Water quality ramifications of draining a reservoir to facilitate salmon passage

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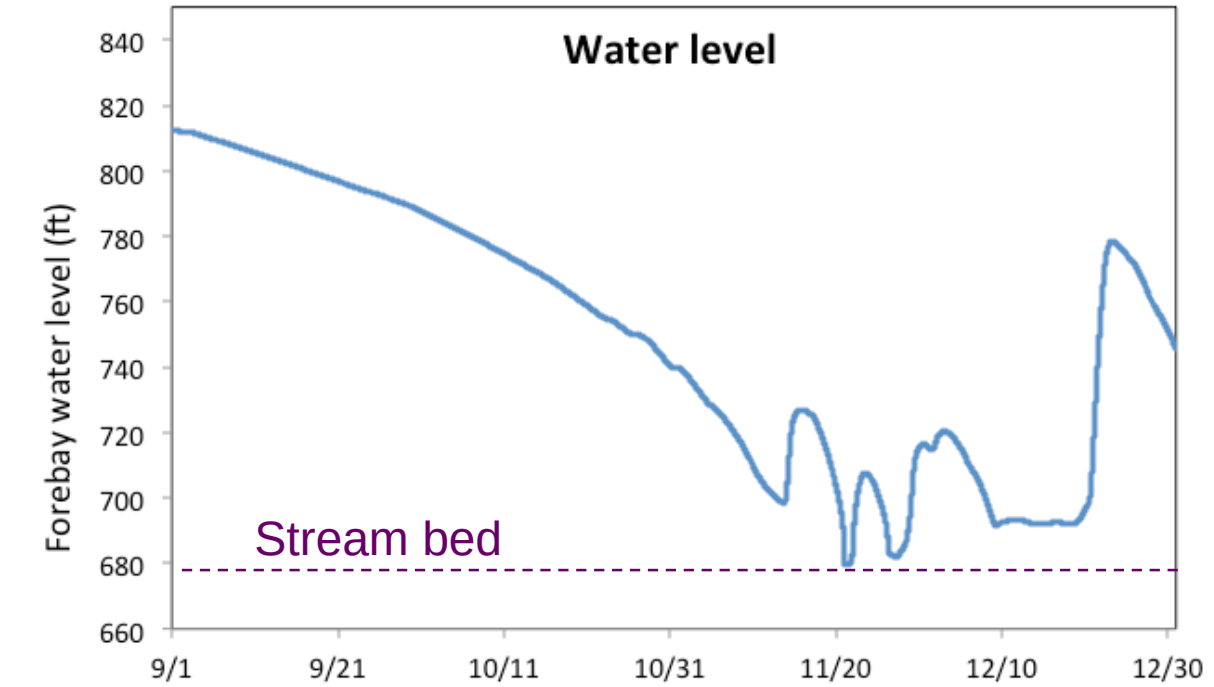
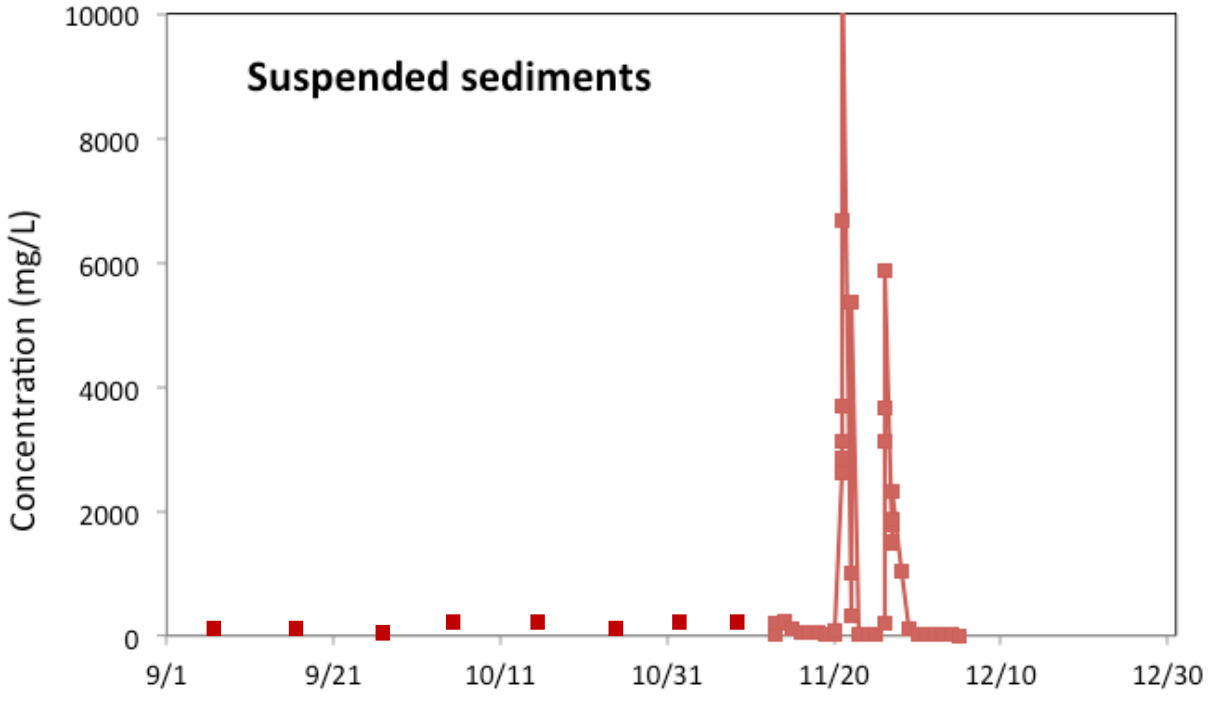
How does drawdown of a reservoir to conservation pool and to stream bed impact downstream water quality?

- Suspended Sediment
- Organic matter in sediment
- Dissolved oxygen and oxygen demand
- Nutrients

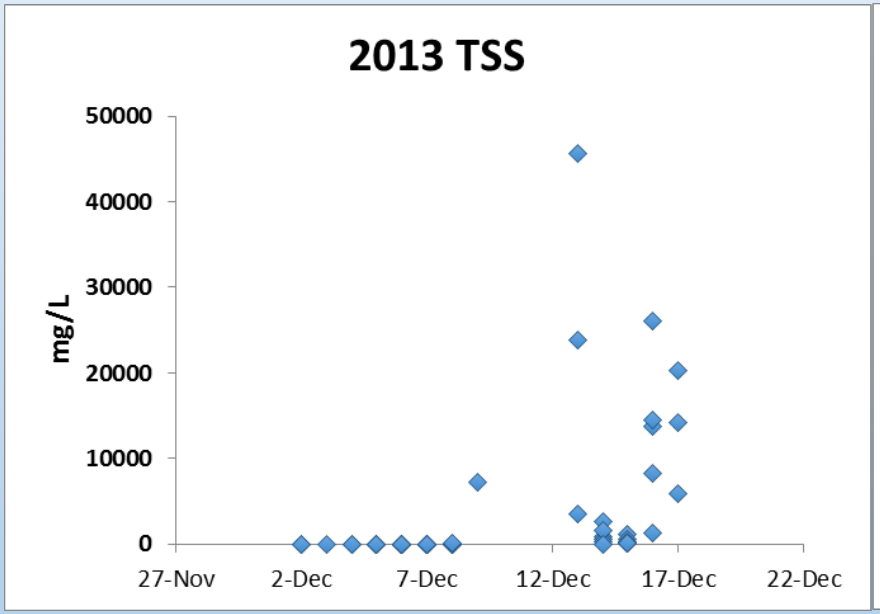
Water quality shifts downstream during the period when reservoir is at streambed

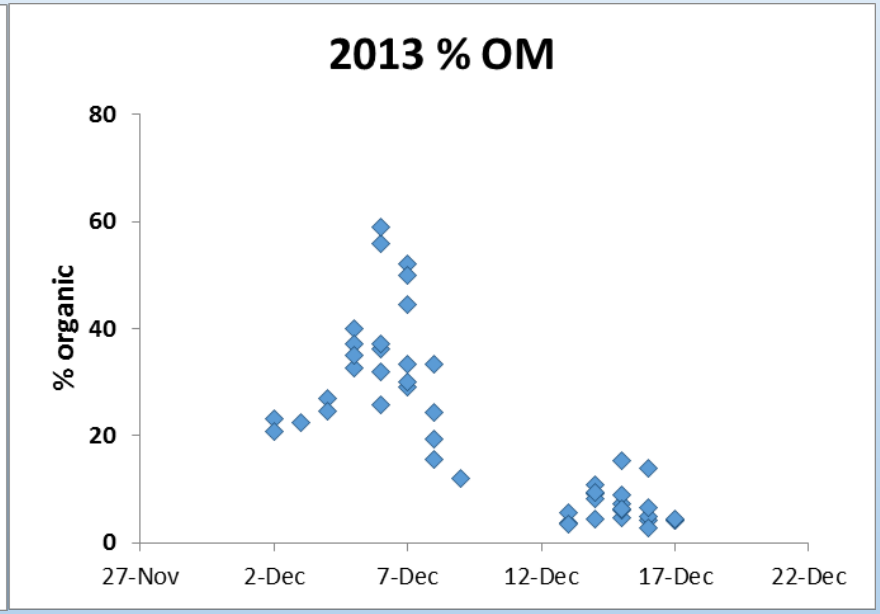
- Biweekly sampling during initial drawdown
- Intensive sampling as elevation in Fall Creek approached stream bed



