Stochastic Analysis of Devils Lake Outlet and Sheyenne River Sulfate Concentrations

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Modeling Subcommittee
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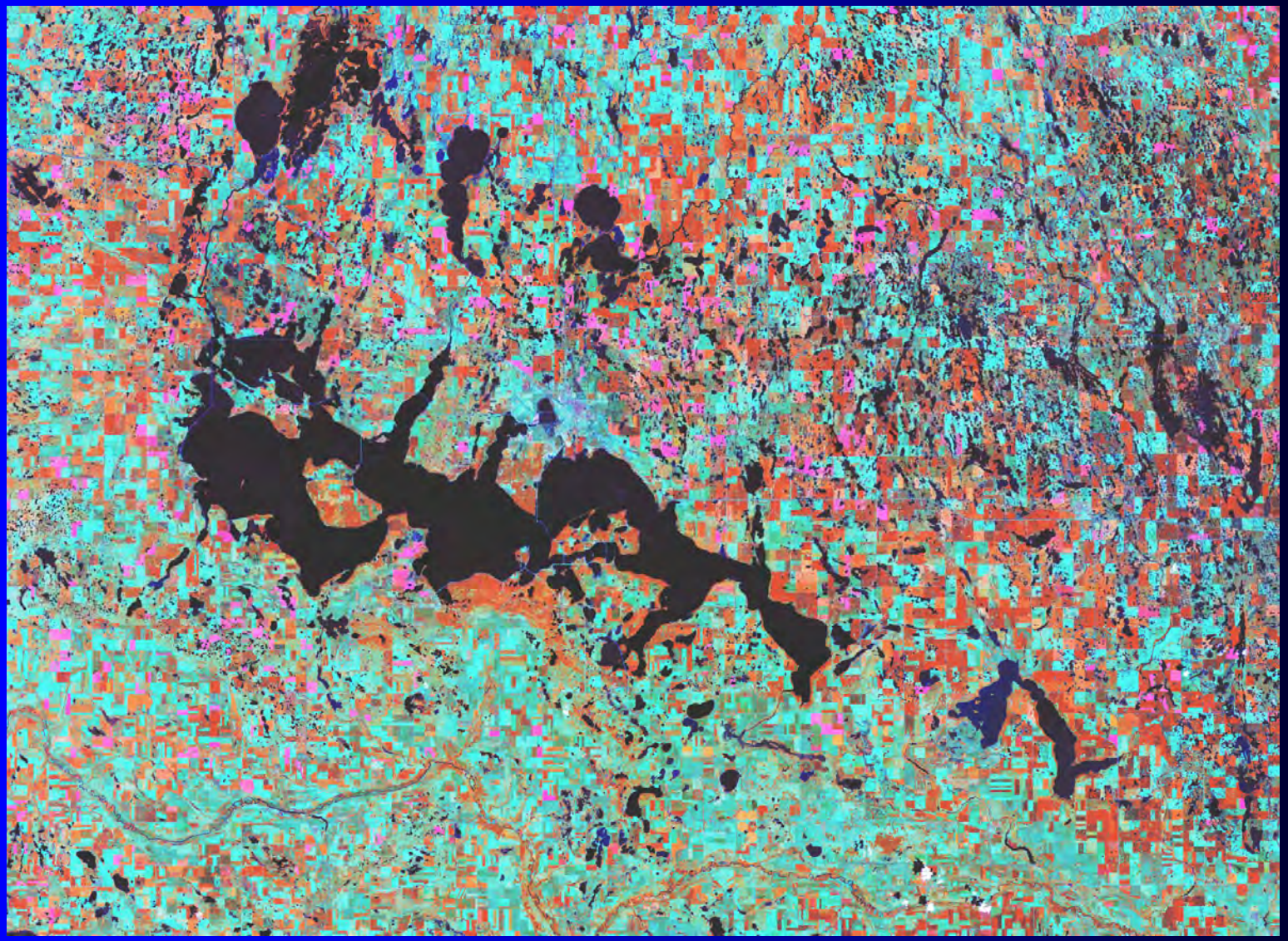
PRELIMINARY DRAFT - NOT FOR RELEASE

Topics

- Brief review of USGS Devils Lake Stochastic Simulation Model
- Linking Devils Lake simulation model with Sheyenne River flows and sulfate concentrations
- Preliminary results showing potential effects of Sheyenne River sulfate constraints on outlet operation
- Plans for linking stochastic simulation model with deterministic model for Lake Ashtabula
- Extending model downstream of Lake Ashtabula

Devils Lake (circa 1998)



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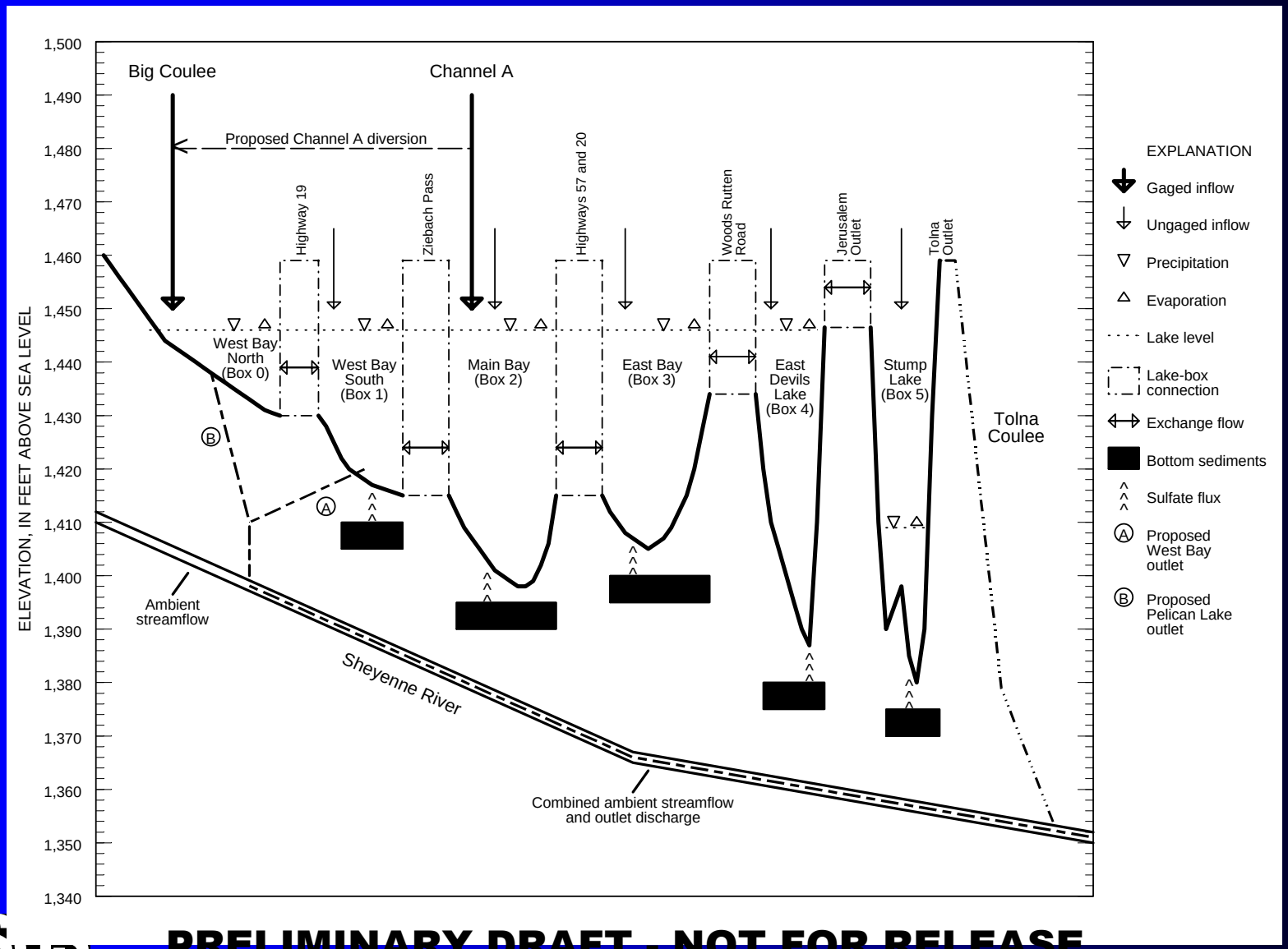
Devils Lake water and sulfate mass-balance model schematic



