Tenkiller Lake
EFDC Modeling Update

Illinois River Watershed Modeling and TMDL Development Project – Informational meeting

November 8, 2012
Springdale, Arkansas

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Water Quality Issues

- Nutrient enrichment (Total-P)
- Eutrophication/algae biomass
- Low oxygen in hypolimnion during seasonal stratification
- Since 2001 Cyanobacterium blooms *Cylindrospermopsis*
- Nutrient Limited Watershed (NLW) designation in 2006

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Tenkiller Lake
EFDC Modeling Update

- **Conceptual model & framework for watershed-lake model**
- Previous watershed-lake model studies
- Current watershed-lake model study

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Conceptual Model of Lake

- Mass balance based lake model is a quantitative tool to link cause-effect interactions from watershed flow, sediment and nutrient loading with water quality conditions in Lake Tenkiller
- “Run-of-river” reservoir with characteristic spatial zones that influence transport, solids settling, water clarity, nutrients and algae biomass
- Seasonal cycle of thermal stratification in summer followed by well-mixed conditions in winter
- Seasonal cycle of hypolimnetic oxygen depletion controlled by stratification and sediment oxygen demand

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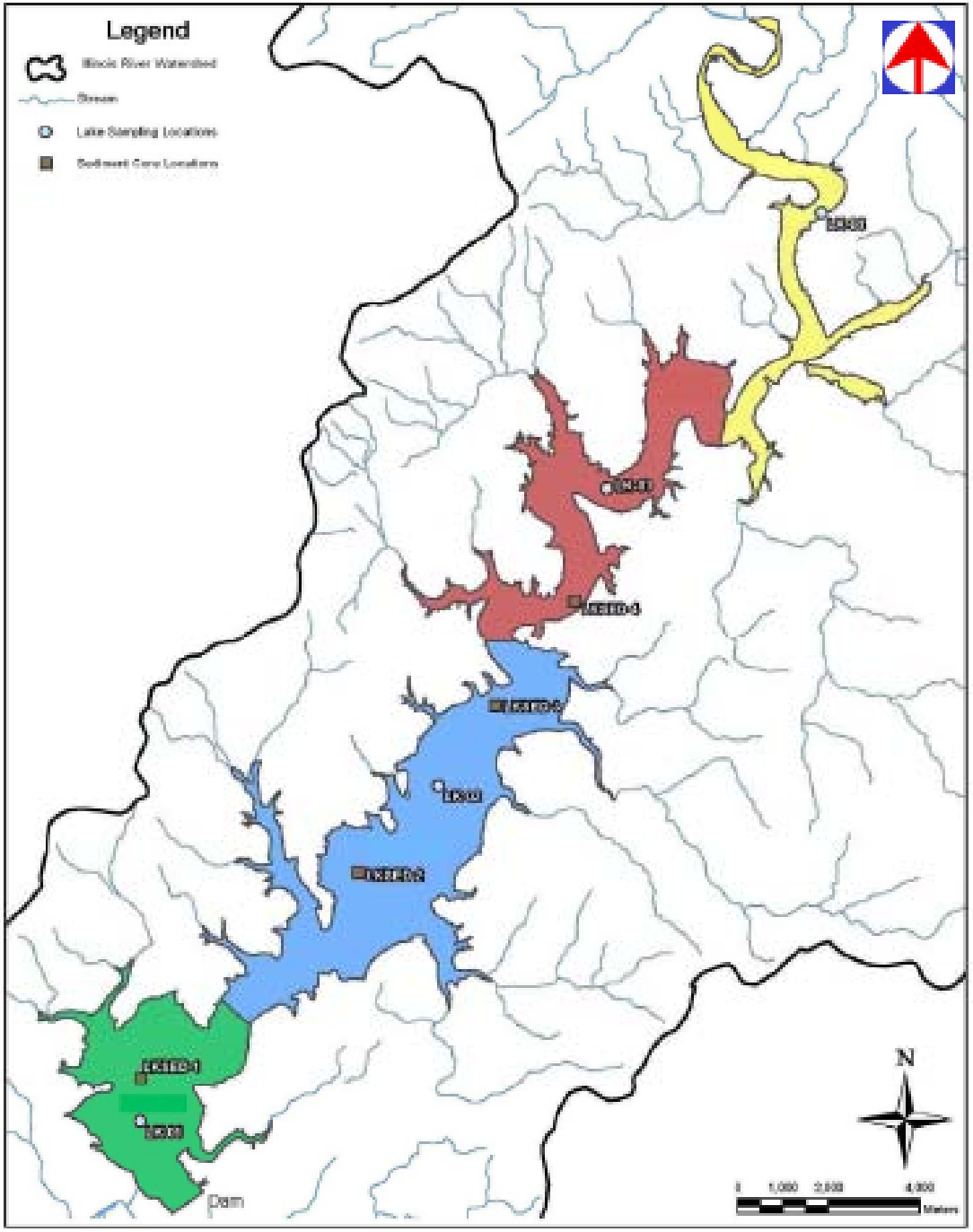

Riverine Zone

- Narrow, shallow
- Short residence time
- High TSS; poor clarity
- High nutrient inflows

Transition Zone

- Broader, deeper
- Increased residence time
- Lower TSS; better clarity

Lacustrine Zones

- Wide, deep
- Long residence time
- Low TSS; high clarity

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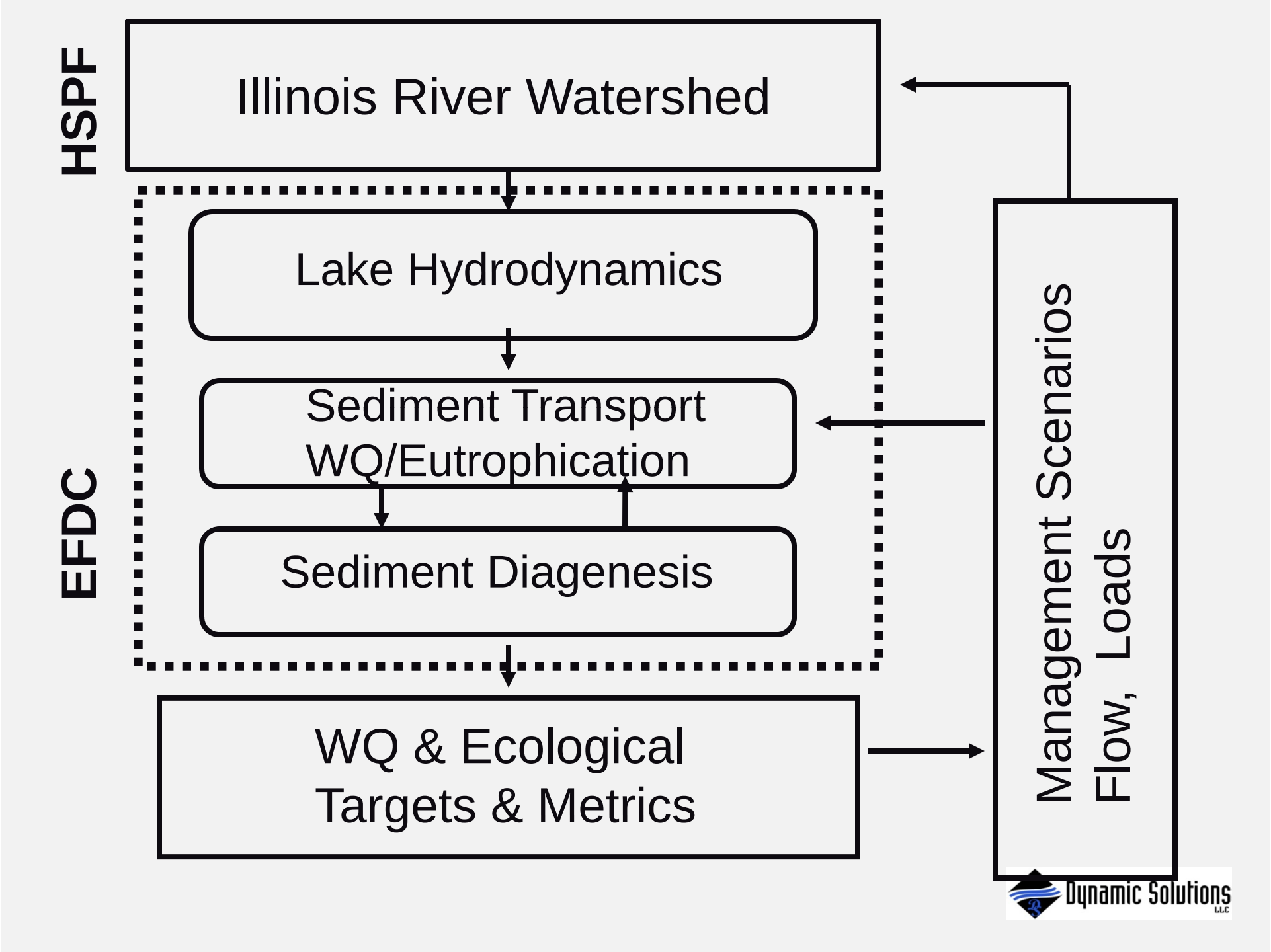
HSPF
Illinois River Watershed
EFDC
Lake Hydrodynamics
Sediment Transport
WQ/Eutrophication
Sediment Diagenesis
WQ & Ecological
Targets & Metrics
Management Scenarios
Flow, Loads
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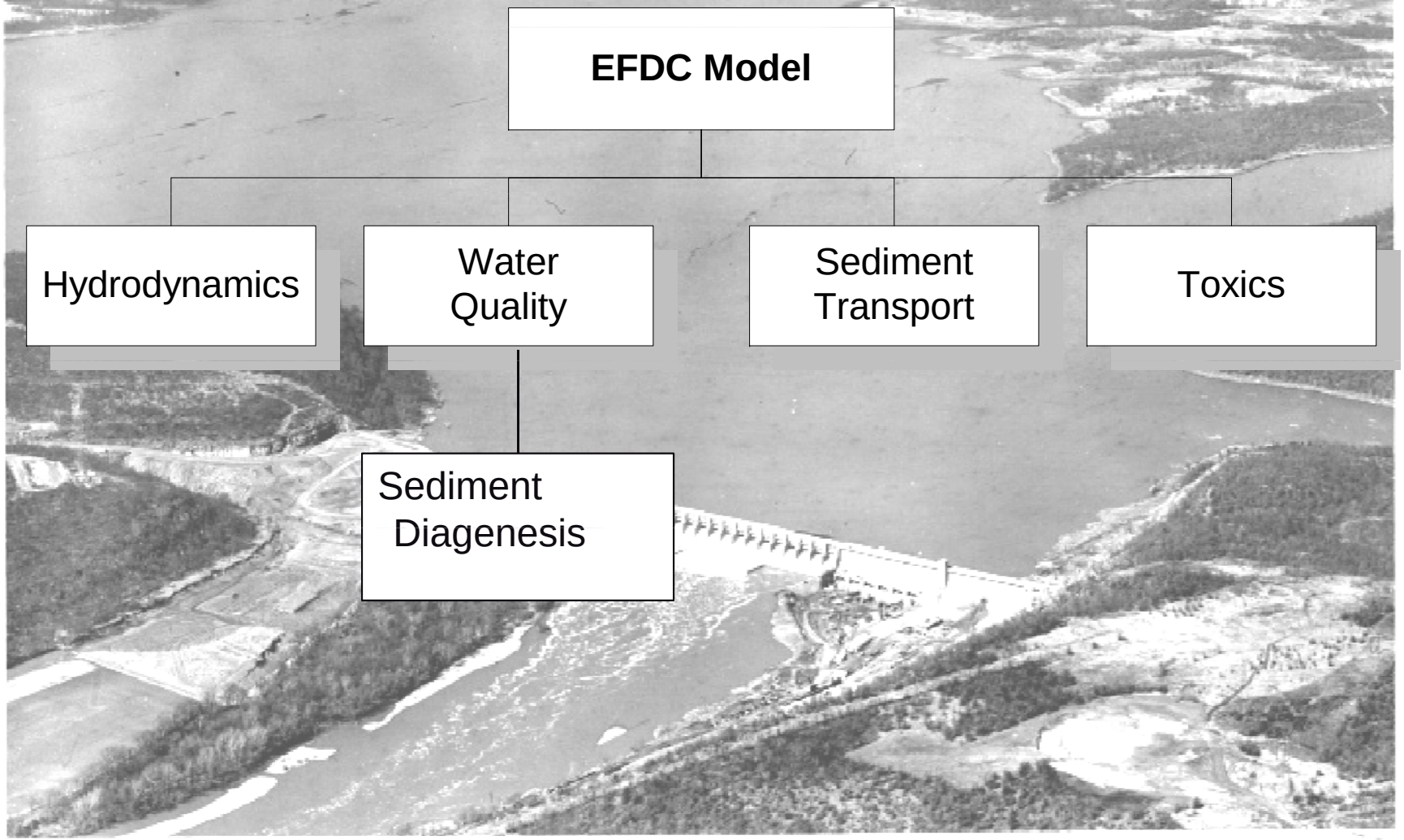
EFDC Model Components



