Selenium Fate and Transport in Ambassador Duck Club Wetlands

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Presentation Outline

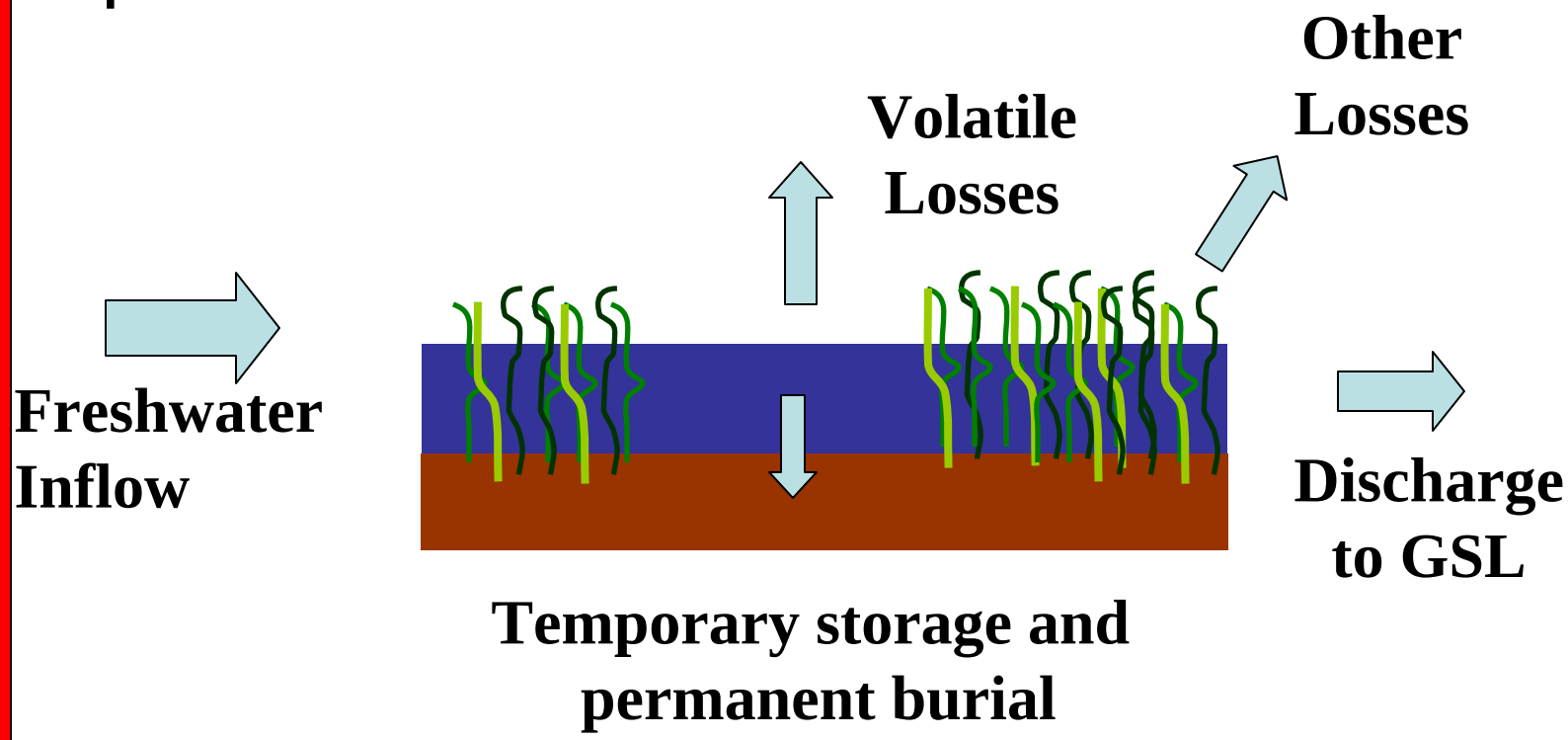
- Research Overview
- Field Observations
- Selenium Partitioning
- Model Development
- Research Status

Research Overview

- What happens to Selenium as it is transported through the GSL wetlands?
- How much of the Se that enters the wetlands is discharged to the GSL?
- Is the wetlands either storing or losing Se?
- Can the wetlands serve as a Se source under the proper conditions?