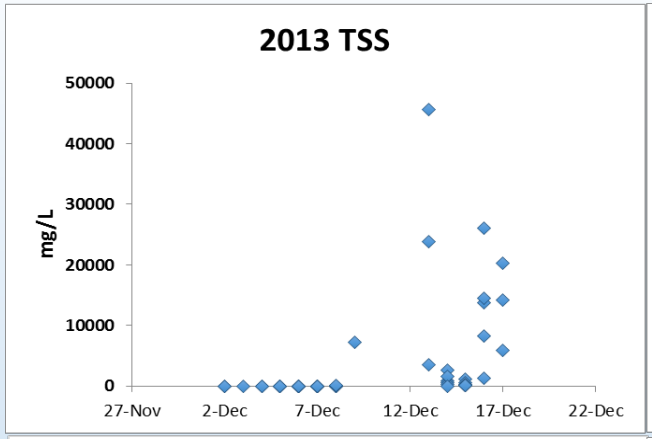


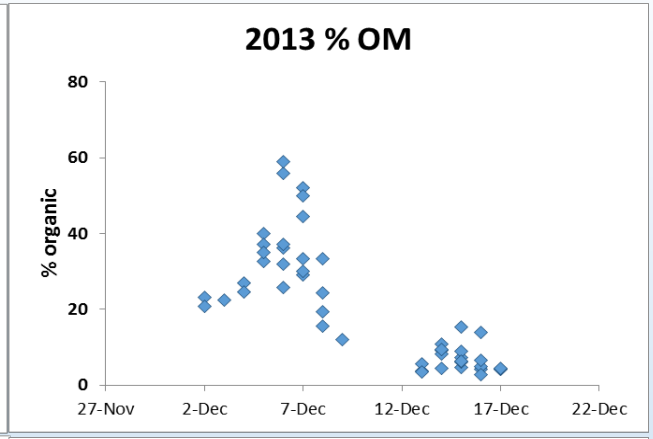
Fall Creek: Increase in suspended sediment doesn't coincide with peak of organic content of suspended sediment

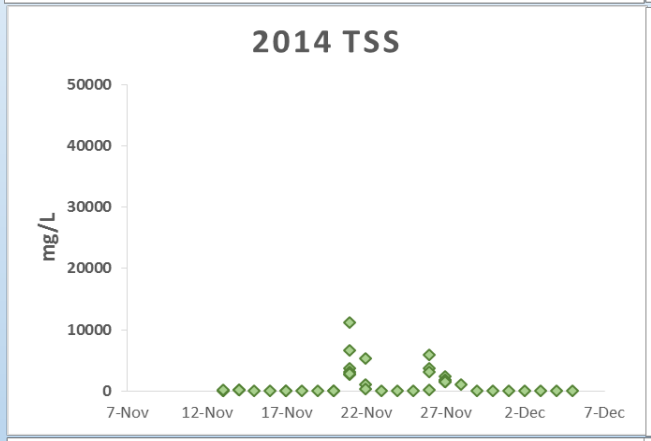


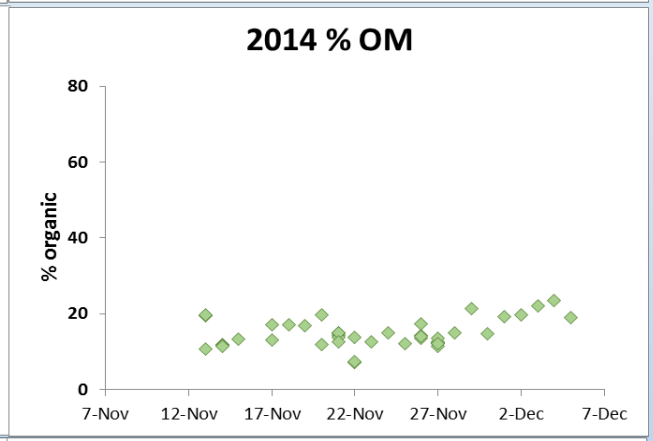


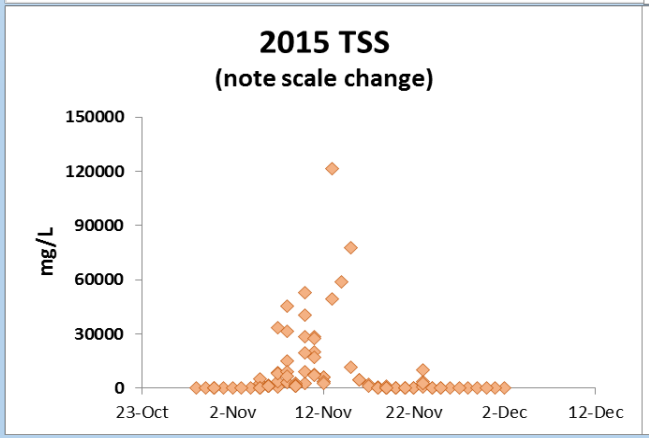
Fall Creek suspended sediment and organic content of suspended sediment

