Batwater Slough 2019

Re-visiting Monitoring Protocols For Wetland Restoration

Lower Columbia Estuary Partnership

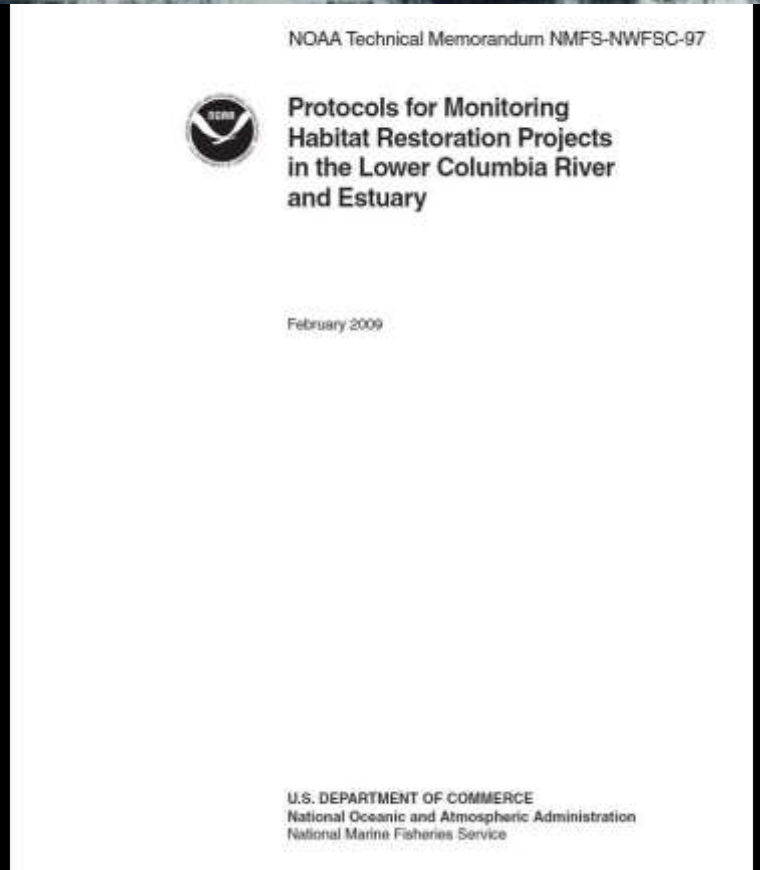
LCEP Science Work Group Meeting, Dec 18, 2019

Sarah Kidd,
Sneha Rao Manohar

Purpose: Continue to the discussion of updating and adding to the original 2009 monitoring protocols.

Providing technical recommendations for monitoring the following parameters:

- **Soil Conditions - LCEP**
- **Sediment Accretion and Erosion –LCEP**
- **Channel Cross-Sections - CLT**
- **Water Surface Elevation & Temp - LCEP**


NOAA Technical Memorandum NMFS-NWFSC-97

Protocols for Monitoring Habitat Restoration Projects in the Lower Columbia River and Estuary

February 2009

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

Future Discussions: Fish & Macroinvertebrate Monitoring, UAV Data Collection, Data Management and Analysis

Purpose: Continue to the discussion of updating and adding to the original 2009 monitoring protocols.

Best Practices – A Quick Guide to Water Surface Elevation and Temperature Data Collection

Prepared by Sarah Kidd, Matthew Schwartz, and Grace Brennan
Lower Columbia Estuary Partnership
October 2018

Lower Columbia Estuary Partnership

Best Practices - Quick Guide: Water Surface Elevation and Temperature Data Collection

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October 2018 we published updates to the WSE and Temp Protocols

You can download them here https://bit.ly/2LYGm6w

Wallooskee Wetland 2015

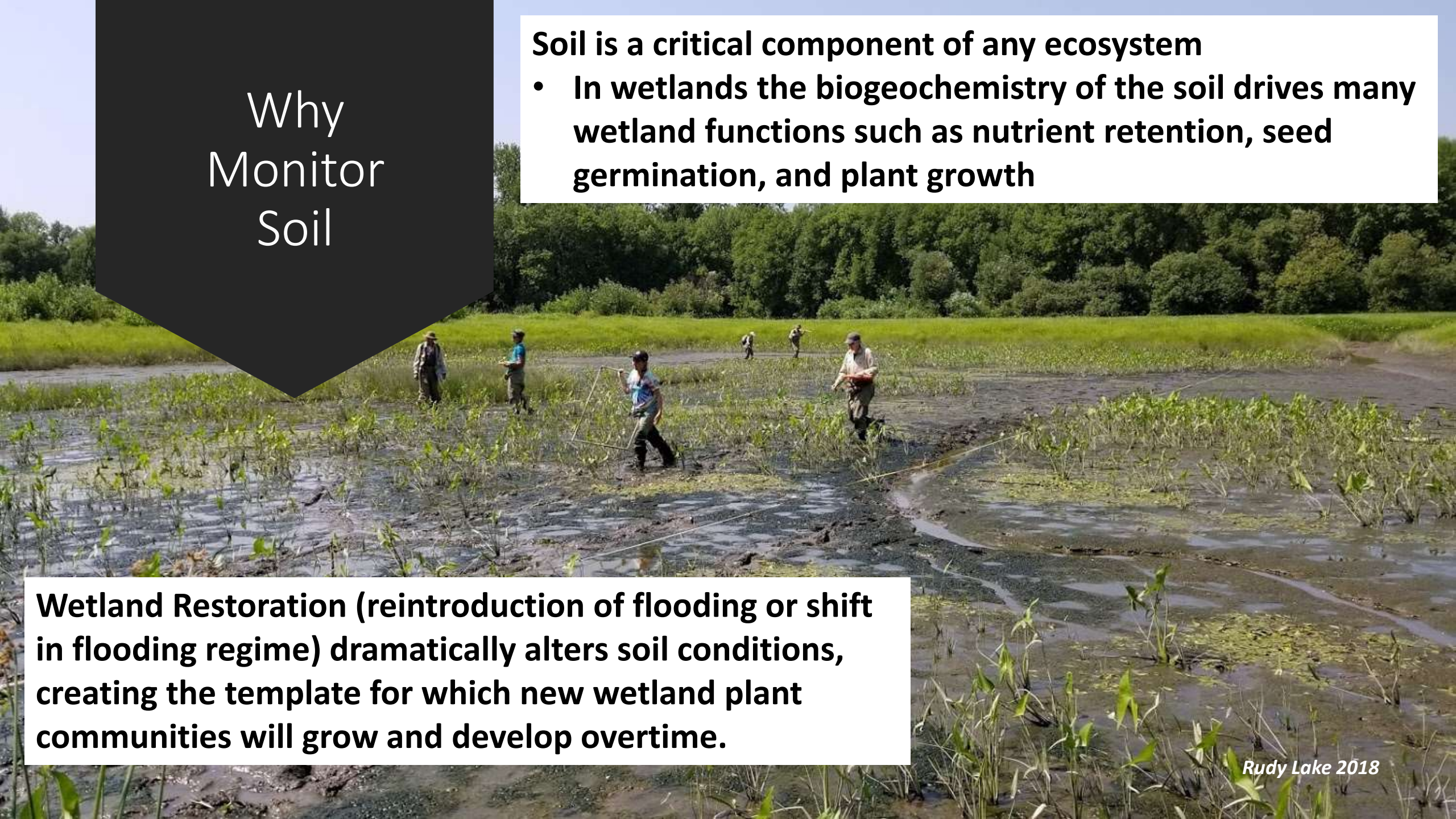
Soil Monitoring

Lower Columbia Estuary Partnership

Why Monitor Soil

Soil is a critical component of any ecosystem

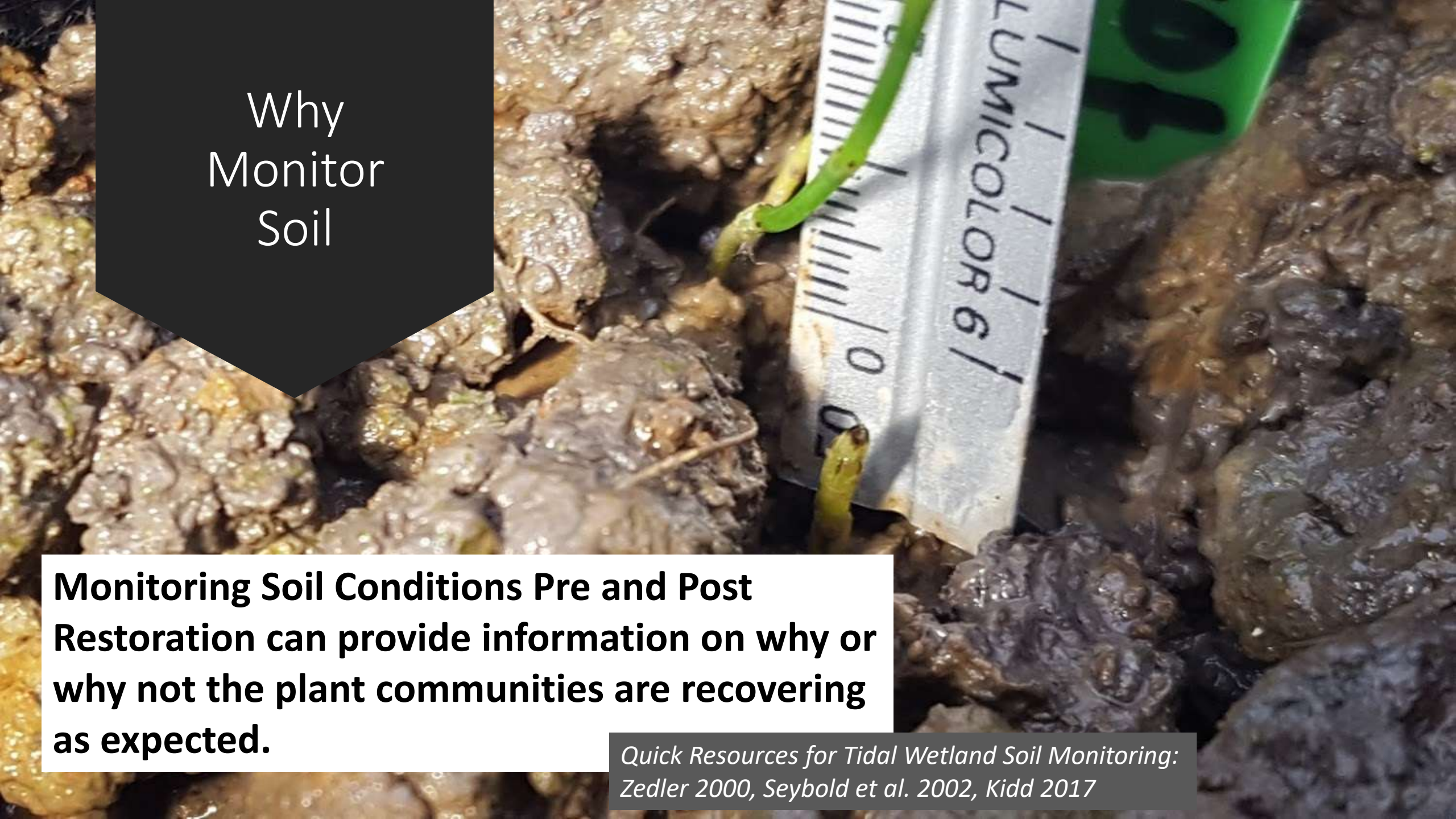
- **In wetlands the biogeochemistry of the soil drives many wetland functions such as nutrient retention, seed germination, and plant growth**



Wetland Restoration (reintroduction of flooding or shift in flooding regime) dramatically alters soil conditions, creating the template for which new wetland plant communities will grow and develop overtime.

Rudy Lake 2018

Why Monitor Soil



Monitoring Soil Conditions Pre and Post Restoration can provide information on why or why not the plant communities are recovering as expected.

Quick Resources for Tidal Wetland Soil Monitoring: Zedler 2000, Seybold et al. 2002, Kidd 2017

What to Monitor

In the Field

- **Soil Texture**
  - → **Sandy, Silty, Loam – these textures can influence conditions and plant growth**
  - → **Soil Color is an indicator of hydric soil conditions (Gleying and Mottling)**

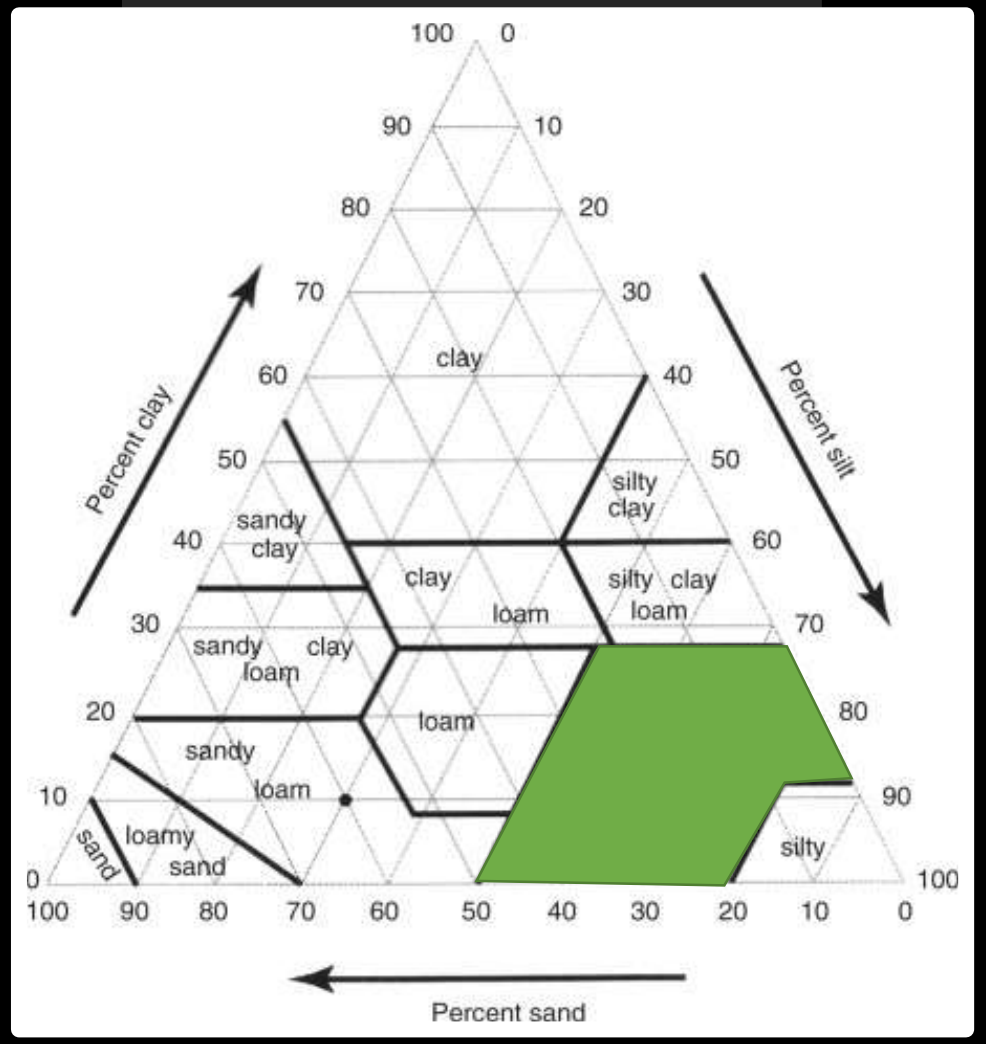


Photo Credit: http://nesoil.com/images/redox.htm

What to Monitor

In the Field

- **pH**
  → **Is the soil too acidic or basic?**
- **Salinity/Conductivity**
  → **How has soil salinity changed?**

