



Rocky Mountain Network Wetland Ecological Integrity Monitoring Protocol

Standard Operating Procedures, Version 1.0

Natural Resource Report NPS/ROMN/NRR—2015/992





ON THIS PAGE

ROMN crew collect vegetation data at a wetland site in Rocky Mountain National Park, 2009

Photograph by NPS, B. Schweiger

ON THE COVER

Monitoring a wetland sentinel site in Florissant Fossil Beds National Monument, 2010

Photograph by NPS, B. Schweiger

Rocky Mountain Network

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

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Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02, etc.) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0, ...). The previous version number, date of revision, author of the revision, and the reason for making the changes are recorded along with the new version number.

This document is the first published version of the protocol SOPs. The creation of the protocol began in 2007. Major changes and their reasoning in these early internal drafts are available from the ROMN Data Manager.

The ROMN Data Manager will be notified of any changes to the Protocol Narrative or SOPs so that the new version number can be incorporated in the metadata of the project database.

New versions will be posted on the ROMN website (<http://science.nature.nps.gov/im/units/romn/>).

Introduction

Rocky Mountain Network (ROMN) wetland monitoring is guided by a detailed Wetland Ecological Integrity (WEI) protocol. The WEI protocol describes an integrated approach to understanding wetland ecological status and trend in ROMN parks. It consists of several pieces including a main narrative, a set of standard operating procedures (SOPs; this document), appendices, and a dynamic set of materials available by request. The SOPs are intended to be “extractable” from the main narrative such that they may be used in the field as step-by-step methods. The narrative portion of the WEI protocol summarizes the rationale for monitoring wetlands in four of six ROMN parks, establishes specific monitoring objectives, and provides general context for the detailed set of methods in the SOPs.

Wetland monitoring field methods are relatively well established in existing state and other federal efforts for Colorado and Montana wetlands and we will draw upon this wealth of knowledge for the protocol. The ROMN wetland protocol emphasizes peer-reviewed and scientifically accepted approaches that integrate biological (vegetation), habitat, and groundwater hydrologic response measures. Sources of methods include various U.S. Environmental Protection Agency (EPA), state, U.S. Geological Survey (USGS), and Natural Heritage Program (NHP) protocols. Tested and reviewed methods suggested by these programs, modified as required, will become the core of the ROMN wetland SOPs. The wetland protocols ROMN has adopted were designed and assessed for efficiency, precision, and accuracy and they are adaptable for more intensive questions and applications as conditions may warrant in a given park. A high degree of flexibility is included in the protocol, allowing emphasis of select components to meet key short- and long-term management needs, yet maintain a core suite of measures, sample and response designs to maintain comparability across ROMN systems. The WEI protocol includes sampling and analysis strategies with varying logistic and cost constraints.

Protocol development efforts and ongoing evaluation of the methods will include revision as necessary to address specific monitoring objectives of the network. Selection of supplemental measures and revision of the core measures of the protocols will be informed by developmental research conducted by ROMN and its partners.

A Note on Field Forms

We have elected to NOT include images of any field forms or other documents used by crews in the field. These vary enough that they would quickly be out of date. Current versions can be obtained from the ROMN data manager.

Overview of ROMN Shared Administrative, Equipment, and Data Management Procedures

The ROMN maintains a set of common data management, administrative, and equipment operating procedures that is shared by all Vital Signs protocols (Table 1). These standard procedures are included in the document with the protocol-specific SOPs and cover all methods to ensure safety, resource protection, and compliance of a field crew working in ROMN parks. Guidance for permitting, vehicle leasing, safety training, communications and radio use, finding housing, hiring crews, and end-of-season procedures are also covered. Other SOPs provide instructions for operation of equipment shared by all protocols, such as compasses, GPS units, and SPOT transponders (GPS personal messengers). Lastly, there are SOPs that are part of the ROMN Data Management Plan that apply to the WEI protocol. These address topics such as data deliverable standards, data quality assurance/quality control (QAQC), archiving data, and equipment maintenance and storage.

Table 1. ROMN Shared Data Management, Administrative, and Equipment SOPs.

ROMN SOP: Safety Preparation and Training
ROMN SOP: Permitting
ROMN SOP: Training
ROMN SOP: Seasonal Hiring
ROMN SOP: Park Logistics
ROMN SOP: End of Season
ROMN SOP: GSA Vehicle Leasing
ROMN SOP: Specimen Tracking and Vouchering
ROMN SOP: Using a Digital Camera
ROMN SOP: Using the Garmin GPS 76csx
ROMN SOP: Field Communications
ROMN SOP: SPOT Transponder
ROMN SOP: Archive Format Standards for Network Data
ROMN SOP: Folder Structure and File Naming
ROMN SOP: Scanning
ROMN SOP: YSI Logger
ROMN SOP: HOBO Logger
ROMN SOP: Photo Management
ROMN SOP: Database Design
ROMN SOP: Quality Control and Quality Assurance

WEI SOP 1: Pre- and Post-Season Workflow

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents procedures conducted before and after a wetland field season. We include before and after activities together in one SOP as many are similar *and a WEI sample season should begin with an understanding of how it must end*. Additional details and supporting materials can be found in the ROMN WEI narrative (Schweiger et al. 2015) and subject-specific WEI SOPs.

Pre- and Post-Season Workflow

Pre-Season Field Equipment Setup

Field Computers

1. Refer to the WEI SOP 3: Use of Electronic Data Recorders for details on the procedures to set up the EcoNab database on the field computers and PDAs.
2. Work with the Protocol Lead to identify the sites where loggers will be downloaded during the season.
3. Gather all the .wsl files of the anticipated sites to visit and save them on both the shared server and the field computer and ensure they are viewable with Win-Situ.
4. Server location:
Z:\MONITORING\Loggers\Data\DataGathering\InSitu_DTW_WinSitu\UploadToFieldPC\Site Data
5. Field computer location: C:\Documents and Settings\[user]\My Documents\WinSitu Data\Site Data

GPS/Maps

1. Ensure all waypoints and tracklogs are cleared from the GPS units.
2. Export a .dbf or .csv file of all visited site locations from the Locations_ROMN_MASTER.mdb saved in the following folder on the shared server: Z:\MONITORING\Locations\Data\Certified.
 - a. This will include all visited sites for all protocols.
 - b. Be sure to also add the coordinates and site names of any new sites.
3. Create one shapefile per UTM Zone named Sites_ROMN_UTM##_YYYYMMDD and save the files in the following folder: Z:\MONITORING\Locations\Geospatial\GeoDatabases.
4. Connect the GPS to the base station computer via a USB cable.
5. Open DNR Garmin.
6. Make sure DNR Garmin is set to the correct projection, i.e., correct UTM zone for the park and NAD83 datum.
7. Select File-Load From-File and navigate to your shapefile for the UTM zone selected in the last step.

- a. Change the file extension to .shp to see shapefiles in the folder.
 - b. The points from the shapefile will appear in the table in DNR Garmin.
8. Select Waypoint-Upload to upload all points from the DNR Garmin table onto each GPS unit.
 - a. Not all waypoints will be visited, but all waypoints should be included.
9. Clear the DNR Garmin table and repeat steps 1-8 for each shapefile needed.
10. Use the same shapefiles to create annual maps for each park by updating the maps located in the following folder: Z:\MONITORING\Locations\Geospatial\MXDs.
 - a. The display should be filtered based on anticipated sites.
11. Create and print maps (on write-in-the-rain paper) that show the appropriate roads and trails to navigate to each wetland complex as well as “zoomed in” maps that show the boundaries and characteristics of each complex.

Cameras

12. Ensure all photos have been cleared from the cameras.

Field Sheets and Printing

13. Make any desired field sheet edits in a new copy of the WEI_FieldForms_YYYY_FINAL database located on the shared server in the following folder:
Z:\MONITORING\Wetlands\FieldForms
14. Export all field sheets from the database into a single PDF named
WEI_FieldForms_YYYY_YYYYMMDD located in Z:\MONITORING\Wetlands\FieldForms.
15. Print five more sets of field sheets than the scheduled visits using write-in-the-rain paper.
16. For each wetland complex, print out a reference sheet that includes well metadata from the previous well visit. Crews can use this reference sheet to compare current year’s values with previous values to determine if any well disturbance has occurred.

Pre-Season Database and Folder Structure Setup

Monitoring Databases

1. Complete any needed schema changes to the master database located on the shared server in the following folder: Z:\MONITORING\Wetlands\Data\Certified.

2. Edit the data entry interface as needed to accommodate any structure edits.
 - a. The interface consists of forms and VisualBasic sub routines within the master database.
3. Test the data entry interface.
4. Make a copy of the master database and name it WEI_ROMN_DataEntry_YYYY_YYYYMMDD in the following folder:
Z:\MONITORING\Wetlands\Data\DataGathering\DataEntry.
5. From the newly created data entry database delete all records in tbl_Events.
6. Keep only “Calculate,” “QAQC,” and “CheckBox” macros, modules, queries, and forms.
7. Keep all tables except any “working*” tables.
8. Compact and Repair the data entry database.
9. Ensure all legacy files have been cleared from all subfolders within
Z:\MONITORING\Wetlands\Data\DataGathering.

Logger Databases: HOBO and InSitu

10. Make a copy of the HOBO processing database located on the shared server in the following folder: Z:\MONITORING\Loggers\Data\Tools. Name the copy
HOBO_ROMN_DataCompiling_YYYY_YYYYMMDD and save it in
Z:\MONITORING\Loggers\Data\DataGathering\HOBO.
11. Delete all records in the Logger_Metadata and IMPORT_Logger_HOBO_Metadata tables.
12. Make a copy of the InSitu DTW processing database located on the shared server in the following folder: Z:\MONITORING\Loggers\Data\Tools. Name the copy
InSituDTW_ROMN_DCompiling_YYYY_YYYYMMDD and save it in
Z:\MONITORING\Loggers\Data\DataGathering\InSitu_DTW_WinSitu.
13. Delete all records in the IMPORT_Logger_InSituDTW_Metadata table.
14. Ensure all legacy files have been cleared from all subfolders within
Z:\MONITORING\Loggers\Data\DataGathering...InSitu_DTW_WinSitu and HOBO folders.

Photo Database

15. Ensure all records have been deleted from the Photo_Metadata table of the photo database located on the shared server in the following folder:
Z:\MONITORING\Wetlands\Data\DataGathering\Photos.
16. Ensure all legacy files have been cleared from all subfolders within
Z:\MONITORING\Wetlands\Data\DataGathering\Photos.

Soil Database

17. Make a copy of the master soils database located on the shared server in the following folder:
Z:\MONITORING\Soils\Data\Certified. Name the copy
Soils_ROMN_DataCompiling_YYYY_YYYYMMDD and save it in
Z:\MONITORING\Soils\Data\DataGathering.
18. Delete all records in the IMPORT_Soil_SampleMetadata table.
19. Ensure all legacy files have been cleared from all subfolders within
Z:\MONITORING\Soils\Data\DataGathering.

Pre-Season Workflow Setup

Trello

Trello is an online tool helpful for organizing and managing tasks. It can be used for project management and collaboration. The ROMN uses Trello for workflow management.

1. The Data Manager administers the protocol workflow sites in Trello: <https://trello.com/>.
2. Copy the Workflow—WEI (Template) board and name it Workflow—WEI YYYY.
3. Modify the Check-in, Data Processing, and Data Tracking columns to reflect the anticipated site visits.
4. Assign estimated due dates and responsible personnel to each card.
5. Invite all ROMN personnel to join the new board.
6. Keep board up to date as tasks are completed.
 - a. Most cards have Checkbox lists within them.
 - b. Add comments if notes are needed.

- c. Move a card to the Done column once all lists are completed within the card.

During Season Operations

1. Refer to the WEI SOP 2: Pre- and Post-Sample Event Workflow for details on the procedures the field crew needs to take to manage field sheets, photos, GPS points, logger data, and EcoNab downloads.
2. The Data Management team is responsible for processing the photographs after they have been downloaded. Refer to ROMN SOP: Photo Management for details on these procedures.
3. The Data Management team is responsible for processing the field sheets after they have been turned into the “Ready to Scan” inbox. Refer to WEI SOP 15: Field Sheet Scanning and WEI SOP 16: Data Entry for details on these procedures.
4. Ensure the Trello board is accurately updated as data are downloaded and processed.
5. Run the Logic QAQC tool within the data entry database periodically throughout the field season and initiate discussion on the reasons and solutions for flagged data. Track progress in the QAQC_QualityTracking table.

Post-Season Operations

Multi-Protocol Databases (loggers and soils)

The data management team is responsible for processing the logger data and soil data delivered from the lab at the end of the season.

2. For information on loggers, refer to WEI SOP 17: InSitu Groundwater Depth Logger Processing and ROMN SOP: HOBO Logger for details on these procedures.
3. Make a copy of the final InSitu and HOBO logger databases for the year and save as WEI_ROMN_Logger[InSituDTW/HOBO]YYYY_FINAL on Z:\MONITORING\Wetlands\Data\Certified\FY##\Databases.
4. Only keep the WEI protocol records in the IMPORT_Logger_[InSituDTW/HOBO]_Metadata tables.
5. Make a copy of the final soil database for the year and save as WEI_ROMN_SoilYYYY_FINAL on Z:\MONITORING\Wetlands\Data\Certified\FY##\Databases.
6. Only keep the WEI protocol records in the IMPORT_Soil_SampleMetadata table.
7. Ensure the Trello board is accurately updated as data are processed.

Wetland Monitoring Databases

8. Ensure all unknowns have been identified in EcoNab.
9. Add all tables, queries, forms, macros, and code from the WEI_ROMN_EcoNab_Tool database in Z:\MONITORING\Wetlands\Data\Tools to the latest EcoNab database in Z:\MONITORING\Wetlands\Data\DataGathering\DataEntry\EcoNab\[GoldFinch/BlueBird].
10. Click the newly added button within the Summary_Import form.
11. Save the final EcoNab DB as WEI_ROMN_EcoNabYYYY_FINAL in Z:\MONITORING\Wetlands\Data\Certified\FY##\Databases.
12. Upload the records from the Summary* tables into the tbl_VegData_EcoNab* tables within the data entry database.
 - a. Some records may need to be created in the root tbl_VegData table for the relationships to authenticate.
13. Check to see if any identified species are not represented in the Species_SpeciesLookup_CNHP table.
 - a. Exclude all records where no species were identified, like unknowns.
14. Update the Species_SpeciesLookup_CNHP and Species_SpeciesLookup_PLANTS tables as needed.
15. Run the CheckBox QAQC tool after all data are entered and QAQCed. Resolve any discrepancies. Run the tool again until no records are flagged.
16. Run the Logic QAQC tool after all data are entered and QAQCed. Finalize discussion on the reasons and solutions for flagged data. This process ends when all cells in the AcceptanceDate field are populated in the QAQC_QualityTracking table.
17. If new GPS locations were needed, then temporarily import the .dbf extensions of the shapefiles located in Z:\MONITORING\Wetlands\Data\DataGathering\Waypoints into the data entry database.
18. Use these files to update the Lat_UTM_GPS and Lon_UTM_GPS fields in the tlu_Sites table and then remove the temporary files.

19. Save the data entry database as WEI_ROMN_AnnualYYYY_FINAL on Z:\MONITORING\Wetlands\Data\Certified\FY##\Databases.
 - a. This is the annual certified database; therefore, data may not be edited after this database is created.
20. Use the Lat_UTM_GPS and Lon_UTM_GPS fields in the tlu_Sites table within this certified WEI database to update the Locations_ROMN_YYYY_YYYYMMDD database located in Z:\MONITORING\Locations\Data\DataGathering.
21. Make a copy of the WEI_ROMN_MASTER database located in Z:\MONITORING\Wetlands\Data\Certified and name it with YYYYMMDD appended to the end of the filename and save it in Z:\MONITORING\Xample\Data\Certified\FY##\Databases.
22. Update the WEI_ROMN_MASTER with the certified annual database.
 - a. Append all data in the tbl* tables.
 - b. Append any new records in the Species_SpeciesLookup* tables.
 - c. Append any new records in the tlu_Crew table.
 - d. Update the Lat_UTM_GPS and Lon_UTM_GPS fields in the tlu_Sites table.
23. The Ecologist and Protocol Lead can now run the Summary tools within WEI_ROMN_MASTER, and can work with the Data Manager on any additions and/or modifications that are needed.

Certify and Archive Data

24. Ensure all GPS files have been named correctly and then move the spatial data to Z:\MONITORING\Wetlands\Geospatial\GeoDatabases.
25. Ensure the final WEI soil, WEI logger(s), WEI annual and WEI EcoNab databases are saved on Z:\MONITORING\Wetlands\Data\Certified\FY##\Databases.
26. Ensure all photos have been named correctly. Save a copy of the photo database as WEI_ROMN_PhotosYYYY_FINAL into Z:\MONITORING\Wetlands\Data\Certified\FY##\Databases and save all Core photos into Z:\MONITORING\Wetlands\Data\Certified\FY##\CorePhotos. The Misc photos are moved to Z:\MONITORING\Wetlands\Images\Photos.

27. Ensure all field sheet scans have been named correctly and move them to Z:\MONITORING\Wetlands\Data\Certified\FY##\Scans.
28. Establish a connection from the certified annual database to the WEI soil database by importing a link from all soil tables into the certified annual database.
29. Establish a link from the certified annual database to the WEI logger database(s) by importing a link from all logger tables into the certified annual database.
 - a. There are two types of WEI loggers: InSitu and HOBO.
30. The Data Management team is responsible for processing, certifying, and archiving the data at the end of the field season. Refer to ROMN SOP: Archive Format Standards for Network Data for details on these procedures.
31. Ensure all sub folders in Z:\MONITORING\Wetlands\Data\DataGathering have been cleared of processing files.

Preparing Soil Samples for Lab Analysis

32. If not already done, prepare soil samples to be sent to the lab at Colorado State University. See WEI SOP 10: General Soil Characterization and Chemistry for details.
 - a. When the samples arrive at the office, double check the labels to make sure they are complete. Labels should include:
 - i. Site and location of collection
 - ii. Date collected
 - iii. Type of analysis needed
 - b. Open the whirlpaks and let the sample air dry for as long as needed.
 - c. When all samples have been collected at the end of the season, prepare shipment to the CSU lab.
 - d. Fill out the soil chain of custody document found in Z / MONITORING / Soils / Data / SampleTracking.
 - e. The following is a list of required fields for this form:
 - Sample # - a unique number identifying the sample for the lab. Write in a bright-colored sharpie on whirlpak.
 - Protocol – which protocol the sample is for.

- SiteName – the site where the sample came from.
 - LocationDetail – specifics about the location. For wetlands, could be a sample collected at 40 cm or a composite from between 0-20 cm. For AVCSS, it could be the aspect of the peak. For VCSS it could be the transect.
 - DateSampled – the date the soil was collected.
 - SampleName_ROMN – the sample name written on the bag.
 - SoilVolume – if the sample is tested for bulk density and the volume is known, record the volume here.
 - Analysis needed – options are chemistry, wetland type confirmation, or bulk density. The specific analyses needed for each are defined at the top of the spreadsheet for the lab.
 - o **Chemistry** (pH, total C, % organic matter, NH₄-N, NO₃-N, Ca, P, K, Mg, SO₄-S, CEC, texture, total N, Al)
 - o **Wetland Type Confirmation** (total C, total N, % organic matter)
 - o **Bulk Density** (*ONLY bulk density*)
- f. Print out a copy of the complete chain of custody for the lab.
- g. Ship or bring to the CSU lab. As of 2014, the administrative contact is Debbie Weddle, Debbie.weddle@colostate.edu, 970-491-5061. The office is at the Natural Resource Ecology Laboratory, A wing, 3rd floor, room A319. The physical address is:
 Soil, Water, & Plant Testing Lab
 Campus Delivery 1120
 NESB Room A319
 Fort Collins, CO 80523-1120
- h. Samples are paid for through a task agreement.

Preparing Moss Samples for Identification

33. All unknown moss collections should be sent to an expert for identification. As of 2015, ROMN was finding a new moss specialist. This SOP will be updated with more information as it becomes available. See WEI SOP 11: Vegetation Composition and Cover for details on moss samples.

Literature Cited

Schweiger, E. W., E. Gage, K. Hanes, D. Cooper, L. O'Gan, and M. Britten. 2015. Rocky Mountain Network wetland ecological integrity monitoring protocol: Narrative, version 1.0. Natural Resource Report NPS/ROMN/NRR—2015/991. National Park Service, Fort Collins, Colorado.

WEI SOP 2: Pre- and Post-Sample Event Workflow

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents procedures conducted before and after visiting each wetland site. We include before and after activities together in one SOP as many are similar (prepare gear, clean gear) *and all WEI sample events should begin with an understanding of how they must end*. Additional details and supporting materials can be found in the ROMN WEI narrative (Schweiger et al. 2015) and subject-specific WEI SOPs.

Pre-Sample Event

Pre-sample activities are generally conducted prior to or on the same day as the sampling visit. These activities are required to ensure that the field teams know where they are going, that access to the wetland site is possible and permissible, that all the necessary equipment and supplies are in good order to complete the sampling effort, that all data management provisions (especially field forms and labels) have been made, and that samples can be packaged and shipped correctly and promptly after collection, as applicable.

Daily Sampling Itinerary

Before each wetland visit crews must develop a sampling itinerary, confirm access to the site, inspect, calibrate, and repair equipment, check that all supplies required for the visit are available, and prepare sample labels and sample containers.

Based upon the sampling schedule provided to each team, crew leaders are responsible for developing daily itineraries. The crew leader reviews each wetland dossier (see WEI SOP 4: Verification of Site Status) to ensure that it contains the appropriate maps, field forms, copies of permits, and access instructions. The team leader also determines the best access routes, confirms permission with landowners or local contacts, confirms lodging plans throughout the sample hitch if needed, and coordinates rendezvous locations with individuals who must meet with a field team prior to or after accessing a site.

Confirming Site Access

The protocol lead and crew leader are responsible for providing field crews location and access information for each wetland they are scheduled to visit. Before visiting a wetland, the field crew must review maps of the wetland sites to be sampled (see WEI SOP 4: Verification of Site Status). Contact the Rangers in the district where the sites are located to confirm any known issues with fire or wildlife and any accommodations or assistance that the district Rangers may be providing. In some cases, private landowner(s) should also be contacted to confirm permission to sample or access a site.

Backcountry Travel Plans

ROMN SOP: Permitting covers all interactions with ROMN parks. In some ROMN parks, any backcountry trip that involves NPS staff may require use of the Park's Backcountry Travel Plan and frequent reports to park dispatch via an NPS radio. The Backcountry Travel Plan provides the itinerary for the sample event to the crew's park staff emergency contact and park dispatch. Crews will typically use the backcountry form specific to the park where the work is being done. Currently, they are required at the large parks (GRSA, GLAC, ROMO).

Failure to adhere to the reported itinerary can result in the initiation of expensive search and rescue procedures and disruption of carefully planned schedules. ***If crews fail to follow backcountry procedures more than once, seasonal employees may be dismissed.***

Sample Gear

Complete an inventory of equipment and supplies prior to departure using the detailed equipment list that is maintained in the field gear box. Note that for many remote ROMN WEI sites, access is by hiking; therefore, all gear will be packed into at least two backpacks. If crew size is greater than two or access is via truck or pack train, items may be dispersed as needed. For vehicle accessible sites, gear can instead be packed into coolers or other containers. In all cases, instruments must be well padded and protected.

Summary of WEI Instrument Inspection and Preparation

The following list summarizes items that will need to be checked before any field event. See the indicated SOPs for more or current details:

Camera (see ROMN SOP: Using a Digital Camera)

1. Camera is functioning properly and has fully charged batteries.
2. There is an extra set of fully charged batteries.
3. Date and time set correctly.
4. All old photographs are removed (if they have been downloaded!).
5. Photo resolution is set to maximum.
6. Photograph format is set to JPG.
7. Date/Time photo imprint is set to OFF.
8. Clean lens cloth for camera lens.
9. Waterproof pouch is in sound shape.

GPS (ROMN SOP: Using the Garmin GPS 76csx)

10. The unit is functioning properly and has fully charged batteries.
11. There is an extra set of fully charged batteries.
12. The unit is set to UTM NAD 83. Note that it is not possible to specify the zone since Garmin determines this automatically while in the field. Use the Units Setup Menu to select the position format and map datum.
13. Set to WAAS “enabled.”

14. Necessary waypoints and base maps have been loaded on to the units.

In-Situ Troll 100 or 300 Water Depth Data Loggers (WEI SOP 8: Installing and Reading Continuous Depth-to-Groundwater Data Loggers)

15. The unit is functioning properly and has at least 80% charge and 50% memory.

16. There is gear to hang or re-hang loggers in wells, and tools are available.

17. Cable/dock and Toughbook are present for installed logger download.

In-Situ SmarTroll Water Quality Sonde (WEI SOP 9: In-Situ Water Physiochemistry)

18. The unit is functioning properly and has fully charged batteries.

19. All calibrations and/or error checks have been performed and readings properly entered on WEI Form #0.

PDA (for Econab Vegetation Software, see WEI SOP 3: Use of Electronic Data Recorders)

20. The unit is functioning properly and is fully charged.

21. Collected data have been uploaded.

22. The correct species list and plot template is loaded onto the unit.

WEI Field Forms

Table 2-1 presents a summary of the forms needed for a typical WEI sample event. All of the forms should be pre-assembled in a site folder. This site folder (often referred to as a “dossier”) should also have topographic maps, aerial images, permits, earlier site visit photos, well metadata reference sheets from previous visits, and any other relevant paperwork. Field crew members should familiarize themselves with each of the forms listed below and the instructions at the start of the field season.

Table 2-1. Forms needed for a ROMN WEI sample event. Note that Field Form numbers not here reference forms no longer used within the protocol.

Form	Quantity per Typical Sample Event	Notes
WEI Form #0 Calibration and Error Check	1	Used for both calibration and error check
WEI Form #2 Survey Site Extent Evaluation	1	Used only for new or QAQC survey site sample events
WEI Form #3 Event: Site Establishment/ Well/Logger/DTW	1-3	Multiple copies may be needed for sites with many wells
WEI Form #4 Water Table Depth, Water Quality and Soil	1-3	Multiple copies may be needed for sentinel complexes or for sites with many wells
WEI Form #5 Vegetation Composition & Cover	1-many	Rarely used, but multiple copies may be needed for sites with many species
WEI Form #6b: Herbivory and Woody Structure	1-many	Multiple copies may be needed for sites with many species
WEI Form #8: Landscape	1	One form may apply to multiple sites in a complex
WEI Unknown Plant Datasheet	1-2	One form used per event to track plant species that could not be identified in the field

Post-Sample Event Procedures

Upon reaching a base station (campsite or office), the crew leader must review all completed data forms and samples for accuracy, completeness, and legibility *on a site-by-site or daily basis*. Fill in missing or illegible information on forms or labels as accurately as possible. In some cases, a completely new version of the form should be carefully reproduced. The crew leader initials all data forms at the top of the page after review. Once QCed by crew, forms should be filed in the “to be scanned” inbox in the ROMN office.

Other activities may include preparing any unknown or voucher specimens (see ROMN SOP: Specimen Tracking and Vouchering), inspecting and cleaning sampling equipment, checking the inventory of supplies, preparing samples for shipment (as applicable), shipping samples, submitting sampling status and tracking information to ROMN staff, and communicating with the field coordinator or park contact person(s).

If these steps cannot be completed directly following the sampling event, a weekly sample schedule must include a day where these activities can be done in mass. However, the review of field forms must be done daily.

Equipment Cleaning

Equipment cleaning procedures are given below. Inspect all equipment, including personal gear, and clean off any plant and animal material to minimize the risk of transferring harmful species between wetlands and to prevent possible cross-contamination of samples. Gear should be cleaned and disinfected with a 10 percent chlorine bleach solution or Sparquat. Some ROMN parks have specific gear and equipment protocols and these must be used by crews in addition to any ROMN procedures. The following provides a summary of general procedures to prevent and treat for possible contamination:

1. Do not handle any amphibians.
2. Consult the site dossier and determine if the wetland has been classified as whirling disease, chytrid or mudsnail positive or negative.
3. If the wetland is listed as “positive” *or no information is available*, chemically treat ALL sampling gear and other equipment that has come into contact with water (i.e., waders, boots, etc.) or sediments. Equipment should be treated by a 10-minute soak in a bleach or Sparquat solution (3/4 cup bleach per gallon of water), followed by copious rinsing.
4. Inspect sampling gear and boots, etc., for evidence of plant fragments or animal remains and remove them. If there appears to be the potential for contamination, disinfect gear with a 10 percent bleach solution.

5. Clean all gear before leaving a site (a stiff-bristled scrub brush or high-pressure water is the best tool for this task). Inspect gear before it is packed for transport. Visible traces of sand, mud, gravel, and plant fragments are signs that gear has not been properly scrubbed and mudsnails may have been retained.
6. Thoroughly rinse your gear with clean water.
7. Thoroughly dry your gear and brush your gear off after it has dried to remove any clinging snails; pay special attention to seams, boot tongue, laces, and inserts.
8. If possible, keep several changes of field gear for use in different wetlands, both within a park and between parks.
9. Rinse coolers with water to clean off any dirt or debris on the outside and inside.
10. Rinse all beakers used to collect water chemistry samples three times with deionized water to prevent contamination of the next sample.
11. Physical treatments are recommended over chemical treatments because they are usually less expensive, more environmentally sound, and possibly less destructive to gear. However, most physical methods require longer treatment times and often cannot be performed in the field.
12. If a team has completed sampling at a known or likely Whirling Disease or chytrid-infested site, treat all gear and sampling equipment with either a strong bleach solution (3/4 cup of chlorine bleach per gallon of water) or a solution containing “Sparquat” disinfectant. Pay particular attention to boots, as the hard spores can embed in this material. Immerse boots in a solution of 1 part chlorine bleach or Sparquat and 5 parts water, brushing the solution into the soles to kill the parasite.
13. Remember: chemical treatments are not a substitute for physically scrubbing and cleaning your gear.

Post-Sample Event Data Management

Each time the crew returns to the office, it is important to immediately download all digital information to a predefined location. The following files are expected in accordance with the WEI protocol: photographs, waypoints, field forms, EcoNab database, logger files. The following procedures describe how these data/information will be downloaded and placed in appropriate sub-folder(s).

Downloading Data to the Base Station Computer

Loggers

- Refer to WEI SOP 1: Pre-and Post-Season Workflow for details of how to download all types of loggers.

Photographs

- Make sure all eight CORE photos (see WEI SOP 5: Plot Layout and Site Photos) are noted on WEI Form #3.
- Connect the camera directly to the base station computer via a USB cable.
- *Avoid using the camera software for downloading since it places the photographs in a different location and can change file names. Instead, use Windows Explorer to copy and paste the photographs.*

Copy all photographs to the following folder:

Z:\MONITORING\Wetlands\Data\DataGathering\Photos \ReadyToRename.

- Immediately after copying, it is important to verify this process was successful by viewing the thumbnails of the photographs and ensuring the proper number were copied.
- Blurry, unnecessary or “error” photographs can be removed at this time; HOWEVER, kept photographs MUST NOT be edited at this time.
- Once all photographs have been successfully copied from the camera and verified, the original photos should be removed from the camera and the Trello board should be updated.
- The Data Management Team is responsible for all additional steps to process photographs. Refer to ROMN SOP: Photo Management for details on these procedures.

Waypoints

- Connect the GPS to the base station computer via a USB cable.
- Open DNR Garmin.
- Make sure DNR Garmin is set to the correct projection, i.e., correct UTM zone for the park and NAD83 datum.
- Select Waypoint-Download to download all waypoints on the GPS into DNR Garmin.

- Use Field Form #3 (or less frequently #2 or #4) to cross reference what waypoints were taken for the sample event.
- Using the table of waypoints in DNR GARMIN, highlight any waypoints collected in the field at a site or other important navigation waypoints and select Save To-File. Select projected shape file. Save the file in the following folder:
Z:\MONITORING\Wetlands\Data\DataGathering\Waypoints.
- Name the waypoint file “WEI_[PARK]_NewXY_UTM##_YYYYMMDD.shp”.
- Note that ROMN WEI waypoints DO NOT have individual “special names” given to them in the field, rather the automatically assigned waypoint number is recorded on relevant forms.
- Once all waypoints and tracklogs have been successfully verified, the waypoints collected in the field should be removed from the GPS and the Trello board should be updated.
- The Data Management Team is responsible for all additional steps to process the GPS data. Refer to the Post Season section of the WEI SOP 1: Pre- and Post-Season Workflow for details on these procedures.

Field Forms

- Field forms should be reviewed for completeness and legibility at the end of each sampling event. Once a form has been reviewed, initial it in the upper right corner.
- Once in the office, turn the reviewed field sheets into the To Be Scanned inbox.
- Data Management will update the Trello board to reflect what has been done.
- The Data Management Team is responsible for scanning, naming, tracking, and filing the field sheets. Refer to the WEI SOP 15: Field Sheet Scanning for details on these procedures.

EcoNab (vegetation and select sample event data on a PDA)

- Refer to the Downloading EcoNab to the PC section of the WEI SOP 3: Use of Electronic Data Recorders for details on these procedures.
- Update the Trello board to reflect what has been done.

Groundwater Data Logger Files

- The download procedure for water table loggers will follow from manufacturer recommended methods. *These methods may supercede the following procedures.*

- Data should be downloaded onto the field computer following these instructions and saved with the filename: [WELLID]_[SITENAME]_[TIMEPERIOD]_[LOGGER Serial#].*. For example, “503_MorainePark_Winter0809_57773”
- Once in the office, transfer the downloaded files to the ROMN shared server in the following folder: Z:\MONITORING\Loggers\Data\DataGathering\InSitu_DTW_WinSitu\Backups. Refer to the WEI SOP 17: In-Situ Groundwater Depth Logger Processing for details on these data transfer procedures.
- Update the Trello board to reflect what has been done.
- The Data Management Team is responsible for all additional steps to process the logger data. Refer to the WEI SOP 17: In-Situ Groundwater Depth Logger Processing for details on these procedures.

Literature Cited

Schweiger, E. W., E. Gage, K. Hanes, D. Cooper, L. O’Gan, and M. Britten. 2015. Rocky Mountain Network wetland ecological integrity monitoring protocol: Narrative, version 1.0. Natural Resource Report NPS/ROMN/NRR—2015/991. National Park Service, Fort Collins, Colorado.

WEI SOP 3: Use of Electronic Data Recorders

Version 1.0, June 2015

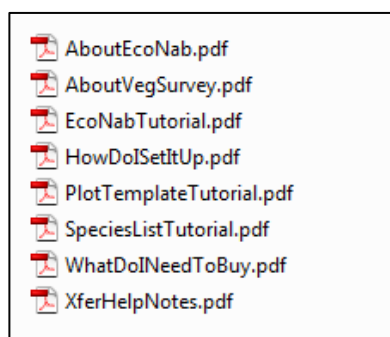
Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

Data on vegetation species in WEI plots are recorded in a Palm PDA-based application called EcoNab. Future revisions to the WEI protocol may include an alternate platform and software for field-based electronic data collection.

EcoNab provides detailed documentation and SOPs (Figure 3-1; available from the ROMN Data Manager or from the [EcoNab website](#)) that describe how to use the software. **This SOP is NOT a substitute for the step-by-step instructions from EcoNab. ROMN staff should read the EcoNab documentation and practice entering data in EcoNab, either using the onscreen Palm emulator or a real PDA.**



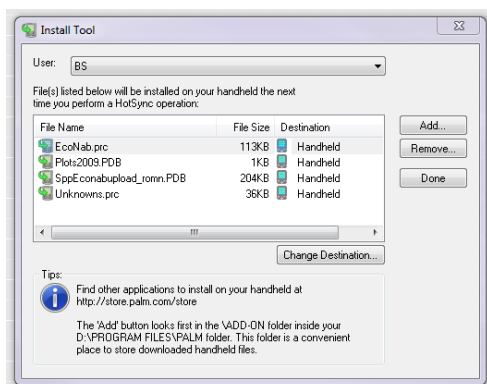
Use of EcoNab is identical at all site and wetland types. There are no WEI forms for using EcoNab, although WEI Form #5 can be used for collection of vegetation data and several items from Form #3 are duplicated in EcoNab.

Figure 3-1. Documentation/SOPs available from EcoNab.