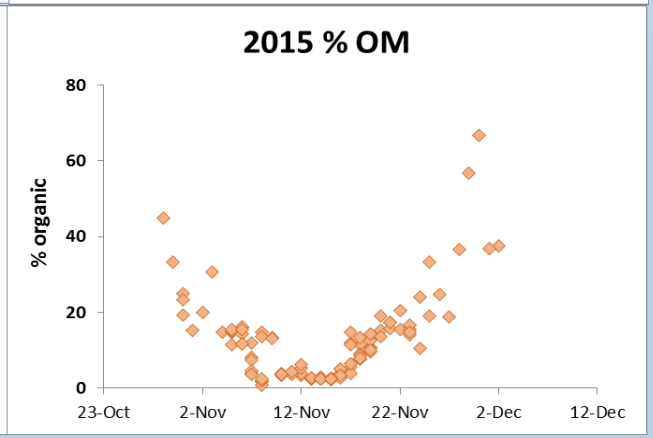




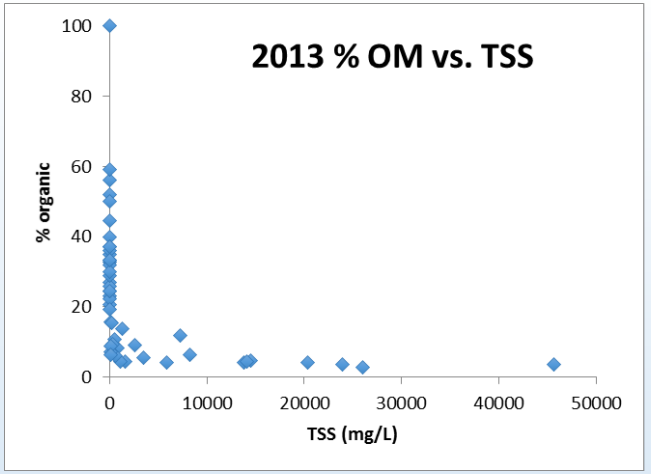


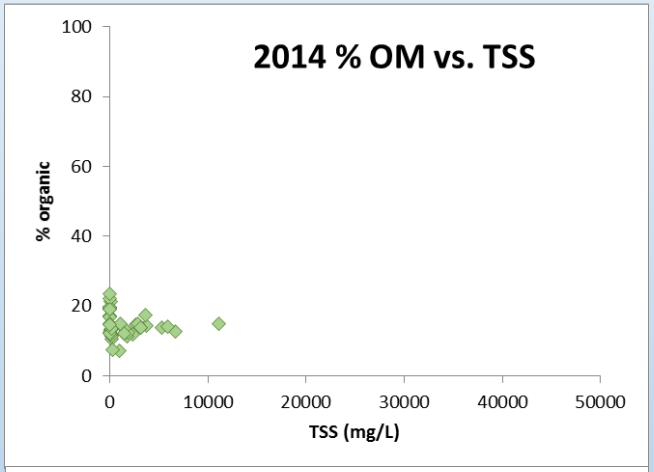


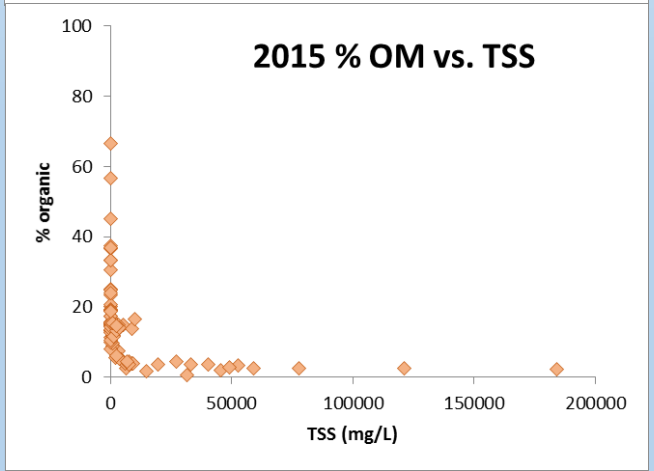




Organic matter appears to be supply limited - Low content at high TSS



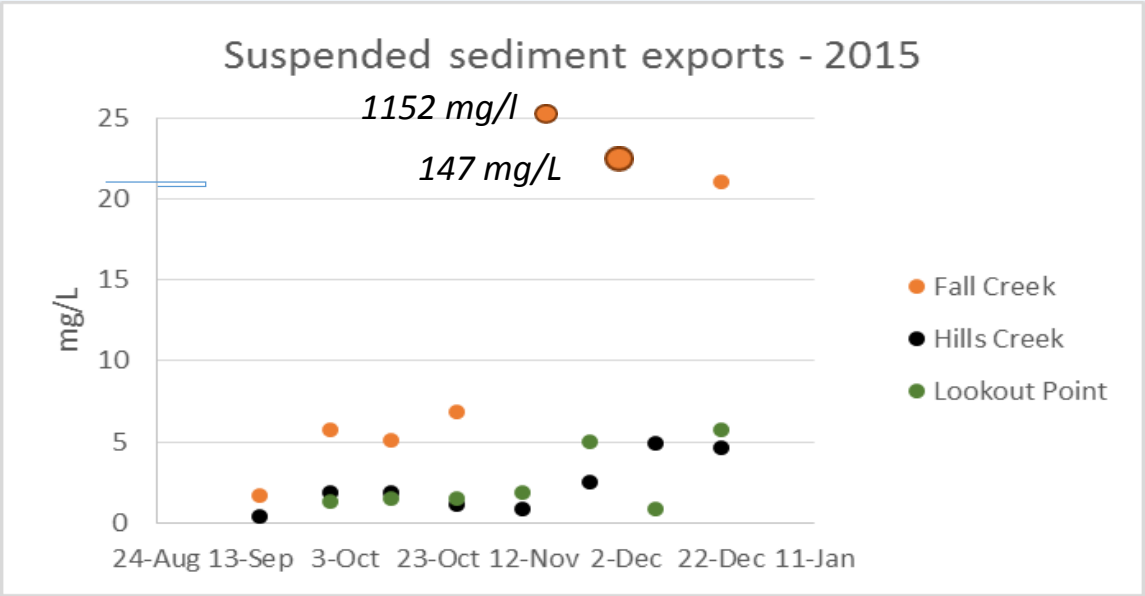


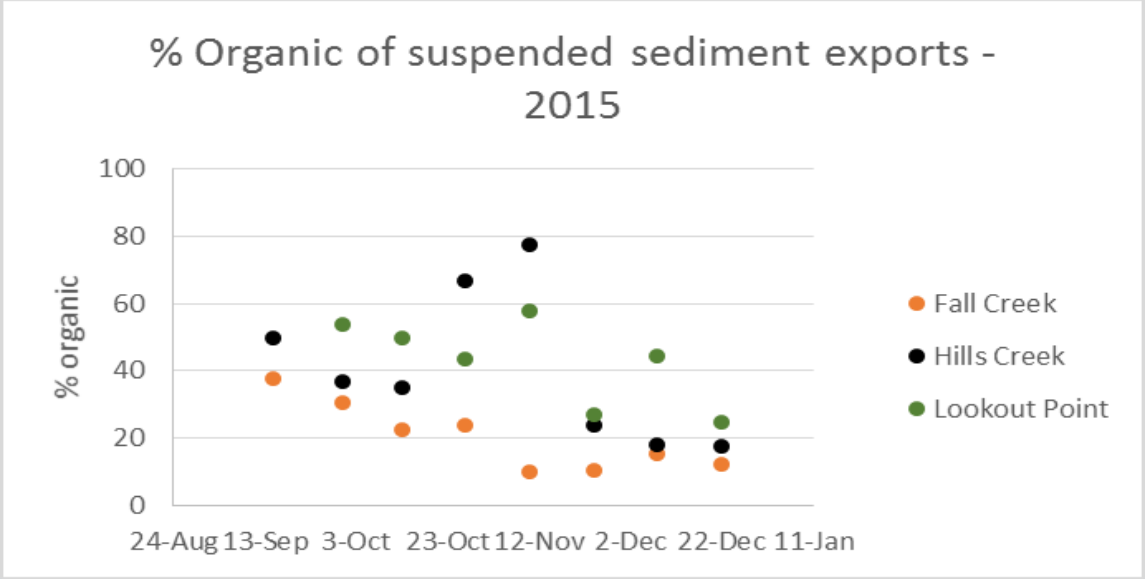


Downstream WQ during standard drawdowns?

Reservoir	Elevation (m)	Full pool depth (m)	Conservation pool depth (m)	Annual change in elevation (m)
Blue River	415	76	25	51
Fall Creek	255	49	18	31 (now 49)
Hills Creek	471	91	62	29
Lookout Point	287	71	40	31

Across reservoirs, during early drawdown TSS concentrations higher and organic content lower from Fall Creek Reservoir

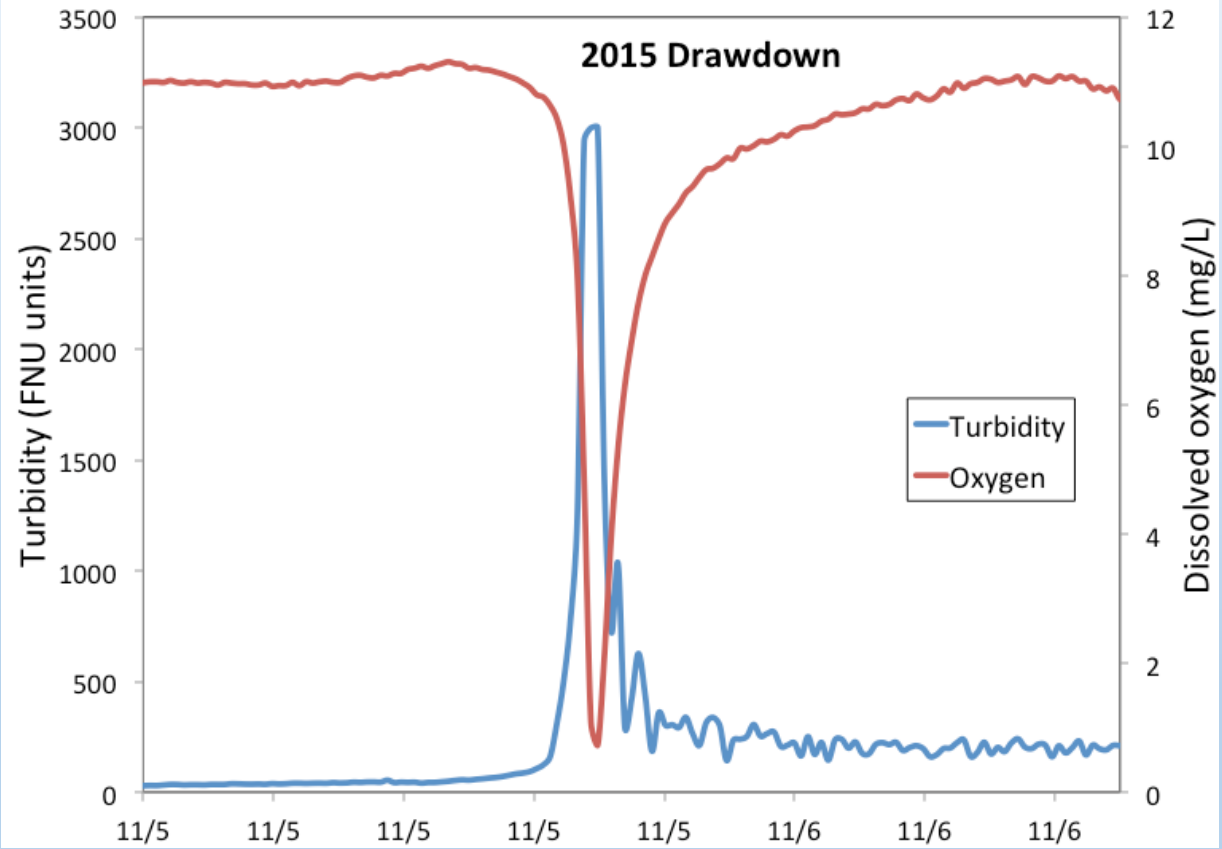




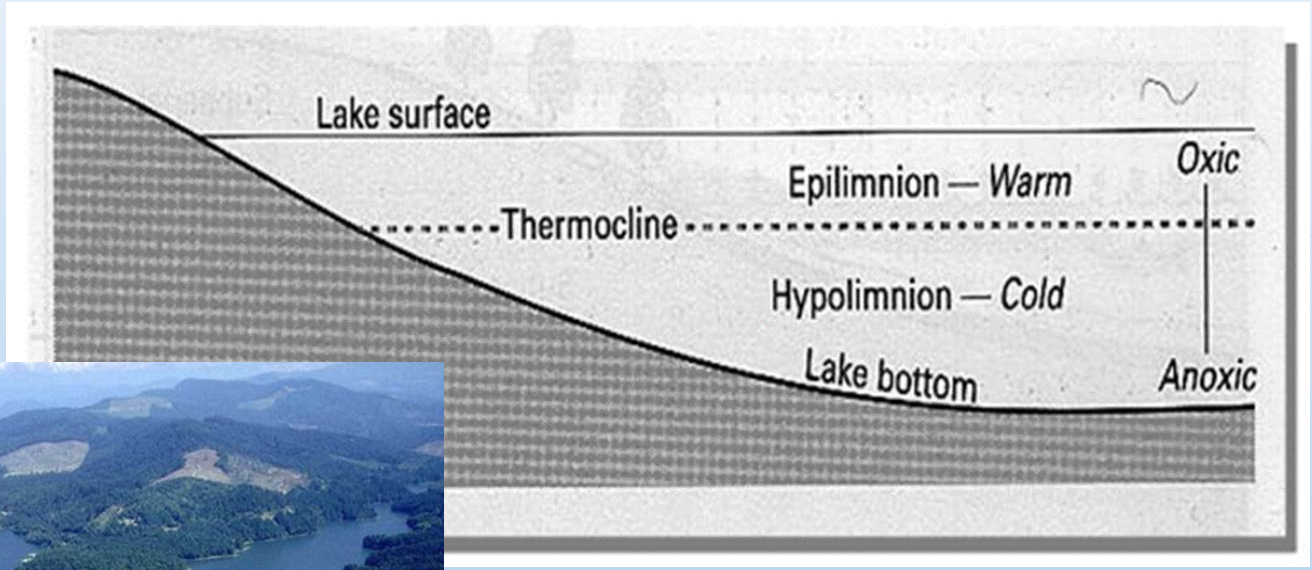
Downstream Dissolved Oxygen

- Dissolved oxygen sag observed by USGS 2015
- Slightly lags turbidity peak
- Minimum O_2 in **2016** drawdown was ~3.5 mg/L

What might be the source of this short sag in 02?