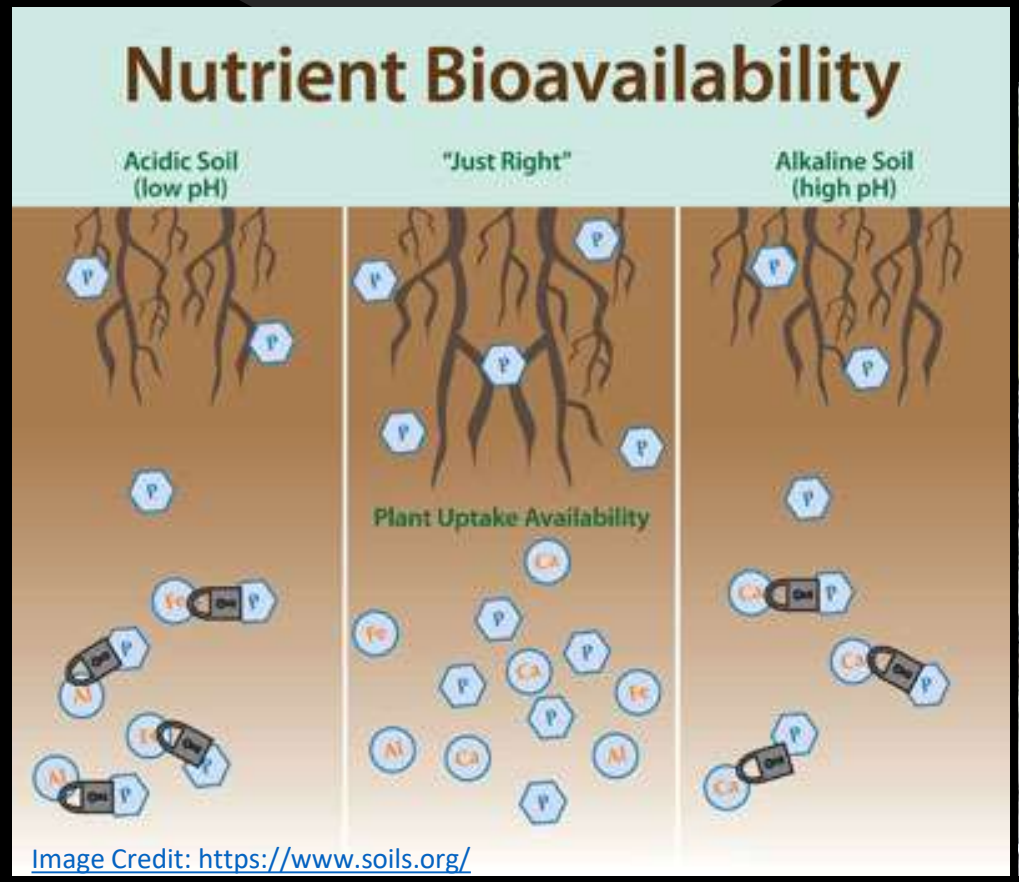


Image Credit: https://www.soils.org/

Photo Credit: Sarah Kidd, Steamboat Slough 2013

What to Monitor

In the Field

Hydric soil (develops with lack of O2) – Rate of O_2 diffusion into soil dramatically reduced when soil is saturated with water. **This can be measured as <u>soil ORP – Oxygen Reduction Potential.</u>**

All Photos: Sarah Kidd – Colewort Creek – Astoria, Oregon – Sept 2015

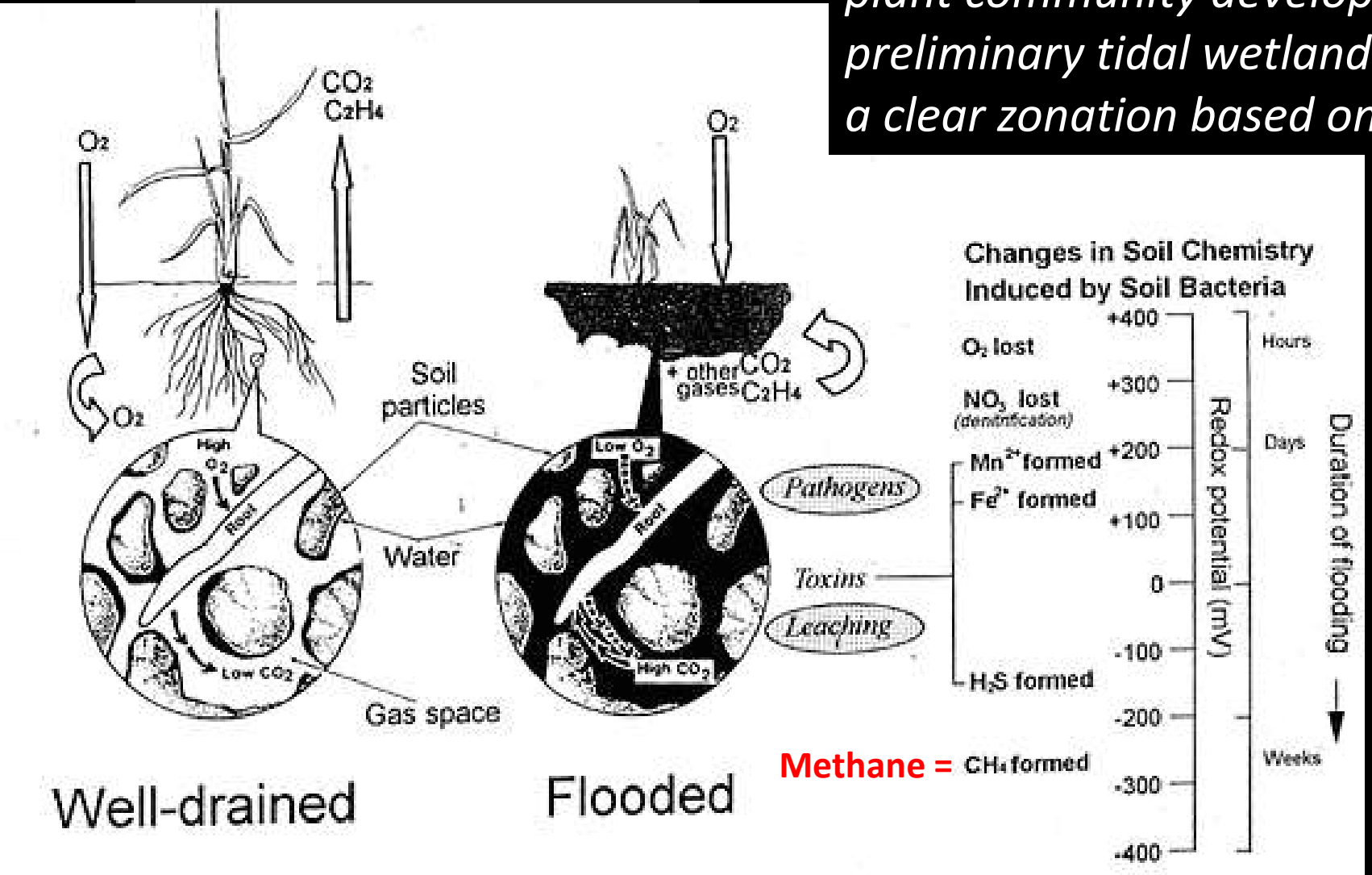
This is an indicator of duration and timing of soil flooding – and these conditions can determine which plant communities can germinate and grow

What to Monitor

In the Field

Soil ORP – Oxygen Reduction Potential

Multiple soil and hydrologic metrics inform plant community development, however preliminary tidal wetland field data indicate a clear zonation based on observed soil ORP conditions



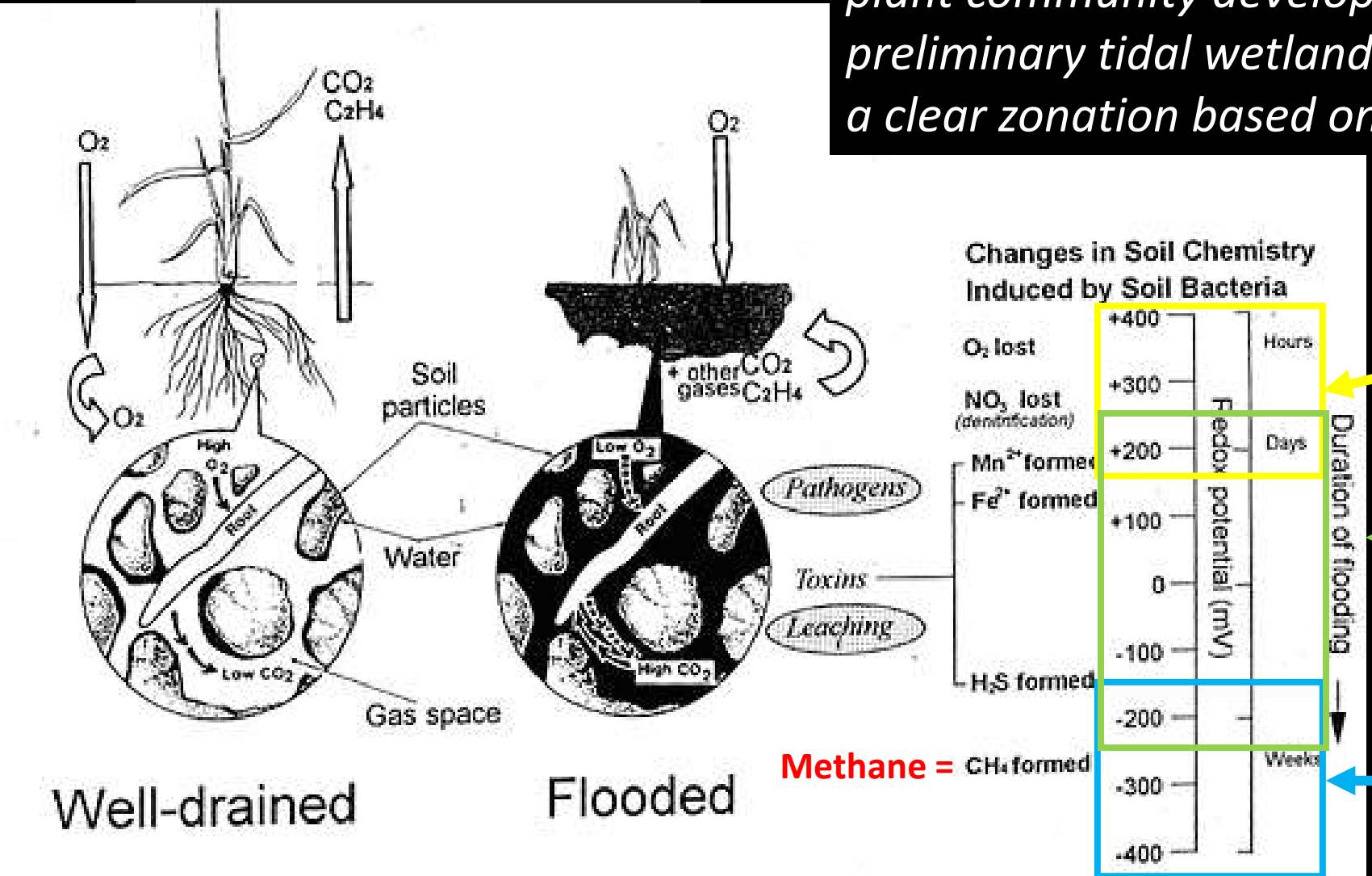
Restored Fresh Tidal Wetland Zonation

What to Monitor

In the Field

Soil ORP – Oxygen Reduction Potential

Multiple soil and hydrologic metrics inform plant community development, however preliminary tidal wetland field data indicate a clear zonation based on observed soil ORP conditions



Restored Fresh Tidal Wetland Zonation

Reed Canarygrass

Native Emergent sp

Mudflat, Ponding, Aquatic sp

Field Equipment

- **Extech ORP Meter**
- **Extech Salinity, pH meter**
- **For sites with more saline influence – a refractometer can be used (Pore-water soil salinity)**

Photo Sarah Kidd - Wallooskee Site, 2017

What to Monitor

In the Lab

- **Bulk Density, Organic Matter Composition, Carbon, Nutrients (N, P etc.), and Mineral Composition, etc.**

- **Baseline Reference Conditions have been Established in Reference Wetlands through the EMP program (EMP 2019)**

These are also important soil metrics that should be considered when monitoring restoration outcomes - however they do involve field collection and lab assessment

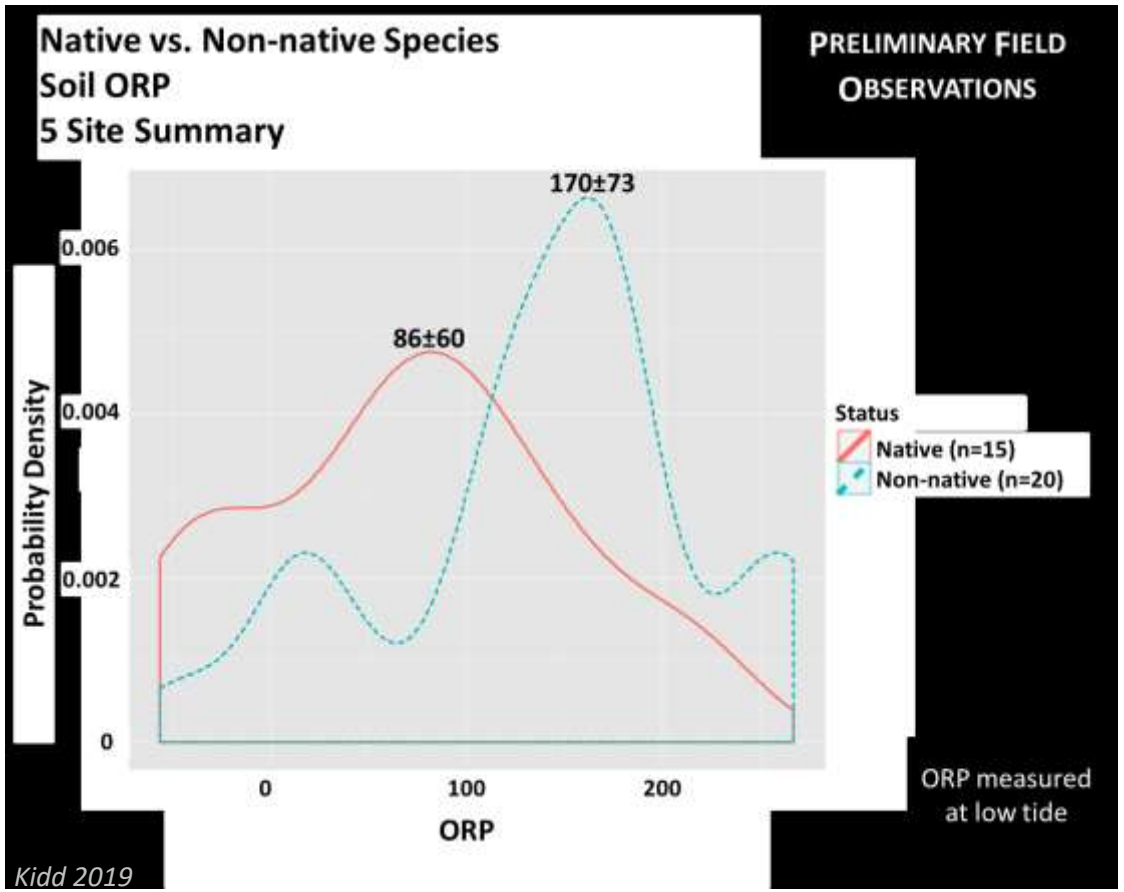
Current Practice

Field EMP Reference Sites & Level 2 AEMR Sites, Conducted Along Side of Vegetation Monitoring	Lab EMP Reference Sites, Soil Collected with Biomass and Vegetation Samples
pH	Bulk Density
Salinity/Conductivity	Organic Matter
ORP	Carbon, Nitrogen, Phosphorus Content
Texture/Color (to be added)	Texture

Next Steps & Understanding Results

In the Office

- Publish/Share Protocols
- Take all collected data and develop thresholds associated with plant community development and recovery
  - Use data to help explain why or why not wetland plant community recovery is occurring across sites



Utilize soil and plant community data to set-up Blue Carbon Study – looking at methane and carbon emissions and storage across LCE wetlands.