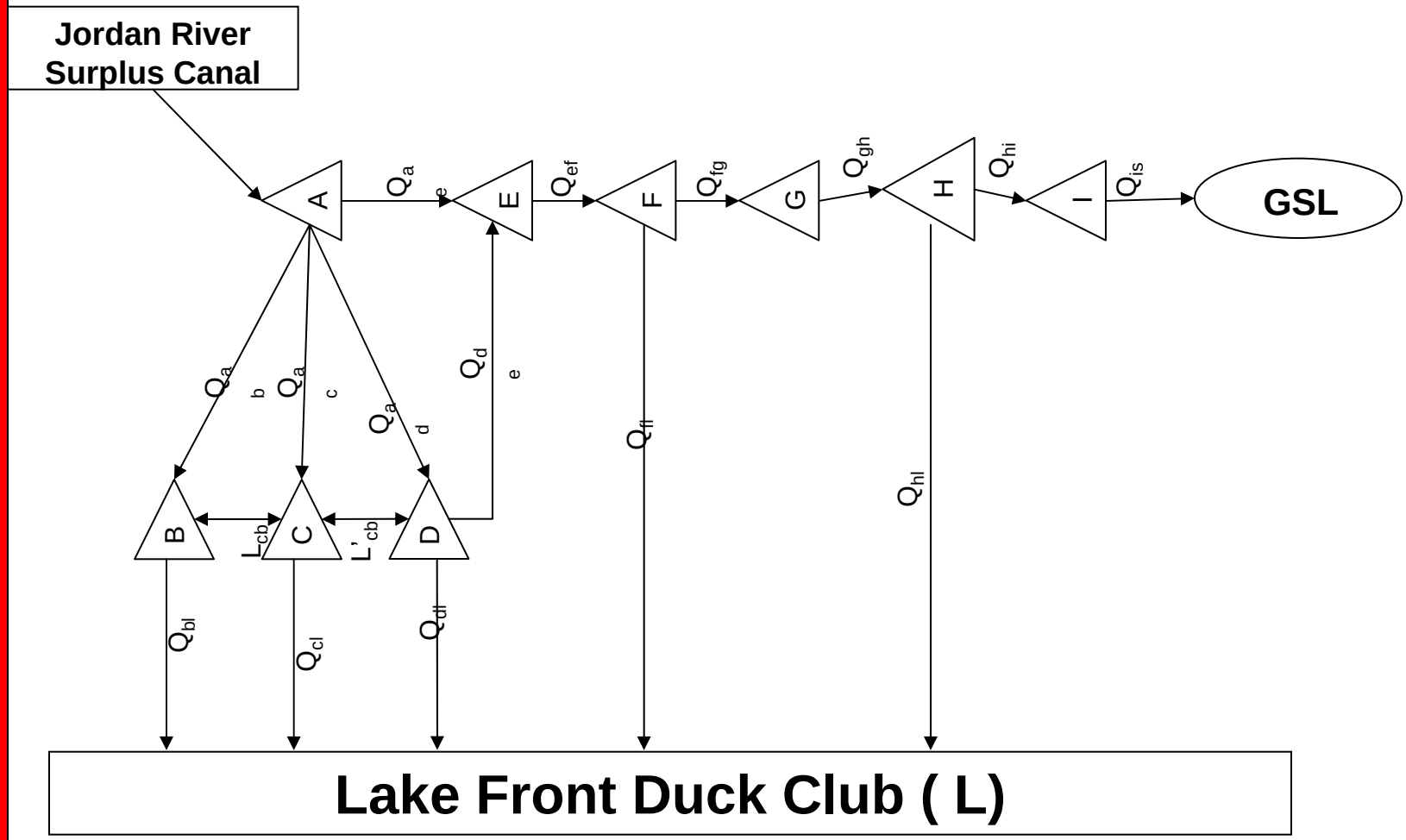
Research Goal

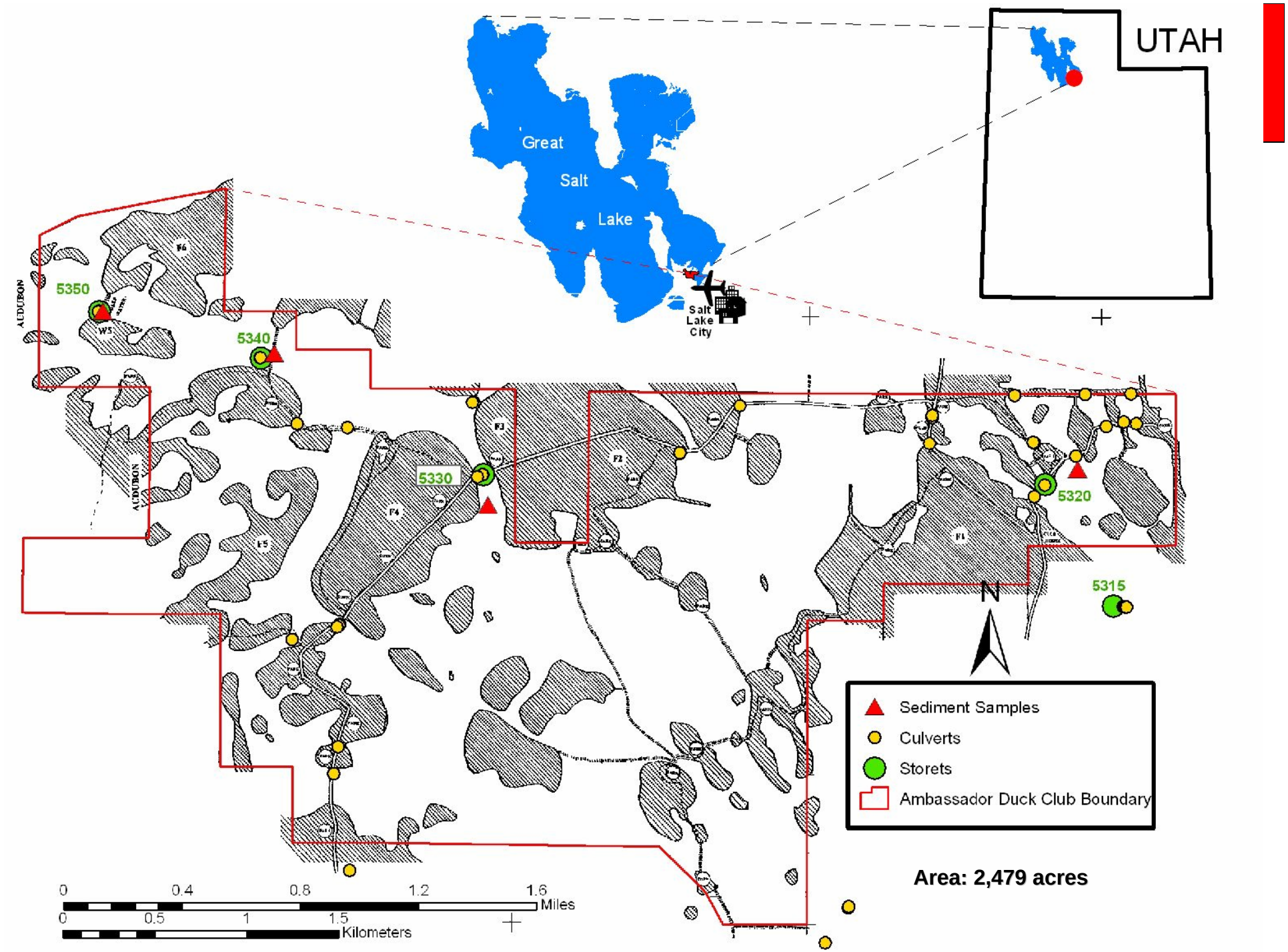
- Quantify selenium fate and transport processes



Interconnected Wetland Ponds

Conditions change significantly as water flows from Pond A to the GSL.




UTAH
Great
Salt
Lake
Salt
Lake
City
5350
5340
5330
5320
5315
N
Sediment Samples
Culverts
Storets
Ambassador Duck Club Boundary
Area: 2,479 acres
0
0.4
0.8
1.2
1.6
Miles
0
0.5
1
1.5
Kilometers