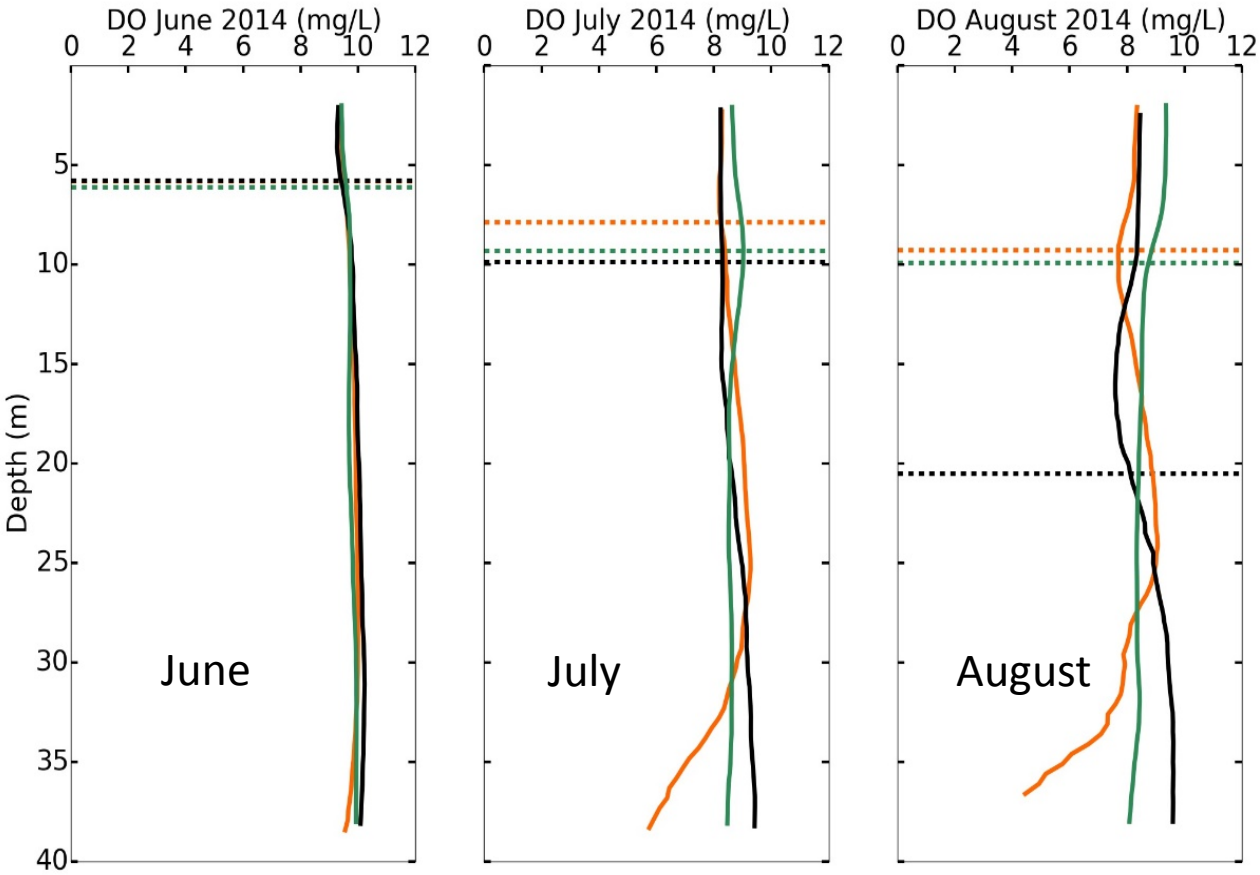


During summer full pool and stratification, many lakes and reservoirs have low oxygen below the thermocline



Dissolved Oxygen:

Only slight decline in O2 in Fall Creek in late summer at depth



Reaeration - but changes in state of iron in TSS

1 Nov 2016, 1:00 PM
Forebay 716.5 ft

No visible increase in turbidity yet.

3 Nov 2016, 3 PM
Forebay 690.6 ft

First increase in turbidity. Color shows oxidized Fe in sediments.

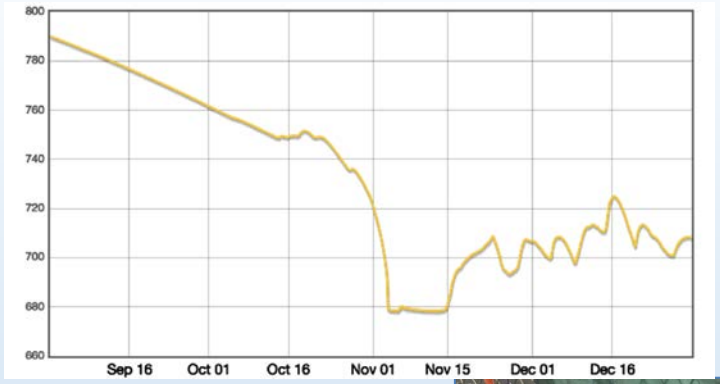
4 Nov 2016, 4 PM
Forebay 678.6 ft (at stream bed)

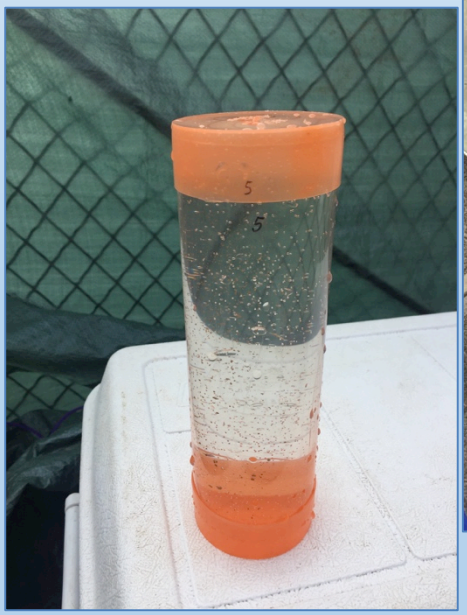
Color shows reduced Fe in sediments. Gray turbidity was still present on 16 Nov!

Oxygen demand of suspended sediments?

- Sediments delivered downstream contain organic matter and reduced iron
- Do the suspended sediments have high oxygen demand?