Sediment Accretion and Erosion Monitoring

Lower Columbia Estuary Partnership

Why Monitor Sediment Accretion/Erosion

Monitoring sediment accretion/erosion conditions pre and post restoration can:

- **Provide information on how natural sediment dynamics have been restored to a wetland**
- **Help us understand if a site is keeping up with potential sea level rise conditions**

Photo Credit: Sarah Kidd, Wallooskee Site 2018

Why Monitor Sediment Accretion/Erosion

- **Existing data has shown that sediment accretion/erosion can be very dynamic.**

- **This variability indicates that to get generalizable results we need to increase the amount of data collected.**

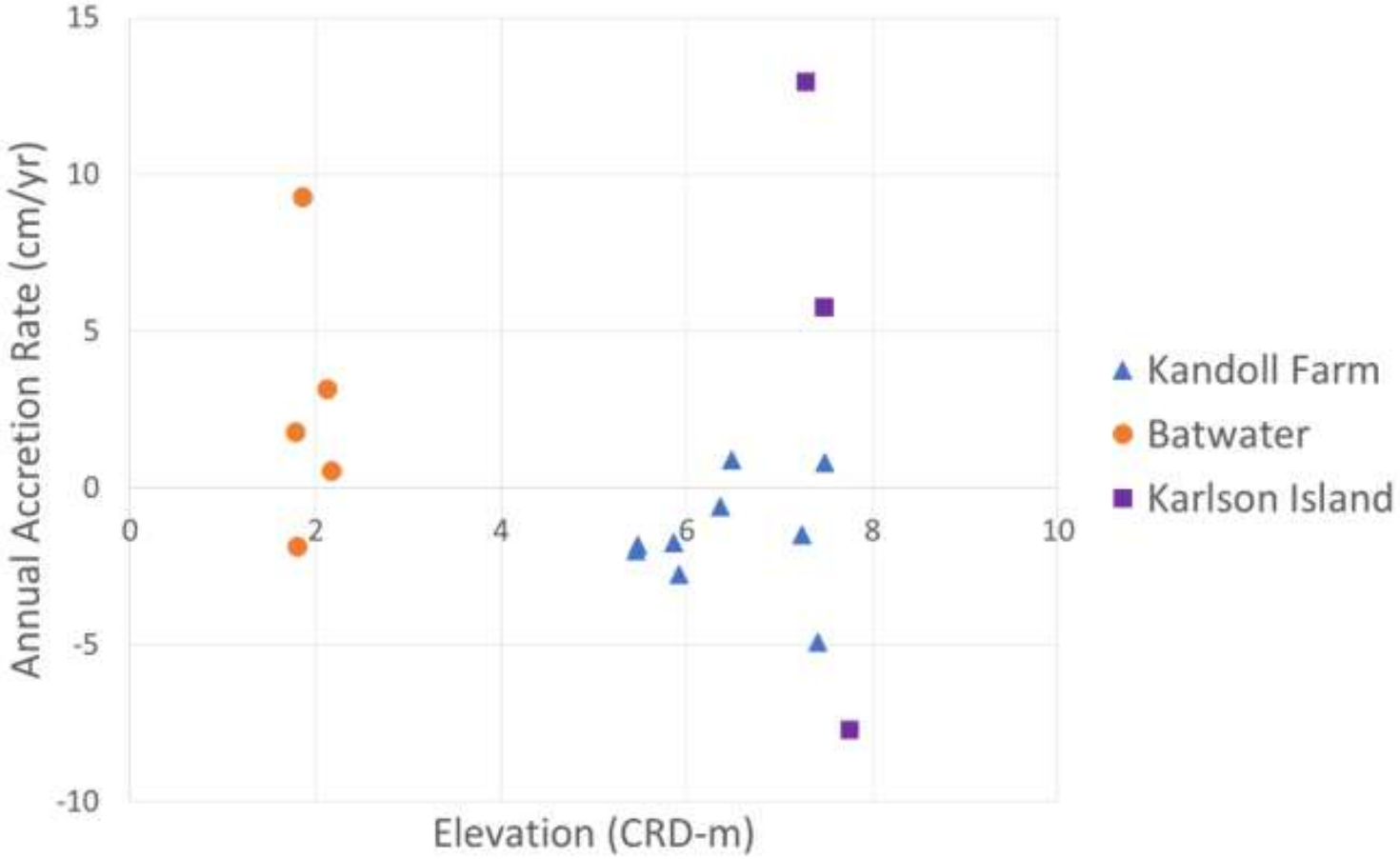
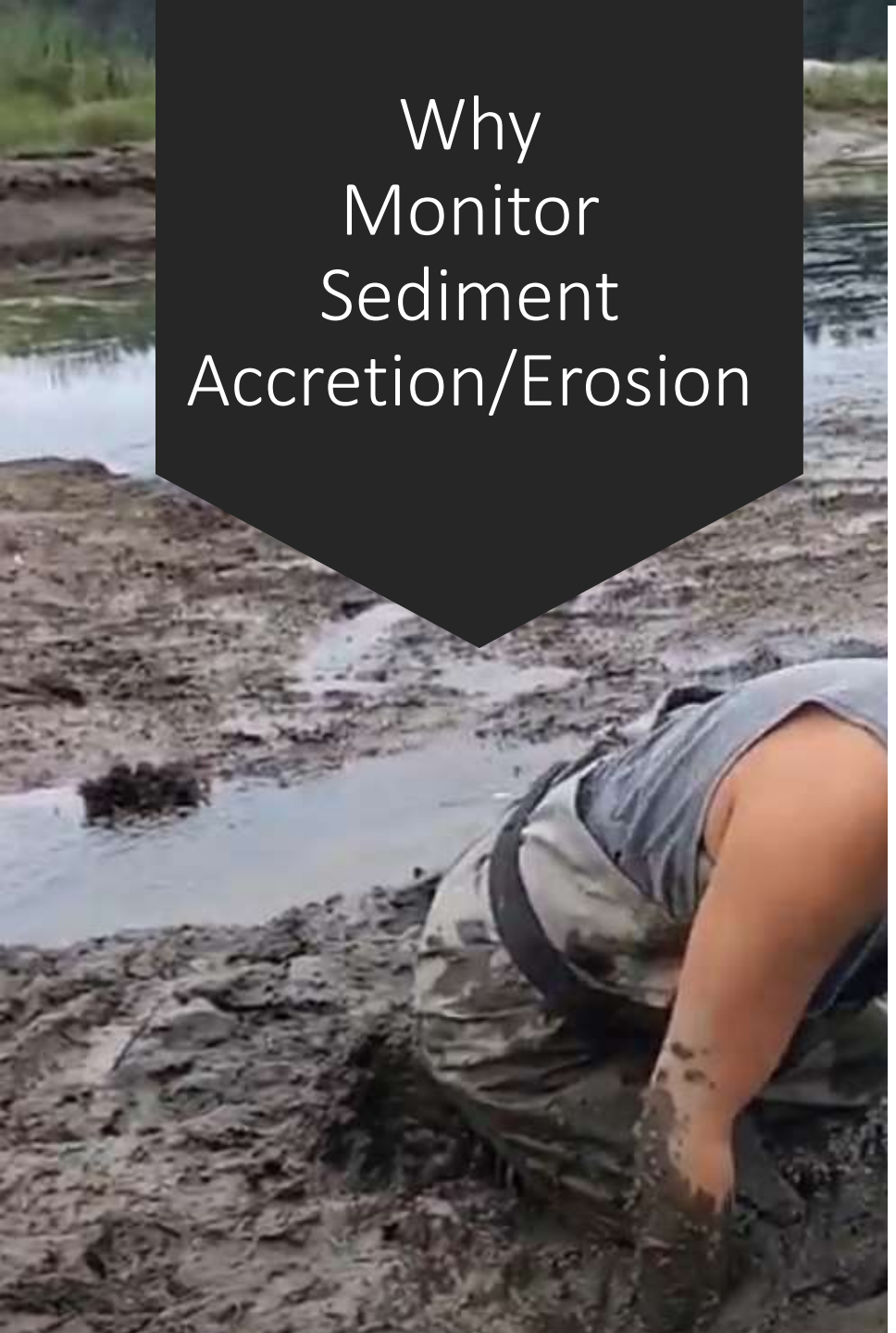


Figure 3.3. Annual accretion rate by elevation for three restoration sites.

Taken from SM2 2018

Why Monitor Sediment Accretion/Erosion

What influences Sediment Accretion/Elevation within a Tidal Wetland Site?



Why Monitor Sediment Accretion/Erosion

What influences Sediment Accretion/Elevation within a Tidal Wetland Site?

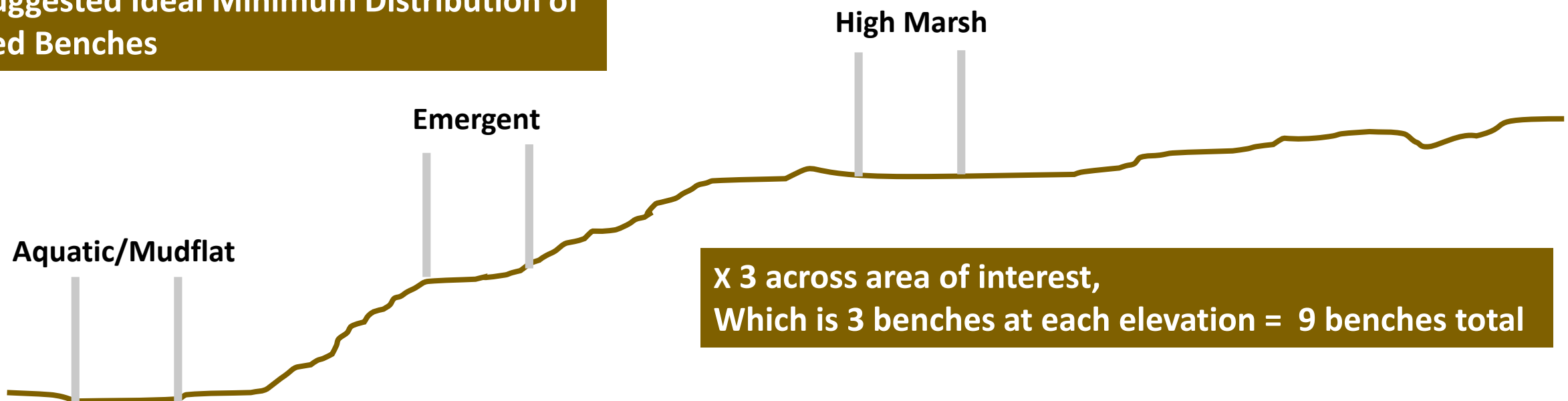
- **Topography**
  - → **Elevation and Distance from Main Channel**
- **Hydrology**
  - → **Frequency, Depth, Velocity of Flooding**
- **Vegetation and Soil**
  - → **Vegetation Type, Cover, Soil Exposed, Soil Texture, Soil Compaction**
- **Disturbance**
  - → **Storm Activity/High Flow, Animal Activity (Cattle, Elk, Deer, Rodents, Carp) – Exposing Soil etc.,**
- **Availability of sediment flowing in/out of site**

Best Practices Sediment Bench Monitoring

Number and Distribution of Sediment Accretion/Erosion Benches Across a Site

- **Multiple Sed Benches Located Across Several Elevation Gradients in Areas of Interest**
- **Pre-restoration use restoration plans to install where possible, post-restoration placement in areas heavily graded**

Suggested Ideal Minimum Distribution of Sed Benches



X 3 across area of interest,
Which is 3 benches at each elevation = 9 benches total

Best Practices Sediment Bench Monitoring

How to install

Best Practices Sediment Bench Monitoring

How to install

Materials:

- 1 inch conduit pipe, 5 ft+ long
- Level: 120+ cm long
- 2 Meter Sticks or Bendy Rulers
- Compass
- Mallet
- Design Plans
- RTK/GPS Unit

Best Practices Sediment Bench Monitoring

How to Monitor, Data Collection – What do I record?

Best Practices Sediment Bench Monitoring

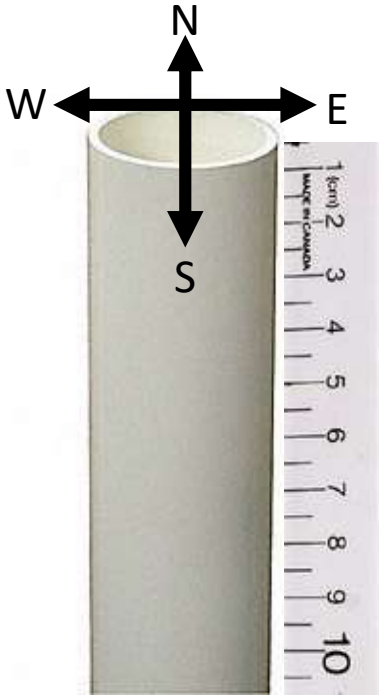
How to Monitor, Data Collection – What do I record?

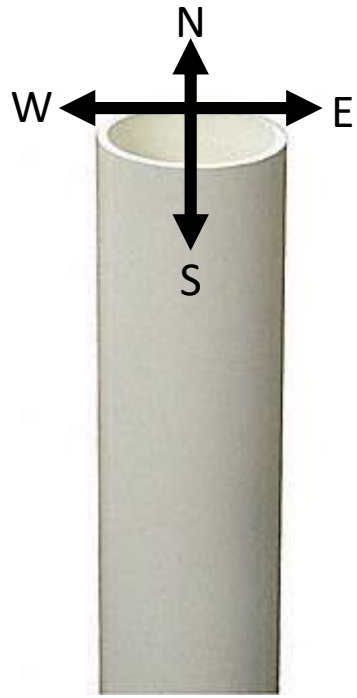
- **Bring your notes from the last time you came out to measure the sed bench**
- **Bring a buddy**
- **Accuracy and Precision comparable to SET if c*<u>are is taken</u> (Nolte et al. 2012)***

Best Practices Sediment Bench Monitoring

- Start by measuring all 4 sides of each PVC Sediment Pin (bring a compass)

How to Monitor, Data Collection – What do I record?





