Assessment of the aquatic plant community and water quality status in Willamette River alcoves and sloughs infested with *Ludwigia* spp.

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[2]U.S. Geological Survey
[3]Willamette Riverkeeper
[4]Oregon State Parks
[5]Benton Soil and Water Conservation District

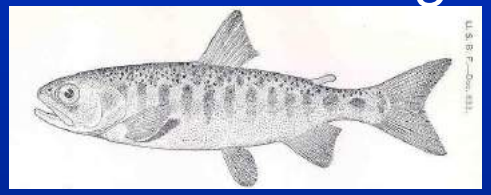
Oregon Department of Agriculture Noxious Plant Forum
Salem, Oregon
March 7, 2018

U.S. Department of the Interior
U.S. Geological Survey

Background on Willamette River floodplain habitats and hydrology

Species dispersal | *Nutrient transport* | *Scour* | *Flushing*

Cold water refugia



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Black Dog
Landing,
downstream
of Salem on
8/20/2015
WR photo

Goal of surveys and studies

- Assess the aquatic plant community status of *Ludwigia hexapetala* infested off-channel habitats (baseline conditions)
- Assess the aquatic plant community status in herbicide treated *Ludwigia hexapetala* infested habitats (post-treatment conditions)
- Assess water quality conditions under baseline and post-treatment conditions

Lead to better management of off-channel habitats

Aquatic plant and water quality assessments:

1. Mission Lake/Windsor Island Slough baseline surveys (Willamette Riverkeeper, Oregon State Parks, OWEB)

2. Collins Bay/Scatter Pond baseline and post-treatment surveys (Benton Soil and Water Conservation District, ODA)

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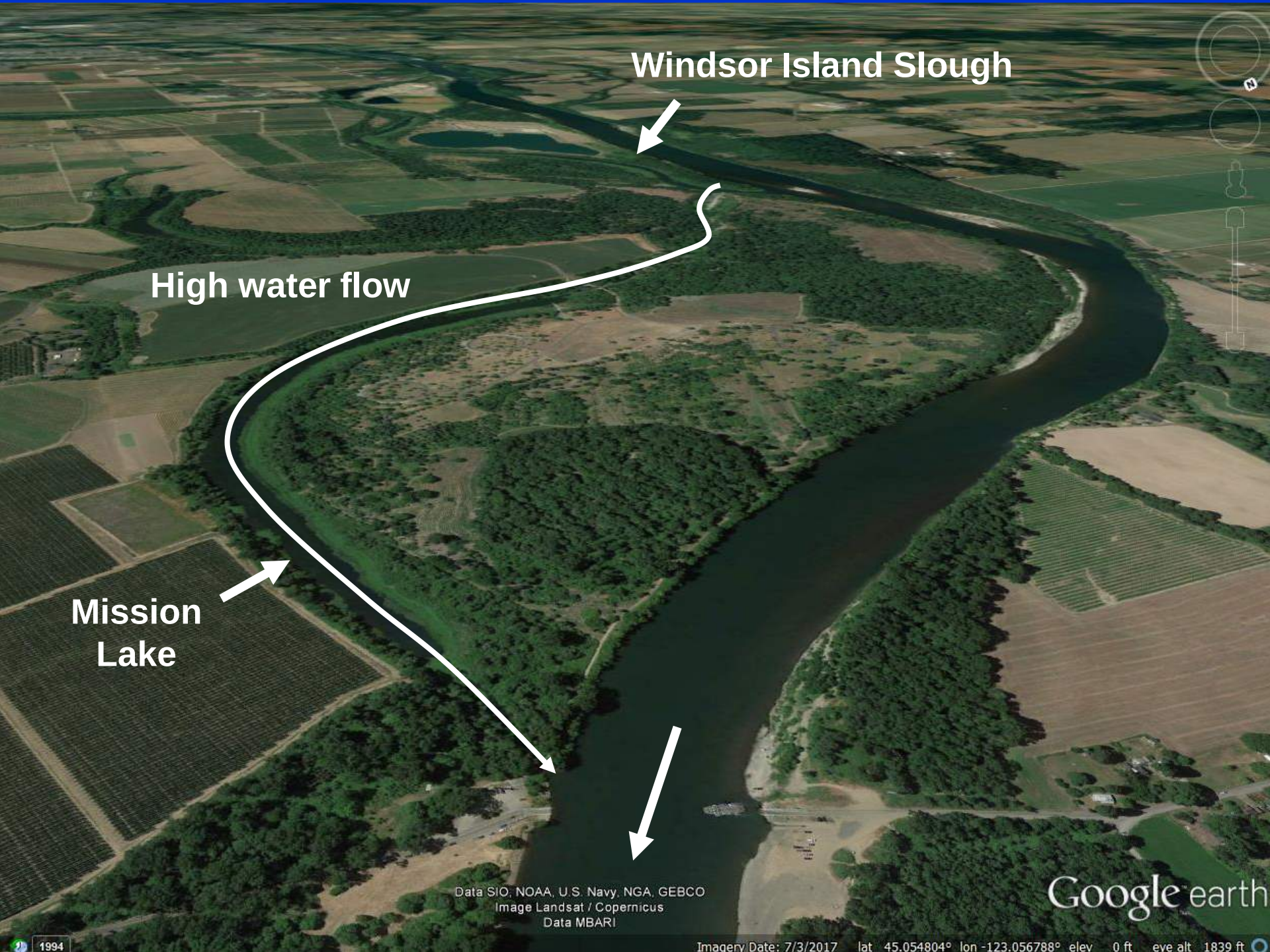
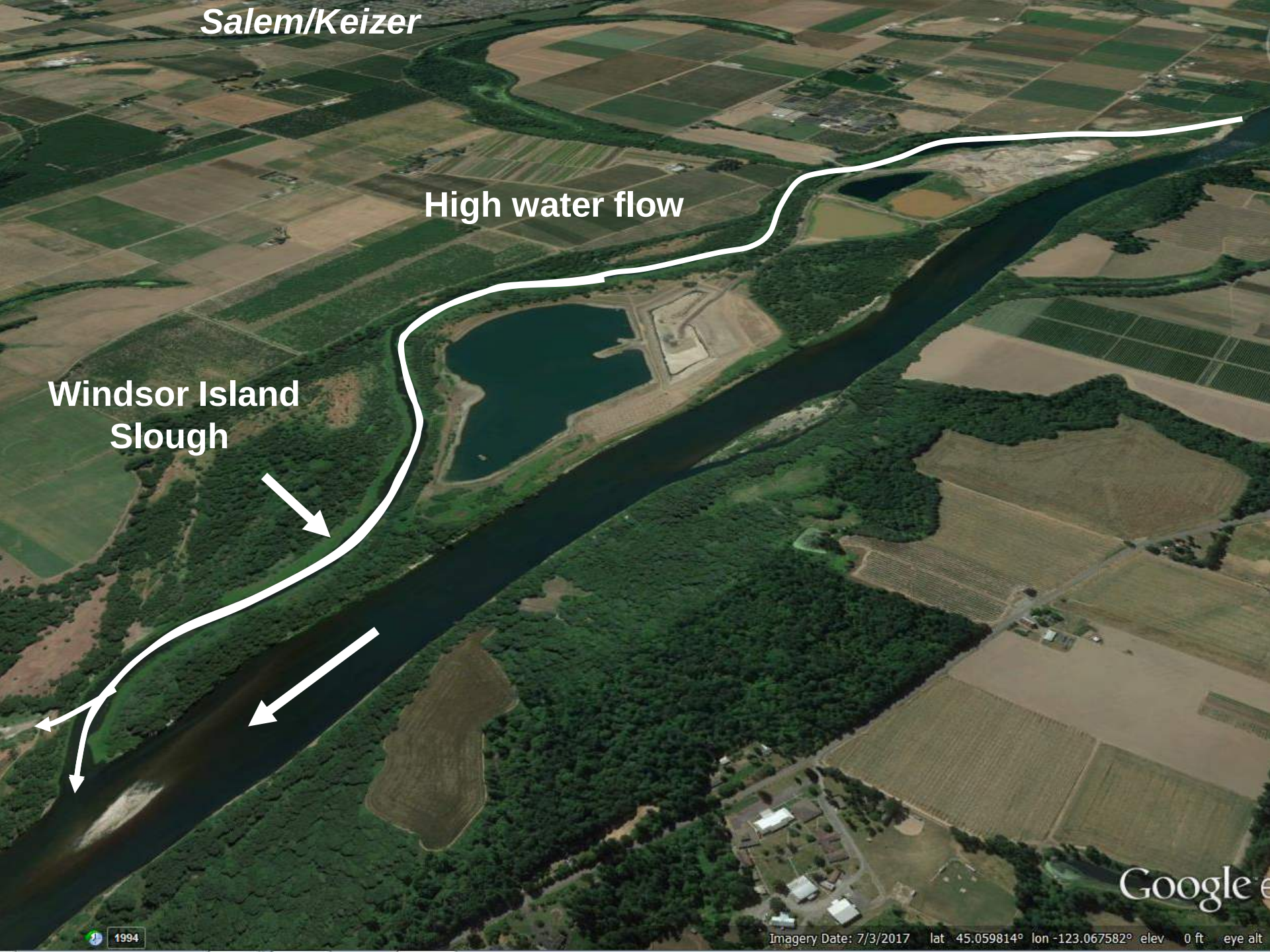

Windsor Island Slough
High water flow
Mission Lake
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Data MBARI
Google earth
1994
Imagery Date: 7/3/2017 lat 45.054804° lon -123.056788° elev 0 ft eye alt 1839 ft


Salem/Keizer
High water flow
Windsor Island
Slough
Google
1994
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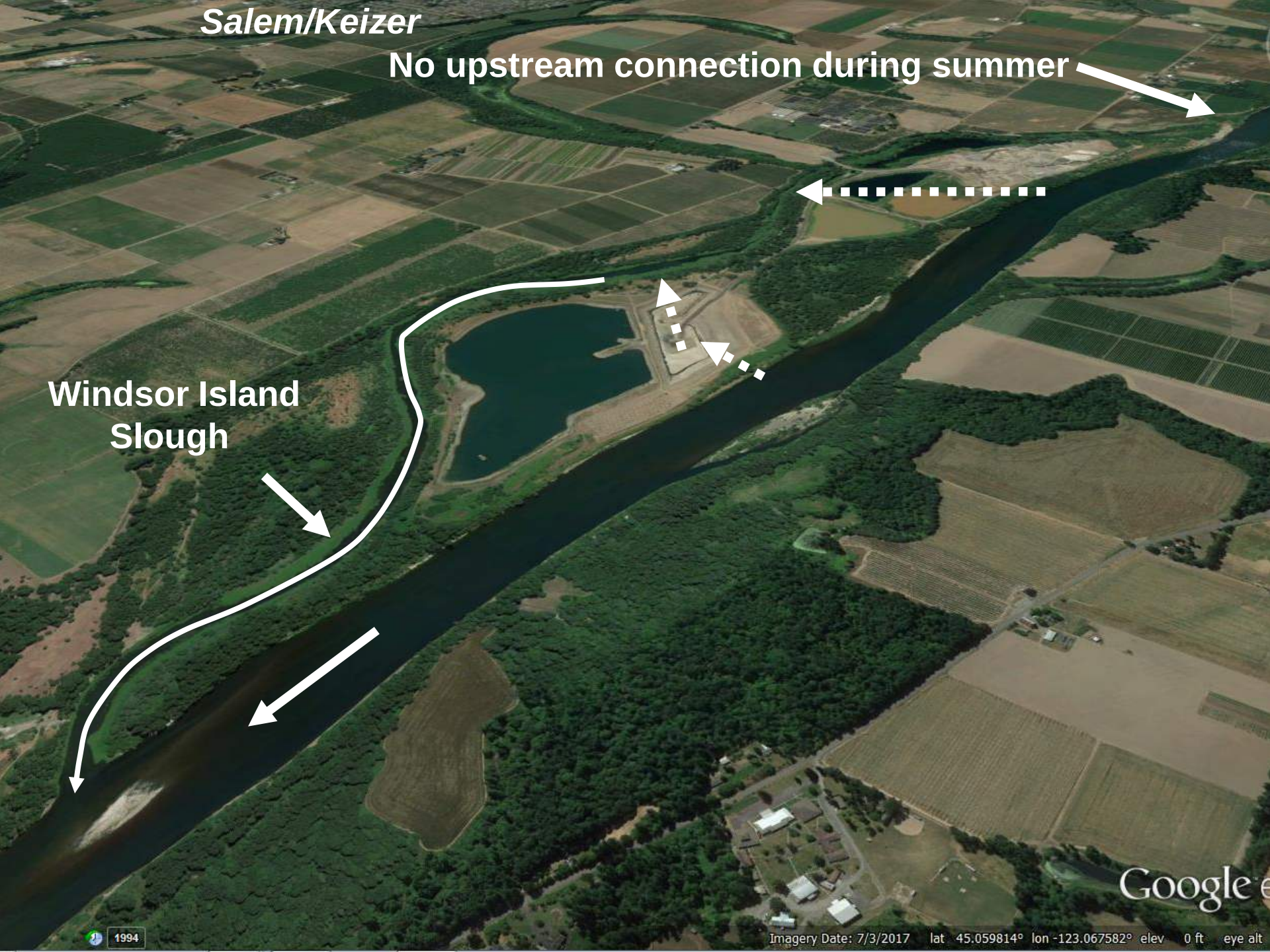
Salem/Keizer
No upstream connection during summer
Windsor Island
Slough
Google
1994
Imagery Date: 7/3/2017 lat 45.059814° lon -123.067582° elev 0 ft eye alt

Windsor Island Slough

- Quarry discharge increases flow, lowers water temperature and conductance

Mission / Windsor Aquatic Plant Methods

- Survey areas defined using LiDAR elevation and aerial images
- Sampled 100 pre-selected random points per survey area
- “Core” sample at each point (0.15 m^2 / 1.6 ft^2)
- Sample depth and fresh weight by species

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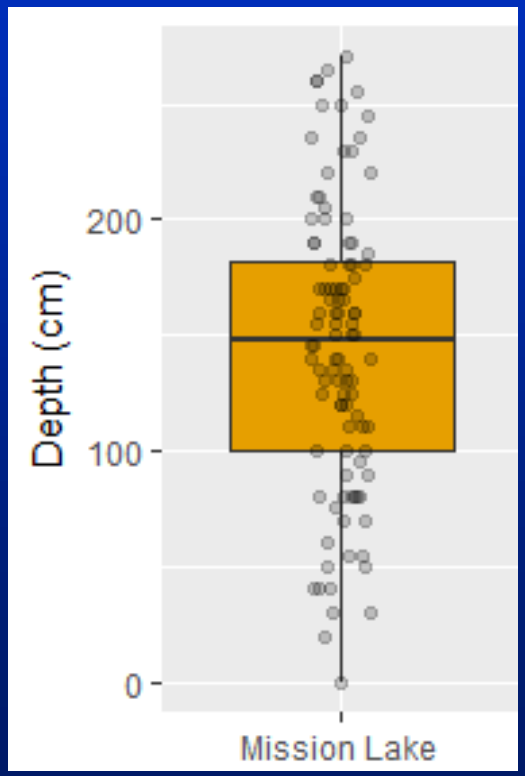
Mission Lake