Creating and Uploading to PDA: EcoNab Application, Plots, Species Lists, and AuxData

1. These activities are usually done by ROMN data management or ecologists prior to the field season. However, crews may need to replicate these or redo them should a field PC or PDA fail/change during the field season.
2. Create a copy of the master EcoNab VegSurvey.mdb and rename it “WEI_[ROMN/GLAC]_EcoNab_YYYY.mdb.” Save this database into the EcoNab_YYYY folder on the desktop of the field computer. This is the annual database that will be used to create upload files and process data from a field season. In many cases, the last VegSurvey database from the previous year is the source of the next season’s initial database. Note that PDAs are used in different parks in Colorado, but only Glacier in Montana. Therefore, there will be a Colorado (ROMN) and a Montana (GLAC) version of the master database. There are a variety of PDAs available for use – crews should have a dedicated unit and a backup assigned to them. The annual database will be on the PCs used to upload and manage data during a season. See the procedures below detailing how data are downloaded into these databases.
3. Files created in steps 4 through 6 are all uploaded to the PDAs during a HotSync operation described below.
4. Locate the Econab.prc and the Unknowns.prc (these are the main program files to be installed on a Palm) usually in the EcoNab_YYYY folder on the desktop of the field computer or available from ROMN data management or ecologists. It is often best to reload the prc files each field season to make sure there are no old or wrong files and data on a PDA. **Always check with ROMN data management before reloading these files as it will delete all old data.**
 - a. Additional software may also be needed on PDAs. This might include software for backing up to the external data cards on the PDAs, software for reading pdf files, etc. ROMN data management or ecologists should be consulted for these options.
5. Create a [Plots*].pdb following instructions in the EcoNab SOP. When the [Plots*].pdb file is created you will replace [Plots] with a smart name for a park/year/project based plot layout. This creates the sample plot structure implemented in EcoNab. **Note that only one [Plots*].pdb can be on a pda at a time.** If others are needed, they must be added, including the associated [AuxData].pdb described below.
 - a. In many cases, a [Plots*].pdb will already exist and may simply be used for the next monitoring season. This will usually be called “PlotWetlandEcologicalIntegrity.PDB” and will be in the EcoNab_YYYY folder on the desktop of the field computer or available from ROMN data management or ecologists.

- b. Other plot designs are possible. These require specific or alternate Plots.pdb files and should be made in consultation with ROMN data management or ecologists.
6. Create a [AuxData*].pdb following instructions in the EcoNab SOP. This creates the auxiliary data (ground cover and event metadata) structure used in EcoNab. The default ROMN WEI plot version is called “AuxDataSpecs.PDB” and will be in the EcoNab_YYYY folder on the desktop of the field computer or available from ROMN data management or ecologists.
 - a. Other Aux Data designs are possible. These require specific or alternate Plots.pdb files and should be made in consultation with ROMN data management or ecologists. Make sure that the right AuxData is associated with the correct Plots.pdb if there is more than one being used.
 - b. Create a [Species List*].pdb following instructions in the manufacturer’s EcoNab SOP. When the *.pdb file is created, you will replace [Species List] with a smart name for a park/year/project-based species list. **The creation of a complete and correct species list is a critical step.** A consistent species list must be used on all PDAs that will be in use. **Note that only one species list can be on a pda** (so a ROMO and a GLAC list cannot be on the same PDA). This will usually be called “[CO/MT] WEI SSP yyyyymmdd.PDB” and will be in the EcoNab_YYYY folder on the desktop of the field computer or available from ROMN data management or ecologists.
 - c. In many cases a [Species List].pdb will already exist and may be used for the next monitoring season. These decisions should be made in consultation with ROMN data management or ecologists. If the nomenclature of a taxa has changed and a new name is to be used in EcoNab, this must be carefully tracked in the WEI master database.
7. The above files are loaded into a Palm PDA by connecting the PDA to a computer with the files described above on them, opening Palm Desktop and adding all *.pdb and *.prc files into the “Install” list located on the Palm desktop. Make sure the correct User is selected in the drop-down box of the Install window. These will vary with the PDA being HotSynced. It will look like this:



8. Next, connect the PDA to computer and HotSync. This uploads all software and EcoNab setup files items to the PDA.

Overview of Using EcoNab in the Field

1. The majority of the detailed steps for how to use EcoNab are in the SOPs and documentation provided with the tool. The following are just general highlights for how to use EcoNab in the ROMN WEI protocol.
2. Open EcoNab on the PDA.
3. Select CREATE and NEW or “Use an existing plot”. If create new, select WEI Plot Type.
4. Select the relevant project. If the first plot of a season in a park, create project:
[ROMN.[CO/MT]].yy
5. On the next screen, enter the numeric Well ID as the plot name.
6. Enter the required botanist initials and optional recorder initials. **Always use one botanist for Montana parks and one for Colorado parks so all unknowns are available for all plots** in a state. Otherwise, an unknown species named by botanist A in Colorado will not be able to accessed by botanist B.
7. Click “I’ll finish later” to allow skipping of GPS data and select GO.
8. ***Note that most of the actions below are done or found in the plot name field (“microplot E”) in the upper left corner of the PDA screen.***
9. Enter Event metadata as indicated. Note that a relev  event is noted in the visit sub-type. Select NEXT.
 - a. If a relev  visit, skip through all subplot screens until you get to the whole plot and enter data only into this scale of plot. Note that you must cancel a species entry in each subplot screen to get past each subplot. You may also at a ground cover screen select Subplot and Go To the wholeplot.
10. Enter ground cover for plot. **This will sum to 100.**
11. Enter first species. Enter a start of a code, scientific name or common name. Click the plot name and a list of options for finding the taxa in the EcoNab species list will appear. Find the best

match and select. Note that once a species is selected by clicking on the plot name again you may zoom in on full name, etc.

12. Enter a **default height value of 1** (we do not track height data for taxa in cover plots) and the **ocular cover estimate of the taxa**.
13. Select the quality of ID. In most cases for known taxa the default value of “OK” is selected. In rare cases one of the two other options can be used here if there is absolutely no chance that the taxa will ever be identified (i.e., it is very young and you won’t be coming back to this plot). Options include:
 - a. “OK” meaning that the field ID is probably correct and it was not an unknown and no specimen was collected.
 - b. “?gen” meaning that the field ID is only certain at the **above genus** level (i.e., family). No specimen is collected.
 - c. “?ssp” meaning that the field ID **is unknown or perhaps only certain at the genus level**. No specimen is collected.
14. In rare cases, specimens of known taxa may be collected if a taxa is important to a park (i.e., it is new to the parks list, is a new invasive taxa, etc.). There is no easy way to handle this in EcoNab. Therefore, the unknown field form should be completed in these cases.
15. **Unknowns** must be treated very specifically as detailed below.
 - a. Unknowns are handled in both EcoNab and on the unknown plant species datasheet. If Form#5 is used (i.e., EcoNab has failed or the PDA was forgotten), all of the same details below apply—they are just recorded on Form #5 and the unknown field notebook instead.
 - b. EcoNab stores unknowns with an internal flag – it will know that a taxa, as entered below, is an unknown.
 - c. It is **very important that only one botanist is entered into EcoNab for each crew** (CO and MT) and this botanist is consistent throughout the field season; this facilitates the database recalling the same unknown list throughout the season.
 - d. Do not forget to take the appropriate cover value for the unknown or moss.
 - e. Nonvascular taxa (mosses) are collected every 5 years at sites where present.

- f. The quality of ID for a true unknown will usually be “?ssp” meaning that the field ID is unknown or perhaps only certain at the genus level but the taxa will be treated as an unknown with a possibility of further ID. If an unknown has a likely known genus the “?gen” can be used, but this is not common.

- g. Create an unknown name as follows:

- i. The first part of the name is a mnemonic that identifies the unknown by taxa:

Umo - is unknown moss

Ulv - is unknown liverwort

Ugr - is unknown grass

Use - is unknown sedge

Uru - is unknown rush

Ugm - is unknown graminoid

Ufo - is unknown forb

Ush - is unknown shrub

Utr - is unknown tree

- ii. The second part is a sequential number for the taxa. Crews will be provided with unique starting numbers for unknowns at the beginning of each season. For example the Colorado crew might start with 01 and the Montana crew start with 501. ROMN data management or ecologists will provide these starting numbers. EcoNab will not allow a duplicate unknown code, but because the first parts of the unknown code will usually be unique, its possible to reuse the numeric part. **Therefore, a running tally of the last unknown number for each taxa should be kept by each crew in the unknown field notebook.**

- 1. Example complete unknown codes are “Ugr01” or “Ufo501.”

- h. Create a simple description (notes about the specimen and its habitat) on the **Unknown plant species datasheet and optionally in EcoNab (note EcoNab requires something to be entered in the description and habitat fields; if Econab is not being used to record details about an unknown, simply enter a “.” in them).** The **Unknown plant species datasheet** (where it is easier to write) includes the site, date, location of plant in the plot, unknown code, and a description to help later identify the specimen. Note that the **Unknown plant species datasheet and EcoNab unknown data fields are filled out regardless if a specimen is actually taken.**

- i. Label newspaper or paper bags of the unknown species with the well/site number, date, plot or subplot found in, and the unknown code as used in EcoNab.
 - j. Label moss sample bags with the unknown code/number as used in EcoNab (see below) plus the site number and date. **Multiple moss specimens from the same plot cannot go into a single bag** because the cover values are linked to the unknown code written on bag and specimens will not be labeled separately with ribbon.
 - k. Vascular plants are labeled with a ribbon with the unknown number, plot ID, etc., written on it. Multiple vascular plants from a plot can be added to a single plastic bag if the specimens are tied up in this way.
 - l. Optionally, use a digital camera to take a close-up picture (or, series of photos if needed to show attributes, e.g., leaf and flower). Be sure to record the photo number(s) in the photo log and note in EcoNab and the unknown field form.
 - m. Attempt to identify samples the same day/week that they are collected; fresh samples are easier to identify. Some plants can be kept reasonably fresh for short periods of time (<1 week) in a refrigerator.
 - n. Reconciliation between the unknown codes and identified species name will be handled in EcoNab or for data entered in Form #5 during data entry or in the database.
 - o. At the end of the field season, any specimens that were not identified by the botanist during the field season will be given a unique code by data management.
16. Note that when moving to a new plot, all taxa and unknowns from previous plots are available in the plot name list. **Unfortunately EcoNab will not auto populate taxa from nested plots but this is appropriate as the cover values will be different.**
17. When all subplots and the whole plot are complete, select DONE and you will return to the plot header info screen and may start a new plot.
18. **At the end of each work day, select “CardBkup” or “BackupMan” from the PDA home page, and back up data to the internal data card using date (yyyymmdd) as the backup name as applicable.**
19. In rare cases, events may be edited some time after the field visit (for example to update a cover item or to change an identification). Ideally, this would be done before the nightly upload to the field PC. If this occurs after EcoNab has been uploaded to the field PC (see below), it is important to create a new event to house these edits. This is done on the second screen of EcoNab

(“Plot Header Information) by entering a **new date and a comment in the notes field like “plot edited to update a cover value or unknowns.”**

Downloading EcoNab to PC

1. Each field computer and the Z drive will have a default location for all EcoNab data.
 - a. Annual EcoNab database on the Field PC desktop. Note that PDAs are used in different parks in Colorado but only Glacier in Montana. Therefore, there will be a Colorado (ROMN) and a Montana (GLAC) version of the master databases:
WEI_[ROMN/GLAC]_EcoNab_YYYY.
 - b. Z:\MONITORING\Wetlands\Data\DataGathering\DataEntry\EcoNab\
WEI_[ROMN/GLAC]_EcoNab_YYYY
2. Sync PDAs to tough book nightly as follows:
 - a. **NEVER delete any data from the PDA during the field season.**
3. Connect PDA and HotSync with Toughbook.
4. Open the “WEI_[ROMN/GLAC]_EcoNab_YYYY.mdb” Access database that is on the desktop.
 - a. If needed, click on the “Options...” on the security warning and select “Enable this content.” If there is a warning that the version of Access is not valid, just ignore.
 - b. If asked “Add nested species?” – select “No” (this is not part of veg data downloading).
5. If a “Main Switchboard” screen is visible, select “Put Data in Database” then “Import Plot Electronically.”
 - a. If a “Main Switchboard” screen is NOT visible, under “All Tables” search “Import,” select “Palm - Import Data,” or find the Form “Palm - Import Data.”
6. Select “Explicitly Import” from the location where Palm HotSyncs go. This is usually “C:\Documents and Settings\[user]\My Documents\Palm OS Desktop\[palm account user, usually “ROMNCREW”]\Backup” (this address should be saved in the Recall Folder tab; if not, navigate to the palm folder where hot syncs are saved). Select “Import Now.”

- a. Windows will often shorten the User names in the above directory and sometimes they can be confusing. ROMNPalm1 is shortened to ROMNPa, ROMNPalm2 is shortened to ROMNPa0, and ROMNCREW is CREWR.
 - b. If more than one PDA has been used, the Backup location will vary and the above path will need to change.
7. The database will import all plots on the Palm. Several screens will pop up and ask for input. They are all intuitive, i.e., accept any new unknowns, print labels if needed, etc.
8. If the PDA had no “old” plots in it before the current data was entered, no warnings about duplicates should appear. Continue to step 11.
9. By default previous plots are not removed from the PDA after downloading. Therefore a warning for each duplicate site will pop up when these are imported. Three options are available:
 - a. “Yes” to create a duplicate of the previously downloaded plot. This can be manually deleted if no new data has been added for the site. If you are unsure if the plot data has been changed, do this and delete the duplicate later. This is risky as it creates a new visit for the duplicate data. **If this is done the duplicates must be managed manually and carefully.**
 - i. You must create a new date and a note for any edited data in a previously downloaded plot.
 - ii. To delete plot data unnecessarily downloaded, open the “Plots” table in the database and select and delete that site’s duplicate row.
 - b. “No” to delete the the previous data and replace with the new data.
 - c. “Cancel” if you know the final data for that site has already been downloaded (this will skip downloading the selected site). **This is the default choice, but use this only if you know the data is being duplicated, otherwise select “No” and replace old data with new.**
10. **YOU MUST CHECK THAT THE PDA’s** data were successfully downloaded. Find the “Plots” table and check that the plot and correct visit date are there. Find the “VegData” table and confirm that the records with each plot’s species appear to be in the database (you don’t need to check each record, just make sure it looks ok).
11. Once you are sure the data were properly downloaded, create an archive of the access database by “Saving As” using the file name
 “WEI_[ROMN/GLAC]_EcoNab_YYYY_YYYYMMDD.mdb” (or you may have to make a copy of the Access file in Windows Explorer and rename the new version as above). The date is

year-month-day of the download. June 22, 2009 would be saved as 20090622. The backup is saved in the “ECONAB_YYYY” folder on the desktop.

12. Once in the office, transfer the downloaded databases onto a thumb drive via USB cable.
13. Connect the thumb drive to the ROMN shared server and save all the EcoNab backups in the following folder: Z:\MONITORING\Wetlands\Data\DataGathering\DataEntry\EcoNab.
14. **The main database will remain “WEI_[ROMN/GLAC]_EcoNab_YYYY.mdb” on the desktop or on Z and will always be the version you download new data into.**
15. Remember to NEVER delete data from the PDA during the field season and always download all data from the PDA into the EcoNab database following the best choice for how to handle duplicate data detailed in step 9 above.
16. In rare cases, events may be edited some time after the field visit (for example to update a cover item or to change an identification). Ideally, this would be done before the nightly upload to the field PC. If this occurs after EcoNab has been uploaded to the field PC (see below), it is important to create a new event to house these edits. This is done on the second screen of Econab (“Plot Header Information) by entering a **new date and a comment in the notes field like “plot edited to update a cover value or unknowns”**.
17. For more information on EcoNab, see “EcoNabTutorial.pdf” found on Z:/MONITORING/Wetlands/Documents/EcoNabEssentials/Econab SOPs.

WEI SOP 4: Verification of Site Status

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents methods for verifying the target population membership and suitability for sampling (together referred to as “status”) of a sample site in any wetland type (fen, wet meadow, riparian, etc.). **Many of the methods described here are unique to the first visit at a survey site and depend somewhat on the details of the survey design used in a given ROMN park.**

Moreover, survey site verification procedures are related to various steps of implementing survey design, such as how sites (or entire watersheds in some designs) are replaced; therefore, the section in the main narrative that covers survey design should be reviewed and used in concert with this SOP.

Sample events at gradient or sentinel sites (especially first visits) can involve procedures analogous to survey site verification, but the steps are generally less involved. Once a site’s status is verified, methods in WEI SOP 5: Plot Layout and Site Photos can be carried out. Additional details and supporting materials can be found in the ROMN WEI protocol narrative (Schweiger et al. 2015).

Site verification in survey sites and all wetland types uses WEI Form #2: Survey Site Extent Evaluation. Some related data for survey sites are recorded on WEI Form #3: Event: Site Establishment / Well / Logger / DTW. All of the abbreviated field and office verification activities for gradient and sentinel sites in any wetland type use WEI Form #3 Event: Site Establishment / Well / Logger / DTW. Some site verification data may also be entered into a PDA-based electronic database in the field (for the 2007-2015 seasons we used [EcoNab](#)), see WEI SOP 3: Use of Electronic Data Recorders.

We first provide a brief narrative overview for all methods followed by detailed procedures (structured as lists).

Site verification includes up to three phases for determining whether a site can and should be sampled:

1. Office-based verification (optional in some cases);
2. Field reconnaissance (optional, may be the same as field-based verification);
3. Field-based verification (always conducted, first part of a sample event).

Because the type of wetland at a site is crucial in determining its suitability for sampling, we first provide methods for classifying wetland types using a classification approach based on hydrogeomorphic and vegetation attributes developed by Gage and Cooper (2013) that we refer to as the “Cooper system.”

Target Population Definition

As discussed in the main narrative (Schweiger et al. 2015), the target population for ROMN WEI monitoring may include riparian, wet meadow, fen, salt flat, or marsh wetland larger than 0.5 ha that has been distinguished from surrounding uplands and any adjacent wetlands of another type via heads up GIS-based delineation using color infrared aerial photography and is confirmed in the field using a suite of wetland attributes.

Cooper Wetland Types

Confirmation that a potential site is actually wetland and identification of its type is a key first step in establishing a site. The primary wetland classification system the ROMN uses follows from Gage and Cooper (2013). Other wetland classification systems are also used in WEI monitoring for data analysis purposes and these are presented in WEI SOP 13: Meso-scale Landscape Context, Site-scale Disturbance, and Site-scale Characterization. A dichotomous key for classifying wetland types to Cooper types is provided with field forms or site dossiers. Not all indicators of wetland type work 100% of the time, so sites must be evaluated using the best professional judgment of the crew lead.

Areas are first classified as wetlands using the definition presented in Cowardin (1979) (two out of three required):

1. Vegetation dominated, at least periodically, by hydrophytes; and
2. Substrate predominantly undrained hydric soils; and
3. Substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year.

Differences among Sample Site Types

There are a few functional differences in verification of site status among WEI site types. Most importantly, for both gradient and sentinel sites there is no field evaluation of the final stage sample design points, since sites are hand selected rather than design generated. In addition, most sentinel sites will be well known wetlands with little ambiguity as to their status and suitability for sampling. All data for gradient and sentinel sample events are recorded on Form #3, with survey samples also using Form #2.

Office-based Verification (optional)

Office-based verification is an optional step that produces an approximate call on site status. These procedures occur before a site is visited, usually prior to the start of the sample season. Often these procedures are done for many sites together and possible sample events are then allocated to hitches or sets of sites to be sampled in a single backcountry trip. Data may be recorded on the various “Office” sections of WEI Forms #2 and #3; however, these forms may not be used if sites are evaluated in mass using GIS. In this case, site status information may be recorded directly in the WEI database.

Possible office site status codes are given in Table -1. Site status in the office phase deals largely with whether the site is in fact a wetland and if it appears to be a suitable for sampling, or that access is safely possible and there are no compliance or landowner permission issues. Most evaluation will be at the scale of an entire wetland complex as the detail needed to evaluate specific points is typically not available when not in the field.

Table 4-1. WEI office phase site status codes.

Status Code	Name	Description
TO	Target and sampleable, office only	Clearly a wetland and sampleable (safely accessible) site. Common status call from office review only. Field recon or verification NOT needed.
NT	Non-target, office only	Clearly non-target (not a wetland); no need to field visit. NO field recon or verification needed.
TA	Likely target, but not sampleable	Site is likely target, but will not be sampleable due to access or other issues. NO field recon or verification needed. This should be a rare status call from office review only.
UN	Unknown (or Other)	Target or access status is irresolvable in the office; field visit is needed. Common status call from office review only. Field recon or verification needed

For survey sites, the first step is to evaluate the sampleability of selected basins (if these are a level in a given park’s survey design, see the Protocol Narrative, Schweiger et al. 2015). This is done in the office in conjunction with park staff. Ideally, any issues with an entire basin in a park not being sampleable are worked out prior to selection of basins; but if not, a non-sampleable basin is simply

replaced by the first available basin in the oversample list for that basin's stratum. No or very little wetland is not grounds for replacing the basin. Any replacement of a basin will require adjustment of sample weights, using functions in the R-GRTS psurvey library (see WEI SOP 19: Data Analysis).

For survey sites, the second step is to evaluate the sampleability of the selected complexes within a basin (note that this can be done for gradient and sentinel sites, but often the nature of the wetland complex is known). This is done in the office in conjunction with park staff and experts familiar with wetlands in the park. The only reasons to replace a complex include a complete lack of access, safety, or a compliance issue (including private property in or around a park). A non-sampleable complex (see below) is replaced by the first available complex *of that type* in the oversample list. Any replacement of a complex will require adjustment of sample weights, using functions in the R-GRTS psurvey library (see WEI SOP 19: Data Analysis). Complexes can be ordered for visit based on basin and/or their arrangement across the landscape. Ideally, the class of complex will not correlate with a dominant gradient like elevation (e.g., all fens are low elevation), but clearly complexes will be visited from low to high as the season advances.

Field-based Reconnaissance and Verification

An actual field visit (during reconnaissance and/or with a sample event as field-based verification) generates a final site status, wetland type classifications, site layout, and defines likely access routes to sites. Reconnaissance or field-based verification is the point at which the details of the survey sample design are resolved and an actual sample point within a survey complex is selected.

Reconnaissance is optionally done prior to a sample event. It is similar to field-based verification, which occurs at the time of sampling a site. If field reconnaissance does not occur (e.g., for sites that are difficult to access or are obviously target and sampleable from office-based verification), field-based verification replaces these steps. At least some field verification will be completed for each wetland and sample site type (regardless of whether more sampling is conducted at the site). The steps of field-based verification are similar to those for reconnaissance, but have more "immediacy" as they actually define the sampleability of a site. In some cases (difficult or remote sites), the only phase of site-verification used is field-based verification (no field reconnaissance). For sample events at sentinel sites where only water table data are collected, an abbreviated version of site verification is done.

Office and Field Equipment for Site Verification

Table 4-2 gives a checklist of items needed for site verification methods. Only items needed for these procedures are included here.

Table 4-2. Equipment for site verification.

Quantity	Item
<u>Office Equipment</u>	
	WEI Protocol Document
	Soft lead (#2) pencils
	Dossier for all complexes and watersheds being assessed
	Other maps
	GIS with relevant data layers
<u>Field Equipment</u>	
1	WEI Protocol document and/or laminated sheets of SOPs and Cooper Wetland type keys (HGM, Cooper, etc.)
1+	WEI Forms #2 (specific to the sites being assessed in the field) and #3 (filled out during office-based phase, if done)
1	Site maps ("dossier")
Many	Soft lead (#2) pencils and sharpies and rite on-rite off markers
1	Previous versions of "dossier" and Form #2 or #3 from earlier site visits, if they exist
1	WEI Protocol document and/or laminated sheets of SOPs
1	Compass
1	GPS with site location waypoints
Many	Extra batteries for GPS receiver
1	Digital camera, with site placards or white board

Office-based (optional) Site Verification Procedure (WEI FORM #2 or 3)

1. FORMS #2 and #3 are always done on paper and one per site is used.
 - a. Some of the fields on Form #3 are duplicated in Econab on the PDA.
2. Use the database created Well_ID-specific version of Form #2 for survey sites (some header information is filled in by the WEI database). Form #3 will be used once an actual sample event is underway.
3. Use Form #3 only for sentinel or gradient sites.
 - a. It is likely that another version of the Form(s) will be used for later field sample activities.
4. Collect all needed GIS data, maps, auxiliary data and advice from park-experts.
5. If a previous year's data are available, be sure to reference these data (especially photos). (Note: if the sample event is a QA visit where the intent is to "test" these methods, do not use previous year's data.)
6. Evaluate the status of the basin/watershed (for survey sites and designs that include this level). The evaluation is done at the scale of the entire basin (if any part of it is sampleable, then for the purposes of this stage of evaluation the whole basin is sampleable). There are no formal parts of a WEI Form for recording this information; it goes directly into the WEI database. There is no real field-based verification analog to basin evaluation.
7. Basins are sampleable if there are no compliance or access issues that impact the entire basin.
8. No or little wetland in a basin is not grounds for excluding a basin. This non-response is critical data, so be sure it is noted.
9. *A non-sampleable basin is replaced by the first available basin in the oversample list for that basin's stratum.*
10. Evaluate selected wetland complexes (for survey sites and as needed for gradient or sentinel sites). The evaluation is done at the scale of the entire complex (if any part of it appears to be wetland and is sampleable, then for the purposes of this stage of evaluation the whole complex is considered sampleable). Record this on WEI Form #2 or #3. Field-based recon or verification will provide similar and better data.
11. Evaluate site status based on the best existing data, elevation, expert knowledge, and the ROMN cost surface. This should be done for the expected hydrology during the expected time of sampling.
12. Place in one of four categories: target office (TO), non-target (NT), target but not sampleable (TA), or unknown (UN).

13. Evaluate wetland type based on the best existing data, vegetation, elevation, and expert knowledge. This should be done for the expected hydrology at time of sampling.
14. Given the coarseness of office evaluation, there is no specific wetland type key for office verification. However the types in the field key can be used to some degree.
15. Record wetland type.
16. *Note that wetland type does not determine the sampleability of the site; wetland of any type is sampleable.*
17. *A non-sampleable complex is replaced by the first available complex in the oversample list for the target complex's wetland type. Cost or access classes are ignored.*
18. Note that some sites will still be reconned in the field even if office-based verification suggests this is not needed. This can happen because a site is reconned on the way to another site, etc.
19. Fill in general directions to site and any other comments.

Field Reconnaissance and/or Field Verification Procedure (WEI FORM #2 or #3)

These procedures are the same for a recon and a sample event visit. If both are done, the sample event visit is the actual relevant data that determines sampleability, status, etc.

1. Forms #2 and #3 are always done on paper. Use one form #2 per survey complex and one form #3 per plot in a survey/gradient/sentinel complex.
 - a. Much of the header on Form #3 is duplicative with other Forms. Note that Form #3 is the most important one to have complete header information on.
 - b. **In addition to completing the header on Form #3, a full or complete site visit will be electronically recorded using EcoNab.**
 - c. If a previous year's data are available, be sure to reference these data (especially photos), and use an existing version of WEI Form #2 and/or #3 from any previous field and/or office based recon. (Note: if the sample event is a QA visit where the intent is to "test" these methods, do not use previous year's data.)
2. After the event is complete, **be sure to complete the event checklist on the back of the form.**
3. Use Form #2 if survey site, and Form #3 if sentinel or gradient site.
4. Navigate to general area of the complex using GPS and other navigation tools (see ROMN SOP: Using the Garmin GPS 76csx).
5. Use all available means to ensure that you are at the correct wetland complex as marked on dossier map (Figure 4-1), including: topographic landmarks, park road maps, local contacts, etc.

Established Sentinel Sites (Form #3)

6. Follow the GPS or existing knowledge and attempt to zero out the distance to the site location.
7. Fill out all relevant header/metadata on Form #3 as detailed below.

New Survey Sites (Form #2 and #3)

8. Within common sense and safety limits, "believe" the GPS and attempt to zero out the distance to the closest or most accessible 3rd stage point in the complex **with a design number rank between and including 1 and 5**. If higher ranked points (6 and above) are encountered, they may also be assessed, but by default the lowest 5 have to be evaluated. The points do not have to be evaluated in their rank order. In many cases the distance will "jump around" with the GPS signal; use the first location that minimizes the distance to the x-site and also matches the imagery in the dossier and other cues.
 - a. Fill out all relevant header information on the Forms.

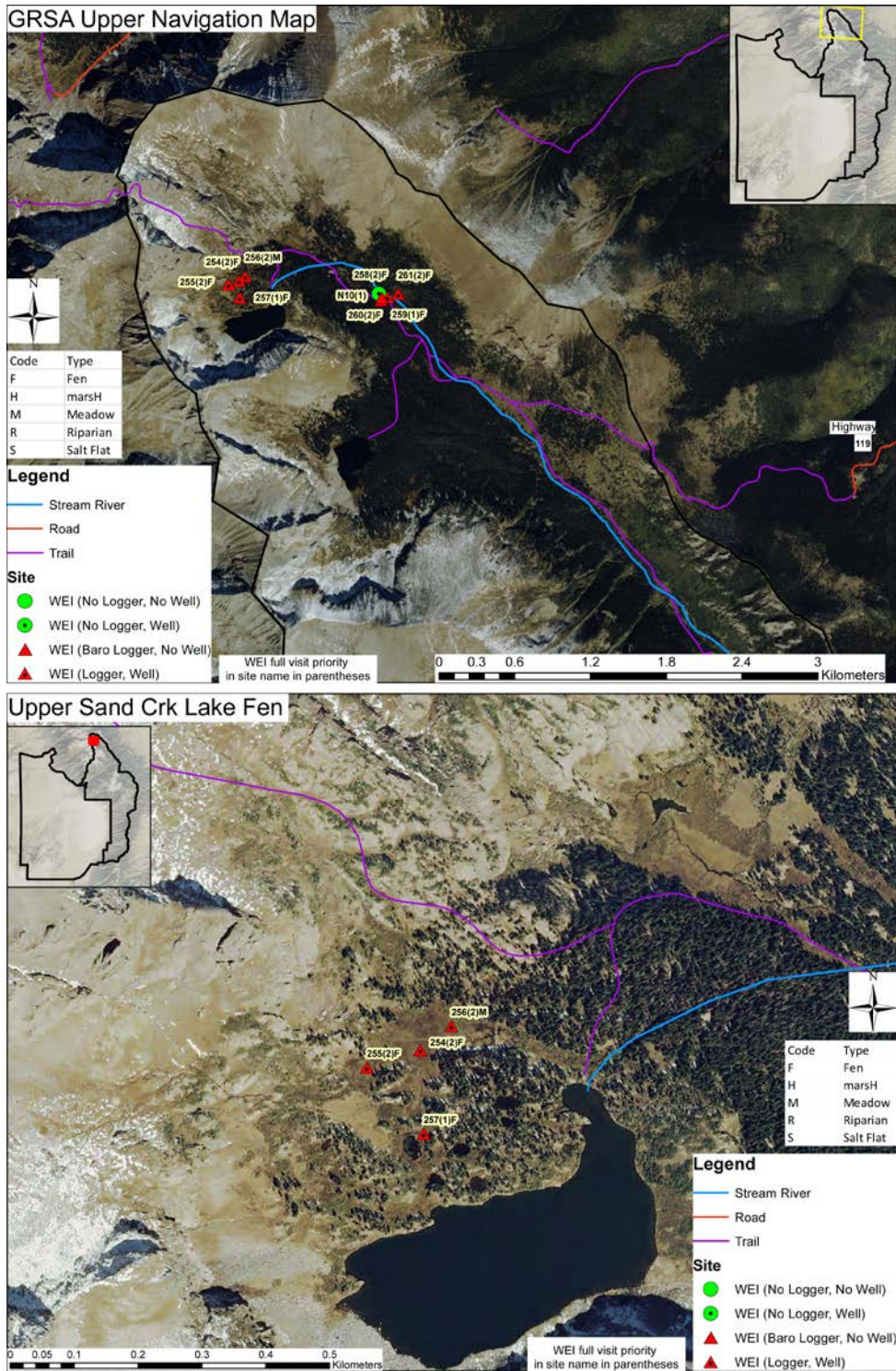


Figure 4-1. Example WEI Dossier maps: (top) entire watershed with access trails, etc; (bottom) close-up of a single complex.

- b. Record sample date, Site or Well ID, visit number (within the current year), lead botanist and other crew names, the site type being evaluated, the Cooper wetland type, and the visit type.
 - c. Record GPS ID and Camera IDs on Form #3. All GPS information is on the back side of the Form.
 - d. Note the start time (and after sample event is complete, the down and end times).
 - e. If the sample event is not a “FULL” type, describe the nature of the sample activities (especially QAQC) with a detailed statement that covers who is conducting the QAQC and how it relates to other sample activities being carried out.
 - f. Record confirmation of monument installation or relocation.
 - g. Record the distance and bearing of any plot shift if a new site is established; explain the shift with notes.
 - h. All shift information is on the back side of the Form.
 - i. Average a minimum of 120 waypoint locations at the plot center (well). Record the GPS waypoint number and other metadata on Form #3 or the WEI GPS Log.
9. If the 10x10 m area centered on the point is safely accessible, evaluate the landcover in the 100 m² area. For wetland types use the components of the Cooper Type key that are *rapid and easy to implement*. The level of effort for evaluation is only marginal at this point; extant vegetation, obvious hydrology, and topological attributes should be considered. No more than 5 minutes should be spent at a point.
- a. Record the percentage of wetland by type, upland, water, or other landcover in this area on WEI Form #2 for the 3rd stage point. The percentage of the area that is wetland is an important response measure.
 - b. If this area is not safely accessible, but the landcover (% of wetland coverage, etc.) can still be assessed remotely, do so and flag the data.
10. Repeat steps 6 and 7 for all 5 lowest ranked 3rd stage points in the complex.
11. In the simplest situation, there will be a site in the lowest ranked five sites that is 100% wetland of the type designated in the sample design; this will be the sample point and there will be no wetland type changes to note (record a **TS** on Form #2 or #3). If this is not the case, look for a site in the lowest five with 100% of another target wetland type; if found, this site will be the

sample point with the wetland type change carefully recorded (also record a **TS** on Form #2 or #3, even if it is not the target type, **but be sure to note the type change**). In general, the lowest-ranked sampleable point of these five that is of **any wetland type being targeted in a given park is the site where the plot should be placed. It does not have to be the type that the sample design designated it to be; it can be a different wetland type.**

12. The following are some additional rules that must be followed:

- a. If more than one site is wetland and is sampleable, the lowest ranked point is the choice.
- b. If an additional wetland type is found in (different type than the design type), it should be sampled and the complex becomes a multitype wetland (this has important sample design consequences). If crews do not have sufficient well materials or monuments the site may have to be returned to at a later date to complete the sample effort.
- c. **Note that if a new wetland type point is not sampled (i.e., due to logistical constraints), there are analytical methods to deal with this (see the main narrative). It is probably most important to be consistent.**
- d. If a complex is a design multitype (e.g., a FenMdw) a site of each of these types will be ideally found in the five lowest ranked sites. If not, sites with ranked order 6, 7, 8, etc. must be searched until a site of each design type is ideally found. However, if sites of other wetland type are found in this process they must also be sampled. If crews do not have sufficient well materials or monuments the site may have to be returned to at a later date to complete the sample effort.
- e. In multitype complexes (e.g., a FenMdw), if the designation of a specific site's type (e.g., as a Fen) is incorrect, but it is a type that is needed within the complex (e.g., Mdw) it can be sampled as the type it is in the field. All of these type changes must be carefully recorded.

13. Crews will often be faced with a dilemma of having a list of 3rd stage points with varying degrees of wetland percentage in each of the 10x10 m assessment areas. Sites must be at least **90%** of a single wetland type to be sampleable. The following methods deal with situations where this is not the case.

Shifting Points

14. Crews may attempt to “shift” the site following very strict guidance to find at least 90% wetland coverage. Shifts may be attempted as each 3rd stage point is assessed, *but all else being equal, a site that was not shifted is preferable to a site that was:*

- a. A site may only be shifted by a distance equal to the estimated GPS error (average of 4 m) plus the average positional accuracy in the base mapping methods (average of 9 m) used for the primary elements of the wetland sample frame (the ROMO VegMap), plus half of the longest axis of the field plot (7 m). For the ROMO design, this maximum value is approximately **20 meters**.

- b. Shifts may occur if the exact x-site location is unsafe or has compliance issues and a safe wetland type is obviously available <**20 meters** away.
 - c. Shifts may occur if the exact x-site location is not the target wetland type, and a “correct” wetland type is obviously available <**20 meters** away.
 - d. Shifts may occur if the exact x-site location would place a field plot in a mosaic of vegetation types and/or hydrologic regimes (therefore likely wetland) types, and a more homogenous wetland location is obviously available <**20 meters** away.
15. If a 3rd stage point cannot be shifted it will be classified as **NS** on Form #2 or #3 if the reason is safety or compliance; be sure that this reason is carefully recorded.
16. If a 3rd stage point cannot be shifted, it will be classified as **NT** on Form #2 or #3 if the reason is that there is no wetland of any type; be sure that this reason is carefully recorded.
17. If a 3rd stage point cannot be placed into TS, NS, or NT classes, an **OT** (other) is available. However, this should be avoided as much as possible, and if used, it must be carefully explained as it is likely that ROMN ecologists or data managers will just have to force it into one of the other categories at a later date.