EFDC Model

- Hydrodynamics
- Sediment Transport
- Water Quality
- Sediment Diagenesis

- Flow/Velocity
- Water level
- Water Temperature
- Cohesive SS
- Algae, Organic Carbon
- Nutrients (N,P), DO
- Bed Organic C,N,P
- Porewater N,P
- Fluxes Inorg-N,P, SOD

Model Data Needs & Data Sources

- Bathymetry: Portland State U. (contour data & 2005 survey by Global Remote Sensing LLC)
- Watershed flow & WQ: HSPF watershed model
- Lake level & releases at dam: USACE Tulsa District
- Water supply withdrawals: computed flow balance
- Lake WQ: OWRB (1994-present); CDM-USGS (2005-2008); Clean Lakes Program; USACE; EPA STORET
- Sediment bed C,N,P organic & inorganic: Fisher (2005)

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- **Previous watershed-lake model studies**
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Previous Lake Modeling Efforts

- OWRB (1996): Lake Tenkiller Clean Lakes Program Phase 1 Diagnostics Feasibility Study; used Vollenweider P-loading empirical model for P allocation
- Tetra Tech (2001): HSPF-EFDC model of Illinois River watershed and Lake Tenkiller; calibrated to USACE 1985-86 data
- AQUA TERRA and Dynamic Solutions (2006): updated HSPF-EFDC model of Illinois River watershed and Lake Tenkiller; calibrated to Clean Lakes Program (CLP), 1992-93 data
- AQUA TERRA and EcoModeling (2009), HSPF-AQUATOX model of watershed and Lake Tenkiller, calibrated to Clean Lakes Program,1992-93 data; flow/volume data from EFDC

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Approach for Lake Model

- Updated bathymetry with 2005 survey data
- Increased grid resolution to improve representation of wind forcing on currents and to reduce artificial mixing in areas with steep bottom slope
- Use updated HSPF watershed flow as input to hydrodynamic model
- Use updated HSPF watershed flow & loading of BOD, C, N, P, TSS, algae and DO as input to water quality model
- Sediment bed initial conditions for sediment diagenesis model available from Fisher survey in 2005
- Calibrate/validate lake model using OWRB and CDM-USGS data collected in 2005-2008

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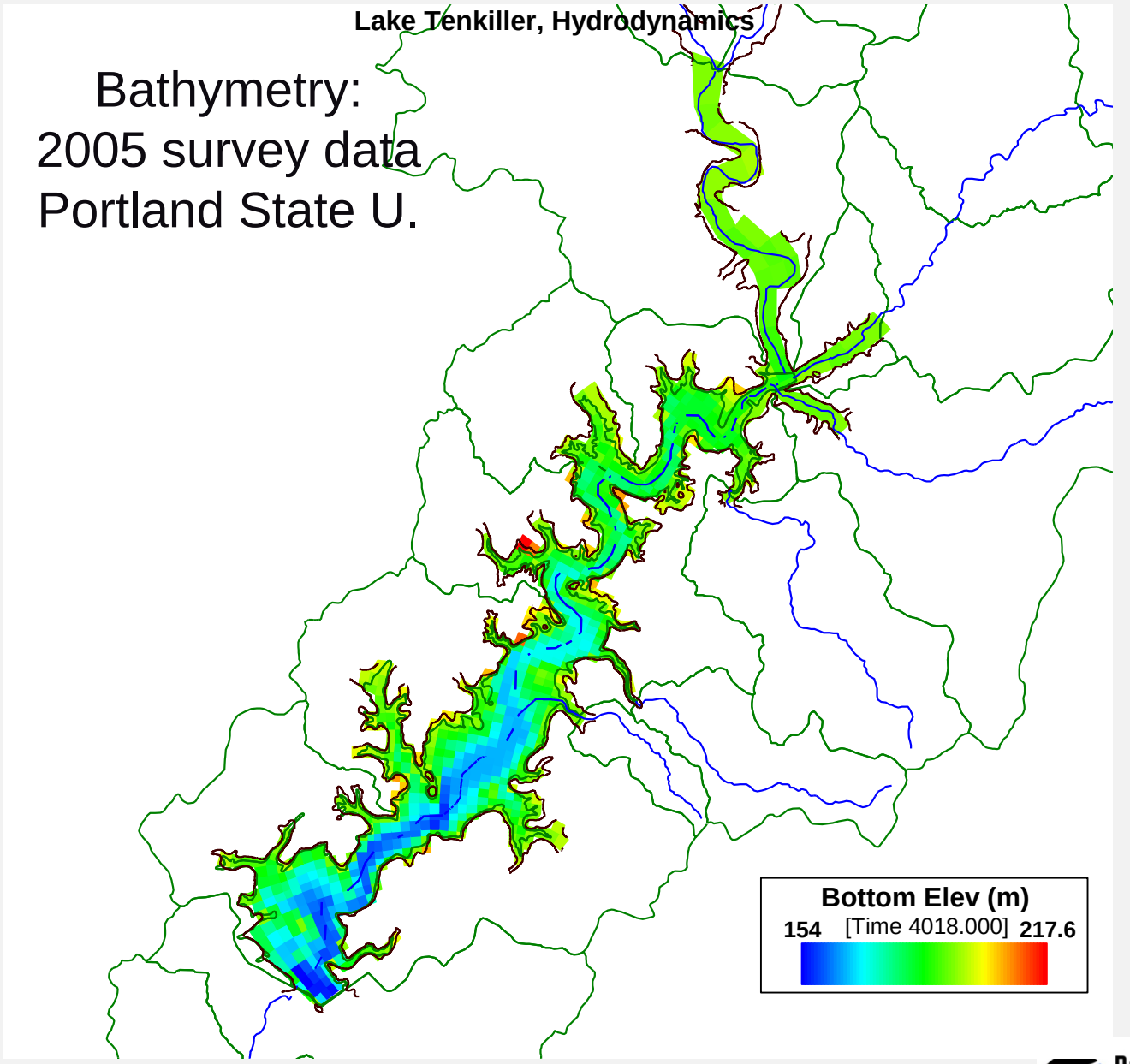