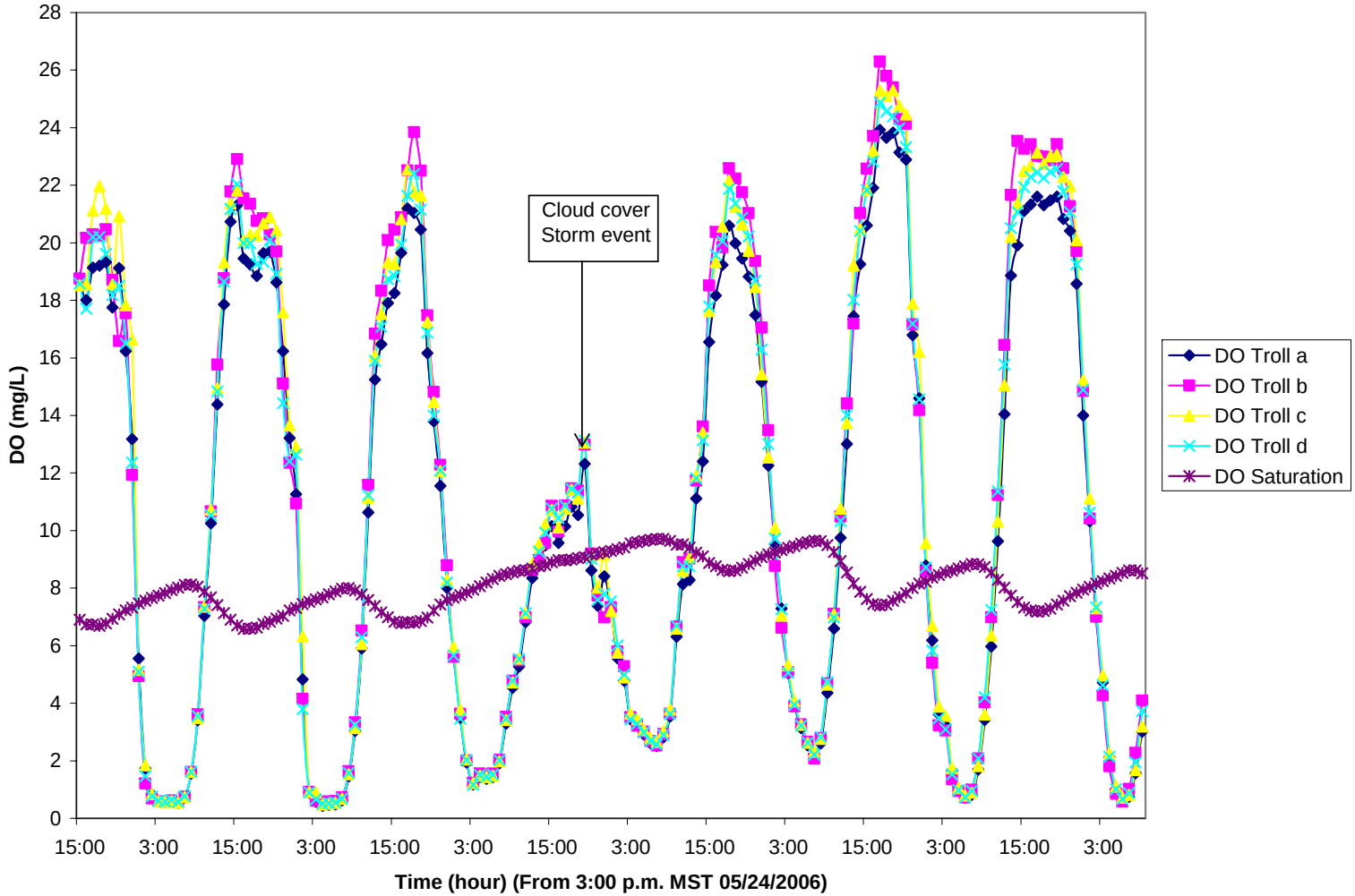
Chemical Parameter	Unit	Site 5315	Site 5320	Site 5330	Site 5340[3]	Site 350[3]	Farmington Bay #4985430)	Typical FW Eutrophic Wetland[1]
Nitrate + Nitrite	mg/L	<0.1 – 1.2	<0.1 – 2.85	<0.1 – 0.28	<0.1 – 0.16	<0.1 – 0.68	<0.1 – 0.1	0.1 – 0.7
Ammonia, N	mg/L	0.1 – 0.9	0.06 – 0.69	<0.05 – 0.26	<0.05 – 0.47	<0.05 – 0.26	0.10 – 0.65	0.1 – 1.6
Total P	mg/L	0.3– 1.1	0.26 – 2.81	0.04 – 0.73	0.04 – 0.38	0.02 – 0.27	0.03 – 0.29	0.1 – 0.7
Dissolved P	mg/L	-	1.0 – 1.1	0.16	-	-	-	0.1 – 0.5
Dissolved Na	mg/L	74 - 281	74.7 - 241	109 - 407	267 – 2110	407 – 3770	520	5 - 24
Dissolved K	mg/L	6 – 20.9	5.7 – 17.6	7.95 – 31.6	20.6 – 106	31.8 – 172	21.6	0.9 – 9.1
Dissolved Ca	mg/L	50 – 83.6	45 – 98.6	42 – 72	40 – 85	39 – 149	39.3	56 – 168
Dissolved Mg	mg/L	21 – 57.3	20 – 55	3.5 – 87.8	17.3 – 200	36 - 275	44.9	23 – 73
Dissolved Mn	μg/L	5 – 48.1	5.6 – 28.7	5 – 15.2	5 – 10	5 - 10	2.5	-
Dissolved Fe	μg/L	<20	<20 – 58	<20 – 49.8	<20 – 32.7	<20 – 30.3	<20	-
Chloride	mg/L	93 - 417	33 - 334	102 - 660	105 – 3590	10 - 5730	296 – 606	17 – 54
Sulfate	mg/L	84 - 278	21 – 315	215 - 461	211 - 476	47 - 1820	114 – 312	15 – 99
Bicarbonate	mg/L	144 - 328	65 – 393	218 - 300	208 - 264	20 – 416	-	-
Carbonate	mg/L	0 - 31	0 – 31	0 - 40	0 – 60	0 – 56	-	-
TOC	mg/L	2.3 – 3.7	0.7 - 34	-	1.5 - 41	-	-	-
Alkalinity	mg/L	142 - 269	131 - 339	179 - 259	171 - 276	85 – 341	74 - 464	270 – 420
TDS	mg/L	412 – 1949	394 - 1690	608 - 6000	1250 – 12338	1606 – 12960	820 – 2380	-
Salinity	ppt	0.5 – 1.6	0.4 – 1.1	0.6 – 1.8	0.6 - 7.9	0.4 - 12	0.95 – 2.25	-
TSS	mg/L	6.4 - 44	<4 - 110	<4 - 52	<4 - 143	<4 – 88	<4 – 33	-
DO	mg/L	2.3 – 15.7	0.4 – 24	0 – 14.4	0 – 17.0	0 – 13.6	2.9 – 13	-
ORP (Ag/AgCl)	mV	-100 - +300	-50 - +400	-50 - +310	-150 - +380	-170 - +290	-	-
Chlorophyll a	mg/L	2.0 – 3.3	3.2 – 67.1	-	-	-	-	-
Water Temp.	^{0}C	3.3 - 27	3.0 – 27.6	1.2– 28.2	2.4 – 29.4	0.7 – 27.7	11.3 – 26.6	-
Flow	cfs	0 – 70[3]	0 – 35[4]	0 – 10.3	0 - 4	0 – 2.4	-	-
BOD_5	mg/L	<3 - 3	<3 - 3	-	-	-	-	-