Literature Cited

- Cowardin, L. M., V. Carter, and E. T. La Roe. 1979. Classification of wetlands and deepwater habitats of the United States. USDI Fish and Wildlife Service, Washington, D.C.
- Gage, E., and D. J. Cooper. 2013. Historical range of variation assessment for wetland and riparian ecosystems. U.S. Forest Service, Rocky Mountain Region USDA Forest Service, Rocky Mountain Region (Region 2).
- Schweiger, E. W., E. Gage, K. Hanes, D. Cooper, L. O’Gan, and M. Britten. 2015. Rocky Mountain Network wetland ecological integrity monitoring protocol: Narrative, version 1.0. Natural Resource Report NPS/ROMN/NRR—2015/991. National Park Service, Fort Collins, Colorado.

WEI SOP 5: Plot Layout and Site Photos

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents field methods for establishing and laying out sample plots. The same general plot layout is used for all sample design and wetland types, although there are some options based on wetland size/shape and whether a site will be used for all WEI methods or just a subset.

The methods here apply to both newly established sites and revisited sites; however, for new site establishment, additional steps covered in other SOPs must occur first or concurrently. Most importantly, crews will first need to determine the site's status and sampleability following WEI SOP 4: Verification of Site Status. This SOP also presents methods for creating and installing monuments used in survey and sentinel sites. Methods for well construction are in WEI SOP 6: Groundwater Monitoring Well Installation.

Plot layout data for any wetland and sample site type are entered on WEI Form #3: Event: Site Establishment / Well / Logger / DTW. Plot layout data may also be entered into a PDA-based electronic database in the field (for the 2007-2015 seasons we used [EcoNab](#)); see WEI SOP 3: Use of Electronic Data Recorders.

Overview

WEI plots use three scales of nested plots. These are all laid out with a compass and field tapes or pre-measured lengths of cord or light cable. The largest or “macroplot” measures 10x10 m (100 m²) and contains one “subplot” (16 m²) and four 1 m² “microplots” (Figure 5-1). At most sites a groundwater monitoring well is in the center of the nested plots. Each corner of the microplots farthest from the well or center of the plot is monumented at the cardinal directions with an

approximately 8 inch long piece of $\frac{1}{2}$ inch diameter rebar, capped with an aluminum survey marker stamped with study and plot information. Markers are pushed flush with the ground surface.

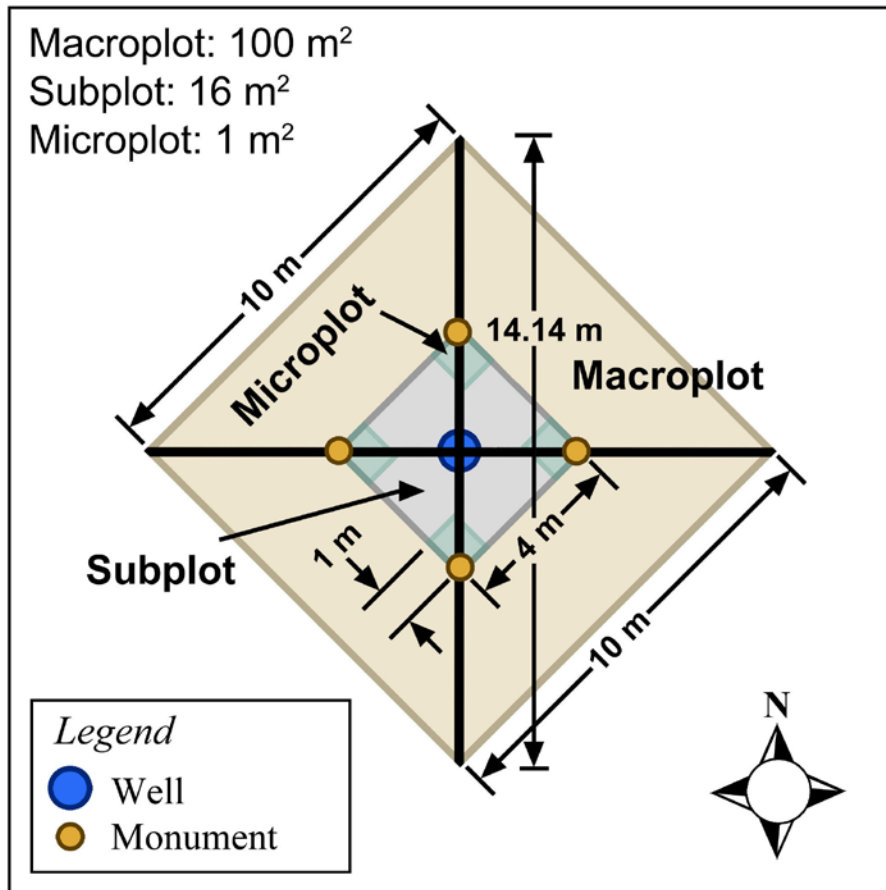


Figure 5-1. Diagram illustrating location and dimensions of nested plots laid out using this SOP. Monuments are installed on the outside corners of each microplot.

There may be variations in how plots are laid out based on sample design or wetland type:

Site layout procedures for gradient sites are identical to the survey site procedures detailed above with the following exceptions:

- There are usually no wells established at gradient sites,
- There are usually no monuments established at gradient sites, and
- All plot layout data for gradient sample events are recorded on the same form used for survey sites.

Site layout procedures for sentinel sites are identical to the survey site procedures detailed above with the exception that for subsets of sites chosen in sentinel complexes only a relevé of vegetation is conducted.

Relevé Sites

Site layout procedures for relevé sites are identical to the procedures detailed above with the following exceptions:

- There are usually no wells established at relevé sites, and
- A single monument at the plot center is established.

Linear and Other Unique Wetlands

In some sites a 10x10 m plot is not possible and a 5x20 m plot is used instead (Figure 5-2).

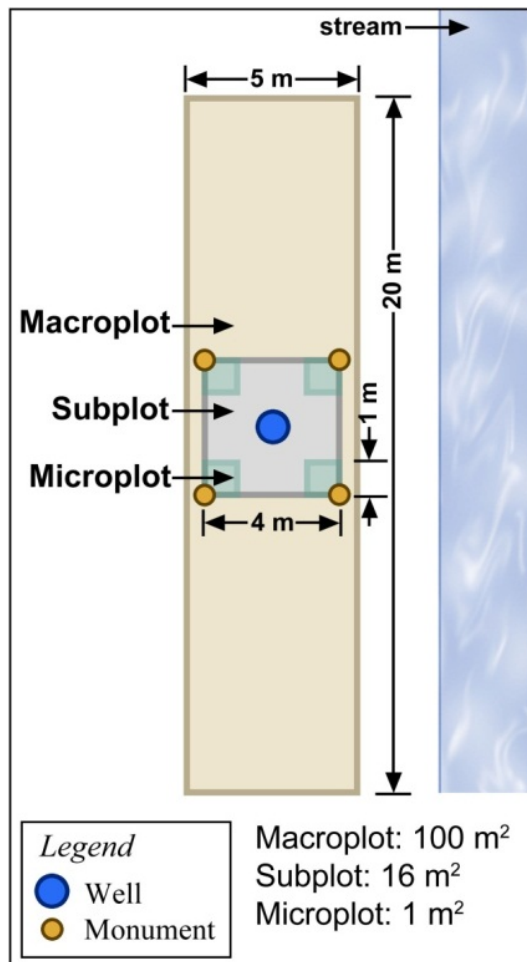


Figure 5-2. Diagram illustrating location and dimensions of optional linear plot layout.

Site Sketch and Photos

Site photographs have several purposes. They can be used to assist future crews in relocating plots. Photographs can be taken of notable landmarks, such as rock outcrops or large trees. Combined with GPS coordinates, they can be very helpful in finding the plot. Photographs can also provide useful information regarding broad ecological processes such as tree or shrub invasion (Jakubos and Romme 1993, Zier and Baker 2006). ***Photography is one of the easier tasks that you will perform. Please relax, take your time, and take quality photos.***

The protocol involves collecting eight CORE photo points (Figure 5-3) at fixed azimuths from the well at the center of the plot module. Always include a Site Placard in the eight CORE photos. Additional photographs may be taken at the discretion of crews. Photographs should also be taken of obvious anthropogenic impacts, such as ditches or diversions. Large patches of exotic species should also be documented. Finally, photos showing any water table at or above the surface are often useful. Be sure to take the site photos *after* plots are established so these boundaries are apparent in the photos. Also, take photos right after plot lines are strung (i.e., before sampling) to minimize crew trampling effects in photos.

In addition to photographs, a site sketch is drawn to help describe the complex and help relocate the site in the future. Often sketches convey information that is not possible in photos or notes. Their value should not be underestimated. Each sketch should include an approximate scale and indication of cardinal directions.

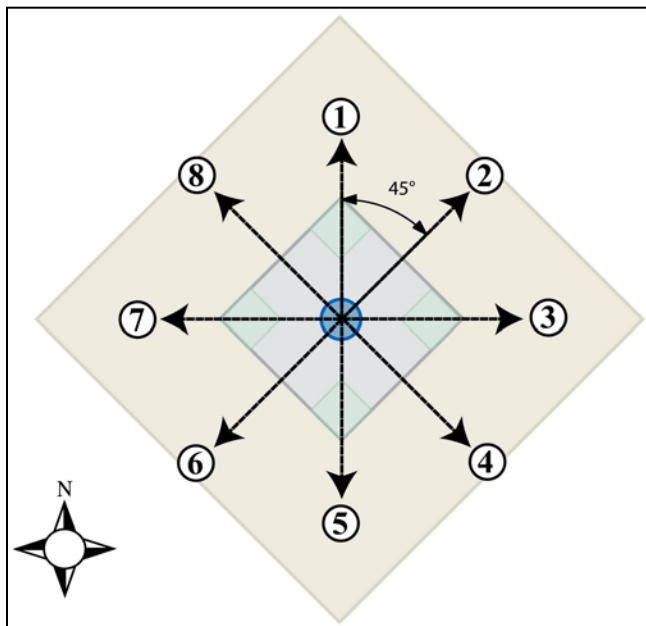


Figure 5-3. Figure illustrating the orientation of photo points taken at sampling locations.

Office and Field Equipment for Plot Layout

Table 5-1 provides a checklist of items needed for plot layout. Only items needed for these procedures are included.

Table 5-1. Gear for plot layout.

Quantity	Item
1	WEI SOP and/or laminated sheets of Procedures
1 per plot	WEI Form #3: Event: Site Establishment / Well / Logger / DTW
1	Site maps ("dossier")
Many	Soft lead (#2) pencils
1	Previous versions of "dossier" from earlier site visits, if they exist
1-2	Fully charged PDA with EcoNab loaded
1	Other maps
1	Compass
2	Field tapes (one 100 m tape and two 50 m in length) (optional, can use plot layout ropes)
2	Pre-measured plot layout ropes
4 per plot	~ 8 in. lengths of ½ in. diameter rebar
4 per plot	1 ½ in. diameter aluminum caps for the top of rebar, pre-stamped with plot information
1	White board and dry erase markers
1 or 2	1 m ² plot frame
1	Hammer to drive rebar (optional, can use a rock if monument head is protected or installed after rebar is in the ground)
4-6	Survey stakes or large diameter nails to temporarily fix tapes
1	Digital camera
1	GPS

Plot Layout Procedures (WEI FORM #3)

1. Form #3 is always done on paper and one per site is used.
2. After the event is complete **be sure to complete the event checklist on the back of the form.**

Event Metadata

3. Fill out the header on WEI Form #3: Event: Site Establishment / Well / Logger / DTW. This is the most important header for any of the Forms used during a sample; it should be filled in completely.
4. If the sample event is not a “FULL” type (all sampling completed) choose “PARTIAL” and then choose one visit subtype, either “1st/year” for site establishment or the first visit of a year, “Revisit” for sites visited earlier in the same season, QAQC for a quality assurance/quality control data check, or “Relevé” for a whole-plot-only vegetation survey.
 - a. Describe the nature of any QAQC sample activities with a detailed note that covers who is conducting the QAQC, how it relates to other sample activities being carried out, etc.
5. Note data sheets or PDA usage on the bottom right of the Form #3.
6. Record confirmation of monument installation or relocation.
7. **If a first time survey sample event, complete the back of the Form:**
 - a. Record the distance and bearing of any plot shift. Explain the shift with notes.
 - b. Record the average (minimum of 120) waypoint locations at the plot center (well). Record the GPS waypoint number.
8. Note that in addition to completing the header on Form #3, select site/event metadata may be electronically recorded using EcoNab. See WEI SOP 3: Use of Electronic Data Recorders.

Plot Layout

9. Starting at the plot center, using a compass, run the end of a 50 m tape or pre-measured length of cord due north (0°) for exactly 7.07 m. If this is the initial set-up, double check that the tape is set along the correct azimuth.
 - a. If this is a revisit, crew member should search for a plot marker at 2.83 m delineating the corners of the 4 m² plot.

10. Temporarily pin end of tape using nail; return to plot center and walk tape spool or pre-measured cord due south (180°) 7.07 m. If this is the initial set-up, double check that tape is set along the correct azimuth.
 - a. If this is a revisit, crew member should search for a plot marker at 2.83 m delineating the corners of the 4 m² plot.
11. Return to the plot center and using the compass, run the end of a 50 m tape (tape #2) or a pre-measured cord due east (90°) for exactly 7.07 m. If this is the initial set-up, double check that tape is set along the correct azimuth.
 - a. If this is a revisit, crew member should search for a plot marker at 2.83 m delineating the corners of the 4 m² plot.
12. Temporarily pin end of tape using nail; return to center and walk tape (tape #2) spool due west (270°) a distance of 7.07 m. If this is the initial set-up, double check that tape is set along the correct azimuth.
 - a. If this is a revisit, crew member should search for a plot marker at 2.83 m delineating the corners of the 4 m² plot.
13. Connect corners of macroplot using remaining length of tapes #1 and #2, pre-measured cord, or a spool of heavy string.
14. Measure out 2.83 m from the monitoring well along each tape or cord and temporarily mark with survey flags. These points correspond to the subplot and microplot corners, if this is a revisit use existing markers.
15. Attach end of tape or pre-measured cord (usually a lighter weight) to one corner of the subplot and extend to connect all sides.
16. If the first sample at a site, standard ROMN monument caps numbered with the Well ID for the site and the corner direction (N/S/E/W) should be pounded flush into the ground at each corner of the subplot.

Site Sketch and Photo Procedures

17. Standing over the well, take a series of eight photos at 45° angles starting at 0° (Figure 5-3).
18. The **site ID and date** are written onto a sheet of paper or white board. A crew member stands within the field of view but outside the plot, holding the clipboard for each photo.

19. Take additional photographs from the well toward any witness features.
20. Crews should also take photographs of anything useful, such as specific stressors encountered during the initial reconnaissance of the wetland. This includes features seen within the wetland and within 100 m of the wetland margin.
21. A detailed sketch of the wetland complex (focused on the plot) should be completed after all sampling has been done or at an appropriate time during sampling:
 - a. Draw the map to scale (relatively) using the grid on the form and strive for clean and simple drawings.
 - b. Show the area around the complex extending at least 10 m beyond the boundaries, the site monument(s), locations of shrubs and trees, large wood, beaver ponds, location of the hill slopes, roads, fences, side channels, tributaries, etc.
 - c. Show any distinct features that will help in relocating the site.

Literature Cited

- Jakubos, B. and W. H. Romme. 1993. Invasion of Subalpine Meadows by Lodgepole Pine in Yellowstone National Park, Wyoming, USA, *Arct. Alp. Res.* 25:382-390.
- Zier, J. L. and W. L. Baker. 2006. A century of vegetation change in the San Juan Mountains, Colorado: An analysis using repeat photography. *Forest Ecology and Management* 228:251-262.

WEI SOP 6: Groundwater Monitoring Well Installation

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents step-by-step instructions for the installation of shallow polyvinylchloride (PVC) groundwater monitoring wells at survey, gradient, or sentinel sites within any wetland type. We also include methods for “armoring” or fixing a well in place that has depth-to-water loggers in it. A suite of metadata on the well and the logger installations are collected when wells are installed AND as part of the episodic measuring of water table depths, and are therefore detailed in this SOP and in WEI SOP 7: Manual Reading of Water Table Height.

Methods are identical at all sites where a well is installed. Field methods vary (a little) by wetland type (or substrate). Wells are established with the first visit to sampleable sites after site status has been verified (WEI SOP 4: Verification of Site Status) and after or in conjunction with plot layout (WEI SOP 5: Plot Layout and Site Photos). These methods also apply (in part or in some cases) to reconstruction of damaged wells. Several other ROMN WEI SOPs are performed after or in conjunction with well installation, including soil sampling and profiling (WEI SOP 10: General Soil Characterization and Chemistry), water chemistry (WEI SOP 9: In Situ Water Physiochemistry), and water table measurement (either manually (WEI SOP 7: Manual Reading of Water Table Height) or via loggers (WEI SOP 8: Installing and Reading Continuous Depth-to-Groundwater Data Loggers)).

All well construction data are entered on WEI Form #3: Event: Site Establishment / Well / Logger / DTW. Form #3 is also used for survey site verification and all site types plot layout.

There are a few differences in well installations among WEI site types, although none of them are functional in nature. Wells are not typically installed in gradient sites. If a gradient site ever becomes

a sentinel site, well(s) will be installed as per the procedures detailed for survey sites. Wells are always installed in sentinel sites. The procedures are the same in sentinel sites as in survey sites with the following exceptions:

- Wells will often be in place already and only require maintenance and updating (e.g., better camouflage).
- There may likely be more than one well per plot to enable QAQC of logger models.
- Sentinel site wells may optionally be surveyed to establish a true position and elevation. By surveying the relative elevations of wells and staff gauges, the direction and slope of groundwater flow can be evaluated and linkages between different sources of water to wetlands, such as hill slope aquifers, springs, and streams can be identified. Information regarding a wetland's water source can predict sensitivity to disturbance or stressors and is a key concern in restoration design (Cooper et al. 1998, Gage and Cooper 2013).
- There are no differences in well installation among wetland types, although riparian types are usually much more difficult due to cobble substrates.

Well Overview

WEI monitoring wells consist of a perforated section of PVC pipe installed vertically in the ground in the center of the plot (Figure). Perforations in the PVC extend from just below the ground surface to the bottom of the pipe, which is capped on the bottom with a PVC cap with a hole drilled for drainage. Water levels inside the pipe result from the integrated water pressures along the entire length of perforations (Figure -1). Solid PVC is attached to the top of the slotted PVC and continues above the ground surface. PVC top caps are installed on wells to protect them from rain or contamination. It is important that caps be loose enough so that they may be removed for measurement without excessive force. Cutting a slot in the cap from the bottom lip vertically up to the top creates a slightly looser fit, but must not be cut in a way that allows rainwater or surface water to contaminate the well. Well caps can be slotted with a hacksaw before leaving for the field or on site. Wells should be vented to allow equilibration of air pressure inside and outside of the well casing. This can be done by drilling two small side-by-side holes into the side of the casing above the surface of the soil and above the expected level of high water tables. These holes are then typically used to hang the numerical tag for labeling (if not tagging, one hole is sufficient for venting). Following well installation, casings are cut to within six inches of the ground surface using a hacksaw (Figure). Using a piece of canvas or tarp to protect the surrounding ground surface, spray paint is used to camouflage the riser (or preferably this is done prior to installation) and cap, and a tag is fixed to the well. Well caps may have a hardware set for suspension of data loggers within them.

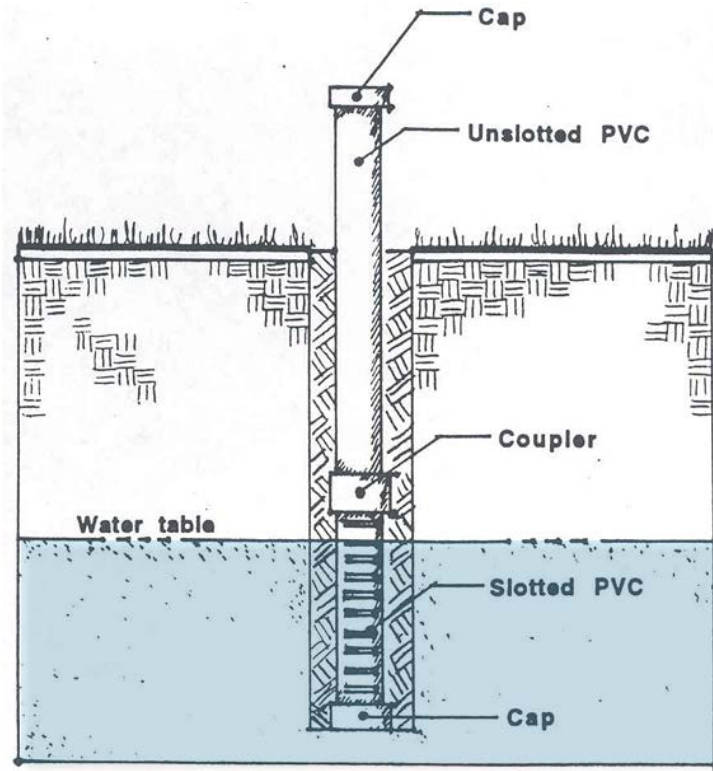


Figure 6-1. Schematic illustration of groundwater well. The position or length of slotted and non-slotted PVC is determined by the water table's likely range; in contrast to this figure, most ROMN WEI wells have more slotted PVC extending closer to the ground surface.



Figure 6-2. Close-up photograph of well casing cut near to the ground and painted to camouflage. Note well armor is not in place on this well.

Time is needed for water levels in wells to equilibrate with the water table after their initial installation. The specific time needed will vary depending on soil texture and composition (peat versus mineral). No well measurement should be made until wells have sat for at least one hour, ideally longer, particularly in peat soils. Wells should be bailed to ensure proper functioning. If, from experience, it is realized that the well will likely not equilibrate during the time available for the site visit, it is possible to use the soil pit to measure water levels prior to well installation. Field crews can hand auger a hole, wait for it to equilibrate (this will often be faster than well equilibration), measure water table depth, and then bail the hole and install the well as per instructions. If this methodology is used it should be clearly indicated on the field forms.

Armoring

Securing monitoring wells that house loggers from movement both horizontally and vertically between sampling events, over seasons, and between successive years is essential to accurately determining and tracking water table depth. Below are two methods developed to armor monitoring wells from shifting or moving. Armor was installed on sentinel wells housing loggers in the summer of 2012. Inspection of wells in subsequent site visits is necessary to assess how effective these armoring devices are and how they might be improved.

The two methods developed in 2012 are described below. The first takes considerable construction time, hardware, and use of a power drill. This method results in a better armor setup, but cannot be constructed in the field and can be frustrating to put together. The second method requires no hardware or power tools and can easily be put together in the field, but results in a slightly less secure setup. The tradeoff between the two is time and effort of construction versus security and tightness of installed armor.

Well Installation Equipment

Table 6-1 provides a checklist of items needed for well installations. Only items needed for these procedures are included.

Table 6-1. Gear for well installation.

Quantity	Item
1	WEI Protocol document and/or laminated sheets of SOPs
1+	WEI Form #3
Many	Pencils
1-2	Fully charged PDA with EcoNab loaded
1-many	Work gloves
1	3 in. diameter bucket auger with handles and extensions
1	Auger tools: 2 box wrenches, silicon spray
1	Plastic tarp to temporarily hold excavated soils
2	Metric tape measure
1	Clip board
1	8 in. sharp shooter spade
1	Small pry bar (to remove cobbles) (optional)
1	Hacksaw, extra hacksaw blades
1 per well	5 ft. long, 1.5" (or 2" for Global loggers) diameter schedule 40 pipe , machine slotted or slotted by hand using hacksaw
1 per well	1-2 ft. long 1.5" (or 2" for Global loggers) diameter schedule 40 pipe, solid with no slots
1 per well	1.5" or 2" diameter PVC cap with hole predrilled though center (bottom cap)
1 per well	1.5" or 2" diameter PVC cap (top cap), notches cut into side to facilitate cap removal, painted in camouflaged colors, and hole predrilled to accommodate attachment of logger (if directed)
1 per well	Pre-fabricated well topper: 6" section of unslotted PVC with 2 small holes drilled for venting and attachment of aluminum tag and a coupler all painted in camouflage colors
1	Electronic well reader (see SOP #7)
1	Spray paint (gray, brown and black) (optional, better to spray caps before)
3	7/32"-5/8" stainless steel hose clamps
1	1.75"-2.75" stainless steel hose clamp (this assumes a 2" monitoring well)
3	sets of bolts, nuts, and washers (smallest size available)
1	Needle-nose pliers and screwdriver to secure bolt and nut
1	Cobalt or other strong drill bit capable of drilling through stainless steel that accommodates the size of nut and bolt used (you will likely need more than one drill bit, as they wear out)
1	Power drill
1	Work bench with clamps to secure items being drilled
3	Three 2-3' pieces of 3/8" rebar
1	Maul to pound rebar into substrate and standard screw driver to tighten hose clamps
3	7/32"-5/8" stainless steel hose clamps

Well Installation Procedures (WEI FORM #3)

1. Form #3 is always done on paper and one per site is used.
 - a. For complexes with more than one plot in them, use a separate version of this form for each site in the complex.
2. After the event is complete **be sure to complete the event checklist on the back of the form.**
3. Fill out the header on WEI Form #3: Event: Site Establishment / Well / Logger / DTW.
4. Lay plastic tarp down next to plot center point where well will be installed. Be sure to not disturb any spot where vegetation plots will be placed.
5. Extract a 12 to 16 inch plug of soil using the sharp shooter shovel of approximately 8 inches in diameter; this is done most easily by working the shovel around a tight circle centered on the well location, jump on the shovel to cut through roots to the appropriate depth. Remove plug by using the shovel as a lever.
6. Place the soil plug on the tarp. It will be used for soil measures. WEI SOP 10: General Soil Characterization and Chemistry describes soil profile characterization and sample methods.
7. Using a 3 inch bucket auger, begin to auger hole at well location. Auger down approximately 8 inches at a time.
8. Place soil cores from the auger bucket end to end on tarp below the first plug taken out by the sharp shooter.
9. Auger to approximately 2 feet below lowest seasonal water table (this can be observed in the mottling and oxidization of soil profile—these characters indicate aeration and seasonal dryness), the full extension of the auger arms, or the point at which the substrate is too loose or too rocky to continue.
 - a. It is often difficult to successfully dig much deeper than the water table in soft and peaty substrates because soil slides out of the auger bucket and the hole often begins to collapse. It may also be challenging to dig in rocky, fluvial deposits. In this situation, the shovel may be used instead of the auger and crews may have to go slowly and remove large cobbles by hand. Installing wells late in the season helps, when water tables have had the opportunity to drop and loose substrates dry.

10. Once a hole is at sufficient depth, test fit sections of slotted 1 or 2 inch diameter PVC. The length of slotted PVC should extend from the bottom of the well to a depth that captures the full range in water table depth. If uncertain about this, extend the slotted PVC to the ground surface. Non slotted PVC may be added to the top of the slotted section. In loose and collapsing holes it may be possible to push the well casing deeper than the auger was able to dig. Using controlled force, push the well casing downward, remaining on a vertical plane, perpendicular to the ground surface. Alternately, the sharp shooter shovel may be used as a hammer to gently “tap” the casing deeper. Use caution with this, PVC is brittle and using excessive force will shatter the well casing or cause couplers to separate.
 - a. **[Optional]** Wrap the slotted portion of the well casing in “pantyhose” material to reduce entrainment of fine silts.
 - b. If insufficient slotted PVC is available, additional slots may be added using a hacksaw or a drill. Be sure these are evenly spaced and match the machine spacing as best as possible.
11. Secure a non-slotted PVC cap (with several holes drilled in the center for drainage) to the bottom of the slotted PVC and test fit well in hole again.
12. Attach an unslotted top section of PVC to the slotted portion using a coupler to extend the well to the ground surface. If slotted PVC reaches or exceeds the ground surface, this step is not necessary.
13. Attach a pre-painted, pre-drilled, unslotted 6 inch length of camouflaged PVC using a coupler onto the top of the casing. **In most cases this is a pre-made well top.** The bottom of the camouflaged section should be flush with the ground surface unless the site is seasonally flooded. If seasonally flooded, the bottom of the camouflaged section should be flush with the level of high water tables allowing the slotted pipe to capture the full range of water table variation. The painting scheme is matte grey, black, and tan mottling using spray paint.
14. Attach a pre-painted and pre-hardwared PVC cap onto the top section of the well. The “pre-hardware” on the cap consists of a vertical slot cut with a hacksaw from the lip of the cap vertically up to edge of the “dome.”
15. Two small vent holes should be drilled about 1 inch apart near the top of the painted length, but not in a position that interferes with or blocks cap placement. Holes directly beneath a firmly attached cap are ideal.

16. Attach a pre-numbered aluminum tag to the well. The tag should be attached with heavy steel wire threaded through the 2 vent holes, then the tag, and twisted together. The tag should hang vertically, snug against the well casing to prevent chewing and other animal damage.
 - a. Using a Sharpie, write the Well ID and date installed on the casing.
 - b. Record the ROMN Well ID on Form #3.
 - c. If the well is an existing one with an old Well ID (i.e., from another project), record this, but all references to the well will use ROMN Well ID.
17. Make a mark on the top lip of the casing with a hacksaw blade or other knife and a Sharpie. This will serve as a reference for measuring the “stick up” height of the well casing and above the ground surface. All measurements will be taken using this marked point in the future.
18. Set the entire well assembly aside.
19. Bail the well hole (the well is not installed yet) using a bailer. Bailing timing and duration should be evaluated on a case-by-case basis. More bailing should be done for dirtier water. If water depth is to be measured using only the soil pit, do this now before bailing. Follow methods in WEI SOP 7: Manual Reading of Water Table Height.
20. Insert the well into the well hole. Making sure pipe is vertical and centered in the hole, begin to backfill with excavated soil. Use two sides of the soil plug removed by the shovel. Use clayey soils to form a water-tight seal around the PVC at the ground surface.
 - a. Because of displacement by the well casing, some leftover soil will be present. Excess soil should be scattered outside of the 10x10 m plot.

Well Armoring

3-Ring Armor

21. Drill a hole opposite the clamp-tightening mechanism on all three small clamps.
22. Drill three holes on the large hose clamp. Orient the holes like the cardinal directions of a compass, with the clamp-tightening mechanism occupying one of the 4 cardinal points (see Figure 6-3, Image 6-1).
23. Secure the smaller clamps to the larger clamp with hardware with the bolt on the outside of the large ring, as this will make tightly securing the rebar much easier (see Figure 6-3, Images 6-1 and 6-2).
24. Installation:

- a. Orient 3-Ring Armor setup to accommodate monitoring well notch, leaving a clear path between the notch and the ground as much as possible for casing stick up measurements (see Figure 6-3, Images 6-3 and 6-4).
- b. Tighten large clamp securely to well casing with a standard screw driver. In some cases, it may be more effective to secure the armor around the PVC coupler. This depends on the size of the well and how loose the PVC top fits to the coupler and slotted casing (see Figure 6-3, Images 6-3 and 6-4).
- c. Position the three small clamps at different angles to maximize resistance to opposing forces that would cause movement. Also, try to point the small clamp-tightening mechanisms up to make final tightening with a screwdriver easier (see Figure 6-3, Images 6-3 and 6-4).
- d. Holding the top of the well in the desired position and orientation, insert a piece of rebar through each small clamp, leaving one or two inches above the top of the clamp (see Figure 6-3, Images 6-3 and 6-4).
- e. Tighten the small clamps around the rebar (see Figure 6-3, Images 6-3 and 6-4).
- f. Re-tighten the larger clamp around the well and make sure well is secure and sturdy.

Image 6-1: 3-Ring Amor**Image 6-2: Clamp attachment detail****Image 6-3: Installation****Image 6-4: Rebar orientation****Figure 6-3.** Images showing 3-Ring Armor detail.

Simple Armor(optional)

1. Unscrew small hose clamp tightening mechanism completely until the end becomes free.
2. Place the small hose clamp behind one of the larger clamps and fit over PVC well casing. Tighten the large hose clamp, which will also hold the small clamp firmly in place. Be sure to orient the tightening mechanism of the small clamp up, so that it can be tightened later.
3. Place the second large hose clamp over the well casing and situate it in the small hose clamp, parallel to the first large clamp. Reconnect the small clamp to itself by inserting it back into the tightening mechanism.
4. Slide two rebar pieces in between the two large hose clamps on opposite sides of the well casing and at opposing angles. Pound these into the ground, leaving 4-6 inches above the clamps.
5. Tighten the outer large clamp securely around the rebar and well casing.
6. Finally, tighten the small clamp as much as possible around the two larger clamps.
7. Note: If done correctly, the inner large clamp provides a tight connection to the PVC casing; the second large clamp holds the rebar tightly to the well casing and first ring; the small clamp holds the two large clamps together, which prevents the rebar and rings from moving up or down along the PVC well head.

Well Metadata

Well metadata consists of several items (many of which were added in 2012): total casing length, casing stick up height, bolt stick up height, casing lean angle, casing notch bearing, and total cable+logger length. This is repeated with every visit at the beginning and end of the sample event (in case the well is disturbed or replaced).

1. Measure the entire length of the well casing to the notch on the casing top (remove the well cap) mark, including any section(s) that will be above the ground (the “stick up”). Do not include the length of any top cap. The easiest way to do this is by inserting the measuring tape down into the casing well until it hits the bottom cap (it may be done with the casing in or out of the well hole). Measure total distance using a marked point on the lip of the well. Record as “Total Casing Length” in cm.x on Form #3.
 - a. If this is changed in any way during the event, repeat and record as the “After” measurement.
2. Using a compass or electronic angle measurer (e.g., on an iPhone), measure the bearing of the notch on the casing top (remove the well cap). The bearing is the angle looking from the opposite side of the well along the line created by the notch. Record as “Bearing of Notch” in degrees on Form #3.
 - a. If not due North, adjust to a 360 degree bearing and record as the “After” measurement.

3. Measure length of the well casing above the ground to the notch on the casing top mark (remove the well cap). Make sure to measure distance using a marked point on the lip of the well casing. Record as “Casing Stick Up” in cm.x on Form #3.
 - a. If this is changed in any way during the event, repeat and record as the “After” measurement.
4. Measure length of the well casing to the middle of the logger suspension bolt above the ground. Measure distance to the ground below the bolt. Record as “Bolt Height” in cm.x on Form #3.
 - a. If this is changed in any way during the event, repeat and record as the “After” measurement.
5. Using a clinometer or electronic angle measurer (e.g., on an iPhone), measure any lean angle of the well casing above the ground at notch on the casing top (remove the well cap). The well should be at a 90 degree angle, but record whatever is measured. Make sure to measure the angle at marked point on the lip of the well casing. Record as “Casing Angle” in degrees on Form #3.
 - a. If not 90 degrees, adjust the well to 90 degrees and record as the “After” measurement.
6. If a logger is present, measure the entire length of the suspension cable plus the logger, attempting to mimic any “bend” in the cable as if it was in the well casing. The easiest way to do this is by holding the logger up, letting the cable hang naturally and then have an assistant measure. Measure the distance along the logger to the sensor location (where the metal housing changes to the plastic screw-on end cap of the logger). Record as “Cable Length” in cm.x on Form #3.
 - a. If this is changed in any way during the event, repeat and record as the “After” measurement.
7. If the well was just constructed or the water in the well disturbed in any meaningful way, allow the water in the well to equilibrate. Conduct other sample tasks as able.
 - a. Take several test measures of the water table depth (but do not record) to determine when the water table has returned to normal and stabilized. WEI SOP 7: Manual Reading of Water Table Height describes the procedures for taking manual water table depth readings.
8. If a logger is to be installed in the well, **all real DTW readings must be conducted with the logger in place down the well.**
9. Record the well status as frozen/dry/wet/submerged/ not equilibrated.
10. Once the water has equilibrated, measure its depth following methods in WEI SOP 7: Manual Reading of Water Table Height for manual measures of the water table height within a well. Always conduct manual measurements of groundwater if you are close to a well.

Literature Cited

- Cooper, D. J., L. H. Macdonald, S. K. Wenger, and S. W. Woods. 1998. Hydrologic restoration of a fen in Rocky Mountain National Park, Colorado. *Wetlands* 18:335-345.
- Gage, E. and D. J. Cooper. 2013. Historical range of variation assessment for wetland and riparian ecosystems. U.S. Forest Service Rocky Mountain Region. Gen. Tech. Rep. RMRS-GTR-286WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

WEI SOP 7: Manual Reading of Water Table Height

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents field methods for manual, episodic reading of groundwater depths (DTW) from wells or other locations within WEI sites. We also include a suite of well metadata collected whenever a manual reading is taken and guidelines for adjusting or reconstructing wells if a shift in well position has occurred.