- August 1 and 3, 2017
- 59 acre survey area
- 0 - 2.8 m sample depths



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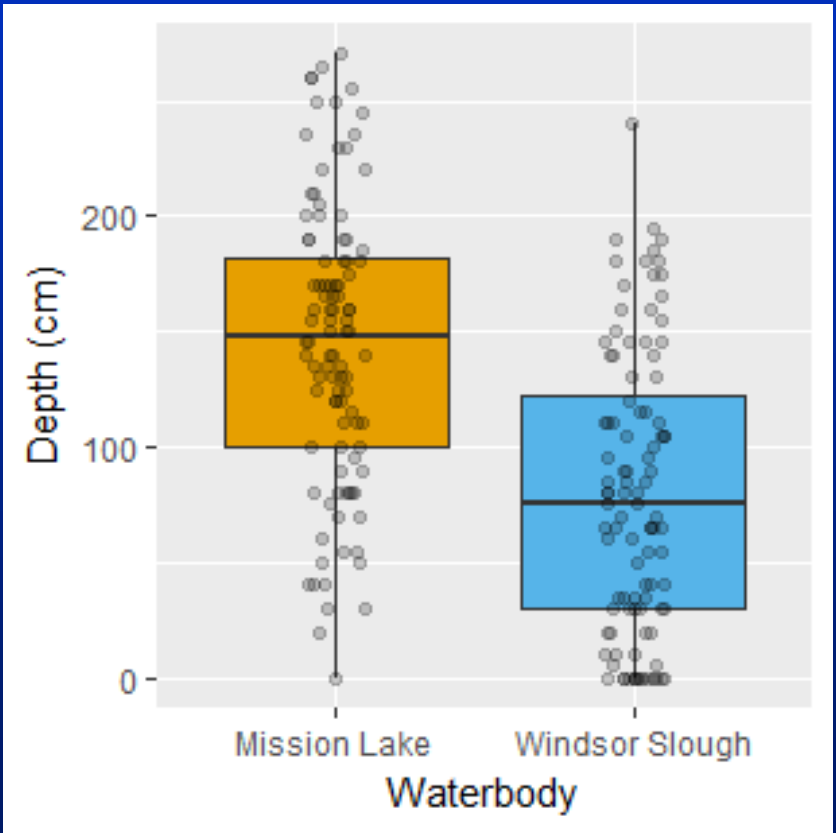
Windsor Slough

- August 15 and 17, 2017
- 45 acre survey area
- 0 – 2.4 m sample depths



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Mission / Windsor Results

	Mission Lake	Windsor Island Slough	Test *p* value*
Number of aquatic invasive species	3	3	-
Number of native aquatic species	5	6	-
Frequency of any plant species	94%	94%	1
Frequency *Ludwigia hexapetala*	39%	65%	<0.001
Frequency *Egeria densa*	78%	39%	<0.001
Frequency *Ceratophyllum demersum*	46%	31%	0.25

Egeria densa
Photo by Lamiot © 2015 Wikipedia Commons

Ceratophyllum demersum
Photo by Chuck Cichra © 2014 University of Florida

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Frequency *Ceratophyllum demersum*	46%	31%	0.25
Avg total sample fresh weight (kg/m^2)	3.68 ± 4.66	6.82 ± 5.50	<0.001
Avg *L. hexapetala* sample fresh weight	6.19 ± 6.26	8.81 ± 5.33	0.01
Avg *E. densa* sample fresh weight	1.03 ± 1.15	0.87 ± 1.11	0.27
Avg *C. demersum* sample fresh weight	0.24 ± 0.46	0.74 ± 1.46	<0.001

** Pearson's Chi^2 to test difference in frequency, Wilcoxon Rank Sum to test fresh weight biomass*

Other Mission L. species at >5% of sites: *Potamogeton zosteriformis, Stuckenia pectinata*

Other Winsdor species at >5% of sites: *Potamogeton crispus, Persicaria* spp.

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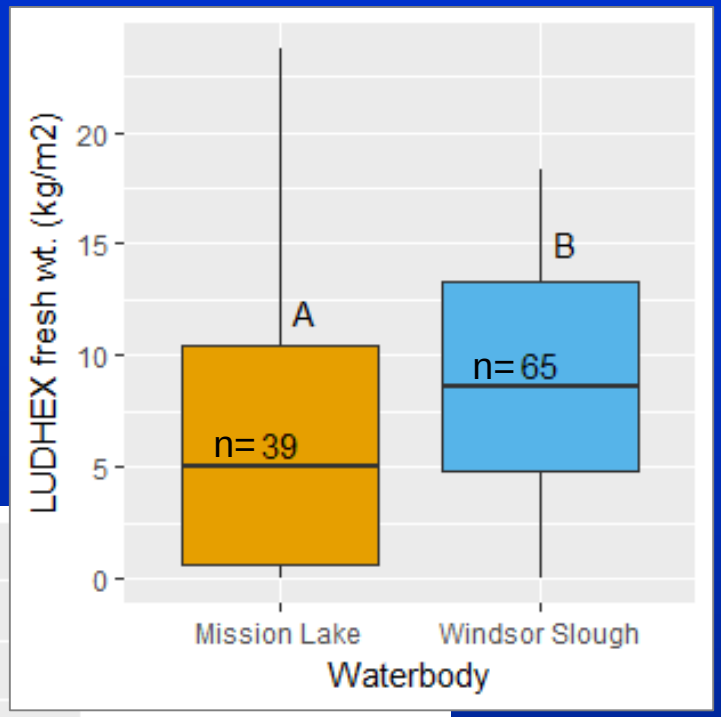
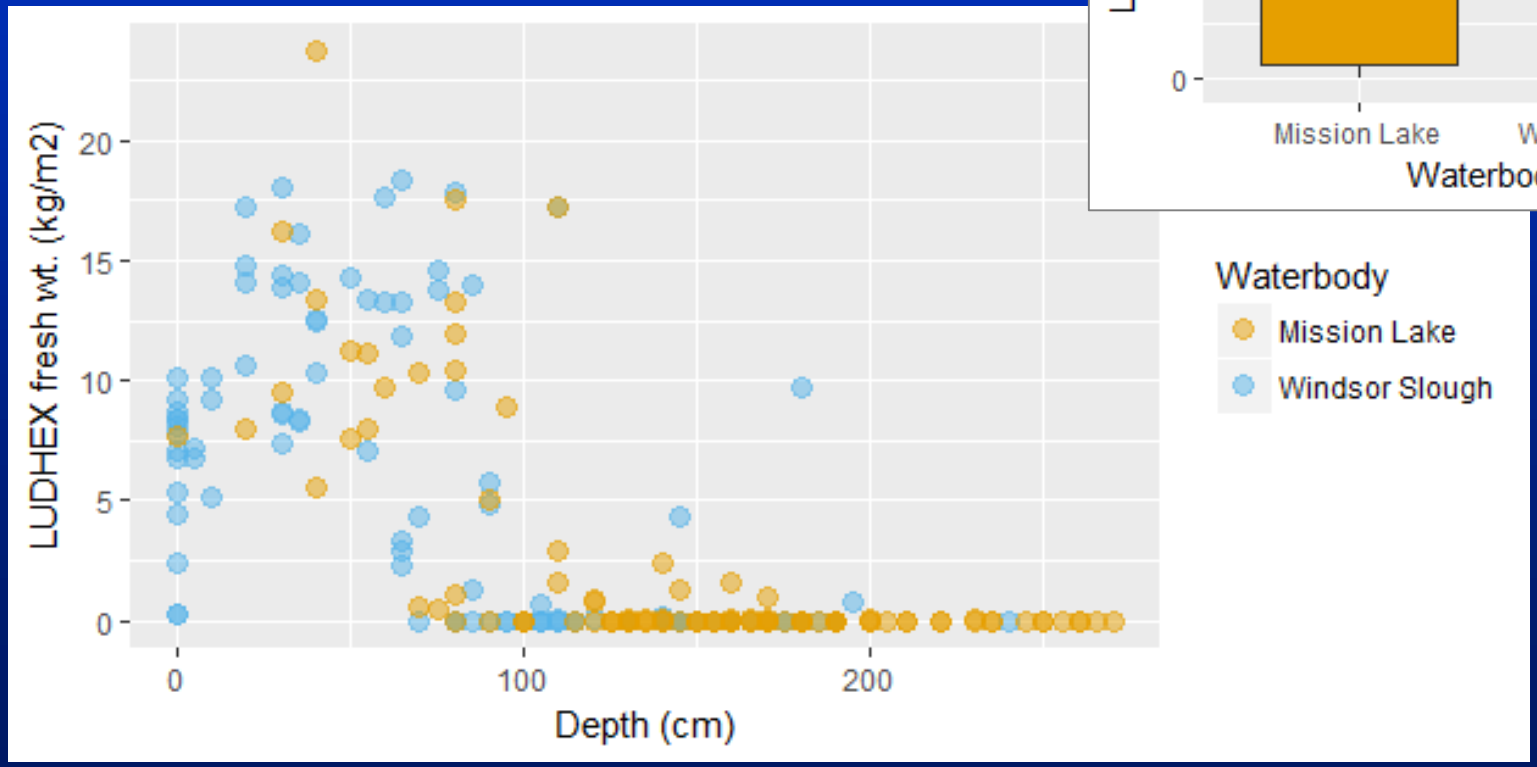
Ludwigia hexapetala

- More common at Windsor
  (p<0.001, Chi^2 test)
- Higher biomass at Windsor
  (p<0.01, Wilcoxon rank sum test)
- Higher biomass < ~1m deep





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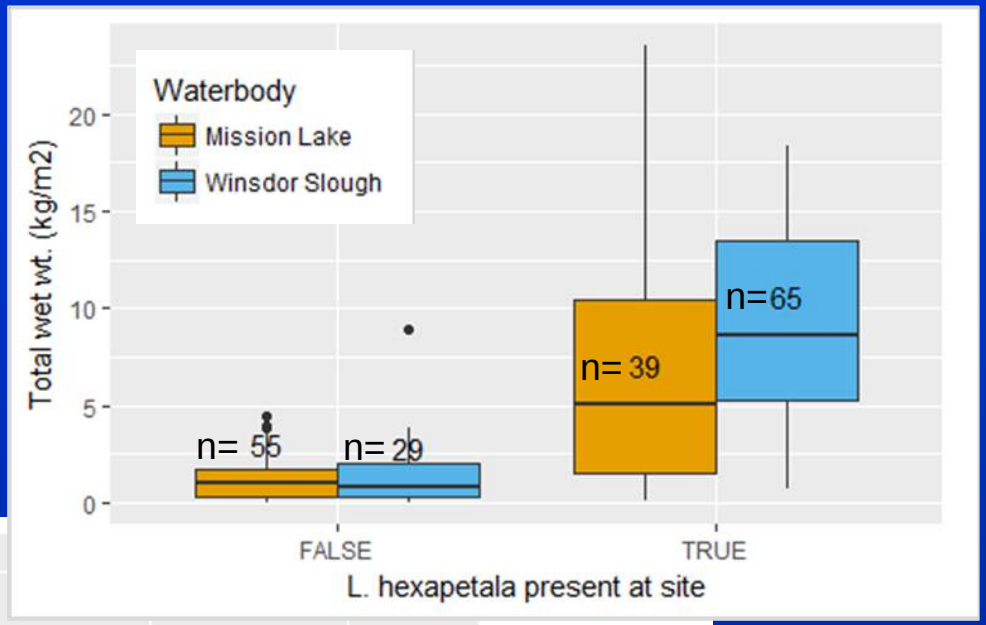
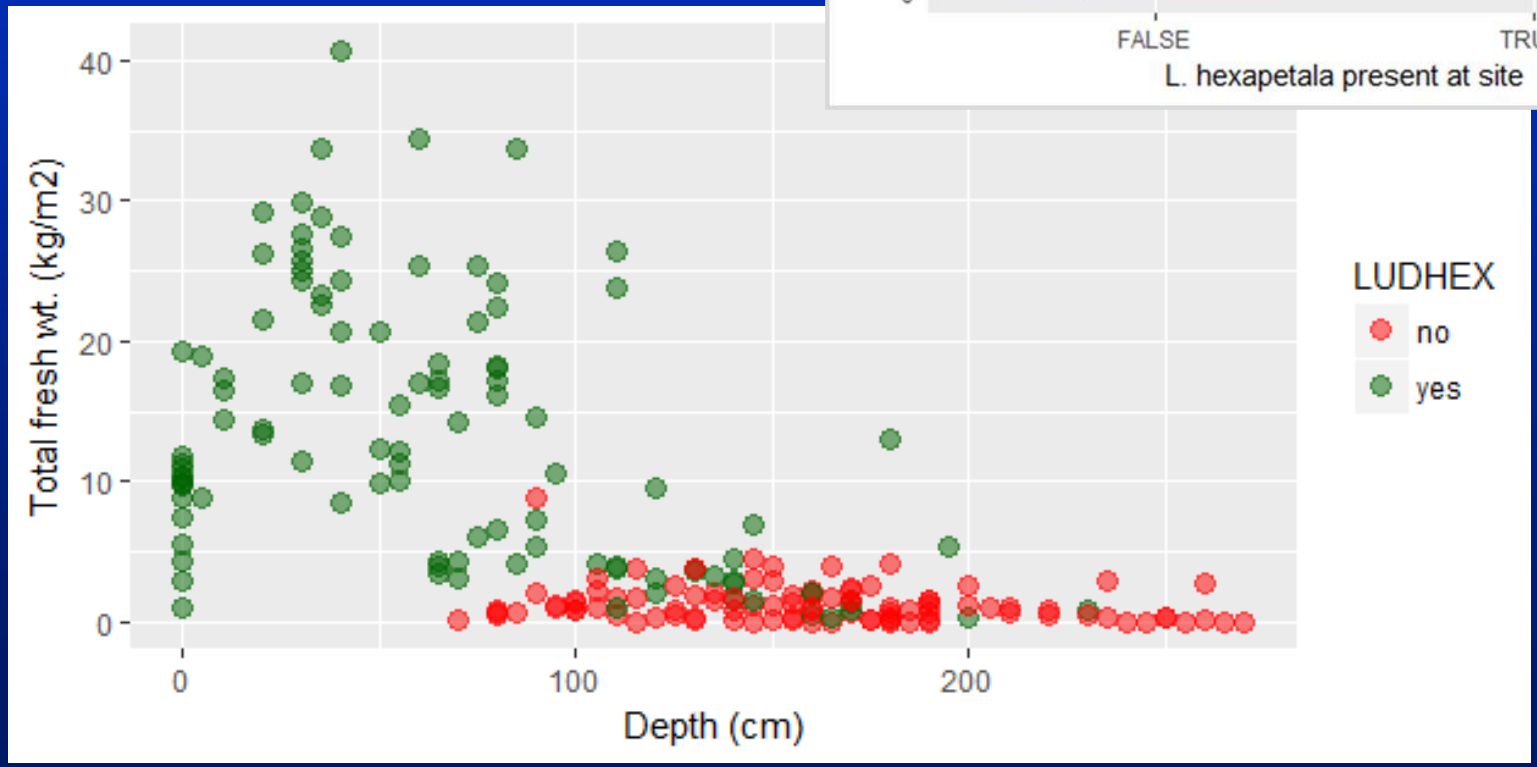
All species

- Plants present at 94% of sites
- *LUDHEX* dominated biomass
- *Egeria densa* (AIS) and *Ceratophyllum demersum* (native) important in deeper samples, but lower biomass

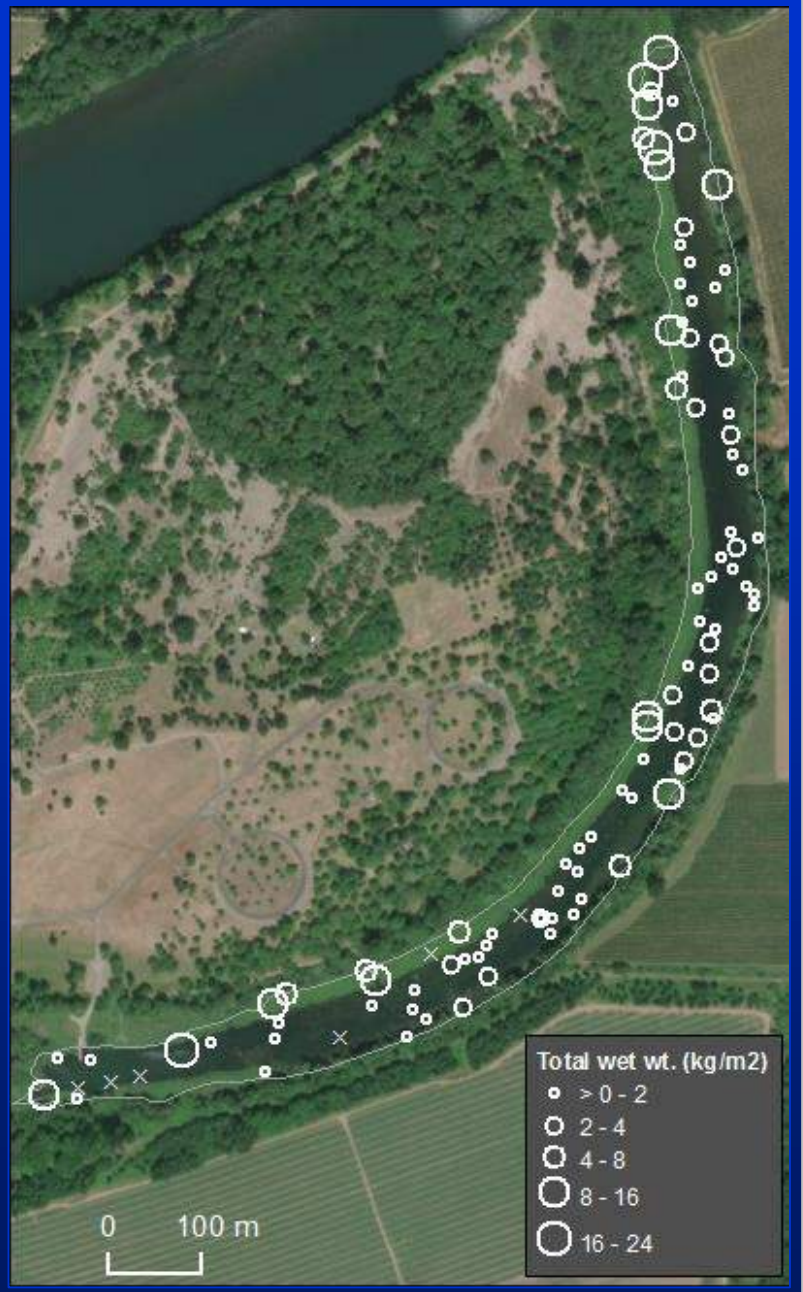




Windsor Island Slough (left)