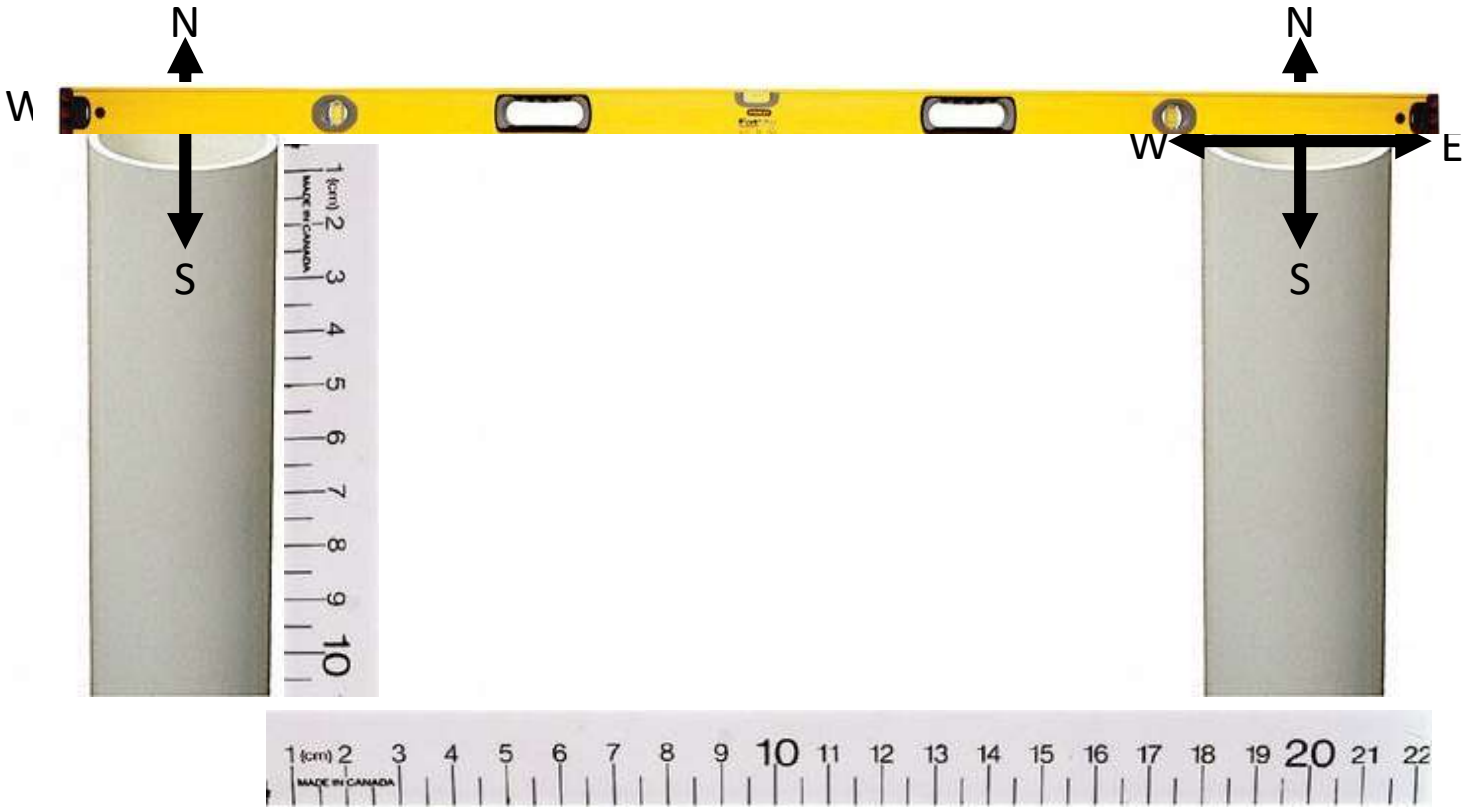
North Pin: South Pin:

N	E	S	W	10	20	30	40	50	60	70	80	90	100	N	E	S	W

Best Practices Sediment Bench Monitoring

- Start by measuring all 4 sides of each PVC Sediment Pin (bring a compass)
- It can help to place a meter stick on the ground – to line up with the level

How to Monitor, Data Collection – What do I record?



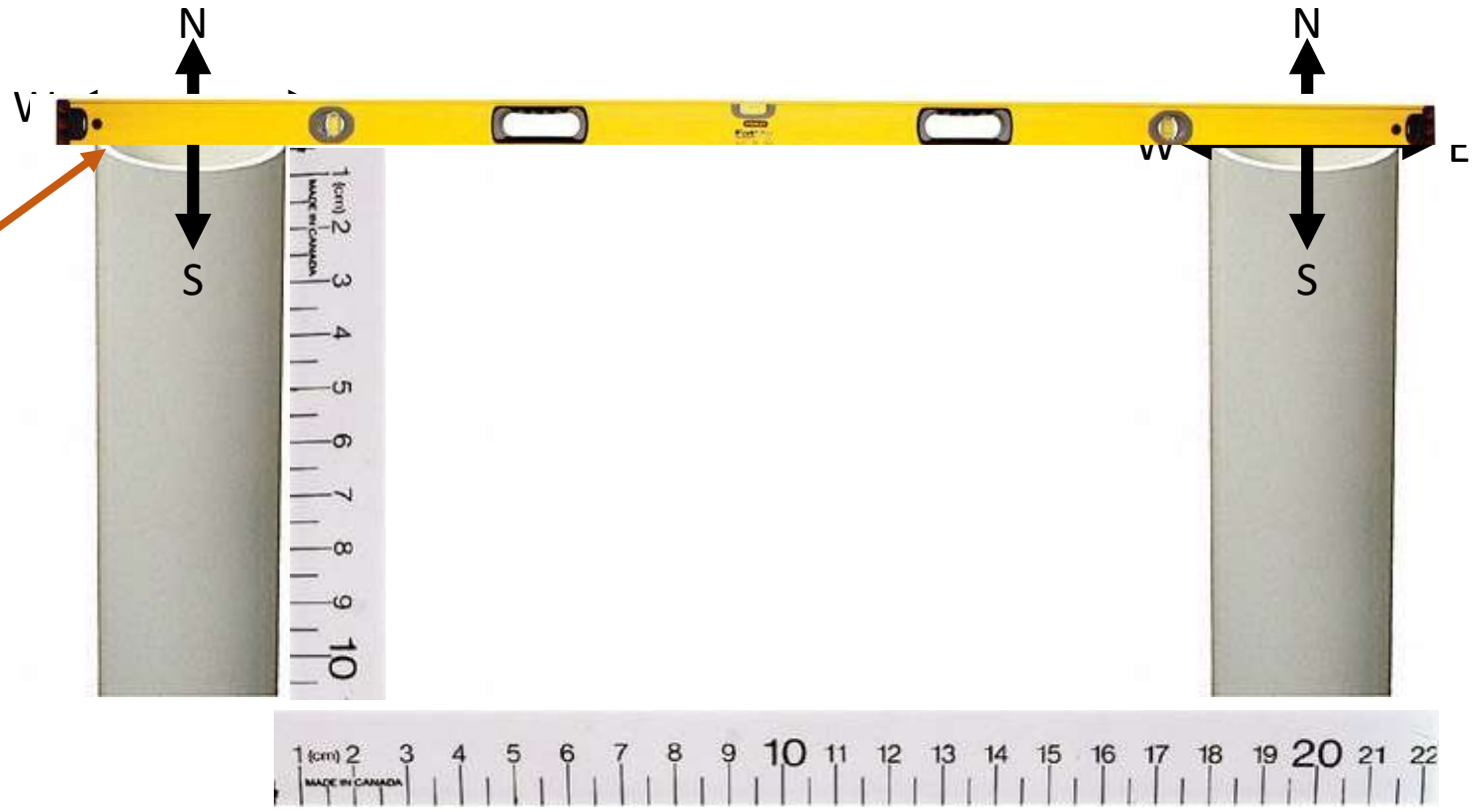
North Pin: South Pin:

N	E	S	W	10	20	30	40	50	60	70	80	90	100	N	E	S	W

Best Practices Sediment Bench Monitoring

How to Monitor, Data Collection – What do I record?

- Always measure from the ground to the top of the PVC – bottom of level (NOT to an arbitrarily place on the level etc).



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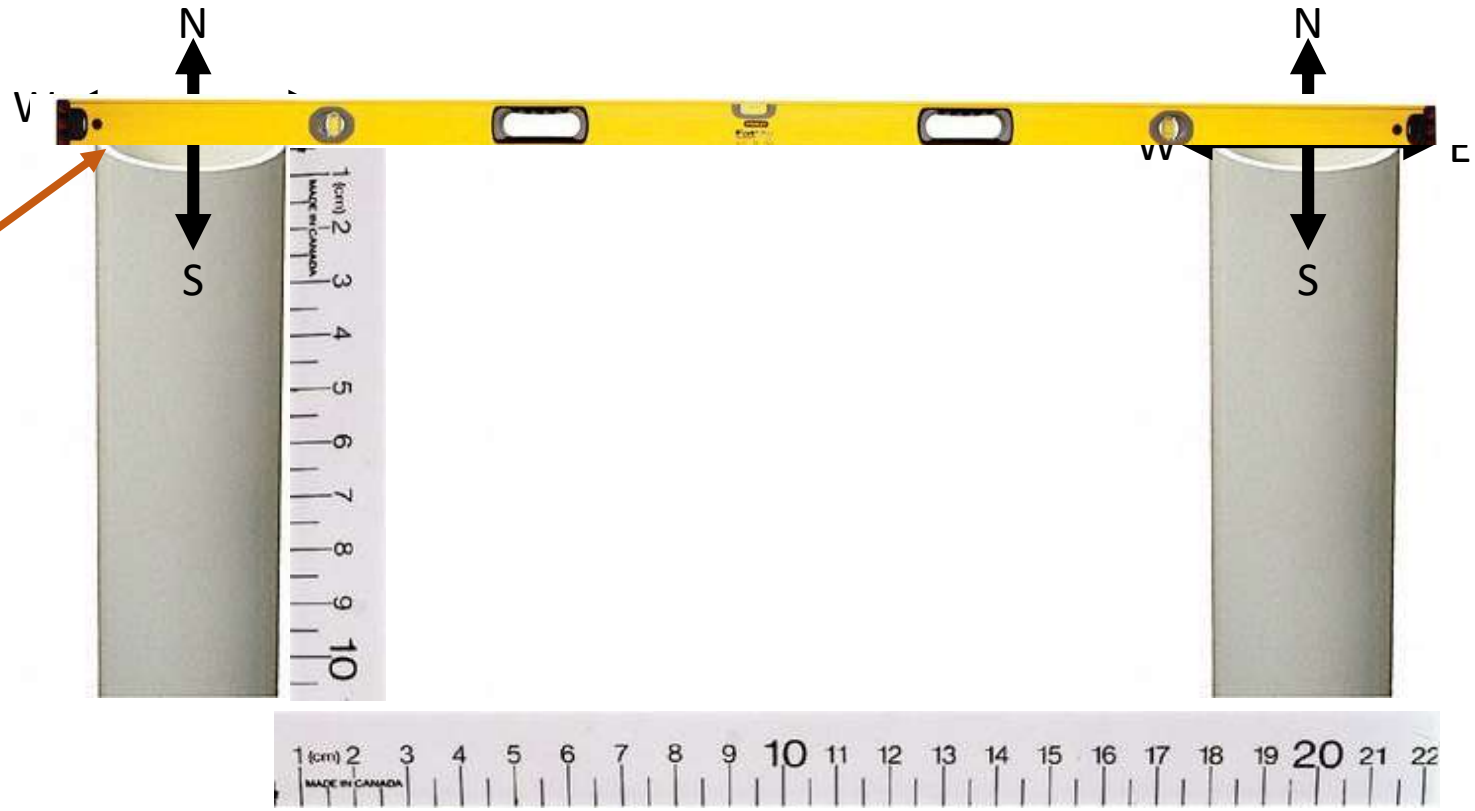
N	E	S	W	10	20	30	40	50	60	70	80	90	100	N	E	S	W

Best Practices Sediment Bench Monitoring

How to Monitor, Data Collection – What do I record?

- Always measure from the ground to the **top of the PVC – bottom of level** (NOT to an arbitrarily place on the level etc).

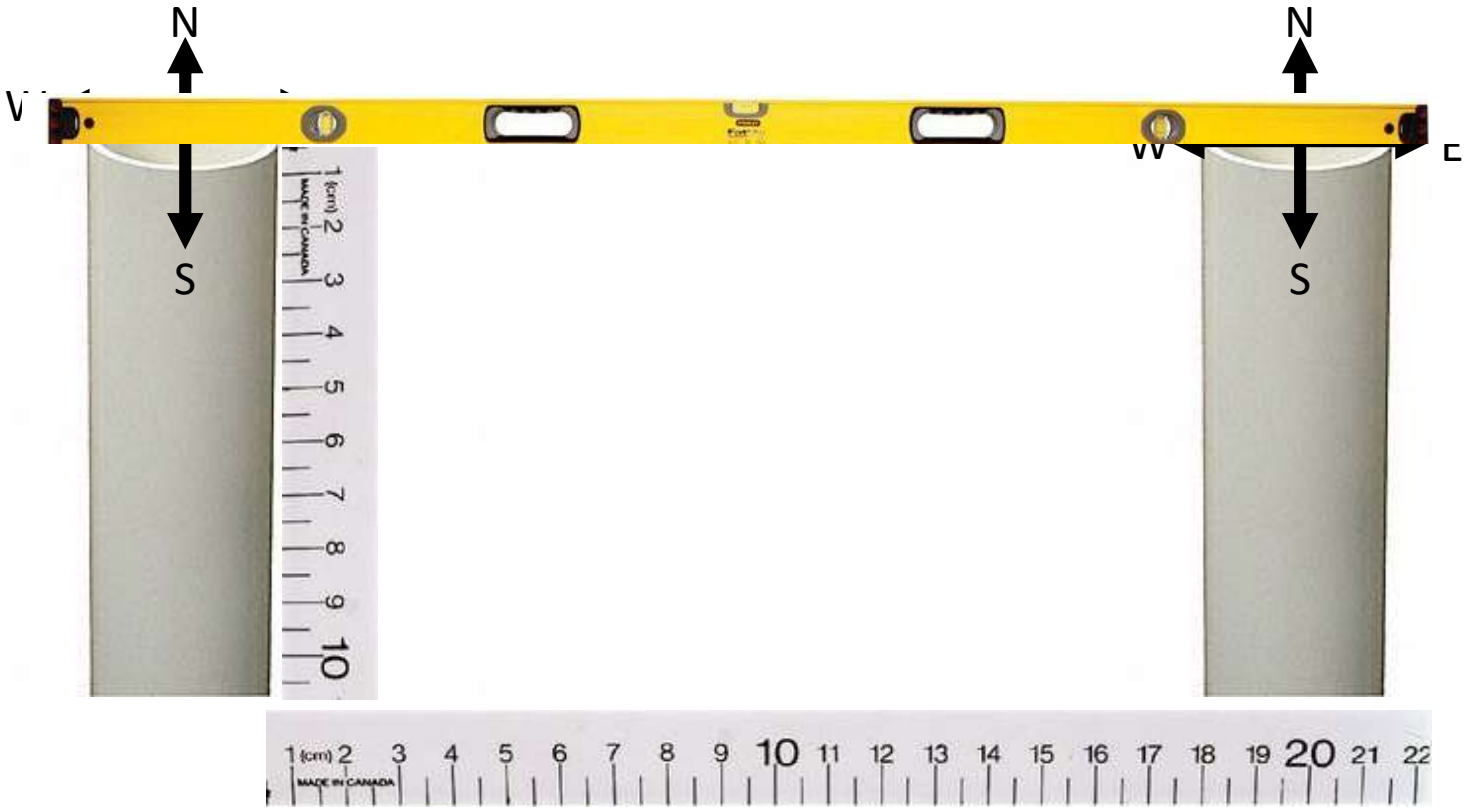


North Pin: South Pin:

N	E	S	W	10	20	30	40	50	60	70	80	90	100	N	E	S	W

Best Practices Sediment Bench Monitoring

How to Monitor, Data Collection – What do I record?



