Iron Oxide Accumulation Profiling Within the Initial Oxidation Unit of a Passive Treatment System

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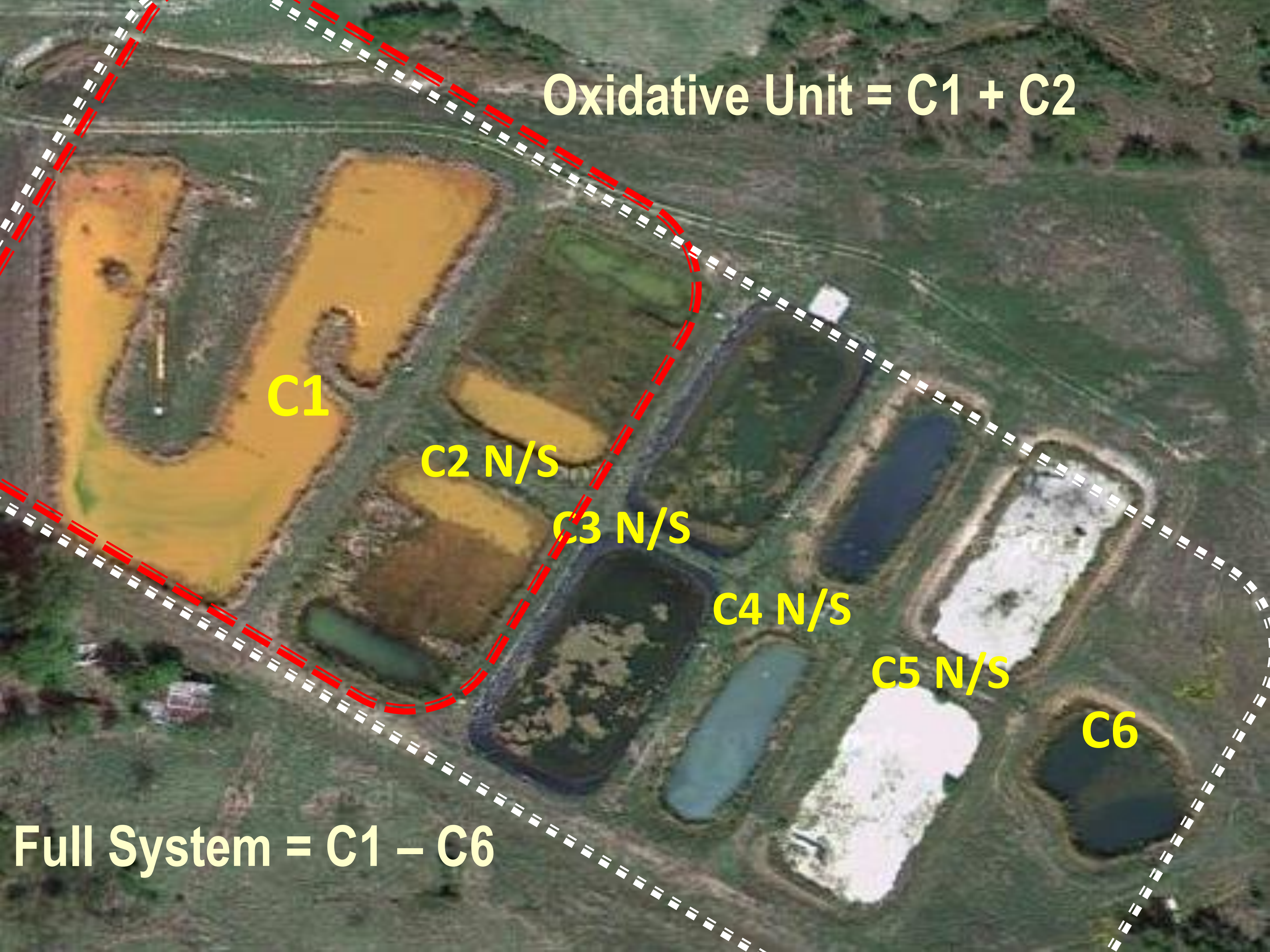

Oxidative Unit = C1 + C2
C1
C2 N/S
C3 N/S
C4 N/S
C5 N/S
C6
Full System = C1 – C6

Average AMD Water Quality Properties

n= 40   2004-2008 pre system construction

Component	Concentration
Iron	191.0 ± 10 mg/L
Zinc	9.65 ± 1.0 mg/L
Manganese	1.60 ± 0.1 mg/L
Lead	62 ± 13 µg/L
Cadmium	15 ± 5 µg/L