Methods are identical at all wetland types and at survey and sentinel site types. Most gradient sites will not have wells, and if a manual water table height is collected, it will be from temporary soil pits only. Single water table measures, such as those done with short visits to a site, are recorded on WEI Form #3: Event: Site Establishment / Well / Logger / DTW. When more than one manual water table depth is taken during a sample event, measurements are recorded on WEI Form #4: Water Table Depth, Water Quality and Soil. WEI Form #4 is also used for water quality and soil information.

There are a few differences in manual water table measurement among WEI site types. Wells are not typically installed in gradient sites, so water table heights must be taken from a soil pit. There are no differences in manual water table measurement among wetland types. A variety of tools to measure groundwater elevations can be used based on existing conditions. These range from visual estimation to the use of simple electronic devices that allow measurement in deeper wells.

Manual Water Table Height Equipment

Table 7-1 provides a checklist of items needed for manual water table height methods. Only items needed for these procedures are included.

Table 7-1. Manual water table height field equipment.

Quantity	Item
1	WEI Protocol document and/or laminated sheets of SOPs
1+	WEI Forms #4 and #3
Many	Pencils
Many	Sharpie or markers
1-2	Metric tape measures
1	Hacksaw
1	Instrument to measure depth-to-water, such as multi-meter-reader (constructed already using speaker wire, electrical tape and measuring tape)
1+	Extra duct and electrical tape
1-2	Well bailer

Manual Water Table Height Procedures (WEI FORM #3 or #4)

1. *It is essential to always collect manual water table heights from all wells whenever a complex is visited!*
2. If a logger is installed in a well, **all DTW readings must be conducted with the logger in place down the well**, if at all possible.
3. These methods use Form #3 and/or #4 and are always done on paper. One form per site is used.
 - a. DTW data may be restricted to Form #3 for partial visits. For full events, both forms will be used.
4. After the event is complete, **be sure to complete the event checklist on the back of the form.**

If the water surface is visible inside the well casing:

5. Carefully measure the distance from the top of the well casing at the mark provided for reference to the water surface. Allow the tape end to just touch the water surface. This takes some patience and practice.
6. If measurements are taken in a soil pit, suspend a shovel or similar implement across the top of the soil pit opening and measure from the bottom of this. A casing stick up height does not apply to these measures; be sure to flag this on the data form.
7. If measurements are taken as part of a set of seven done with the installation of the well or with a QAQC visit, have one crew member repeat this measure three or four times, record them on Form #4 (blind to other crew members), then have a second crew member record additional readings until seven total are complete. Record the crew initials next to each depth reading.
 - a. If measures are off by more than an average of **1 cm**, discuss the procedure used by each crew member and adjust in the future (but do not change the recorded values).
8. Record the well status as frozen/dry/wet/submerged/not equilibrated.

If the water surface is NOT visible inside the well casing:

9. Use a multi-meter or hydrobuzzer or similar (see below).
10. Carefully insert the multi-meter wire/measuring tape assembly/hydrobuzzer into the well and lower it to the water level. Dip the tape in and out of the water until you have a feel for how the multi-meter needle or light responds to touching the water. Once you have this position fixed, record the distance from the top of the well casing at the mark provided for reference to the water surface. This takes some patience and practice.

- a. Make sure the casing stick up height at the time of measure is recorded on Form #3.
11. Taking measurements in a soil pit using the multi-meter is not a likely option; however, if done, suspend a shovel or similar across the top of the soil pit opening and measure from the bottom of this. A casing stick up height does not apply to these measures; be sure to flag this on the data form.
 12. If measurements are taken as part of a set of seven done with the installation of the well or with a QAQC visit, have one crew member repeat this measure three or four times, record them on Form #4 (blind to other crew members), then have a second crew member record additional readings until seven total are complete. Record the crew initials next to each depth reading.
 - a. If measures are off by more than an average of **0.6 mm** (this is less than the visual estimation method, given the likely higher precision of meter), discuss the procedure used by each crew member and make sure the multi-meter-reader is not bent, out of batteries, or excessively dirty. Clean and adjust methods in the future (but do not change the recorded values).
 13. Record the well status as frozen/dry/wet/submerged/not equilibrated.

If none of the above apply:

14. Make an educated guess at DTW. This is sometimes easier to do from a soil pit than a well casing.
15. Record the distance on Form #3 if just a single measure; flag it on the data form as a guess.
16. If measurements are taken as part of a set of seven done with the installation of the well or with a QAQC visit, have one crew member repeat this measure three or four times, record them on Form #4 (blind to other crew members), then have a second crew member record additional readings until seven total are complete; flag these data as a guess.

Well Metadata

Well metadata consists of several items (many of which were added in 2012): total casing length, casing stick up height, bolt stick up height, casing lean angle, casing notch bearing, and total cable+logger length. This is repeated with every visit at the beginning and end of the sample event (in case the well is disturbed or replaced).

1. Measure the entire length of the well casing to the notch on the casing top (remove the well cap) mark, including any section(s) that will be above the ground (the “stick up”). Do not include the length of any top cap. The easiest way to do this is by inserting the measuring tape down into the casing well until it hits the bottom cap (it may be done with the casing in or out of the well hole). Measure total distance using a marked point on the lip of the well. Record as “Total Casing Length” in cm.x on Form #3.

- a. If this is changed in any way during the event, repeat and record as the “After” measurement.
2. Using a compass or electronic angle measurer (e.g., on an iPhone) measure the bearing of the notch on the casing top (remove the well cap). The bearing is the angle looking from the opposite side of the well along the line created by the notch. Record as “Bearing of Notch” in degrees on Form #3.
 - a. If not due North, adjust to a 360-degree bearing and record as the “After” measurement.
3. Measure the length of the well casing above the ground to the notch on the casing top (remove the well cap) mark. Make sure to measure the distance using a marked point on the lip of the well casing. Record as “Casing Stick Up” in cm.x on Form #3.
 - a. If this is changed in any way during the event, repeat and record as the “After” measurement.
4. Measure the length of the well casing to the middle of the logger suspension bolt above the ground. Measure the distance to the ground below the bolt. Record as “Bolt Height” in cm.x on Form #3.
 - a. If this is changed in any way during the event, repeat and record as the “After” measurement.
5. Using a clinometer or electronic angle measurer (e.g., on an iPhone) measure any lean angle of the well casing above the ground at the notch on the casing top (remove the well cap). The well should be at a 90 degree angle, but record whatever is measured. Make sure to measure the angle at a marked point on the lip of the well casing. Record as “Casing Angle” in degrees on Form #3.
 - a. If not 90 degrees, adjust the well to 90 degrees and record as the “After” measurement.
6. If a logger is present, measure the entire length of the suspension cable plus the logger, attempting to mimic any “bend” in the cable as if it was in the well casing. The easiest way to do this is by holding the logger up, letting the cable hang naturally and then have an assistant measure. Measure the distance along the logger to the sensor location (where the metal housing changes to the plastic screw-on end cap of the logger). Record as “Cable Length” in cm.x on Form #3.
 - a. If this is changed in any way during the event, repeat and record as the “After” measurement.
7. If the well was just constructed or the water in the well disturbed in any meaningful way, allow the water in the well to equilibrate. Conduct other sample tasks as able.
 - a. Take several test measures of the water table depth (but do not record) to determine when the water table has returned to normal and stabilized.

8. If a logger is to be installed in the well, all real DTW readings must be conducted with the logger in place down the well.
9. Record the well status as frozen/dry/wet/submerged/not equilibrated.

Guidelines for Reconstructing Wells

Based on the suite of well metadata described above, crews may need to reconstruct or adjust a well.

Always be aware of measurement error in previous and current well metadata measurement. If a well needs to be reconstructed, it is important... be sure you are measuring correctly. Always apply the action that is least invasive yet fixes the well (Table 7-2).

Table 7-2. Troubleshooting notes and actions for reconstructing wells.

Attribute	Deviation	Action	Notes
Total Casing Length	See below	See below	This will only change if casing stick up (CSU) changes.
Casing Stick Up	±10%	Reconstruct well or push down/up current well to former CSU.	This can change due to the well breaking, the well moving up or down, or due to the ground surface eroding/accreting. Full-on well breaks require replacement/extensive repair. Movement up or down may require replacement, but ideally can just be moved back to the last position. If it appears that the ground level itself has changed, be sure there is no new litter or sediment in the way; this can be cleared off to return the CSU to the former reading.
Casing Angle	±20%	Reconstruct well or straighten current well to ~90 degrees.	Straightening a well can alter other metadata; re-measure and correct as needed.
Bearing of Notch	±30%	Reconstruct well or rotate current well to ~ 360 degrees (North).	Rotating a well can alter other metadata; re-measure and correct as needed.
Bolt Height	±10%	Reconstruct well or push down/up current well to former CSU.	This should only change with a change in CSU.
Cable Length	±5%	Reconstruct logger hanger setup.	This may happen if a logger needs to be switched out. Always make sure a new logger setup keeps the logger wet and not on the well bottom. Attempt to make any new hanger place the logger sensor in the same location as the old one.

DTW Volt Meter

1. A simple water level reader can be constructed using a voltmeter, a 2 m length of stereo wire, a metric steel tape measure, and duct or electrical tape (see Figure 7-1).
 - a. Attach the wire to the multi-meter leads.
 - b. Tape the leads of the wire connected to the multi-meter to the end of a tape. Make sure they are not touching and are even with the bottom of the tape.



Figure 7-1. Direct manual measurement of water table depths using a volt meter.

Gawley's Hydrolite

A low-cost, hand-made hydrolite device designed by Bill Gawley (Acadia National Park) can be assembled quickly to use for relatively accurate well readings (Figure 7-2).

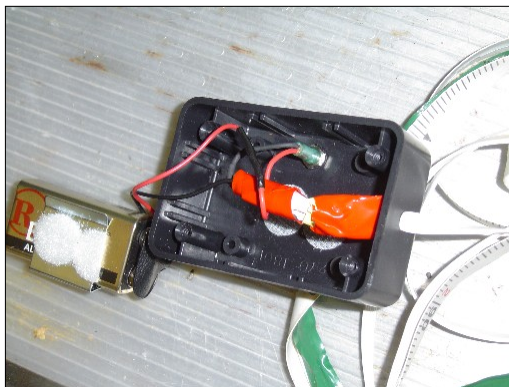


Figure 7-2. Gawley's Hydrolite.

Materials

- Measuring tape
- 2 silicon stoppers (size 3)
- 2 nails (1.25-1.5" long)
- Low profile, flat telephone cord (2-4 wire)
- Adhesive silicon caulk
- Project enclosure box (4x2x1 or larger, Radioshack)
- 5 mm LED Assembly lamp
- 9v battery
- 9v battery mount
- Adhesive back Velcro
- 9v battery snap connectors
- Electrical Tape
- Wire stripper/Utility knife
- Drill, drill bits, 5/16 (LED hole) and 5/32 (wire hole)

Construction

1. Insert 2 nails into the stopper to serve as the contacts of the “sensor.” Insert the nails so that the heads are flush with the bottom of the stopper. The nails should not be touching at either end. An extra form of weight is necessary if the stopper is not weighted. In this case, we used 2 stoppers and a piece of ½ inch thick PVC pipe (6 inch length).
2. Strip the insulation surrounding the copper wire(s) to expose approximately ½ inch of wire at each end of the phone cord.
3. If using a 2-wire phone cord, wrap one wire around each nail and secure with electrical tape. If using a 4-wire telephone cord, twist 2 of the copper wires together on each side leaving two double copper wires to connect to each nail. Secure with electrical tape.
4. Adhere the measuring tape to the stopper, also using electrical tape.
5. Secure the telephone cord to the measuring tape every 12 inches with duct tape (preferred) or electrical tape.
6. Drill a hole in the side of the project box (5/32 bit) to insert the telephone wire.
7. Drill an additional hole in the top of the project box (5/16 bit) to mount the LED light. Keep the hole as close to the edge of the box as possible to avoid contact with other materials inside the box.
8. Mount the LED.
9. Connect the red wire from the LED to the red wire of the 9V battery snap connector and secure with electrical tape.
10. Insert the telephone wire through the project box.
11. Attach/twist one copper phone wire to the black wire of the 9V battery snap connector and secure with electrical tape.
12. Attach/twist the second copper phone wire to the other/yellow LED wire and secure with electrical tape.
13. Place the 9V battery in the mount and attach to the bottom of the project box using adhesive Velcro.
14. Secure all drilled areas with silicone caulk.
15. Attach the lid to the project box.

WEI SOP 8: Installing and Reading Continuous Depth-to-Groundwater Data Loggers

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents field methods for continuous data logging of groundwater depths from wells within WEI sites. Given cost and complexity, the data loggers used to continuously record water table depths are only installed in a subset of survey and sentinel sites. Methods are identical at all wetland types and at survey and sentinel site types. The metadata for data loggers are recorded on WEI Form #3: Event: Site Establishment / Well / Logger / DTW.

The ROMN evaluated three types of water table loggers in three years of pilot testing in ROMO (Schweiger et al. 2010). We also drew upon the many years of experience David Cooper and his students have in water table monitoring in ROMN parks. Our current choice is to use small, relatively inexpensive non-vented pressure transducers, such as the RuggedTroll 100 or LevelTroll 300 from In-Situ, Inc. These types of loggers have proven to be easy to use and to generate reliable and precise data. They do require an independent time series of readings from a “barologger” for water depths to be adjusted for local atmospheric pressure and careful adherence to specific setup procedures. In-Situ makes a software interface called [Win-Situ 5](#) for downloading and initiating the Troll water table and barologgers. ***The remainder of this SOP assumes a Troll 100 or 300 and Win-Situ 5 is being used (although many steps are common to several types of loggers, especially any non-vented pressure transducer).***

Manufacturer SOPs

SOPs for the loggers used within the WEI protocol can be found on the InSitu website (<https://in-situ.com/>) or may be obtained from the ROMN.

Locations for Data Loggers

If enough loggers are available (or over time as funds accrue) all wells in a sentinel complex should have permanent loggers. If not, loggers should be placed along the dominant hydrologic gradient within the complex, ideally spanning wet to dry conditions. This is usually along a series of sites arranged parallel to the dominant direction of water flow in the wetland complex.

If there are enough data loggers available, additional units can be placed in other WEI survey or gradient sites. The first priority is the subset of survey revisit sites when they are sampled during a survey implementation (over a 2- to 3-year period). These sites are not likely to be logged beyond these years (although if there are interesting things happening at these sites, they could be). The second priority is any site (sentinel, gradient, or other projects) that is of specific interest to the park or the network.

Barologger Locations

Barologgers must be placed across a park at locations (elevations) that can serve multiple loggers in wells. There is no existing research that places vertical or horizontal distance limits on this, but the networks' experience has been around 10 km horizontal and 3,500 m vertical. The real limits will be a function of localized weather patterns and topography. If possible, barologgers should be placed in close proximity to wells with loggers in each sentinel complex (this is only possible at small ROMN parks). In larger parks, barologgers may be some distance from some wells with data loggers. An attempt to optimize the placement among sentinel complexes should be made, and trial and error may be needed to find locations that are ideal.

Differences among Site and Wetland Types

Procedures for data logging water table depth are identical in any site type that has a well and a common logger type. Wells are not typically installed in gradient sites so water table heights are rarely logged in these sites. All data are recorded on Form #3 and #4. There are no differences in manual water table logging among wetland types.

Schedule

Loggers should be downloaded at an absolute minimum once a year. This may happen for remote loggers (GRSA high-elevation sites). Ideally, loggers are downloaded twice a year: as soon as they are accessible in the spring, and again at the end of the summer or early fall.

Field Equipment for Water Table Data Loggers

Table 8-1 provides a checklist of items needed for data logging water table height. Only items needed for these procedures are included.

Table 8-1. Data logging water table height field equipment.

Quantity	Item
1	WEI Protocol document and/or laminated sheets of SOPs
1+	WEI Form #3
Many	Soft lead (#2) pencils
Many	Sharpie or markers
1-2	Metric tape measures
1-2	Well bailer
1-many	Troll 100 or 300 loggers
1+	Barologger(s)
12-24	Crimping ferrules
12-24 ft	Narrow gauge steel cable
1	Crimping tool
1	Cable cutters
1	Toughbook (or similar field laptop) with current Win-Situ 5 version installed

Procedures for Data Logging of Water Table Height: (WEI FORM #3)

1. Crews should always hike into remote sites with a logger programmed to start a log at the site. This way, if all fails (computer dies, etc.) and yet a new logger is needed, it will be in hand. This will require the log to be set to start after the latest possible time it could be put in the well.
2. These methods use Form #3 and are always done on paper. One form per site is used.
 - a. For complexes with more than one plot in them, use a separate version of the form for each site in the complex.
3. After the event is complete **be sure to complete the event checklist on the back of the form.**
4. Complete any well construction and metadata collection in sites as needed (WEI SOP 6: Groundwater Monitoring Well Installation).
 - a. Be sure to record the logger type and serial number for **old and new loggers** on Form #3.
5. Complete any manual water table depth measures and record on Form #3 (WEI SOP 7: Manual Reading of Water Table Height).

Downloading Logs

6. Remove the well cap (don't lose the bolts) and pull the logger out. If the well is frozen, record as much manual data as you can and return when it is warmer.
7. **Remember all manual DTW readings must be conducted with the logger in place down the well, if possible.**
8. **If the ambient temperature is very cold and a Troll 100 logger that is removed from a well is to be transported for long distances, Troll 100s must be kept upright; they must not be laid on their side.**
9. Connect the logger to a field laptop with the Win-Situ 5 software install used for the park/season and open the software.
10. Note that "Use Local Time" should be selected within Win-Situ and on the laptop, and choose to "Ignore Daylight Savings Time" should also be selected.
11. Accept the invitation to connect to the logger, or initiate the connection using the "plug" icon in the bottom right corner of the main window.
12. A data screen will appear that shows the real time parameters on the logger.

13. Record the ambient barometric pressure on Form #3 **using the logger that will be placed in the well** (even if a new log will not be started).
14. **If possible, compare the logger removed from the well to a separate new/calibrated logger or barologger connected to a separate laptop.**
 - a. The ambient barometric pressure of the logger should be ± 10 mm Hg of the barologger.
 - b. If not, the logger may need to be reset to the factory calibration (*after all data is downloaded*) and/or serviced.
 - c. A factory reset is performed in the sensor tab of Win-Situ 5. It will remove all settings and old data from the logger and the logger will need to be completely set up again (i.e., units, time sync, etc.).
 - d. After a reset, check the logger against a new barologger. If the pressures are still off, replace the logger with a new unit and get the old one serviced.
15. Synchronize the logger and the computer's clock by clicking the double arrow icon in the upper right corner.
16. Select the well location from the drop-down list. All sites should be in the list. They are named with a legacy of different approaches (the wetland name plus well ID or just the well ID, etc.), but the correct site should be obvious.
 - a. Rarely, a new site may be needed in Win-Situ. This is done following the menu prompts in Win-Situ and is intuitive (the only needed input is the site name). Sites are named with the wetland complex name and the Well ID (i.e., "Moraine Park 506").
17. Select the second tab (a "clipboard and pencil" icon). The log should appear. Make sure that the Site and Log Name make sense; if not, be sure to note on Form #3 the log name, etc. However, usually the log name does not need to be recorded.
18. Select the "download arrow" icon (large curved down pointing arrow icon on bottom middle of screen).
19. Select Download All Data.

20. Data will be downloaded into the predefined working directory (preset in the field computers). It will be placed in a folder named for the site. There should be a shortcut to this directory on the field laptop's desktop.
21. The log name will be what it was called when the log was started. It should be the Well ID (507) plus the time period of the log (summer2010) plus the logger serial number ("146082") (i.e., 507_summer2010_146082), but this may vary. You cannot change the log name.
22. View the data in Win-Situ 5. Look at the starting and ending dates, etc. Take notes on Form #3 as needed. Look especially for large spikes in the data that may suggest a membrane in the logger failed.
23. Under the File menu select "Export to csv." Data will go to the predefined directory and folder.
24. Navigate to the data folder (using the desktop shortcut). Make sure that the Win-Situ file *.wsl and the exported *.csv are there.
25. If you are removing the logger from the site, you are done. Replace the cap on the well, etc. and be on your way.
26. If you are reinstalling the logger to continue logging, keep the logger connected to the computer and move on to the next section.

Installing (or reinstalling) a Logger in a Well and Starting a New Log

27. These steps assume you have a logger connected to the field computer (previous steps above). On the "clipboard and pencil" icon page, select the bottom right corner icon to start a new log.
28. Select the site. All sites should be in the list. Make new sites only if needed.
29. Sites in Win-Situ 5 software are named using the Site Name ("BigMeadows") plus the WellID (i.e., "BigMeadows507"). There can be multiple logs within a site (as they accrue over time), but there should not be multiple wells within a Site.
30. Name the log. Logs within Sites are named using the Well ID (507) plus the time period of the log (summer2010) plus the logger serial number ("146082") (i.e., 507_summer2010_146082).
31. **Select to log only Pressure and Temperature. Units should be mm_Hg and degrees C.**
32. Choose a linear log.

33. Choose one reading per hour.
34. Review the log setup screen; if anything needs changing, return to the relevant screen and correct.
35. **Logs should always be on a schedule to start after a logger is in the well. Delay the start by one full day from when the logger was put in the well.**
36. **If not done previously (within the last 30 minutes), and just prior to installing a logger in a well, record the ambient air pressure from the logger on Form #3. Get this off the home screen before disconnecting the logger.**
37. Disconnect the logger by unclicking the “plug” icon.
38. (Re)install the logger into the well casing using a cable/ferrule loop on each end (Figure 8-1). Make sure the logger is suspended above the bottom of the well but in the water column (in very wet wells it can be well above the well bottom).



Figure 8-1. Photo of suspension cable used to hang Troll 100/300.

Barologgers

39. The procedures for initiating barologgers are largely the same as for Troll 100/300s.
40. Barologgers are installed inside a short piece of slotted PVC with caps on each end and either suspended from the top with a cable/ferrule or (preferred) with a bolt/wing nut passing directly through the opening on the barologger cap.
41. Barologger housing should have a weatherproof ROMN label with a contact name and number of the ROMN Data Manager or Ecologist affixed to the outside of the housing (Figure).



Figure 8-2. Barologger housing with ROMN label. A Troll 100 logger is pictured in between the middle and bottom housings.

42. The PVC assembly should be attached using two hose clamps (or similar) to a permanent pole (ideally at a park weather station) or a solid tree out of the reach of curious public or hungry deer (Figure).



Figure 8-3. Barologger installed on a ROMO weather station.

Critical Elements of Working with In-Situ Troll 100/300s Include:

NEVER perform a “zero in air” calibration; this removes the factory settings and complicates data adjustment.

NEVER set up a log to begin before the logger is in a well and under water. If this happens, the log must be erased and a new one started after the logger is to be immersed.

ALWAYS set up logged values to be simple depth (pressure in mm_Hg). Do not create a Level Reference.

DO NOT set an initial level reference. If this is an option, you made a mistake somewhere...start over.

ALWAYS record on Form #3 (or #4) the Stick Up Height, Depth to Water from casing top, and other well and water table data when establishing a logger in a well.

Literature Cited

Schweiger, E. W., E. Gage, D. Shorrock, I. Ashton, D. Cooper, D. Pillmore, and M. Britten. 2010. Wetland ecological integrity in Rocky Mountain National Park, pilot report. Unpublished report available by request from the Rocky Mountain Network of the National Park Service.

WEI SOP 9: In Situ Water Physiochemistry

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents pre-field (calibration, etc.) and field methods for collecting in situ groundwater physiochemistry at WEI sites. We include three of the four core NPS Water Resource Division monitoring indicators (temperature, specific conductance (SC), and pH). (Given cost and lack of clear justification in wetlands, the fourth, dissolved oxygen (DO) is not included in ROMN WEI monitoring.) Collecting meaningful in situ temperature from groundwater using WEI methods is more problematic; we do collect temperature data, but only use this information when extreme values might be an indication that more careful work is needed.

Methods are identical at all wetland and site types. Most gradient sites will not have wells and in situ chemistry will likely be from temporary soil pits. Calibration and error check readings are recorded on WEI Form #0 Calibration and Error Check and field data on Form #4: Water Table Depth, Water Quality and Soil.

Differences among Site and Wetland Types

Procedures for collecting water chemistry data are identical in any site type that has a well. Wells are not typically installed in gradient sites, so water chemistry samples are collected from other locations (i.e., soil pits). All data are recorded on Forms #0 and #4. There are no differences in collection of water chemistry data among wetland types.

Multiprobe Sondes

After a sample has been collected, all in situ data will be recorded using a multiprobe sonde. A variety of multiprobe instruments are available. From 2007 to 2011, a small inexpensive [Hanna HI 98129 probe](http://shop.hannainst.com/hi98129-ph-ec-tds-) was used (see the Hanna website <http://shop.hannainst.com/hi98129-ph-ec-tds->

[tester.html?id=005005&ProdCode=HI%252098129](http://shop.hannainst.com/downloads/dl/file/id/1743/manhi_98129_98130.pdf)). Beginning in 2012, a [YSI Proplus](http://www.ysi.com/productsdetail.php?Professional-Plus-18) was used (see <http://www.ysi.com/productsdetail.php?Professional-Plus-18>). Beginning in 2014, an In-Situ SmarTroll was used (see http://shop.hannainst.com/downloads/dl/file/id/1743/manhi_98129_98130.pdf).

Field personnel must be familiar with the instructions provided by equipment manufacturers for the instrument being used. This SOP provides only generic guidelines for sampling with a multiprobe, equipment use, and maintenance. There is a large variety of available field instruments and they are continuously being updated or replaced using newer technology. At a minimum, the instrument selected must meet the specifications shown in Table 9-1.

Table 9-1. Multiprobe reporting units and performance specifications for parameters used in the WEI protocol.

Sensor	Reporting Units	Range	Accuracy	Resolution
Temperature	°C or Celsius, round to nearest degree or tenth of a degree as warranted by instrument	-5 to 45°C	±0.15°C	0.01°C
Specific Conductance	microsiemens per centimeter (µS/cm) rounded to two or three significant figures	0 to 100,000 µS/cm	±0.5% of reading +1.0 µS/cm	10 to 100 µS/cm (range dependent)
pH	standard pH units (su) rounded to nearest 0.1 pH unit pH is reported as a temperature-compensated value	1 to 14 units	±0.2 units	0.01 unit

Multiprobe Calibration and Error Check

Calibration and error check procedures are conducted episodically during the season (Penoyer 2003), and sometimes are referred to as “premobilization.” The default ROMN protocol requires, at a minimum, for premobilization to be done at the start of a week or set of survey site sample events.

Calibrations use the manufacturer’s suggested routine for a multiprobe and certified traceable standards (unexpired, w/stock number). Premobilization calibration resets the instrument or removes electronic drift that has occurred since the last calibration. By recording pre-calibration readings immediately prior to a calibration and then again immediately after calibration (while the sensor is still in the standard), a check can be completed for gross errors that might indicate the sensor is failing. This also ensures the calibration “sticks.”

Error checks, just after a calibration, determine how accurately the calibrated instrument is performing. Error checks use a certified standard or an uncertified prepared solution. *Do not adjust the instrument (using calibration controls) during error check procedures. If the error check values are not within the acceptance criteria in Table 9-2, the calibration should be redone.* Error checks are ideally conducted in the field just prior to sample events to confirm any drift in the instruments.

These methods should be simple and not prohibitively time consuming in the field; however, they may be optional under severe time constraints.

Table 9-2. Summary of multiprobe annual calibration and error check methods with acceptance criteria for parameters used in the WEI protocol.

Parameter	Calibration Method Summary	Error Check Method Summary	Frequency	Error check acceptance criteria	Optimum acceptance criteria (USGS ref)
Temperature	No calibration is performed; calibration of thermistor is done by manufacturer.	2 pt. temperature error check with thermometer referenced to NIST standards (i.e., at least NIST-traceable), with a range from at least -1°C to 45°C with 0.1°C divisions. Temperature points should bracket expected range in sites.	NA	±0.3°C	±0.2°C
pH	Perform a <u>2-point calibration</u> with pH standards that bracket the anticipated water of environmental interest (e.g., using pH buffers of 4 & 7 or 7 & 10 su).	Error check with a third buffer (4 or 10) not used in the 2-point calibration and record pH readings.	Annually, prior to field season and monthly thereafter	±0.3 su	±0.2 su
Specific Conductance	2-point calibration using air and a 1412 µS/cm standard.	Error check with standards 100 and 10,000 µS/cm. Do <u>lower one first</u> .	Annually, prior to field season and monthly thereafter	±5 µS/cm or ±3%	±5 µS/cm or ±3%

Field Equipment for In Situ Water Physiochemistry

Table provides a checklist of items needed for collecting in situ water chemistry data. Only items needed for these procedures are included.

Table 9-3. In situ water chemistry field equipment.

Quantity	Item
1	WEI Protocol document and/or laminated sheets of SOPs
1+	WEI Form #4 and Form #0
Many	Pencils
Many	Sharpie or markers
1-2	Hanna HI 98129 probe (or similar)
1 each	100 ml of pH and SC error check standards
1-2	Pore sipper
1-2	Well bailer
2-4	HDPE 100-200 ml beakers (for error check and sample testing)

In Situ Procedure YSI, Error Check (WEI FORM #0)

1. These methods use Form #0 and are usually done on both paper and recorded in the sonde.
 - a. Error checks may be applied to multiple sample events.
2. Pre-sample sonde set up; follow the sonde manual to connect sonde to the data logger.
3. Turn on logger.
4. Remove calibration cup and install sample cup.
5. Select parameters to be logged (usually just accept the default).
6. Set stable data settings (usually just accept the default).
7. Select “Log One Sample.”
8. Create or select a site (use the Well ID of the first or main site to be sampled) and create or select a Folder as EC + [date as yyyyymmdd].
9. Conduct error check as described below and in the YSI manual. Use the correct Site and Folder code EC + [date as yyyyymmdd].
 - a. Note that because this is not a calibration, it can be done as if it is just a grab sample with the line log button. Do this in order (pH, SC, DO) with a single line log after each parameter is placed in the sample cup.
10. Error check conductivity with 100 $\mu\text{S}/\text{cm}$ or similar. Place probe in clean calibration solution, let equilibrate and line log a reading. Write down value on Form #0.
11. Error check pH with pH 7 or similar. Place probe in clean calibration solution, let equilibrate and line log a reading. Write down value on Form #0.
12. (*optional*) Error check DO with zero DO water. Place probe in clean calibration solution, let equilibrate and line log a reading. Write down value on Form #0.
13. NOTE if a calibration is required, refer to the YSI manufacturer SOPs.

In Situ Procedure In-Situ SmarTroll, Error Check (WEI FORM #0)

1. These methods use Form #0 and are usually done on both paper and recorded in the sonde.

a. Error checks may be applied to multiple sample events.

2. Follow the sonde manual to connect sonde to the battery pack and iPod.

3. Turn on battery pack and iPod. Open iSitu app on iPod.

Under “Sites,” select a site or add a new site and create a site name under “Site Details” using the Well ID of the first or main site to be sampled and EC (error check) + [date as yyyyymmdd]. For example, “ROMO 533 EC 20140913.” Select camera and take photo to aid in site identification. Often this is a picture of the data collector. Save site details.

4. Remove storage cap and insert sonde into plastic sample tube. Be sure to leave opening at top of seal.

5. Conduct error check as described below and in the SmarTroll manual. Select the correct Site code EC + [date as yyyyymmdd] and push “Set.”

6. Error check conductivity with 147 $\mu\text{S}/\text{cm}$ or similar. Place probe in clean calibration solution, let equilibrate and record value by selecting “RECORD,” allow to record for 1-2 seconds and then stop. Write down value on Form #0.

7. Error check pH with pH 7 or similar. Place probe in clean calibration solution, let equilibrate and record value by selecting “RECORD,” allow to record for 1-2 seconds and then stop. Write down value on Form #0.

8. *(optional. Only error check DO if you are collecting data on dissolved oxygen.)* Error check DO with zero DO solution. Place probe in clean calibration solution, let equilibrate and record value by selecting “RECORD,” allow to record for 1-2 seconds and then stop. Write down value on Form #0.

9. NOTE if a calibration is required, refer to the SmarTroll manufacturer SOPs.

In Situ Water Physiochemistry Procedures with YSI (WEI FORM #4)

1. These methods use Form #4 and are usually done on both paper and recorded in a sonde.
2. Pre-sample sonde set up; follow the sonde manual to connect sonde to the data logger.
3. Turn on logger.
4. Remove calibration cup and install sample cup.
5. Select parameters to be logged (usually just accept the default).
6. Set stable data settings (usually just accept the default).
7. The start and stop time and date of data collection is automatically added to the file, distinguishing these data from other sample events at the site.
8. Collect samples of groundwater using the following order. In some cases the sonde may be inserted directly into a well or other groundwater source (this is preferred):
 - a. In situ in a bailed well. Bail the well at the beginning of the sample event (after or as part of water depth measurements, etc.; see Figure 9-1). Wait until the end of the sample event for the well to refill and stabilize.
 - b. Pore sipper from well saturated soil/groundwater. Samples will be placed in a sample cup. Find a wet or saturated location in or near the plot (ideally close to the well). Insert the pore sipper slowly into the soil to a depth of about 20 cm. Slowly extract a sample of groundwater (Figure 9-2). Plunge this sample into the sample cup, rinse well and discard. Repeat this three times. Collect a series of samples sufficient to fill the sample cup with 100-200 ml of sample. Place in shade and immediately proceed to measure in situ parameters.
 - c. Pore sipper or bailer from bailed groundwater well. Bail the well at the beginning of the sample event (after or as part of water depth measurements, etc.). Wait until the end of the sample event for the well to refill and stabilize. Same procedures as above except for source of water.
 - d. Other groundwater discharge locations (i.e., at the base of a large hummock or a slope discharge). Same procedures as above except for source of water.

- e. As deep as possible from a standing surface water feature. Same procedures as above, except sonde may be inserted directly into source.
- f. As deep as possible from a flowing surface water feature. Same procedures as above, except sonde may be inserted directly into source.

9. Record the location and method for the sample.



Figure 9-1. Removing water from a well using a bailer.

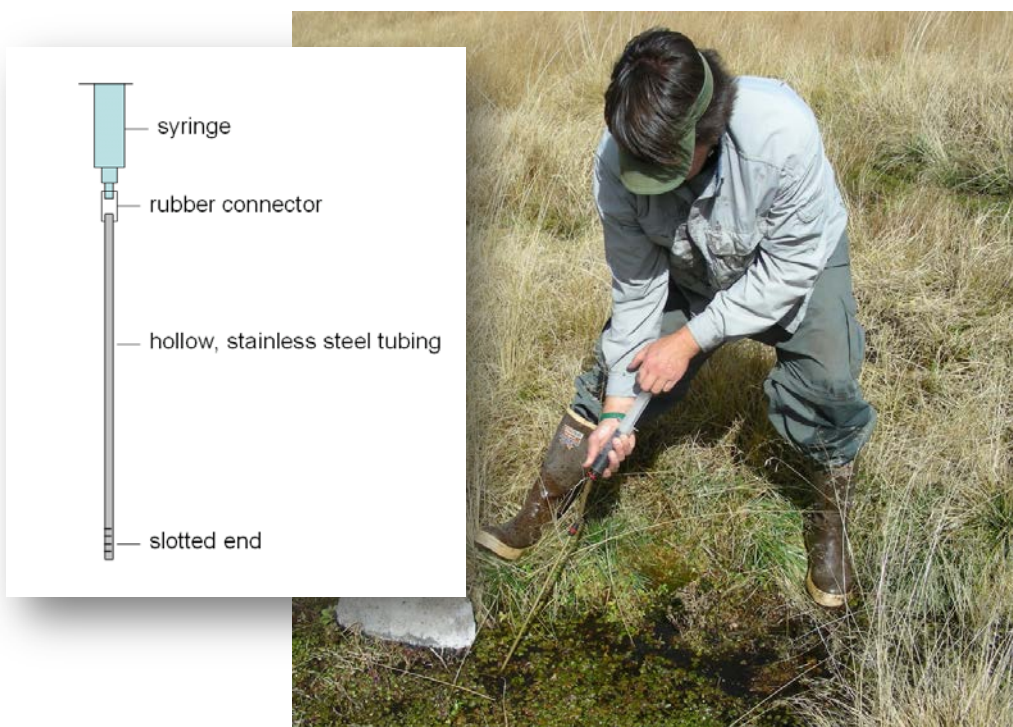


Figure 9-2. Pore sipper (Portnoy and Giblin 1997) constructed from crimped and slotted stainless steel or copper tubing, a syringe and rubber tubing. Diagram is courtesy of B. Mitchell, NPS.

Measuring Parameters

10. Select Log One Sample.
11. Create or select a Site (use the Well ID of the first or main site to be sampled) and create or select a Folder as GW + [date as yyyyymmdd].
12. Record the time for the collection of the core sample.
13. Press the Log Now button at least seven times letting the sonde cycle after each press.