Metals

Metal[1]	Units	Site 5315	Site 5320	Site 5330	Site 5340	Site 5350	Utah Water Quality Standards[2]	Constructed Wetlands [3]
Se, total	**µg/L**	**0.66 – 1.78**	**0.75 – 1.99**	**0.36 – 1.50**	**0.78 – 1.88**	**0.41 – 1.07**	**-**	**4.0 - 300**
Se, filtered	**µg/L**	**0.21 – 1.43**	**0.31 – 1.78**	**0.26 – 1.32**	**0.33 – 0.78**	**0.29 – 0.41**	**4.6**	**-**
As, filtered	µg/L	6.9 – 10.3	7.3 – 12.7	5.3 – 27.3	6.9 – 30.5	11.0 – 26.9	150	-
Al, “	µg/L	< 30.0	< 30.0	< 30.0	< 30.0	< 30.0 – 60.0	87	30 - 300
Ag, “	µg/L	< 2.0	< 2.0	< 2.0	< 2.0 – 4.0	< 2.0 – 4.0	1.6	0.4 – 4.0
Ba, “	µg/L	<100	<100	< 100 - 137	< 100 - 268	120 - 203	-	-
Cd, “	µg/L	-	< 1.0	< 1.0 – 2.0	< 1.0 – 2.0	< 1.0 – 2.0	0.25	0.2 - 70
Cr, “	µg/L	5.0 – 5.3	5.0 – 7.0	5.0 – 5.5	5.0 – 10.0	5.0 – 10.1	74	< 2.0 - 160
Cu, “	µg/L	< 12.0	< 12.0	< 12.0	< 12.0	< 12.0	9	1.4 - 1510
Hg, “	µg/L	< 0.2	<0.2	-	< 0.2	< 0.2 – 0.31	0.012	3.0 - 7400
Pb, “	µg/L	< 3.0	< 3.0	< 3.0	< 3.0 – 6.0	< 3.0 – 6.0	2.5	-
Zn, “	µg/L	< 30.0	< 30.0	< 30.0 – 60.0	< 30.0 – 60.0	< 30.0 – 60.0	120	3.9 - 2200

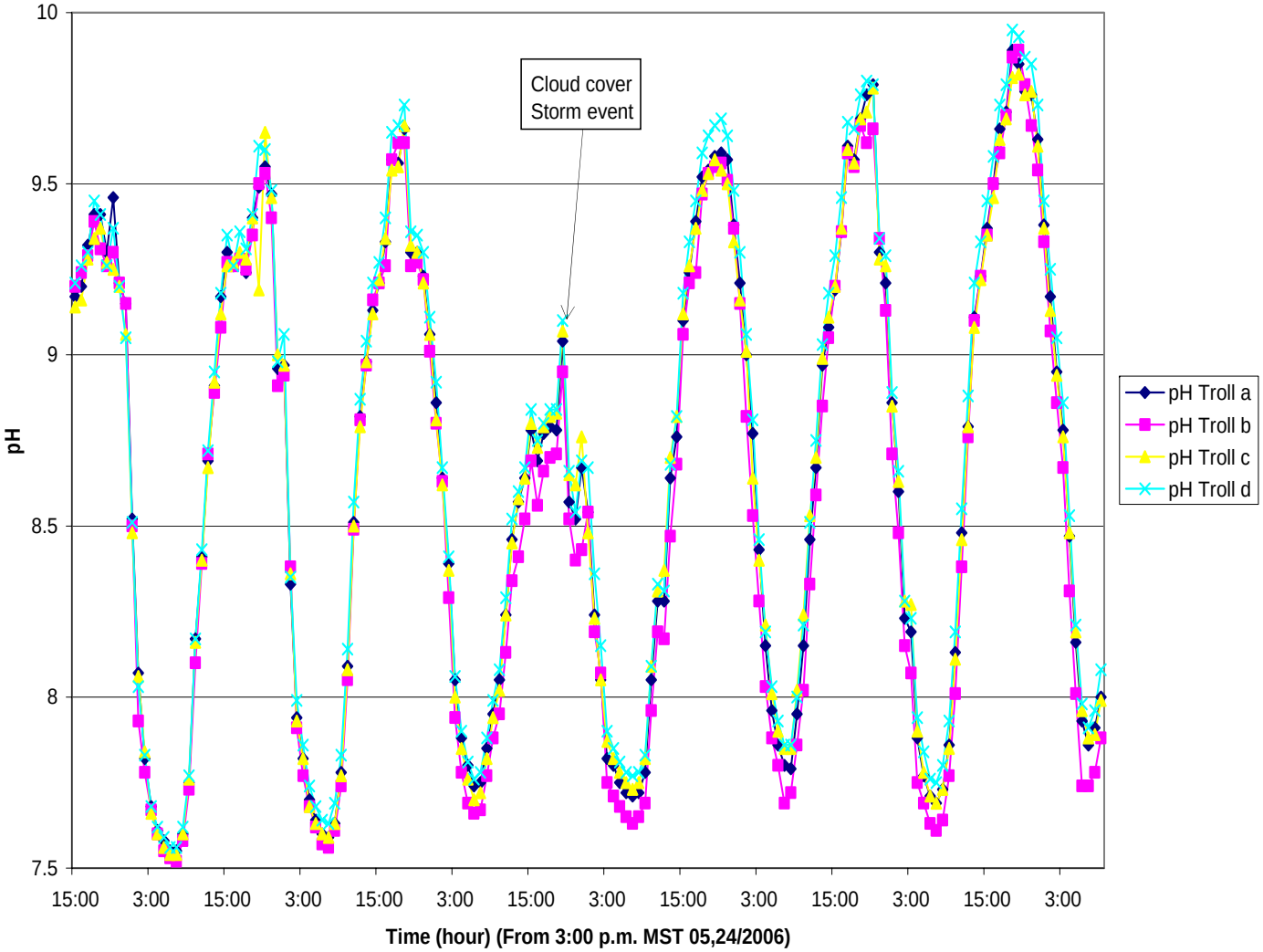
1MDL for selenium with HGAAS method is 0.18 mg/L. As, Al, Ag, Ba, Cd, Cr, Cu, Hg, Pb, and Zn were measures by ICP-MS method.
2Utah Administrative Code R317-2, Numeric Criteria for Aquatic Wildlife, Classification 3D. Based on acute standards and 100 mg/L as CaCO3 Hardness.
3(43).