What is ground? ☺

- When measuring in dense vegetation be sure to move plants out of the way so the ruler measures from the top of the soil/organic matter layer to the top of the PVC
- When measuring in mud, don't let ruler sink into the mud – always measure from the top of the mud to the top of the PVC

North Pin: South Pin:

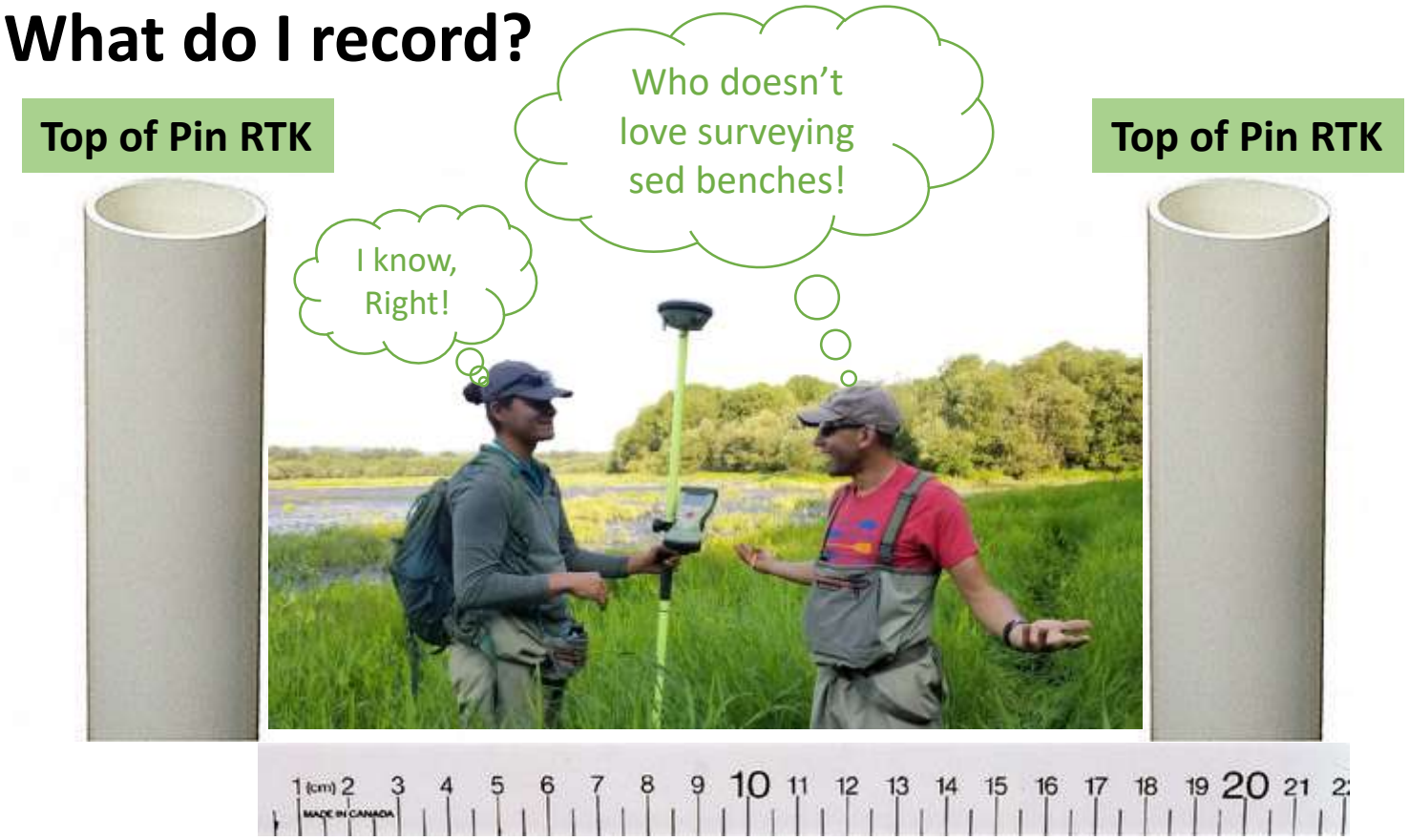
N	E	S	W	10	20	30	40	50	60	70	80	90	100	N	E	S	W

Best Practices Sediment Bench Monitoring

How to Monitor, Data Collection – What do I record?

Monitoring Elevations and Possible Shifting:

- **Always RTK top of PVC Sed Pins to identify if shifting has occurred**
- **Elevation of top of PVC pins should not change if installed properly, however settling and large wood disturbance can cause issues that need to be accounted for in the data**
- **Monitoring these elevations can inform if the sed pins have been disturbed**



North Pin: South Pin:

N	E	S	W	10	20	30	40	50	60	70	80	90	100	N	E	S	W

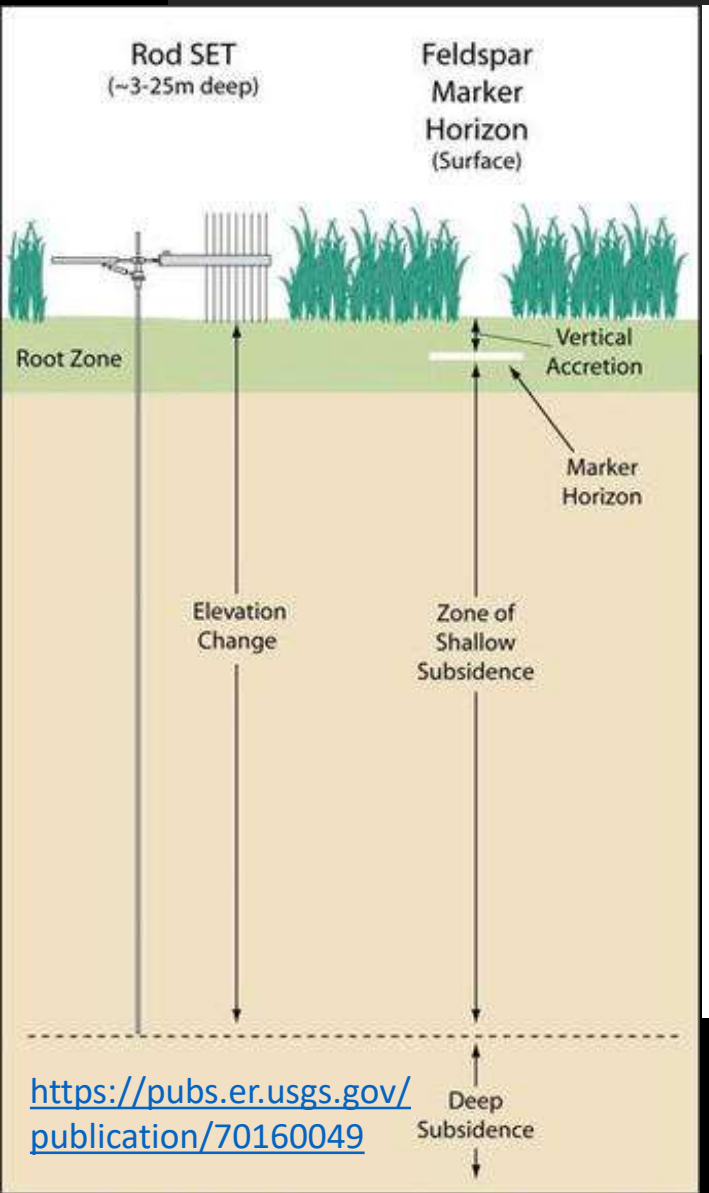
Recommendations to Start Collecting Additional Data

- **Install Multiple Sed Benches Across an Elevation Gradient**
- **RTK Sed Bench PVC Elevations**
- **Note Vegetation Cover of Dominant Species**
- **Monitor Field Soil Parameters at Sed Bench**
- **Take Photo Point of Sediment Bench and Surrounding Area**

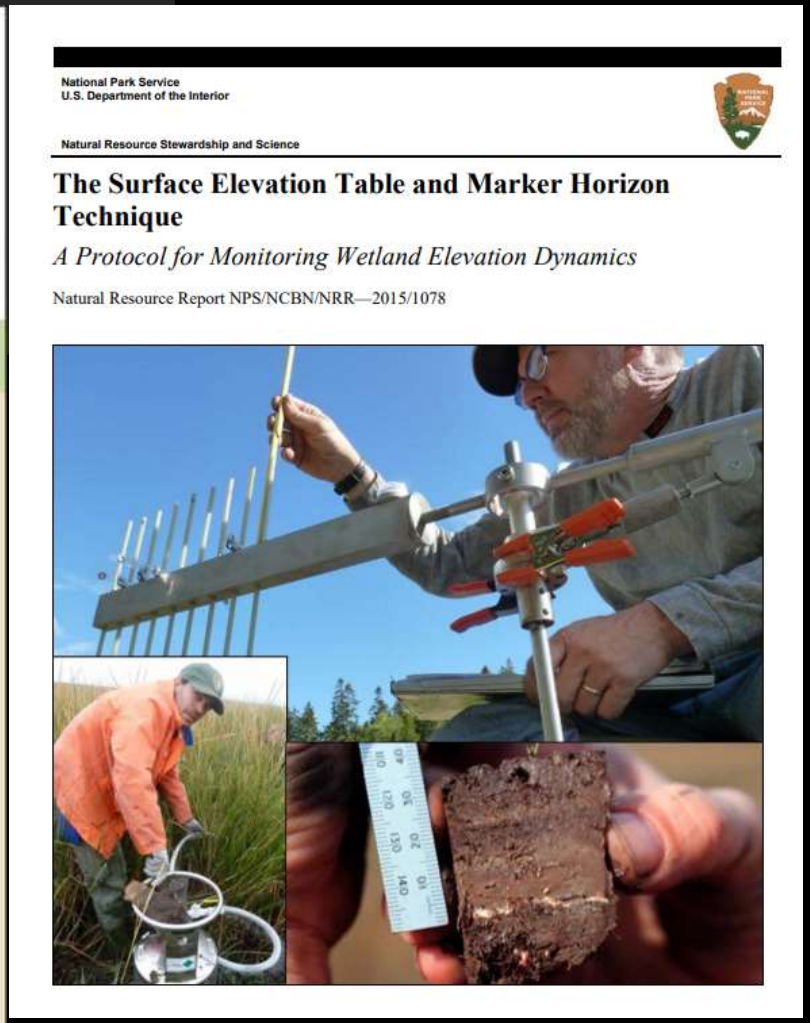
Other Methods

Other methods for monitoring sediment accretion and erosion:

- SET tables
- Marker horizons
- Sediment Plates
- UAV – Surface Monitoring



https://pubs.er.usgs.gov/publication/70160049



National Park Service
U.S. Department of the Interior

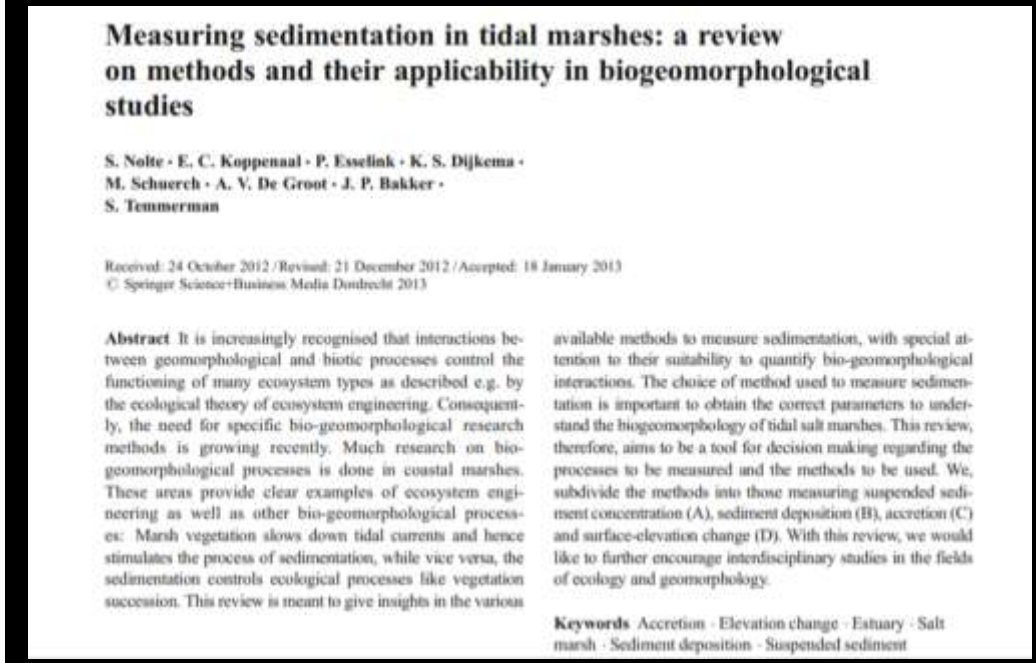
Natural Resource Stewardship and Science

The Surface Elevation Table and Marker Horizon Technique

A Protocol for Monitoring Wetland Elevation Dynamics

Natural Resource Report NPS/NCBN/NRR—2015/1078

Basic Overview Found Here:
http://www.tidalmarshmonitoring.net/



Measuring sedimentation in tidal marshes: a review on methods and their applicability in biogeomorphological studies

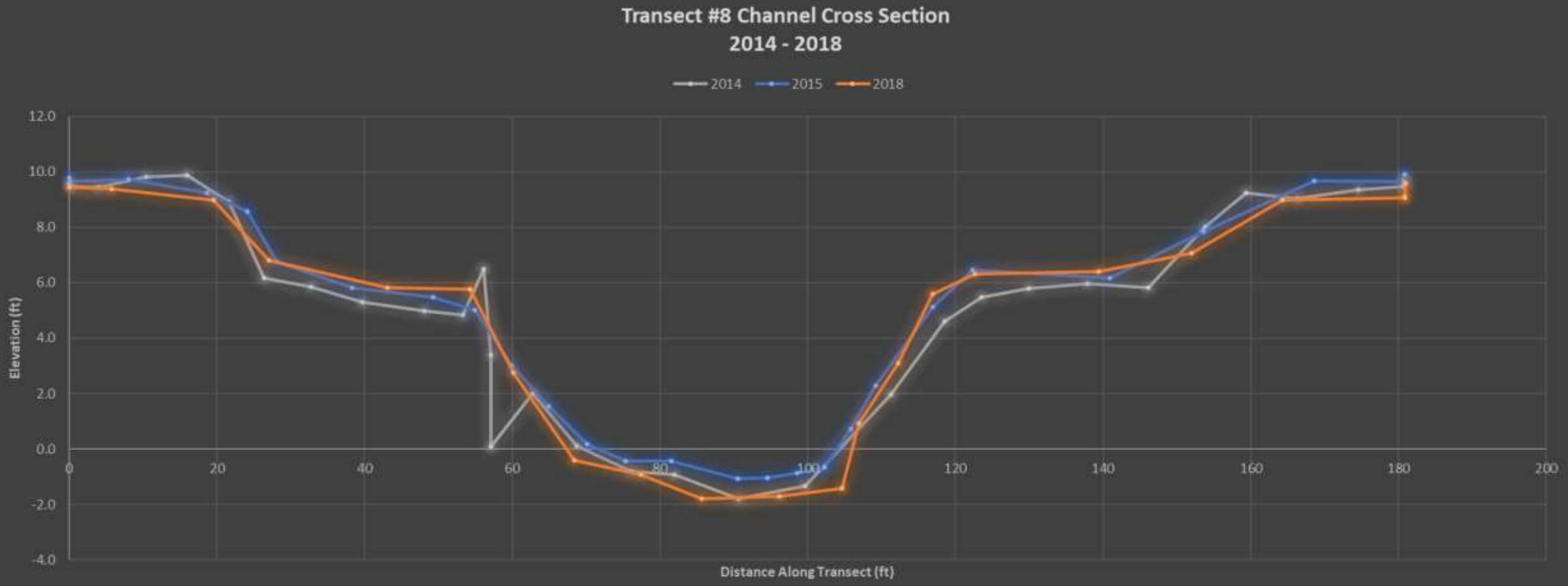
S. Nolte · E. C. Koppenaal · P. Esselink · K. S. Dijkema · M. Schuerch · A. V. De Groot · J. P. Bakker · S. Temmerman

Received: 24 October 2012 / Revised: 21 December 2012 / Accepted: 18 January 2013
© Springer Science+Business Media Dordrecht 2013

Abstract It is increasingly recognised that interactions between geomorphological and biotic processes control the functioning of many ecosystem types as described e.g. by the ecological theory of ecosystem engineering. Consequently, the need for specific bio-geomorphological research methods is growing recently. Much research on bio-geomorphological processes is done in coastal marshes. These areas provide clear examples of ecosystem engineering as well as other bio-geomorphological processes: Marsh vegetation slows down tidal currents and hence stimulates the process of sedimentation, while vice versa, the sedimentation controls ecological processes like vegetation succession. This review is meant to give insights in the various available methods to measure sedimentation, with special attention to their suitability to quantify bio-geomorphological interactions. The choice of method used to measure sedimentation is important to obtain the correct parameters to understand the biogeomorphology of tidal salt marshes. This review, therefore, aims to be a tool for decision making regarding the processes to be measured and the methods to be used. We, subdivide the methods into those measuring suspended sediment concentration (A), sediment deposition (B), accretion (C) and surface-elevation change (D). With this review, we would like to further encourage interdisciplinary studies in the fields of ecology and geomorphology.