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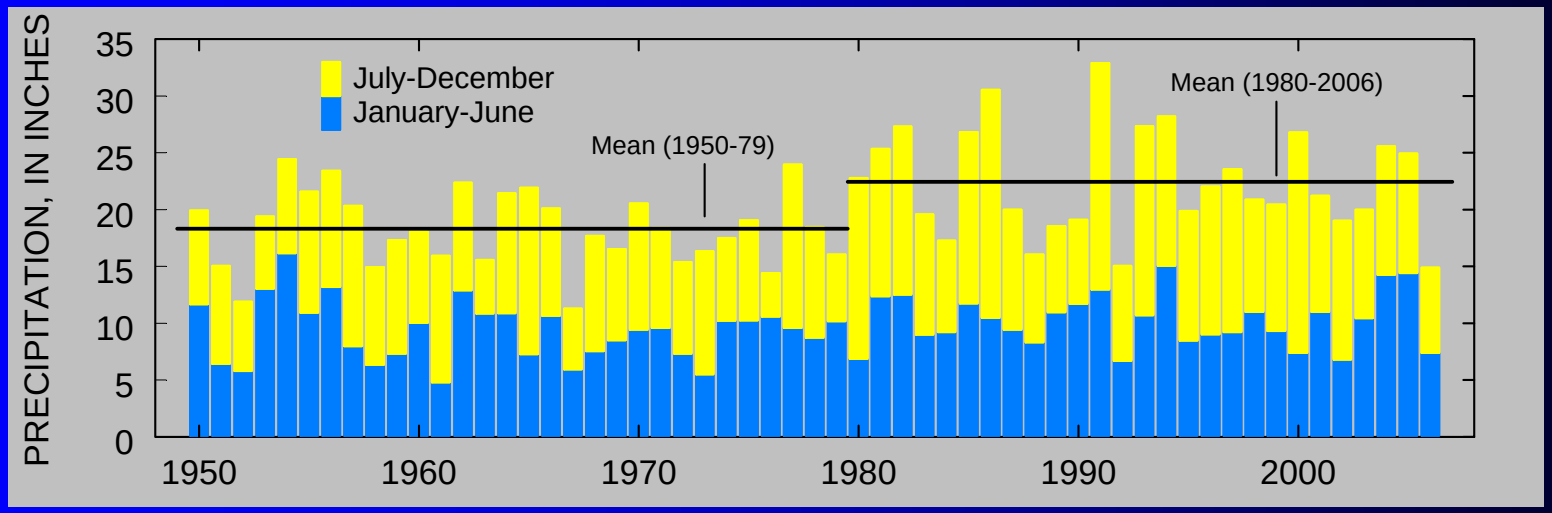
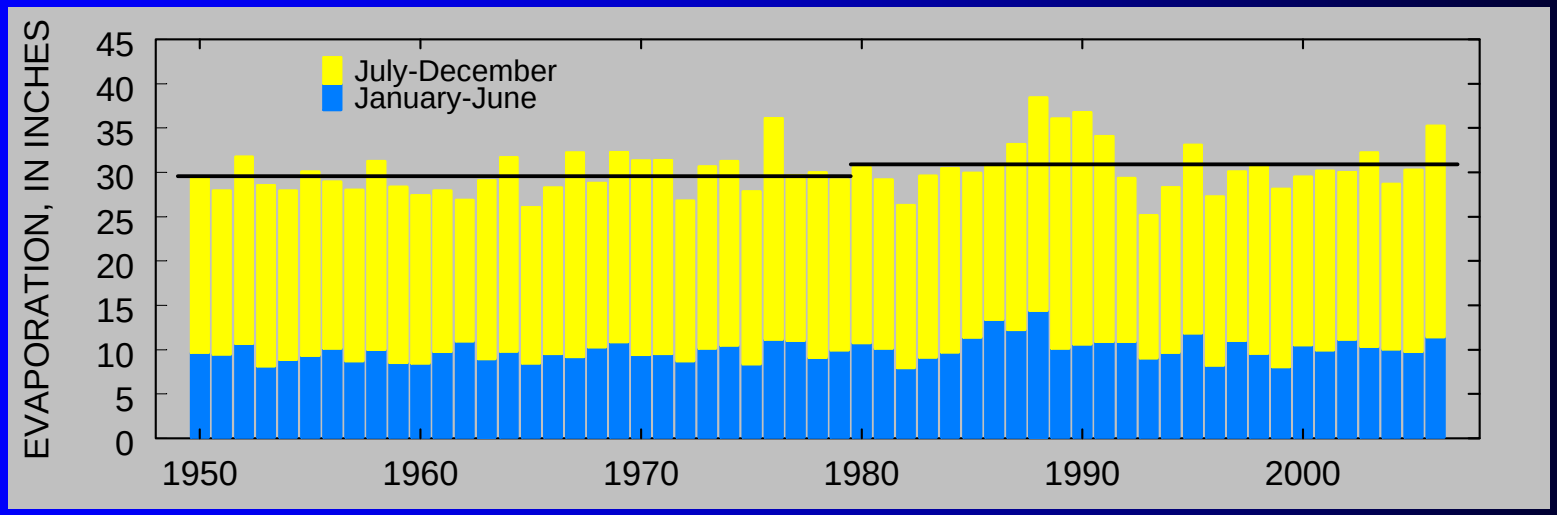
Stochastic simulation model for Devils Lake

- Based on a monthly time step
- Developed in 2000, updated in 2008
- Generates potential future precipitation, evaporation, inflow volumes and sulfate concentrations (given starting conditions)
- Water and sulfate mass-balance model used to generate future lake levels and sulfate concentrations
- Includes potential outlet discharges and "natural" spill from Tolna Coulee outlet