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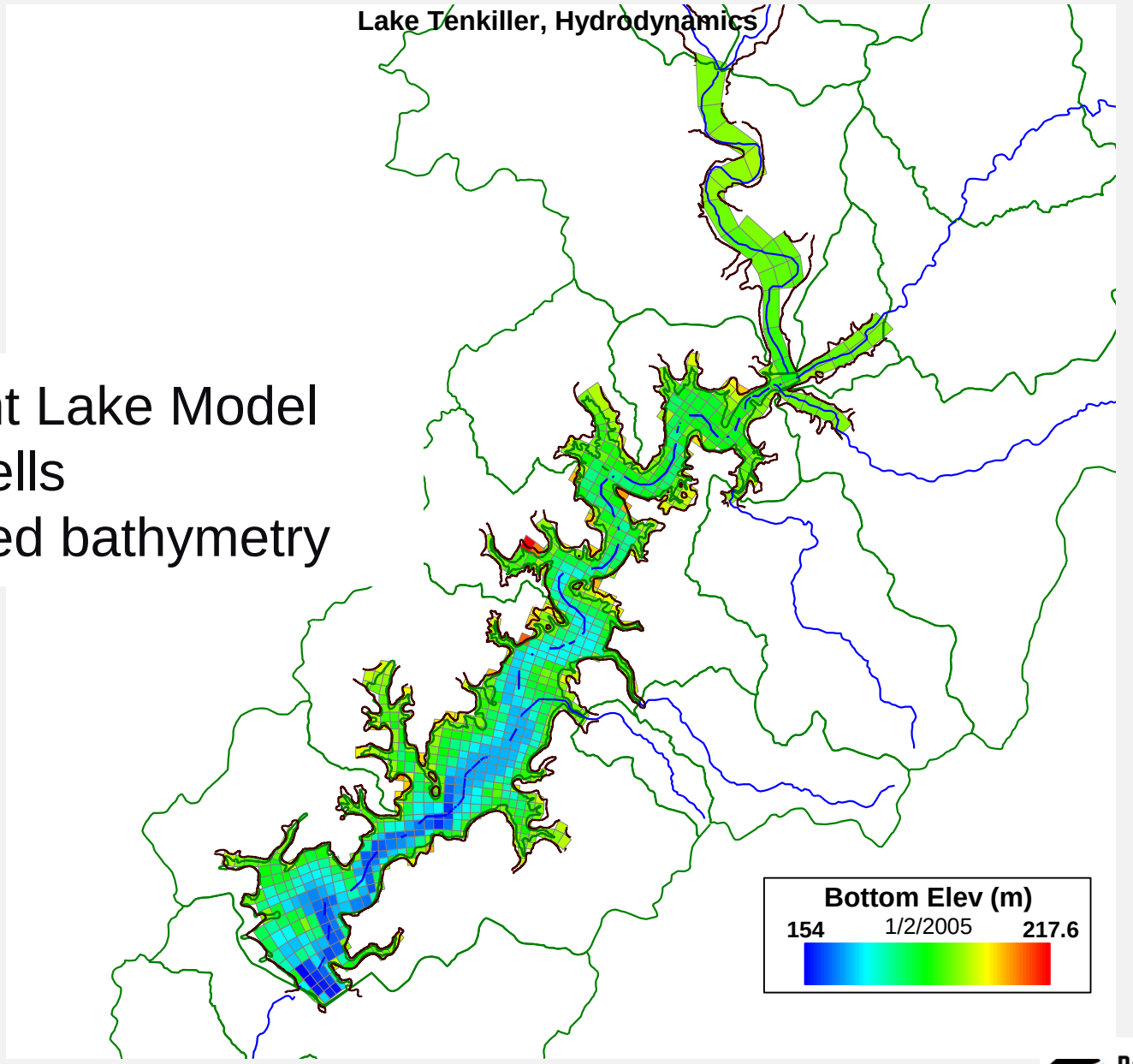
Current Lake Model
789 Cells
Updated bathymetry



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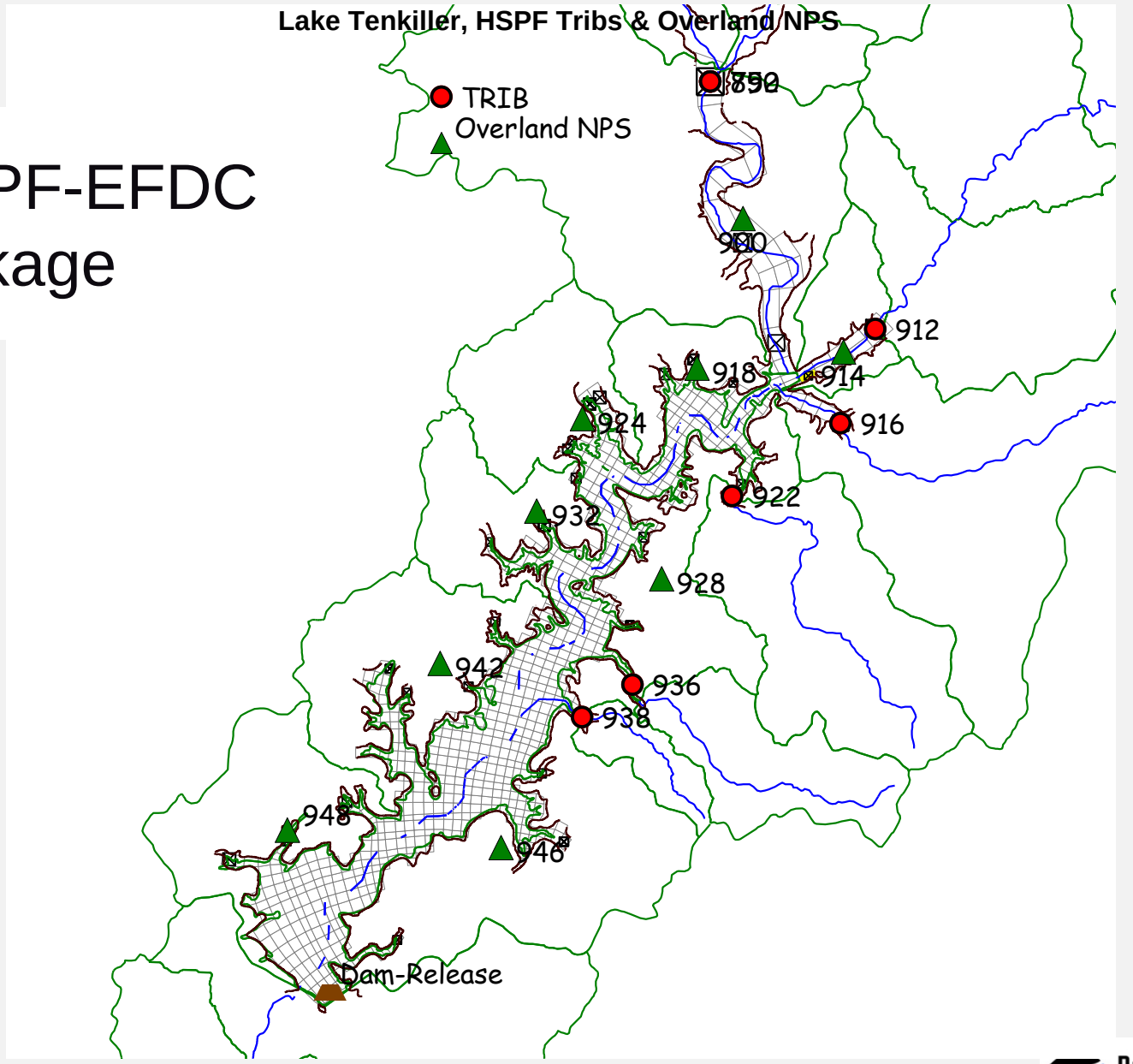
HSPF-EFDC Linkage



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Hydrodynamic Model

- HSPF watershed flow from tributaries & overland NPS
- COE release flow at dam
- COE evaporation & precipitation
- COE Inflow Adjustment
- COE lake level and storage volume
- Water supply withdrawals included in flow balance
- Seepage loss at dam included in flow balance
- Preliminary comparison of model lake level to observations