DAILY DO CYCLE



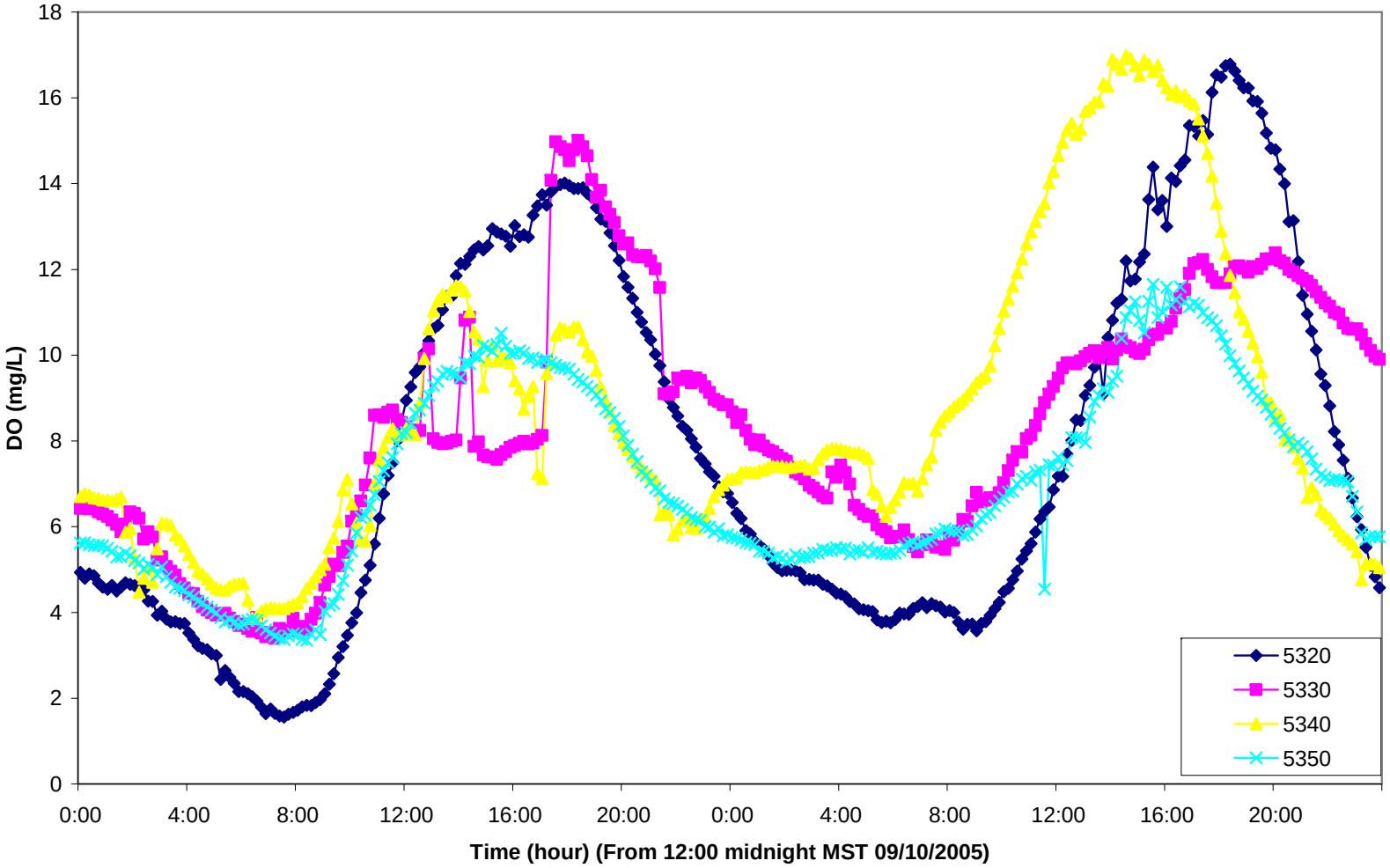
Site #5320 during Spring 2006 using 4 INSITU TROLLs 9000.

DAILY pH CICLE

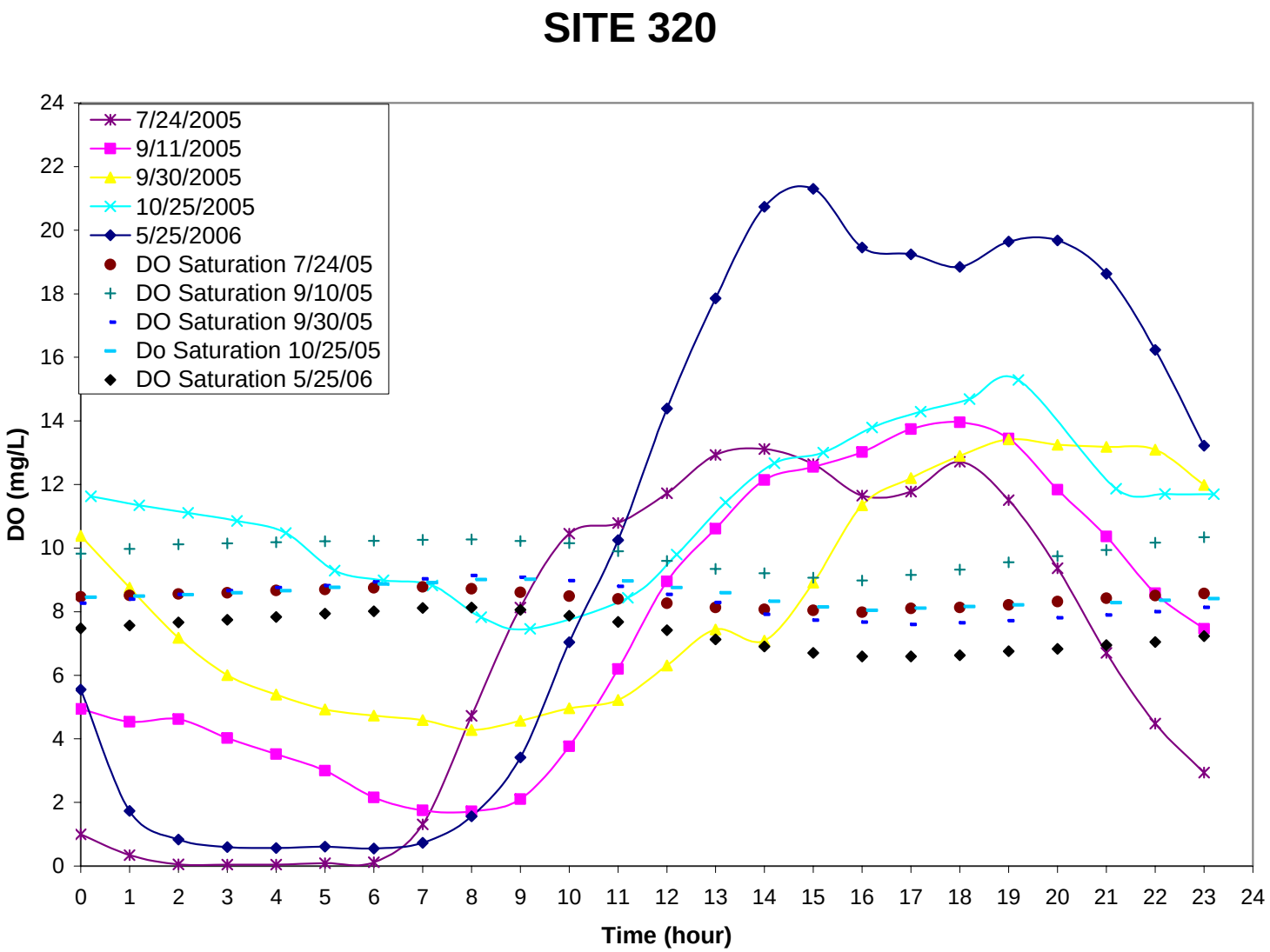


Site #5320 during Spring 2006 using 4 INSITU TROLLs 9000.