Annual Devils Lake precipitation and evaporation for 1950-2006





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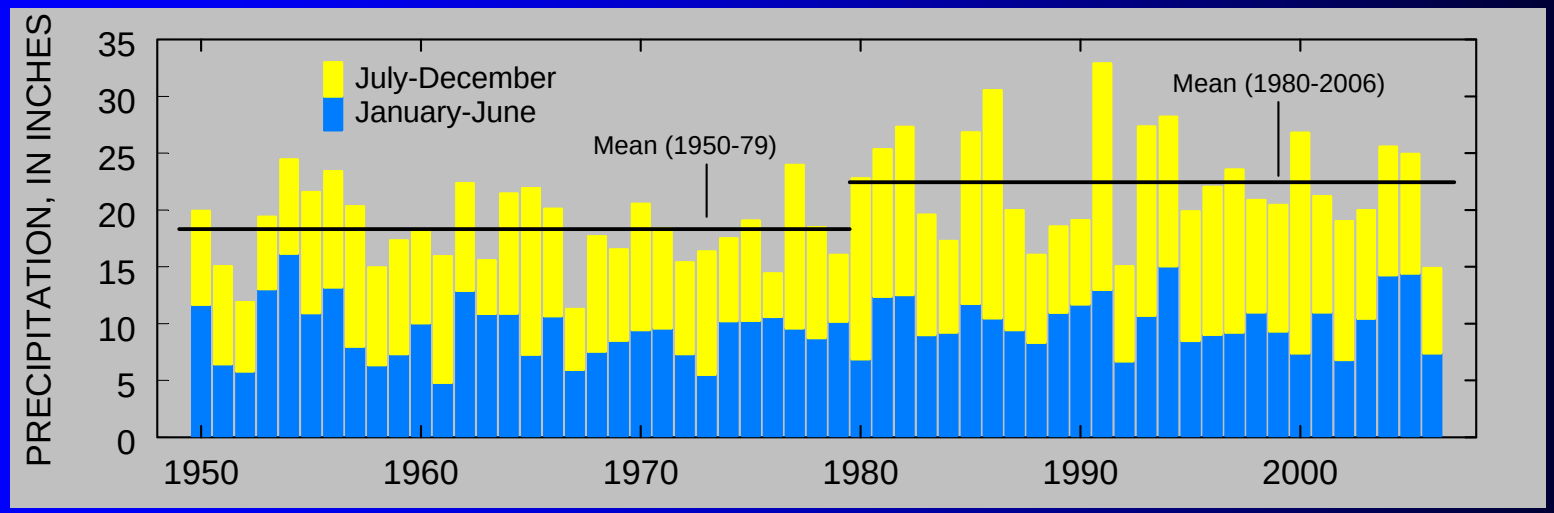
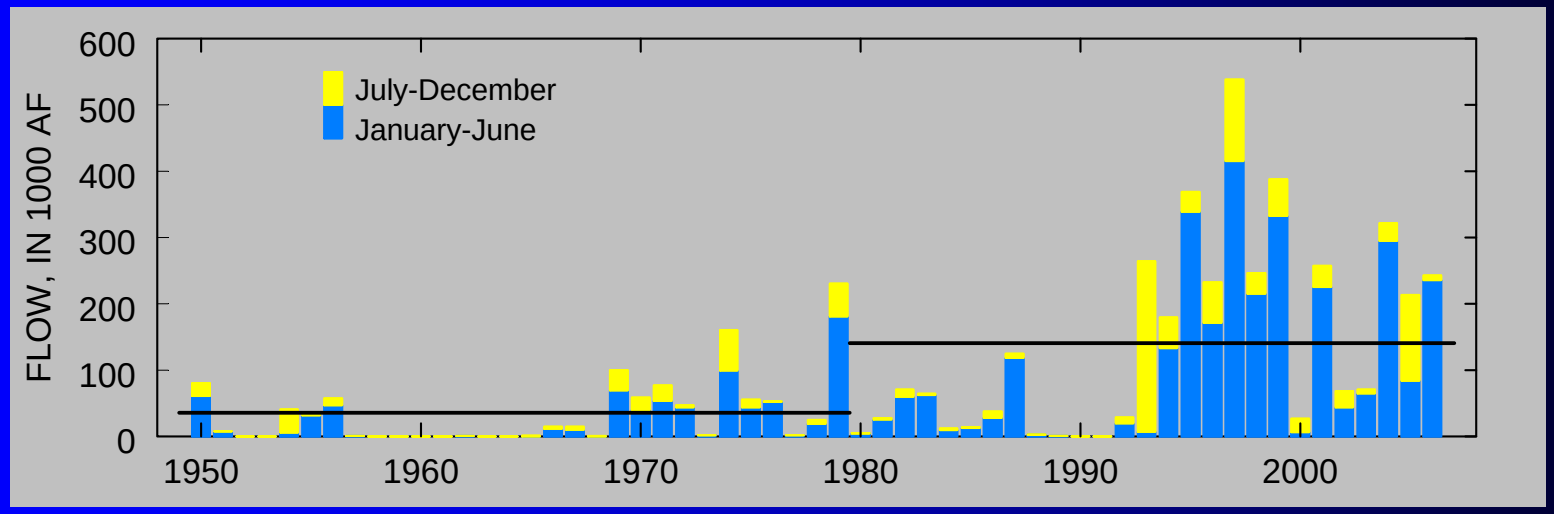
Effect of climate shift on Devils Lake inflows