In Situ Water Physiochemistry Procedures with In-Situ SmarTroll (WEI FORM #4)

These methods use Form #4 and are usually done on both paper and recorded in a sonde.

1. Follow the sonde manual to connect sonde to the battery pack and iPod.
2. Turn on battery pack and iPod. Open iSitu app on iPod.
3. Remove storage cap and attach metal sonde protector. Insert sonde directly into well/water or into plastic sample cup.
4. Collect samples of groundwater using the following order. In some cases the sonde may be inserted directly into a well or other groundwater source (this is preferred):
 - a. In-Situ in a bailed well. Bail the well at the beginning of the sample event (after or as part of water depth measurements, etc.; see Figure 9-1). Wait until the end of the sample event for the well to refill and stabilize.
 - b. Pore sipper from well-saturated soil/groundwater. Samples will be placed in a sample cup. Find a wet or saturated location in or near the plot (ideally close to the well). Insert the pore sipper slowly into the soil to a depth of about 20 cm. Slowly extract a sample of groundwater (Figure 9-2). Plunge this sample into the sample cup, rinse well and discard. Repeat this three times. Collect a series of samples sufficient to fill the sample cup with 100-200 ml of sample. Place in shade and immediately proceed to measure in situ parameters;
 - c. Pore sipper or bailer from bailed groundwater well. Bail the well at the beginning of the sample event (after or as part of water depth measurements, etc.). Wait until the end of the sample event for the well to refill and stabilize. Same procedures as above except for source of water.
 - d. Other groundwater discharge locations (i.e., at the base of a large hummock or a slope discharge). Same procedures as above except for source of water.

- e. As deep as possible from a standing surface water feature. Same procedures as above, except sonde may be inserted directly into source.
 - f. As deep as possible from a flowing surface water feature. Same procedures as above, except sonde may be inserted directly into source.
5. Record the location and method for the sample.
 6. Measuring parameters: Under “Sites,” select a site or add a new site and create a site name under “Site Details” using the Well ID of the first or main site to be sampled and GW (groundwater) or SW (surface water) + [date as yyyyymmdd]. For example, “ROMO 533 GW 20140913.” Select camera and take photo to aid in site identification. Save site details.
 7. Select the correct Site code EC + [date as yyyyymmdd] and push “Set.” Log values by selecting “RECORD,” allow to record for 5-15 minutes and then stop. Leave iPod out of sun while recording and do not push button on top of iPod (power/screen off) while recording.

Literature Cited

- Penoyer, P. 2003. DRAFT guidance on WRD required and other field parameter measurements, general monitoring methods and some design considerations in preparation of a detailed study plan. National Park Service. Available by request from National Park Service, Rocky Mountain Inventory and Monitoring Network.
- Portnoy, J. W. and A. E. Giblin. 1997. Biogeochemical effects of seawater restoration to diked salt marshes. *Ecological Applications* 7:1054-1063.

WEI SOP 10: General Soil Characterization and Chemistry

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents methods for general characterization of wetland soil profiles, collection of soil samples, and an overview of their lab analyses.

Our methods are not intended to generate rigorous characterizations of soil profiles in a wetland site. Their precision will be such that they will only be sensitive to large changes in soil characteristics. ROMN methods should not be used when regulatory or jurisdictional requirements must be met. They only serve to (1) confirm wetland designation at the time of a sample event, and (2) suggest a more detailed examination of soils if a change is seen in these indicators when monitored over time.

Methods are identical at all site and wetland types. The full set of soil methods are done with the first visit to sites in conjunction with well construction (WEI SOP 6: Groundwater Monitoring Well Installation) or as QAQC.

These data will only be collected every 5-10 years when the large surveys are redone. When funds are available, soil cores can be taken more frequently (annually), but may be analyzed for a reduced set of parameters (pH, total nitrogen, and total carbon).

Soil data are entered on WEI Form #4: Water Table Depth, Water Quality and Soil. Note that some of the general soil classification methods presented here are useful in site verification (WEI SOP 4: Verification of Site Status), but the detail presented in this SOP is difficult to implement while evaluating possible sites for a survey plot.

Differences among Site and Wetland Types

Procedures for describing soil characteristics and collecting samples are identical in any site type that has a well. Wells are not typically installed in gradient sites, so all methods are done in soil pits. Optionally, complete chemistry samples may be taken annually from sentinel sites. All data are recorded on Form #4. There are no differences in methods among wetland type.

Soil Profile (Horizons)

ROMN methods **do not require specific or exact identification of soil horizons in a profile**, rather, the methods only need to discriminate “*different*” *soil layers* (that may mirror horizons). Therefore, a more accurate term might be “unique layers” (versus “horizon”). We also limit the included layers or horizons to those both readily observable in the field with simple observations in shallow wells or pits, and those that can occur in most ROMN wetlands. We provide the following general description of horizons, as these characteristics will often be observable to non-soil scientists and used to describe soil heterogeneity at a site.

Soil color and other properties including texture, structure, and consistency are used to distinguish and identify soil horizons (layers) and to group soils. A soil profile (Figure 10-1) consists of recognizable layers or horizons of soil that are described in sequence from the surface downward. Most soils have two or more identifiable horizons. A soil horizon is a layer of soil approximately parallel to the land surface, which can be differentiated from adjacent layers (or horizons) by identifiable physical, chemical, and biological characteristics that can be recognized in the field (e.g., color, structure, texture, etc.; NRCS 2006). Soils typically have O, A, E, B, and C horizons (Figure 10-1). Note that not all horizons must be present in a given soil profile.

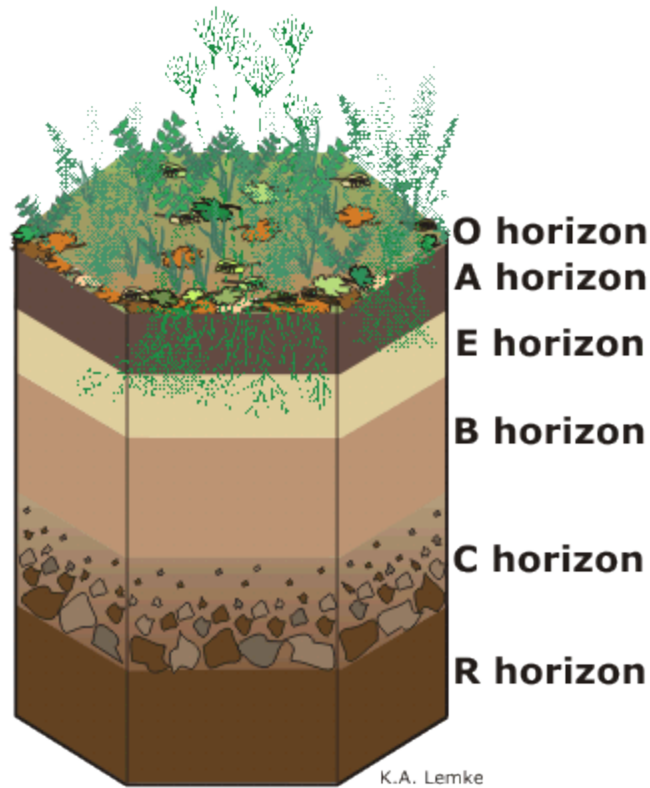


Figure 10-1. Example of a soil profile with generalized horizons (NRCS 2006). Figure courtesy K. A. Lemke at <http://www.uwsp.edu/geo/faculty/lemke/geog101/>.

The O horizon is a surface or sub-surface layer consisting of greater than 20% organic matter by dry weight. There is very little mineral material in this layer and soil will consist of humified or partially decomposed plant material, have a high water-holding capacity, and may often be saturated. This horizon will not be present at all sites.

The A horizon is mineral, formed at the surface or below O, with little remnant rock structure, and some accumulation of humified organic matter but dominated by mineral matter. The A horizon typically is dark colored due to the presence of some organic matter and is colloquially referred to as topsoil or humus. This horizon will not be present at all sites.

The E horizon (sometimes referred to as an AB or A/B) is also mineral soil with a loss of clay, iron, aluminum, and/or organic matter leaving a net concentration of sand and silt, but little remnant rock structure. It is typically lighter color (higher value, chroma) and coarser texture than A horizons. This horizon will not be present at all sites.

The B horizon is also mineral soil, typically formed below O, A, or E. It has little or no rock structure and often the accumulation of silicate clay, strong gleying (see below) in the presence of hydric conditions, and often finer particles. B horizons may often be very dense in organic soil wetlands.

The C horizon consists of soil parent material, either created in situ or transported into its present location, that has experienced little weathering. The C Horizon may contain gravel, boulders, or more likely, large shelves of unweathered rock. This horizon will be present at most sites, but may be extremely deep.

The R horizon is made up of solid parent material, or bedrock. This horizon is present at all sites, but may not be encountered frequently because it is often extremely deep.

Hue, Value, and Chroma (Munsell)

ROMN methods specify that a Munsell value be recorded for any mineral soil horizon (or layer). The Munsell System (www.munsell.com) allows for direct comparison of soils anywhere in the world. The system has three components: hue (a specific color), value (lightness and darkness), and chroma (color intensity) that are arranged in books of color chips (Figure 10-2). The color chips are arranged by a color's **hue**, **value**, and **chroma**. Hue refers to principle spectral colors such as yellow (Y), red (R), and their intermediate midpoints, such as yellow-red (YR). The value describes the lightness or darkness of a color from black (0) to white (10). Chroma refers to the relative purity or dullness of a color, ranging from the purest colors (8) to the most neutral colors (0). A color's hue, value, and chroma are combined in a numerical expression to form a designation for each color chip. For example, a color chip having a designation of 10 YR 4/2 has a hue of 10 YR, a value of 4, and a chroma of 2. Wetland soils have a specific set of possible hues due to the soil processes that are occurring on site. It is not necessary to carry and use the entire Munsell chart catalogue. Hue charts 10YR, and Gley 1&2 will be used by crews to determine the hue, value, and chroma of wetland soils.



Figure 10-2. Example 10YR page from a Munsell Chart.

Peat Classification

Von Post (1924) developed a field method to indicate stages of organic soil decomposition within peatlands. Peat forms when plant material, usually in marshy areas, is inhibited from decaying fully by acidic and anaerobic conditions. In ROMO wetlands, peat is composed primarily of plant roots, sedges, and bryophytes. Peat material is either fibric (peat), hemic (mucky peat), or sapric (muck) based on the level of decomposition. Fibric peats are the least decomposed, and are comprised of intact fiber; individual plant pieces can be easily differentiated. Hemic peats are somewhat more decomposed; there are few discernible plant pieces and some mucky, smooth material. Sapric peats are the most decomposed, they appear homogenously smooth with no discernable plant pieces and are often loose and watery. The Von Post scale (Table 10-1) recognizes 10 steps, from little-decomposed fibrous, light-colored peats (H1), to well-decomposed, colloidal, dark-colored materials (H10). The Von Post scale has three more generalized classes (fibric, mesic, and sapric types), which can be quantitatively defined by analysis of fiber content and size to remove subjective bias and appear in other soil taxonomic systems.

ROMN methods specify that a Von Post value be recorded for any peat soil horizon (or layer). Von Post classes are identified for any **organic** soil horizon (layer). Soil or peat is manipulated to find a match with the degree of humification classes as in Table .

Table 10-1. Table of Von Post Classes (Von Post 1924).

Degree of Humification	Nature of Material Extruded on Squeezing	Nature of Plant Structure in Residue	Horizon Descriptor
H1	Clear, colorless water; no organic solids squeezed out	Unaltered, fibrous, undecomposed	Fibric
H2	Yellowish water; no organic solids squeezed out	Almost unaltered, fibrous	
H3	Brown, turbid water; no organic solids squeezed out	Easily identifiable	
H4	Dark brown, turbid water; no organic solids squeezed out	Visibly altered, but identifiable	Hemic
H5	Turbid water and some organic solids squeezed out	Recognizable, but vague; difficult to identify	
H6	Turbid water; 1/3 of sample squeezed out	Indistinct, pasty	
H7	Very turbid water; 1/2 of sample squeezed out	Faintly recognizable; few remains identifiable, mostly amorphous	Sapric
H8	Thick and pasty, 2/3 of sample squeezed out	Very indistinct	
H9	No free water; nearly all of sample squeezed out	No identifiable remains	
H10	No free water; all of sample squeezed out	Completely amorphous	

Texture

ROMN methods specify that the dominant texture of all *mineral* layers should also be classified (use the NRCS flow chart, 10-3). Most WEI sites will have a simple set of textures (a subset of the options in 10-3) and little time will be required to do this.

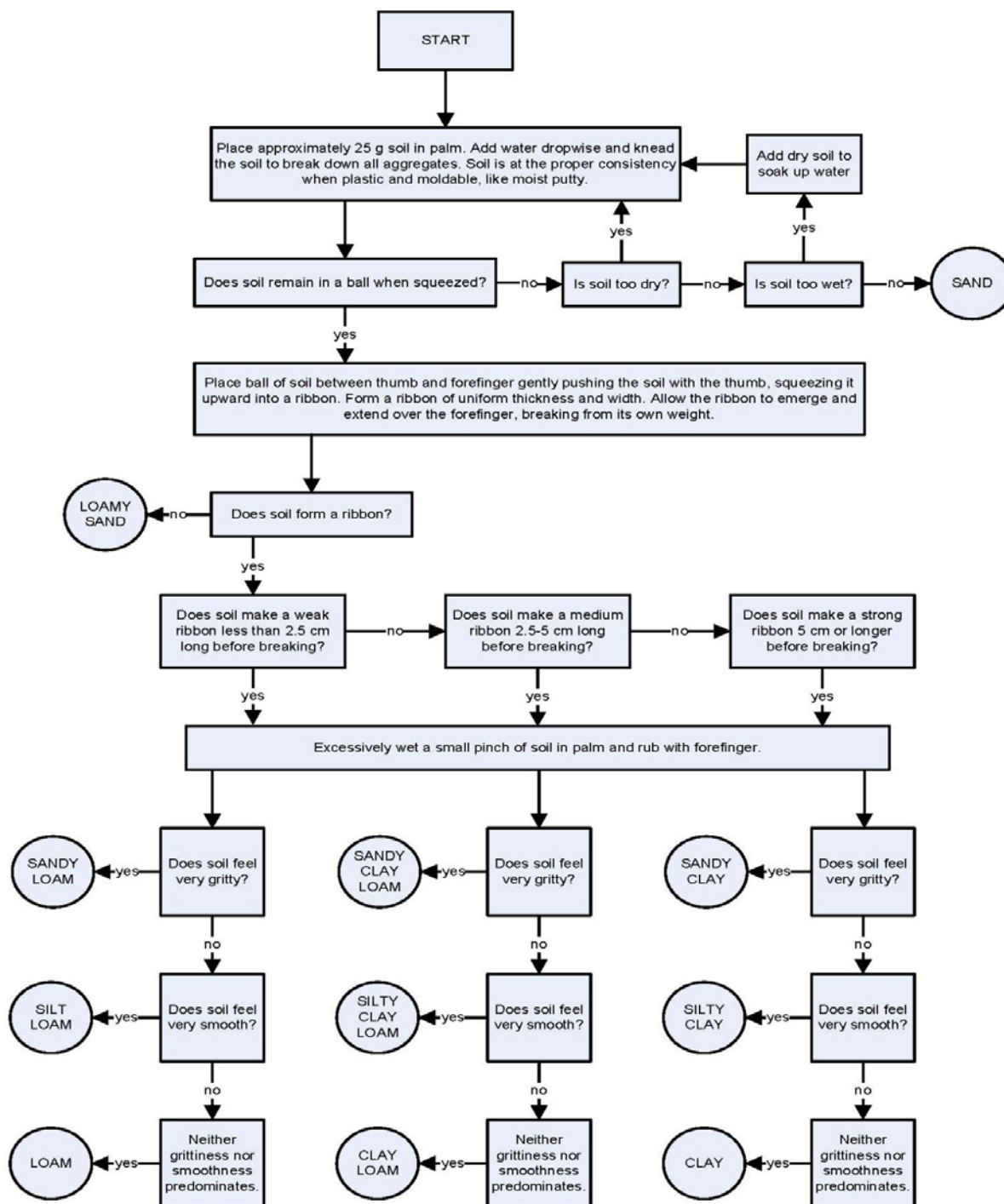


Figure 10-3. Soil type flowchart (modified from Thien 1979).

Hydric Soil

The definition of a hydric soil is a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (USDA 2006). ROMN uses four indicators of hydric soils. The first is peat as described above. The other three indicators are gleyed soils (mineral), mottles (mineral), and sulfidic odors (all soils) and are summarized below (Figure 10-4). All of these characters must occur in the upper 80 cm of the soil profile to be valid hydric soil indicator. If no characters are found in the upper 80 cm, the site does not have hydric soils and may not be a wetland.



Figure 10-4. Examples of hydric soil indicators: (A) strongly gleyed soil (on the right), (B) loamy gleyed matrix, (C) sandy redox masses removed from hand auger, (D) oxidized root channels visible against matrix color. (Image in A is from B. Schweiger, B-D courtesy of USDA 2006)

Gleyed Soils

Gleyed soil is a type of hydric soil common in wetlands. During gley soil formation (a process known as gleization), the oxygen supply in the soil profile is restricted due to soil moisture at saturation. Anaerobic micro-organisms support cellular respiration by using alternatives to free oxygen, such as iron and manganese as electron acceptors. These reduced mineral compounds leach from the soil, leaving behind a depleted soil matrix with gley soil color (blackish-gray to gray or blue) lacking the rich browns and blacks of iron, manganese, and other minerals. The Munsell System classifications will help confirm a gleyed color (usually a value of 4 or higher and a chroma of 2 or less on the appropriate hue charts).

Mottles and Redox Depressions

In a soil layer that has been reduced, one of the first areas where oxygen will be reintroduced is along pores and the channels of live roots. As oxidation occurs in these areas, characteristic reddish-orange redoximorphic mottling (value and chroma of four or more) will be apparent along the pores and linings. These will stand out as bright orange (iron) or solid black (manganese) in contrast to gley or the matrix color of the overall soil layer. Often, if the soils are broken apart by hand, the reddish-orange or black redox concentrations along pores and root linings will be apparent.

Sulfidic Odor

A “rotten egg smell” indicates that sulfate-sulfur has been reduced (the reduced form is sulfur gas) by microbial activity due to anaerobic conditions. Often this indicates extreme, year-round saturation of the “smelly” horizon because sulfur is only used by microbes as an electron acceptor when iron and manganese supplies are exhausted. Sulfidic odor is a hydric soil indicator, but will typically be encountered deep in soil profiles in highly saturated and/or very old peat layers.

Soil Samples for Laboratory Analysis

Soil organic matter, carbon, pH, and plant nutrient concentrations can provide a powerful index of productivity and ecosystem processes and are often determinants of vegetation structure (Sollins et al. 1999). Results from lab analyses of soil samples are used to characterize the storage, cycling, and abundance of nutrients and water available to plants, and the potential for acidification of the soil from the deposition of pollutants. Soil cores will be sent to a cooperating laboratory for the analysis of nutrients and mineral concentrations (e.g., P, Mg, Mn, Al, Ca), soil pH, carbon and nitrogen content, percent organic matter, and cation exchange capacity. Other parameters may be included, such as salinity measures, depending on wetland type and park-specific needs.

Depending on the nature of the sample event, up to three distinct samples are collected from each site. A “wetland type confirmation” sample is taken when a well is first constructed (or from a soil pit if a gradient site). A “full chemistry” sample is taken every 5-10 years from each site (these may be more frequent for a subset of parameters at sentinel sites).

Wetland Type Confirmation Sample

When a well (or soil pit) is first constructed at each site, a 40 cm sample is collected and analyzed for carbon and nitrogen content and percent total organic matter. This sample is used to confirm if the site has mineral or organic soils. Detailed methods are provided below.

Chemistry Sample

During main survey panel implementation (every 5-10 years), a sample analyzed for a complete matrix of plant nutrients, percent organic matter, cation exchange capacity, pH, and total carbon and nitrogen is taken from a 0-20 cm composite sample taken from the well or a series of shallow cores near the well. When funds are available, soil cores can be taken more frequently (annually) and a minimum analysis may include pH, total nitrogen, and total carbon. After the first visit or when money is limiting or in sentinel sites, this list can be reduced to pH, total carbon, and total nitrogen.

Post Field

After returning from a sample event, several key steps must be followed. These include organizing and checking all data forms and care of any gear. Most importantly, any soil samples must be properly stored, packaged, and/or shipped.

Soil Sample Storage and Shipping

Both the chemistry and the bulk density samples can be kept closed in plastic bags for a few days, as long as they are kept cool. However, if you cannot ship samples to the laboratory within a week, the samples should be air-dried. If this is the case, find a location inside (housing/laboratory/office), place samples on a table, open the top of sample bags, and let sit until dry (or until you ship them). If there is a fan available, running it above the samples will hasten this process.

When possible, pack the sample in a box. Keep the chemistry and wetland type samples (if done) in separate boxes. Mail to the following address requesting (1) the wetland type confirmation (**Fc**) samples analysis for percent organic matter, total nitrogen and carbon; (2) the complete chemistry (**Cm**) samples analysis for pH, electrical conductivity, cation exchange capacity, organic matter, nitrate-nitrogen, phosphorus, potassium, zinc, iron, manganese, copper, total nitrogen and carbon, calcium, and aluminum; and (3) the bulk density (**Bu**) soil texture and bulk density analysis.

Address is current as of 2015, but please confirm prior to mailing:

Dr. James Self
Soil, water, and plant testing laboratory
Colorado State University
Room A319, Natural and Environmental Sciences Building
200 West Lake Street
Fort Collins, Colorado 80523-1120

Field Equipment for Soils

Table 10-2 provides a checklist of items needed for soil methods.

Table 10-2. Soil field equipment.

Quantity	Item
1	WEI Protocol document and/or laminated sheets of SOPs
1+	WEI Form #4
Many	Soft lead (#2) pencils
Many	Sharpie or markers
1-many	Powder free gloves
1+	Munsell chart pages 10YR and 5G
1	Soil corer (marked at 20 cm)
Many	Whirlpaks or plastic bags
1	Soil knife or trowel

Soil Characterization Procedures (WEI FORM #4)

1. Form #4 is always done on paper with one copy per plot; use additional copies of form if >2 sets of soil data are collected. Use additional copies for other sites in a complex.
2. The soil plugs from the well should be carefully removed and placed from top to bottom during well construction. If the soil removed from the pit is intact and in the correct position, and the face of the well pit is not readily visible, the soil plugs may be used for these procedures instead.
3. Using the face of the well pit (if visible) or the removed soil plug, identify all soil layers (horizons) and measure the depth to the top of each layer. Record either layer name (O, A, E, B, or C) or more likely, layer 1, 2, 3, etc. on Form #4. Not all horizons may be in all profiles. Be sure to record a “NA” or cross out each cell on Form #4 that is not used;
4. **Record separately the total sum depth of peat soil in the top 80 cm (or as deep as the pit allows).**
5. For each mineral layer, use the 10YR and Gley 1&2 Munsell charts to classify a representative sample of soil. Record this on Form #4.
6. For any organic layer, use the Von Post key (Table -1 and on Form #4) to classify a representative sample of soil. Record this on Form #4.
7. For all mineral horizons, classify the texture of a representative sample of soil. Use the key in Figure 1 (also on Form #4). Record this on Form #4.
8. For all organic layers, classify a representative sample of soil as gleyed or not and the presence or absence of mottles/redox features. Record this on Form #4.
9. For all layers, classify a representative sample of soil as sulfidic in odor. Record this on Form #4.
10. Take notes as needed on each layer. Especially note any other indicators of hydric soil and any complex mixing of horizons.

Grab Soil Sample Procedures (WEI FORM #4)

1. **These data will only be recollected every 5-10 years when the large surveys are redone.**
When funds are available, soil cores can be taken more frequently (annually), but may be analyzed for a reduced set of parameters (pH, total nitrogen, and total carbon).
2. The header on Form #4 should have been filled in with previous procedures; if not, do this now.

Wetland Type Confirmation Sample

3. If a well or soil pit has just been dug, take a **40 cm** sample from the ground surface, along soil pit wall, or from removed soil plugs (soil pit wall is preferred to minimize error). It is important to take the sample from one uniform layer. If two layers meet at approximately 40 cm, choose one or take two samples; make notes on this and don't mix samples.
4. (*Optional*) If the well is already in place (usually this means the sample event is a revisit), a soil pit must be dug to 40 cm. The pit should be dug adjacent to but outside of the 10x10 m sample plot, in an area that looks very similar to the sample plot with the same wetland and vegetation types. If no similar area outside the plot is present, a plug can be taken from just inside the 10x10 m plot, avoiding all the smaller nested plots. This may be skipped if time is constrained. If the site is using an existing well, or no well is to be installed and it is the first event at the site, a pit *should* be dug.
5. Write the sample number on the outside of the bag with an indelible Sharpie and on Form #4. The sample number is **Well_ID+date+Fc**, "505_20090806_Fc." Keep the sample in the shade.
6. Always fill any core hole with litter and any loose soil to reduce visible disturbance and future erosion.

Complete Chemistry Sample

7. If a well or soil pit has just been dug, create a composite sample from each layer present in the soil well, pit, or extracted plug not exceeding **a depth of 20 cm**.
8. Make sure that all detritus, such as surface vegetation and litter (peat is not detritus), is removed from any upper horizons.
9. Composite soil material equal in volume to three, 20 cm cores, with a diameter of approximately 2 cm. Place soil from corer into a whirlpak.
 - a. You may use your hand if it is clean (or very dirty from wetland soil from the site!), but gloves are preferred.
10. If the well is already in place and no soil pit is dug, a soil corer may be used.

- a. Select three random locations near the well, within the subplot, but not in any of the 1x1 m vegetation plots. Go to the first location.
 - b. Remove surface vegetation and litter to expose mineral soil.
 - c. Carefully drive the soil corer to 20 cm depth. Remove corer and place soil from corer into a whirlpak. Use soil knife or trowel to assist in the removal, as needed.
 - d. Do this three times from an area immediately adjacent to the well. Composite these samples.
 - e. If the soil is very saturated, you may have to collect many more than three cores, as only a small amount of soil will be extractable from each core. Continue collection until an equivalent amount to three, 20x2 cm cores is generated.
11. Write the sample number on the outside of the bag with an indelible Sharpie and on Form #4. The sample number is **Well_ID+date+Cm**, “505_20090806_Cm.” Keep the sample in the shade.
 12. Always fill any core hole with litter and any loose dirt to reduce visible disturbance and future erosion.

Literature Cited

- Natural Resources Conservation Service (NRCS). 2006. Field indicators of hydric soils for the United States, version 6.0. USDA Natural Resources Conservation Service, Fort Worth, Texas.
- Sollins, P. C., E. A. Glassman, P. C. Swanston, K. Lajtha, J. W. Heil, and E. T. Elliott. 1999. Soil carbon and nitrogen: pools and fractions. Pp. 89-105 in G. P. Robertson, ed. *Standard soil methods for long-term ecological research*, Oxford University Press, Cary, North Carolina.
- Thien, S. J. 1979. A flow diagram for teaching texture by feel analysis. *Journal of Agronomic Education* 8:54-55.
- Von Post, L. 1924. Das genetische System der organogenen Bildungen Schwedens. Memoires sur la nomenclature et la classification des sols. *International Committee of Soil Science*:287-304.

WEI SOP 11: Vegetation Composition and Cover

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP provides methods for sampling the composition and abundance of vascular and non-vascular plants (mosses, etc.) at ROMN wetland sites. Methods are also given for the collection and processing of unknown and non-vascular specimens.

Methods are identical at all site and wetland types, with the exception of a subset of sites in sentinel complexes that are treated more simply. Vegetation data can be entered on WEI Form #5: Vegetation Composition and Cover. However, in most cases vegetation data are entered into a PDA-based electronic database in the field (see WEI SOP 3: Use of Electronic Data Recorders).

Vegetation Cover

Ocular estimates of percent cover of all vascular and non-vascular plants are recorded in each 1x1 m microplot and the 4x4 m subplot (Figure). Lightweight, collapsible 1x1 m plot frames constructed from wood dowels and painted orange with 10 cm demarcations (Figure 11-2) are used. Larger plots use ropes to layout the site as plot boundaries. After all species in the microplot and subplot are recorded, any *additional* species in the 10x10 m plot that did not occur in the smaller plots are also added to the list **with cover estimates over the whole 10x10m plot**. Wetlands can have strong micro-topographical gradients that control species distribution, even at the scale of WEI plots (Figure 11-3); therefore, it is likely that new taxa will be added with each plot, especially if plots are in different microhabitats. As each plot is completed, the cover of litter/duff, unvegetated bare ground, water, and the total basal area of vegetation is recorded in each of the six plots. We define total basal area as the summed area of all plant parts as they exit the substrate. Note that all ground cover classes (litter/duff, unvegetated bare ground, water, vascular and non-vascular basal area) should sum to 100, but that the cover of all taxa may not necessarily sum to 100 (or can add to more than 100).

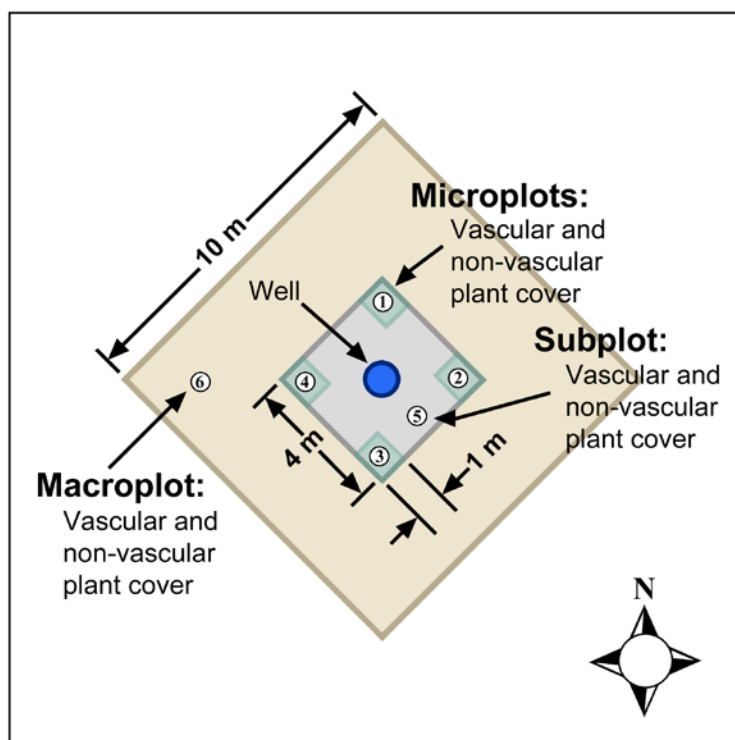


Figure 11-1. Overview of plot layout indicating key vegetation attributes measured in each plot type (e.g., macroplot, subplot, microplot).



Figure 11-2. Light weight 1x1 m microplot sample frame constructed from wood dowels painted orange and marked in 10 cm increments. The ropes used for the plot as a whole that demarcate the larger plots are also visible. Site is a disturbed wetland in Moraine Park, ROMO.

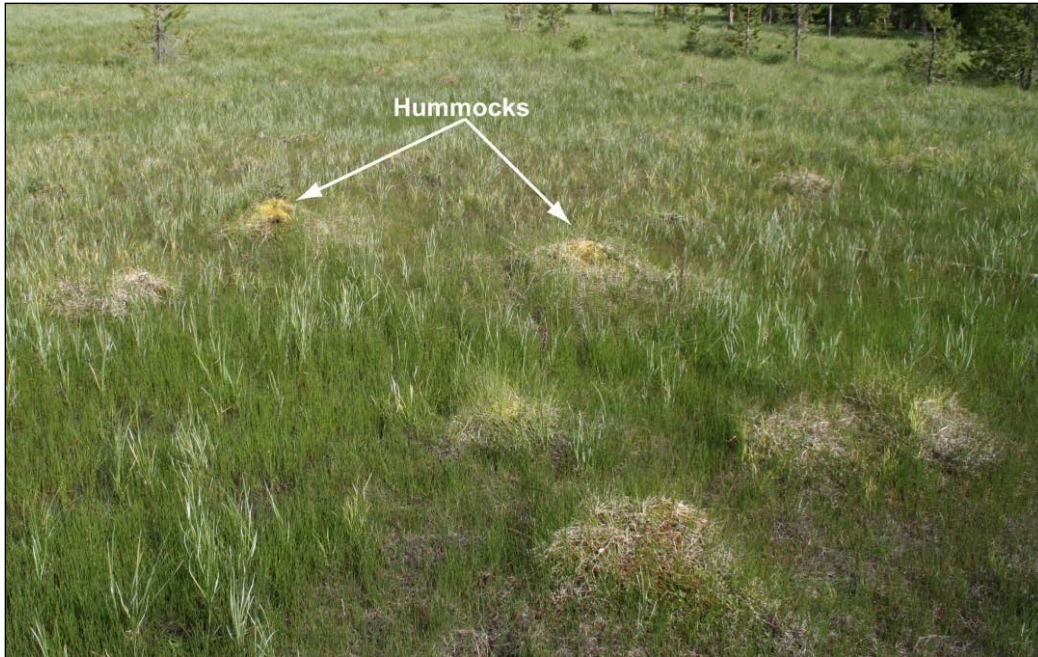


Figure 11-3. Moss-dominated hummocks in Spring Fen, ROMO. Moss species composition on the tops of hummocks often differs from that at hummock bases.

Vegetation sampling may be most efficiently accomplished in teams where one person inspects the plot and verbalizes descriptions while another person records the data. Teams are not necessary, however, and once a crew is well practiced it may be more efficient for one person to do the vegetation work. Using EcoNab on the PDA greatly enhances the efficiency of one person doing the vegetation work. The overall work flow and details of recording cover are largely controlled by [EcoNab](#); see WEI SOP 3: Use of Electronic Data Recorders.

Relevé Sentinel Sites

A subset of sites in sentinel wetlands are treated more simply than usual plots. These sites are called “relevé plots.” They are generally only monumented at the center of the plot and usually do not have a well. Data collected at these sites are limited to a whole-plot-scale vegetation and ground cover. They use a slightly different approach in EcoNab.

Continuous Cover vs. Cover Classes

Cover is defined as the vertically projected outline of all above-ground parts for any plant in the plot, ignoring any normal spaces occurring between the leaves of plants, and expressed as a proportion of plot area (Daubenmire 1959). Parts of plants that are not rooted in a plot are included in the cover estimates (but not in basal area estimates for the plot). Cover is estimated for each taxon in each plot. Using this scheme, it is possible for quadrats to have a total cover >100% for all species because multiple strata (i.e., mosses, herbaceous, shrubs) create overlapping covers, but no individual species’ cover can exceed 100%.

To deal with some of the subjectivity in cover estimates, multiple observers (within or between wetlands or years) should calibrate their percent-cover estimates with each other to maintain consistency between different plots. Moreover, visual aids such as “1% cards” (Figure) and the 10 cm demarcations on the quadrat frames should be used. Figure 11-5 shows a range of cover within plots and Figure 11-6 gives estimates of cover with a diversity of foliage shape and rooting locations.



Figure 11-4. Vegetation plot (here from the ROMN VCSS protocol, Manier et al. 2009) showing a “1% card” that can be used to calibrate ocular cover estimates. Note also the 10 cm marks on the frame edge.

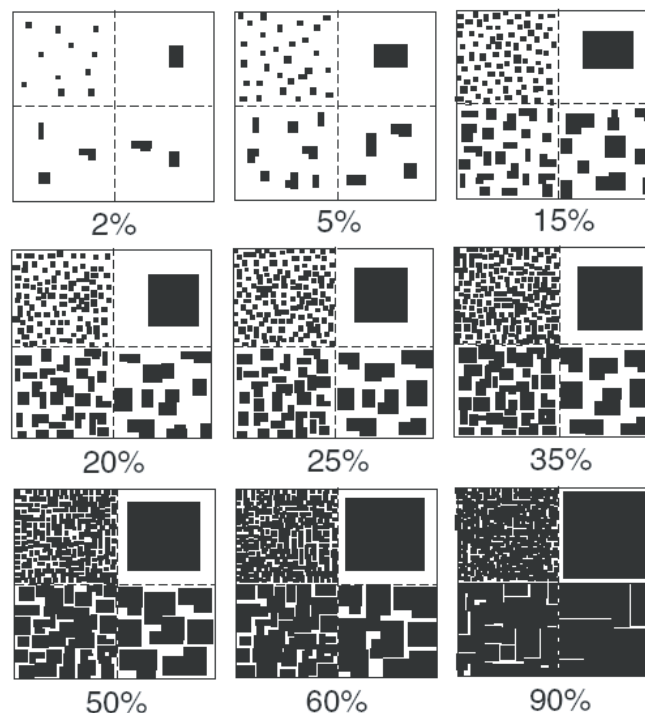


Figure 11-5. Cover estimation guide for percent of area covered (from Schoeneberger et al. 2002). Each subpanel within a percentage shows how the same cover estimate can appear given a different pattern.