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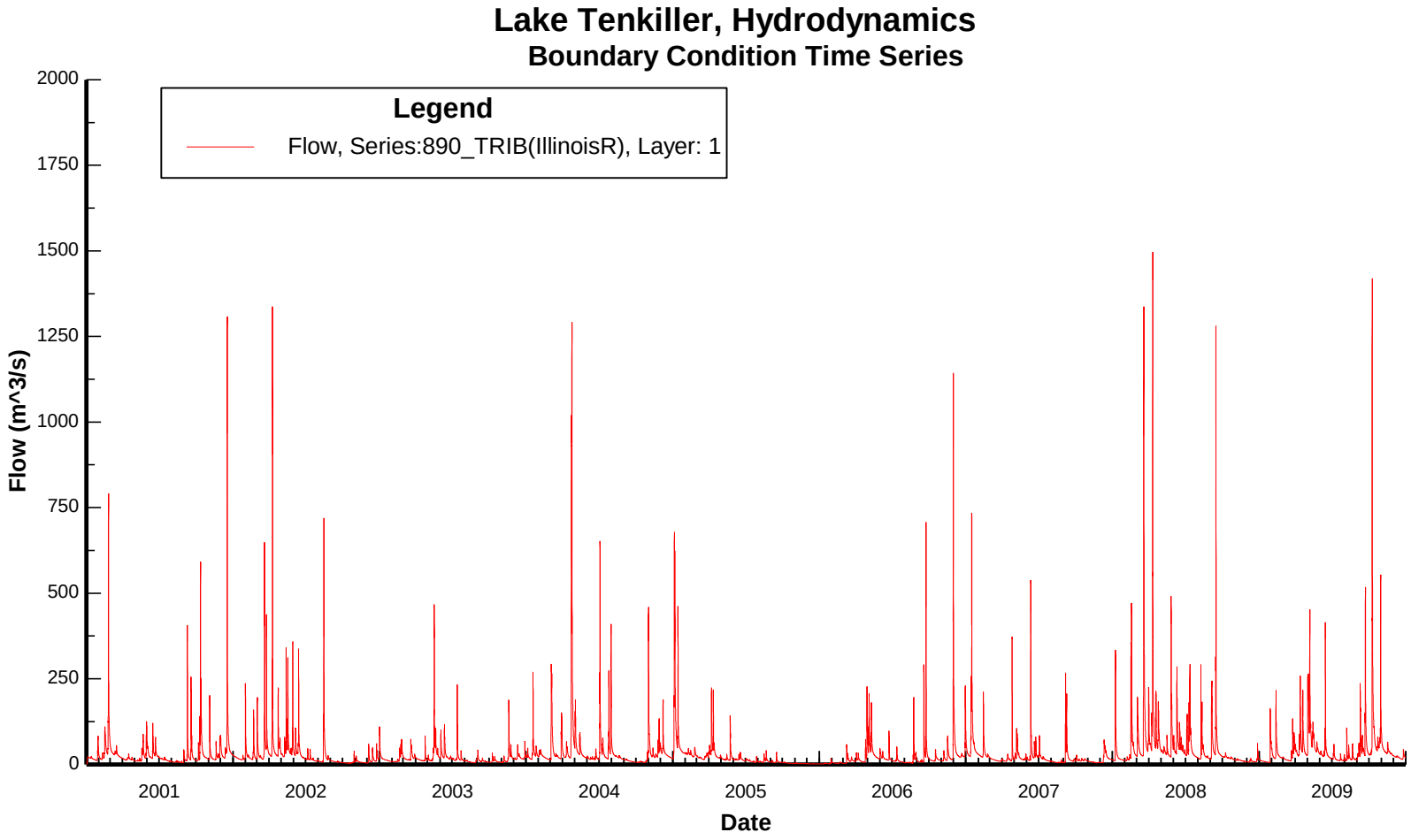
HSPF Flow: Illinois R (890_Trib)



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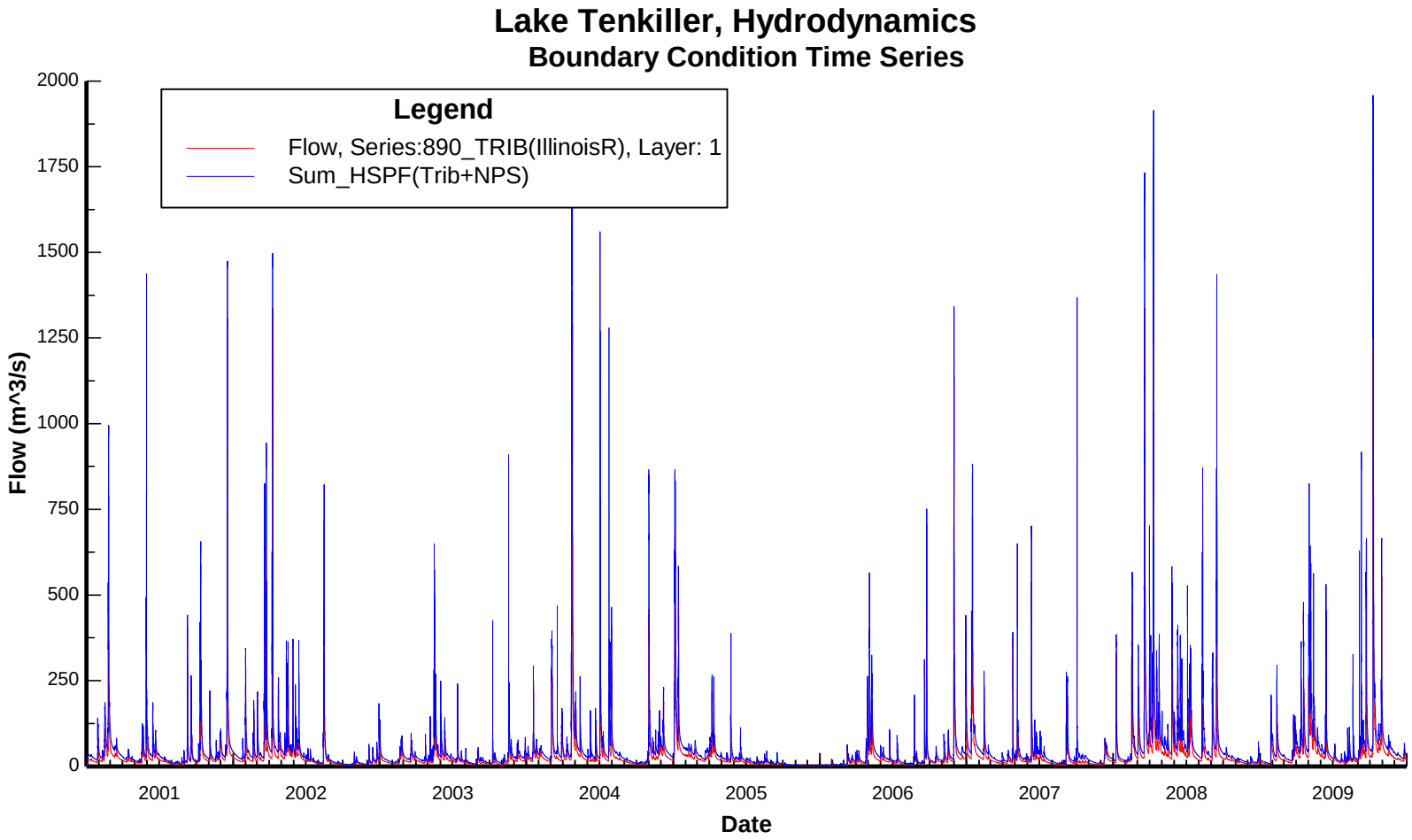
HSPF Flow: Trib+NPS



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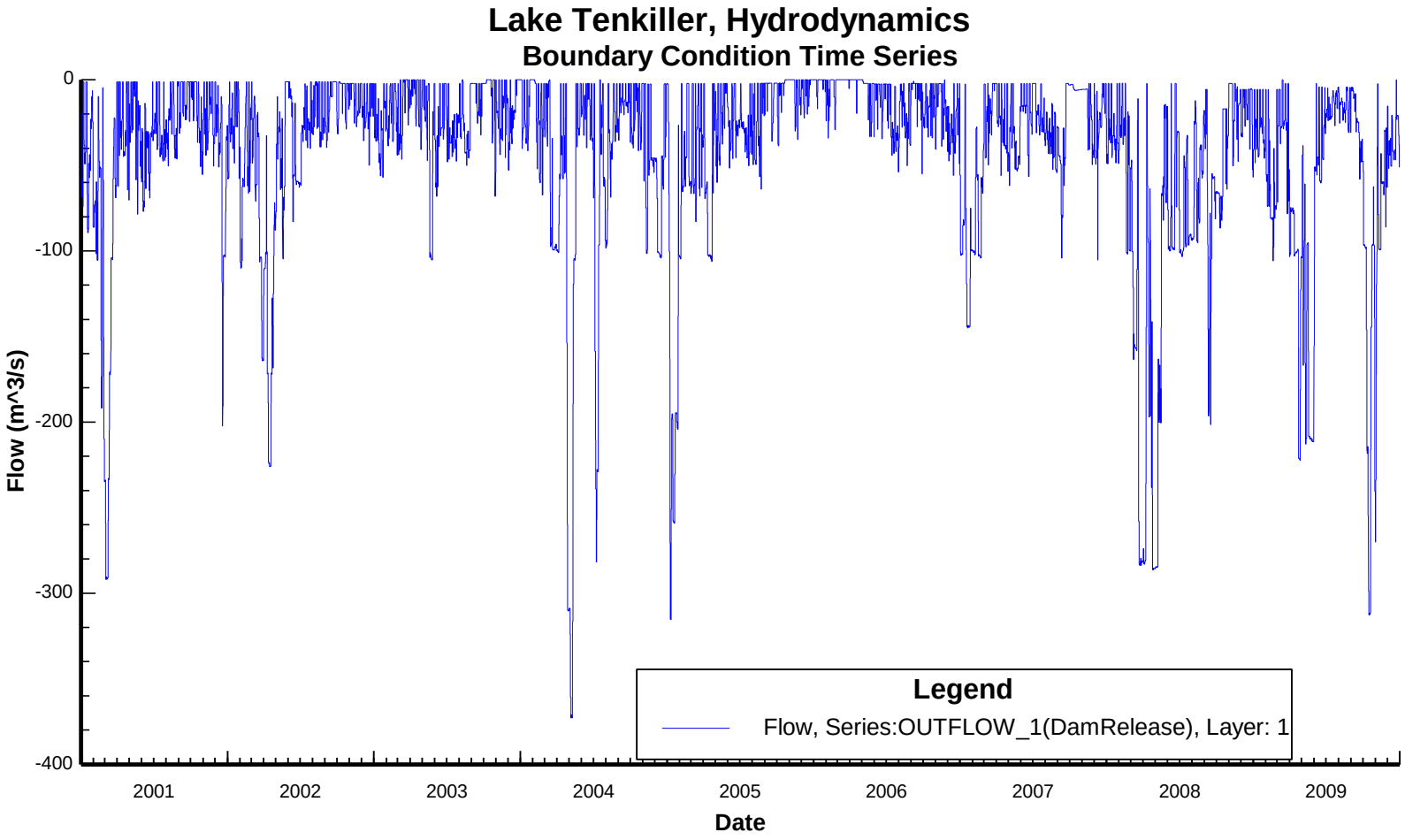
COE Release Flow at Dam