Mission Lake (right)

Total plant fresh wt. (kg/m2)



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Mission Lake


Windsor Island Slough

Summary of Mission Lake / Windsor Slough aquatic plant community

- Across waterbodies
  - Very high *Ludwigia hexapetala* fresh weight biomass
  - Greater LUDHEX and total plant biomass at shallows sites
  - *Egeria densa* (AIS) and *Ceratophyllum demersum* (native) common at deeper sites
- *Between waterbodies*
  - *E. densa* was more common at Mission Lake
  - *C. demersum* biomass was greater at Windsor Island Slough
- Algae and cyanobacteria were diverse and abundant

Aquatic plant and water quality assessments:

1. Mission Lake/Windsor Island Slough baseline surveys (Willamette Riverkeeper, Oregon State Parks, OWEB)

2. Collins Bay/Scatter Pond baseline and post-treatment surveys (Benton Soil and Water Conservation District, ODA)

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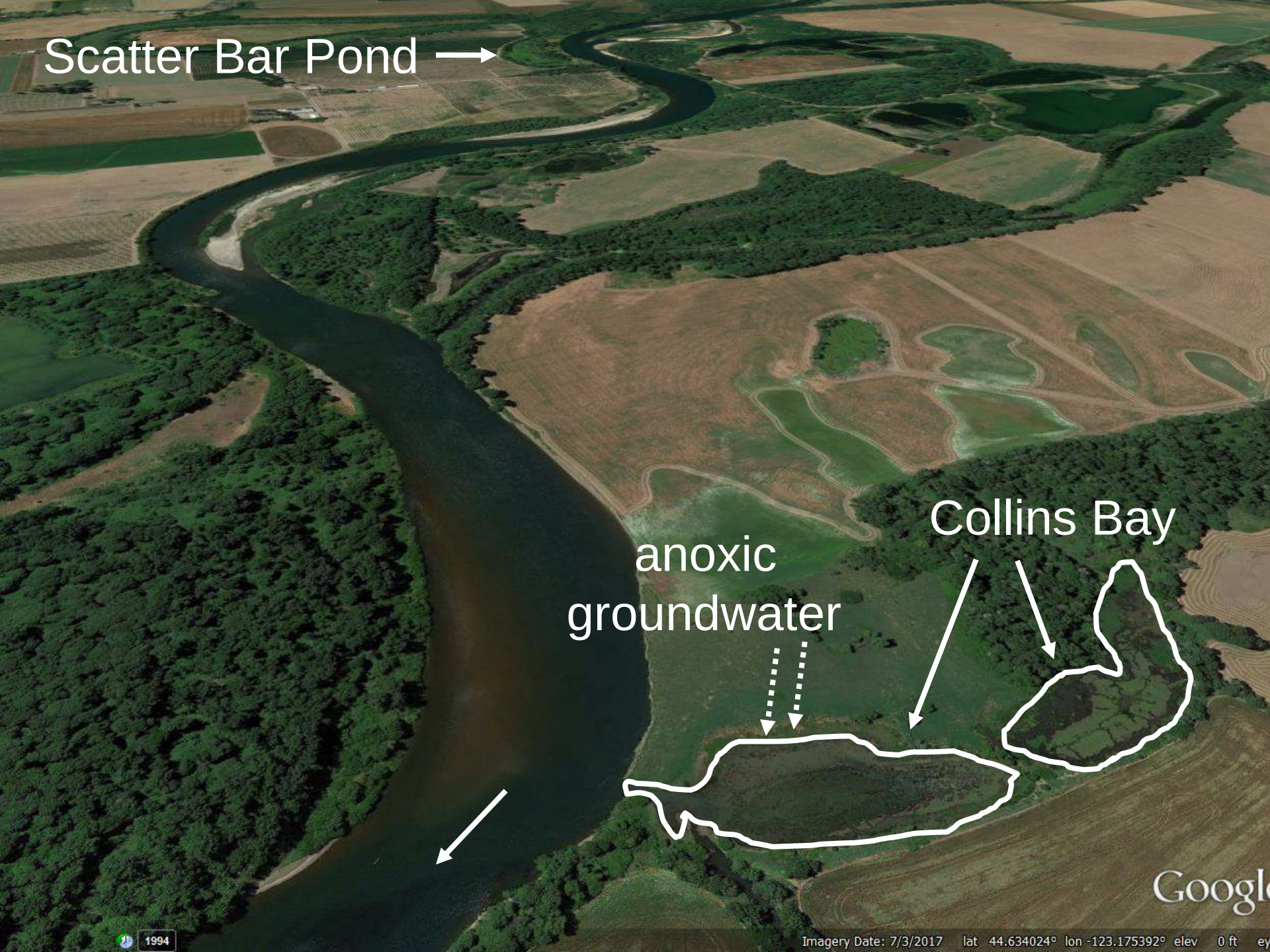
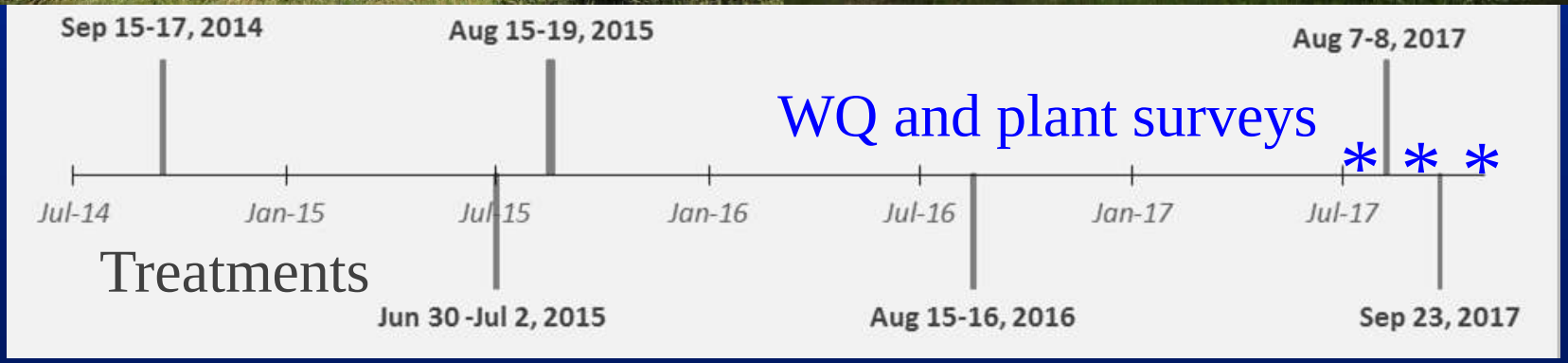

Scatter Bar Pond
Collins Bay
anoxic
groundwater
1994
Imagery Date: 7/3/2017 lat 44.634024° lon -123.175392° elev 0 ft

Collins Bay aquatic label glyphosate treatment history and 2017 surveys



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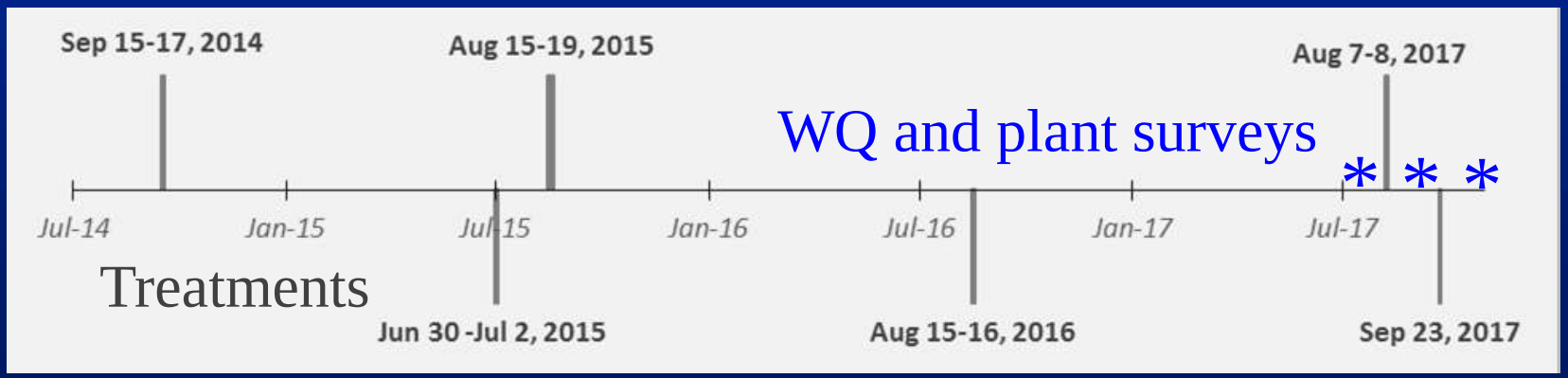

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greenbelt
land trust
Google earth
1994
Imagery Date: 7/3/2017 lat 44.603983° lon -123.180538° elev 0 ft eye alt 678 ft

Collins Bay / Scatter Bar
Aquatic Plant Survey Methods

- Survey areas defined using LiDAR elevation and aerial images
- Sampled 60 pre-selected random points per survey area during three events
- Recorded sample depth and semi-quantitative species abundance

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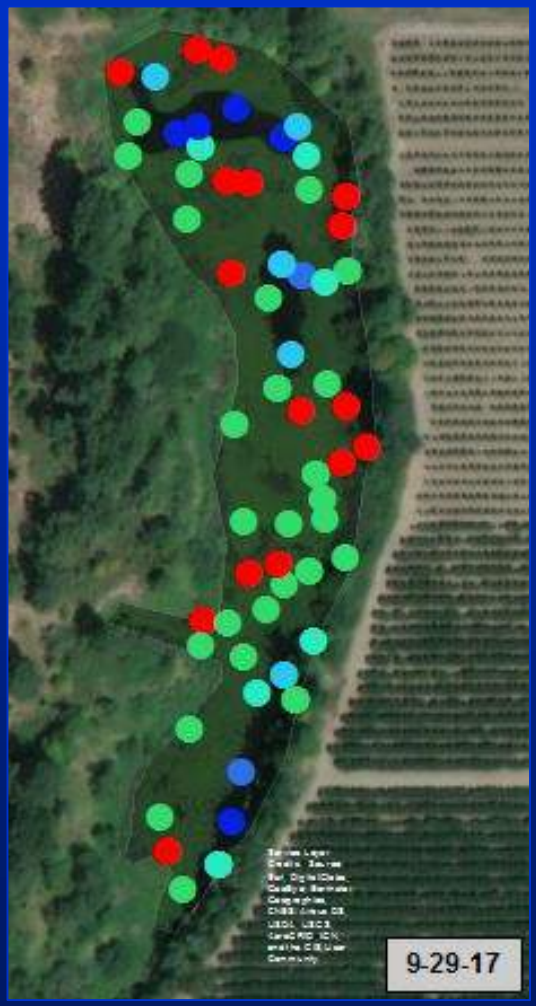
Semi-quantitative species abundance
= hoop coverage + rake fullness

Scatter/Collins sampling sites



Scatter Bar Pond freq of occurrence (%)

Species	Common name	Type[1]	Status[2]	Jul	Sep	Oct
Number of species present				13	8	6
Number of AIS species present				6	3	3
Percent of sites with plants present				96	97	93
Ludwigia hexapetala	Uruguayan primrose willow	E	AIS	**78**	**88**	**83**

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Ludwigia sp.	water primrose, uncertain	E	AIS	2	-	2
Ceratophyllum demersum	coontail	S	N	13	12	12
Persicaria sp.	smartweeds	W	-	30	22	13
Poaceae	grass	W	-	3	8	2

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Poaceae	grass	W	-	3	8	2
Myriophyllum aquaticum	parrotsfeather	E	AIS	3	-	-
Sagittaria latifolia	wapato	E	N	3	-	-
Egeria densa	Brazilian elodea	S	AIS	7	5	2
Elodea nuttallii	Nuttall's waterweed	S	N	3	-	-
Potamogeton pusillus	thin leaf pondweed	S	N	5	3	-
Phalaris arundinaceae	reed canary grass	W	AIS	7	-	-
Potamogeton zosteriformis	flatstem pondweed	S	N	2	2	-
Potamogeton crispus	curlyleaf pondweed	S	AIS	-	2	-
Lythrum salicaria	purple loosestrife	W	AIS	2	-	-

[1]E = emergent, S = submersed, W = wetland, F = floating leaf. [2]AIS = aquatic invasive species, N = native species

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Collins Bay frequency of occurrence (%)

Species	Common name	Status	Jul	Sep	Oct
Number of species present			26	22	20
Number of AIS species present			5	6	4
Number of sites with plants present			97	100	98
Ludwigia hexapetala	Uruguayan primrose willow	AIS	47	58	42
Myriophyllum aquaticum	parrotsfeather	AIS	8	10	13
Egeria densa	Brazilian elodea	AIS	2	3	3
Potamogeton crispus	curlyleaf pondweed	AIS	2	3	2
Ceratophyllum demersum	coontail	Nat	53	33	30
Sparganium emersum	European bur-reed	Nat	18	23	12
Sagittaria latifolia	wapato	Nat	15	13	2
Nuphar polysepala	spatterdock	Nat	12	7	5
Alisma triviale	northern water plantain	Nat	3	7	0
……..more species not displayed…..	……..	….	….	…..	…..