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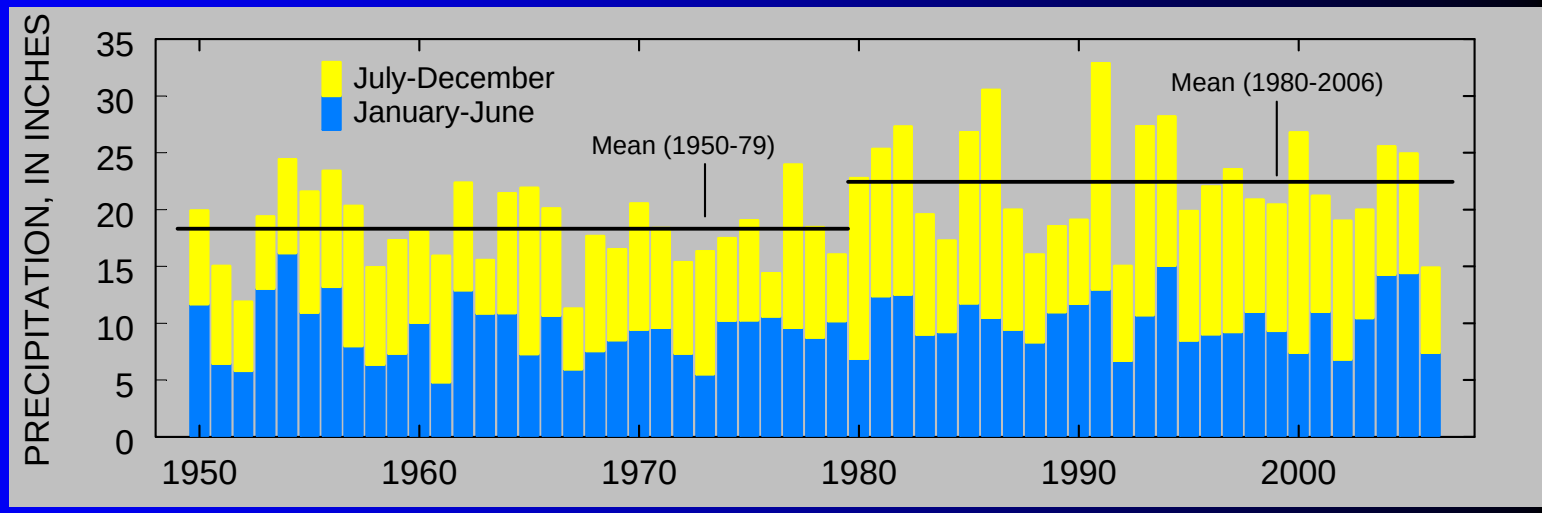
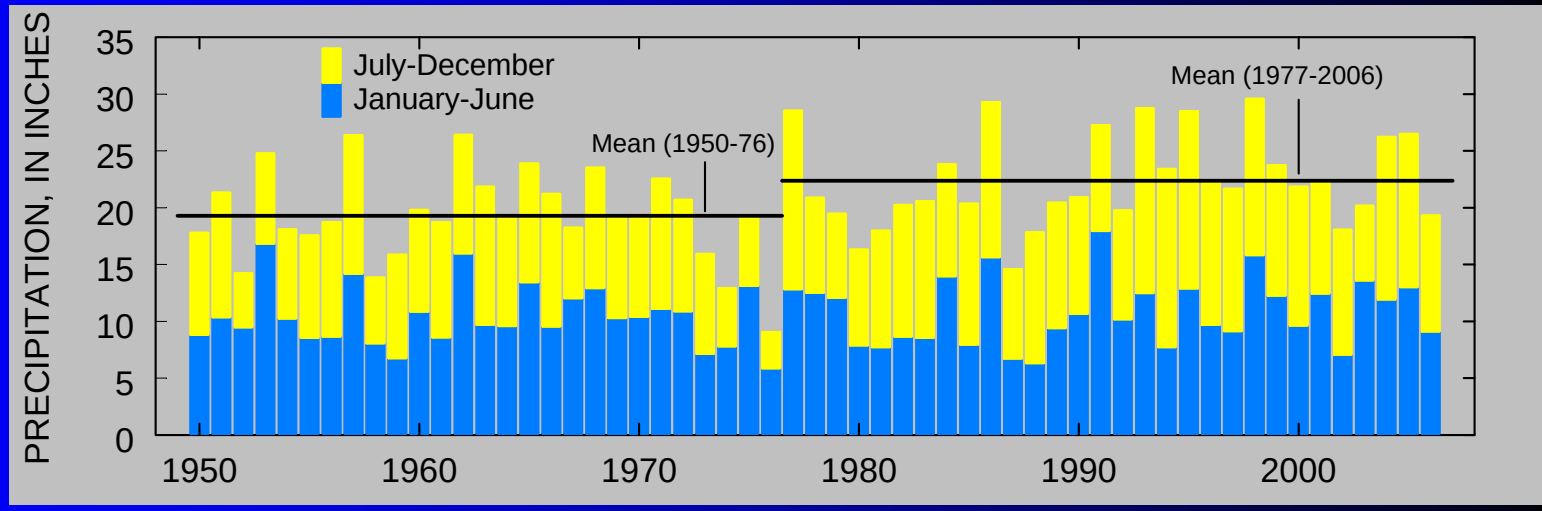
Abrupt climate shift is a regional phenomenon

This is for Devils Lake



This is for NE S.Dak. Climate Division



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Linking the Devils Lake simulation model with Sheyenne River flows and sulfate concentrations

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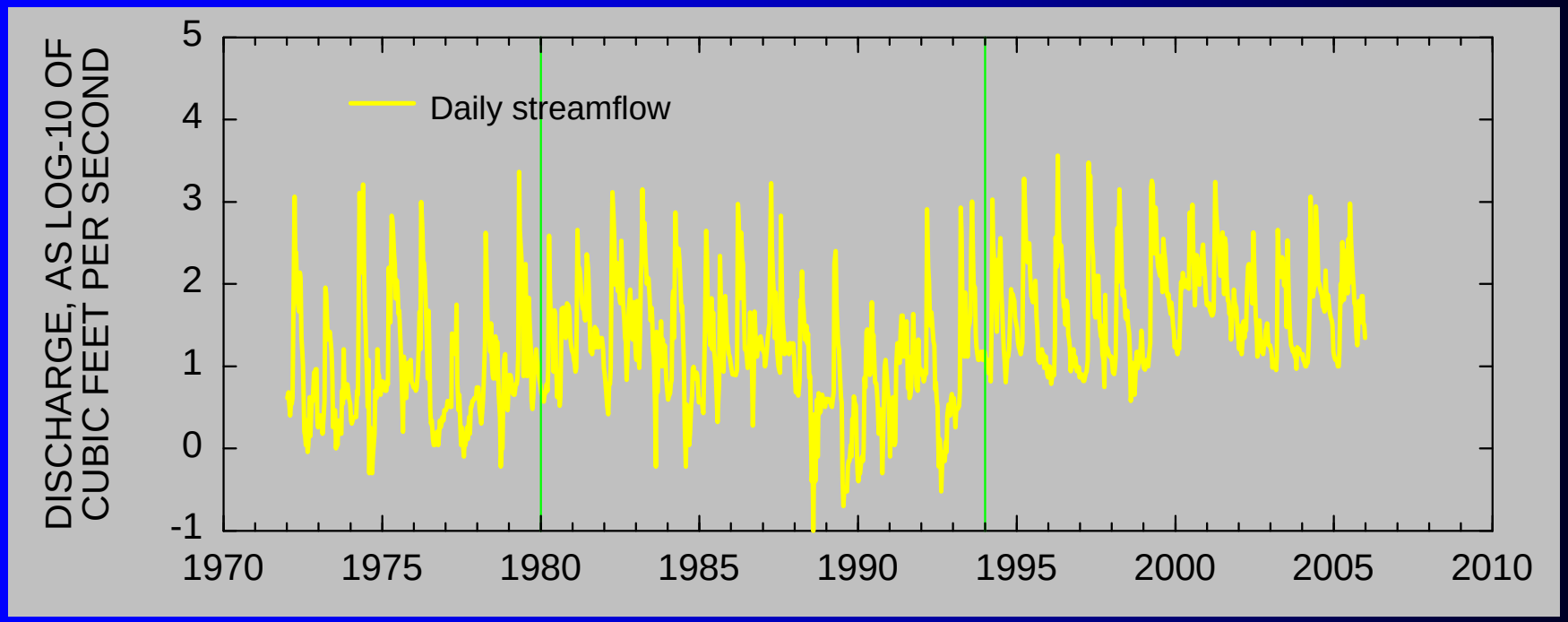
Daily streamflow for Sheyenne River near Warwick (1972-2006)