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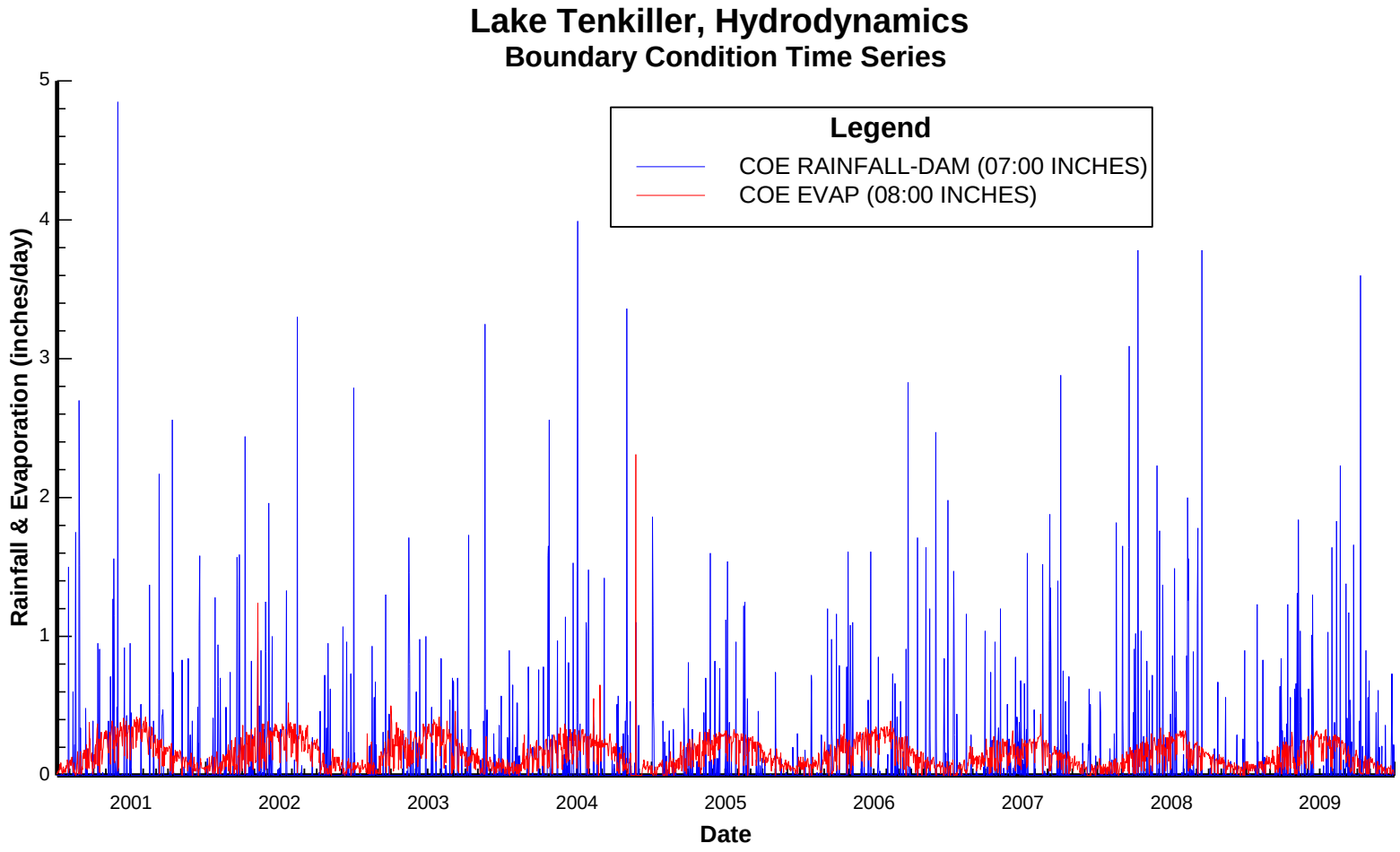
COE Precipitation & Evaporation



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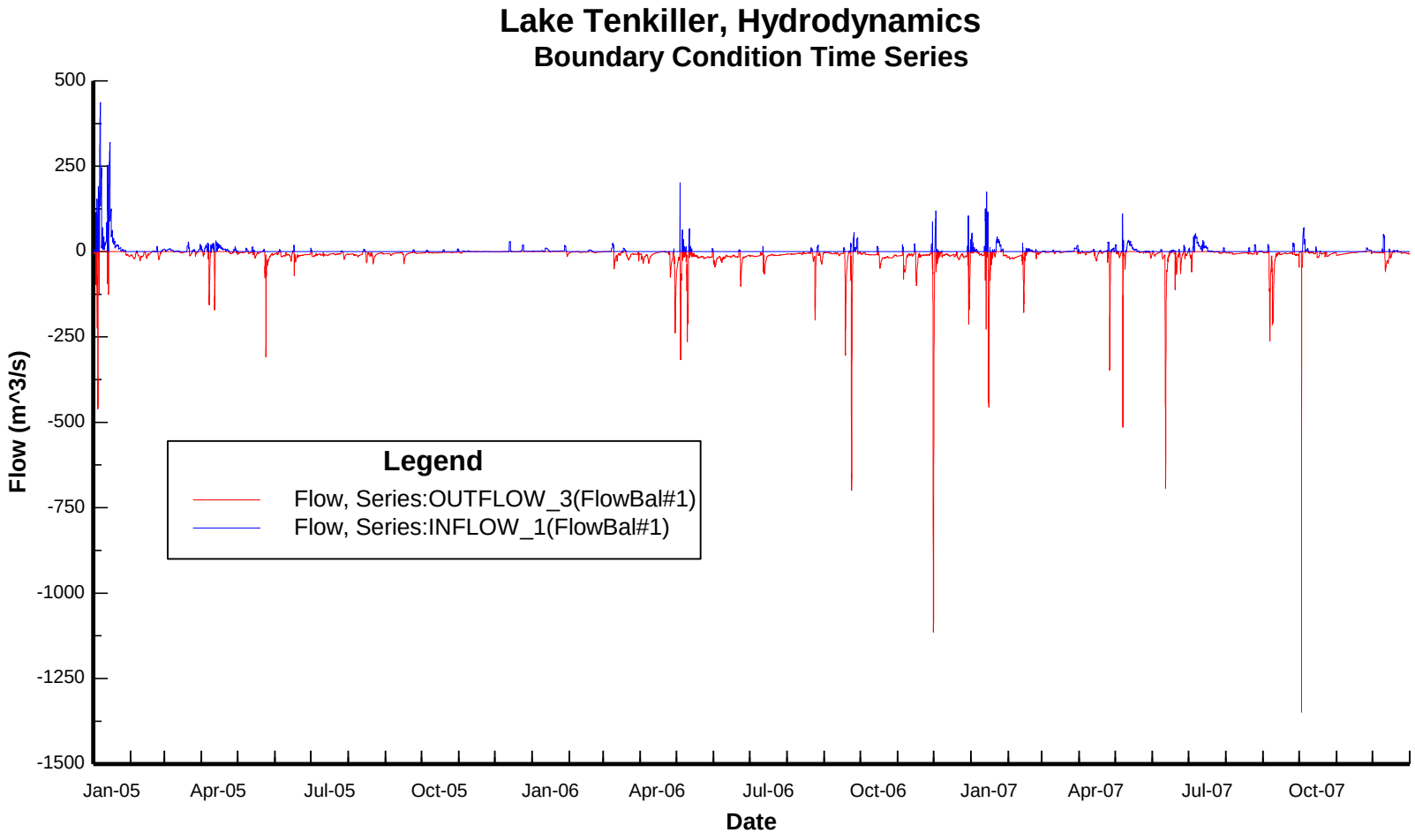
FlowBalance#1
COE InflowAdj – Sum HSPF Flow



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Summary of Flow Data

Average from 1 Jan 2005-1 Jan 2008		
	m**3/s	cfs
HSPF Tributaries	33.53	1184.1
HSPF Overland NPS	2.43	85.8
HSPF Trib+NPS	35.96	1269.9
Rainfall (Basin)	1.57	55.4
Release at dam	-27.16	-959.1
Water Supply (7.1 mgd)	-0.31	-10.9
Evaporation	-2.20	-77.7
Leakage (21,900 ac-ft/yr)	-0.86	-30.3