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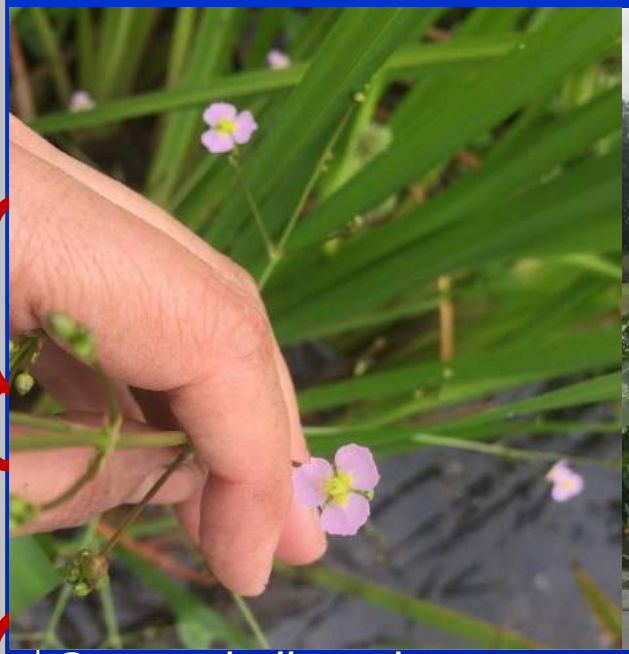

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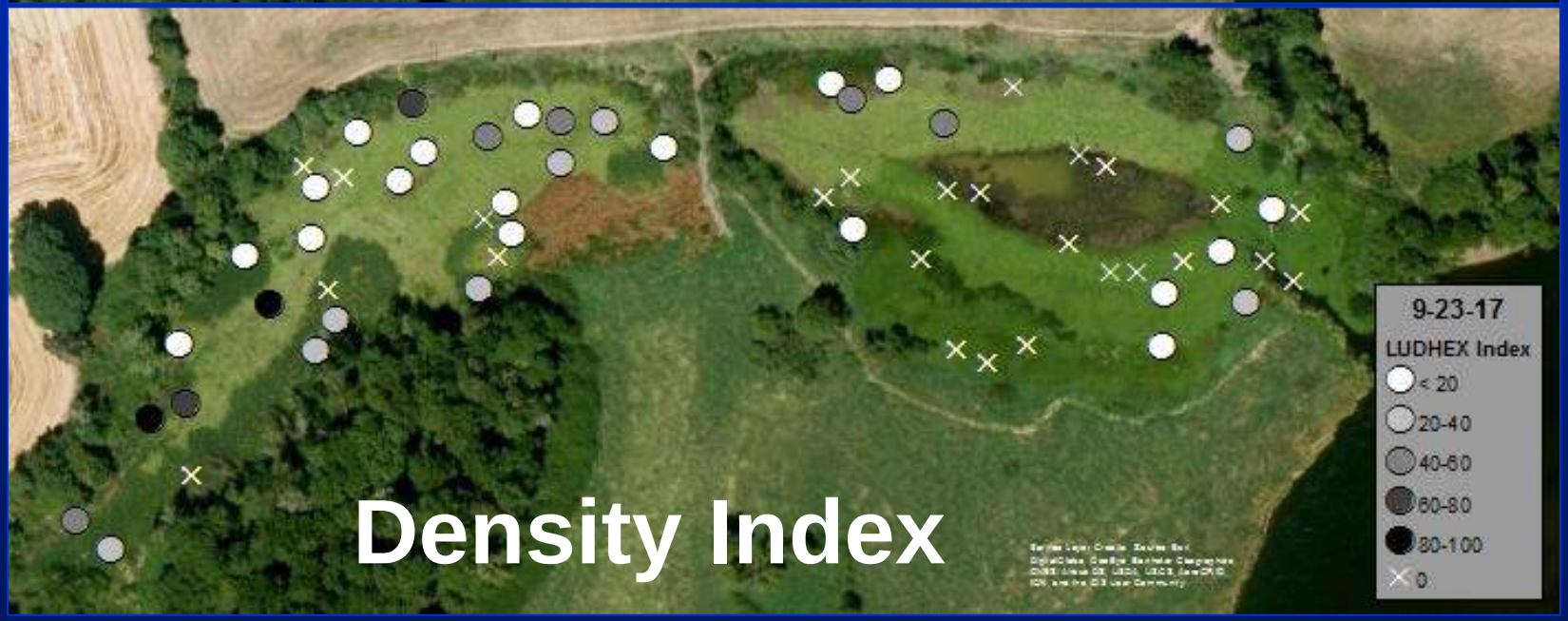

Density Index

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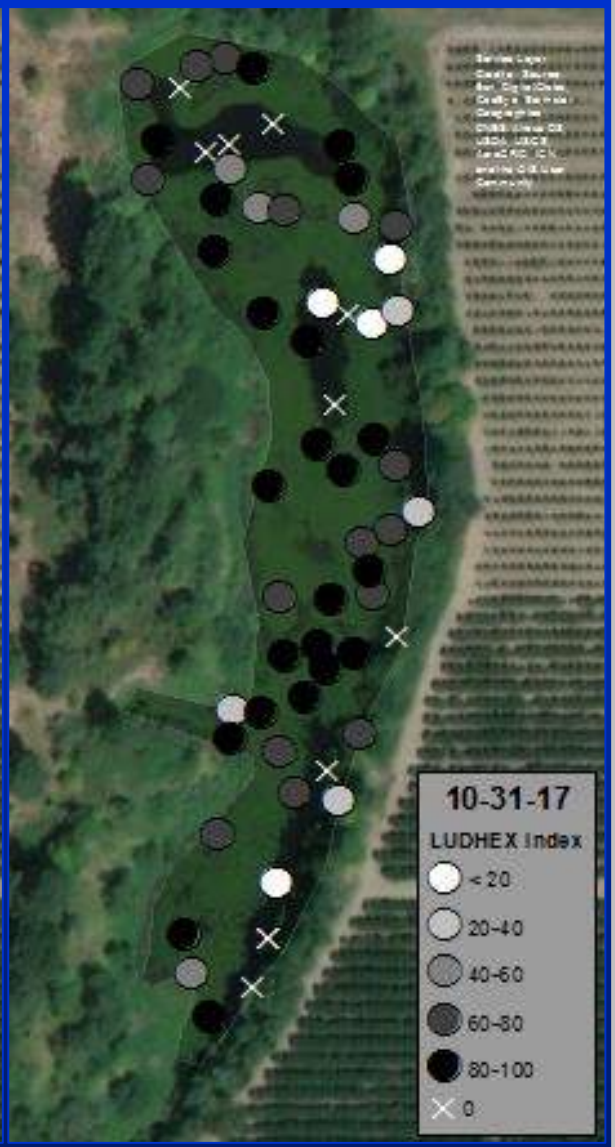

Density Index

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Summary of aquatic plant assessment – Collins Bay / Scatter Bar Pond

- High *LUDHEX* density index at Scatter Bar Pond
- Low *LUDHEX* density index at Collins Bay
- Higher diversity at Collins Bay and native species are doing well
- Floating mat at Collins Bay is a dominant feature
- Differences though season << differences between waterbodies

What happens to Collins Bay if treatment stops?

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Water Quality Data Collection

- Continuous water temperature, DO and SC
- (YSI OMS sonde, up & downstream locations in Mission Lake and Windsor Is Slough

- High frequency spatial surveys using a YSI EXO2 sonde
  - ✓ Water temperature
  - ✓ Dissolved oxygen
  - ✓ pH
  - ✓ Turbidity
  - ✓ Total chlorophyll
  - ✓ Phycocyanin

	CB	SBP	ML	WIS	Total
Surface measurements	9,987	5,124	66,966	54,751	136,828
Deeper measurements	5,029	6,177	4,295	17,186	32,687
	15,016	11,301	71,261	71,937	169,515

- Mapping of near-surface tows within each waterbody with periodic depth profiles of conditions
- Fine sediment and epiphytic algae cause major spikes in turbidity, total chlorophyll, and phycocyanin

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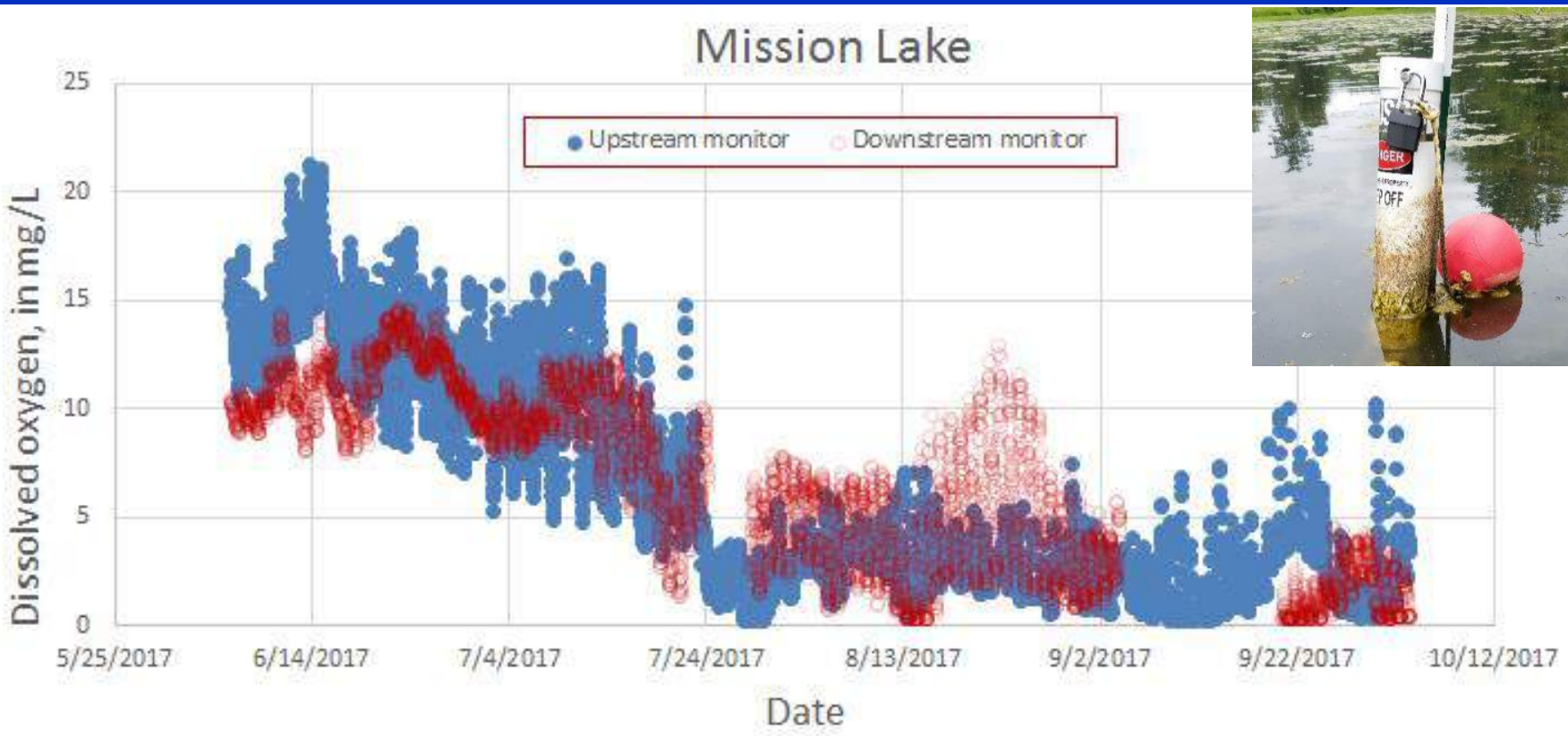
Mission Lake: Dissolved Oxygen

- Marked decline toward end of July. Why?
- Drop in water level? N or P limitation? Resp >>Photosyn
- Not water temperature, it was lower in August than July



USGS Provisional Data – Subject to Revision

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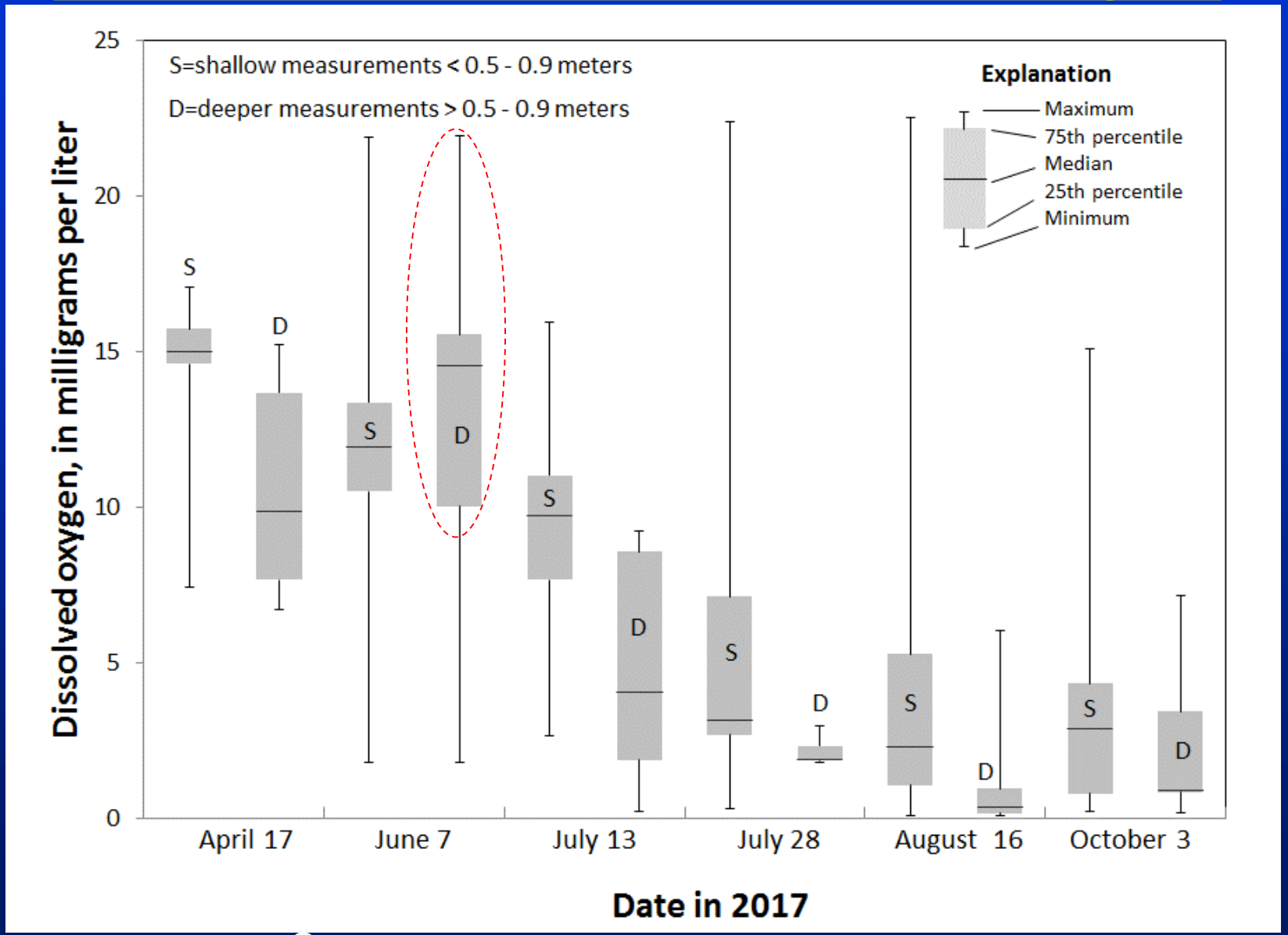
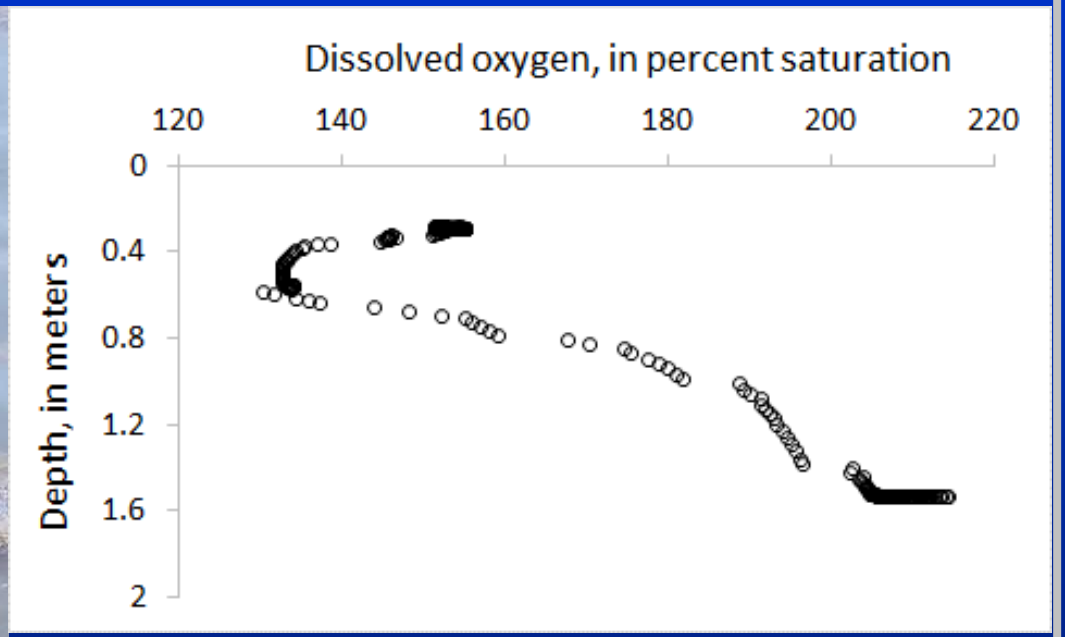
Mission Lake: Dissolved Oxygen