Keywords Accretion · Elevation change · Estuary · Salt marsh · Sediment deposition · Suspended sediment

Detailed Review of Methods – Nolte et al. 2012
http://www.vliz.be/imisdocs/publications/242783.pdf



Updates on Protocols for Measuring Channel Cross Sections

Jeff Malone and Mitch Attig

Columbia Land Trust

Lower Columbia Estuary Partnership

Troubleshooting errors in water surface elevation and Temperature Data

Overview

Best Practices – A Quick Guide to Water Surface Elevation and Temperature Data Collection

Prepared by Sarah Kidd, Matthew Schwartz, and Grace Brennan
Lower Columbia Estuary Partnership
October 2018

Lower Columbia Estuary Partnership

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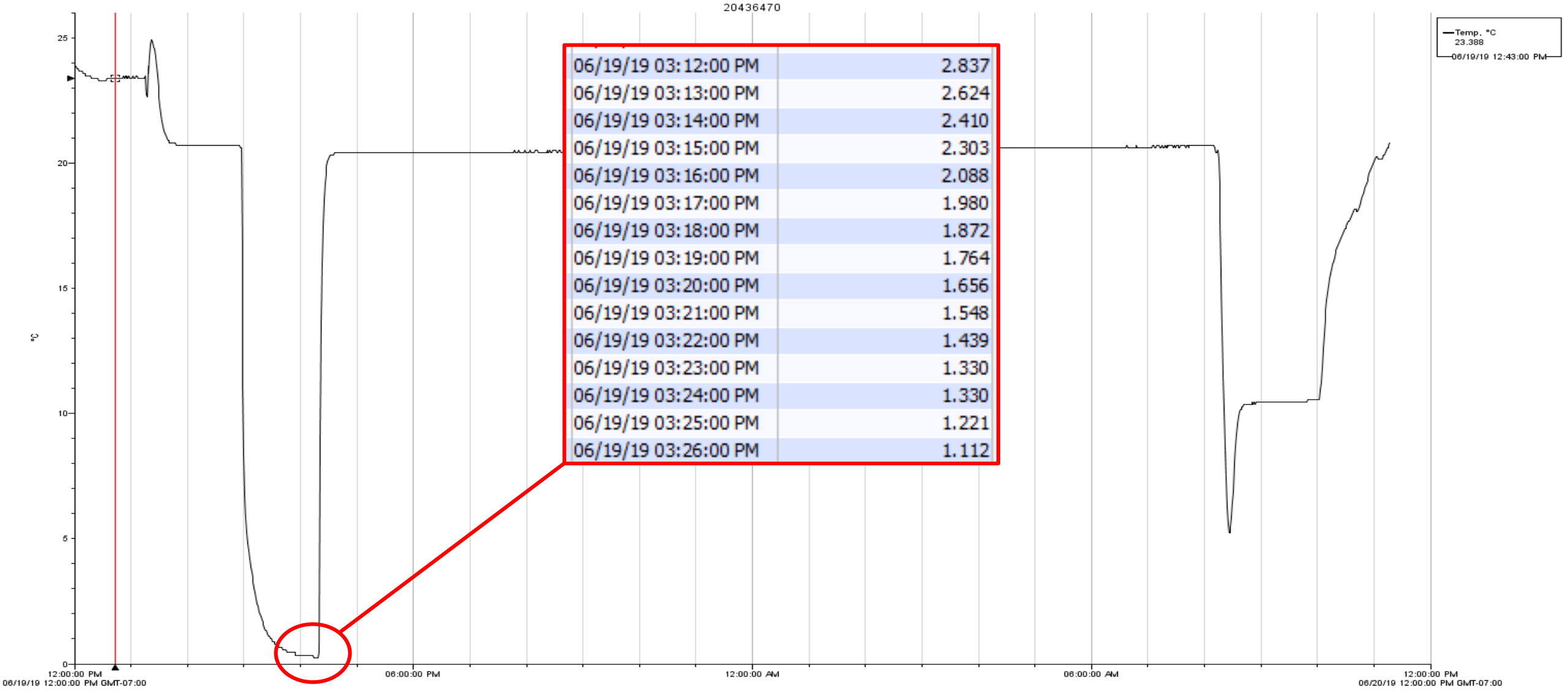
What are the problems?

Are these data any good? – Calibration Errors

0° C Bath:

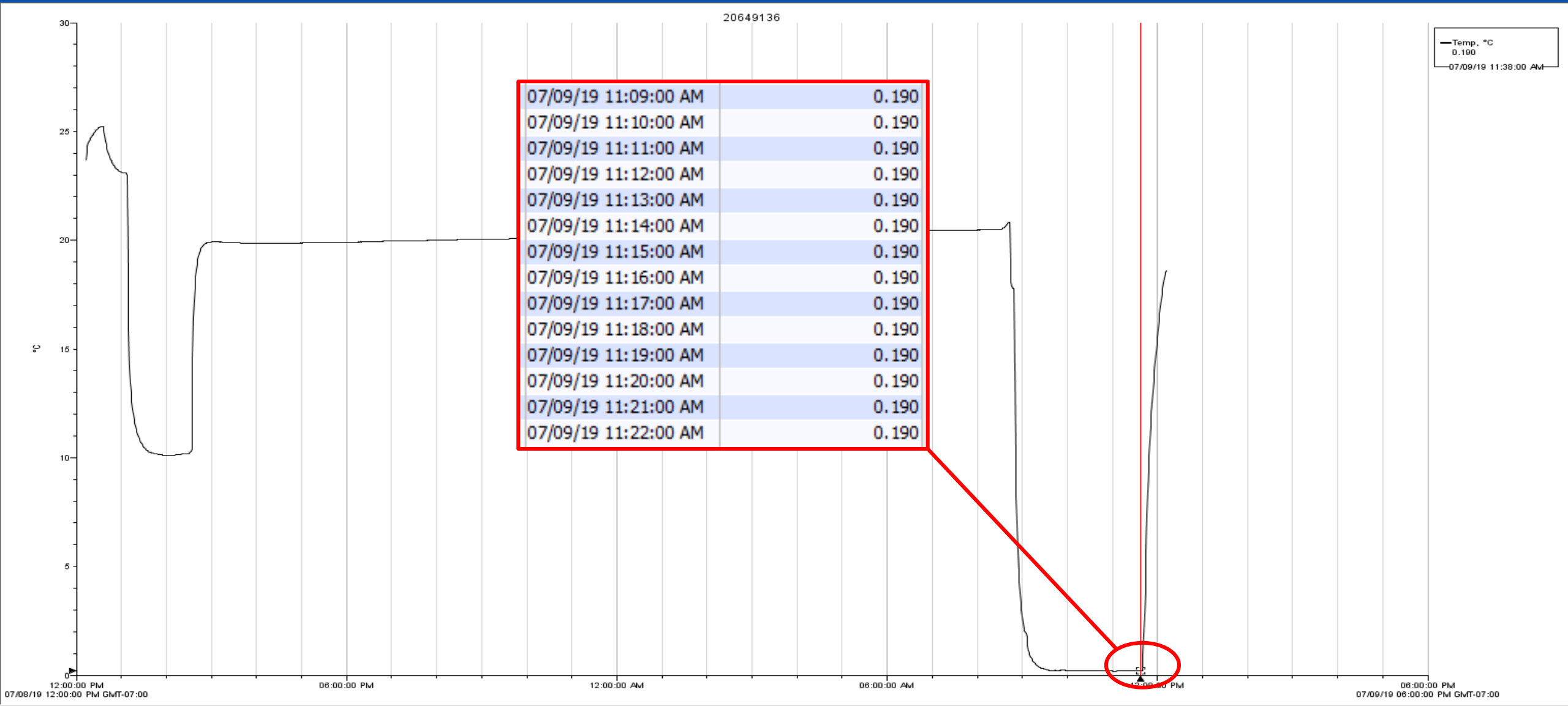
- Use a waterproof pump for best mixing
- Lay WSE sensors down flat, measure sensor depth
- Sink temperature loggers with weights
- Wait at least 10 – 20 minutes for loggers to stabilize
- Measure Temperature of the bath for at least 75 – 90 minutes **to get 10 consecutive minutes of the same temperature**

Prior to using water pump



06/19/19 03:12:00 PM	2.837
06/19/19 03:13:00 PM	2.624
06/19/19 03:14:00 PM	2.410
06/19/19 03:15:00 PM	2.303
06/19/19 03:16:00 PM	2.088
06/19/19 03:17:00 PM	1.980
06/19/19 03:18:00 PM	1.872
06/19/19 03:19:00 PM	1.764
06/19/19 03:20:00 PM	1.656
06/19/19 03:21:00 PM	1.548
06/19/19 03:22:00 PM	1.439
06/19/19 03:23:00 PM	1.330
06/19/19 03:24:00 PM	1.330
06/19/19 03:25:00 PM	1.221
06/19/19 03:26:00 PM	1.112

After using water pump



07/09/19 11:09:00 AM	0.190
07/09/19 11:10:00 AM	0.190
07/09/19 11:11:00 AM	0.190
07/09/19 11:12:00 AM	0.190
07/09/19 11:13:00 AM	0.190
07/09/19 11:14:00 AM	0.190
07/09/19 11:15:00 AM	0.190
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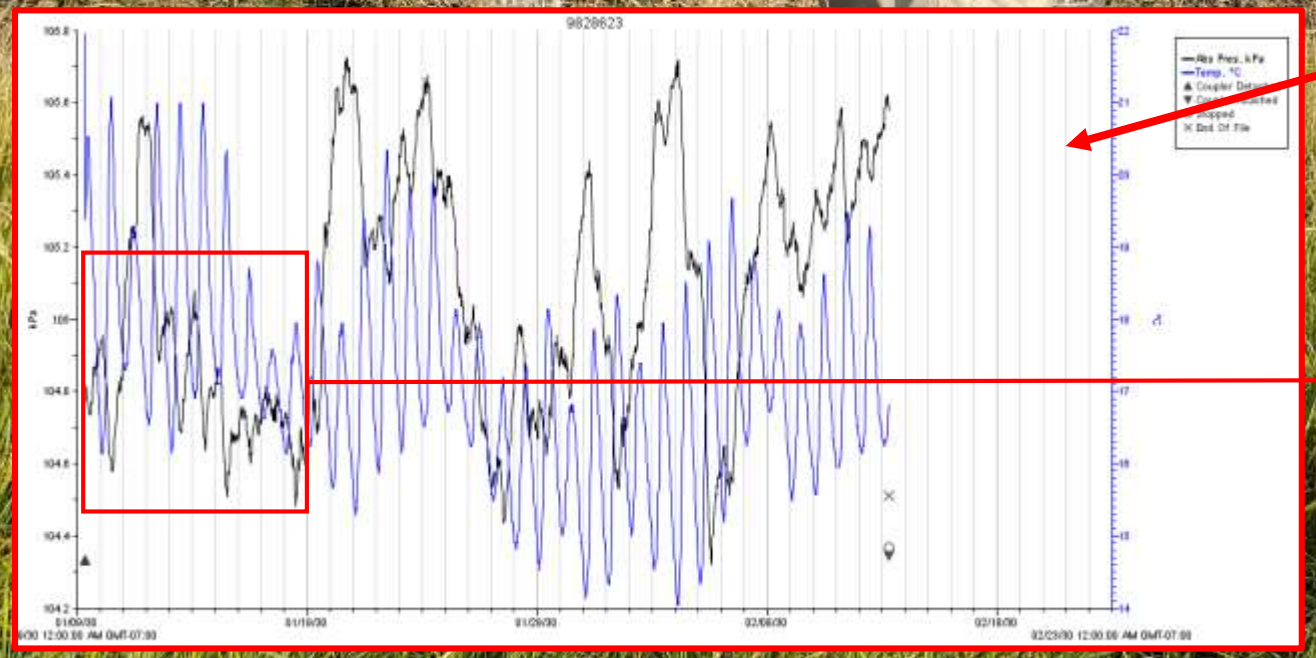
07/09/19 11:21:00 AM	0.190
07/09/19 11:22:00 AM	0.190

Are these data any good? – Data transfer Errors



- Failing Loggers
  - Temperature shocks
  - Biofouling
  - False fails
- Incorrect dates and times on files transferred onto the Shuttle

Time, GMT-07:00	Abs Pres, kPa	Temp, °C
01/09/30 09:00:00 AM	104.773	21.951
01/09/30 09:30:00 AM	104.816	19.377
01/09/30 10:00:00 AM	104.808	19.758
01/09/30 10:30:00 AM	104.798	20.043
01/09/30 11:00:00 AM	104.788	20.329
01/09/30 11:30:00 AM	104.776	20.519
01/09/30 12:00:00 PM	104.745	20.519
01/09/30 12:30:00 PM	104.744	20.424
01/09/30 01:00:00 PM	104.742	20.329
01/09/30 01:30:00 PM	104.738	20.138
01/09/30 02:00:00 PM	104.735	19.948
01/09/30 02:30:00 PM	104.745	19.662
01/09/30 03:00:00 PM	104.741	19.472

So you got the data

Water depth above sensor = D – ((A+B2)-C)

4. Calculating movement of data logger housing during deployment
   - Compare measurements A, B1, B2 and the RTK elevations pre and post deployment, if measurements are significantly different then the data logger housing has shifted and the WSE data may need to be corrected or not usable. Data correction can be done if the precise timing of data logger housing movement can be identified in the hydrologic data and then the new data logger elevation (collected upon retrieval) applied to all data after the shift occurred (See example Figure 5).