- Q varies between 400-700 L\min annually
- Influent pH = 5.95 ±0.06
- Net Alkaline
- (Alkalinity 393 ± 13 mg\L $CaCO_3$)
- Average iron removal rate = 22 $g/m^2/day$

Average Iron Removal Performance of Oxidative Unit

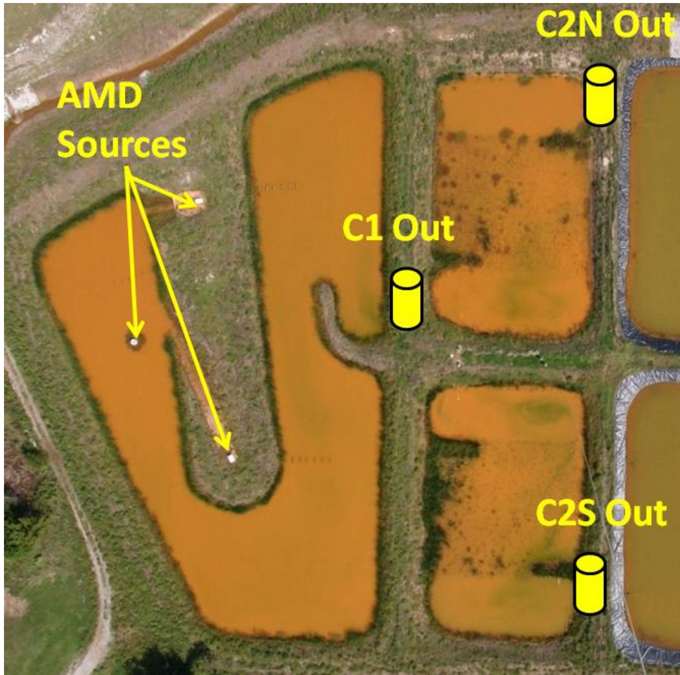
Effluent Discharge	% Total Iron Removal	[Dissolved Fe] in Effluent (n=13)	[Particulate Fe] in Effluent (n=13)
Cell 1	81.6%	23.380 ppm (72.4%)	8.904 ppm (27.6%)
Oxidative Unit	96.0%	5.180 ppm (73.7%)	1.851 ppm (26.3%)
System	99.7%	0.129 ppm (25.9%)	0.369 ppm (74.1%)

Iron Accumulation in Passive Treatment Systems

- Oxidative system units are designed for:
  - Removal (dissolved Fe^{2+} to particulate FeOOH) via oxidation and hydrolysis reactions.
  - Transport of Suspended (settling of FeOOH solids) within the cell, retention within the cell.
  - Storage (settled FeOOH solids mineralize) accumulated solids manifest bulk properties.

Scope of Project

- Interest in iron oxide accumulation profile with respect to total retained solids:
  - Transport out of the oxidative unit
  - Spatial distribution
  - Accumulation volume
  - Physical and chemical characteristics



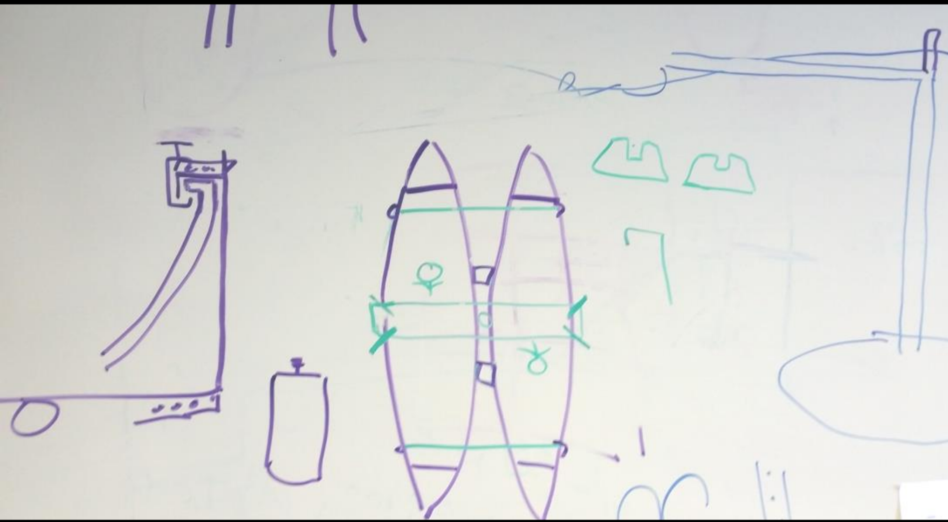
Objective

- Develop methods for profiling iron oxide accumulation in a surface flow wetland of a passive treatment system, with applications to the preliminary iron oxidation pond
  - Sampling
  - Field measurements
  - Transport / Processing
  - Analysis