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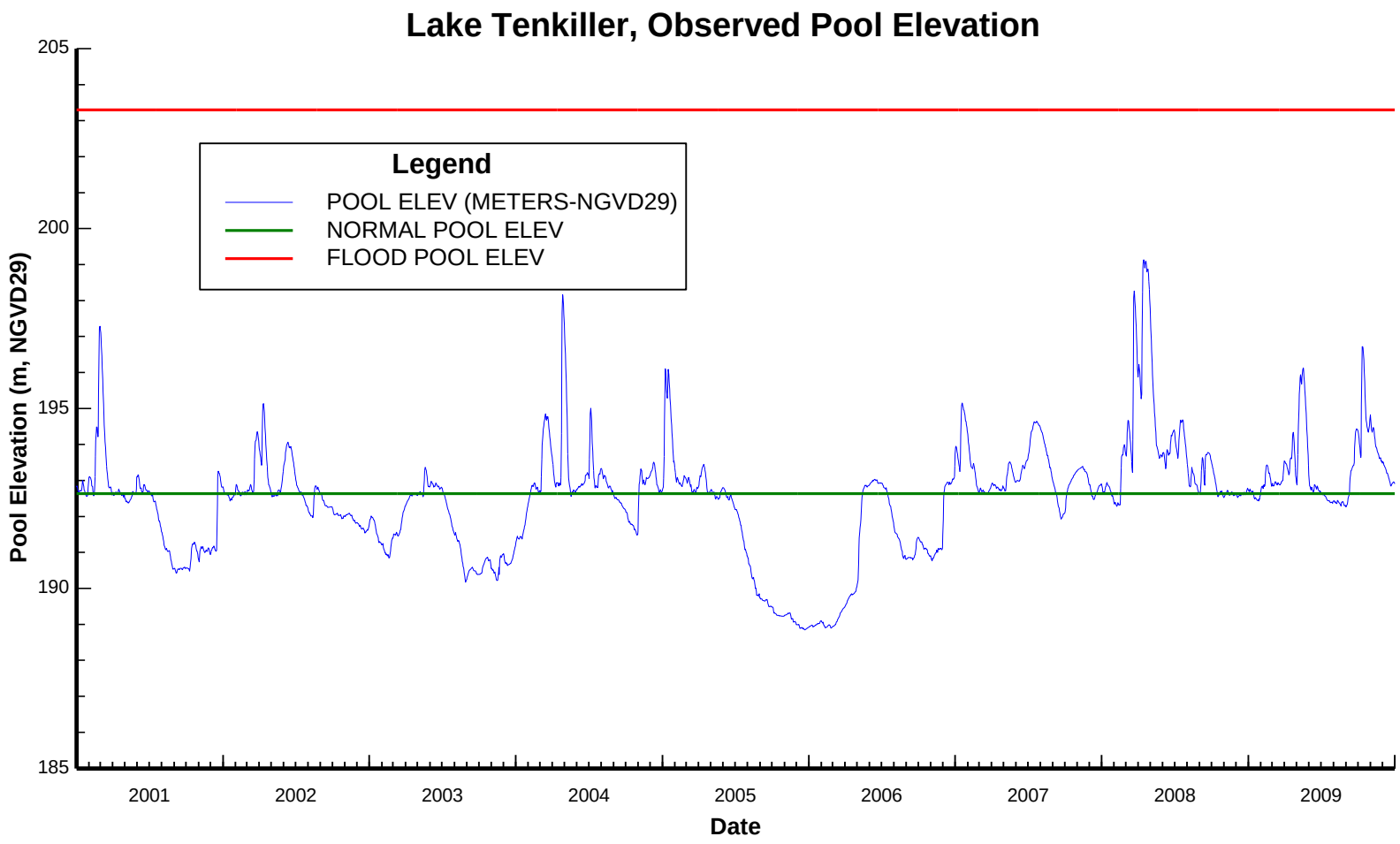
COE Lake Level at Dam



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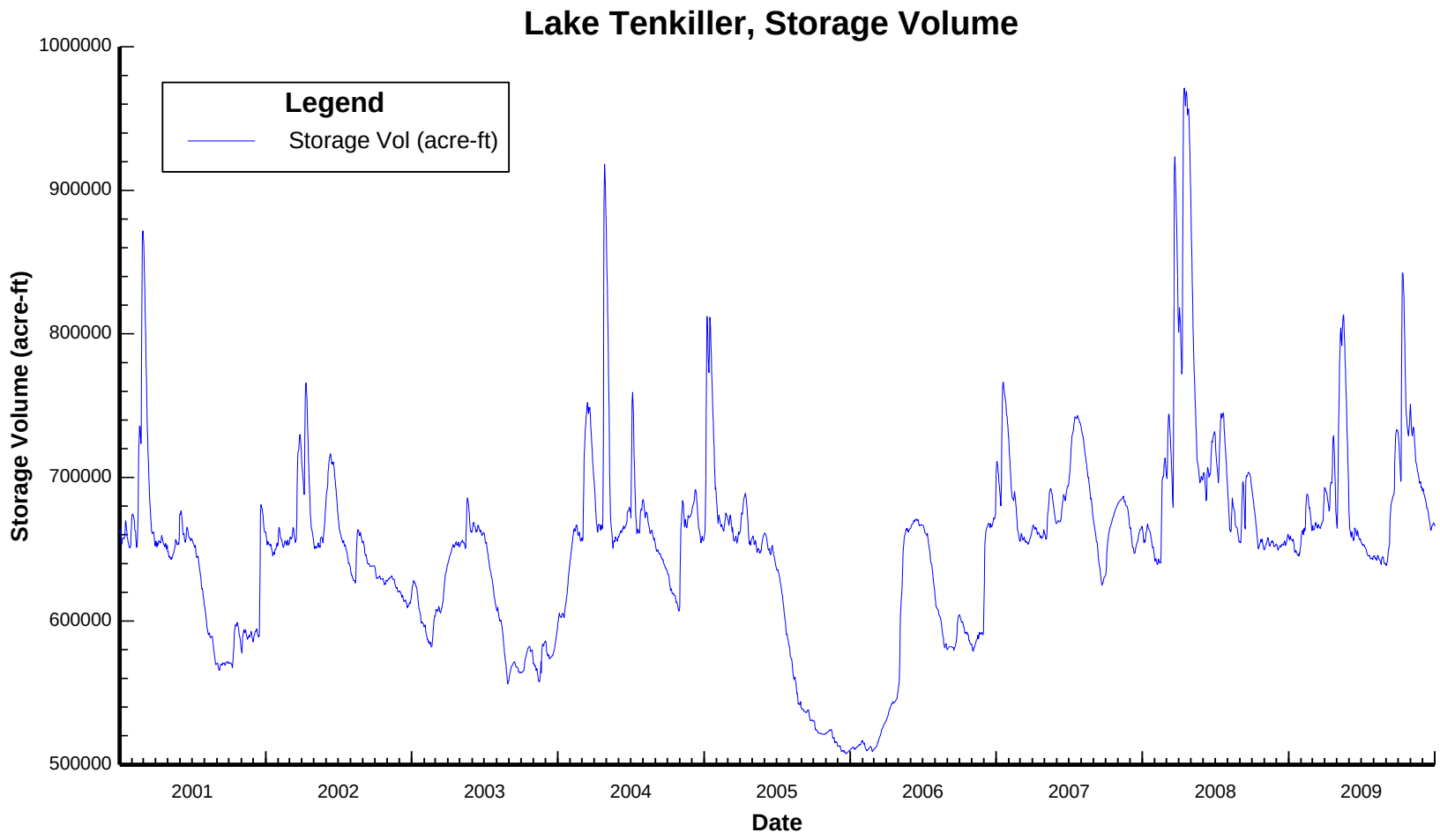
COE Lake Volume