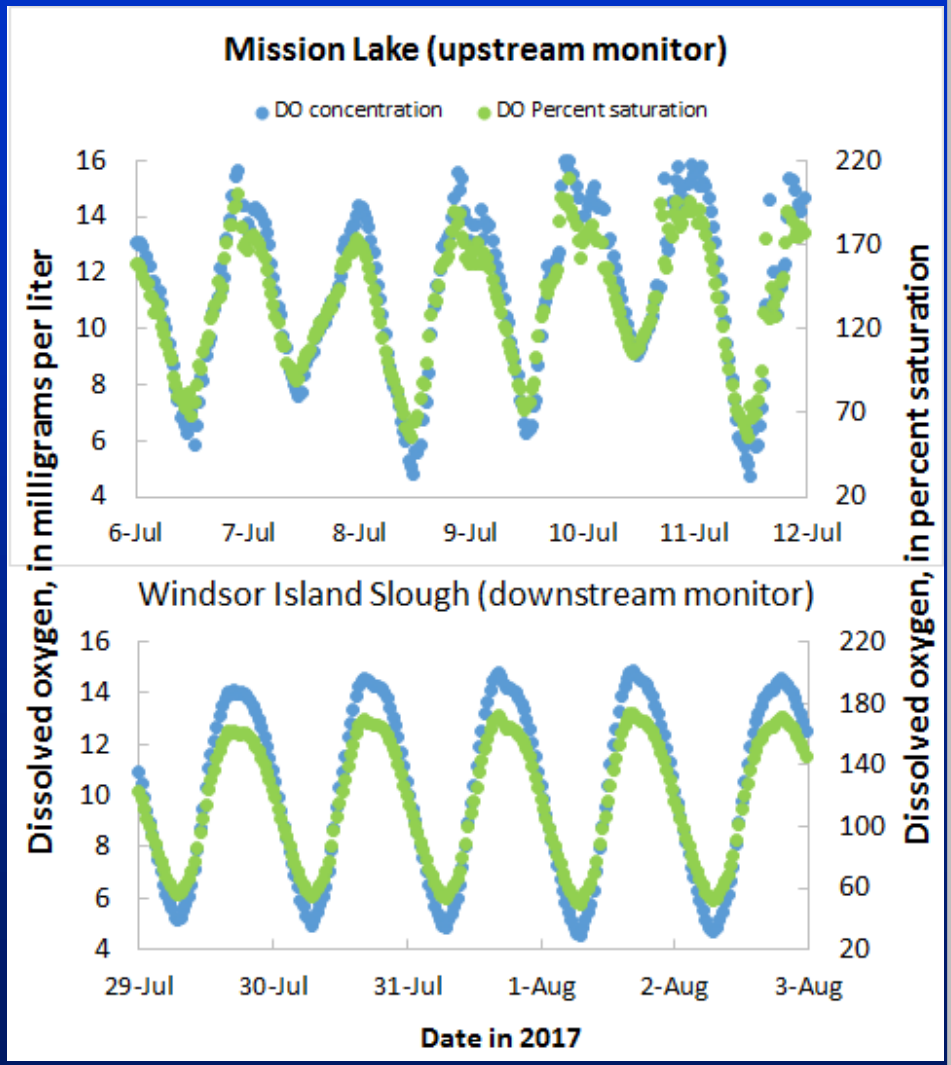


Higher DO at depth was observed where *Egeria densa* and *Melosira* proliferated to the bottom



Plant photosynthesis causes large diel fluctuations in DO

- Daily swings of 9–10 mg/L in both waterbodies
- Percent saturation swings of 120%–130%
- Minimum DO was less than 5 mg/L



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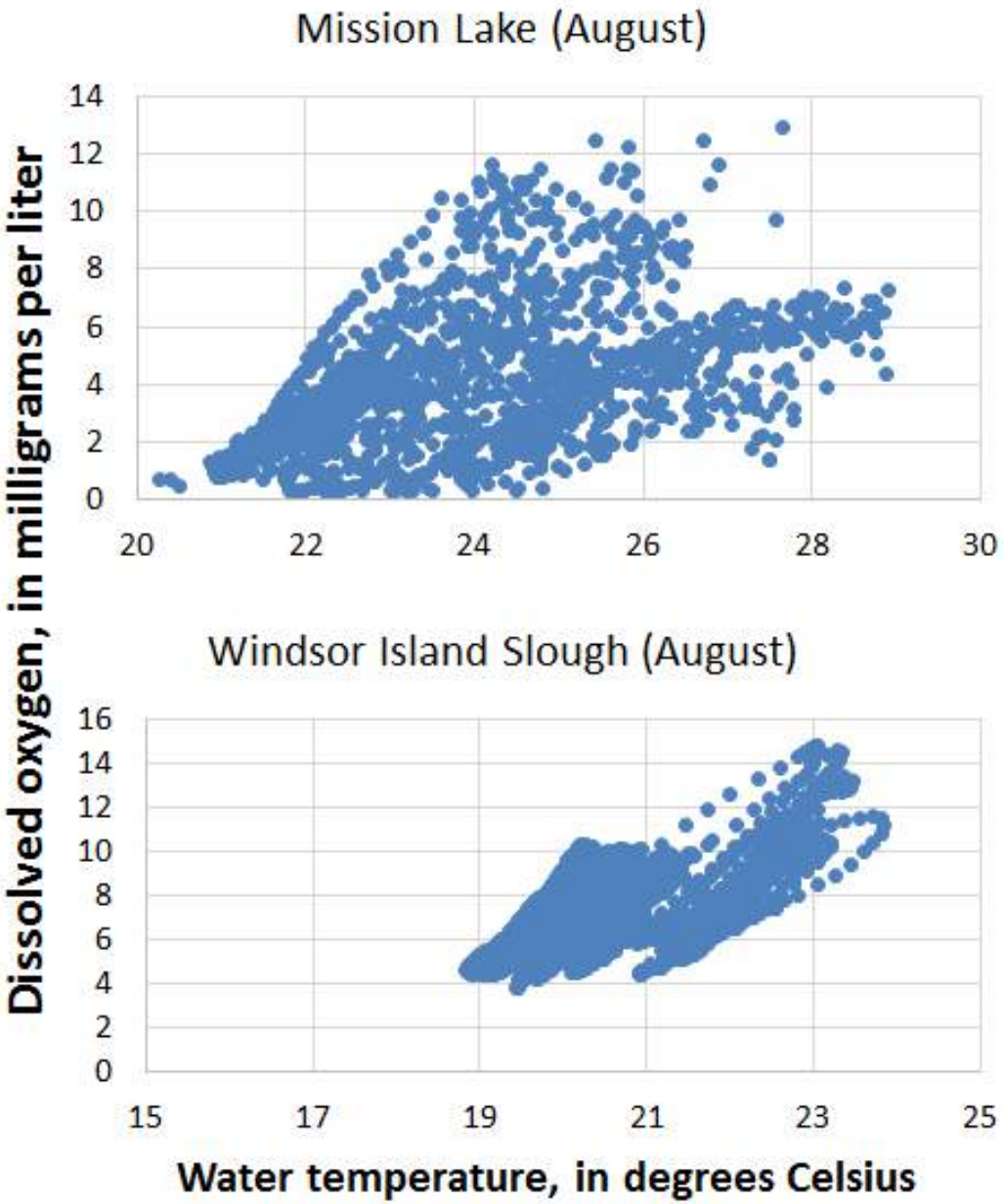
- DO increases during the day along with water temperature,
- SO.. aquatic plant photosynthesis controls DO (not water temperature)



miniDOT Dissolved Oxygen Sensor Pilot Mission Lake

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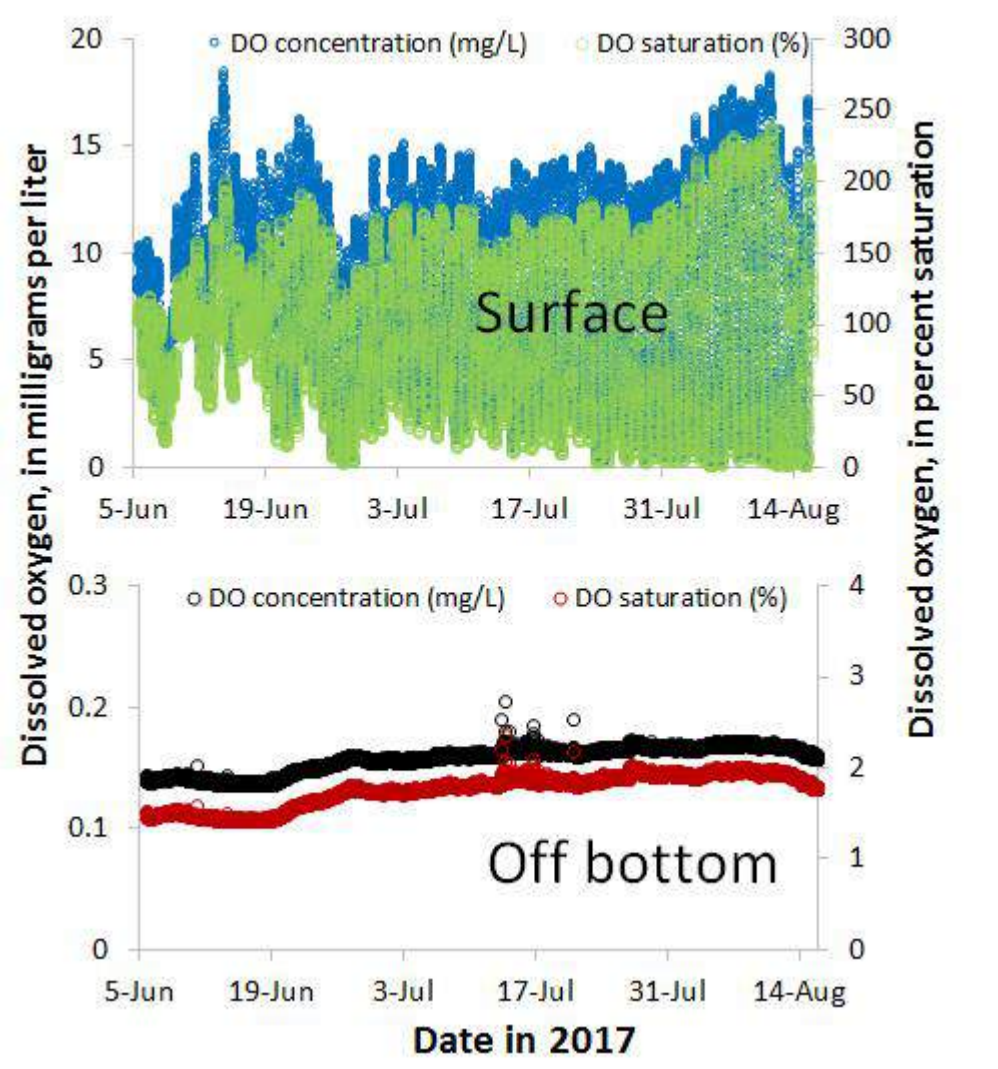
miniDOT DO Sensor Pilot: Mission Lake

- **Large diel fluctuations in DO (0–18 mg/L, or 0–250% saturation)**
- **Stable, low DO (near anoxia) off bottom**



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Mission Lake: Dissolved Oxygen - April

DO (mg/L)
- 0.1–2.0
- 2.0–5.0
- 5.0–10.0
- 10.0–15.0
- 15.0–28.0

- *Ludwigia* just starting to sprout

- Median DO 10–15 mg/L
- Higher DO along inside bend where plant biomass highest

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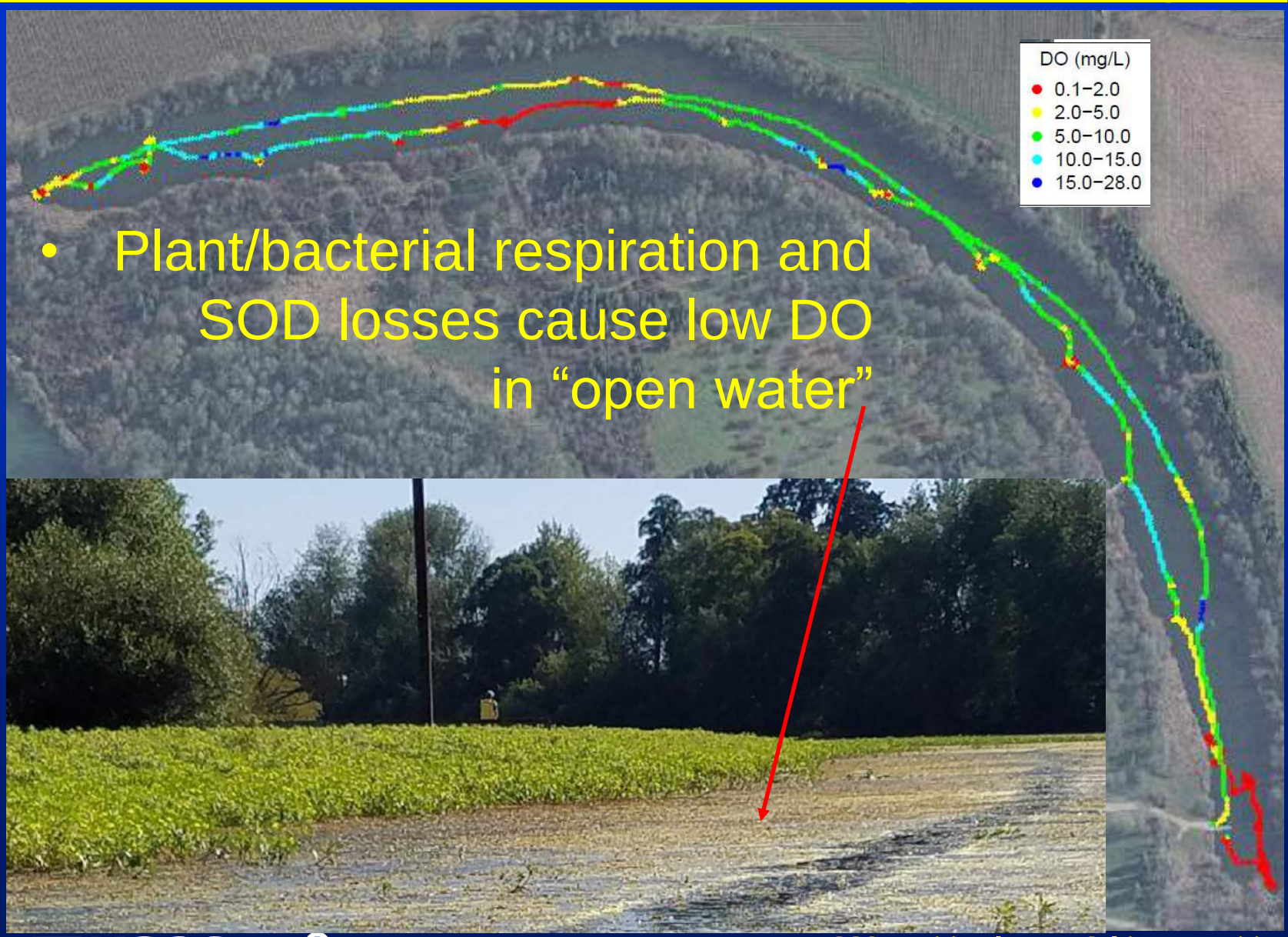
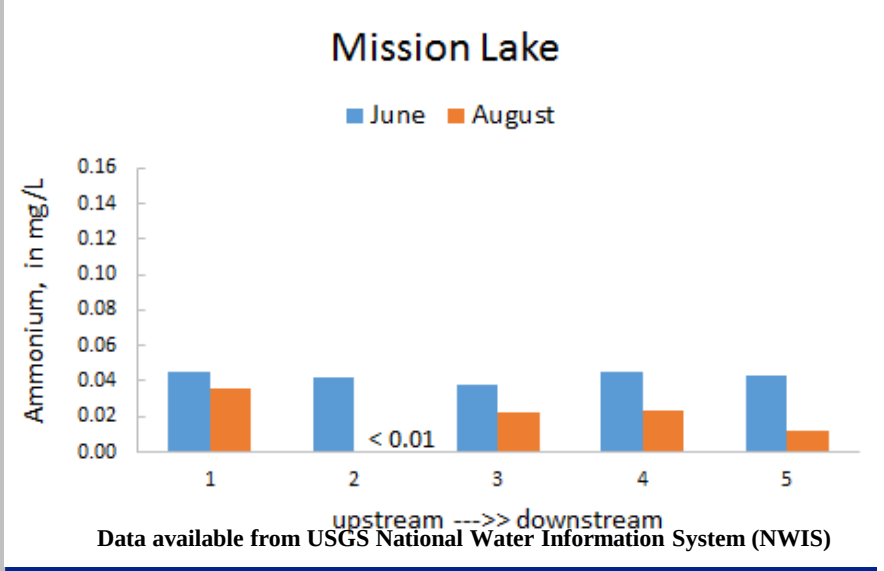
Mission Lake: Dissolved Oxygen - August