*Note: 10-day sampling interval – values not shown for every day

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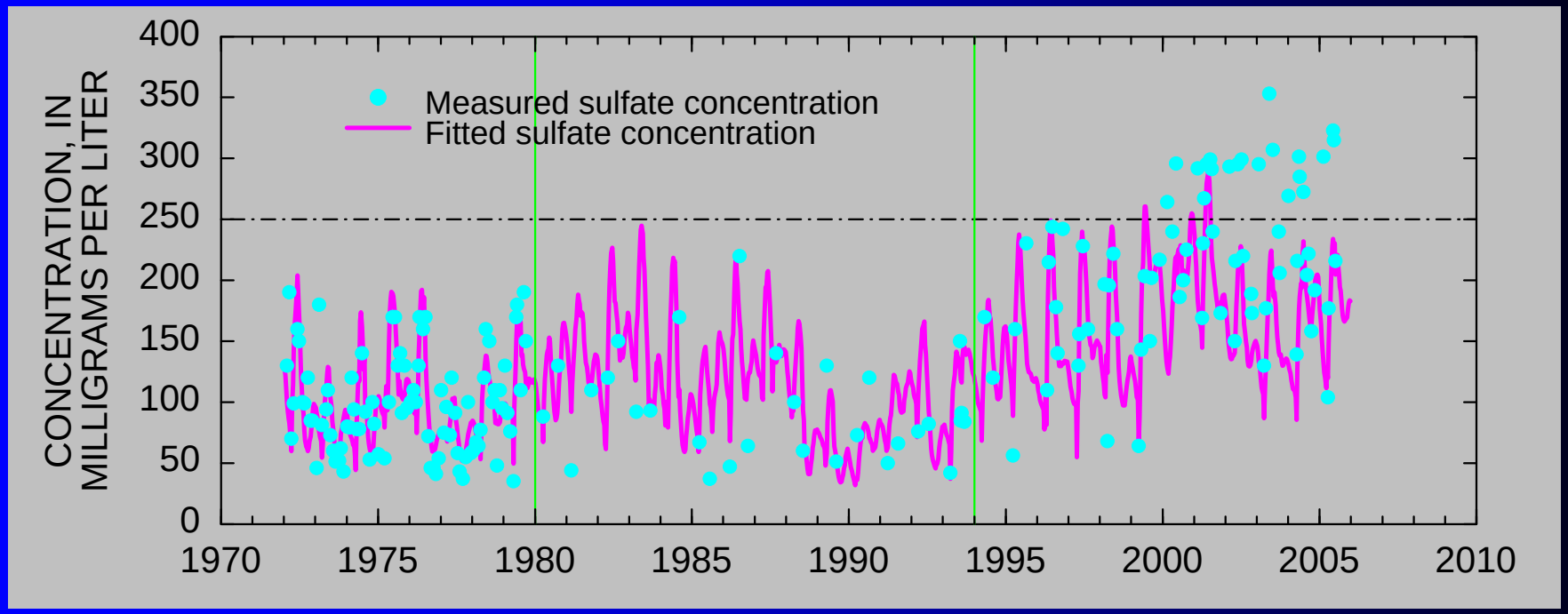
Sulfate concentration for Sheyenne River near Warwick (1972-2006)



Fitted concentrations based on statistical model relating sulfate to streamflow and time of year – calibrated using 1972-99 time period

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Preliminary simulation of future effects of outlet operation on Lake Ashtabula and the Sheyenne River

Devils Lake Simulation model

State outlet
- 100 cfs 2009
- 250 cfs 2010 - ?
- April-November
- <600 cfs flow at Bremen
- < 450 mg/L SO4 blw Baldhill

Incremental inflows and sulfate concentrations

Bremen

Warwick

Coopers-town

"Ashtabula"

Completely Mixed

No ice

BBHD

Lisbon

Kindred

Horace

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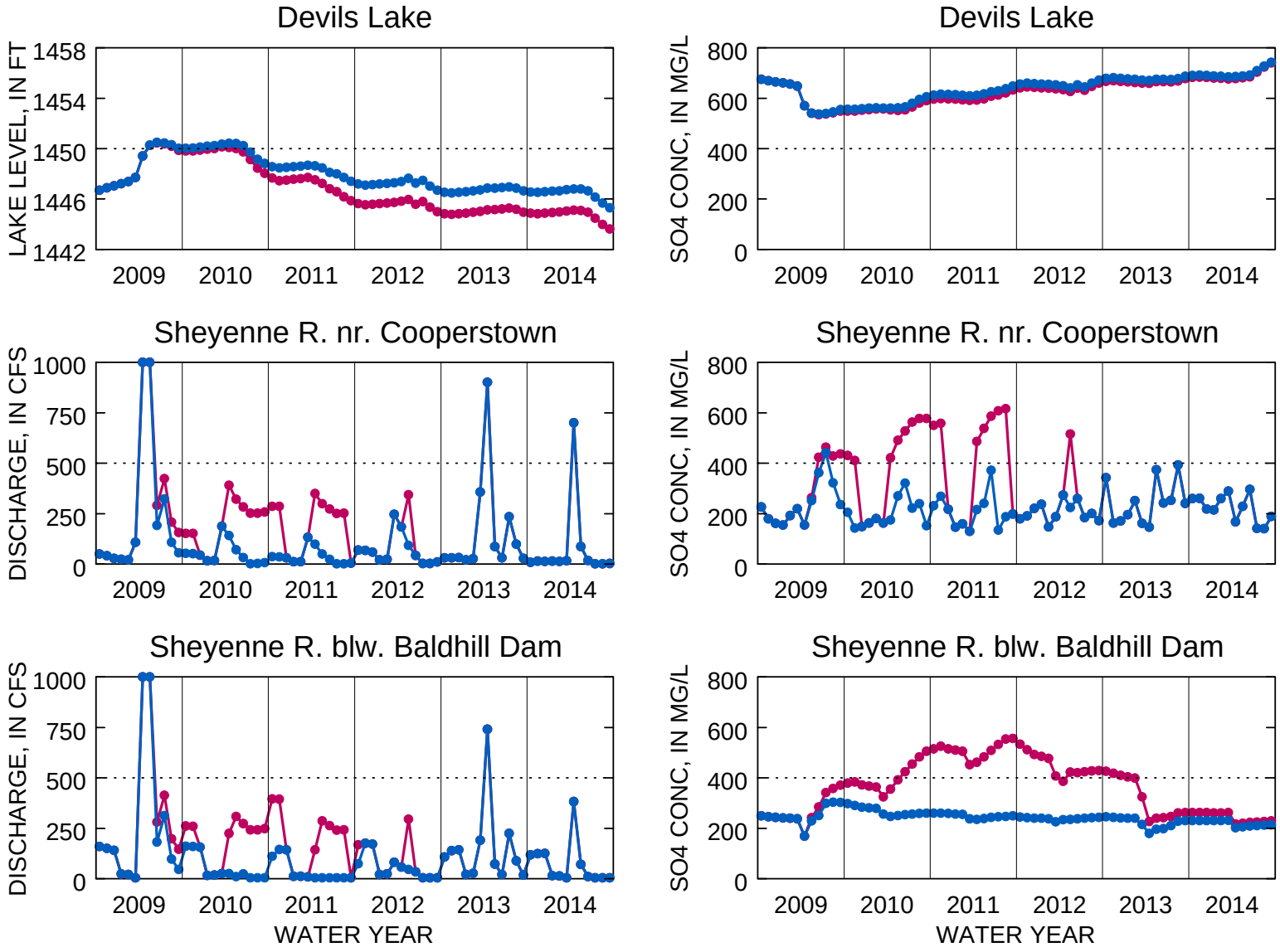
SIMULATED TRACE NUMBER 6 - NO SULFATE CONSTRAINT
MONTHLY TIME SERIES (BLUE: AMBIENT, RED: WITH PUMP)