We performed experimental assays to examine O2 demand during maximum turbidity

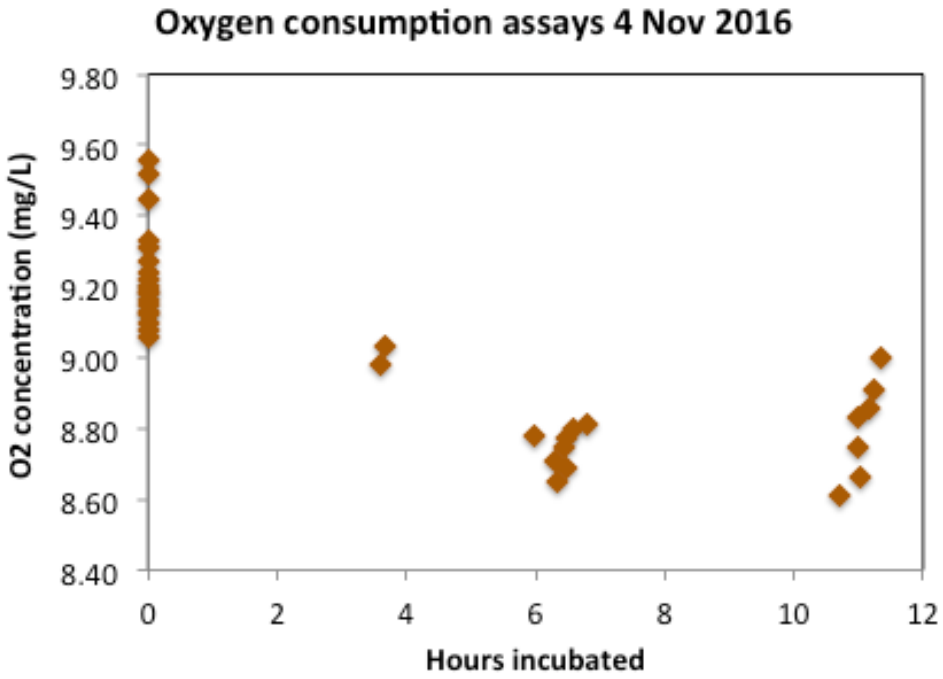


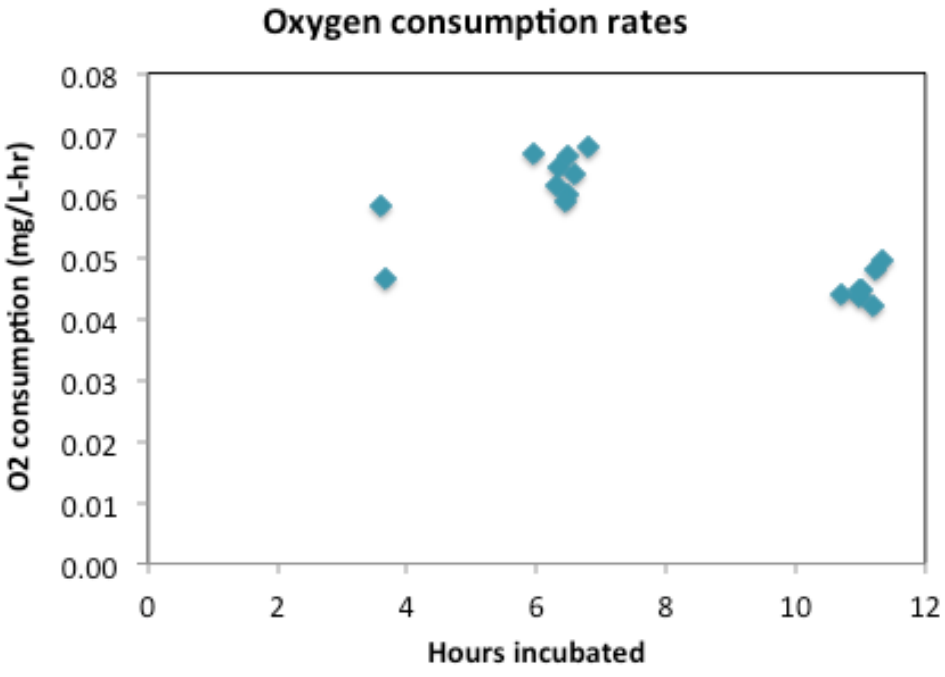


Oxygen demand of suspended sediments

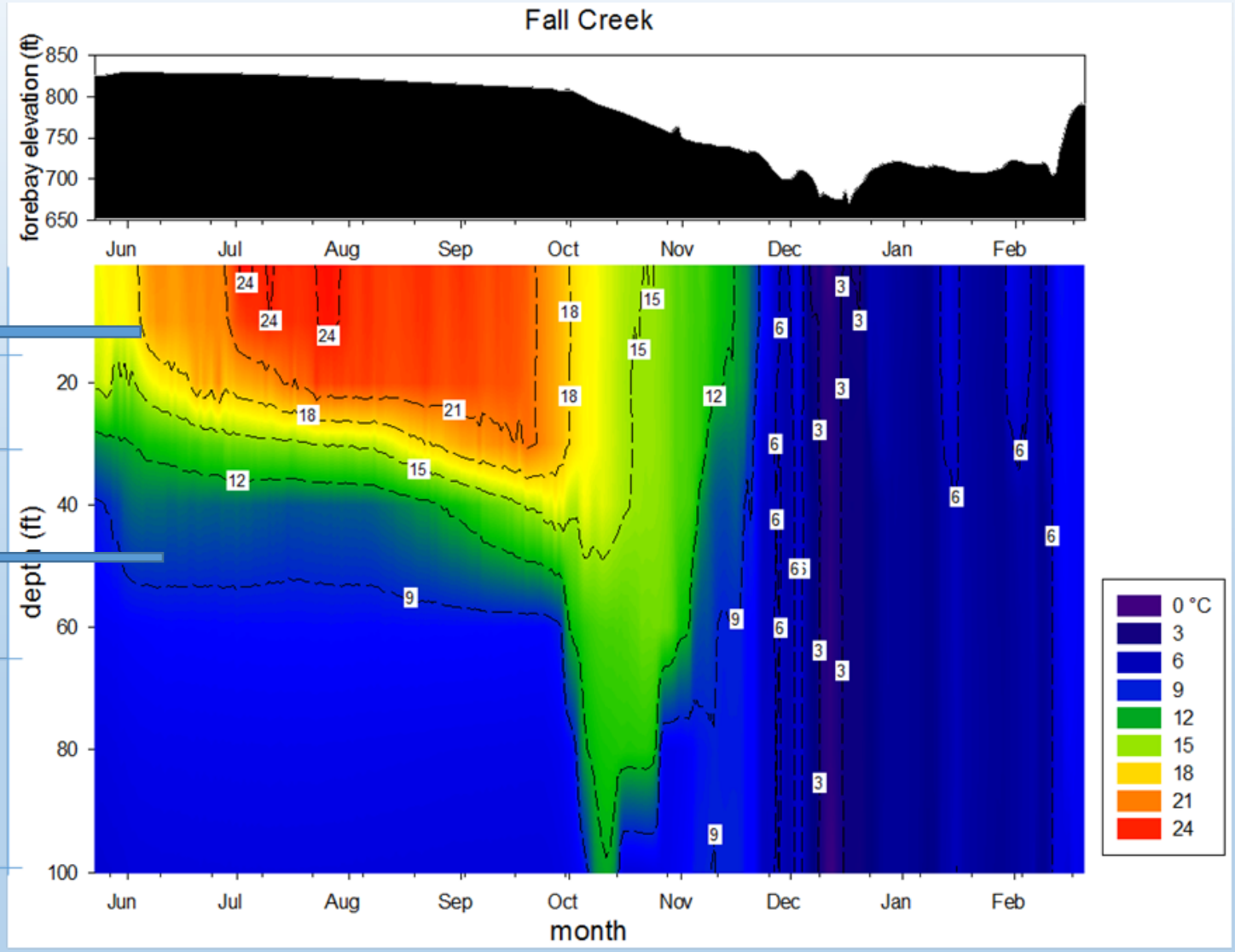
- Very modest rates of O_2 consumption
- Seemed to slow down after 6 hours

It would take many days to draw O_2 down very far based on sediments

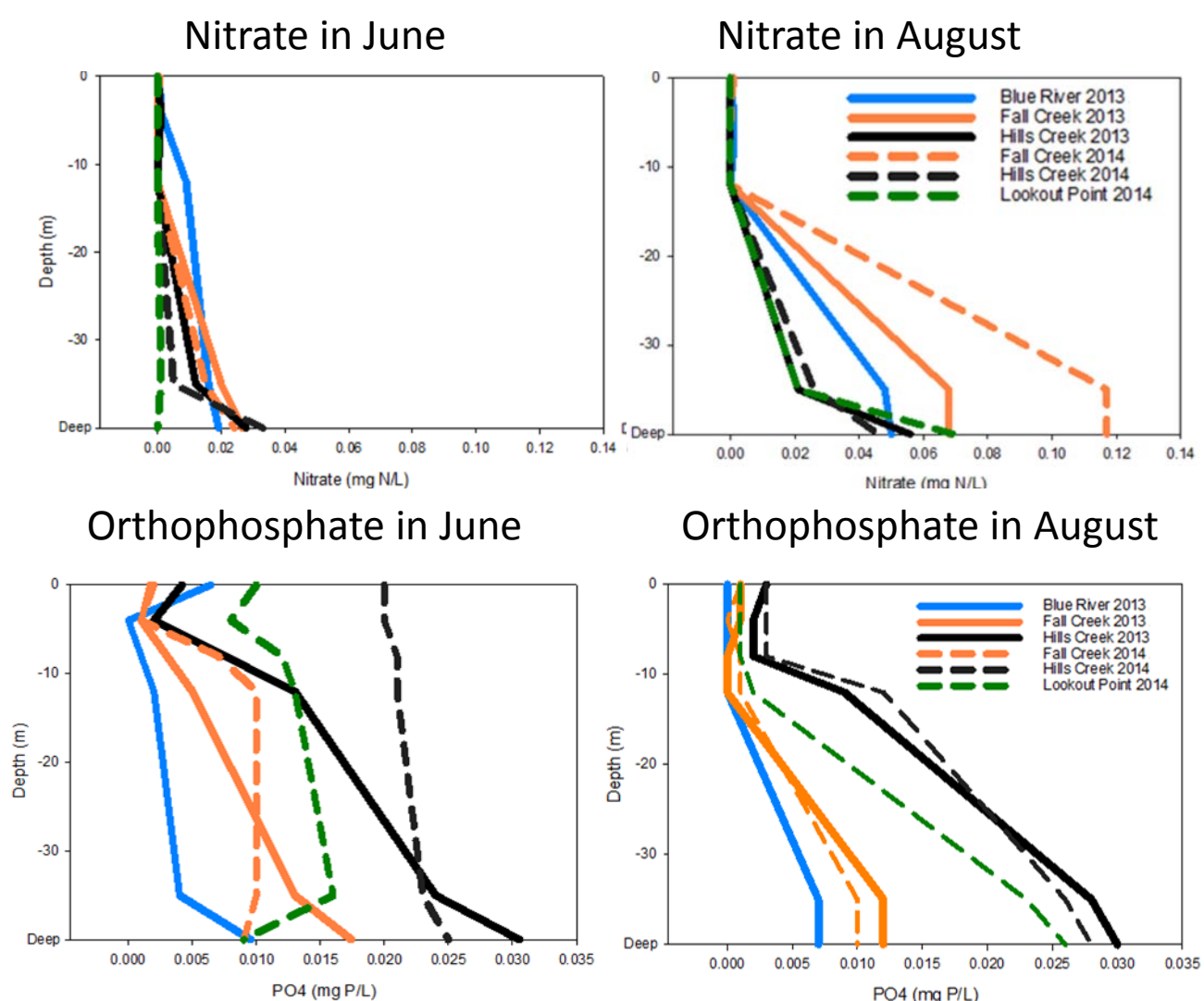




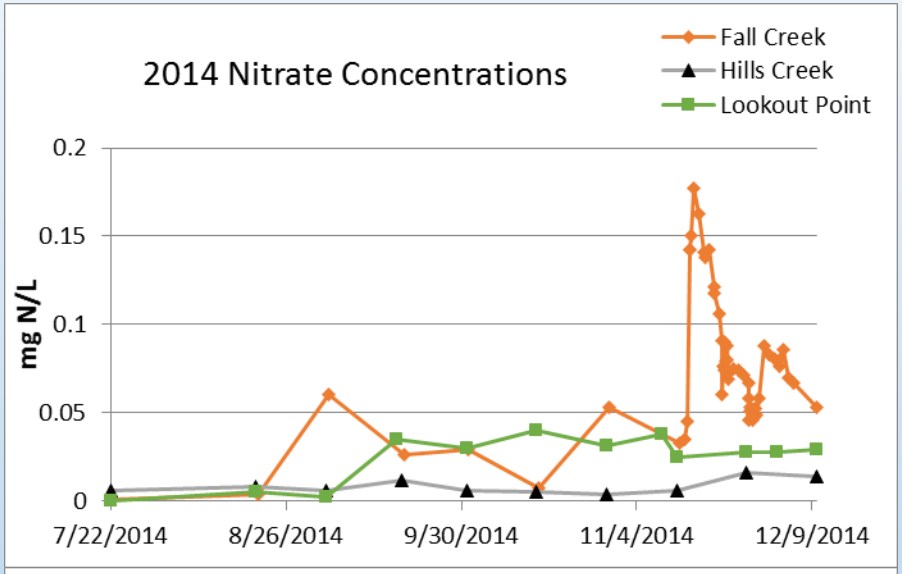
Temperatures and nutrients downstream influenced by within reservoir water dynamics and location of outlet

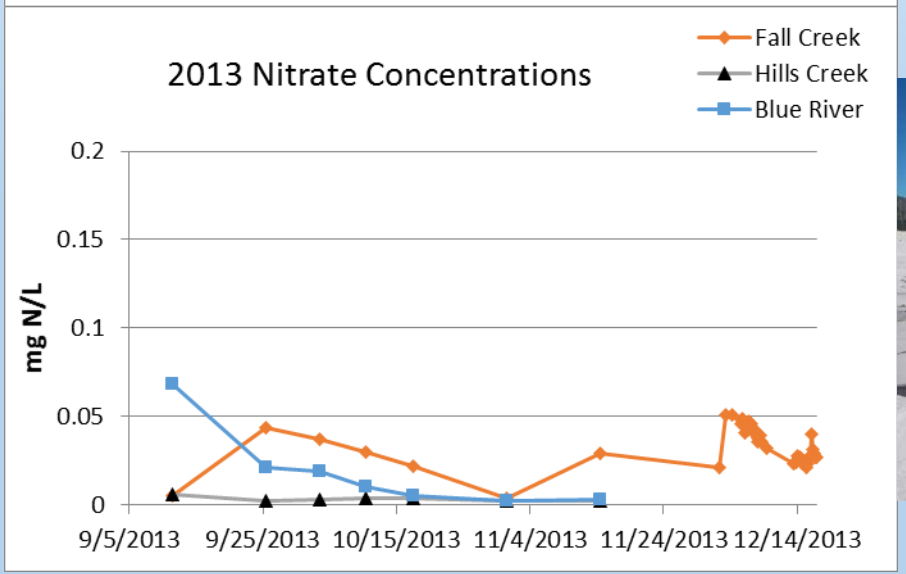


Nutrient profiles within reservoir in August show increased concentrations at depth