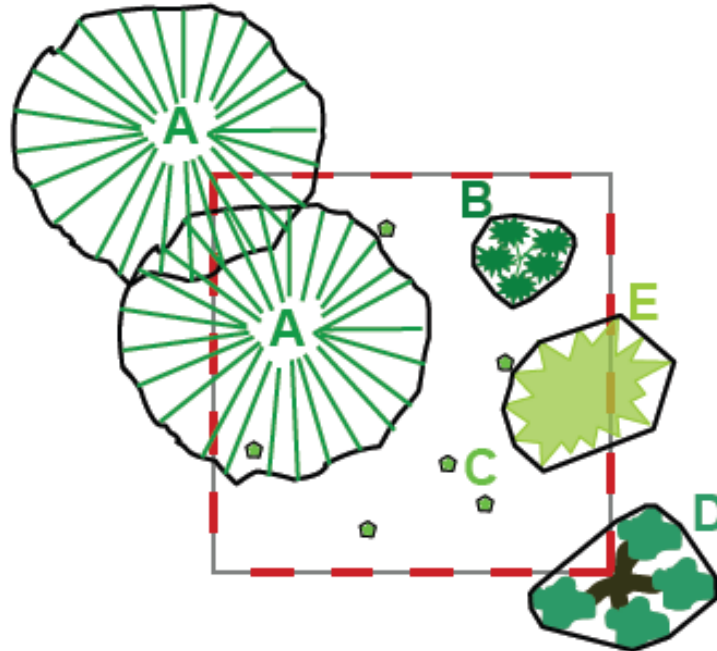


Figure 11-6. Foliage polygons, indicated in black lines, for different types of plants (all shapes are intended to be leaves, not flowers). The 1x1 m plot frame is indicated in gray, with red-gray dashes each being 10 cm in length. Cover of the species as represented here would be: A 36%, B 5%, C 2%, D 2% (but this plant does not contribute to basal area), and E 7% (adapted from Symstad et al. 2008).

Nomenclature

The ROMN uses a modified database maintained by the Colorado Natural Heritage Program (CNHP 2009) as the primary source for all plant identifications and nomenclature in Colorado parks. The CNHP database was developed from Weber and Wittman (2001a, 2001b, 2007), given the importance of these floras in Colorado. However, all records in this treatment are also cross-walked with the official NPS [NPspecies](#) lists for each park. The WEI species list is pre-loaded into EcoNab on the PDAs used by the crews and functions as a pick list for all vegetation identifications for all WEI plot work. A similar database will be developed for Montana. ***Under no circumstances are alternative names allowed. If a crew has its own nomenclature, this can be used only in an unofficial way and the final names must be derived from the official list. If a new species is found, a new name may be required, but this must be carefully noted.***

Identifying Species

Species will be identified in the field (and occasionally in the office or back at camp) using dichotomous keys. Often there will be several plant keys for specific regions available. It is important to use recommended keys and standard nomenclature, using additional references for confirmation purposes only. For example, in Colorado parks, the recommended references and standard nomenclature follows *Colorado Flora: Eastern Slope* and *Colorado Flora: Western Slope* (Weber and Wittman 2001a, 2001b). When other keys are used (such as taxa-specific sedge or grass keys), the resulting identification must be cross-referenced with the default ROMN nomenclature.

The use of an ocular hand lens (also called a jeweler's lens) with a minimum of 8x magnification is recommended for field keying specimens. Additionally, a dissecting scope for difficult taxa should be made available at the office, crew housing, or local/park herbarium. The first time a species is encountered, or if species identification is difficult or tentative, samples should be collected following collection rules and labeling described below. After samples dry in a plant press they should be taken for comparison against plants in an existing WEI herbarium, park herbarium, or that of a cooperating university. If identification is still tentative after an herbarium visit, samples can be treated as unknowns, vouchered, and sent for expert identification. Specimens that become vouchers must be handled in specific ways (see the ROMN SOP: Specimen Tracking and Vouchering for important requirements). The contacts for expert identification will vary by taxa and by park, and samples should be labeled and given to the field crew leader for further processing.

Unknown Taxa and Specimens

Specimens **are not required for all taxa**. However, specimens should be collected for unknown or uncertain identifications. A working collection of key taxa can and should be maintained. *All collection procedures for a park must be followed.*

EcoNab has a specific procedure for handling unknowns - see WEI SOP 3: Use of Electronic Data Recorders and EcoNab SOPS/documentation for more detail. In summary, upon encountering unknown or non-vascular species within a quadrat, collect one to several individuals of the plant *from outside the 10 x 10m plot if possible*. Make an effort to obtain entire individuals, including flowering and/or fruiting structures, stems, leaves, stem bases, roots, rhizomes, etc. Place these specimens in a plastic bag (day trips) or field press (backcountry trips) with a label or a piece of flagging tied around the specimen.

The coding schema for unknowns is very important. ROMN uses a two part name. The first part of the name is a mnemonic that identifies the unknown by taxa and starts with a U followed by a two letters identifying the taxa, separated from the rest of the code by an underscore. The second part is a sequential number specific to the plot for the taxa. This code is used in both the "Code" and the "Label Number or other ID" screen EcoNab. The code should be written on the flagging wrapped around the specimen and/or written on a label placed with specimen in a plastic bag (flagging is preferred as this allows use of one bag or fold for multiple specimens). EcoNab also allows a field description for each unknown and a field for habitat. Fill in as much information in these fields as possible. The list of unknown codes along with the descriptions will be available within EcoNab for all future plots. **Along with entering the unknown species into EcoNab, the crew must also fill out the unknown species datasheet.** If a specimen of an unknown is found in a new plot and the botanist is certain it is the same as a previous unknown, the same code can be applied. *However, be careful with this practice – it is often better to just make a new unknown with a novel code and ID in EcoNab for new specimens and resolve overlap in subsequent identification and database cleanup back in the lab.*

Field planning should include time for unknown identification. While EcoNab has a dedicated routine for updating identified unknowns, ALWAYS fill out the unknown species datasheet with the plot id, date, place recorded in the plot (microplot N, 4 X 4 subplot), unknown code, species identification, the identifying botanist, and species characteristics. This spreadsheet should be updated during plant identification and used as a back-up for EcoNab or when unknowns were recorded on Form #5. After identification, if unknowns were recorded on Form #5, DO NOT update the original datasheet with the species id; reconciliation between the unknown codes and identified species name will be handled during data entry or in the database.

At the end of the field season, any specimens that were not identified by the botanist during the field season will be given a unique code by data management.

Non-vascular Species

Formerly, WEI methods required sampling of all moss taxa in a plot with all sample events. This was changed in 2010 to only occur with the first full vegetation sample event at a site. As crews search plots, any moss encountered is sampled following the same procedures as with vascular taxa with the following exceptions. First, because moss identification is challenging, requiring examination under a microscope and special identification skills, any moss encountered must be collected for expert analysis after the field season. Crews should develop visual cues for all moss morphotypes at a site and collect representative samples of each. Second, vertical zonation of moss species is common in wetlands with well-developed microtopography (Andrus et al. 1983), so crews should concentrate search efforts around such features as hummocks and slopes. Third, moss specimens will typically come from the interior of each WEI plot (vs. external, like most vascular taxa) given the uncertainty in matching specimens from outside to those inside the plot. Fourth, moss are drained but not squeezed and placed into paper bags (not plastic) with the ID numbers (used in EcoNab), the plot number, cover, and the date written on the outside of the bag (typically one bag is sufficient per moss) so the moss can air dry retaining its natural 3-dimensional form.

Cover for individual moss taxa should be estimated within each plot (microplots, subplots, and whole plot). Total non-vascular cover is also estimated as part of the ground cover (we assume that all moss are basal). Total non-vascular cover should be estimated with every sample event at a site (that includes a vegetation component).

Post Field

After returning from a sample event, several key steps must be followed (see also WEI SOP 2: Pre- and Post-Sample Event Workflow). These include organizing and checking all data forms and care of any gear. If Form #5 was used, **it must be entered into EcoNab (either the PDA or the Access VegSurvey EcoNab database)**. Finally, unknown specimens should be **keyed or pressed** as soon as possible after every sample event.

Using a Plant Press

The goal of a plant press is to flatten and preserve the plant material for future study. The more quickly the plants dry in the plant press, generally the better the preservation. Plant presses consist of two stiff outer layers (usually wood lattice), which press the plants while allowing for good ventilation (to facilitate drying). Within the press, the layers alternate between corrugated cardboard, blotting felt, newspaper, plant material, newspaper, blotting felt, corrugated cardboard. This pattern of layers is repeated for each specimen. The blotting felt and cardboard both cushion and ventilate the specimen pressed between the two newspaper sheets. In order to flatten the specimens and squeeze them for drying, tighten the press using a bungee cord, cinch strap, or rope bound around the outside (Figure 11-7). In the Rocky Mountains we are fortunate to have extremely dry conditions and plants typically dry within the press quickly without discoloration or mold. In humid environments, it is often necessary to use precise arrangements of cardboard spacers, extra blotting felt, and even electrically powered drying boxes to prevent rotting.

Crews press as much of the specimen as possible, including roots, stems, leaves, and fruit/flower structures. If the plant is tall, zigzag the stem across the newspaper. Specimen arrangement is important. When arranging the plant for pressing, be sure that all important identifying features will be visible on the flattened specimen. Spread out leaves and stems so that they are not clumped on top of one another. You may also have to turn over leaves so that both the top and underside are visible. It is sometimes best to float aquatic specimens directly onto mounting paper so as to ensure good dispersion of filmy leaves. If loose seeds are involved, collect them in a little newspaper pouch to press with the specimen. Remember to label each specimen with the EcoNab unknown number (or unique unknown name if using Form #5), collection location, date, and any notes that you would like to remember from the field.

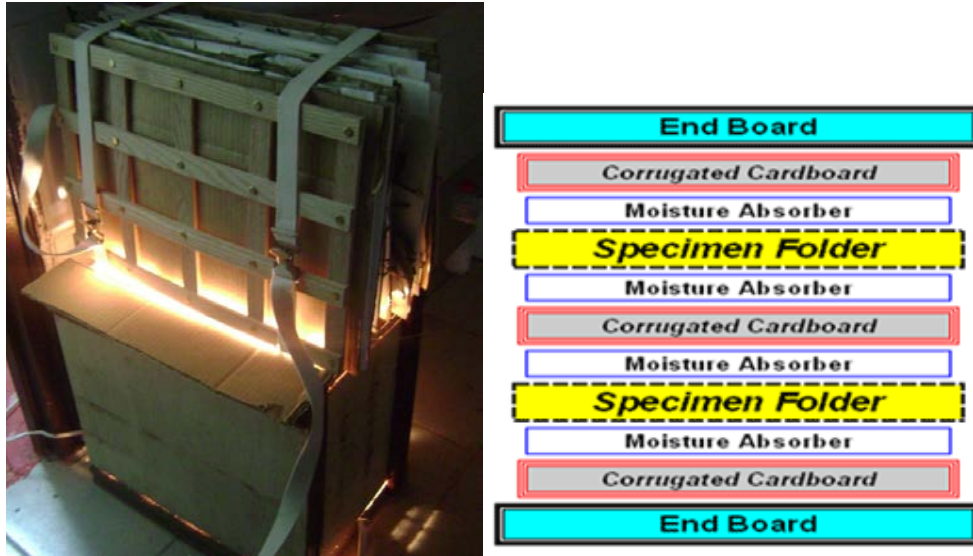


Figure 11-7. Examples of correctly arranged plant presses. Tightly cinched press on light bulb drying box (left) and diagram of proper alternating of press materials (right, courtesy of Wisconsin Department of Natural Resources).

A field plant press is a smaller, lighter version of a wooden plant press. These can be purchased from a supplier and typically look like small art portfolio folders with nylon covers and Velcro wrapped around a light, stiff press. Since field presses are *ad hoc* equipment and made for temporary use only, homemade presses can be effective as well. Several pieces of thick corrugated cardboard can be used in place of the wooden lattices and filled with blotting and newspaper in the same manner. These presses are typically about half the size of a regular press and cinched with one or several smaller straps. Cardboard supports should be replaced often, as they become bent and softened from use.

Moss Specimens

Moss samples collected in the field must be packaged and sent to bryological experts for identification. Moss specimens are not pressed; rather, remove excess substrate and litter from samples and allow them to dry naturally in a “free form” shape. Do not crush or squeeze specimens to remove excess water as this compacts them; just allow to drain naturally. Then place the specimen in a paper herbarium envelope with proper label for delivery to an expert. Make sure all the information needed by the bryologist is present on the sample label and include the usual unknown label as well. An example of a standard label for Colorado mosses is below (Figure). Often the bryologist will receive a digital copy of sample labels in addition to paper copies included in the moss envelopes. Species names and authorities are left blank so the correct name can be added after identification. Identification usually involves re-hydrating a subsample of the dried moss and examining it under dissecting and compound-light microscopes.

COLORADO, USA	
det. W. A. Weber	
Eagle Co.: Along Interstate 70 corridor near mile marker 190. UTM Zone 13n NAD83, 395055 E, 4375929 N, 3200 msm. In small fen dominated by <i>Salix planifolia</i>, <i>Salix wolfii</i>, <i>Betula glandulosa</i>, <i>Carex aquatilis</i> and <i>Carex utriculata</i> with low areas of <i>Eleocharis quinqueflora</i> and <i>Carex gynocrates</i>.	
10 September 2009	K.M. Driver 003
Herbarium COLO (Boulder)	

COLORADO, U.S.A.	
Brachythecium erythrorrhizon Bruch & Schimper det. W. A. Weber	
Grand Co.: Western slope of Rocky Mountain National Park. UTM Zone 13n NAD83, 430169 E, 4450629 N, 2600 msm. In narrow riparian zone dominated by <i>Alnus incana</i>, <i>Calamagrostis canadensis</i>, <i>Equisetum arvense</i> and <i>Poa pratensis</i>.	
6 August 2008	K.M. Driver, D.J. Cooper 170
Herbarium COLO (Boulder)	

Figure 11-8. Examples of moss labels before (top) and after (bottom) expert identification.

Field Equipment for Vegetation Composition

Table 11-1 provides a checklist of items needed for vegetation methods. Only items needed for these procedures are included; see other SOPs for other gear.

Table 11-1. Field gear for vegetation.

Quantity	Item
1	WEI Protocol document and/or laminated sheets of SOPs
1+	WEI Form #5
Many	Pencils
1-2	Fully charged PDA with EcoNab loaded
1-many	Work gloves
1	Clip board
1	1 m ² plot frame and subplot and macroplot ropes
1+	Wetland plant identification guide(s)
Many	Voucher labels
1	Plant press (optional)
Many	Paper bags for non-vascular specimens
Many	Plastic bags for vascular specimens
Many	Materials for labeling specimens (ribbons, sharpies, etc.)
1	Hand lens (jewelers lens) with ≥8x magnification
1	Dissecting scope (for office, not field)

Vegetation Cover Procedure (PDA EcoNab or WEI FORM #5)

1. **Vegetation data are usually recorded in EcoNab. If Form #5 is used, use as many sheets as needed per site. Use new sheet(s) for new plots in a multitype or sentinel complex.**
2. The exact timing of the quadrat work will vary with the specific dynamics within a given plot. Ideally, the botanist or crew lead will conduct the procedures detailed below as other crew members install the well, measure the water table, etc.
3. If using Form #5, fill out the header (use of Form #5 is rare).
4. Enable EcoNab (see [EcoNab](#) and WEI SOP 3: Use of Electronic Data Recorders).
 - a. Record the event/plot metadata in EcoNab, including the identifying well number, wetland type, site type, sample type, etc.
5. **If the plot is a “relevé” plot, no nested subplots are done.** All data is collected at the whole plot scale only.
6. Place the 1 m² plot frame down in the microplot due N of the well (microplot #1). The frame should lie so that the survey flag is at the outer-most corner of the plot (2.83 m from the center), and the meter tape from the center should run through the center of the plot leaving the opposite corner 1.83 m from the center. Vegetation plots are always done in the same order: microplots N, E, S, and W, followed by the subplot.
7. Sample frames are constructed from wood dowels and joined using surgical tubing or from PVC sections. They may be painted orange and are always marked in 10 cm increments.
8. Record the litter/duff, bare ground, water, total basal vascular and total basal non-vascular cover for the plot. *We assume that all moss are basal.*
 - a. Ground cover estimates are made of the surface of the ground under all live canopy cover (except cushion-like plants and mosses that are flush to the ground) and total ground cover (all of these elements combined) **will always equal 100%**.
 - b. Litter/duff estimates include dead leaves and other plant materials, including wood and surface accumulations of dry, partially decomposed, or pulverized plant material (duff). If material will burn (when dry) and is not peat or currently alive, it is probably litter or duff. Litter/duff estimates should be made by “looking under” the live plant canopy at the surface of the ground.

- c. Bare ground estimates include soil, peat, and any size gravel, cobble, or rock. Bare ground estimates should be made by “looking under” the live plant canopy at the surface of the ground.
 - d. Water estimates include any surface water, whether it is pooled or moving (i.e., stream). Even if bare soil, rock, or plant basal area is visible directly under the surface of the water, what is at the surface is counted. Water estimates should be made by “looking under” the live plant canopy at the surface of the ground.
 - e. Total basal area (vascular and non-vascular done separately) is estimated as the total cover of the “growth point” or the part of the plant connected to the ground, such as the basal meristems in grasses, base of tree trunks, etc. Alpine cushion plants and mosses often have relatively large basal areas, while grasses and sedges have small basal areas. A useful visualization technique is to imagine cutting all plants down, flush with the ground (i.e., with a lawnmower), and estimating the cover of the remaining stubble.
9. Identify each species in the plot (see below for more details on unknowns and moss). Record the percent cover of each known (and unknown) vascular and non-vascular plant taxa found in the plot. Use the pick list in EcoNab to select the appropriate nomenclature. **If using Form #5 any “name” for a taxa may be used, but this must be changed later to the default ROMN nomenclature when entering into EcoNab.** Enter the estimated cover for the taxa along a continuous scale from 0.5 (a trace) to 100%.
- a. **Each taxon must have $\leq 100\%$ cover. The plot as a whole may have $>100\%$ cover.**
 - b. No separate cover estimates are done by height strata (in EcoNab the height strata is always “1”).
 - c. “1% cards” and frame marks should be used to assist in estimating cover. Hold the tool over the plants in the plot to judge whether the cumulative cover of the species is half, one, or several (count) of these units. For small, well-spaced species, create an index by approximating the number of individuals per 100 cm² (1%) area; once you establish an index, always use the same index value for that species (i.e., at other plots and other sites). Divide the plot into half or quarters to allow for sub-estimates when the vegetation is dense, diverse, or otherwise makes the estimation complicated. We are estimating canopy cover; this means that you need to estimate the cover of an individual, or bunch, or indexed set of individuals, based on the approximate, irregular, but nearly regular, circumference of the leafy canopy cover. Do not include dead branches (e.g., of shrubs), but do include “dead centers” of bunchgrasses (e.g., *Muhlenbergia* spp.). Do not try to estimate “interlacing” of leaves with open space, but estimate the cover of the unit based

on the perimeter. In most cases, the total cover within the plot will make up greater than 100% because it incorporates vertical structure and overlapping strata.

10. Upon encountering **unknown or non-vascular** species within a quadrat, sample several individuals of the plant (or morphotype for moss) *from outside the 10x10m plot, if possible* (however, many moss will have to be collected from within the plot), and store in a plastic (or paper for moss) bag. Make an effort to obtain entire individuals, including flowering and/or fruiting structures, stems, leaves, and stem bases.

- a. An unknown is selected from the EcoNab plot name pick list and then given a name as follows:

- i. The first part of the name is a mnemonic that identifies the unknown by taxa and is separated from the rest of the code by an underscore:

Umo_ - is unknown moss

Ulv_ - is unknown liverwort

Ugr_ - is unknown grass

Use_ - is unknown sedge

Uru_ - is unknown rush

Ugm_ - is unknown graminoid

Ufo_ - is unknown forb

Ush_ - is unknown shrub

Utr_ - is unknown tree

- ii. The second part is a sequential number for the taxa

1. So an unknown code might be “Ugr_01” or “Ufo_02”

- b. Create a simple description in EcoNab. Record the unknown species on the unknown species datasheet.

- c. Specimens are always taken for non-vascular taxa (every 5 years that these are collected).
 - d. Label newspaper or paper bags of the unknown species with the well/site number, date, plot or subplot found in, and the SAME code used on the PDA in EcoNab.
 - e. For unknowns on Form #5, use the same code as would be used in EcoNab. To facilitate this, a running tally of the last unknown number for each taxa should be kept by each crew.
 - f. Label moss sample bags with the unknown code/number for any specimens as used in EcoNab (see below) plus the site number and date. Multiple specimens from the sample plot cannot go into a single bag because species (or morphotype) cover values will be linked to the unknown code written on bag and specimens will not be labeled separately with ribbon.
 - g. Vascular plants from a plot can be added to a single plastic bag if the specimens are tied up with a ribbon with the unknown number, plot ID, etc.
 - h. Optionally, use a digital camera to take a close-up picture (or, series of photos if needed to show attributes, e.g., leaf and flower). Be sure to record the photo number(s) in the photo log and note in EcoNab or on Form #5 that photos were taken.
 - i. Attempt to identify samples the same day/week that they are collected; fresh samples are easier to identify. Some plants can be kept reasonably fresh for short periods of time (<1 week) in a refrigerator.
 - j. While EcoNab has dedicated 'unknown identification' routines that should be followed (see the ROMN data manager or ecologists for the EcoNab SOPs) an additional datasheet should be completed for each event and updated during unknown identification with the plot id, date collected, place recorded in the plot (microplot N, 4 X 4 subplot), unknown code, species identification, the identifying botanist, and species characteristics.
 - k. Reconciliation between the unknown codes and identified species name will be handled in EcoNab or for data entered in Form #5 during data entry or in the database.
 - l. At the end of the field season, any specimens that were not identified by the botanist during the field season will be given a unique code by data management.
11. Repeat steps 6-10 in each microplot, working clockwise through plots #2 (East), #3 (South), and #4 (West).

12. Repeat steps 6-10 in the 4x4 m subplot. **The scale of reference for cover estimates for these values is the entire 16 m² plot area (a taxon with a cover of 100% in one of the nested microplots that occurs nowhere else will have a cover of 1/16 or ~6% in the subplot).** Note that EcoNab will pre-populate a list of taxa from the 4 nested 1x1 plots, but these must be manually selected from the drop-down list with a new estimate of cover at the proper scale added.
13. Search the macroplot (10x10 m) for any species that were not found in the smaller plots. EcoNab will add the list of species from the nested plots as present in the macroplot, so that only new taxa need to be added. **The scale of reference for cover estimates for these values is the entire 100 m² plot area (a taxa with a cover of 100% in one of the nested microplots that occurs nowhere else will have a cover of 1/100 or 1% in the macroplot).**
14. Collect ground cover data for the whole plot (step 8 above).
15. At the end of each work day, select “CardBkup” from the PDA home page, and back up data to card using date (yyyymmdd) as the backup name.

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WEI SOP 12: Woody Structure and Herbivory

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP provides methods for enumeration of woody species by size class for use in coarse estimates of woody species stand structure. This SOP also presents methods for estimating damage on woody species caused by herbivory and other sources of stress on woody plants. These methods were streamlined in 2010. These changes were minor, and we therefore do not retain the former approach. These methods are very rapid in their implementation and are not intended to generate rigorous site-specific estimates of utilization of woody species by ungulate herbivores (Bilyeu et al. 2007).

Methods are identical at all site and wetland types that have woody vegetation. Woody herbivory count and stem-count data are entered on WEI Form #6: Herbivory and Woody Structure.

Stand Counts and Structure, Pre-2010 Plot Methods

Through the fall of 2009, crews enumerated **all** woody stems by taxa depending on general age/size within nested plots for all woody species (or morphospecies) at a site. All individuals less than 0.15 m tall were counted in each of the four microplots. All individuals between 0.15 and 0.50 m tall were counted in the subplot (including the nested microplots). All individuals greater than 0.50 m tall were counted in the macroplot (including the nested subplots and microplots). Dense canopies of shrubs made accurate counting difficult, if not impossible, so grouped estimates were allowed. ***These methods were continued in 2010 and 2011 in concert with the new methods below in plots where they were done in 2007-2009.***

Stand Counts and Structure, Post-2010 Point-Intercept Methods

In 2010, we streamlined these methods to include **only a subset of the woody taxa in a plot: *Salix* spp., *Alnus* spp., and *Populus* spp.** Stand-count data are collected along transects using the point-intercept method. This method is used because if executed properly, it may be more precise and efficient (Bonham 1989) than our previous methods for enumeration of all taxa by size class and plot type.

Crews count target woody species and place in height classes along two line-intercept transects, **one on the northeast side of the whole plot and one on the southwest side of the whole plot** (Figure 12-1). “Individuals” are evaluated from south to north. For each “individual” with any living or dead part crossing the tape (above ground), the species is recorded along with the starting and ending tape distance (in meters) and the height class (and for stems greater than 0.5 m, damage metrics, see below).

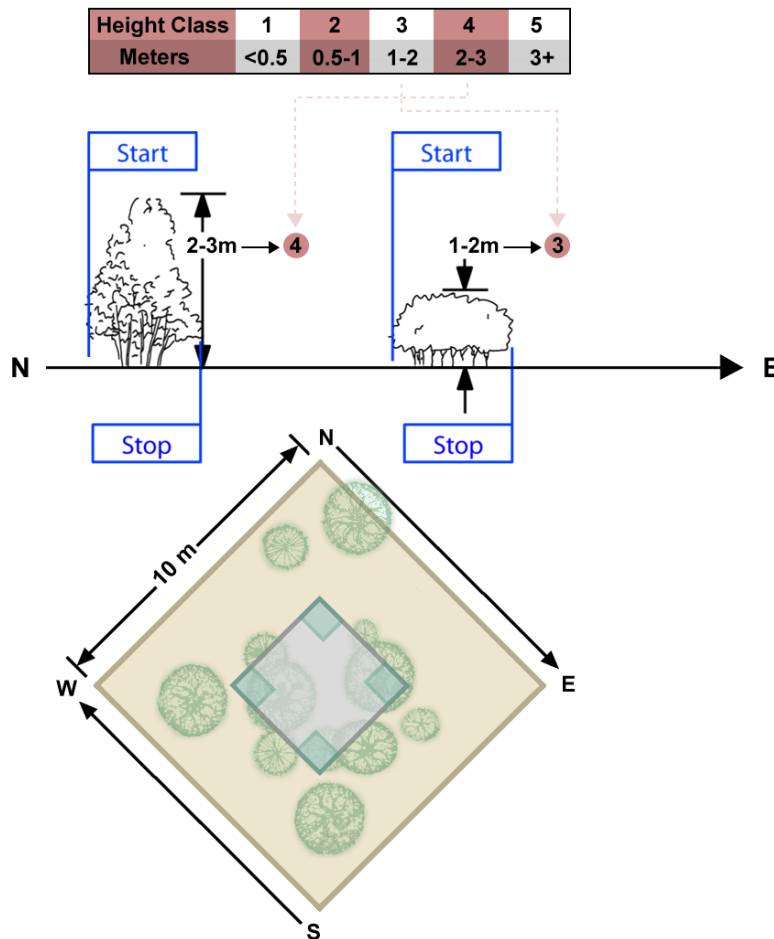


Figure 12-1. Schematic illustrating the line-intercept approach used to assess woody species. The horizontal distance and height class of all woody taxa intersecting the NE and SW sides of a plot are recorded.

Herbivory and Other Physical Stem Damage

In 2010, we streamlined these methods to include **only a subset of the woody taxa in a plot**. Former methods were not retained. Previous methods required these indices for all taxa and all stems in plots that have less than 40 woody “individuals” (see above). In dense stands, with more than 40 individuals in the macroplot, the assessment was done for only stems in the 4x4 subplot.

Herbivory and other damage to woody stems potentially directly or indirectly due to vertebrate herbivores or other forms of physical damage is evaluated by estimating three general aspects of a woody plant: percent dead, percent crown dieback, percent live browsed. While all three indices are highly correlated and may reflect different irresolvable causes of injury, collecting a broad array of such measures may help describe general wetland condition better. Of the three, only the percent live browsed measure is likely to be due only to vertebrate herbivores, although the other measures may also be affected by herbivory (but usually from the compound effects of multiple seasons of herbivory).

Selection of Stems to Include

Only stems from taxa that are typically browsed by ungulates including *Salix* spp., *Alnus* spp., and *Populus* spp. (eliminating taxa like *Rosa* spp., *Ribes* spp., and most conifers) are assessed. We also limit the assessment to only stems intersecting the two line intercepts. We allow a “group approach” to small-stature stems. If a large number of stems less than 0.5 m are encountered, crews estimate the number of stems, and apply the metrics below to these groups.

1. Percent Dead

For each woody species individual, estimate the percent of stems that are clearly dead (stems are defined as trunks or large branches originating from below ground). Do not quibble over marginal cases of death (“hmmm... I’m not sure if this whole stem is dead or not...” = not dead). Indications of a dead stem include dry and desiccated tissue, no living cambium under the bark, completely defoliated, broken apart, and full of fungus or other signs of rot, etc. (Figure). The cause of stem death is not relevant (even if it appears that it was due to herbivory). The proportion is taken over all unique (originating underground) stems; if there are approximately 200 stems (do not count stems if more than a few dozen!) in a willow and only a few are dead, the percent dead is very small!



Figure 12-2. A willow in ROMO with a high percentage (~70%) of dead stems. Although it is difficult to see in this image, the bulk of the defoliated, dry, gray stems are dead.

2. Percent Crown Dieback

Methods for estimating percent crown dieback follow from USFS (2007). Estimate the percentage of the live crown area, including the dieback area that has recent mortality of branches with fine twigs, which begins at the terminal portion of a branch and proceeds toward the trunk (Figure 12-3).

Dieback should occur from the top of the crown down, and from the outside in toward the main stem. Dieback is only considered when it occurs in the upper and outer portions of a tree. When whole branches are dead in the upper crown, without obvious signs of damage, such as breaks or animal injury, assume that the branches died from the terminal portion of the branch. If the main bole has an old dead portion in the upper crown, it is ignored. Dead branches in the lower portion of the live crown are assumed to have died from competition and shading and are not included. Dead branches in the lower live crown are not considered as part of crown dieback, unless there is continuous dieback from the upper and outer crown down to those branches. The crown base is defined as an imaginary horizontal line drawn across the trunk from the bottom of the lowest live foliage of the “obvious live crown” for trees, and from the lowest live foliage of the lowest twig for saplings. The “obvious live crown” is described as the point on the tree where most live branches/twigs above that point are continuous and typical for a tree species (and/or tree size) on a particular site. The base of the live branch/twig bearing the lowest foliage may be above or below this line. Assume the perimeter of the crown is a two-dimensional outline from branch-tip to branch-tip, excluding snag branches and large holes or gaps in the crown.

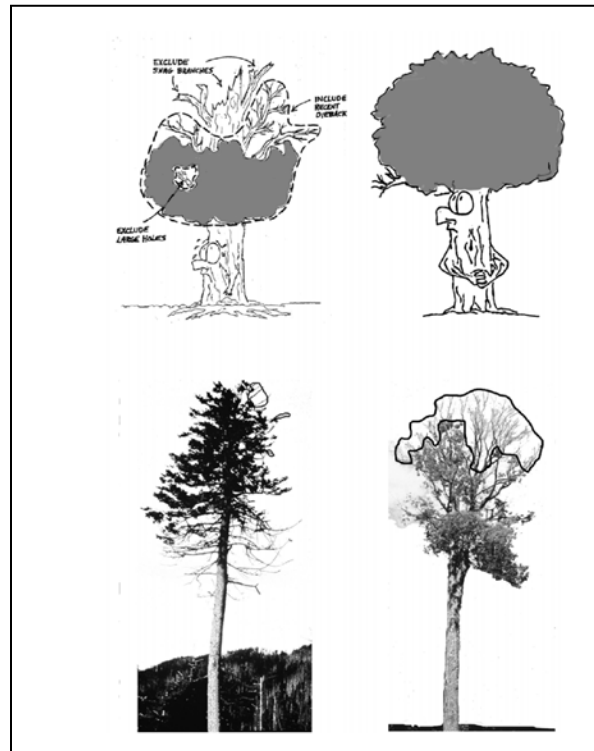


Figure 12-3. Example of crown dieback. The tree in the top left panel has ~40% dieback because the large, old snag portion of the crown is not included. The tree in the top right panel has 0% dieback. The large conifer in the lower left has ~3% dieback as the dead branches at the base of the crown are not included. The tree in the lower right has ~35% dieback (USFS 2007).

3. Percent Live Browsed

For each woody species individual, estimate the percent of apparently live stems originating from anywhere on the plant that has evidence of ungulate browse. Browse evidence includes stems stripped of all or most bark material, with a shredded appearance (Figure 12-4). Other indications are cleanly clipped stem tips, often with the clip at an angle. Evidence of browse is treated as a yes or no response; any evidence on a stem counts as a “yes” (the degree is not assessed). The proportion is taken over all living stems; for example, if there are approximately 100 stems (but do not count stems if more than a few dozen!) in a willow and 50 have at least some browse evidence, the percent live browsed is 50%.



Figure 12-4. Typical browse damage (probably from elk) on *Salix* sp.

Field Equipment for Woody Structure and Herbivory

Table 12-1 provides a checklist of items needed for woody counts and herbivory/damage methods. Only items needed for these procedures are included; see other SOPs for other gear.

Table 12-1. Field gear for woody counts and herbivory/damage methods.

Quantity	Item
1	WEI Protocol document and/or laminated sheets of SOPs
1+	WEI Form #6
Many	Pencils
1-2	Fully charged PDA with EcoNab loaded (optional)
1-many	Work gloves
1	Clip board
1	1 m ² plot frame
1+	Wetland plant identification guide(s)
1	Field plant press (optional)
Many	Plastic bags for vascular specimens
Many	Ribbon for labeling specimens

Woody Structure and Herbivory Procedure (WEI FORM #6)

1. Form 6 is always done on paper with from one to many copies per plot. Use additional copies for other plots in a complex.
2. Crew member navigates to the southern end of the NE plot edge.
3. A tape should already be extended along the plot edge. If not, place a tape with the 0 end on the south plot corner.
4. The crew member begins walking northwest along tape. At each instance where *Salix*, *Alnus*, or *Populus* species cross the tape, the crew member records the species, the starting distance and ending distance (in meters), and the height class from Table 12-2. If this same plant crosses the tape in multiple locations, a single height class is recorded. Use the first and final locations for a plant for the start/stop distances. **Height is for the whole of the individual, not the limited portion of the plant crossing the tape.** Start/stop distances will overlap if plants along the tape do.

Table 12-2. Height classes defined.

Class	Height
1	<0.5 m
2	0.5-1 m
3	1-2 m
4	2-3 m
5	>3 m

5. Estimate the percent dead, percent crown dieback, and percent live browsed for each target individual encountered on the line.
6. If there is an overwhelming number of individuals greater than 0.5 m tall along a transect and there is a consistent level of percent dead/crown dieback/live browsed among stems, it is permissible to assign damage classes to a bulk number of individuals. For example, record “20 height class 1 *Salix planifolia* with 10% browse, 15% dieback, and 5% dead.”
7. Repeat for the SW edge of the plot.

Literature Cited

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WEI SOP 13: Meso-scale Landscape Context, Site-scale Disturbance, and Site-scale Characterization

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents field methods for characterizing human and natural disturbances and the physical structure across multiple scales (the immediate area up to meso-scale landscape) around each site. They are intended to be rapid in their field implementation. They are mostly categorical, with some degree of subjectivity. Rigorous adherence to the methods presented here will remove as much of the bias in these methods as possible, but they are not used in analyses that require a great deal of precision (Schweiger et al. 2010).

The methods given here are identical at survey, gradient, or sentinel sites, but vary (a little) by wetland type. All data are entered on WEI Form #8: Landscape.

These methods include the following major elements:

1. Classification of wetland type (using systems other than the default ROMN approach suggested by David Cooper);
2. General hydrologic and physical attributes, including wetland potential size and physical complexity;
3. Natural disturbances (8 categories);
4. Human disturbances (12 to 14 categories, depending on wetland type); and

5. Patch-type richness.

The classification of wetland type and general hydrologic and physical attributes are completed once when the site is established. The other elements of the methods are done once per year, as QAQC during a revisit, or within a single sample event. The workflow for collecting these measures will vary with sample event, but they are usually done by the non-botanist while vegetation plot work is underway. Crews should discuss each measure and reach consensus, but there should be a consistent crew member conducting the assessment who becomes the “expert.” They should be done near the end of a sample event so as much experience with the complex is gained as possible. Note that in all sentinel sites, and some survey or gradient complexes, there will be multiple plots on a single instance of Form #8; be sure to carefully note what plot is referenced for measures below the complex or buffer scale.