DO DAILY CYCLE

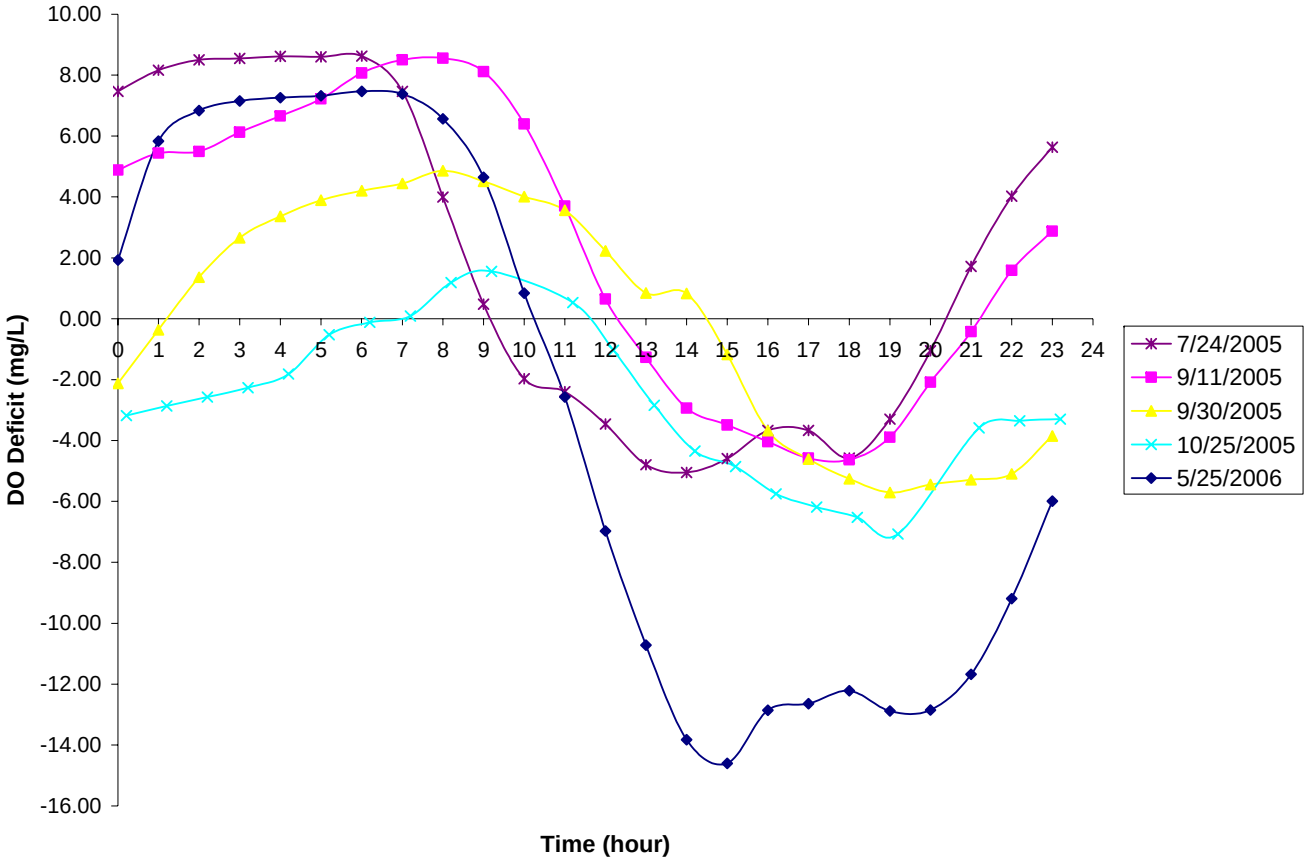


DO SEASONAL CYCLE

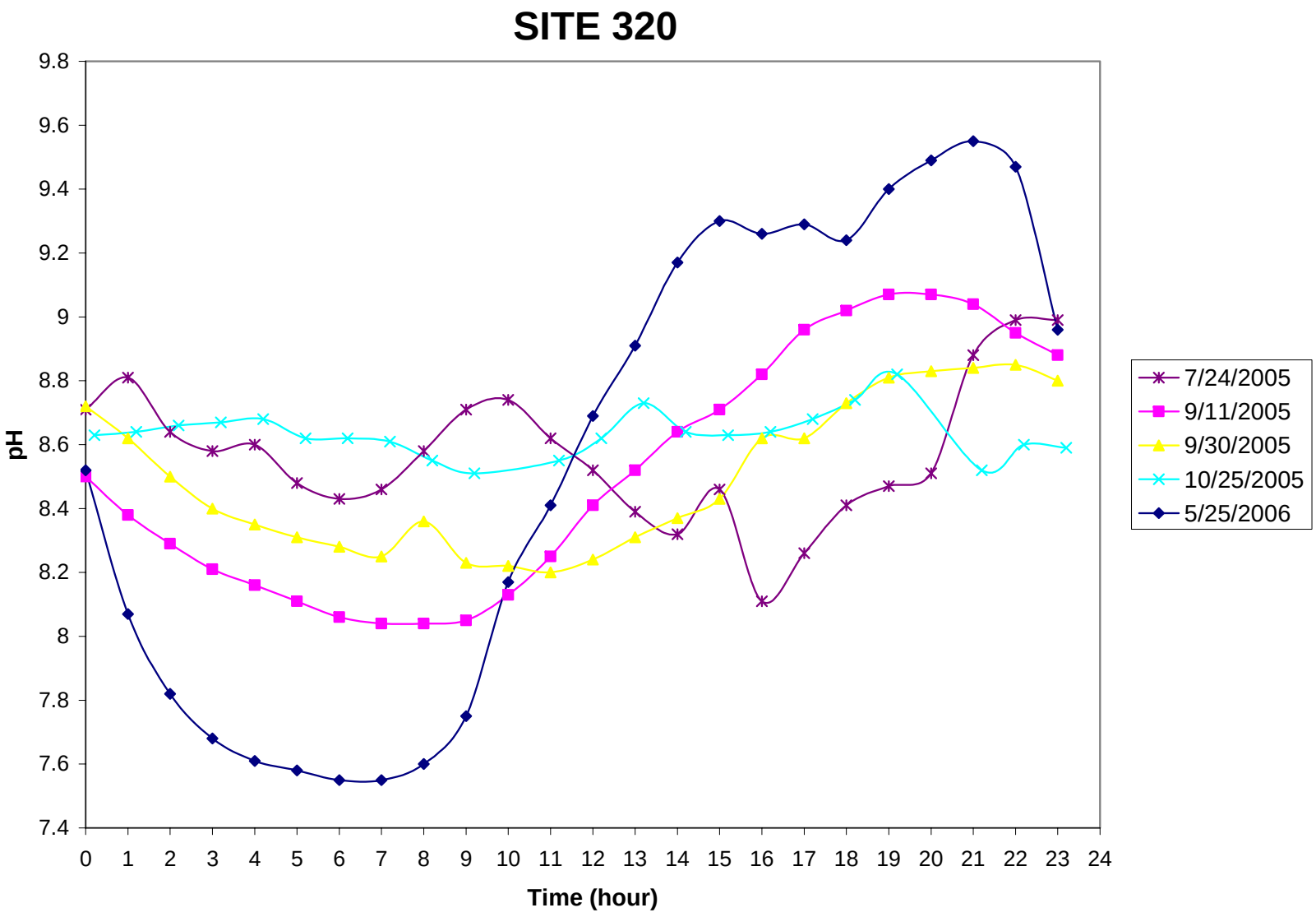


DO DEFICIT

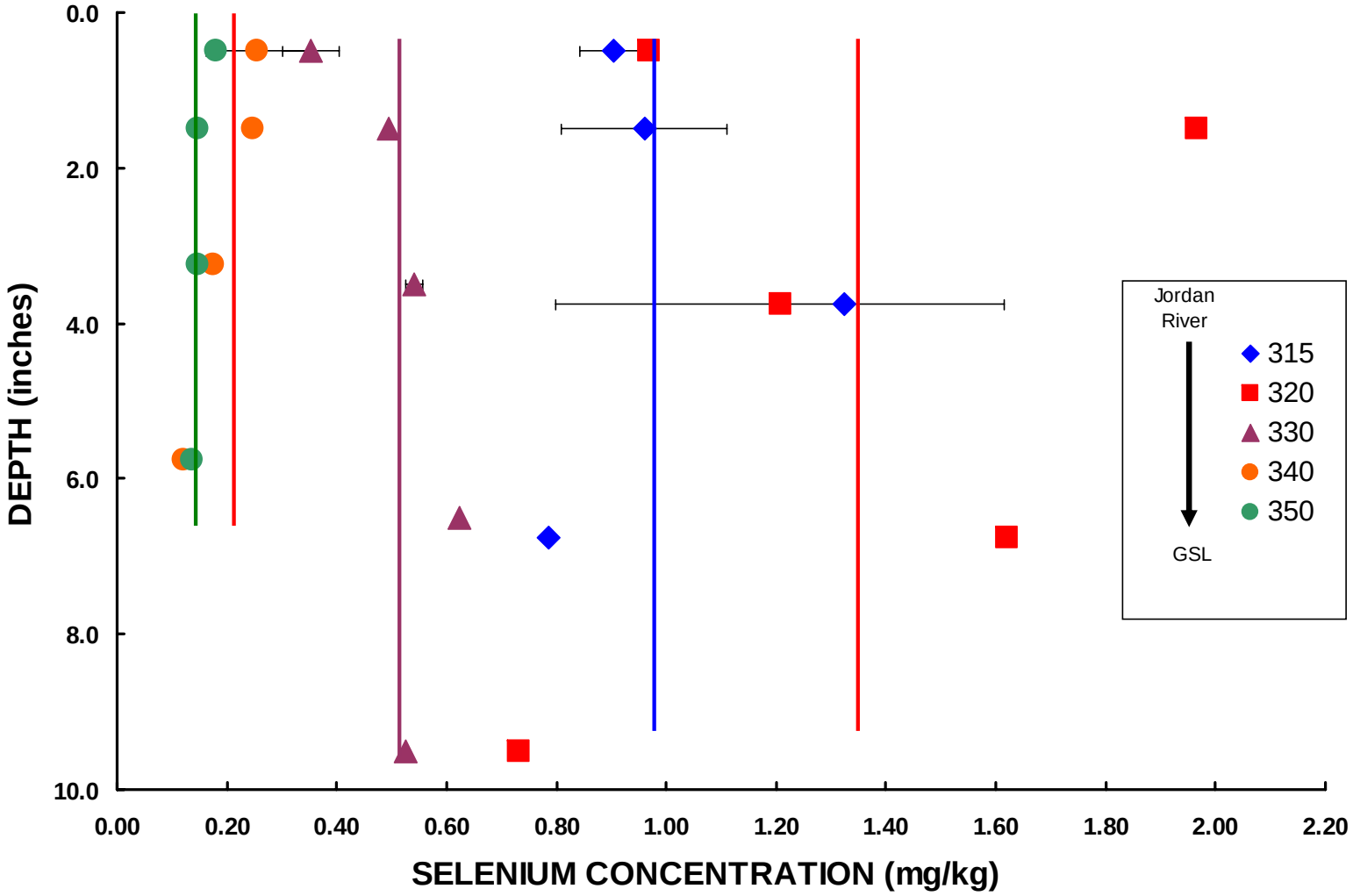
SITE 320



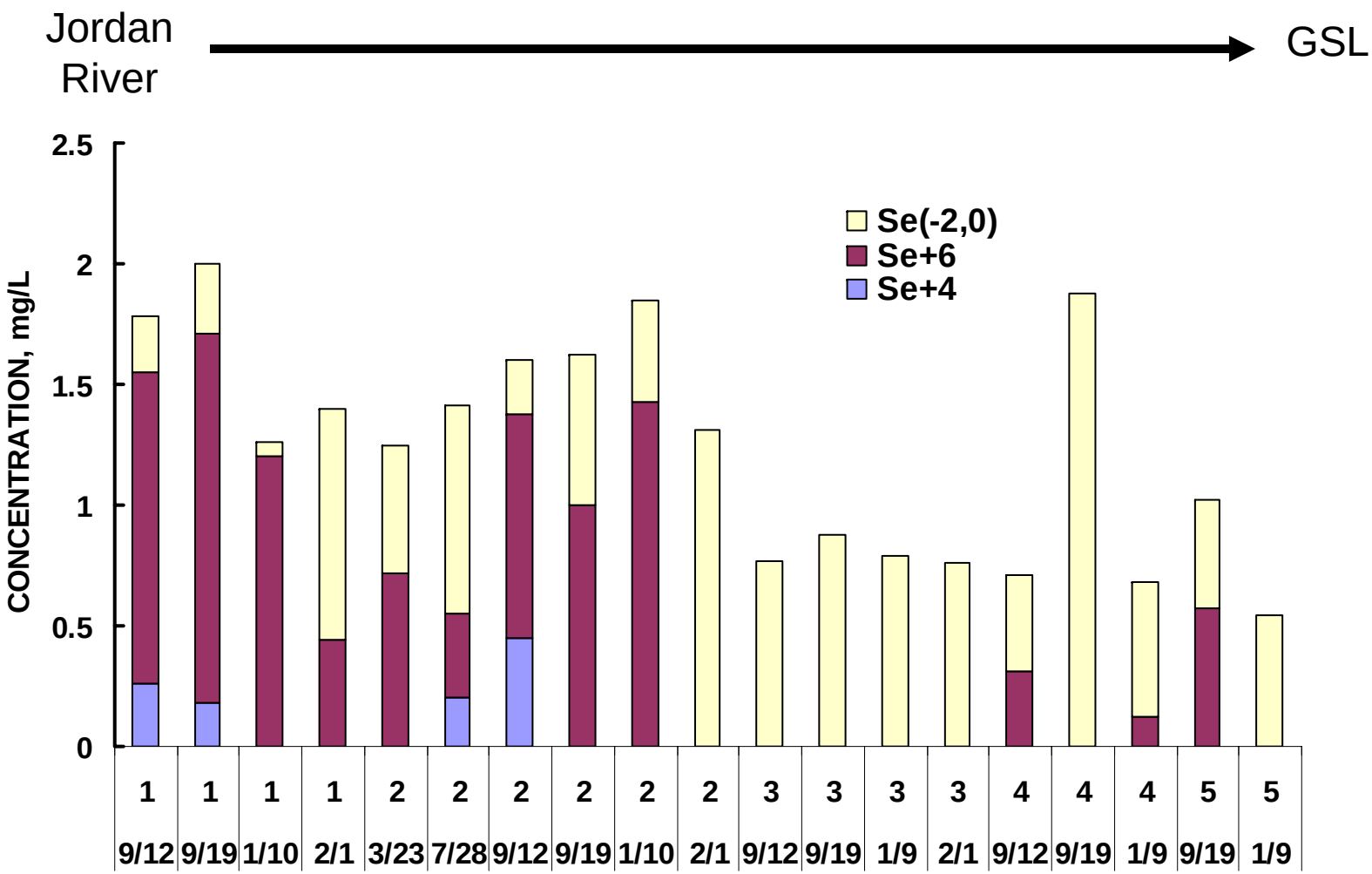
pH SEASONAL CYCLE



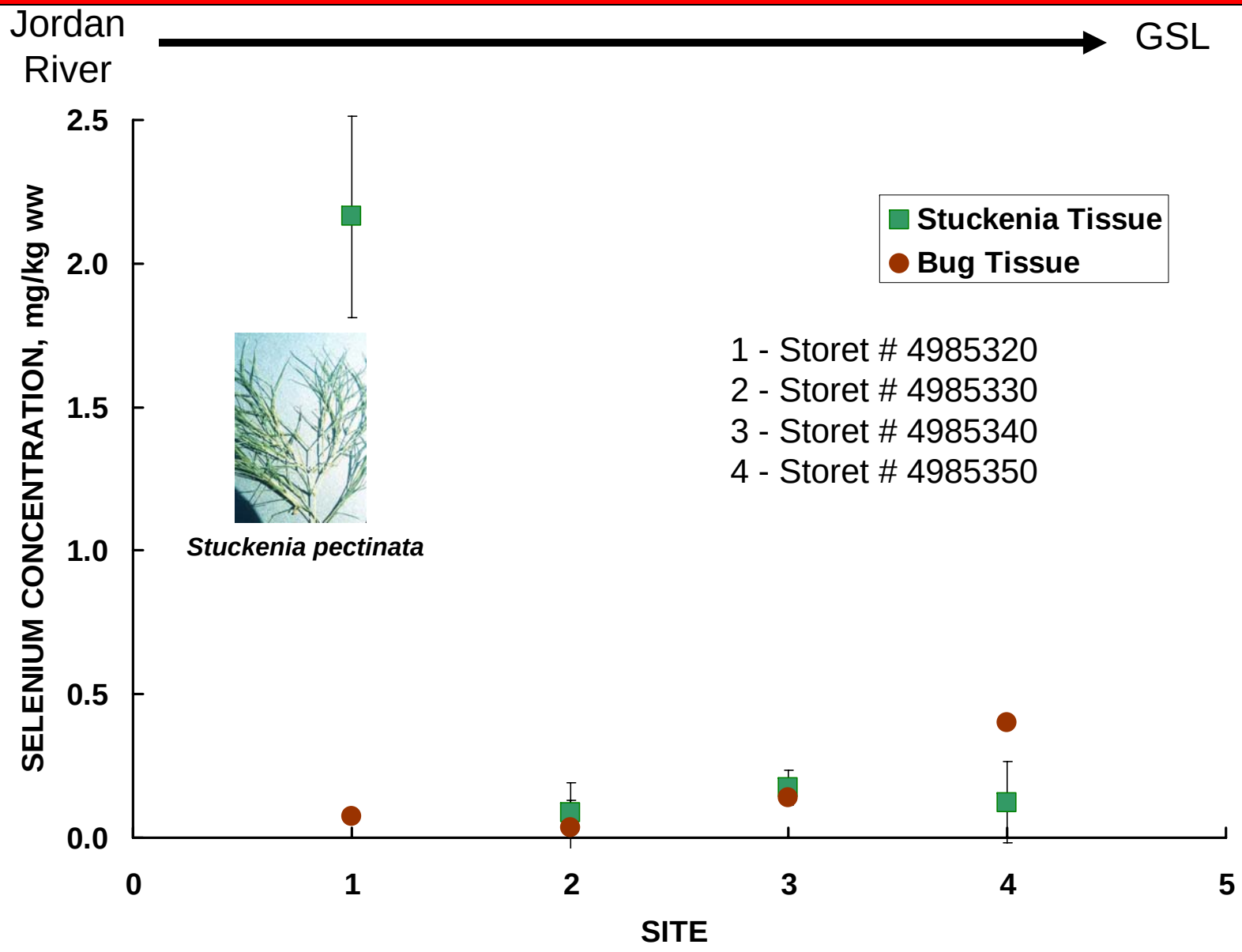
Sediment Selenium Concentrations



Selenium Fate - ADC Wetlands



Selenium in Tissues



Field Data Summary

- Most of the data have been collected
- Some supplemental data collection in Spring/Summer 2007
- Environmental conditions within the wetlands vary dramatically over the course of a day; this impacts Se fate and transport
- Se generally decreases as it goes through the wetland