7. Post-processing and Analysis

Once the data logger has been retrieved from the site and post- deployment water depth measurements have been made (See 4.6) the data can be processed and used to evaluate the conditions on the site. Below are some tips for processing the data in HOBOware:

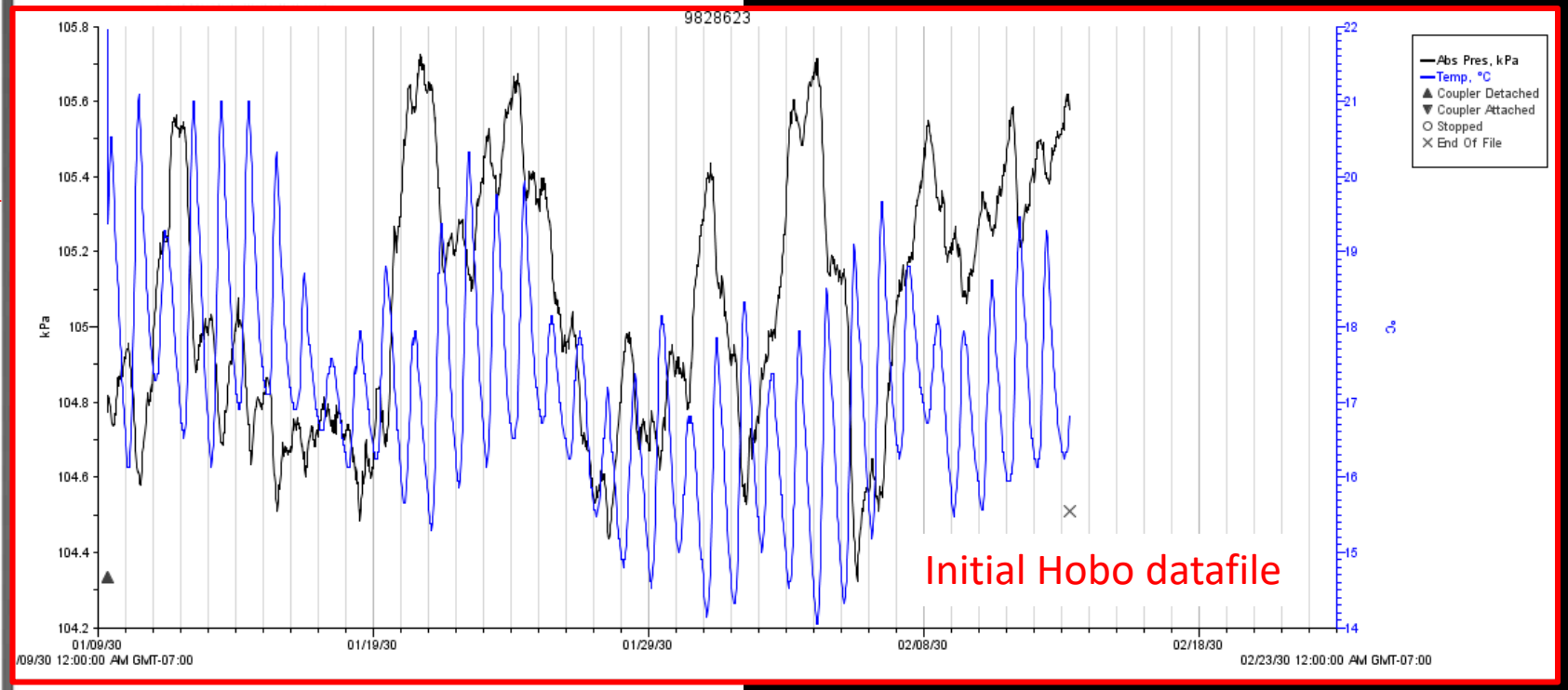
1. Understanding GMT and Correcting for Daylight Savings

It is best practice to always be aware of which time zone the data logger is collecting in. HOBOware does not automatically correct for daylight savings. Additionally, the data logger will be launched in whichever time zone your computer clock is in at the time of deployment unless it is adjusted manually. This means if you deploy your data logger in the summer (Daylight Savings Time) and then retrieve your data logger in the winter (Standard Time) your data will be read out in Daylight Savings Time, all time stamps after the fall time boundary (such as November 4 at 2 am) will be an hour off (one hour behind) because HOBOware does not adjust for shifts between Daylight Savings and Standard Time. This adjustment will need to be done manually in Excel, once exported from HOBOware. Correcting data for the end or beginning of daylight savings time can cause issues with time series data analysis because it involves deleting or duplicating a date and time when the data crosses a time boundary. Specifically, when daylight saving times begins clocks are moved forward one hour, meaning the 2 am date time on that day is deleted, while when daylight savings time ends the clocks go back one hour, meaning the 2 am time stamp is repeated. To avoid issues with duplicate and deleted time stamps data should be collected and stored in Standard Time, in the Pacific Time Zone this is GMT-8.

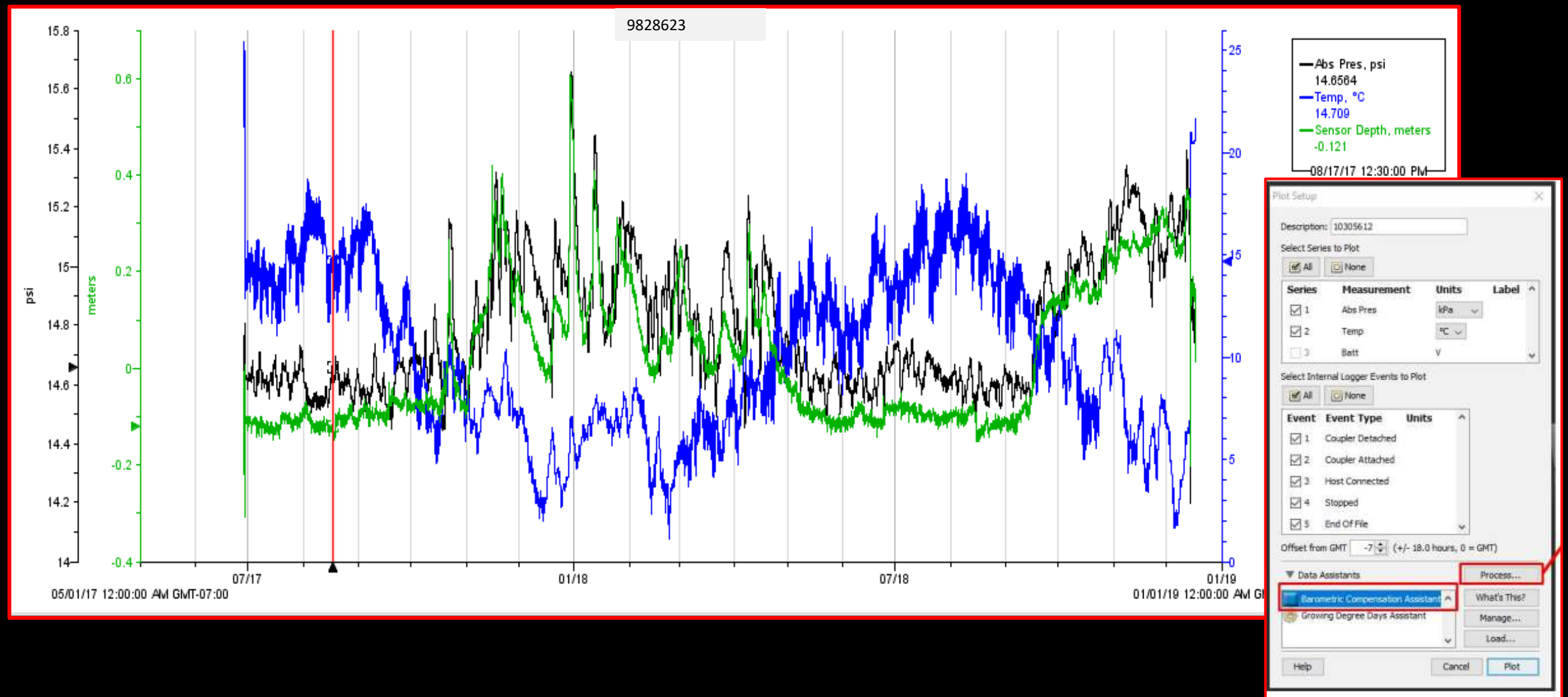
It is particularly important to understand how these shifts between daylight savings ending and beginning impact your date and time stamps when trying to compare your reference water levels and temperatures collected to your data logger data. For example is you are collecting all your data in Standard Time (i.e. GMT-8) you will need to make a small adjustment to your reference measurement date and time stamps collected during daylight savings time (i.e. Mar – Nov, see an annual daylight savings table for exact dates) so that the reference measurement time and dates match the loggers time and dates. To shift a daylight savings time stamp (i.e. GMT-7) to a standard time stamp (i.e. GMT-8) you only need to add one hour.

Lastly, understanding the time zone your data is collected in is critical for comparing time series data sets such as multiple loggers to one another or to a gage station, and when correcting your data with barometric data. It is essential to make sure all data sets are in the same time zone for meaningful analyses to be conducted.

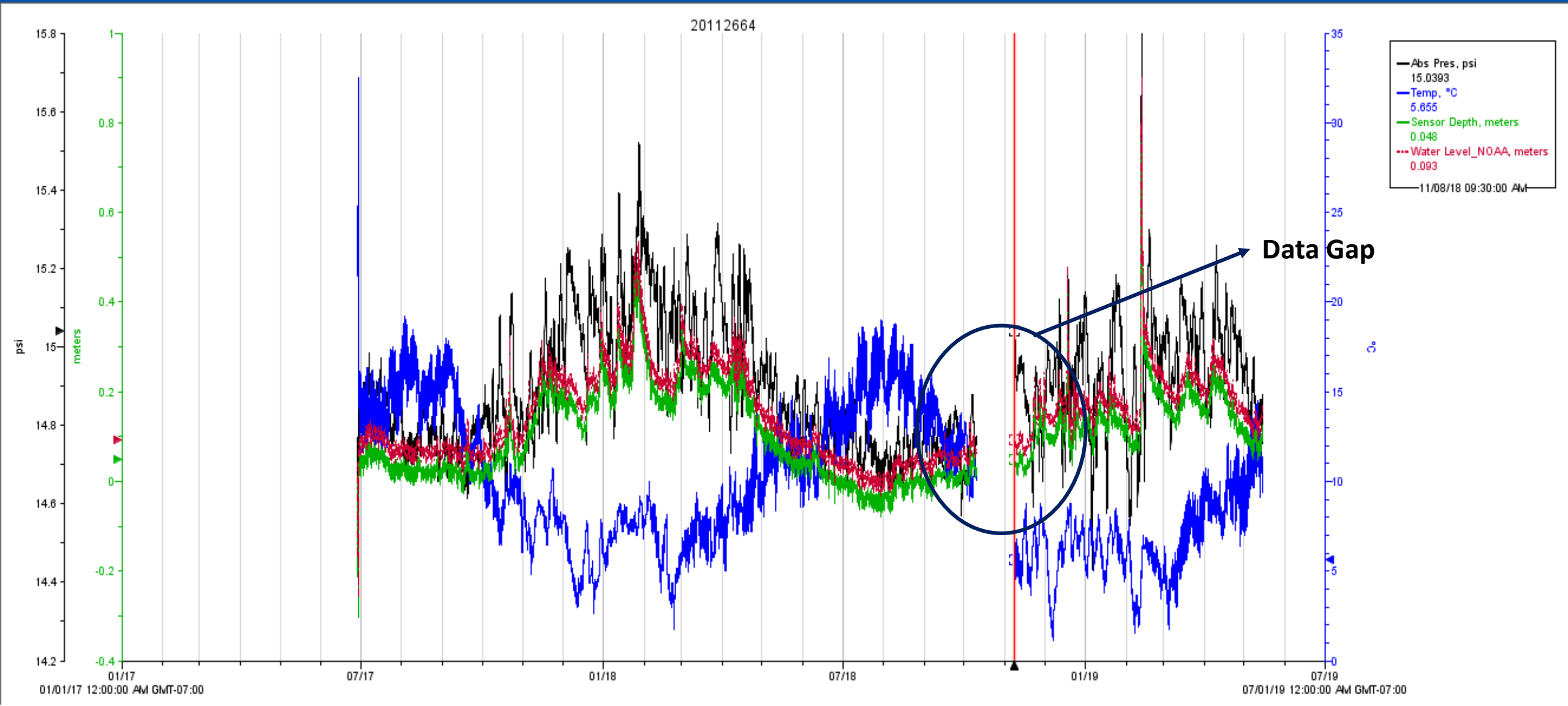
Best Practices - Quick Guide: Water Surface Elevation and Temperature Data Collection



After applying Barometric compensation assistant



Data Processing Errors: Data Gaps



Data Processing Errors: Due to Freezing temperatures

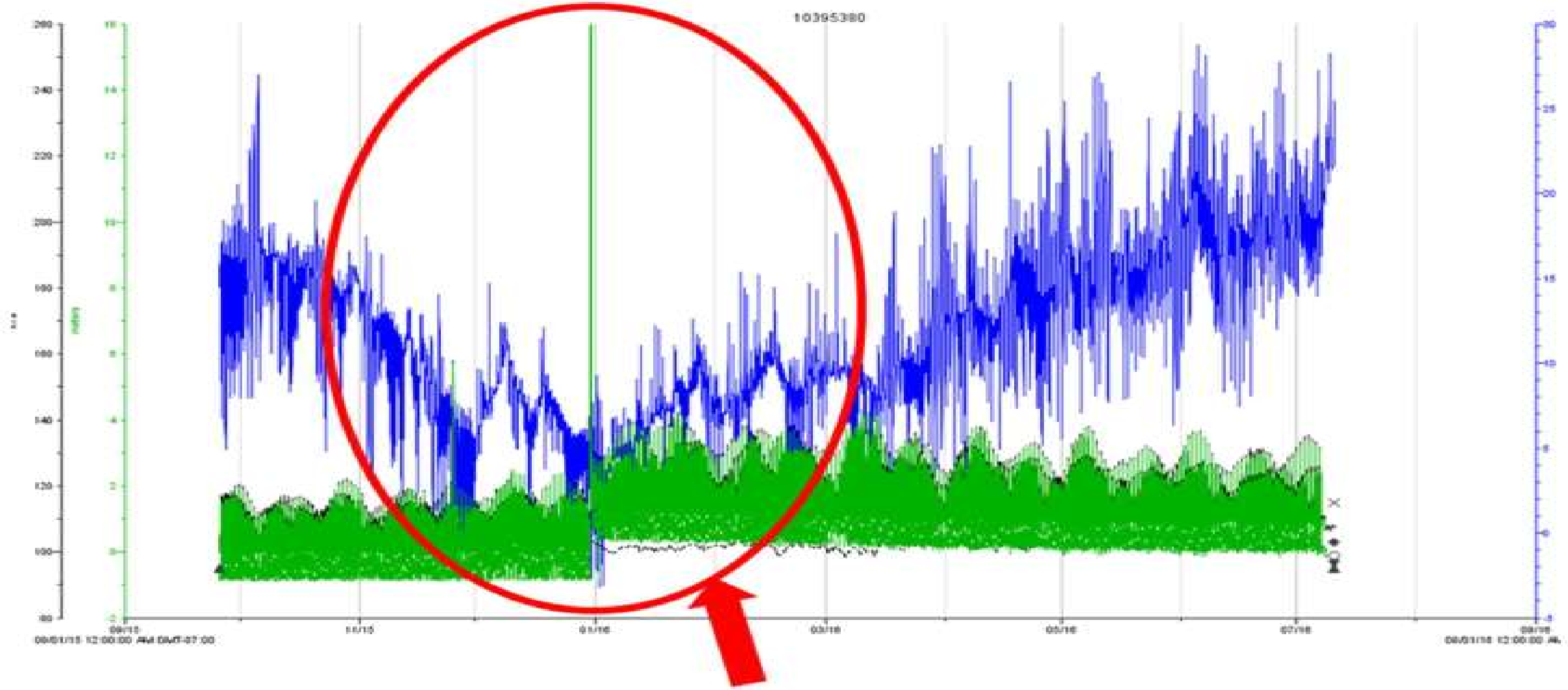
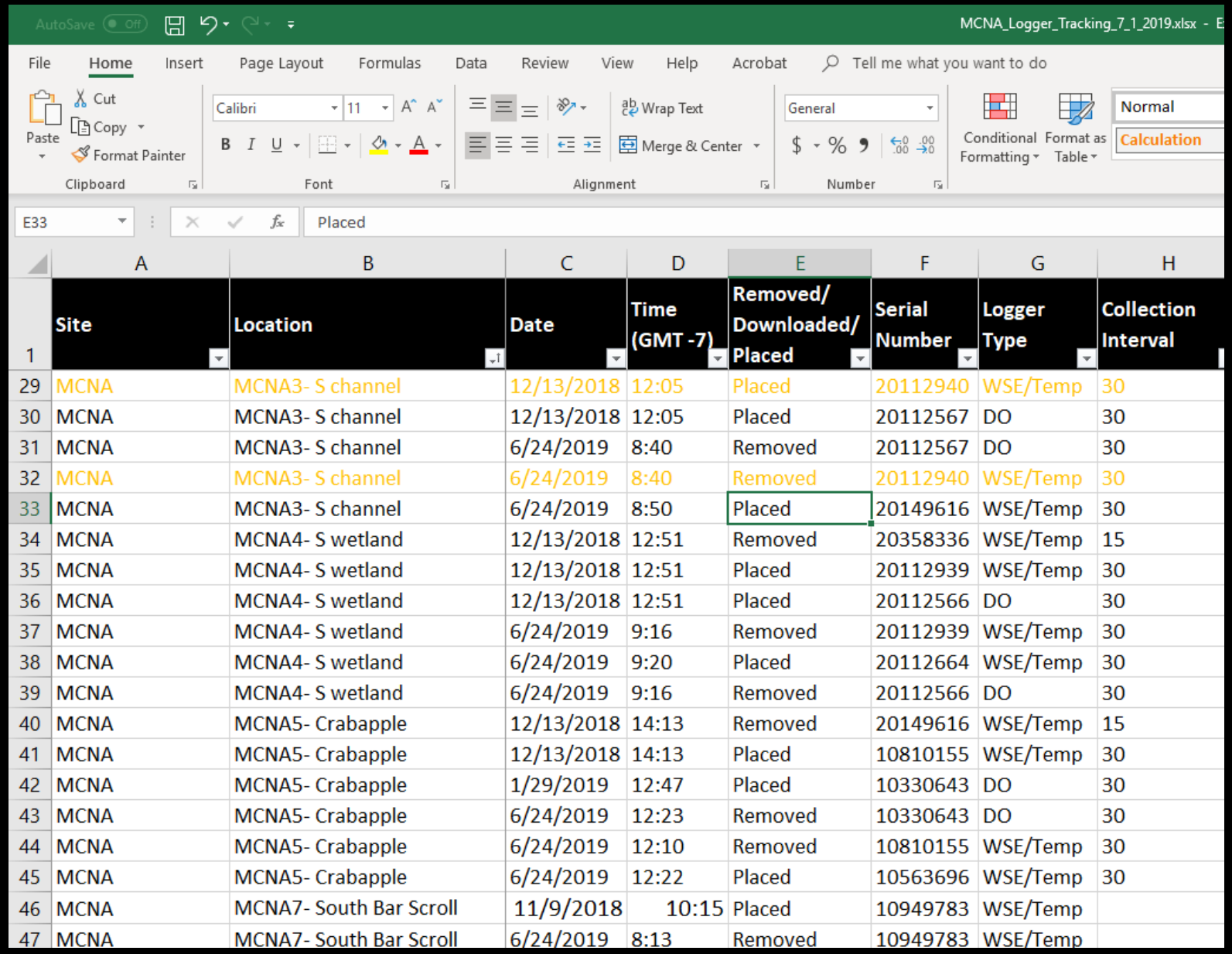