- Plant/bacterial respiration and SOD losses cause low DO in “open water”

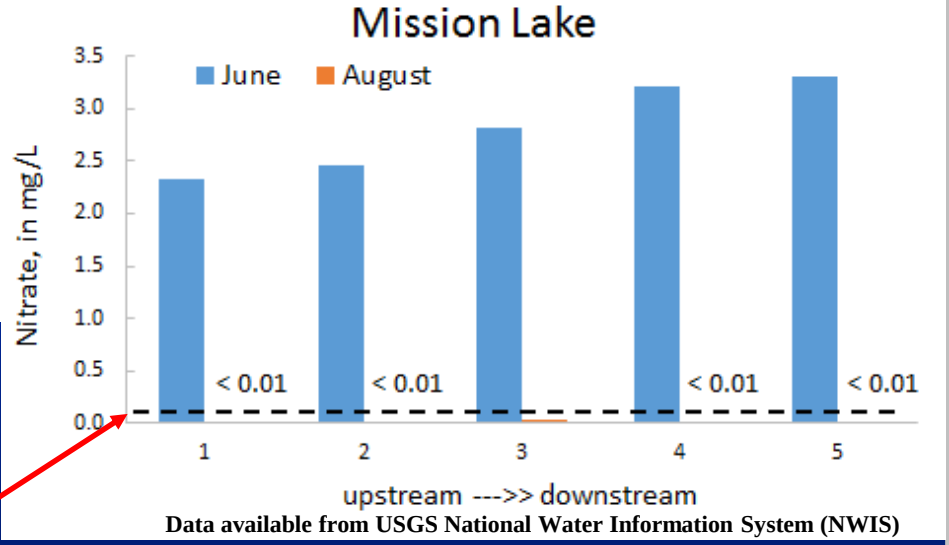
Mission Lake: Bioavailable Nutrients

- Ammonium declined between June and August: from plant uptake, ammonium oxidation



Data available from USGS National Water Information System (NWIS)

EPA Reference Nitrate concentration for Willamette Valley ecoregion 0.15 mg/L



Data available from USGS National Water Information System (NWIS)

- Nitrate increases downstream in June (GW?), then mostly below detection in August – from plant uptake and denitrification (?)

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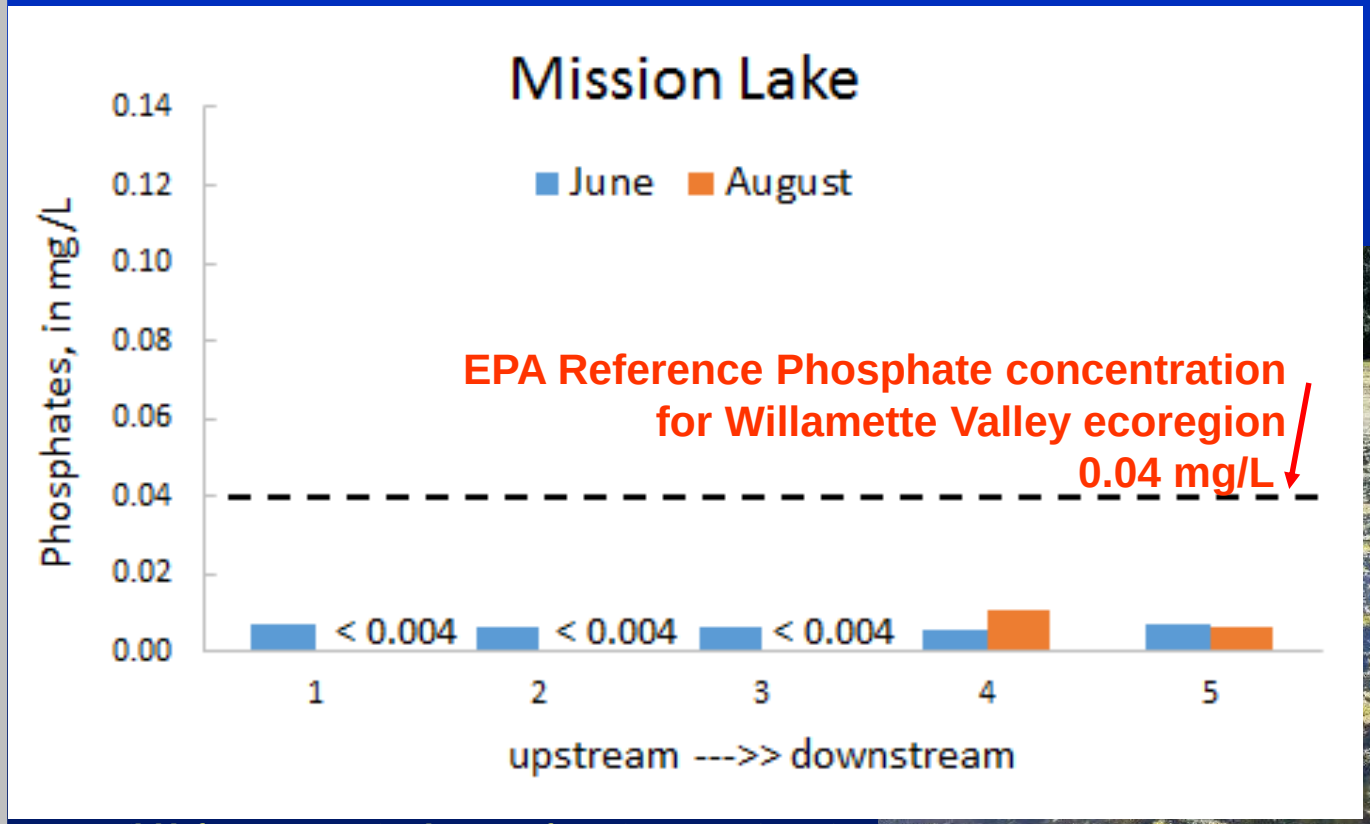
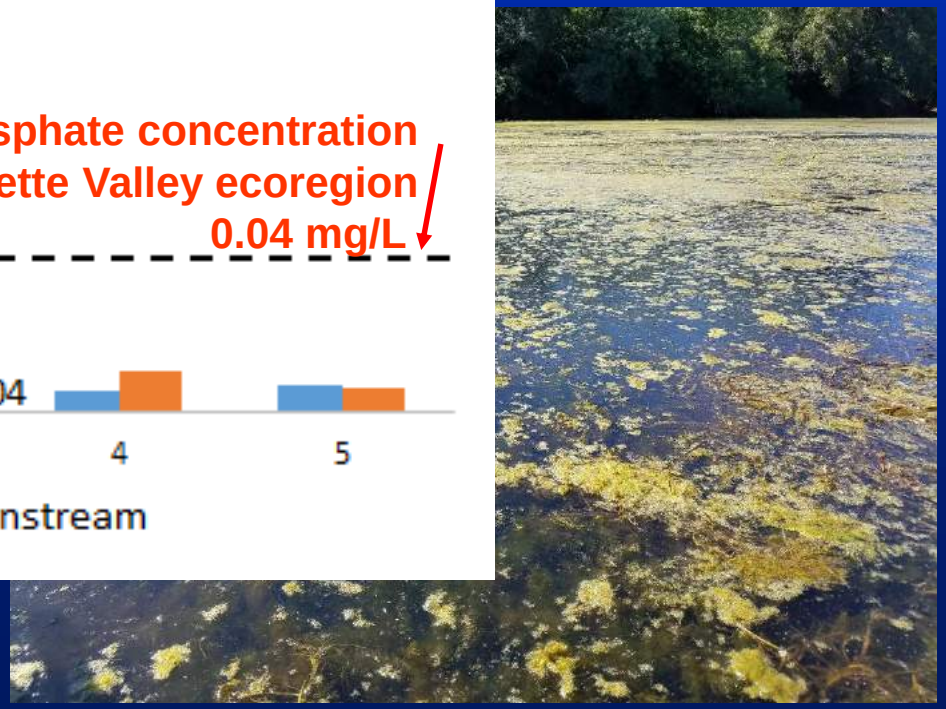
Mission Lake: Bioavailable Phosphorus

- Phosphorus (PO_4) concentrations were low in June and August, and may have been limiting for plants deriving nutrients from the water column, but not rooted plants





Data available from USGS National Water Information System (NWIS)

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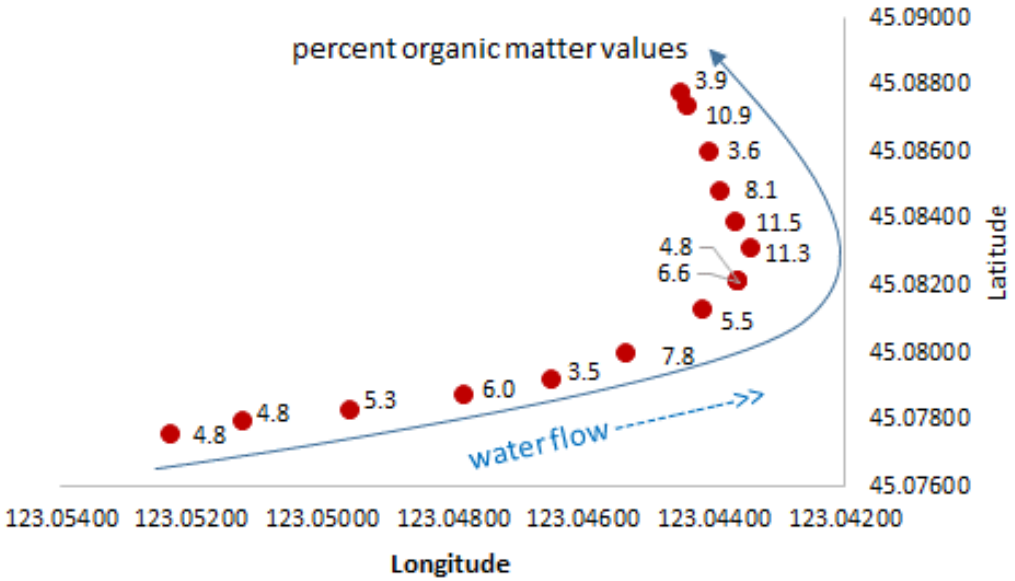
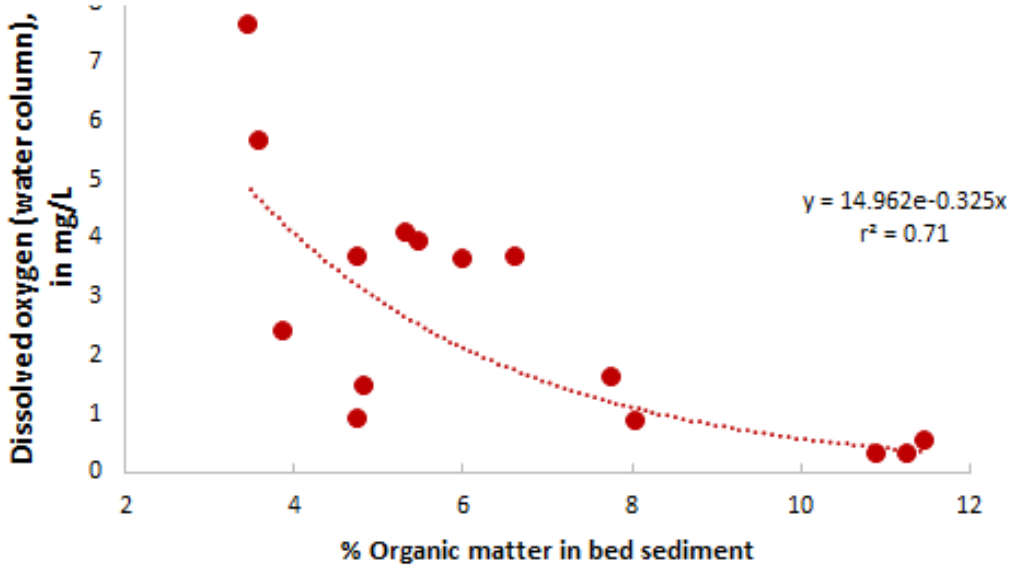
Mission Lake Bed Sediment - August 2017

- Percent organic matter in bed sediments high - increased downstream
- DO in water column lowest where % OM in sediments was highest
- Respiration/ sediment oxygen demand





Data available from USGS National Water Information System (NWIS)

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Windsor Island Slough: Algae and Cyanobacteria

- Elevated concentrations of nitrogen and phosphorus fueled growth of filamentous algae - both greens (*Oedogonium*) and diatoms (*Melosira*) - and cyanobacteria (*Oscillatoria*)

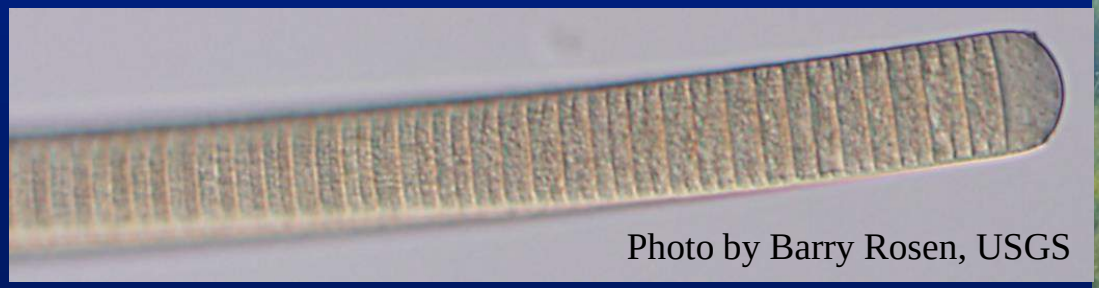
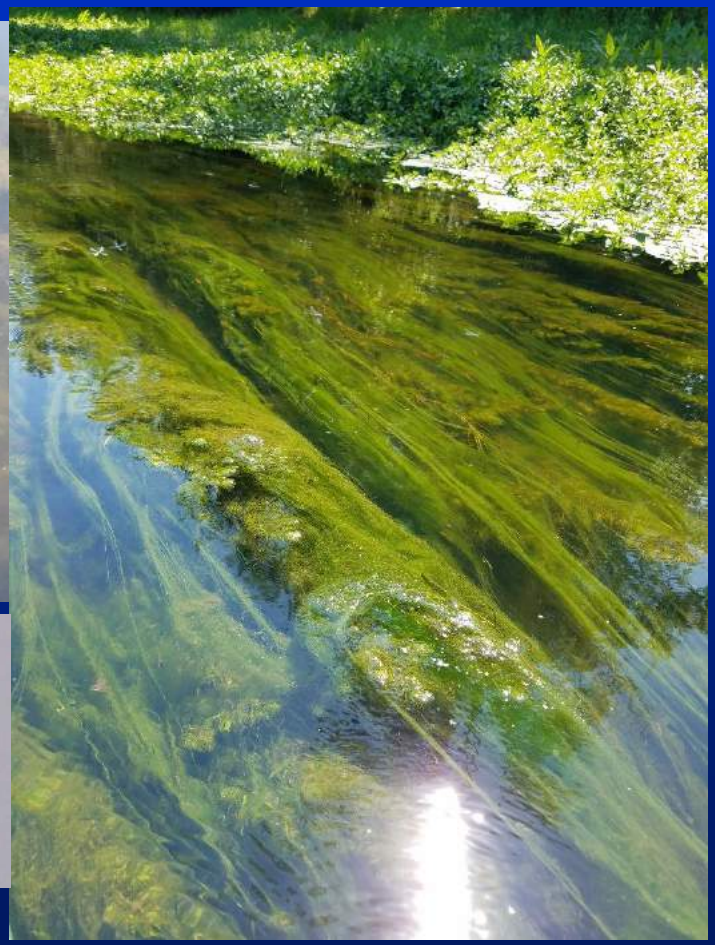