Low concentrations exported from the reservoirs, except during deep drawdown in Fall Creek





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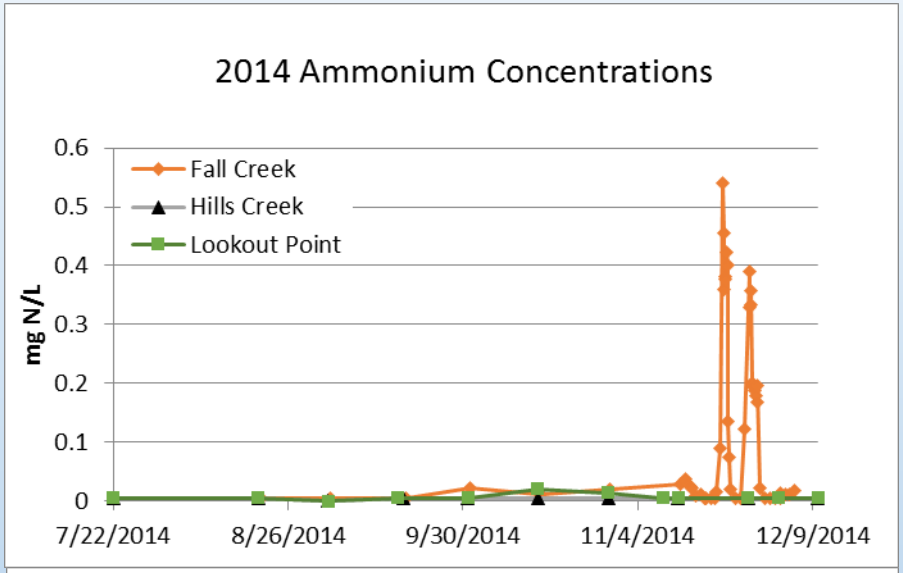

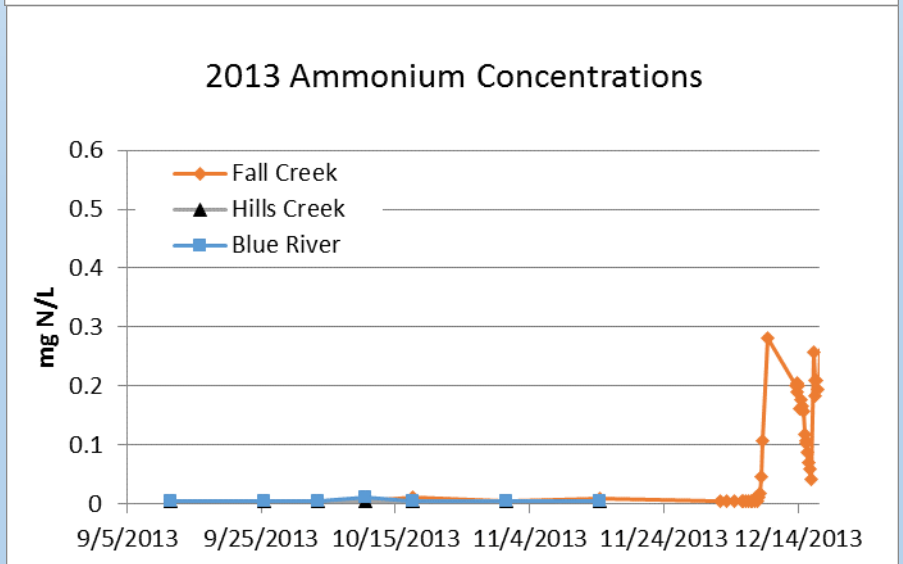

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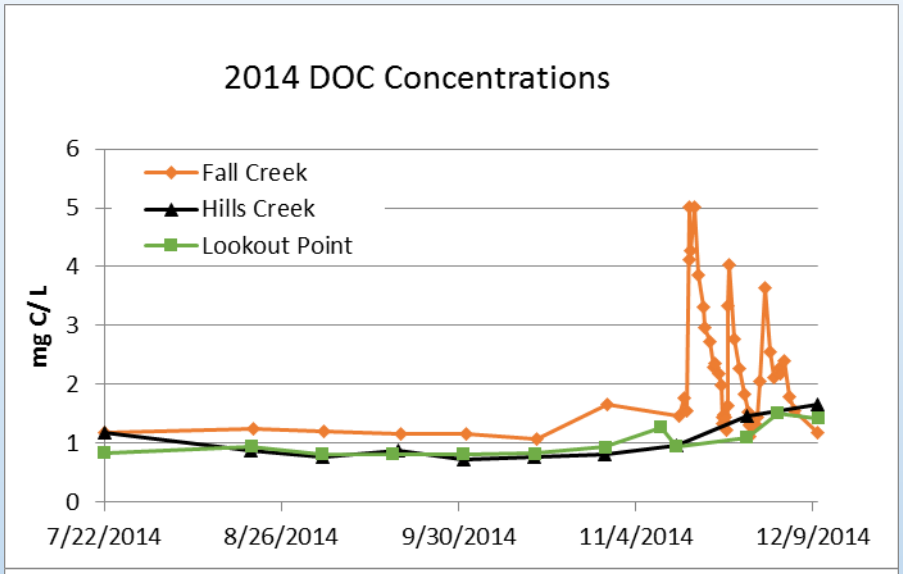

