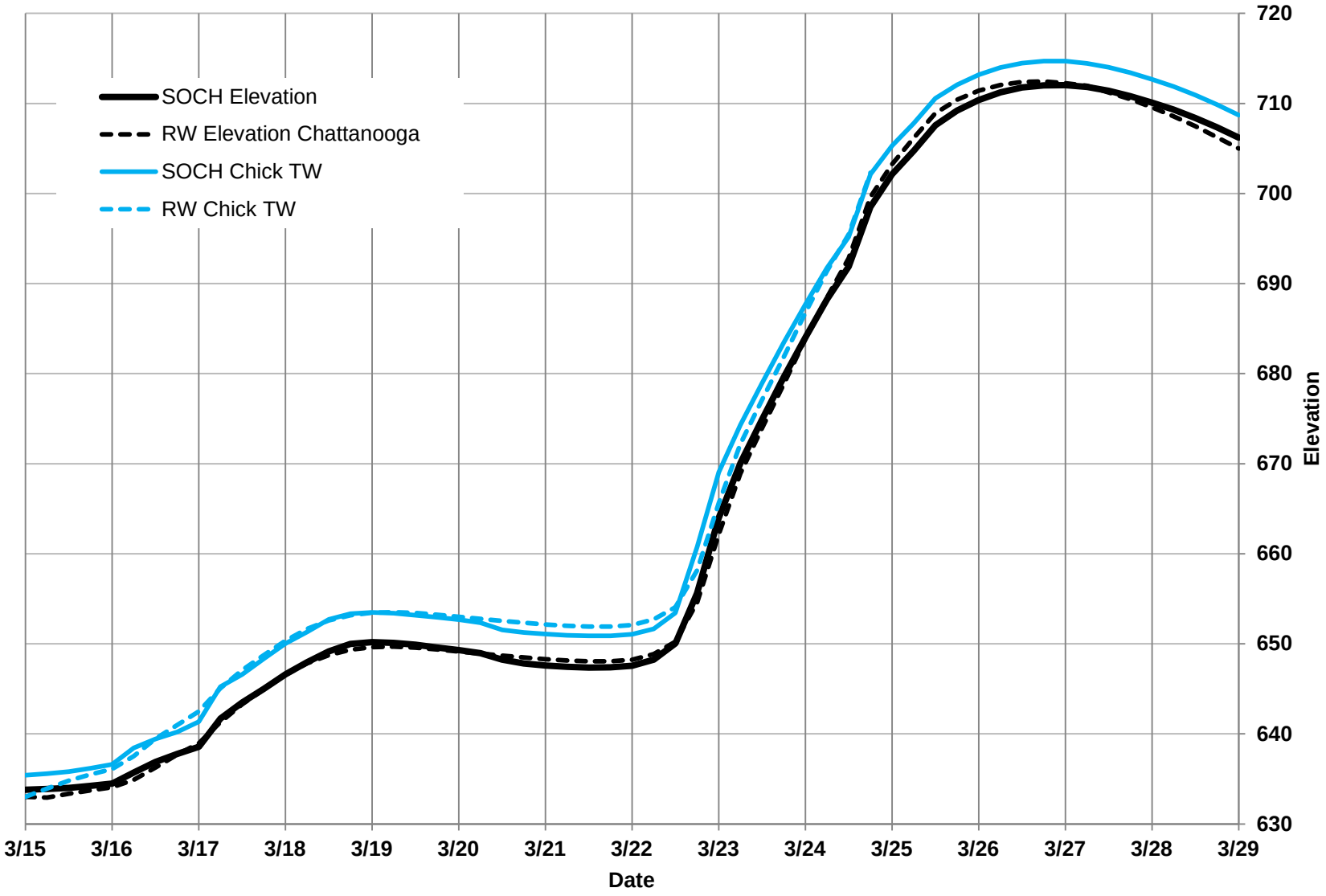

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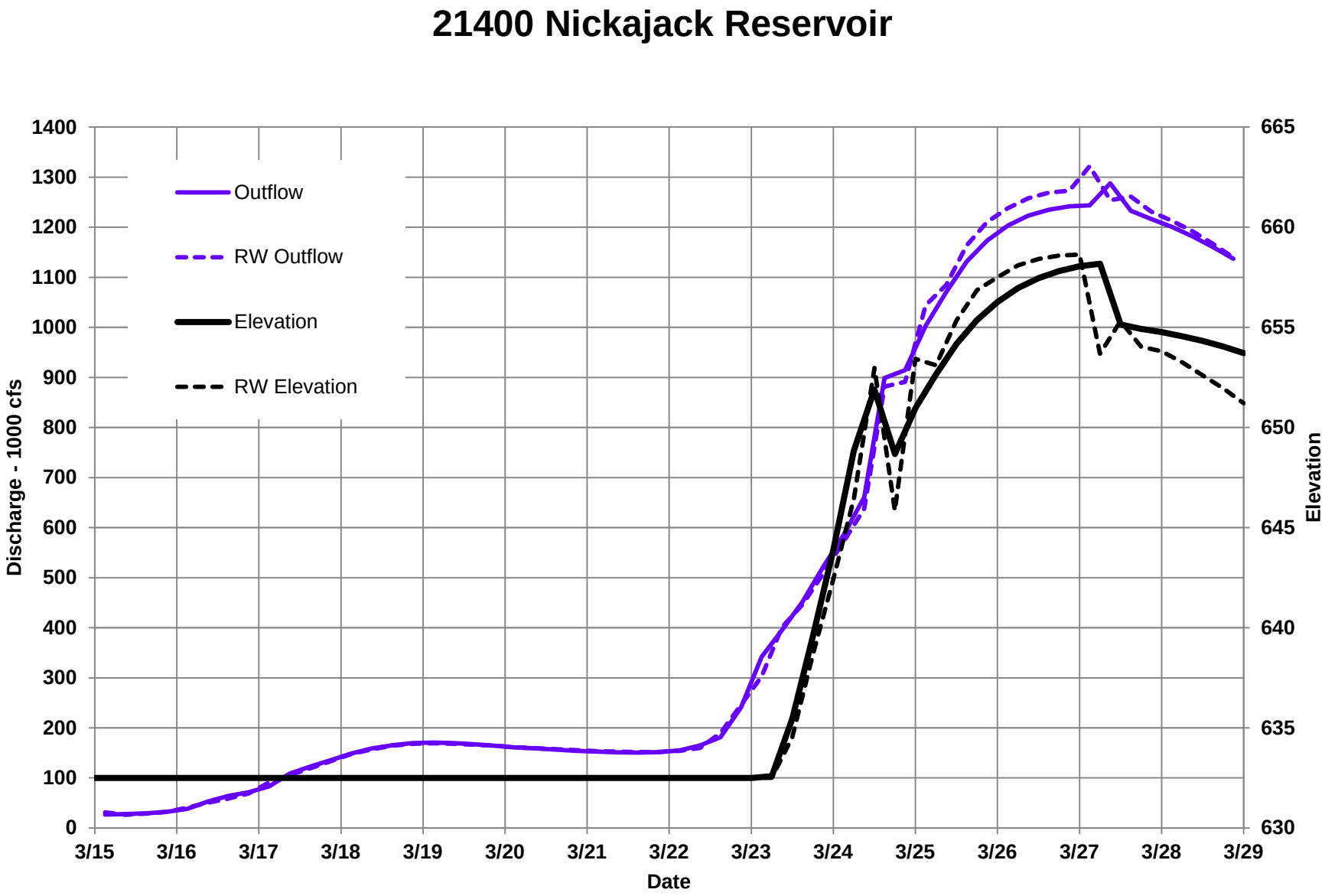