Photo by Barry Rosen, USGS



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Windsor Island Slough: Green Algae (*Oedogonium*)

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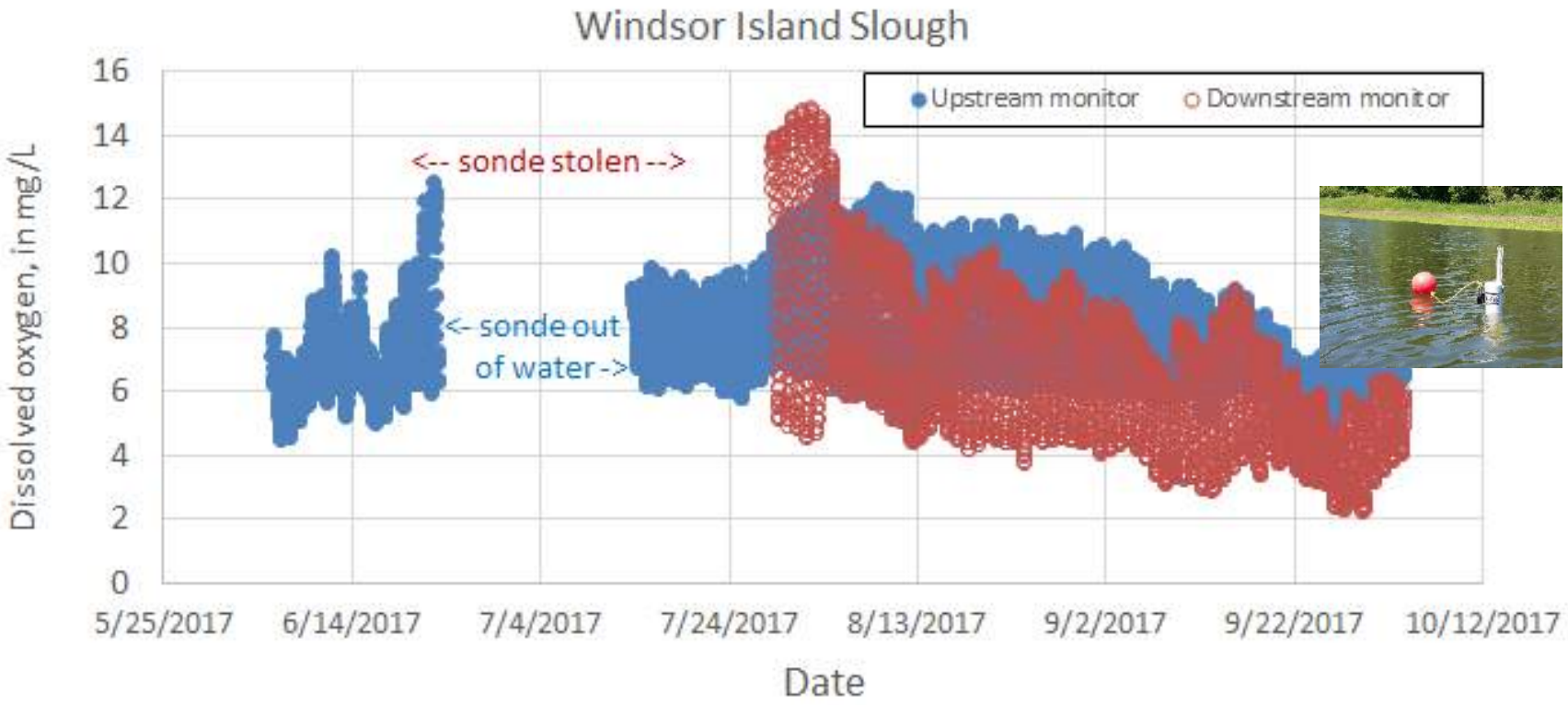
Windsor Slough: Cyanobacteria on Green Algae

Windsor Island Slough: Dissolved Oxygen

- DO spiked in late July, coinciding with seasonal decline in flow, then declined in August



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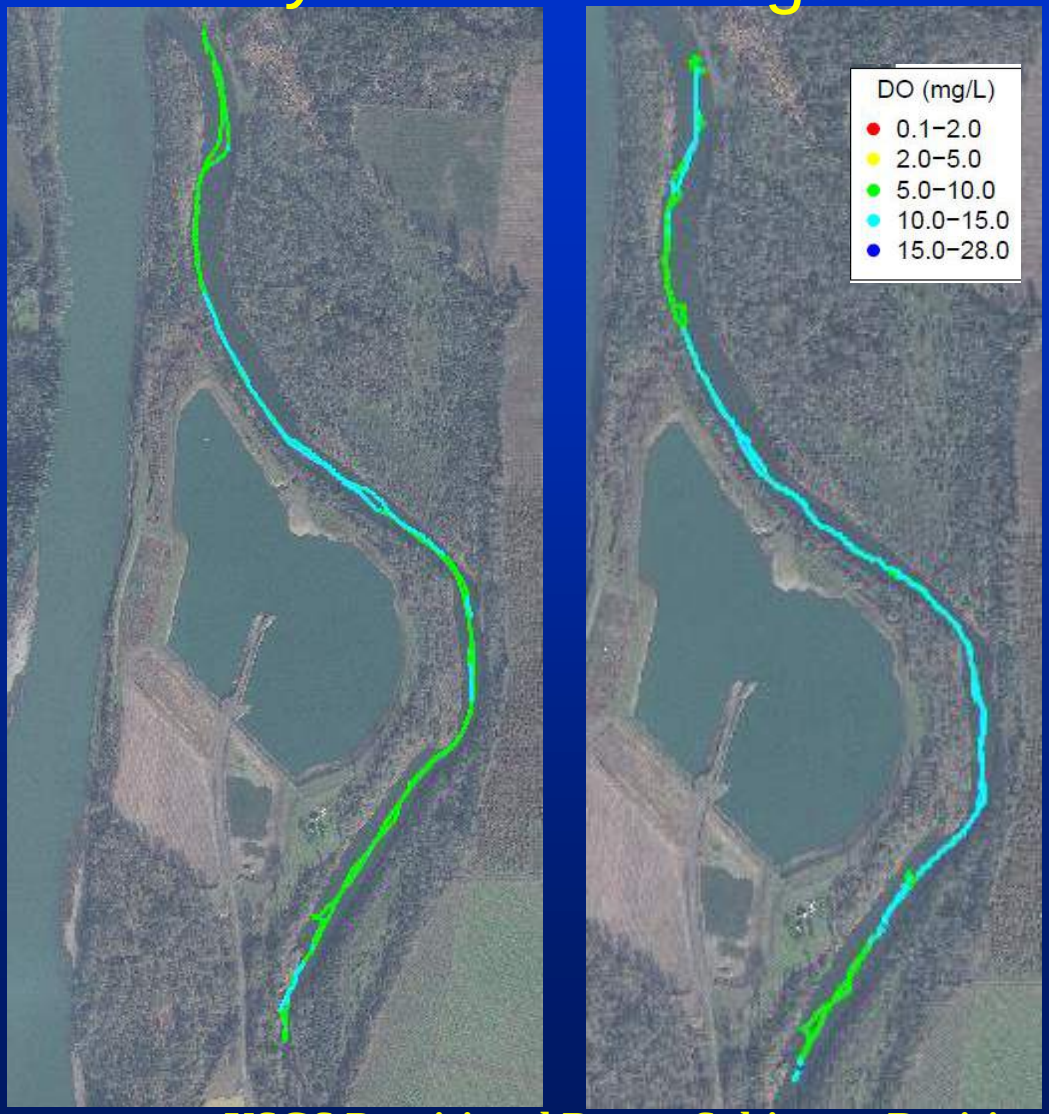
Windsor Island Slough: Dissolved Oxygen

July

August



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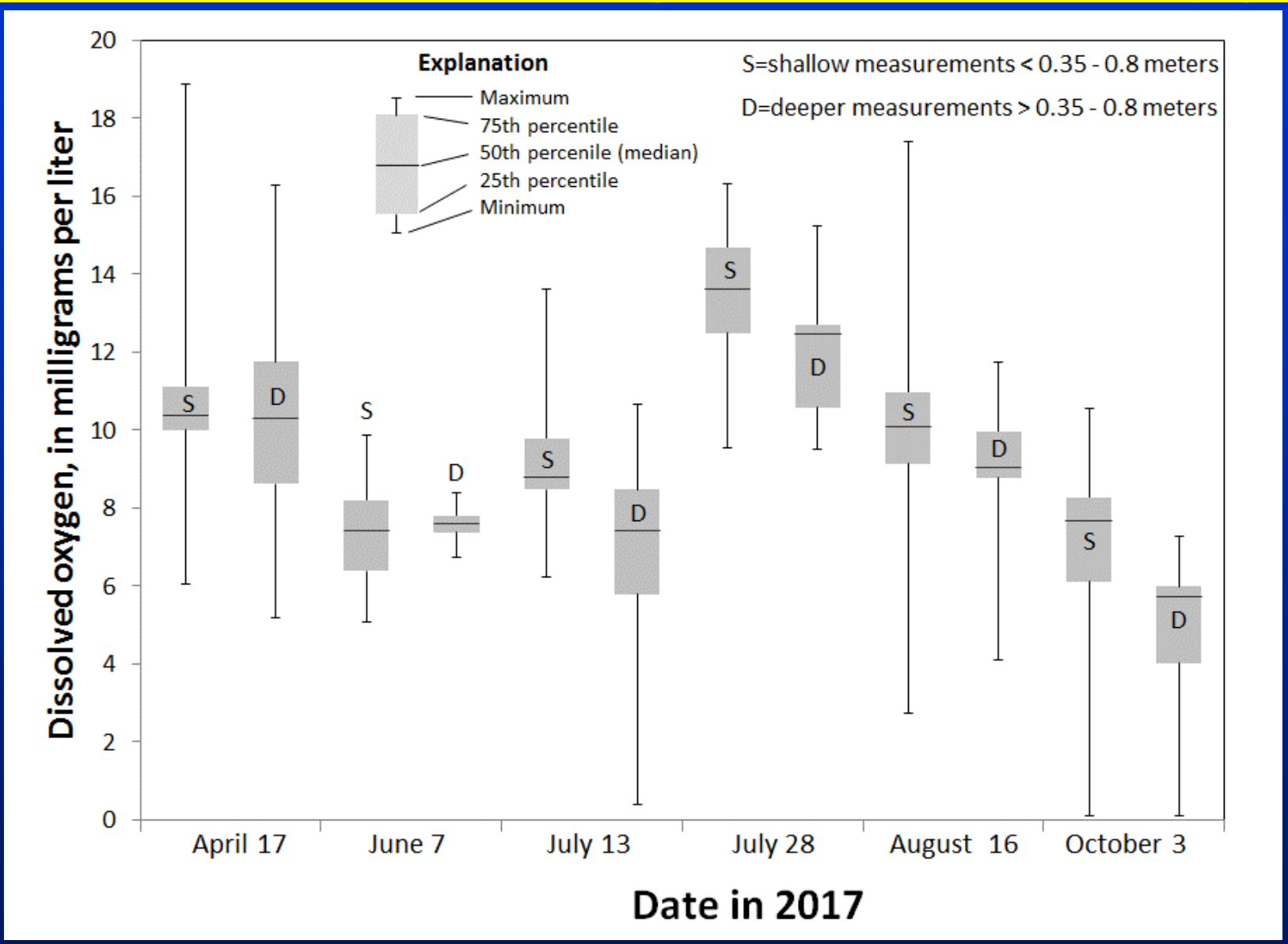
Windsor Island Slough: Dissolved Oxygen



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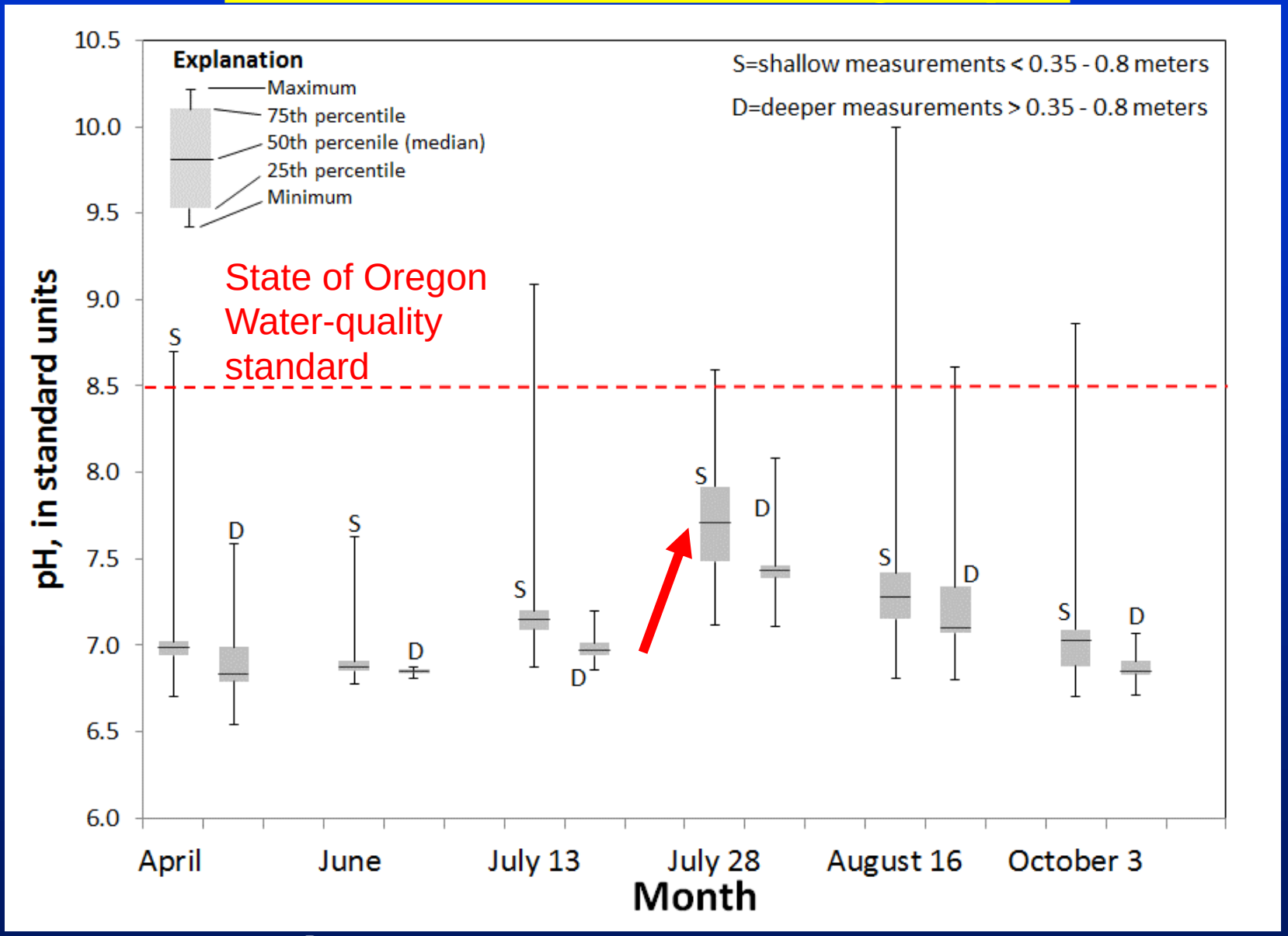
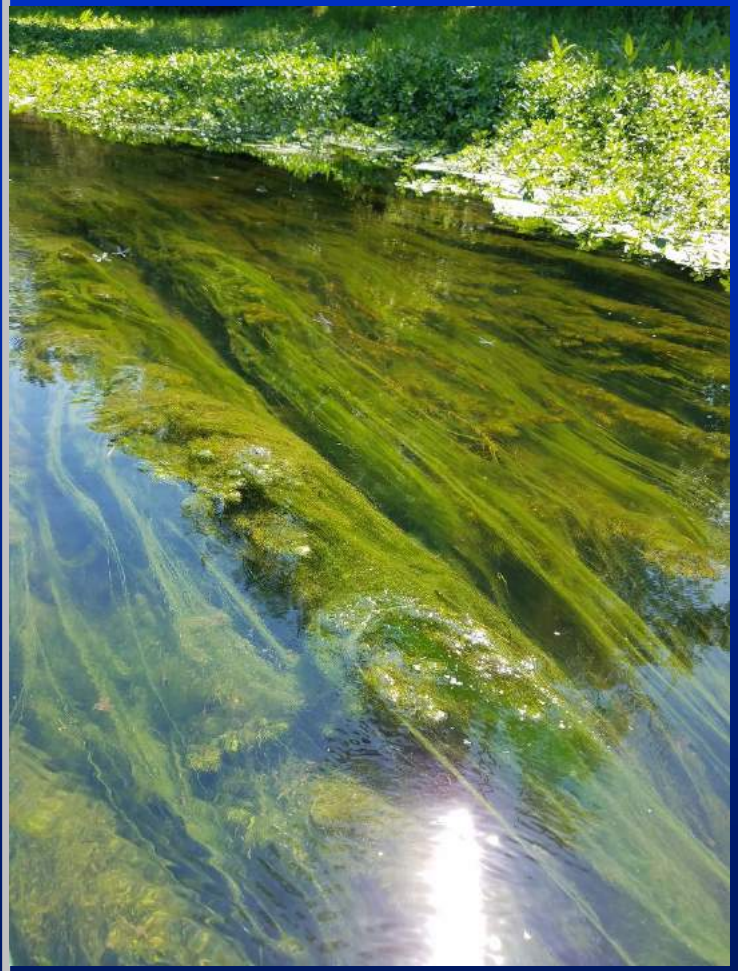
Windsor Island Slough: pH