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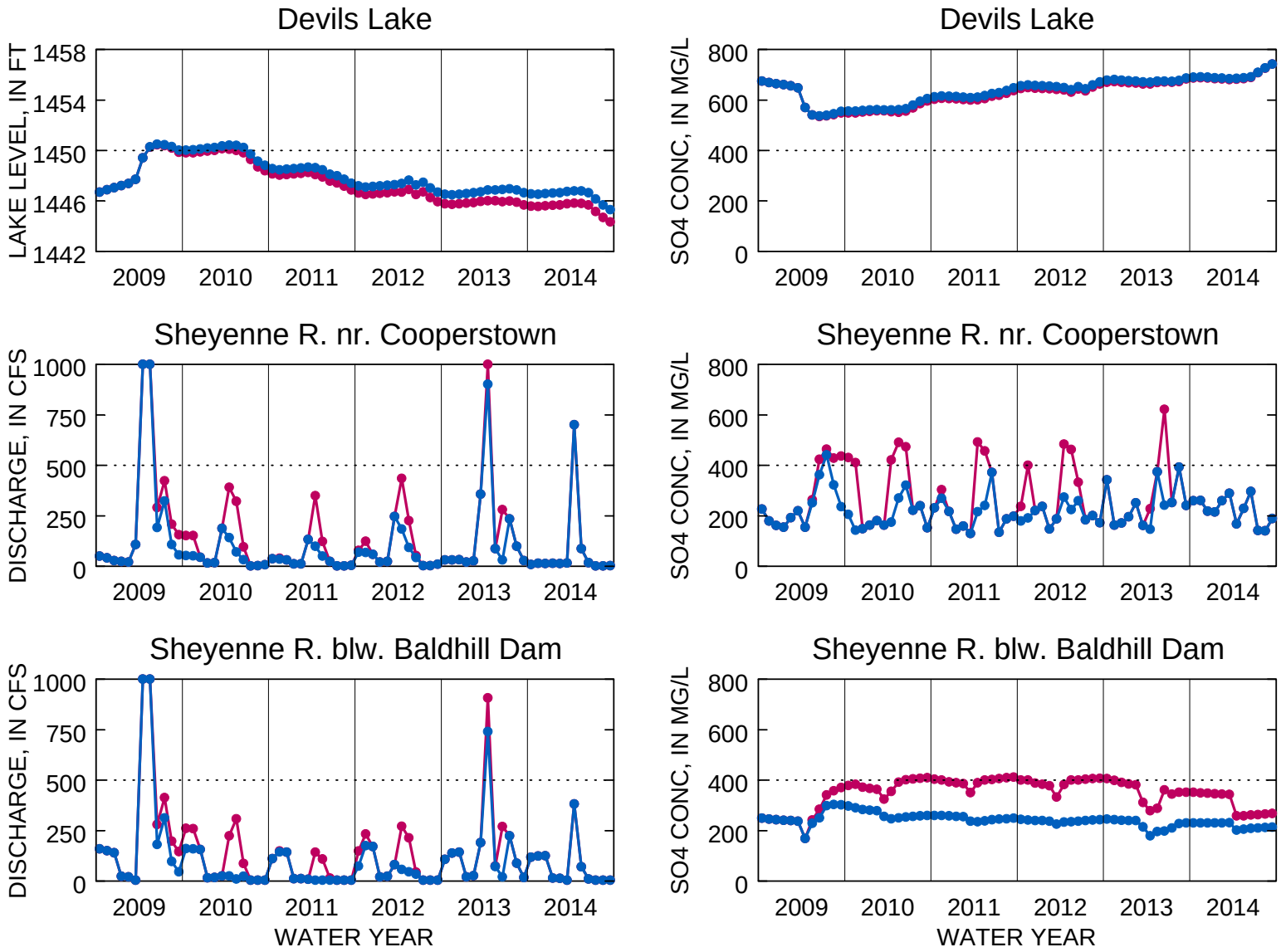
MONTHLY TIME SERIES (BLUE: AMBIENT, RED: WITH PUMP)