Assessment Scale(s)

Using a well-defined and consistent assessment scale or area over which these measures are conducted is an important, but often challenging, part of collecting quality WEI data. The appropriate scale for each varies and can be the 10x10 m plot, the immediate area around a plot, the wetland complex a plot is within (which can be from the minimum area defined by the sample design of 0.5 ha to several hectares), a 100 m buffer around the complex, or a 1 km buffer around the complex. Each measure has its assessment area defined in the procedures below and on Form #8. The complex boundary is often the most difficult extent to define in the field. Crews will always have site dossiers that contain aerial images with polygon boundaries (plus a hydrologically defined buffer, see the WEI protocol narrative, Schweiger et al. 2015) developed for each complex. These delineations are often useful to understand the extent of a complex, but may not match the situation in the field during any given sample event. Therefore, complex boundaries should be defined using vegetation that is dominated, at least periodically, by hydrophytes; substrate predominantly consisting of undrained hydric soils; and substrate that is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year. More detail on these procedures is presented in WEI SOP 4: Verification of Site Status and the WEI protocol narrative (Schweiger et al. 2015).

When a measure calls for a scale that exceeds the visible area around a plot (such as a large complex or a 100 m or 1 km buffer that exceeds the area a crew can explore), crews must do their best to accurately describe the required scale. If this is not possible, data should be flagged. Moreover, many of these large-scale measures are replicated using remotely sensed data within a GIS as described in WEI SOP 14: Large-scale Landscape Context, Disturbance, and Characterization.

Differences among Site and Wetland Types

There are no functional differences among WEI site types, with survey, gradient, and sentinel sites treated identically. All data are recorded on the same Form #8 regardless of site type.

Sentinel sites will have a slightly more complex implementation, with data usually applying to more than one plot (some survey and gradient complexes will also have more than one plot per complex).

In many cases, gradient sites are chosen to reveal the very kinds of disturbances the methods describe, so the proper application of the measures is key. There are small differences in measures among wetland type, with riparian systems having additional human disturbance categories.

Auxiliary Classifications

The primary, default classification system used in ROMN WEI work was presented in WEI SOP 4: Verification of Site Status, given its key role in determining the sampleability and status of a site. However, to enable WEI data to be used with other wetland monitoring efforts that do not use this system, to better describe WEI sites, and to provide analytical alternative, we also place each site into three other commonly used systems: Cowardin (Cowardin et al. 1979), Hydrogeomorphic (Brinson 1993), and Ecological Systems (CNHP 2009). The details of each of these approaches are beyond our scope here. We include simplified and slightly modified field keys used by crews for each type with a season field form set. Methods for implementing each of these classifications are given in procedures below.

Physical Context

The procedure below provides methods on how to collect data on the physical nature of the sample site and the wetland complex it is embedded within. Measures include the dominant aspect and slope of the sampled plot, the topographic or geomorphic position of the complex, dominant water sources, and general hydrologic regimes.

We also include a few measures that help characterize the diversity of macro habitats and the physical template of the wetland complex. Physical patch richness (Collins et al. 2008) is the number of different types of physical surfaces or features that may provide habitat for wetland or aquatic species. This metric is different from topographic complexity in that it addresses the number of different patch types, whereas topographic complexity evaluates the spatial arrangement and interspersions of the types. Horizontal biotic structure (Collins et al. 2008) refers to the variety and interspersions of plant “zones.” Plant zones are plant monocultures or obvious multi-species associations that are arrayed along gradients of elevation, moisture, or other environmental factors that seem to affect the plant community organization in plan view. Interspersions is essentially a measure of the number of distinct plant zones and the amount of edge between them. Potential size is the current size of the wetland complex in relation to its abiotic potential if there were no anthropogenic limits to its size (e.g., a road or a dam). Patch richness is the presence of distinct patch types using *a priori* lists (on WEI Form #8). Crews should use common sense as to whether a given example of a patch type is large enough to count. If it appears to add to the complexity of the wetland complex, include it. The lists of types on the Form are not exhaustive or restrictive; include other notable and repeatable types in the comments.

Human Disturbance

The procedure below provides methods on how to collect data on a suite of human or anthropogenic disturbances that may be impacting the sample site and the wetland complex it is embedded within. Measures fall into three general categories (alterations within buffers and landscape context,

hydrological alterations, physical/chemical disturbances) and several sub-categories within these. Within most sub-categories there are three to four scores that incorporate the severity and spatiotemporal proximity of the disturbance. In other categories a checklist is given. The distinction between a natural (see above) or human-caused disturbance is often difficult to decipher. When it is ***not*** clear if a disturbance is natural or anthropogenic, crews should be conservative and ***not*** include it as anthropogenic. Field crews should not fret over the ultimate cause of an observed disturbance. Use the cues that are observable at the site, in the complex or its 1 km buffer. Information about the larger surrounding landscape may also be brought to bear (beyond 1 km around the site). If crews know there is some human disturbance beyond this distance and that it is clearly having an impact on the complex it may be included, but should be clearly described with a note. *Note that the rank order of the no evidence class to the high evidence class is opposite that in the natural disturbances described above (this is intentional). Common sense is important. Be sure to include lots of notes to clarify any complex or confusing situations.*

Natural Disturbance

The procedure below provides methods on how to collect data on a suite of “natural” disturbances that may impact the sample site and the wetland complex it is embedded within. Measures are broken into seven common types of natural disturbances in ROMN parks plus a catch-all “other” category. Within each class there are four degrees of disturbance that include the severity and spatiotemporal proximity of the disturbance. Be as consistent with the application of these methods as possible. If any case arises that is meaningfully different than one of these four degrees of disturbance, be sure to carefully describe it in the notes. *Note that the rank order of the no evidence class to the high evidence class is opposite that in the human disturbances described below (this is intentional).*

The distinction between a “natural” and “human-caused” disturbance (see below) is often difficult to decipher. When it is ***not*** clear if a disturbance is natural or anthropogenic, crews should be conservative and ***not*** include it as anthropogenic. Field crews should not fret over the ultimate cause of an observed disturbance. Use the cues that are observable at the site, in the complex, or in its 100 m or 1 km buffer. Information about the larger surrounding landscape may also be brought to bear (beyond 1 km around the site). If crews know there is some natural disturbance beyond this distance and that it is clearly having an impact on the complex, it may be included, but should be clearly described with a note. *Common sense is important. Be sure to include lots of notes to clarify any complex or confusing situations.*

All data are recorded on WEI Form #8. Crews should be as consistent across measures and sample events as possible. If any case arises that is meaningfully different than that allowed and the “other” score is selected, be sure to carefully describe it in the notes.

Office and Field Equipment

Table provides a checklist of items needed. Only items needed for these procedures are included; see other SOPs for other gear for a typical WEI sample event.

Table 13-1. Equipment list.

Quantity	Item
Office Equipment	
	WEI Protocol document
	GIS with relevant data layers
Field Equipment	
1	WEI Protocol document and/or laminated sheets of SOPs
1+	WEI Form #8 Landscape
1	Site maps (“dossier”)
Many	Pencils
1	Previous versions of “dossier” from earlier site visits, if they exist
1	Other maps
1	Compass

Physical Attributes and Characterization Procedures (WEI FORM #8)

1. This form is always done on paper and at least one per complex is used.
2. It is possible that these measures will be done when little or no other activities are done at a site. Therefore, much of the header on Form #8 is duplicative with other forms. Form #3 is the most important form to have complete header information on; however, if a sample event is abbreviated (just landscape measures), Form #3 may not be used and the header on Form #8 must be more complete.

HGM Type

3. Use a key to determine the Hydrogeomorphic (HGM) type of the site. It may be necessary to extend the assessment scale to beyond the plot's boundaries to include all aspects of the key, but the target area is the plot itself (therefore there may be more than one type within a complex).

Record the code for each plot.

Ecological System Type

4. Use a key to determine the Ecological System type of the site. It may be necessary to extend the assessment scale to beyond the plot's boundaries to include all aspects of the key, but the target area is the plot itself (therefore there may be more than one type within a complex). **Record the code for each plot.**

Cowardin Type

5. Use a key to determine the Cowardin type of the site. It may be necessary to extend the assessment scale to beyond the plot's boundaries to include all aspects of the key, but the target area is the plot itself (therefore there may be more than one type within a complex). **Record the code for each plot.**

Physiognomy (plot to complex scale)

6. Circle the dominant (>50%) physiognomy of the complex. If there are co-dominants circle them all and describe with a comment. This is especially important if the plot is different than the complex as a whole. **Record the code for each plot.**

Aspect and Slope (plot scale)

7. Visually determine the dominant aspect of the 10x10 m plot and make sure your compass is using magnetic north (**no declination**). Orient yourself parallel with this and record the aspect in degrees. Be sure the (usually red) north arrow is centered in the north bounding box on your compass. If the aspect of the plot is much different from the complex as a whole, be sure to note this in the comments.
8. Visually determine the dominant slope of the 10x10 m plot. Orient a compass or clinometer parallel with this and record the slope in degrees. If the slope of the plot is much different from the complex as a whole, be sure to note this in the comments.

Topography (plot to complex scale)

9. Record the topographic position of the sample plot. Usually only one type will apply. If there is more than one it is acceptable to check off all that apply. This is especially important if the plot is different than the complex as a whole. **Record the code for each plot.**

Water Source and Hydrologic Regime (plot to complex scale)

10. Using the best available cues, record all sources of water at the time of the sample event. If there is more than one, it is acceptable to check off all that apply. This is especially important if the plot is different than the complex as a whole. **Record the code for each plot.**

- a. Be sure to note if the water source has anthropogenic influences, such as runoff from a parking lot.

11. Using the best available cues, record the hydrologic regime at the time of the sample event. “Flooded” means standing water is present in more than 50% of the complex. “Saturated” means that the water table appears to be at the substrate surface in more than 50% of the complex. “Ephemerally flooded” is the most difficult class to make a call on with a single sample event. If previous visits have been done at the site, this information may be used (but make a note of this). Evidence of surficial flooding such as debris or high-water marks may also indicate a transitional hydrology. If there is more than one regime, it is acceptable to check off all that apply. This is especially important if the regime in the plot is different than the complex as a whole. **Record the code for each plot.**

- a. Be sure to note if the hydrologic regime has anthropogenic influences such as diversions, dikes, dams, etc.

Patch Type Richness, Interspersion, and Actual vs. Potential Size (plot to complex scale)

12. Evaluate the presence of patch types using the lists on WEI Form #8. Scan the entire complex for each type. Use common sense as to whether a given example of a patch type is large enough to count. If it appears to add to the complexity of the complex, include it. The lists of types on the form are not exhaustive or restrictive. Include other notable and repeatable types in the comments. Patches can be **natural or unnatural**.

13. Evaluate the zonation of the complex. Zones may be discontinuous and they can vary in number within a wetland. Zones often consist of more than one plant species, but some zones may be monospecific. In some cases, one or two plant species dominate each zone. Evaluate the wetland from a “plane view,” i.e., as if the observer was hovering above the wetland in the air and looking down upon it.

14. Evaluate the current size of the wetland complex in relation to its abiotic potential. Envision how big the complex could be if there were no **anthropogenic** limits to its size (e.g., a road or a dam).

Natural Disturbances Procedures (WEI FORM #8)

1. This form is always done on paper and at least one per complex is used.
2. It is possible that these measures will be done when little or no other activities are done at a site. Therefore, much of the header on Form #8 is duplicative with other forms. Form #3 is the most important form to have complete header information on; however, if a sample event is abbreviated (just landscape measures), Form #3 may not be used and the header on Form #8 must be more complete.

Beaver (complex to ~1 km scale)

1. **First evaluate if the site could be viable beaver habitat.** Criteria for this include: (1) water with a gradient <2%, (2) water longer than 50 m in length and more than 1 m wide, (3) water within 1 km, and (4) vegetation within a 1 km buffer including willows or other shrubs or aspen >3 m in height. Given the limitations of being on site, if three of these four criteria are observable, the site can be called viable. Overall, *use common sense*; if current or historical beaver sign are seen on or near the site, it is probably viable beaver habitat (but if no sign are seen it may still be!).
 - a. **If the site is viable habitat, continue on to the next step.** If not, select class 5 NA and move on to the next measure.
2. Scan the complex and its 1 km buffer for signs of beaver activity (beavers, dams, canals, food harvesting—e.g., gnawing of willows, cottonwoods, and aspens). In ROMN parks, historical beaver dams have been found in high-elevation (>3,000 m) fens and wet meadows that are outside the current habitat range of this species. In many parks, historical populations were much larger and beaver used a wider range of habitat. These dams are often small, eroded, and well vegetated, but crews should be alert to the possibility and importance of these features.

Native Ungulates (complex to ~1 km scale)

3. *Do not include impacts from domesticated animals (cattle, sheep, horses);* if unsure, assume that ungulate disturbance in national parks is from non-domesticated animals and can be included here (be careful in areas with lots of trail stock, and look for animal droppings to help ID species).
4. Scan the complex and its 1 km buffer for signs of native ungulate activity (animals, hoof punches, scat, wallows, food harvesting—e.g., gnawing of willows, cottonwoods, and aspens).

Frost Heave (complex to ~1 km scale)

5. Scan the complex and its 1 km buffer for sign of frost heave. Cues include vertically broken, up-thrust, and patterned bare ground.

Rodents (complex to ~1 km scale)

6. Scan the complex and its 1 km buffer for sign of non-beaver rodent disturbance. Cues include castings from pocket gophers, vole runways, scat, and burrow entrances.

Fire (complex to ~1 km scale)

7. Scan the complex and its 1 km buffer for sign of fire. Cues include burned trees, blackened deadfall, charcoal in the upper soil profile, smell, etc. Assume, unless you know otherwise, that fires in national parks are natural and can be recorded here.

Pests/Pathogens (complex to ~1 km scale)

8. Scan the complex and its 1 km buffer for sign of disturbance from pests like mountain pine beetle, smuts, fungus, etc., “Red trees,” extensive conchs or cankers on tree boles, grasses with blackened panicles, etc. Assume *unless you know otherwise* that pests in national parks are natural and can be recorded here.

Landslides (complex to ~1 km scale)

9. Scan the complex and its 1 km buffer for sign of disturbance from landslides and avalanche. Cues include debris piles, scared trees or ground, cleared pathways, etc. Assume *unless you know otherwise* that landslides in national parks are natural and can be recorded here.

Other (complex to ~1 km scale)

10. Scan the complex and its 1 km buffer for any sign of any other natural disturbance. Carefully name and describe the disturbance. As a sample season in a park progresses the “other” types should be consistently named. Examples of additional natural disturbances may include digging or scratching by bears, the presence of large ant colonies, etc.

Human Disturbances Procedures (WEI FORM #8)

1. This form is always done on paper and at least one per complex is used.
2. It is possible that these measures will be done when little or no other activities are done at a site; therefore, much of the header on Form #8 is duplicative with other forms. Form #3 is the most important form to have complete header information on; however, if a sample event is abbreviated (just landscape measures), Form #3 may not be used and the header on Form #8 must be more complete.
3. For each of the following, select the best score (usually level 1-4). Only one may be chosen. If “other” is chosen, it must be explained in the notes.

Hydrologic Alterations (complex to 100 m scale)

4. Evaluate land use(s) and human activity **in wetland complex or within 100 m** that appear to be altering the hydrological regime of the complex. Features include roads, diversions, dikes, tiles, etc. **Do not include likely natural causes of hydrologic disturbance.**

Number of Diversions (complex to 100 m scale)

5. Record the actual number of diversions **in** the complex. Diversions are any man-made feature that diverts water such as a ditch, dam tile, etc.

Percentage Unfragmented Landscape (complex to 1 km scale)

6. Estimate the percentage of unfragmented area in a **1 km buffer** surrounding the wetland complex. **Do not include natural patchiness** (e.g., caused by wildfire, landslides, natural vegetation community structure, etc.).

Buffer Width (complex to 100 m and 1 km scale)

7. Buffers are **naturally vegetated** areas with no or minimal human use. A buffer extends from the complex edge to **intensive human land uses** that result in non-natural areas. Some land uses, such as light grazing and light recreation may occur in the buffer.
 - a. Estimate the average width of the buffer surrounding **the wetland complex**. Visually estimate the buffer distance in each cardinal direction and average these four numbers into one of the four classes given on WEI Form #8.
 - b. Estimate average distance in meters to edge of buffer **for each plot** (with a maximum of 1 km).

Substrate/Soil Disturbance (complex to 1 km scale)

8. Evaluate if any soil or substrate disturbances have caused or appear to have caused more than trivial alterations to the wetland complex’s natural soils or substrates, or have occurred so far in

the past that current conditions should be considered to be “natural.” Examples include filling and grading, plowing, pugging (hoof punching from **livestock** hooves), vehicle use (motorbikes, off-road vehicles, and construction vehicles), sedimentation, dredging, and other mechanical disturbances to the surface substrates or soils. **Do not include natural soil disturbances.**

Algae (complex to 100 m scale)

9. Evaluate the extent of algae (soft bodied, diatoms, etc.) in standing water in or near (100 m) the complex. **Do not include algae that appear to be due to natural causes.**

- a. If there is no standing water in the complex or 100 m buffer class 5 (NA) is selected.

Sediment and Turbidity (complex to 100 m scale)

10. Evaluate the extent of sediment or turbidity in any standing water in or near (100 m) the complex. **Do not include sediment that appears to be due to natural causes.**

- a. If there is no standing water in the complex or 100 m buffer class 5 (NA) is selected.

Toxics/Heavy Metals (complex to 100 m scale)

11. Evaluate the extent of mine tailings, acid mine drainage, hydrocarbons, pesticides, etc., in or near (100 m) the complex. Look for different color of water (e.g., orange or bright blue), odors, no or dead aquatic life, or obvious point sources. If there are oil sheens on water surface, poke it with a stick, if the sheen immediately comes back together, it is likely petroleum, otherwise it may be natural.

- a. If there is no standing water in the complex or 100 m buffer class 5 (NA) is selected.

Invasive Monoculture (complex to 100 m scale)

12. Record if invasive plants, such as *Typha* spp. (cattail) or *Lythrum* spp. (loosestrife) are dominant in or within 100 m of the complex. **Dominance=70% of vegetated component.**

Riparian Corridor Continuity (complex scale)

13. Evaluate the ratio of uninterrupted naturally vegetated riparian corridor relative to anthropogenic patches within the riparian corridor. Anthropogenic patches are defined as areas that have been converted or are dominated by human activities, such as heavily grazed pastures, roads, bridges, urban/industrial development, agriculture fields, and utility rights-of-way. **Do not include natural unvegetated patches.**

Riparian Bank Stability (complex scale)

14. Evaluate eroding and unstable banks within the complex. Signs include crumbling, unvegetated banks, exposed tree roots, exposed soil, as well as species composition of streamside plants. **Do not include natural causes of bank instability.**

Riparian Floodplain Interaction (complex scale)

15. Evaluate overbank flooding, channel migration, and geomorphic modifications that are present within the riparian area that affect the possible interaction of the channel with the riparian wetland complex. **Do not include natural causes of flooding.**

Adjacent and Complex Land Use (complex or 100 m scale)

16. Separately estimate (1) the percent of the wetland complex and (2) the percent of an area formed by a 100 m buffer surrounding the wetland complex with each of the ANTHROPOGENIC land uses listed on WEI Form #8. **For each scale (100 adjacent meters and complex) the total should sum to 100%.** If a land-use type overlaps with another, use percent area from the type with the most disturbance.

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WEI SOP 14: Large-scale Landscape Context, Disturbance, and Characterization

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

As of publication, this SOP was under development. Future revisions will include updated background and methods.

WEI SOP 15: Field Sheet Scanning

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents the ROMN Data Management Team's process for scanning, renaming, and storing field sheets in PDF form for future reference.

Detailed Procedure Lists, Preparing Field Sheets for Scanning

1. Divide the papers by Site ID and Start Date.
2. Make sure that they're ordered according to the numbers on the field sheets.
 - a. The exact position of page numbers varies by protocol (e.g., in WEI, the numbers are found in the upper left-hand corner or top of the papers (#3, #6, #8 etc.).

Detailed Procedure Lists, Scanning the Field Sheets

1. Go to the printer in the copy/fax room.
2. If the screen is black, press the power button.
3. Our Department ID is 2119, and you do not need to enter a password.
4. Press the Log In/Out button.
5. Click the Send tab and then click the Address Book button and navigate to the person you want to send the PDFs to (probably yourself) and click okay.
6. Click the 2-Sided Original button, select Book Type and click okay.
7. Click the File Format button, select PDF and Compact and click okay.

8. Put all the datasheets from the first Site ID and Start Date, face up, into the machine.
9. Press the green Start button on the printer.
10. Put all the datasheets from the next Site ID and Start Date, face up, into the machine.
11. Click the Send tab and then click the Recall button and then click 1-Before and click okay.
12. Press the green Start button on the printer.
13. Repeat the last three steps until you've scanned all the events.

Detailed Procedure Lists, After Scanning

1. Go to your scans folder in your H: drive on your computer.
2. The scans will be there named with a date and time stamp (e.g., 20120702084924).
3. Rename the scans using the Site ID and Start Date and the format:
 - a. Protocol_Park_SiteID_yyyymmdd (e.g., WEI_ROMO_617_20120614)
4. Move the scans into the appropriate protocol folder on Z: according to the ROMN SOP: Folder Structure and File Naming (e.g., Z:\MONITORING\Wetlands\Data\Scans\)

WEI SOP 16: Data Entry

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents the ROMN Data Management Team's process of acquiring, entering, and QA/QCing data for the WEI protocol. These data are updated in the WEI database. This section does not represent data housed outside of the WEI database.

Receiving Data

1. WEI data can be received as:
 - Original datasheets
 - Copies of the original datasheets
 - Scanned PDFs
 - HOBO loggers
 - Depth to water loggers
 - PDAs
 - o Databases exported from PDAs
2. When WEI datasheets are received, they will go in the WEI Inbox. When PDFs are received, they will be emailed (zipped) to the Data Management Team.
3. Make sure all data that have been collected in the field are received in the office by checking the FieldAndData_Calendar for 2013.
4. If PDFs are received, put them in:
 - a. Z:\MONITORING\Wetlands\Data\Scans
5. Rename them using the Site ID and Start Date and the format:

- a. WEI_Park_ SiteID_yyyymmdd (ex. WEI_ROMO_617_20120614)
6. If the datasheets are received and there is no PDF version of them already in existence, scan the datasheets before beginning the data entry process. Put the scanned PDFs in the same place as other PDFs. See the ROMN SOP: Scanning for detailed instructions.

Data Entering Procedure

1. The WEI database for the current field season is stored at:
 - a. Z:\MONITORING\Wetlands\Data\DataGathering\DataEntry
2. When beginning a new day of data entry/QAQC, copy and paste the latest version of the database and change the date to the current date.
3. To enter data in its designated table in the database, click the checkbox to the left of the section name.
4. Figure 16-1 shows a screen shot of the data entry interface. When finished with entering data in a table, save and exit the table to return to the main data entry form.
5. The ESC key can be used to escape any record, not saving any changes if need be (e.g., if an extra meter location was added).

The screenshot shows the 'frm_DataEntryMaster' form. At the top, there's a header bar with several input fields: 'Site Name' (a dropdown menu), 'StartDate' and 'EndDate' (text boxes), 'FieldVisitType' (a dropdown menu with options 'Full', 'Partial', and 'Revisit-Full'), and a 'Close Current Record' button. Below the header is a large text area labeled 'EventComment'. A prominent red-bordered box with a blue background and red text is overlaid on the form, stating 'Click Here to Save BEFORE Continuing onto the Checkboxes'. Below this box, there are several checkboxes arranged in three rows: 'hasCrew', 'hasSiteDescription', 'hasVegData', 'hasCalibrationError', 'hasTimes', 'hasMeasurements', 'hasLandscape', 'hasSiteSketch', 'hasPhotos', 'hasNewSite', and 'hasSoil'. At the very bottom, a status bar shows 'Record: 1 of 1', 'No Filter', and a 'Search' button.

Figure 16-1. Data entry form.

Form #3: Event: Site Establishment / Well / Logger / DTW

1. Top set of boxes (see Figure 16-2):
 - a. Enter the Site Name, Start Date, and Visit Type into SiteName, StartDate, and FieldVisitType respectively.
 - b. EndDate will be automatically set to the value of StartDate, if the EndDate is different it can be manually edited.
 - c. Click the Save button to activate the checkboxes.
 - d. Enter the crew on EACH page in hasCrew.
 - e. Enter the times on EACH page in hasTimes.
 - f. Enter the Camera Name and Photo Numbers in hasPhotos.
2. Right set of boxes:
 - a. Enter the Ambient Barometric Pressure, Air Temperature, and Monuments in hasSiteDescription.
 - b. If a logger has been set and the Barometric Pressure has NOT been recorded, bring it to the attention of an ecologist.
 - c. Check the units of the Temperature and convert, if necessary, to enter in Celsius.
 - d. Enter the status of each monument in its field. Additional monument information is entered in hasSiteDescription>HasMonuments
3. Left set of boxes:
 - a. Well measurements are entered in hasMeasurements>hasWell.
 - b. Logger data is entered in hasMeasurements>hasWell>hasLogger.
 - c. Additional logger information is entered in hasMeasurements>hasWell>hasLogger>hasLoggerLocation.
4. Bottom set of boxes:
 - a. Event Notes go in the Event Notes field.

- b. Site Notes go in hasSiteDescription Notes.
 - c. Well Notes go in hasMeasurements>hasWell Notes.
 - d. Logger Notes go in hasMeasurements>hasWell>hasLogger Notes.
 - e. PDA Notes go in hasVegData Notes.
 - f. “How Data Was Recorded?” is used to check that all sheets are accounted for.
 - g. If Form 5 is recorded on the PDA, checkmark hasVegData>hasEcoNab.
5. Back:
- a. The New Site boxes (GPS, Type, Status, etc.) go in hasNewSite.
 - b. Additional waypoints go in hasNewSite>hasAdditionalPoints.
 - c. The Event Checklist is recorded in the Event Checklist Excel Spreadsheet in:
Z:\MONITORING\Wetlands\Data\DataGathering\DataEntry
 - d. If there is a Site Sketch make a note by checking hasSiteSketch.

Review Initials:		Review Date:		Data Entry Initials:		Entry Date:	
WEI Form #3				Event: Site Establishment / Well / Logger / DTW		Version 2015	
THIS FORM IS ALWAYS DONE ON PAPER AND ONE PER PLOT IS USED							
Date (mm/dd/yyyy):		Botanist: (or crew lead)		Park:			
Event Start Time:				Site ID: Well #			
Est. Down Time (minutes):		Other Crew:		Visit Type:		Circle One: Full Partial	
Event End Time:				FULL or PARTIAL; indicate sub-type		Circle all that apply: QA/QC Revisit 1st/year	
8 Core Photo Series # (first, last)		Site Name:					
Camera Name							
ALL MEASUREMENTS (EXCEPT BOLT) ARE MADE AT THE NOTCH ON CASING TOP. TAKE ALL WELL METADATA WHENEVER A SITE IS VISITED							
		Well #1		Well #2 (Usually Blank)		Ambient Barometric Pressure: (When installing logger, take reading from logger before placing it in well)	
(ROMN) Well ID:							
(OLD) Well ID: (Usually blank)		 (Usually blank)					
Blanks Null (Y/N)		Before After (if different)		Before After (if different)		Well logger Reference logger	
Logger Serial #:						Air Temperature: (C or F, Note Units)	
Logger Downloaded? (circle one)		Yes No		Yes No		Well logger Reference logger	
Tot. Casing Length: (cm.x)						Logger Battery Level:	
Casing Stick Up: (cm.x)						Est. Days Since Last Rain: (# of days, Now, Unknown)	
Casing Angle: (degrees)						Monuments Installed or Located? (Y/N/Not Checked/Need Replacement)	
Bearing of Notch: (undeclinated degrees)						N S	
Bolt Height: cm.x (at mid. bolt)						E W	
Cable Length: (cm.x bolt to logger sensor)						Moss Collected?	
Well Status? (circle one) default = Wet; water present		Wet / Frozen / Dry / Mud / Submerged / Not Equilib.		Wet / Frozen / Dry / Mud / Submerged / Not Equilib.		No Moss Present	
Depth To Water: (from top of casing)(cm.x) WITH LOGGER IN WELL						Moss Present but Not Collected	
Depth Method: (circle one)		Bubbler / Tape / Volt / WAG / Other:					
EVENT CHECKLIST - Check the box next to what happened this event							
New Site	Monuments Checked	Well Metadata	DTW	Logger	Baro	Calib.	EC
Water Chem	Veg (Paper)	Veg (PDA)	Woody	Soil profile	Soil sample	Landscape(HDI, etc.)	
Write notes on back.							

Figure 16-2. WEI Form #3: Event: Site Establishment / Well / Logger / DTW.

Form #4: Water Table Depth, Water Quality and Soil

1. Left side:

- a. The Well Depth Measurements go in hasMeasurements > hasWell > hasDepths.

2. Right side:

- a. The SondeType and WQ Location go in hasMeasurements>hasWaterQuality.
- b. The Measurements go in hasMeasurements> hasWaterQuality>hasMeasures.

3. Back:

- a. Peat Thickness goes in hasSoil.
- b. Soil Horizons go in hasSoil>hasHorizon.
- c. Soil Samples go in hasSoil>hasSample.

Form #5: Vegetation Composition and Cover

1. Form #5 data can be collected in the field on a PDA or on a paper form.

2. Data collected on a PDA can be moved into the EcoNab database.

3. To do this, reference

Z:\MONITORING\Wetlands\Documents\EcoNabEssentials\DownloadingEconab.doc

4. Data collected on paper can be entered into a PDA and moved into the EcoNab database or entered into forms directly into the EcoNab database.

5. To enter data into a PDA, reference pages 8-27 of

Z:\MONITORING\Wetlands\Documents\EcoNabEssentials\EcoNabTutorial.pdf

6. To enter data into the database, reference pages 32-34 of

Z:\MONITORING\Wetlands\Documents\EcoNabEssentials\EcoNabTutorial.pdf

7. If an event has Form 5 data, check hasVegData>hasEcoNab

Form #6b: Herbivory and Woody Structure

1. Front:

- a. Form 6b data goes in hasVegData>hasHerbivory.
- b. For species with a Height Class of 1, the field Stem Group Count is often collected.
- c. The field Count defaults to 1 in the database, and should be changed to the Stem Group Count, if it was collected, or blank, if it was not collected.
- d. Blanks in Stem Group Count on the field forms should not be left as the default (1), in the database.

2. Back:

- a. The notes section is entered in hasVegData>Comments field.

Form #8: Landscape

1. Form 8 is done at both a complex and site scale, so when choosing which event to tie it to, use the site at the top of the first page.
2. There is 1 Form #8 for multiple sites, done once a year. It is normal for an event to be marked Full even if the Form #8 was done earlier in the season or was tied to a different site.
3. Classification:
 - a. Cowardian Classification, Ecological System, and HGM for EACH SITE go in hasLandscape>hasClassification.
4. Physical attributes:
 - a. Physiognomy, Aspect, and Slope for EACH SITE go in hasLandscape>HasPhysicalAttributes.
 - b. Topographic, Water Source, and Hydrologic Regime for EACH Site go in hasLandscape>HasPhysicalAttributes>hasPlotDetails, where the ParameterName is one of the above or flag and ParameterValue is the corresponding value.
5. Size and complexity:
 - a. Abiotic Potential and Interspersion for THE COMPLEX go in hasLandscape>hasSizeComplexity.

6. Natural disturbance:

- a. Beaver, Native Ungulates, Frost Heave, Rodents, Fire, Pest Pathogens, Landslide, and Other for THE COMPLEX go in hasLandscape>DisturbNatural.

7. Human disturbance:

- a. Hydrologic Alterations, # Diversions, percent Unfragmentation, Average Buffer Width, Soil Disturbance, Algae, Turbidity, and Toxics for THE COMPLEX go in hasLandscape>DisturbAnthro.
- b. Buffer distance for EACH SITE go in hasLandscape>DisturbAnthro>hasBuffer.
- c. If there are NO dominant invasive Taxa check the box and ignore the next two boxes, otherwise leave unchecked and enter the species codes in the next boxes.
- d. At a riparian part of the complex only: Corridor Continuity, Bank Stability, and Floodplain Interaction for THE COMPLEX go in hasLandscape>DisturbAnthroRiparian.

8. Land use:

- a. Values for the COMPLEX and the BUFFER go in hasLandscape>hasLanduse.

9. Patch types:

- a. Check the box for each patch type present in THE COMPLEX in hasLandscape>hasPatchTypes.

10. Flags:

- a. Throughout the hasLandscape tables there are locations to flag or comment on values; to check those values and to indicate there are flags present check hasLandscape>hasFlags.

Quality Assurance and Quality Control Data Procedure

1. After the data have been entered, QAQC them (see ROMN SOP: Quality Control and Quality Assurance).
2. Let a different person than the one who entered the data originally be the one to QAQC them.
3. Follow the same process as one would follow if they were entering data, but just look at the data to make sure everything was entered into the database correctly and make changes as necessary.

WEI SOP 17: In-Situ Groundwater Depth Logger Processing

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents the ROMN Data Management Team's processing of InSitu loggers from download from the field computers to final summary tables, including acquiring, processing, compiling, importing, adjusting, and summarizing the data.

Win-Situ Setup

Make sure that whenever you are dealing with files in Win-Situ, ESPECIALLY when exporting files to CSV, your instance is set to ignore daylight savings time.

1. This setting can be found in Preferences>General Settings.
2. Make sure that “Ignore DST” is checked.

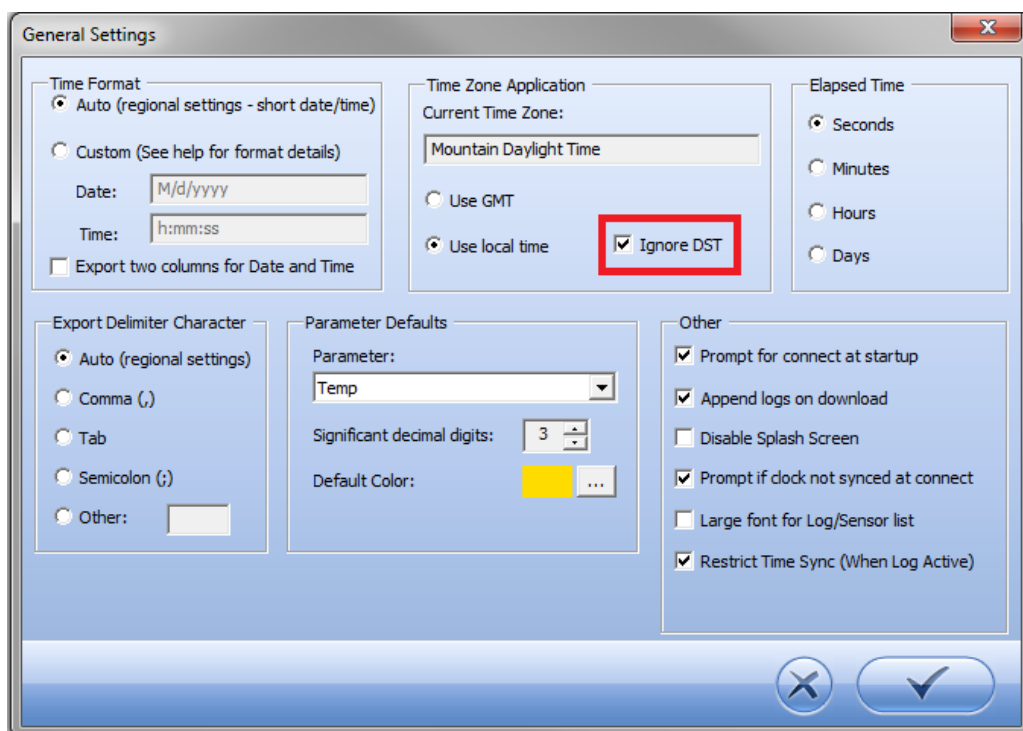


Figure 17-1. Win-Situ General Settings screenshot.

Pre_Season Setup

Database Set-up

1. Make a copy of the InSitu DTW tools database in the tools folder (Z:\MONITORING\Loggers\Data\Tools) and put that copy in the DataGathering folder (Z:\MONITORING\Loggers\Data\DataGathering\InSitu_DTW). Name that database InSitu_DTW_DataCompiling_YYYY_[CurrentDate]
 - a. The new monitoring database is created from the tools database because the code to bring in files from a folder and the code for automatic trimming are considered tools. They are not run on master data so they are not in the master database.
2. Open the InSitu DTW Master database (path pending SQL conversion). Copy the records in the Expecting_Metadata table and paste into the Import_Metadata table in the data entry database. Copy the records in the Expecting_Data table and paste into the Import_Data table in the data entry database.