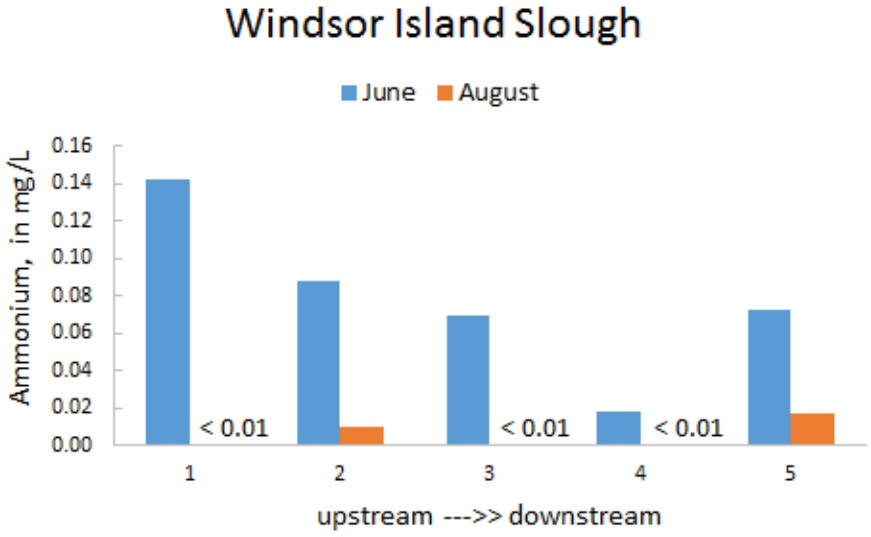
Bioavailable Nutrients: Windsor Island Slough

- Nitrogen and phosphorus fueled filamentous periphyton – green algae (*Oedogonium*) and diatoms (*Melosira*), and rooted, submerged, and emergent macrophytes

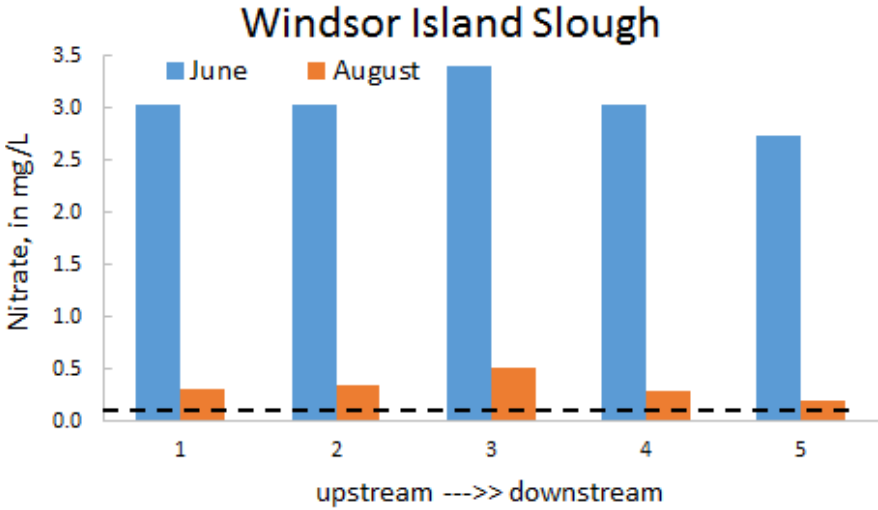


Bioavailable Nutrients: Windsor Island Slough

- Elevated NH_4-nitrogen and especially NO_3-nitrogen
- Seasonal and longitudinal declines in ammonium-nitrogen consistent with plant uptake and oxidation



Data available from USGS National Water Information System (NWIS)



Data available from USGS National Water Information System (NWIS)

- Large seasonal decline in NO_3-nitrogen consistent with plant uptake and possibly denitrification and/or seasonal reduction in groundwater inflows (?)

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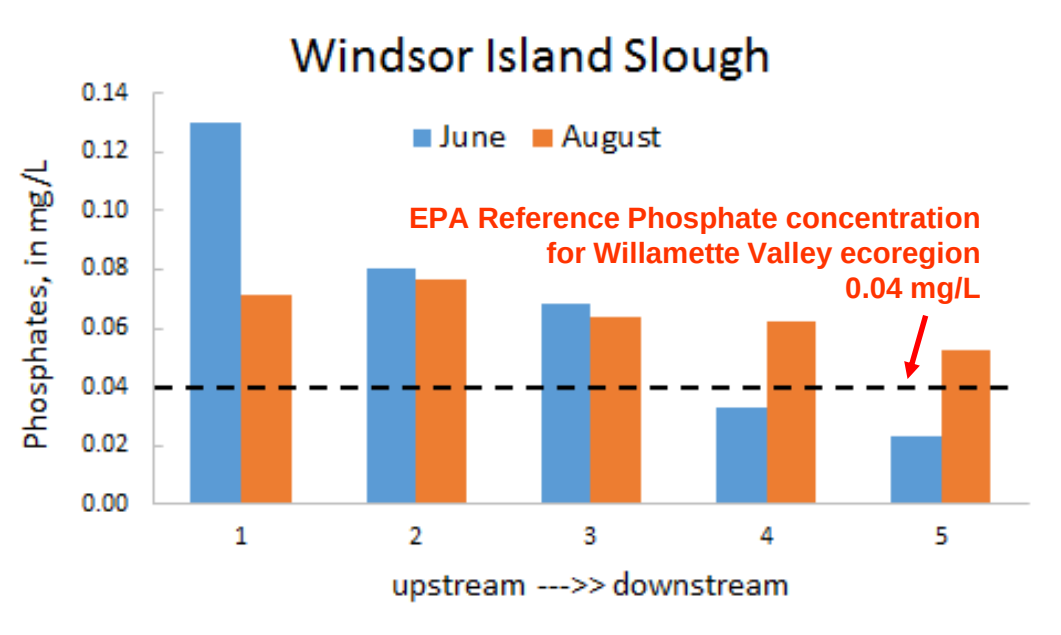
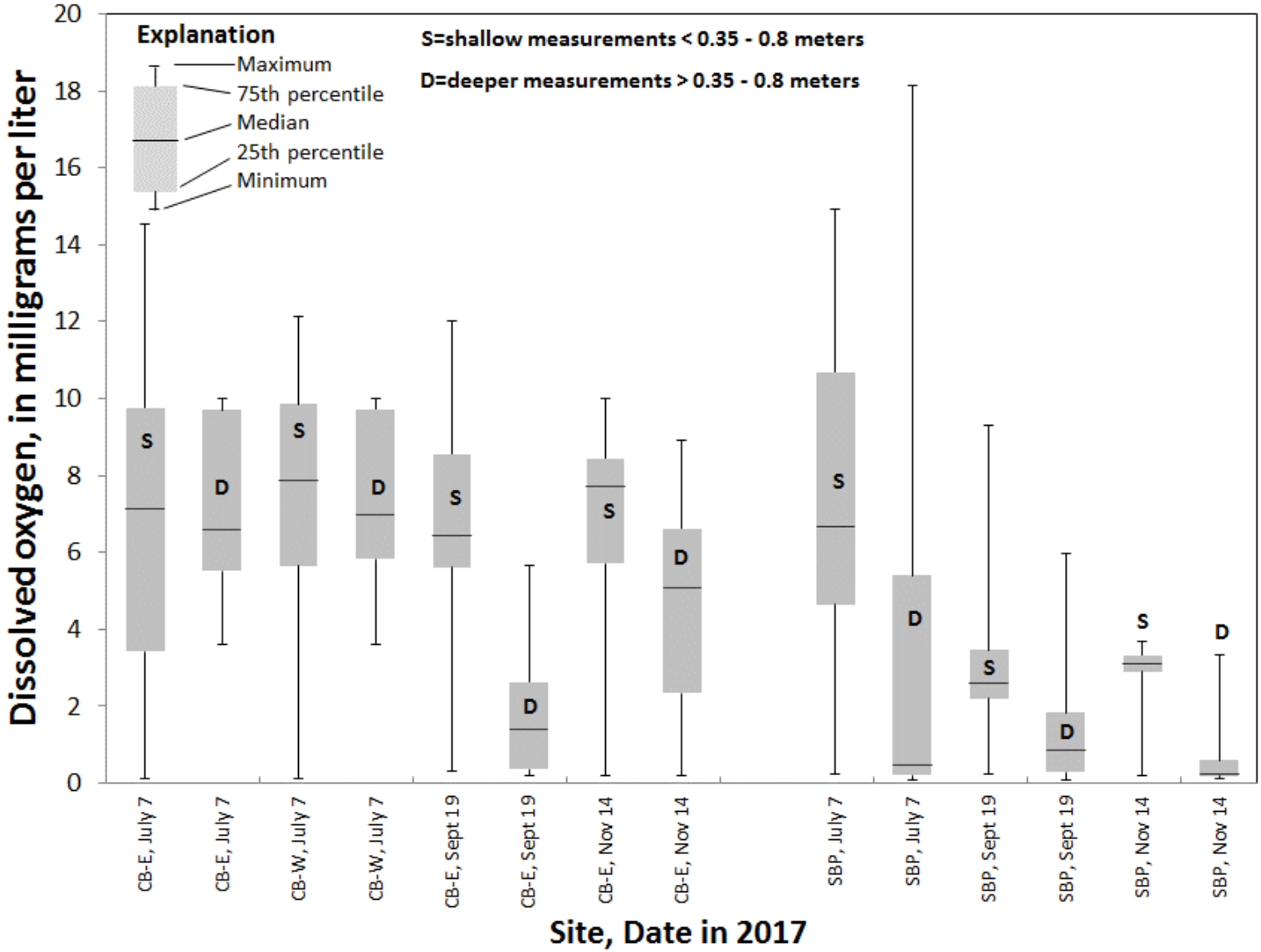
Bioavailable Nutrients: Windsor Island Slough

- Phosphorus concentrations were over 3 times the EPA reference (0.04 mg/L) – fueled growth of green algae and filamentous diatoms and macrophytes (*C. demersum*) that obtain nutrients from the water
- P concentrations declined downstream in June, then stable but still elevated in August



Data available from USGS National Water Information System (NWIS)

Collins Bay and Scatter Bar Ponds: DO



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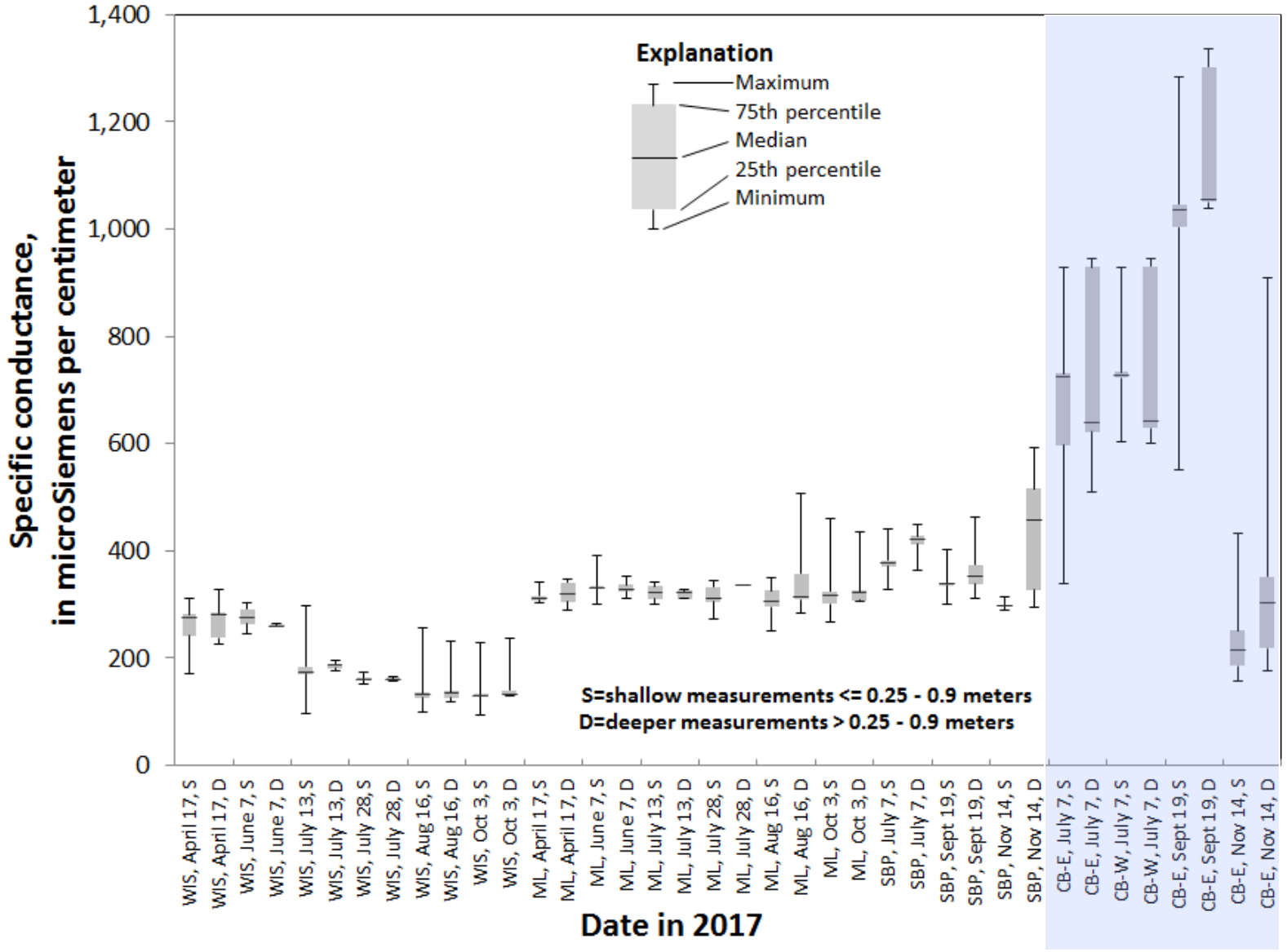
Collins Bay-East: Conductivity



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Water Quality Conclusions

- Aquatic plants (macrophytes and algae) produce swings in DO and pH to levels that do not meet WQ standards
- Habitat impacts include loss of open water and, in Mission Lake, organic enrichment of bed sediment
- Community respiration in the water and bed sediments cause hypoxic conditions
- Low oxygen may limit suitable habitat for cold water fish but may provide opportunity for denitrification
- Connectedness of side channels, hydrology, and local influences (GW and quarry discharges) may affect water-quality, habitat, and plant communities

Possible Next Steps

- Potential herbicide treatments
- Post treatment removal of dead biomass (?)
- Planning pre- or post-treatment monitoring
- Funding for publications

Swamp Devil® Weed Cutting Machine
Aquarius-Systems

From Invasive *Ludwigia hexapetala* Management Plan for the Delta Ponds Natural Area (Eugene, OR)

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