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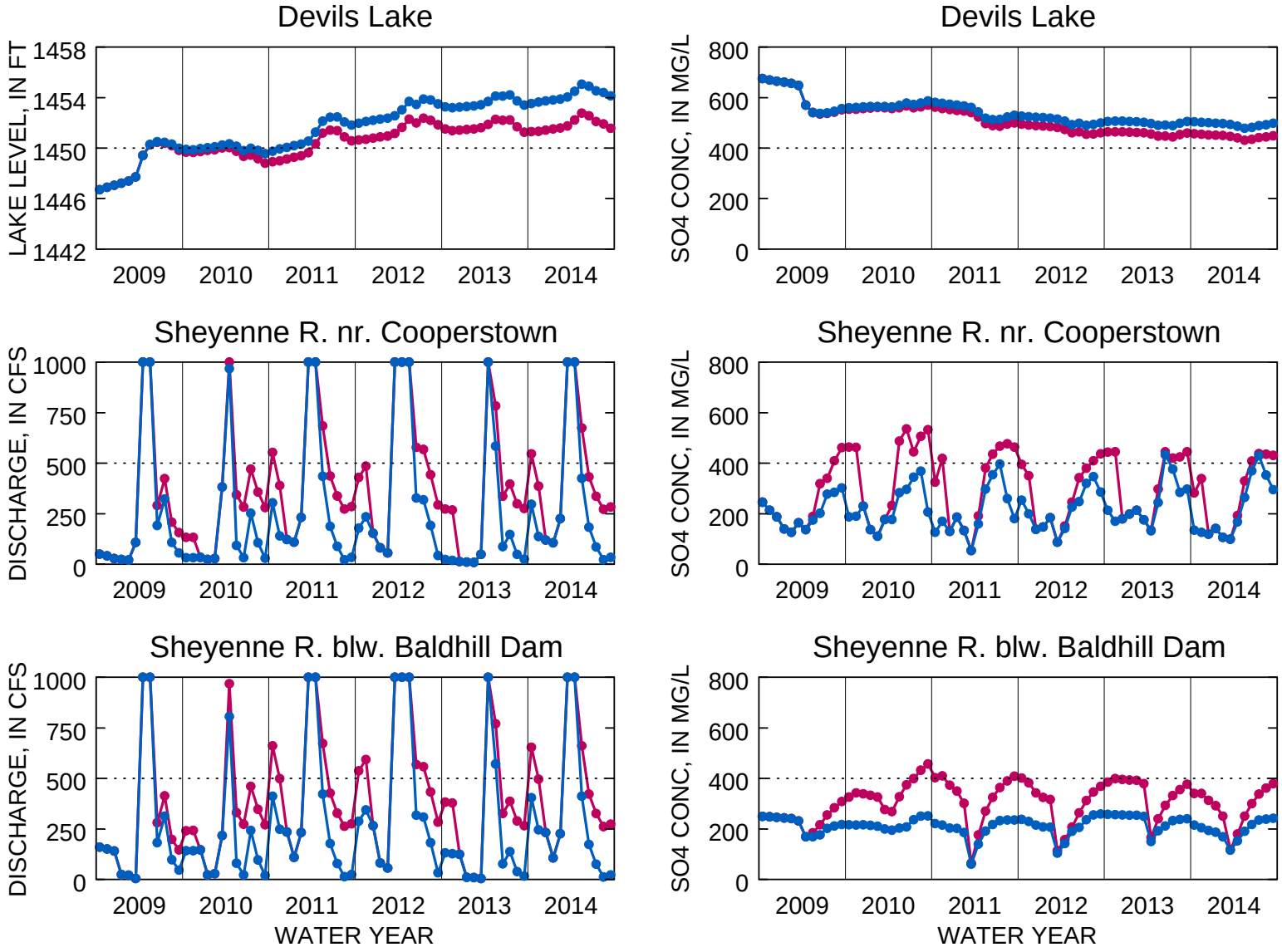
MONTHLY TIME SERIES (BLUE: AMBIENT, RED: WITH PUMP)



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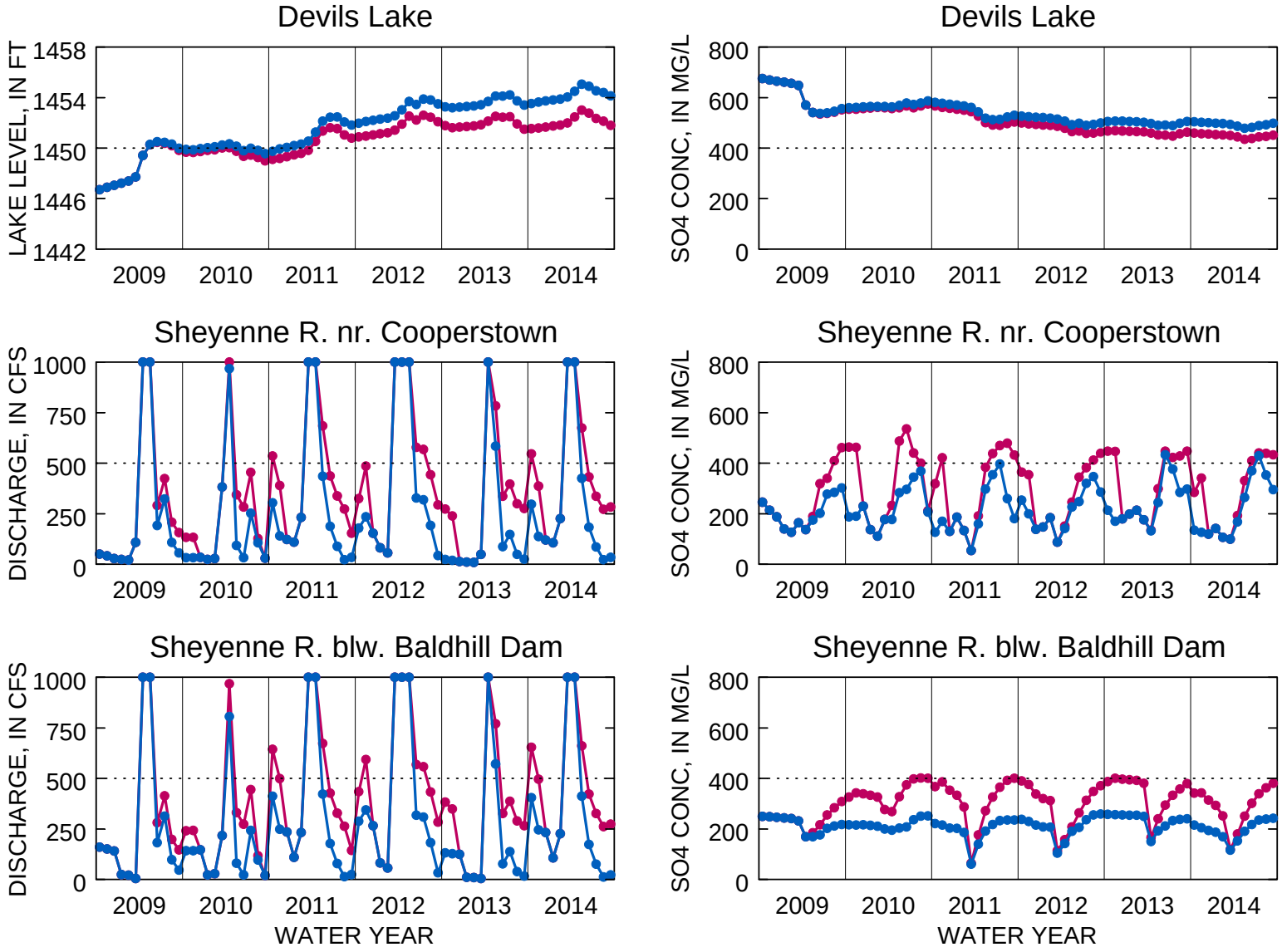