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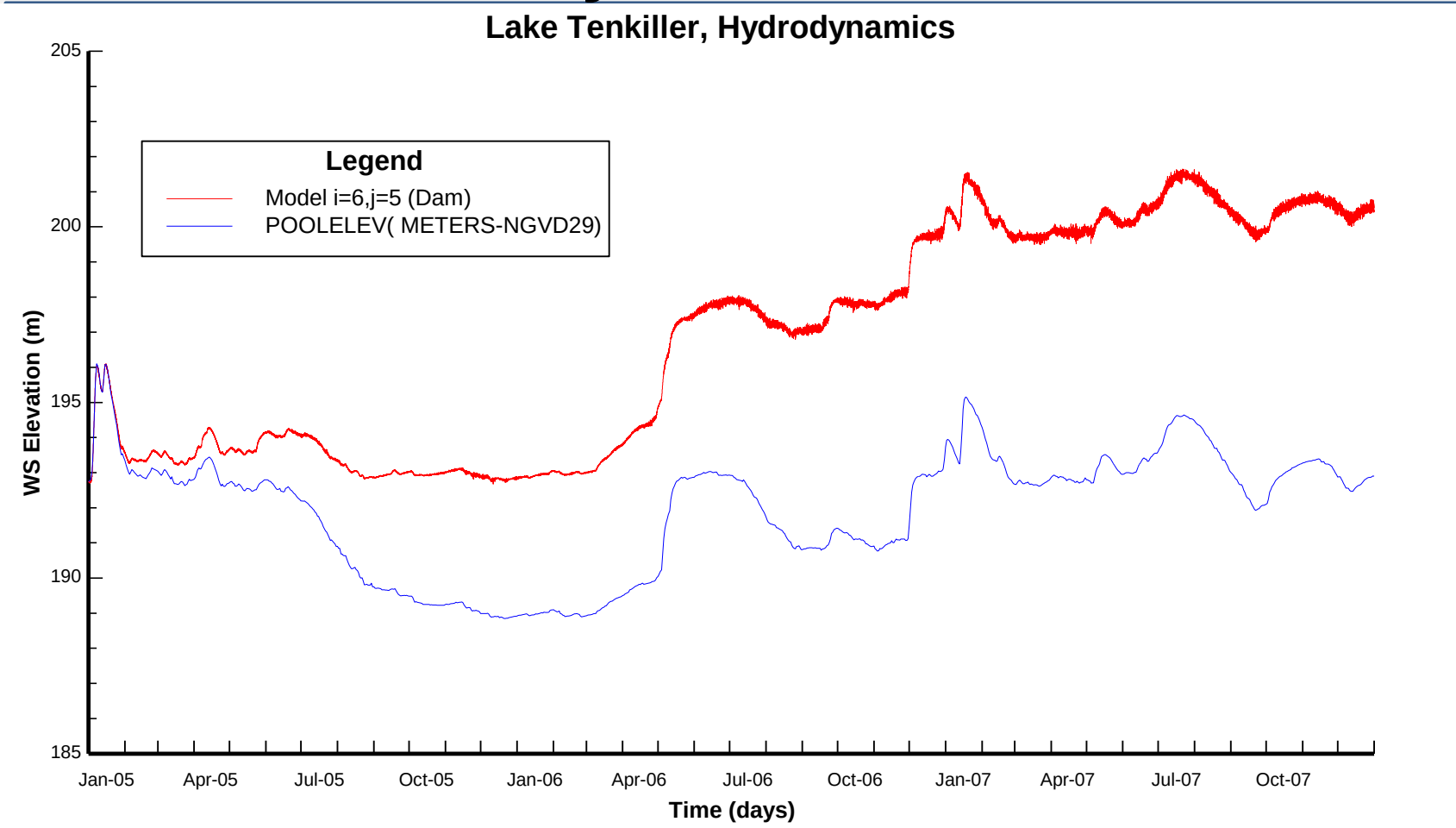
Preliminary Model Results



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Summary

- Updated bathymetry and increased grid resolution
- Used updated HSPF watershed to assign HSPF-EFDC linkage locations for tributary and overland flow input
- Computed Flow Balance#1 = COE Inflow Adjustment – Sum HSPF Flow
- Preliminary comparison of water level to observations needs additional Flow Balance#2 to model water level
- Computed flow balances account for water supply withdrawals, leakage & seepage losses and other +/- flows

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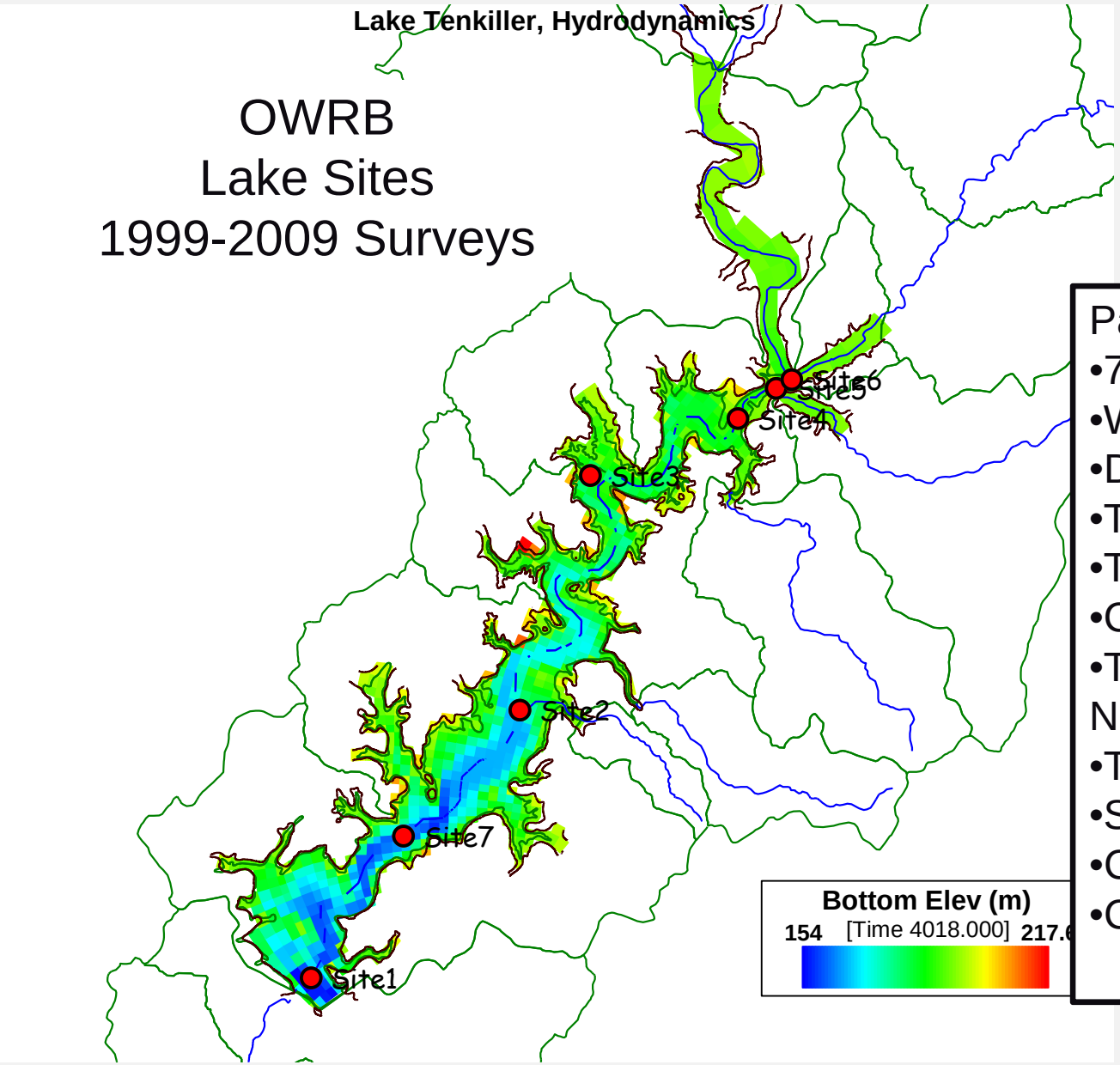
Next Steps for Hydrodynamics

- Complete flow balance estimates to improve model agreement with observed water level
- Model water temperature
- Setup meteorology and wind forcing data
- Compile time series & vertical profiles of water temperature for lake stations
- Obtain HSPF water temperature for input to EFDC model
- Setup & test vertical resolution (10-15 layers)
- Calibrate water temperature to observed data

OWRB
Lake Sites
1999-2009 Surveys



Parameters
- 7 stations
- Water temperature
- Dissolved oxygen
- TSS, Turbidity
- Total dissolved solids
- Chlorides
- Total-N, TON, TKN,NH3, NO2,NO3
- Total-P, OPO4
- Secchi depth
- Color
- Chl-a

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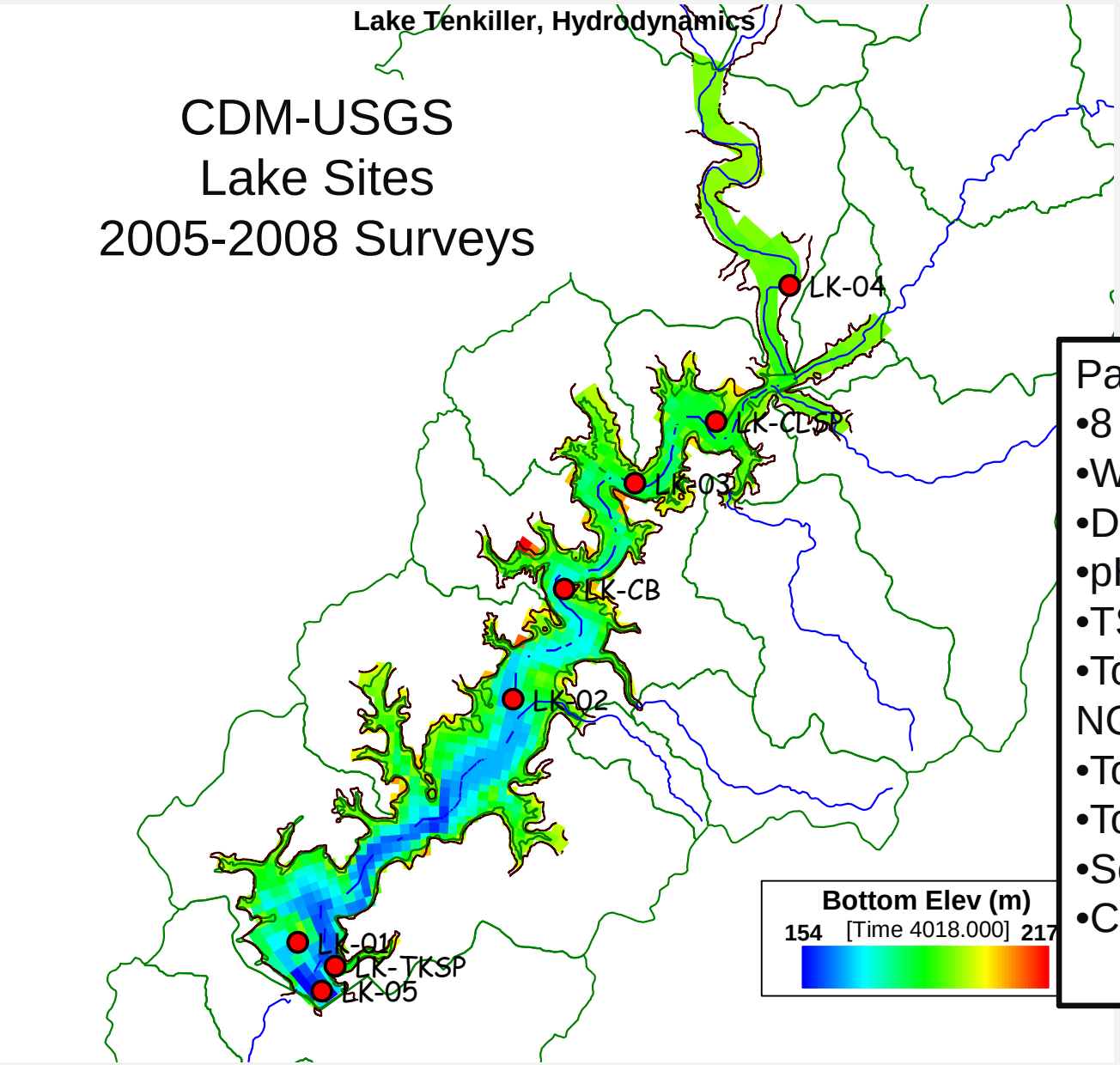
CDM-USGS Lake Sites 2005-2008 Surveys