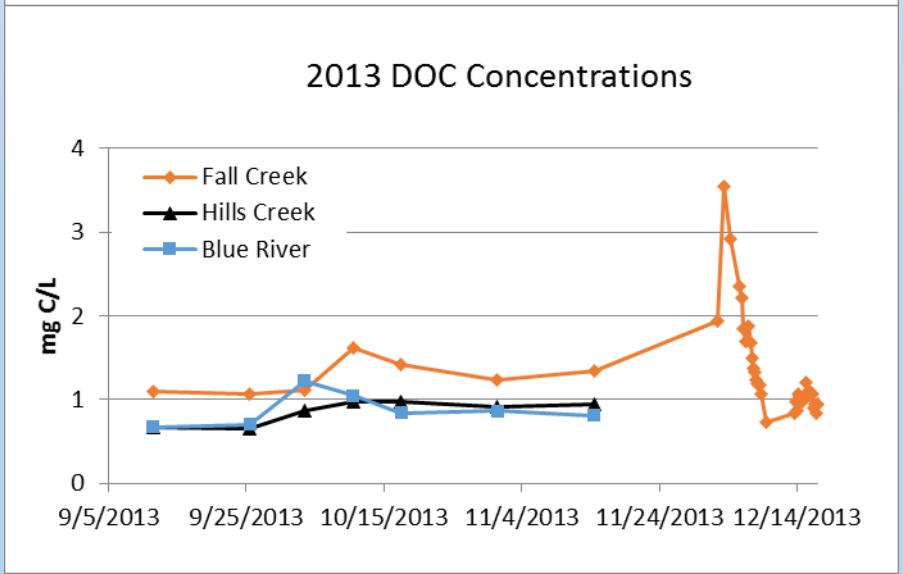

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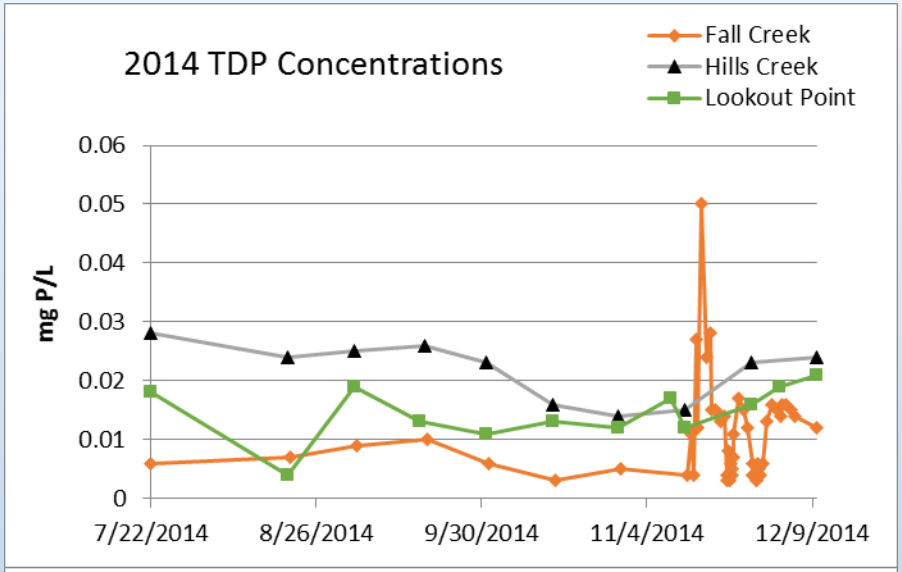
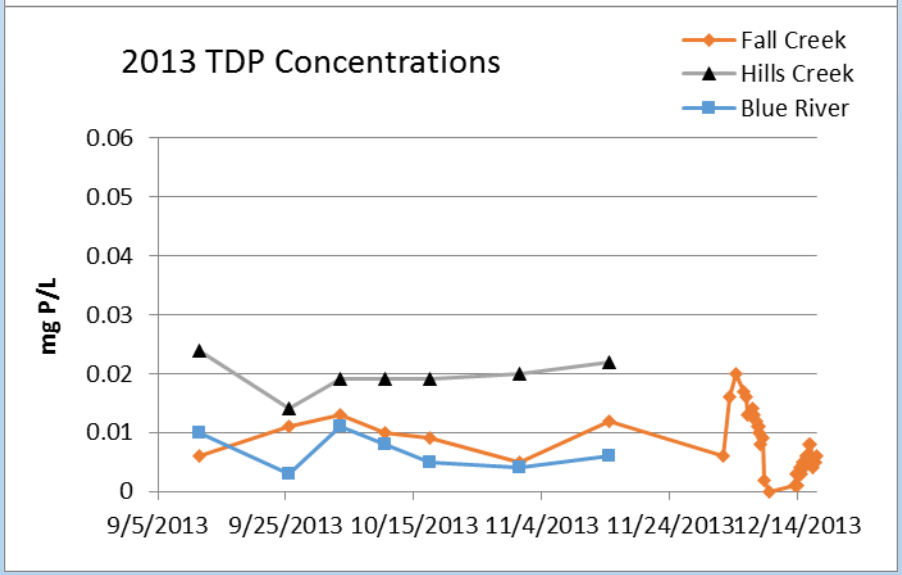
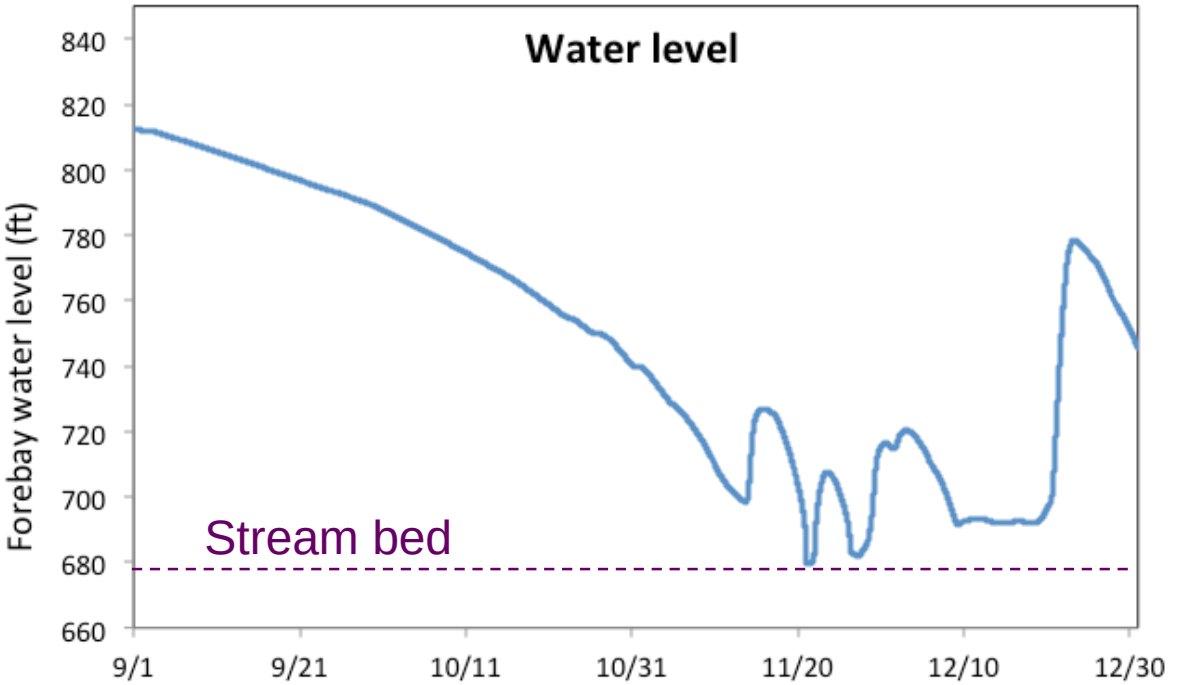
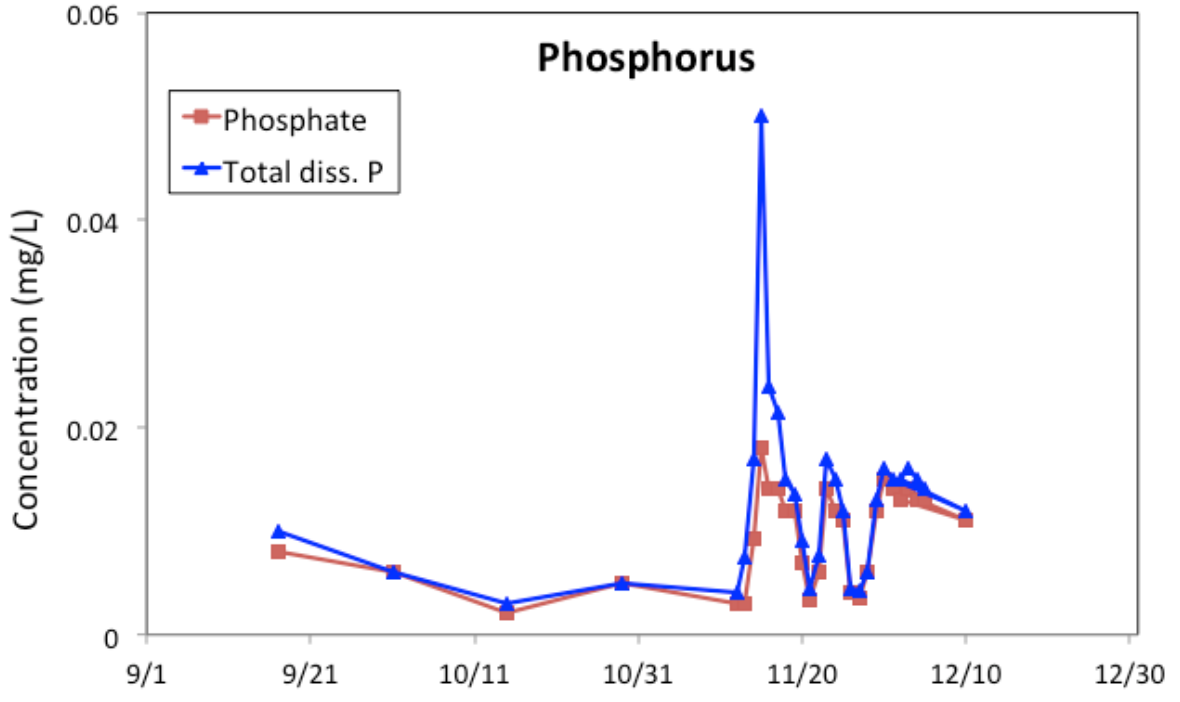




2014 drawdown in Fall Creek: Peaks of phosphorus species show strong synchrony

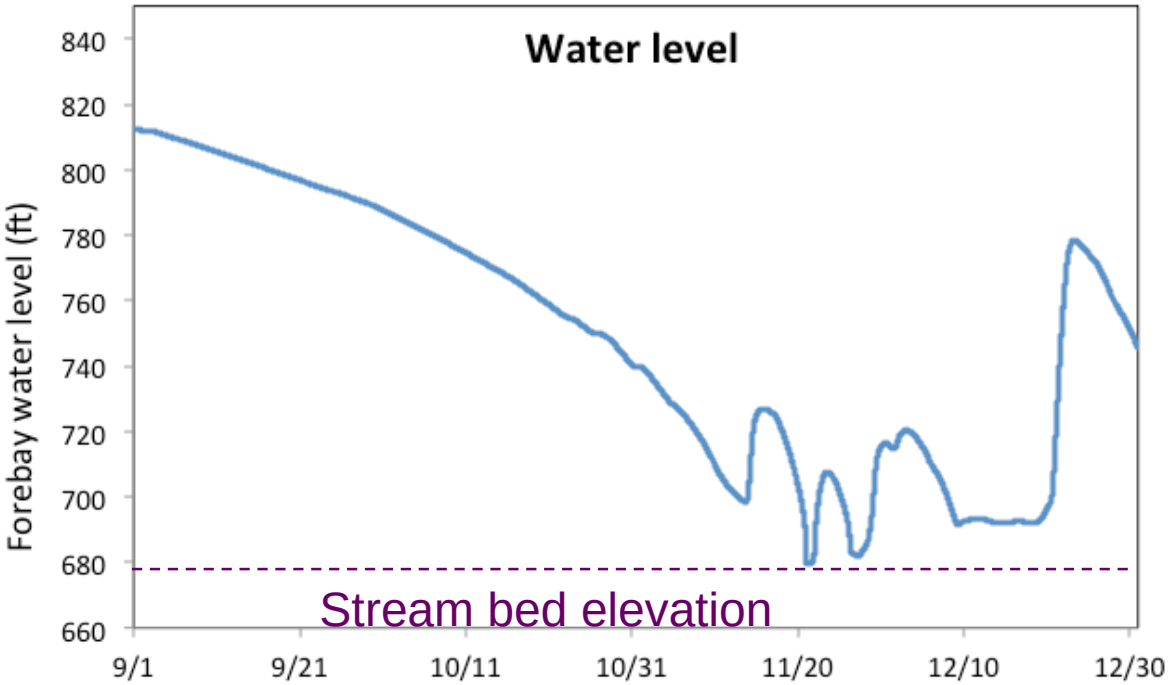
- High phosphorus associated with withdrawal of water near bottom
- Sediments do not seem prone to releasing much P
- Chemistry of porewater – awaiting results