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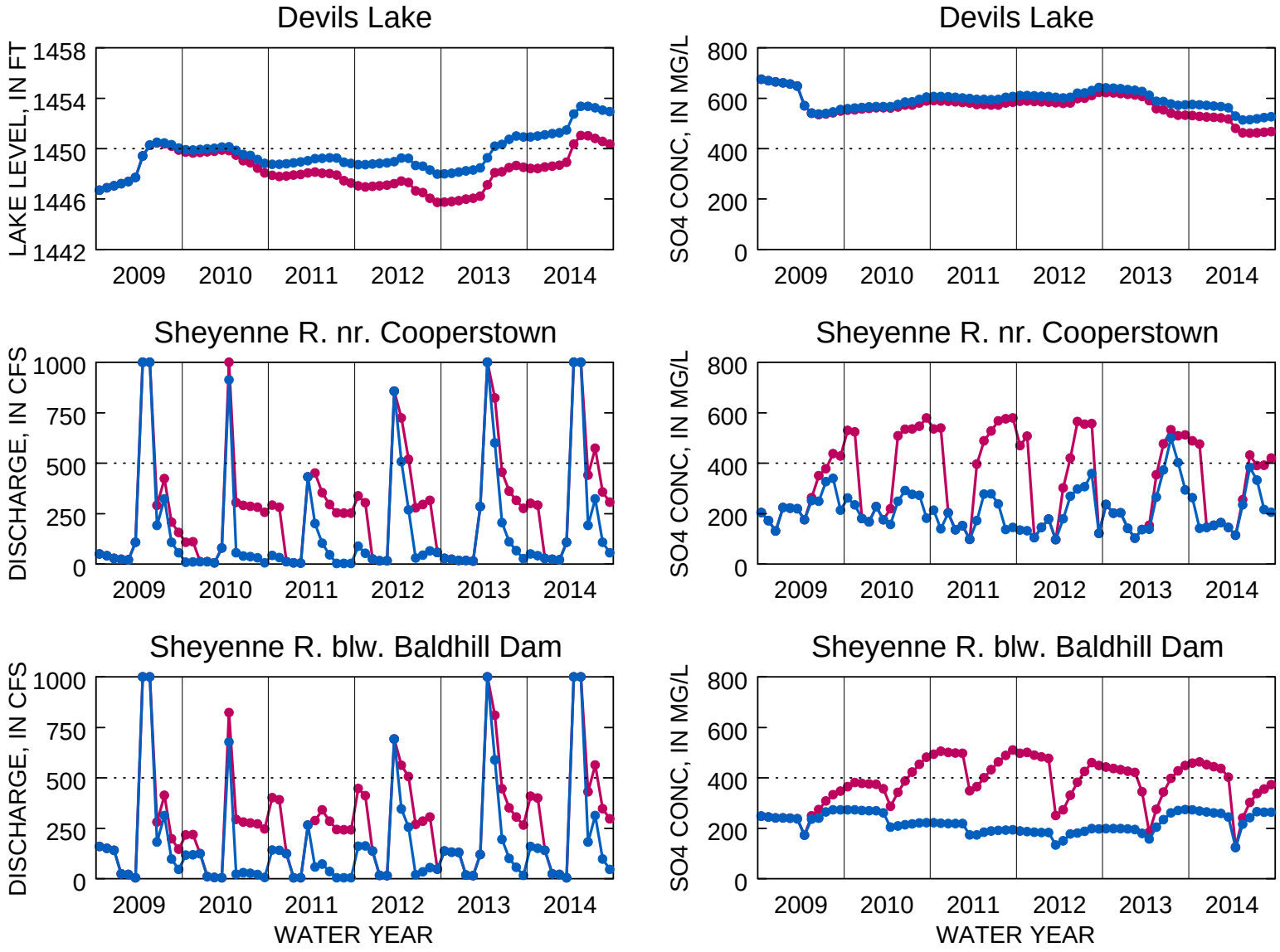

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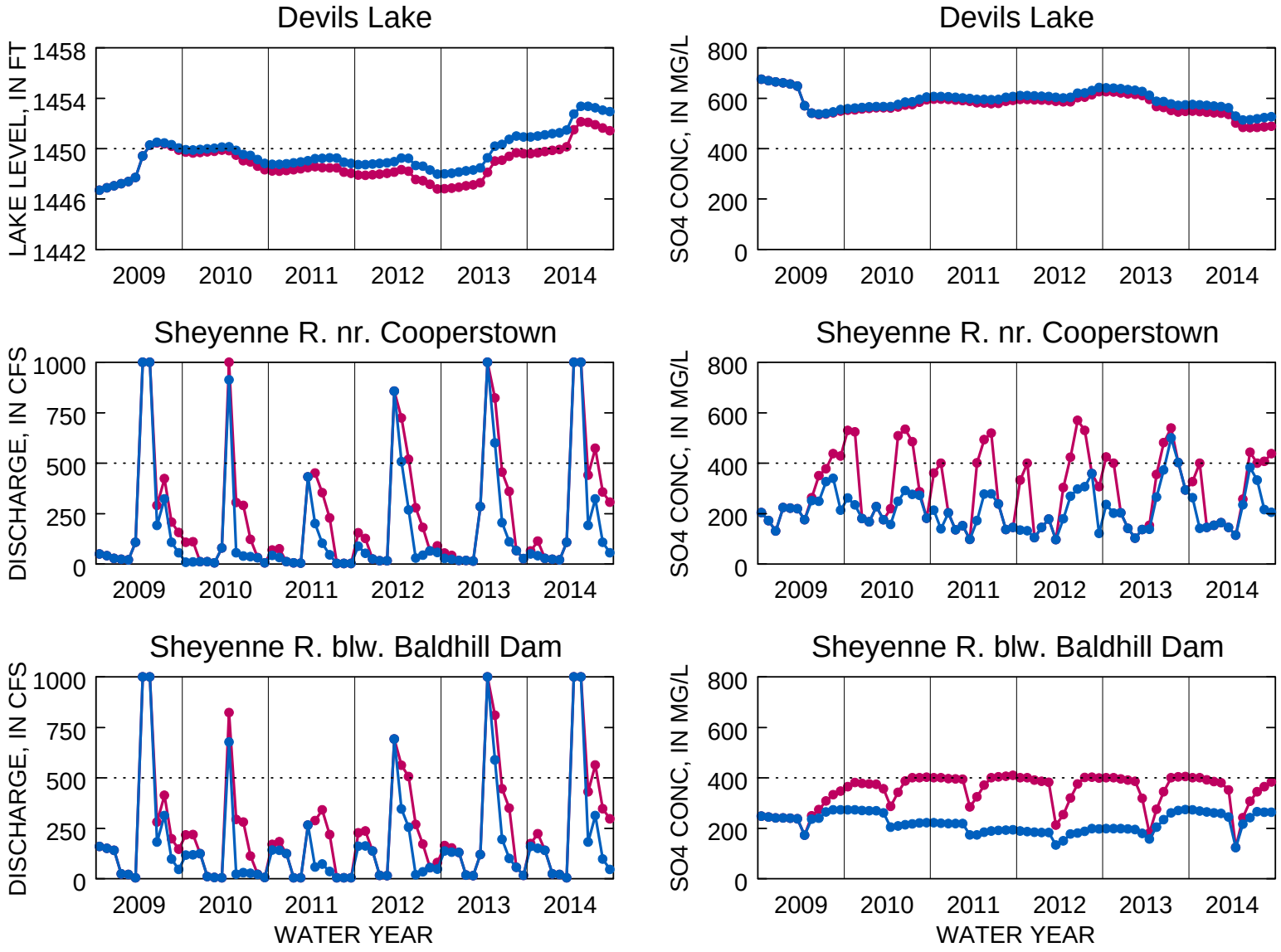

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