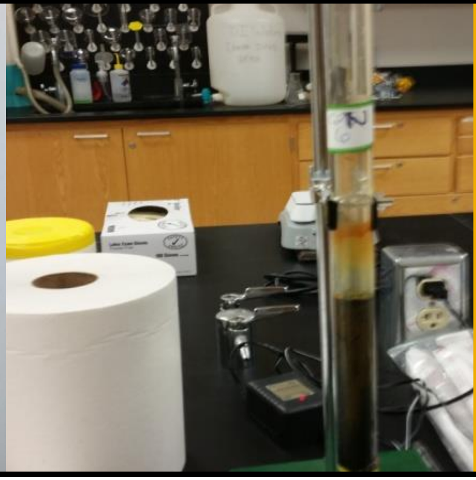
Focus on Long Term Performance

- Solids Accumulation
  - Impaired unit performance via decrease in unit volume (decrease in HRT) + elevated water levels.
- Physical and Chemical Properties
  - Characterization for removal, recovery, and potential commercial applications for iron oxides

Sample Collection and Transport



Method Development Challenges



Sample Processing and Characterization

Sampling Challenges

Sampling Solutions

Sample Collection Methods

CORE SAMPLES

- Vertically sink a clear, acrylic pipe through the solids into the compacted clay.
- Cap both ends of the pipe and measure core depths immediately.
- YSI data and water samples collected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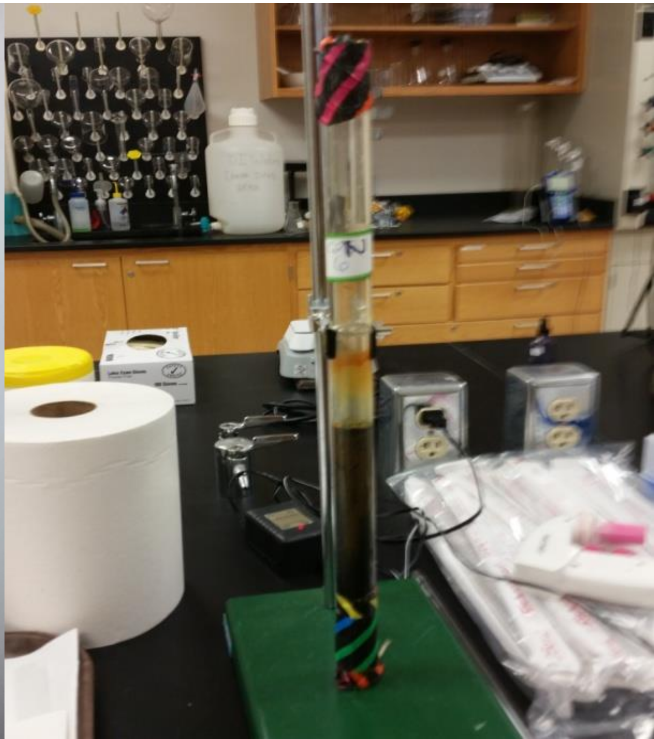
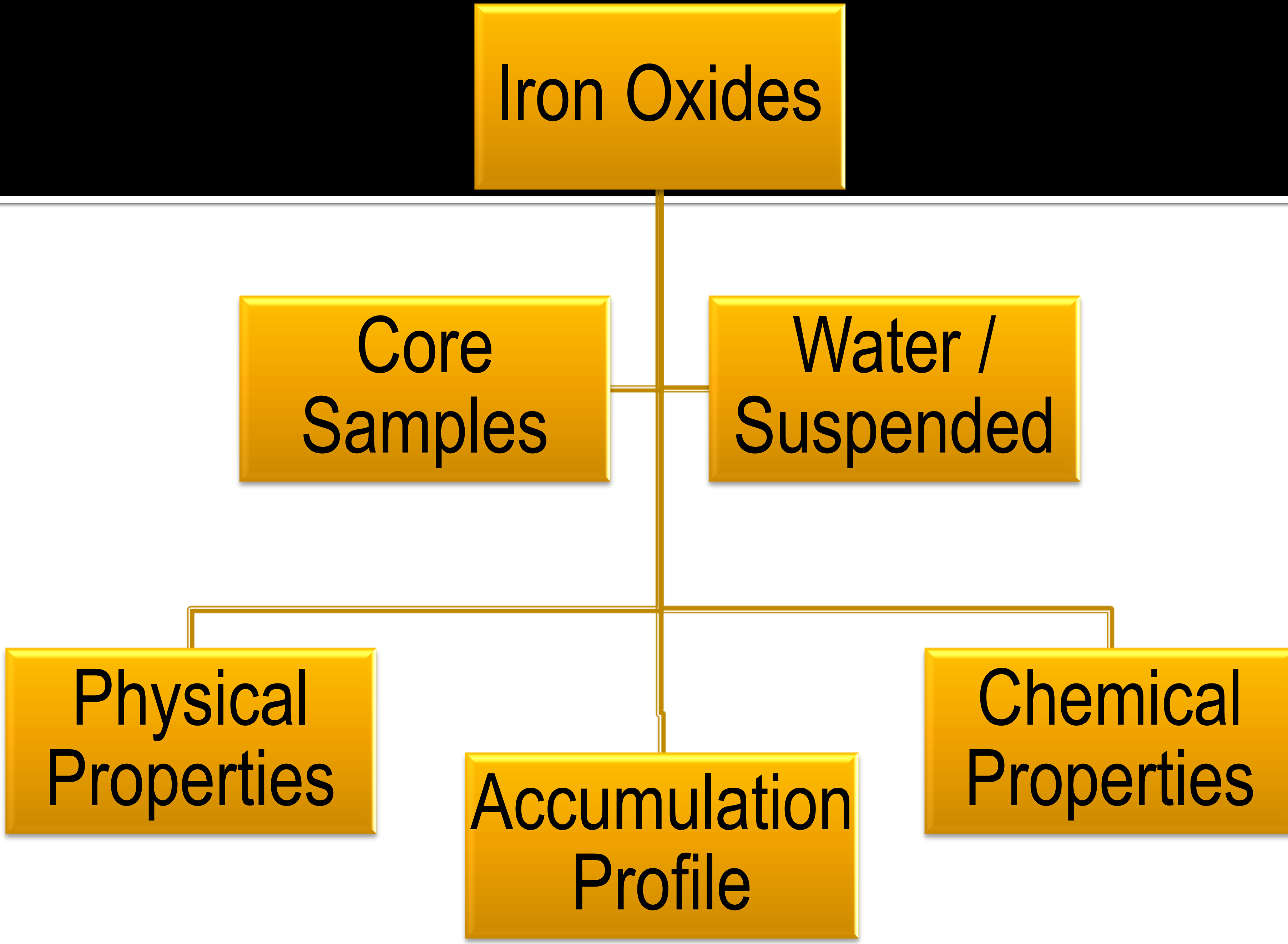
Sample Processing