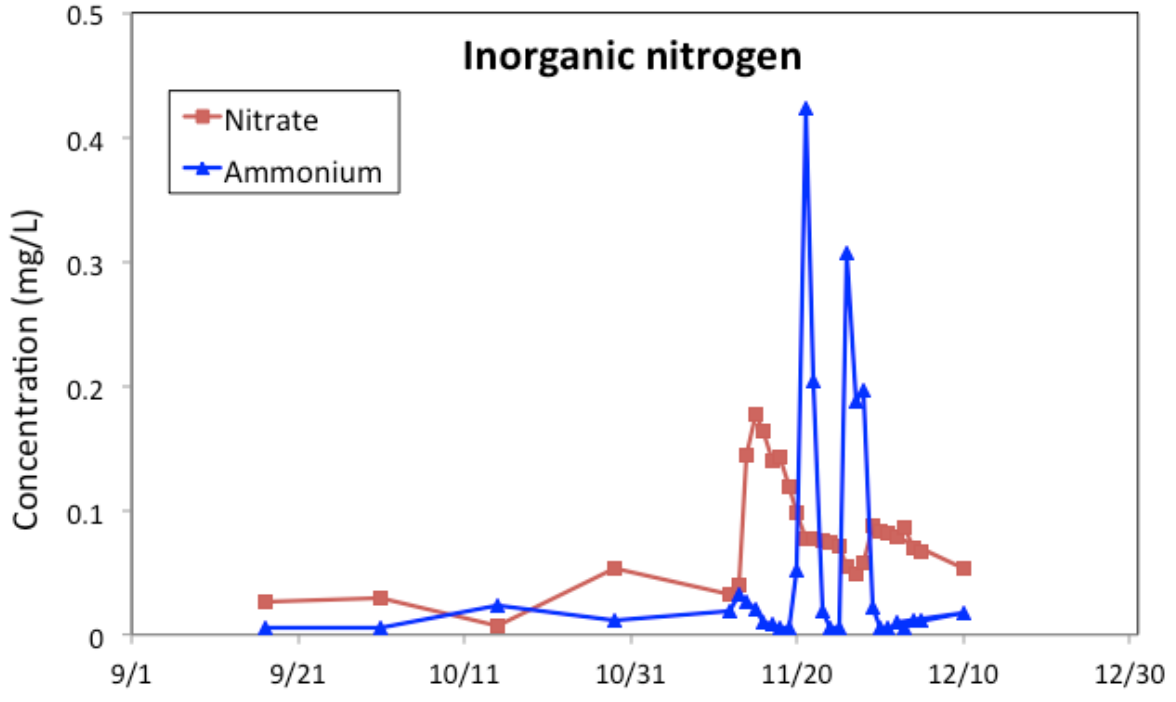




2014 drawdown in Fall Creek: Nitrogen species peak at different times

- Nitrate comes from withdrawal of water near bottom
- Ammonium likely comes from porewaters draining from emergent sediment





Summary

- Changes in nutrient concentrations (and other water quality variables) were not large
  - Likely inconsequential given transient nature and cool season
  - Would be important if sustained during lower flows and warm season

Summary II

- Organic content of suspended sediments is low and variable from Fall Creek
- Oxygen demand of sediments is modest
- Downstream sediment and nutrient concentrations peak as reservoir elevation hits stream bottom

Funding and assistance from:

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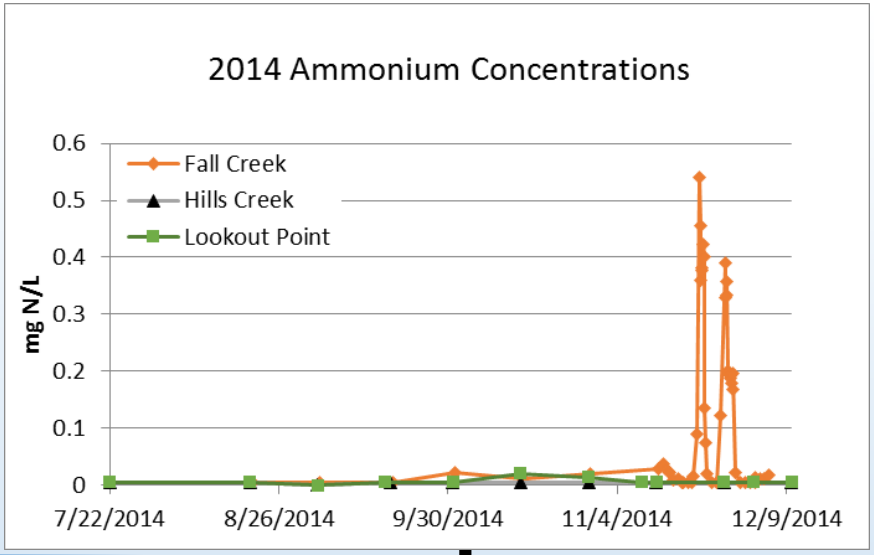
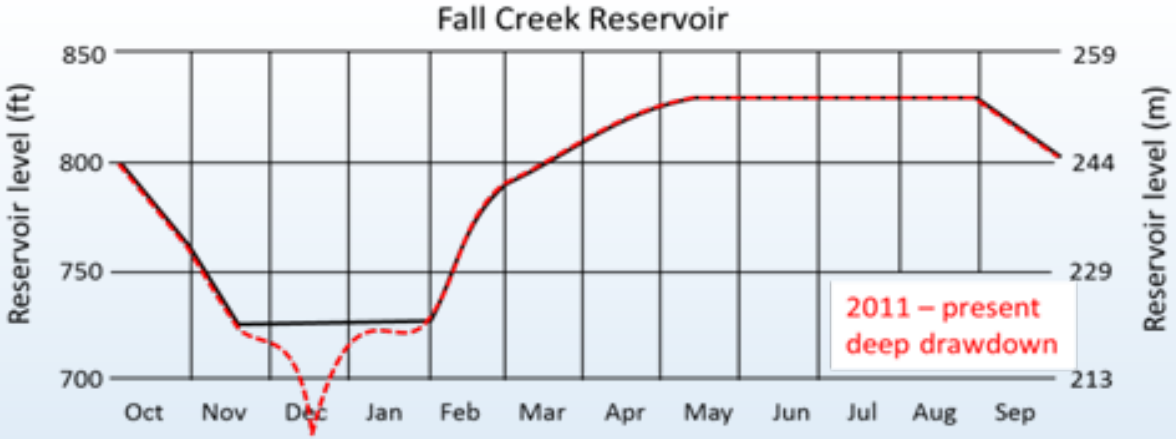
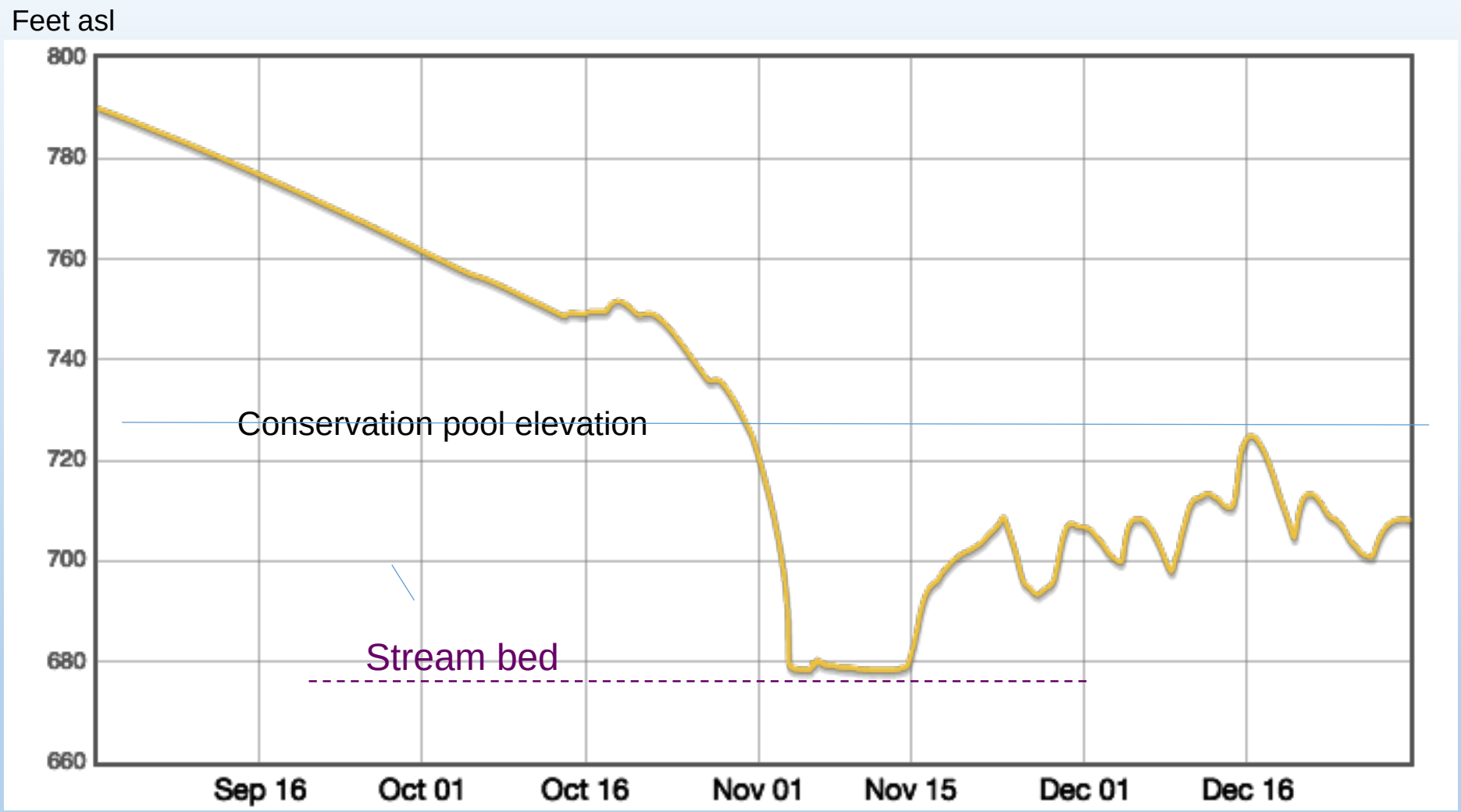


Conventional reservoir drawdown to minimum conservation pool

Deep drawdown to streambed


Fall Creek Reservoir
Reservoir level (ft)
850
800
750
700
259
244
229
213
Reservoir level (m)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
2011 – present
deep drawdown

Fall Creek Reservoir – Oxygen experiment during 2016 drawdown



What are the implications of reservoirs on downstream water quality?