Parameters
- 8 stations
- Water temperature
- Dissolved oxygen
- pH
- TSS, Turbidity
- Total-N, TKN,NH3, NO2+NO3
- Total-P, TPO4
- Total-Diss-P, Diss-PO4
- Secchi depth
- Chl-a

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Discussion

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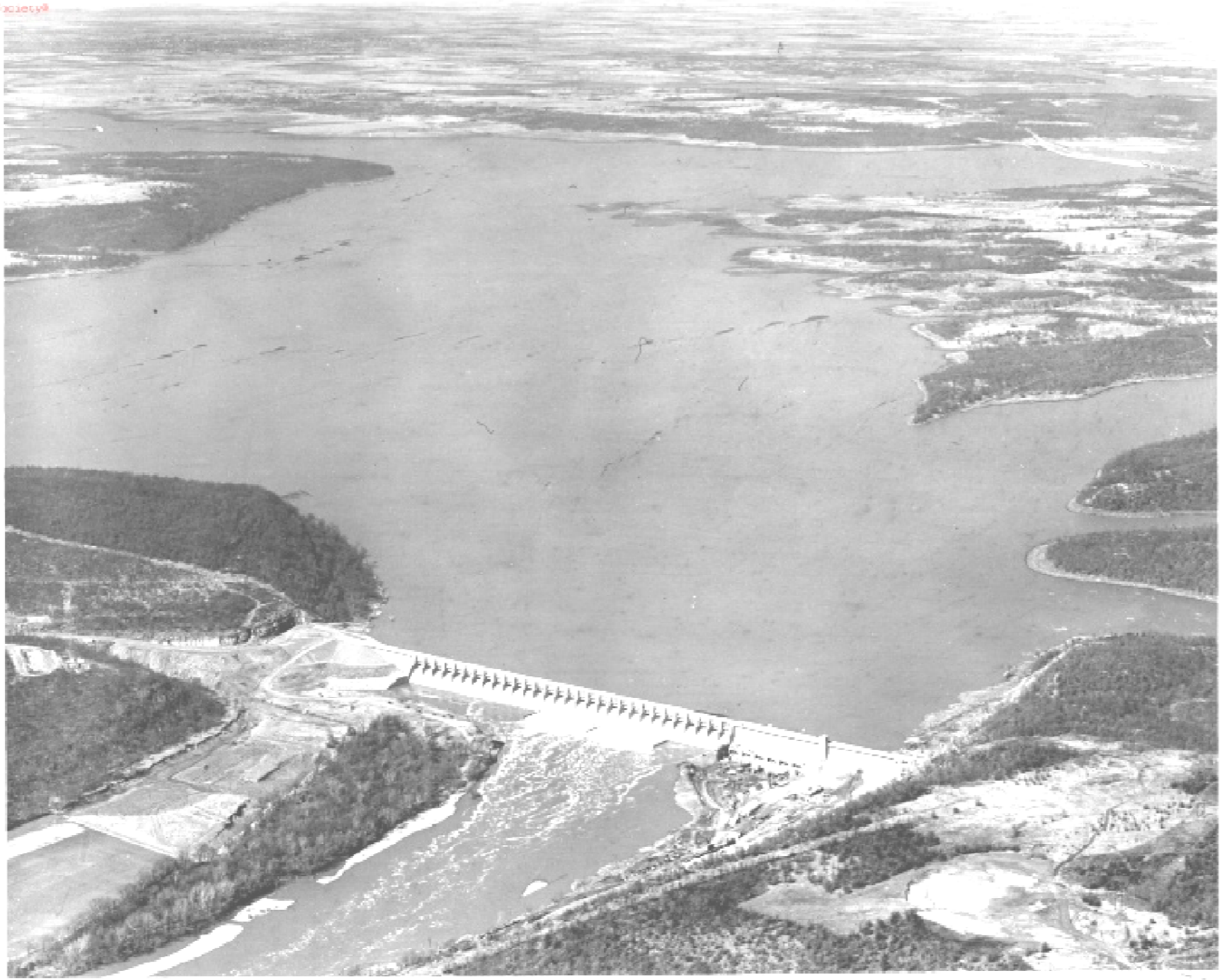
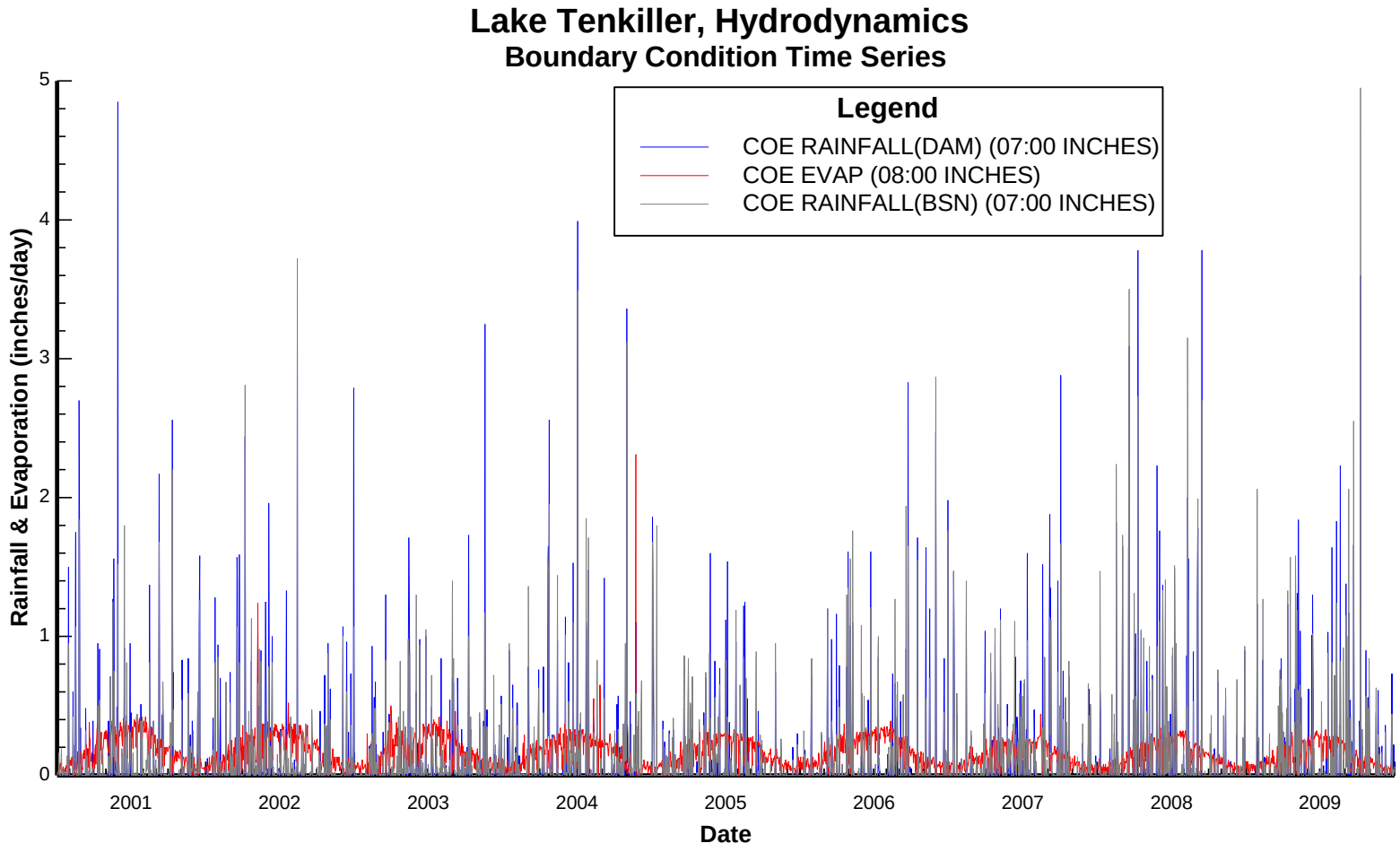


COE Precipitation & Evaporation



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