Figure 7. Error in data caused by a sensor freezing during deployment.

Let’s reduce those errors!

- Erase old data and always relaunch Hobo Shuttle
- QA/QC of loggers during calibrations
- Ensure loggers are set to the right logging intervals
- Swap loggers every six months
- Update hoboware pro regularly
- Ensure accurate field measurements: Water level, Temperature and RTK data
- Check deployed loggers and housing for algal growth and damages

Next Steps: Data Sharing – Creating a database



	A	B	C	D	E	F	G	H
1	Site	Location	Date	Time (GMT -7)	Removed/ Downloaded/ Placed	Serial Number	Logger Type	Collection Interval
29	MCNA	MCNA3- S channel	12/13/2018	12:05	Placed	20112940	WSE/Temp	30
30	MCNA	MCNA3- S channel	12/13/2018	12:05	Placed	20112567	DO	30
31	MCNA	MCNA3- S channel	6/24/2019	8:40	Removed	20112567	DO	30
32	MCNA	MCNA3- S channel	6/24/2019	8:40	Removed	20112940	WSE/Temp	30
33	MCNA	MCNA3- S channel	6/24/2019	8:50	Placed	20149616	WSE/Temp	30
34	MCNA	MCNA4- S wetland	12/13/2018	12:51	Removed	20358336	WSE/Temp	15
35	MCNA	MCNA4- S wetland	12/13/2018	12:51	Placed	20112939	WSE/Temp	30
36	MCNA	MCNA4- S wetland	12/13/2018	12:51	Placed	20112566	DO	30
37	MCNA	MCNA4- S wetland	6/24/2019	9:16	Removed	20112939	WSE/Temp	30
38	MCNA	MCNA4- S wetland	6/24/2019	9:20	Placed	20112664	WSE/Temp	30
39	MCNA	MCNA4- S wetland	6/24/2019	9:16	Removed	20112566	DO	30
40	MCNA	MCNA5- Crabapple	12/13/2018	14:13	Removed	20149616	WSE/Temp	15
41	MCNA	MCNA5- Crabapple	12/13/2018	14:13	Placed	10810155	WSE/Temp	30
42	MCNA	MCNA5- Crabapple	1/29/2019	12:47	Placed	10330643	DO	30
43	MCNA	MCNA5- Crabapple	6/24/2019	12:23	Removed	10330643	DO	30
44	MCNA	MCNA5- Crabapple	6/24/2019	12:10	Removed	10810155	WSE/Temp	30
45	MCNA	MCNA5- Crabapple	6/24/2019	12:22	Placed	10563696	WSE/Temp	30
46	MCNA	MCNA7- South Bar Scroll	11/9/2018	10:15	Placed	10949783	WSE/Temp	
47	MCNA	MCNA7- South Bar Scroll	6/24/2019	8:13	Removed	10949783	WSE/Temp	

Create a user friendly Data Log!

Next Steps: Data Sharing – Creating user-friendly DETs

5_Measurement_DET

Paste atmospherically corrected and elevation corrected water level data into this form for upload into Oncor.

Water_Elevation_Instrument	Instrument_Deployment_Dat	Water_Measurement_Dat	Water_Temperature	Temperature_Sensor_Exposed	Water_Surface_Elevation	Instrument_Measurement_Notes	DB_Access
Hobo_9782045	3/12/2014 15:20	3/12/2014 15:20	11.24		1.4074	WSE Output converted to Meters	
Hobo_9782045	3/12/2014 15:20	3/12/2014 15:30	10.94		1.3473		
Hobo_9782045	3/12/2014 15:20	3/12/2014 15:40	10.94		1.2946		
Hobo_9782045	3/12/2014 15:20	3/12/2014 15:50	10.94		1.2378		
Hobo_9782045	3/12/2014 15:20	3/12/2014 16:00	10.94		1.1851		
Hobo_9782045	3/12/2014 15:20	3/12/2014 16:10	10.94		1.1355		
Hobo_9782045	3/12/2014 15:20	3/12/2014 16:20	10.94		1.0835		
Hobo_9782045	3/12/2014 15:20	3/12/2014 16:30	10.94		1.0314		
Hobo_9782045	3/12/2014 15:20	3/12/2014 16:40	10.94		0.9833		
Hobo_9782045	3/12/2014 15:20	3/12/2014 16:50	10.94		0.9387		
Hobo_9782045	3/12/2014 15:20	3/12/2014 17:00	10.85		0.8965		
Hobo_9782045	3/12/2014 15:20	3/12/2014 17:10	10.85		0.8510		
Hobo_9782045	3/12/2014 15:20	3/12/2014 17:20	10.85		0.8048		
Hobo_9782045	3/12/2014 15:20	3/12/2014 17:30	11.04		0.7645		
Hobo_9782045	3/12/2014 15:20	3/12/2014 17:40	11.04		0.7257		
Hobo_9782045	3/12/2014 15:20	3/12/2014 17:50	11.04		0.6894		
Hobo_9782045	3/12/2014 15:20	3/12/2014 18:00	11.04		0.6516		
Hobo_9782045	3/12/2014 15:20	3/12/2014 18:10	11.04		0.6169		
Hobo_9782045	3/12/2014 15:20	3/12/2014 18:20	11.04		0.5847		
Hobo_9782045	3/12/2014 15:20	3/12/2014 18:30	11.04		0.5530		
Hobo_9782045	3/12/2014 15:20	3/12/2014 18:40	11.04		0.5248		
Hobo_9782045	3/12/2014 15:20	3/12/2014 18:50	11.04		0.4997		
Hobo_9782045	3/12/2014 15:20	3/12/2014 19:00	11.04		0.4765		
Hobo_9782045	3/12/2014 15:20	3/12/2014 19:10	11.04		0.4560		
Hobo_9782045	3/12/2014 15:20	3/12/2014 19:20	11.04		0.4377		
Hobo_9782045	3/12/2014 15:20	3/12/2014 19:30	11.04		0.4225		

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https://irma.nps.gov/DataStore/DownloadFile/563851

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http://docs.streamnetlibrary.org/Protocols/021.pdf

Washington Department of Ecology Quality Assurance Monitoring Plan: Continuous Monitoring for Oxygen, Temperature, pH, and Conductivity in Statewide Rivers and Streams
https://fortress.wa.gov/ecy/publications/summarypages/0903122.html

HOBOware User's Guide:
http://www.onsetcomp.com/support/manuals/12730-MANBHW-UG

HOBOware Pro Barometric Compensation Assistant User's Guide:
http://www.onsetcomp.com/files/manual_pdfs/Barometric-Compensation-AssistantUsers-Guide-10572.pdf

HOBO® U20 Water Level Logger Manual:
http://www.onsetcomp.com/files/manual_pdfs/12315-F-MAN-U20.pdf

Specifications for HOBO® U20 Water Level Loggers:
http://www.onsetcomp.com/files/datasheet/Onset%20HOBO%20U20%20Water%20Level%20Data%20Loggers.pdf

Specifications for HOBO® U20L Water Level Loggers:
http://www.onsetcomp.com/files/datasheet/Onset-HOBO-U20L-Water-Level-DataLogger-Series.pdf

US Geological Survey. 2012. Water level continuous standard operating procedures. Unpublished protocols. USGS, Western Ecological Research Center, San Francisco Bay Estuary Field Station, Vallejo, CA.
http://www.tidalmarshmonitoring.org/monitoring-methods-hydrology.php

SWG Discussion

Input on other protocols

Use of remote sensing, e.g., drones for data collection

- Use of drones is specific to monitoring goals and available equipment and expertise of handler, so protocols need to be specific to these items and may not be practical. BUT are there a subset of metrics that we can standardize?
- Is this a topic of discussion for future SWG?

Topics for future SWG:

- Results from 5 years of AEM - what seems to be working, what might need “tweaking”, other lessons to share amongst partners
- Results from @ 20 years of restoration in lower Columbia - what seems to be working, what might need “tweaking”, other lessons to share amongst partners

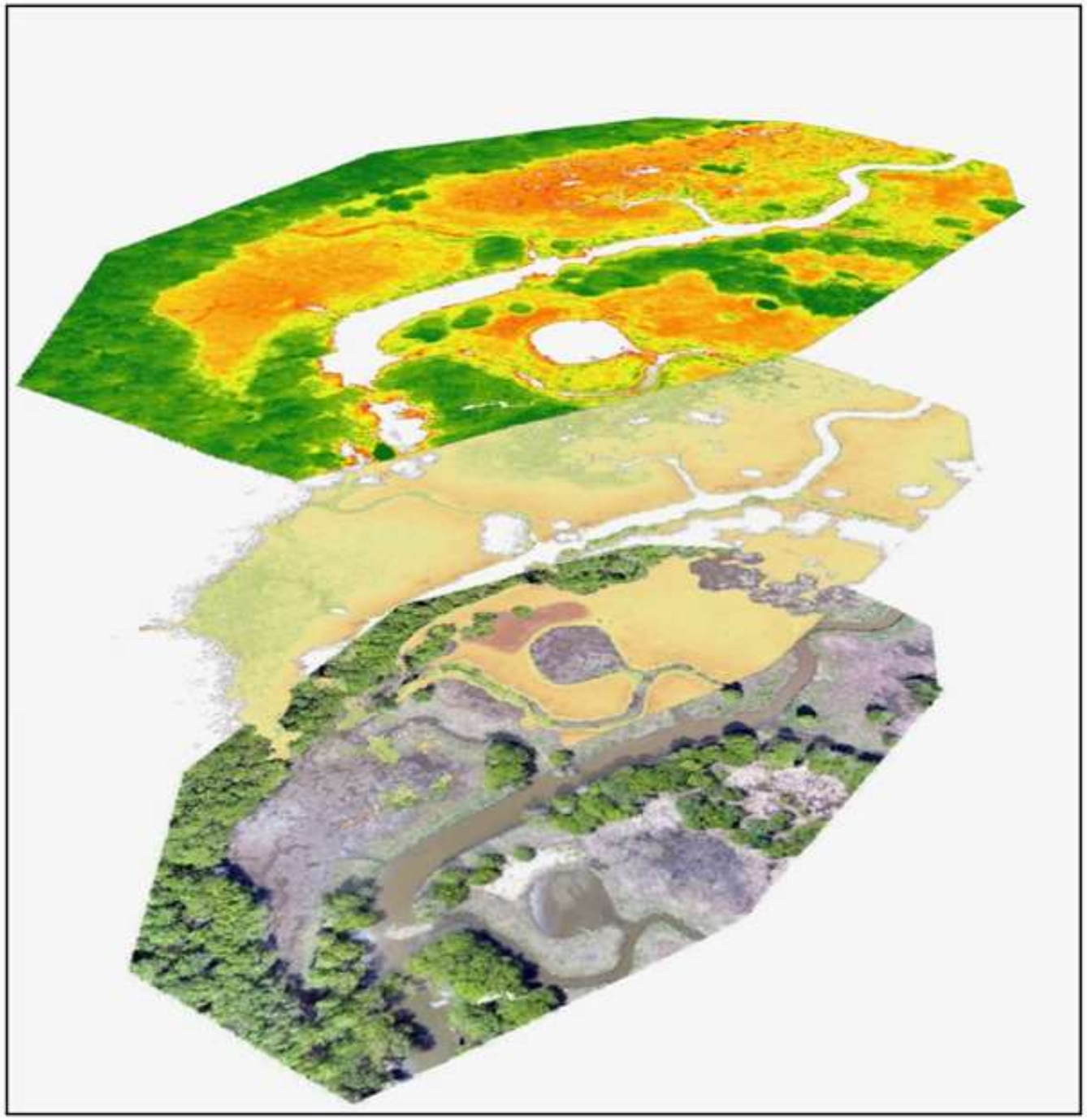
UAV – Future Discussions

UAV best practices (short list) –

- Develop a **flight plan** and do a site visit prior to see if your plan matches with the detail that you need to collect
- Spend some time thinking about what type of data you are collecting and how much **detail you need**
- Have back-up SD cards and batteries (car chargers are good too if large area)
- Download all **software updates** prior to field day
- We have used a high degree of **sidelap and frontlap (e.g. 80%/80%) with a lot of success**
- In areas where there are high trees (e.g. riparian areas adjacent to a body of water) and you want detail along the riparian edge then you may need to collect additional detail. For instance, you may choose to add flying up the streambank if you need that detail on top of your grid
- Also, the **edges of the project area** are likely to not have the same level of detail (unless you extend flight plan beyond project area)
- **Flying altitude- flying at 275- 300 ft.** means that you might have to plan for more flight time but that you will also collect more visual details then flying at 400 ft.
- Areas with more topographic relief or shadows could require additional **ground control points**
- Location and amount of ground controls matter
- **Time of day matters and shadows effect post-processing**
- Flat light (cloudy days) are ‘mo better

Drone Data Processing & Vegetation Survey

Multispectral Drone Imagery was combined with the Digital Elevation Model and Field Vegetation Survey Data to create an accurate Plant Community Map using R & ArcGIS, 0.25 m^2 resolution



Drone Image - July 2018

Classifications	Acres	% Cover
Open Water	2	2%
Emergent *Wapato, Aquatic Mix*	4.5	4%
High Marsh Mix *Rushes, Sedges, Reed Canarygrass*	4.9	4%
Reed Canarygrass	58.3	50%
Riparian Forest/ Shrub Scrub	44.8	39%

MCNA North Unit