- Solids collected from the top and the bottom of the core via aspiration.

- Samples represent the oldest material and the newest material




Iron Oxides
Core Samples
Water / Suspended
Physical Properties
Accumulation Profile
Chemical Properties

Accumulation

- Solids gradient observed along design flow path for surface flow wetland.
  - Greatest accumulation in first deep water zone
  - Iron oxide accumulation in all zones

Specific Conductance (mS/cm)

- Spatial distribution patterns observed for:
  - pH
  - Specific conductance
  - Salinity
  - Total dissolved solids
- Supports core sample data for iron removal

Conclusions of Accumulation Profile

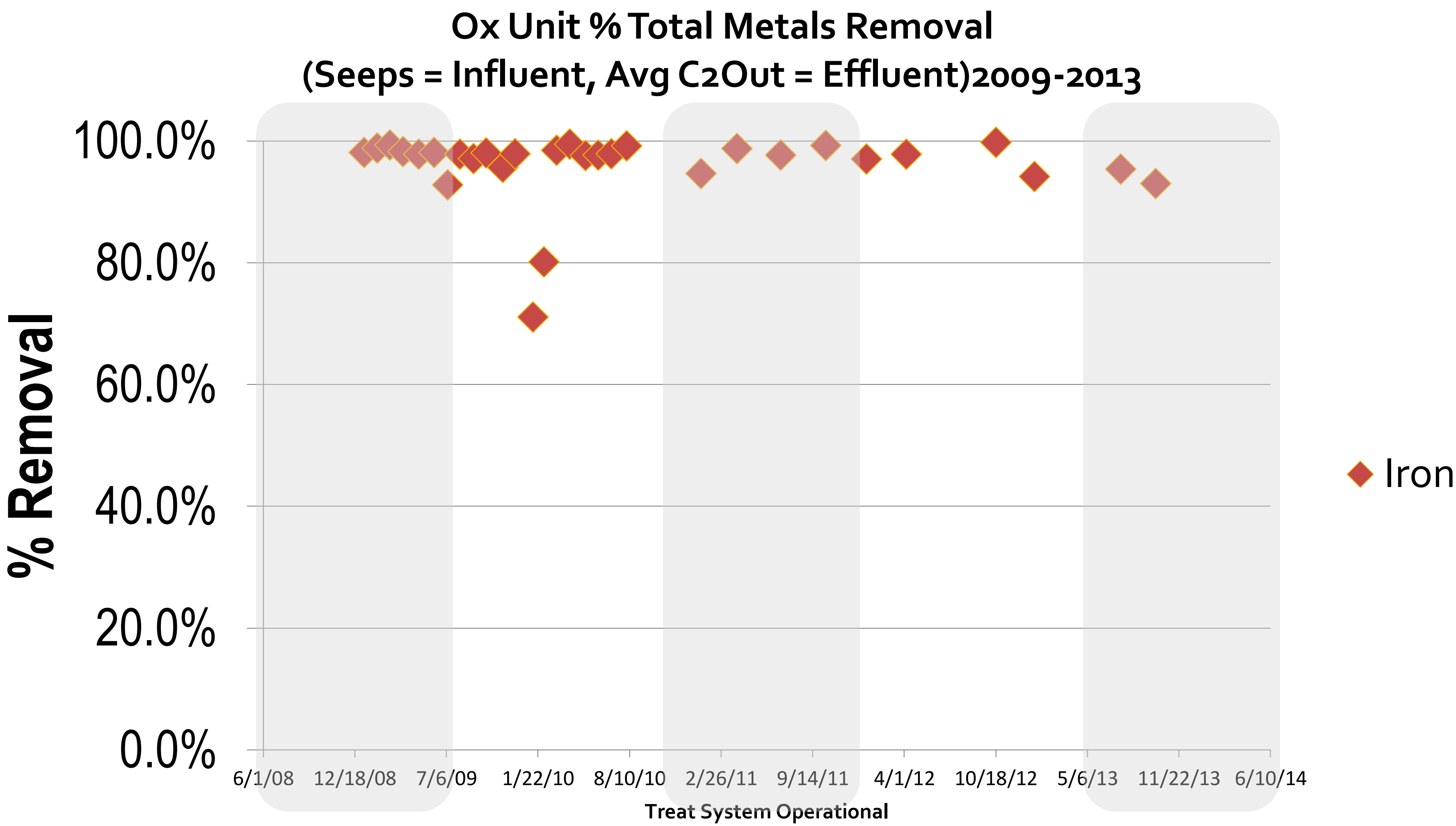
- Solids gradient observed along design flow path for surface flow wetland.
  - Greatest accumulation in first deep water zone
  - Iron oxide accumulation in all zones
- Heterogeneity in solids accumulation
  - Greater resolution achieved via more data points
  - Greater resolution of GIS imagery

Impact on Cell Function

- Deep water zone design depth = 153 cm
- Max accumulation = 39 cm
- % Loss of Depth$_{max}$ = 24% over six years

- Accumulation in planted zone observed but not impacting plant growth / dev
  - high water levels and muskrats reduce plant coverage

Oxidative Unit Iron Removal



What's Next?

- Characterization of Collected Solids
- Expand scope to parallel SF wetland for comparison
- Expand scope to preliminary iron oxidation pond.

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ASMR
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Physical Properties

Test	Method	Purpose
Raman Microscopy	Renishaw InVia Raman microscope	Mineral phase identification, transformation gradients
Specific Surface Area	Nitrogen Gas Adsorption (BET method)	Surface area and pore size
Particle size and morphology	SEM microscopy via AuPd sputter coating	Size and particle shapes, gradients
Particle size Distribution	Sequential sieving, MATLAB sieve analysis 5, laser diffraction particle analyzer	particle size distribution and classification
Particle Density	ASTM D5550 - Specific Gravity of Soil Solids by Gas Pycnometer	Particle density (dry) Particle density (wet)
Color Classification	Size selected powders, Munsell Color Scale	Dry bulk powder value, hue, chroma
Organic Matter Content	weight loss on ignition (LOI)	% Composition of organic material
Water Content	weight loss via drying at 105°C)	% Composition of water

Chemical Properties

Test	Method	Purpose
Solids Metal Content (Fe, Pb, Zn, Cd, As)	EPA 3051a; EPA 6010 (2009) Solids Acid Digestion Percent composition of trace metals (w/w) per unit mass of solids (MARS, ICP-OES)	Verification of trace metal removal observed in water quality data
% Crystallinity	Acid Oxalate Extractions (AOE)	% Crystallinity, Gradients