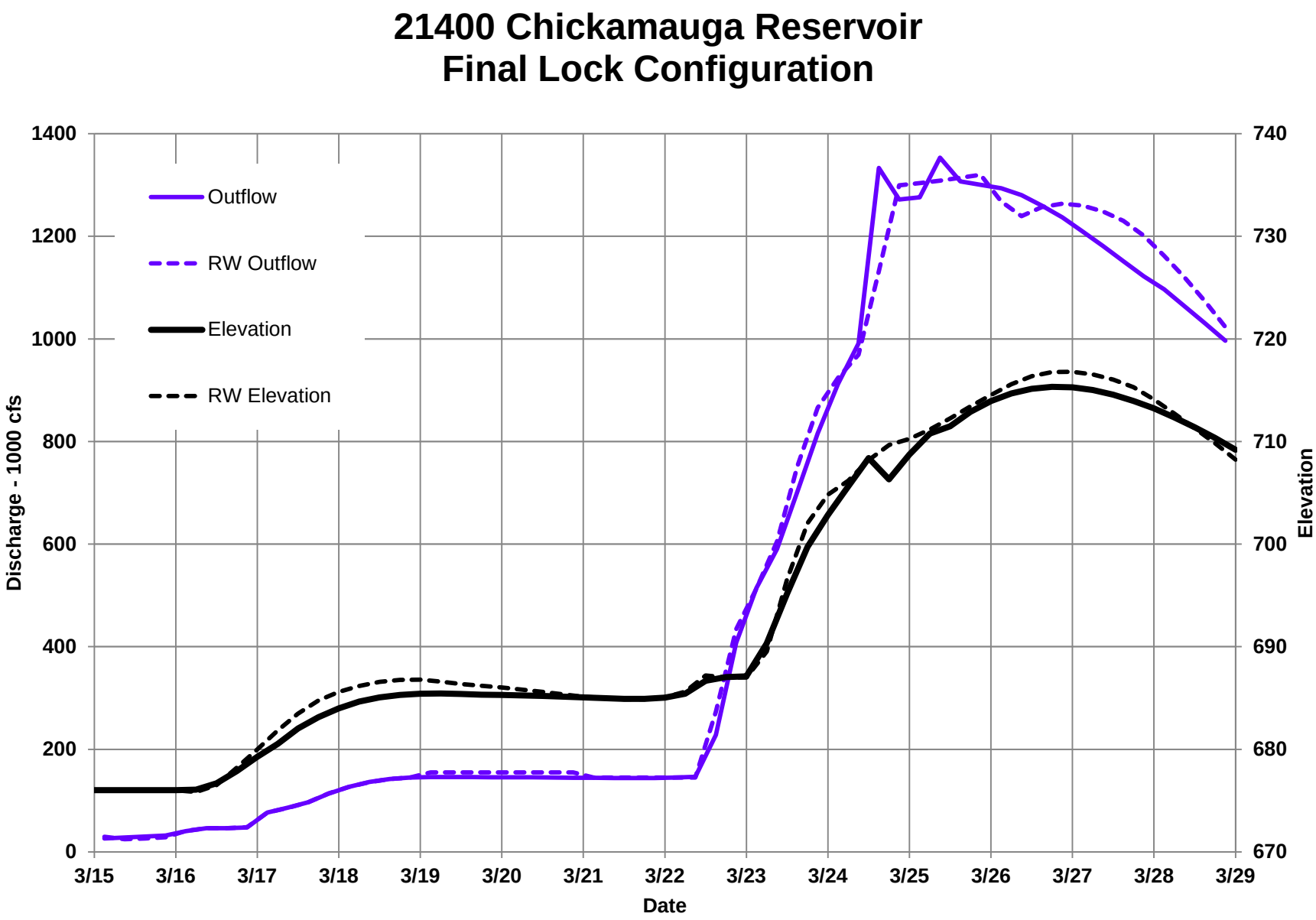
21400 Chickamauga Reservoir
Final Lock Configuration
Outflow
RW Outflow
Elevation
RW Elevation
Discharge - 1000 cfs
Elevation
Date
1400
1200
1000
800
600
400
200
0
740
730
720
710
700
690
680
670
3/15
3/16
3/17
3/18
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