Se Partitioning – Water Column

- Particulate/Dissolved Se:

  $Kd = c_P/c_W$

Site	Kd Value, L/Kg
315	36
320	67
330	97
340	69
350	25

Se Partitioning - Sediments

- Sediment/Water Se

$Kd = c_S/c_W$

Site	Kd Value, L/Kg
315	706
320	707
330	340
340	242
350	242

Se Model Formulation Efforts

- Time-variable Se Model is necessary to understand short-term and long-term based fate and transport
- System drivers
  - Selenium loading to the wetlands
  - Solar energy (Photoperiod & cloud cover)
  - Water Temperature
  - Nutrient concentrations
  - Algal production
- Effects are shown by
  - Dissolved Oxygen
  - pH
  - Selenium speciation
- Short-term modeling (~ 1 day) will help understand the system dynamics
- Long-term modeling (1 yr or more) will understand seasonal pattern and broad impacts on GSL Se loading

Research Status

Task	% Complete
1. Literature Review	100%
2. Wetland Water Budget	100%
3. Initial Field Studies	100%
4. Supplemental Field Studies	85%
5. Biological Studies	95%
6. Model Formulation/Validation	50%

Student Support

- Rino Dicataldo (PhD) – transient model of Se fate & transport in a single wetland pond
- Nagendra Dev (PhD) – extend Rino's model to the integrated wetland ponds
- Beau Uriona (MS) – Se partitioning rates under varying conditions