- a. Make sure the Expecting_Metadata records are copied first.
 - b. These records represent those that were downloaded last year but could not be baromerged because the second file did not have downloaded records during that time.
 - i. Eg. The baro logger was downloaded first, then the well logger. The well logger will have a few records after the baro logger was downloaded. The baro logger records to match these well logger records will be the start of the next year's baro download.
3. Copy the records in tlu_SiteBaro in the Master database into the same table in the data entry database.

Note on DTW Logger Tracking

We have used the logger tracking table in the DTW database. However it is mostly used to figure out when our sites have been logged so that we can use that information in other tables. The loggers are rarely replaced and extremely rarely fail or are lost. So the DTW do not need tracked as closely as the HOBO temperature loggers.

Office Processing

DTW loggers are downloaded in the field. The Toughbook is brought back into the office where processing begins.

Moving Logger Files from Toughbook

1. Plug the thumb drive into the Toughbook, check if a logger folder exists, if not create one.
2. Navigate to My Documents\WinSitu Data
3. Copy the Site Data and Exported Data folder onto your thumb drive.
4. Copy the Copy of Site Data and Copy of Exported Data from the desktop onto your thumb drive.
 - a. We grab each in case a file ended up in one folder and not the other
5. Then move the thumb drive to a computer connected to Z:, open windows explorer and copy the contents of the logger folder into a new folder with the current date and name of the Toughbook in the folder.
6. Z:\MONITORING\Loggers\Data\DataGathering\InSitu_DTW_WinSitu\Backups\2013_ToughBookBackups\
 - a. For example, Toughbook_Granite_Back-up_20120628
7. This way at the end of the field season there will be a series of folders containing backups from the tough books.
8. There are two types of files that are collected in the field:

- a. Level Troll. These files come from the loggers in the well, the data in these files have the pressure of the water in the well and the barometric pressure above the well.
 - b. Baro Troll. These files come from loggers that are positioned outside of a well. This logger measures the barometric pressure and is used to adjust the Level Troll file.
9. These files generally have VC (for visitor center) or baro in the name; this is set by hand and may be subject to variation.

Getting a Unique Copy of the Data

1. Navigate to the “ReadyToProcess” where the unique data will be compiled. Make sure there is a “Site Data” folder. The final path structure should look like:
 - a. Z:\MONITORING\Loggers\Data\DataGathering\InSitu_DTW_WinSitu\ReadyToProcess\Site Data
2. Navigate to the oldest Toughbook backup of the season and copy the wsl files from the Site Data folder from the backup into the Site Data folder in ReadyToProcess.
3. Navigate to the next oldest Toughbook backup and repeat the process. If windows explorer gives a popup message about the file already existing, select skip.
4. Repeat for all backups
 - a. Note we keep the exports from the Toughbook in case we need them but the exporting process is quick and due to folder structure WinSitu creates it is easier to re export than ensure a unique copy of the csv files.
5. A file from each site is preloaded onto the Toughbook so that the sites will appear. These have already been processed and don’t need processed again.
6. Sort the Site Data folder by data modified and delete any file that was not created this field season.
7. NOTE: Win-Situ will add a “_append” to a file that was not stopped in the field before being redeployed. This is a unique file containing the data since the logger was downloaded.
8. NOTE: *There are two folders that Win-Situ creates that we are interested in:*
 - a. Site Data. This folder contains the .wsl files, Win-Situ’s data format. When we are working with files in Win-Situ, this is the file format we are working with.
 - b. Exported Data. This folder contains the .csv files that have been exported from .wsl files. When we are working with Excel in later steps we are using these files.
9. Once all of the Toughbook backups have been processed open WinSitu.
10. Say no when asked if you want to connect to a device.

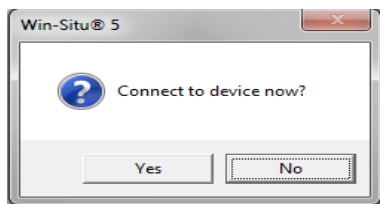


Figure 17-2. Win-Situ pop-up that will ask you if you want to connect to a device (click no).

11. In Win-Situ, change your workspace to the “ReadyToProcess” folder.

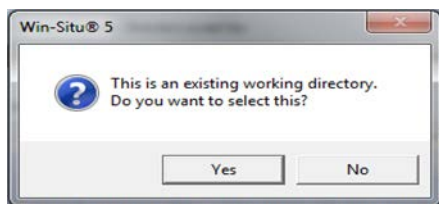


Figure 17-3. Win-Situ pop-up: select an existing working directory (click yes).

12. Use the option “Do not move or copy files from the existing Working Directory.”

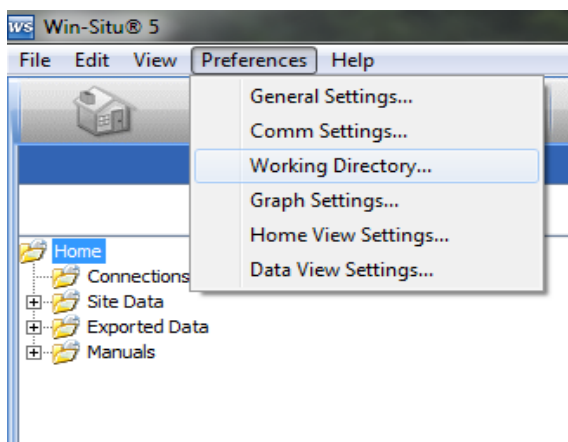


Figure 17-4. Win-Situ screenshot, navigating to Working Directory.

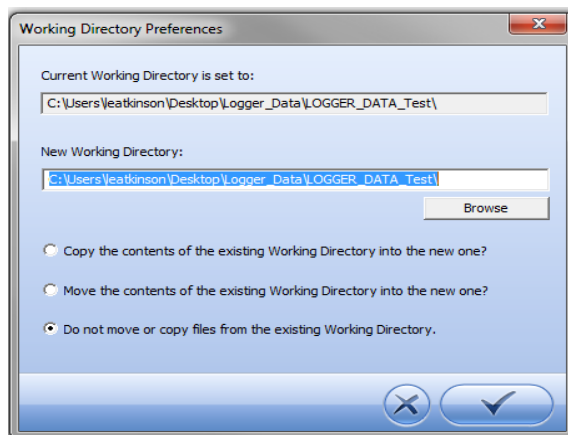


Figure 17-5. Win-Situ Working Directory screenshot.

13. Export each .wsl to .csv:

- a. Export the file by right clicking on the file name in Win-Situ and clicking “Export to CSV.” Win-Situ will automatically save the exported file in the exported folder of the workspace.

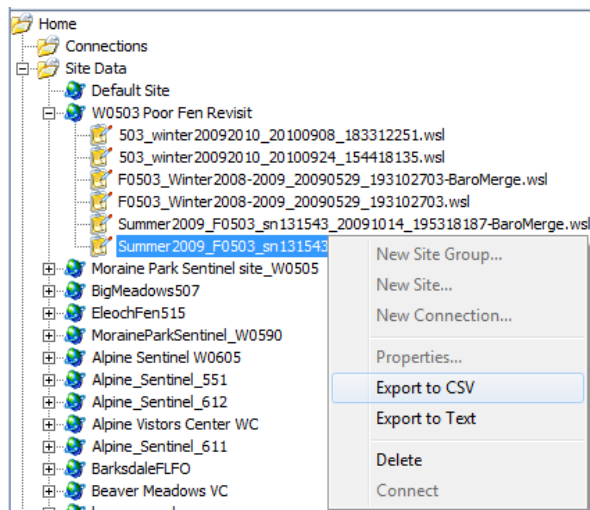


Figure 17-6. Win-Situ screenshot, exporting to CSV.

14. When every .wsl file has a corresponding .csv you are ready to go onto the next step.

Getting the Data into the Database

1. Once the files are compiled, they need to be formatted to be put into the database.
2. Open the Insitu_DTW_LoggerMacro.xlsm file in the Tools folder.
(Z:\MONITORING\Loggers\Data\Tools)
 - a. Click enable if the spreadsheet asks you to.
3. In the logger file, open the macro menu:

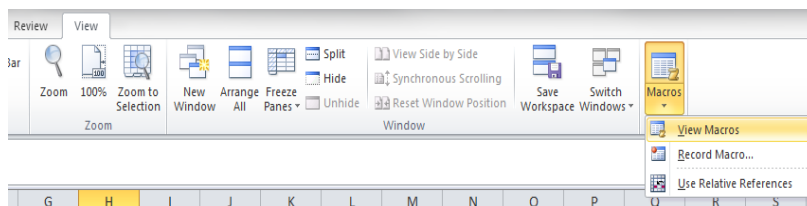
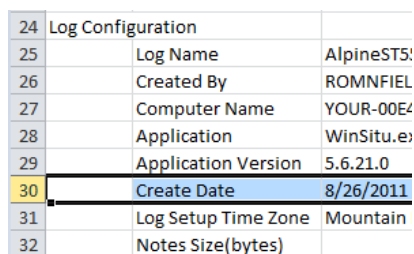


Figure 17-7. Excel screenshot, opening the macro menu.

4. Make sure that the FormatAllLoggers macro is highlighted and click Edit.
5. Confirm that the hard coded import path name is pointing to
Z:\MONITORING\Loggers\Data\DataGathering\InSitu_DTW\ReadyToProcess\Exported Data

6. Confirm that the hard coded export path name is pointing to
Z:\MONITORING\Loggers\Data\DataGathering\InSitu_DTW\ReadyToProcess\ReadyToImport
7. Save then run the macro.
8. This macro will navigate through all of the folders in Exported Data looking for .csv files. It will then try to process them.
9. This macro will create three new spreadsheets in the Excel file. These sheets are Metadata, Data, and Notes. The macro will also rename the existing sheet to Original.
10. The Metadata sheet has the metadata for the logger.
 - a. Serial Number
 - b. Create Date
 - c. Scheduled Start Time
 - d. Scheduled Stop Time
 - e. Interval
 - f. Device
 - g. Site
 - h. Used Battery (How much battery has been used to date by the logger)
 - i. Depth of Probe (Not found in Baro Logger files)
 - j. Head Pressure (Not found in Baro Logger files)
 - k. Temperature (Not found in Baro Logger files)
11. The Data sheet has values recorded at each time interval.
 - a. Serial Number (Key field linking to the metadata record)
 - b. Create Date (Key field linking to the metadata record)
 - c. Report Date
 - d. Log Name
 - e. Date and Time
 - f. Seconds
 - g. Temperature

- h. Pressure
12. The Notes sheet has logger generated notes.
- a. Serial Number (Key field linking to the metadata record)
 - b. Create Date (Key field linking to the metadata record)
 - c. Report Date
 - d. Log Name
 - e. Date and Time
 - f. Note
13. NOTE: The macro checks the original sheet for each data piece it needs and moves it into the correct space. The macro checks the first 100 rows of the original sheet for all pieces of metadata and headers. If it is unable to find an expected variable in that time then a pop up box is created to notify the user and the macro moves onto the next piece of data.



24	Log Configuration	
25	Log Name	AlpineST5!
26	Created By	ROMNFIEL
27	Computer Name	YOUR-00E4
28	Application	WinSitu.e
29	Application Version	5.6.21.0
30	Create Date	8/26/2011
31	Log Setup Time Zone	Mountain
32	Notes Size(bytes)	

Figure 17-8. Excel screenshot of macro locating metadata and headers.

14. NOTE: The macro is able to deal with dynamic number of rows of notes and data as well as dynamic starting locations for these data pieces.
15. NOTE: *The Create Date that is used in the macro is the log configuration create date, it is not the create date for the log file.* This is the date that the log itself was created, not the date that the log file was created.
16. NOTE: If any data gets flagged as missing by the macro, first check the original sheet to see if the fields are missing on the original. If so, try exporting the .wsl file to .csv again according to the directions in step 13 of Getting a Unique Copy of the Data. If that does not work and the values just aren't in the .wsl file at all, go talk to the data manager and see what they want to do.
17. Once all of the logger files have been reformatted, the individual sheets can be imported into the Data Entry database:
- a. Z:\MONITORING\Loggers\Data\DataGathering\InSitu_DTW
18. Click the Import button on the ProcessData form.

19. The Vba code will go out the “ReadyToImport” folder and read in every Excel file. The metadata sheet will be appended to the IMPORT_Logger_Metadata table if there is not already an existing record. The data sheet will be appended to the IMPORT_Logger_Data table if there is not already an existing record. The notes sheet will be appended to the IMPORT_Logger_Notes table if there is not already an existing record.
20. If a message box pops up asking for parameters then hit the cancel button.
 - a. A message box will pop up telling the file that caused the issue.
 - b. Navigate to that file and figure out the value for the missing parameter.
 - c. Click the Import button again.
21. Check the number of imported records by going to Logger_Metadata and filtering to only records with null EventNames. If the number of records is not the number of Excel workbooks in the ReadyToImport folder, it might be because some of those Excel workbooks were downloaded or exported multiple times and thus were duplicate records of each other. Go through each Excel workbook to make sure there is a corresponding record in the database to determine which were not imported.
 - a. A quick way to do this is by creating a temporary query in the database. Add in Logger_Metadata and Logger_Data. Join the two by serial number and create date. Add LogName from Logger_Data and EventName from Logger_Metadata. Add the criteria that EventName ‘Is Null’. Click the ‘Totals’ button. Click the ‘View’ button.
 - b. Now the list of LogNames provided by the query should correspond with the Excel workbooks in the ReadyToImport folder. Make sure the ReadyToImport folder is sorted by name and just scan through the LogNames and ReadyToImport folder to determine which Excel workbooks were not imported.
 - c. Once you find the missing Excel workbooks, see if there are any records that they could have been a duplicate of (usually directly above or below the missing one as they would have very similar names). Check to make sure the data are definitely duplicates by opening them both in Excel and looking between the data (making especially sure they have the same start and end dates). Once you’ve determined that it was definitely a duplicate, delete the duplicate Excel workbook from the ReadyToImport folder. Repeat as many times as needed until the number of imported records matches the number of Excel workbooks in the ReadyToImport folder.

Connecting Logger Records to Events

1. Wait until the WEI data has been certified and imported into the master database and the event names have been finalized.
2. Once the WEI event names have been finalized, the logger data need to be matched up to the event where the manual depth to water (DTW) was taken.
 - a. Take note that there is probably a difference of a day between the manual depth to water and the start of the log. This is because to ensure that the temperatures are accurate, the

log was programmed to start after the logger is in the well and the temperature is stabilized.

- b. After the correct event has been identified, enter that EventName, WellNum, WellName, and SiteName into the Logger_Metadata table in the DataCompiling database.

Baromerging and Manual Trim Flags

1. After all of the records have an EventName, click the Update Event Names button to indicate that you have finished updating them.
2. Then click the Calculate Baromerge button in the ProcessData form.
 - a. This set of queries will subtract the barometric pressure, at that hour, of the nearby Baro Troll file from the pressure of the level troll in the well. This leaves the pressure from the water above the logger sensor.
 - b. The identity of the nearby Baro Troll is determined by the table tlu_SiteBaro.
 - i. This table lists every site with a well logger and the name of the corresponding baro logger.
 - c. The baromerged pressures will be stored in a new table Calculated_Baromerge.
 - d. This button will also run the Trim_LoggerRecords VB code which will flag the first and last two hours from the Baromerged file for trimming in the table Calculated_Baromerge.
 - i. This flag does not affect the raw data.
 - ii. The reason for this flag is there is a possibility that at the beginning and end of the log the logger was outside of the well, it needs time to equilibrate.
3. Locate records in Calculated_Baromerge where the baromerge could not be performed. Do this by filtering the Calculated_Baromerge table to those records with a null BaroSiteName.
4. The next several steps will be performed for each event individually, so select one event that has a null BaroSiteName and filter to the record(s) from that event only.
5. For that event, look at the DateAndTime column. Scroll through the DateAndTime column to make sure it doesn't contain jumps. If the column does not contain jumps, the section that will be referred to in the next several steps refers to all the records currently displayed. If the column contains jumps, consider each consecutive timespan as a separate section. Filter the DateAndTime column to contain only one section and continue with the next steps.
6. Note the section's first date and time and the last date and time that you observe the DateAndTime column.
7. For that section, copy its WellSiteName. Open tlu_SiteBaro and filter the WellSiteName column to the text you just copied. Copy the BaroSiteName.

8. Open `Logger_Metadata` and filter the `SiteName` to equal the `BaroSiteName` that you just copied. Now look at the `SerialNumber` column. If there is only one serial number in the column, copy that one. If there are multiple serial numbers, copy one and come back for the second one.
9. Open `Logger_Data` and filter the `SerialNumber` to the number(s) you just copied. Then filter the `DateAndTime` column to show records after the first date and time which you observed in step 6.
10. If there are no records after that first date and time, it is because that section was at the end of the baro record. The download next field season will provide us with the baro record to baromerge the data from that section. If there are records after that first date and time, it is because that section was a gap in baro data which occurred in the middle of a record (likely while the baro was being downloaded). Note which is the case for this section of data for use in step 12.
11. Still in the `Logger_Data` table, clear filters and filter the `SerialNumber` column to the `SerialNumber` from the `Calculated_Baromerge` table. Then filter the `DateAndTime` in the `Logger_Data` table to be between the first date and time and the last date and time observed in step 6. Check to make sure the number of records coincides with the number of records in the `Calculated_Baromerge` table.
12. In the `Logger_Data` table, find the `Manual_Trim` column. Select the column and do a find and replace. Replace the default value, 0, with 'yes'. Find the `Manual_Trim_Reason`, select it, and do a find and replace. If the reason for the lack of baro data was due to it being the end of the baro record (observed in step 10) replace the default value, Null, with "Download Next Field Season." If the reason for the lack of baro data was due to a gap in the baro record (also in step 10) replace the default value, Null, with "No Baro."
13. Close all tables and click the `Update Event Names` button and then the `Calculate Baromerge` button from the `ProcessData` form. When it is done running, check the `Calculated_Baromerge` table filtered to a blank `BaroSiteName`. As long as there are still records with a blank `BaroSiteName`, continue on to the next step. When there are no longer any records with a blank `BaroSiteName`, you are done.
14. If in step 5, you determined that there were no jumps in the data, go back to step 4, selecting the next event to continue the steps. If you determined there were jumps in the data and thus split one event's data into sections, go back to step 5, selecting the next section from the same event, until you are finished with the last one. Then go back to step 4, selecting the next event to continue the steps.
15. Click the `finalize` button to prepare the data for import into the master database

Append to DTW Master

1. Once the `Finalize` button in the data entry database has been clicked open the master DTW database (Path pending SQL conversion).
2. Append the raw data in the following tables to the corresponding table in the master database.
 - a. `IMPORT_Logger_Metadata`

- i. There should be some records that could not paste because of a key field violation. This is expected because they were the previous year's Expecting_Metadata records and are already in the master metadata table.
 - ii. Check that there is the same number of records that could not paste as appear in the Expecting_Metadata table.
- b. IMPORT_Logger_Data
 - i. There should be some records that could not paste because of a key field violation. These records are the Baro data records that were identified the last year as needed to analyze this year's data.
 - ii. Filter the Expecting_Data table so that only Baro records appear and check that the same number of records appear in this filtered table as the number of records that failed to paste.
 - iii. Well data records will not cause a paste error because they are removed from the Logger_Data table in the master.
- c. IMPORT_Logger_Notes
- 3. Replace the following tables in the Master database AFTER step 2 is done.
 - a. Expecting_Metadata
 - b. Expecting_Data

Ecologist Trim

1. Open DTW Master and run the Tracking Table queries.
2. Put the updated tracking table into the WEI Master.
3. Open the WEI master database run the macro Measurements_DTW to generate the SUMMARY_Measurements_DTW_Hand table.
4. Run the query QAQC_Ecologist_DTWgh to produce a combination of SUMMARY_Measurements_DTW_Hand and tbl_Measurements_Well for the ecologist to look over and determine if there are any flags or adjustments that should be made to the hand dtw measurements. This measurement could have big impacts on the log.
5. Make sure that the ecologist's comments, flags, well status and logger impacts are added to the QAQC_WellMeasurements table.
6. Rerun the macro Measurements_DTW to generate the SUMMARY_Measurements_DTW_Hand table and import this table into the DTW master.
7. Once all of the tables have been brought into the Master database, click the SUMMARY DTW Logger button in the ProcessData form. This button will run a set of queries to convert the pressure from water on the logger sensor from the Calculated_Baromerge table to a Depth to

Water from ground. Additional Metadata will be added to the records and the resulting summary tables are:

- a. SUMMARY_Measurements_DTW_LoggerDaily with daily DTW values at each site.
 - b. SUMMARY_Measurements_DTW_LoggerHourly with hourly DTW values at each site.
 - c. SUMMARY_Measurements_DTW_LoggerWeekly with Weekly DTW values at each site. (note the week is set to start on Monday)
8. Export each of the summary tables to Excel.
- a. Put each into its own tab labeled Daily_DTW, Weekly_DTW, and Hourly_DTW.
 - b. Populate the empty sort field.
 - c. Give these tables to the ecologist.
9. The ecologist will run the daily summary through a visualizing tool to produce graphs of the data to help identify issues
10. As the ecologist is looking through the data, he/she will identify three things
- a. Flags: Points in the log where the data is odd but legitimate. For example when the site is covered in snow the logger can't properly read the pressure.
 - i. Flags will still be seen in output summary tables.
 - b. Trims: Points in the log where there is a big issue with the data. Example the logger was dying and decided it was 1969 or that it the site had an extra two feet of water for an hour.
 - i. Trimmed values will be marked in the raw data and will NOT appear in summary outputs. (The data is never deleted).
 - ii. This is very rarely done. Most cases will call for a flag rather than a trim.
 - c. Adjustments: Sometimes there are dramatic shifts in the log where there is a sudden jump or drop in the dtw reading that continues normally from that higher or lower point. This can be caused by several things such as the length of the logger cable being adjusted mid log. In this case we need to add an adjustment value to bring that data in line with the rest of the file.
 - i. The ecologist will mark the point the shift occurs with an adjustment value that needs to occur (such as -5 or 2).
 - ii. Work with ecologist to get a figure of what kind of adjustments are being made and what it means.

11. Flags and adjustments will be marked on both the daily and the hourly logger but the reason that goes along may be different depending on the scale.
12. Trimmed values will be marked in the hourly data.

WEI SOP 18: In-Situ Water Physiochemistry Logger Processing

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP presents the ROMN Data Management Team's processing of Water Physiochemistry loggers for download from the field computers to final summary tables, including acquiring, processing, compiling, importing, adjusting and summarizing.

Introduction

This SOP presents the ROMN Data Management Team's processing of water physiochemistry loggers for download from the field computers to final summary tables. The SOP includes acquiring, processing, compiling, importing, adjusting and summarizing temperature data.

In Situ Water Physiochemistry Logger Processing Procedure: Office Processing YSI Sonde

1. During the field season, the downloaded YSI files will be saved as YSIDataManager_YYYYMMDD on Z in:

Z:\MONITORING\Loggers\Data\DataGathering\InSituYSI_WaterQuality\YSI

2. Copy YSI_ProcessingCode.accdb from:

Z:\MONITORING\Loggers\Data\Tools

3. Save it as YSI_DataProcessing_YYYY_YYYYMMDD.accdb on Z in:

Z:\MONITORING\Loggers\Data\DataGathering\InSituYSI_WaterQuality\YSI

4. Open that database, and you will see the following interface.

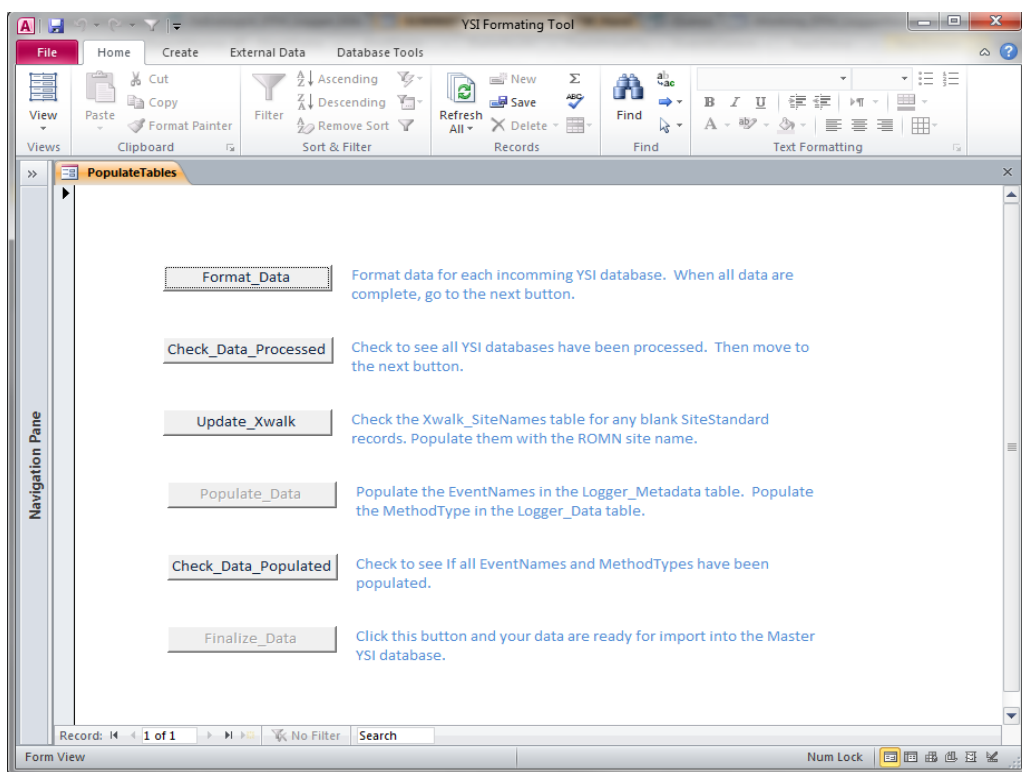


Figure 18-1. YSI Formatting Tool Access database.

5. Open the first YSIDataManager file and copy all the tables into the YSI_DataProcessing_YYYY_YYYYMMDD.accdb database. Replace the existing tables with the same name.
6. Run the “Format_Data” button from the YSI_DataProcessing database.
7. Move the first YSIDataManager database into the Done folder:

Z:\MONITORING\Loggers\Data\DataGathering\InSituYSI_WaterQuality\YSIDone

8. Repeat steps 4-6 for each YSIDataManager database. When copying the tables replace the existing tables. Ensure that all databases have been moved to the Done folder and click the “Check_Data_Processed” button.
9. Check the “Xwalk_SiteNames” table and fill in SiteStandard and Protocol where they are null. Once there are no null fields click the “Update_Xwalk” button.
 - a. The field crew manually enters the Site name and it isn’t always the same as the standard format.
10. Figure out and populate the event name for each record in the Logger_Metadata table using the SEI and WEI Master databases. At this time confirm that all expected sites have been accounted for.
11. Populate any null values in the MethodType field in the Logger_Data table. Click the “Populate_Data” button.
12. If any YSI data were written on field sheets, enter them with a Folder value of None and a Method_Type value of Manual. Ensure a Metadata record is populated. Click the “Check_Data_Populated” button.
 - a. If the Event name or MethodType is left null in any record a message box will pop up and the next button will not be enabled. Populate these fields fully to enable the next button.
13. Click the “Finalize_Data” button.
14. Replace the “Xwalk_Sitenames” table in the database in the tools folder with the one that has been updated this season.

Z:\MONITORING\Loggers\Data\Tools

15. Delete all tables other than the Logger_* tables and save the database as YSI_YearlyMaster_YYYY_YYYYMMDD.accdb on Z in:

Z:\MONITORING\Loggers\Data\Certified\FY##

16. Append the data in the Logger_* tables into the InSituYSI_WaterQuality_MASTER database:

Z:\MONITORING\Loggers\Data\Certified

In Situ Water Physiochemistry Logger Processing Procedure: Office Processing In Situ Sonde

1. During the field season, the InSitu .dbf files will be saved on Z: in a new folder for that day on:

Z:\MONITORING\Loggers\Data\DataGathering\InSituYSI_WaterQuality\InSitu

- a. There are three types of files that the InSitu sonde produces:

- i. Header files, which contain the metadata and Unique Key for each file
- ii. Manual files
- iii. Timed files

2. Copy InSitu_ProcessingCode.accdb from:

Z:\MONITORING\Loggers\Data\Tools

3. Save it as InSitu_DataProcessing_YYYY_YYYYMMDD.accdb on Z in:

Z:\MONITORING\Loggers\Data\DataGathering\InSituYSI_WaterQuality\InSitu

4. Open that database and you will see the following interface.

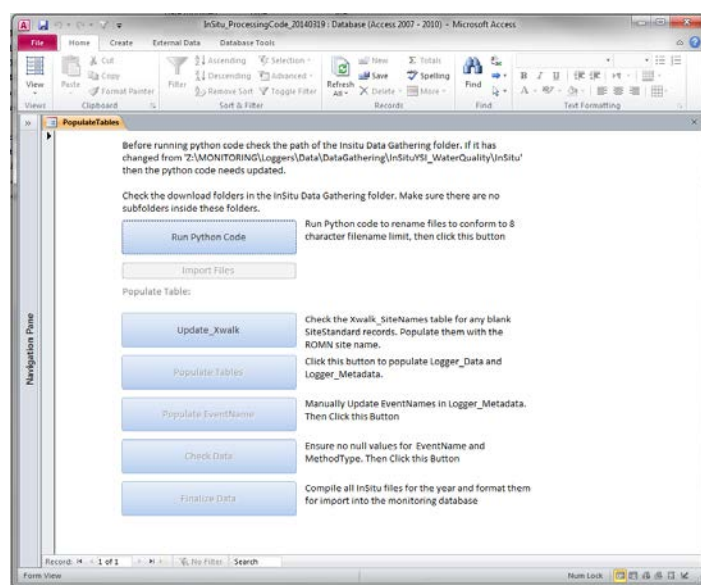


Figure 18-2. InSitu_ProcessingCode Access database.

5. Before running the python script check the path of the InSitu DataGathering folder. If it has changed then update the path in the python script.
6. Check the download folders in the InSitu DataGathering folder to make sure there is no more than one layer of sub folders in these folders. If there are .dbf files inside multiple layers of subfolders in the download folders they will be missed by the python script.
7. Check that there are no .dbf files still in the done folder before the script is run for the year.
8. Click the “Run Python Code” button to run the python script that renames files.
 - a. This script renames the InSitu files, keeping their file type, to meet the character limit needed for later automated processing steps to work.
 - b. Note, only files in the following location and one level of subfolders will be renamed:
Z:\MONITORING\Loggers\Data\DataGathering\InSituYSI_WaterQuality\InSitu\
 - c. The other folders in this location (Done, Old, ProcessNotes, Legacy) are automatically skipped by the code.
 - d. Files are automatically moved from the individual download folders into the done folder as they are renamed.
9. Click the “Import Files” button to import the files into the database.
 - a. The code will navigate to the done folder and read-in all .dbf files contained there that meet the format of beginning with Header, Manual, or Timed.
 - b. The code will append the .dbf file to the appropriate table in the database if the file is not already present.
 - c. The function in this code to open files has an eight character limit on the file names it will accept. If the code complains of being unable to find a file you know is present in the folder, check the length of the filename.
10. Check the “Xwalk_SiteNames” table and fill in SiteStandard and Protocol where they are null. Once there are no null fields click the “Update_Xwalk” button.
 - a. The field crew manually enters the Site name and it isn’t always the same as the standard format.
11. Click the populate data button.
12. Figure out and populate the event name for each record in the Logger_Metadata table using the SEI and WEI master databases. At this time confirm that all expected sites have been accounted for.

- a. If the record is an error check record (even if it occurs at a site) then enter the event name as “Error Check”.
 - b. This means looking at the folder as well as the site name.
13. Check that the Method_Type field is populated with timed or manual for every record.
14. If any InSitu data was written on field sheets, enter them with a Folder value of None and a Method_Type value of Manual. Ensure a Metadata record is populated.
15. Once all of the Event names have been populated click the “Populate Event Name” button.
16. Click the “Error Check Events” button to populate tlu_ErrorCheckEvents with a record for each error check file.
17. If it is obvious what event that error check would tie to then change the EventName in tlu_ErrorCheckEvents to the correct event name.
 - a. Leave the event name in Logger_Metadata as is.
18. If it is not obvious or the error check could correspond to multiple events then update the event name in tlu_ErrorCheckEvents to “To be determined”
19. Click the “Check Data” button.
 - a. If the Event name or method type is left null in any record a message box will pop up and the next button will not be enabled. Populate these fields fully to enable the next button.
20. Click the “Finalize Data” button.
21. Replace the “Xwalk_Sitenames” table in the database in the tools folder with the one that has been updated this season.

Z:\MONITORING\Loggers\Data\Tools
22. Delete all tables other than the Logger_* tables and save the database as InSitu_YearlyMaster_YYYY_YYYYMMDD.accdb on Z in:

Z:\MONITORING\Loggers\Data\Certified\FY##
23. Append the data in the Logger_* tables into the InSituYSI_WaterQuality_MASTER database:

Z:\MONITORING\Loggers\Data\Certified

 - a. There are a few fields that do not have identical names from one database to the other.

In Situ Water Physiochemistry Logger Processing Procedure: Office Processing Hanna Sonde

1. The data from the Hanna sonde is recorded on the field sheet packet.
2. These data are entered into the Data Entry database and QAQCed.

In Situ Water Physiochemistry Logger Processing Procedure: Office Processing InSitu SmartTroll

Offloading data from the iPod to a computer requires either wifi or a USB cable. Watch for files that are on the ipod but don't want to sync to iTunes.

Offloading via iTunes to a computer (no internet needed)

1. You must have an iTunes account with a purchased copy of the iSitu app. Up to 5 devices can be authorized with the same account information.
2. Connect iPod to computer using a USB cord. Open iTunes.
3. Select "SmartTroll iPod".
4. Select the "Apps" tab at the top.
5. Scroll to the bottom and select the i-Situ app icon.
6. On the right hand side of the screen, i-Situ Documents should come up.
7. Drag files to any location on your computer or select "Save to ..."
8. Save files to Z / MONITORING / Loggers / Data / DataGathering / InSituYSI_WaterQuality / SmartTroll. Make a new folder that includes the date in the name and a description of the files to be offloaded.
 - a. These can be separate folders for each download. It is fine that there will be multiple copies of files with this download method. The duplicates will be taken care of by the database.
 - b. Make sure that the only files in this folder are from the current year. (You can't just put it into a "done" folder because the database will check through all sub folders looking for files since we got a variety of folders.)

Offloading via email (WiFi needed)

1. The iPod must first be set up with an email account.

2. Open i-Situ app.
3. Select lower left most icon to bring up the logs.
4. Select the log you want to view or email (a red dot indicates it is selected).
5. Once the logs you want to email are all selected, click on the email icon on the lower right of the screen. It will open a message with the logs automatically attached. Send email.

Next Steps

1. Make sure the ready to import folder is empty. (You can put them into a “done” folder if you want to archive.)
2. Open the SmartTroll macro enabled workbook and go to macros and edit the import all loggers macro. Confirm that the path in the macro matches the path to the parent folder. Run the macro. This will take time, possibly up to 30mins to 1hr depending on how many files are going to be processed. More downloads will take more time to process.
 - a. If it is determined that this is too long (not bad for once a year but a lot to run many times) then look into turning off the screen updating while the code is running. I don't know how much time this will save but it should be a significant amount. This is done by the following:
 - i. At the beginning of your code put this line:
 - ii. `Application.ScreenUpdating = False`
 - iii. At the end of your code put this line:
 - iv. `Application.ScreenUpdating = True`
3. Once the macro is finished, open the processing database for the year. Get this from tools for the year and make sure the format will still work with the master.
4. Open the import excel macro and double check that the path is pointed towards the ready to import folder.
5. Click the import button.
 - a. The smart troll files includes the number of records the logger thinks it recorded so we include a check to see if the number of records that are read in matches that count. If not, a popup will occur listing the offending file name.
6. Click the update xwalk button to check the of the import files. Any new units that we have not seen before for that field will be added to the Xwalk_Units table. Check the accepted unit for that field and figure out the necessary conversion from the unit that was reported and the accepted unit.

7. If the conversion is a simple multiply or divide then list the conversion operator and the conversion factor in the appropriate fields. If there is a more complicated conversion needed then write a function and edit the query to call that query.
8. Note: There are some fields that are recorded by the sonde but we do not report on. If there is a decision to add these in the future then add a query to the update_LoggerSmartTroll section.
9. Click the Populate Tables button to populate the logger data and metadata tables. Note that this will start by clearing these tables.
10. Update all event names and site names and method types. (In 2014 they were all timed.)
11. Click the Check Data Button.
13. Click the Populate Error Check button to populate the tlu_Errorcheck table.
14. Test that the Error Check button is working. This was done by hand in 2014 for all three WQ Databases.
15. If the file is an error check then make the event name = "Error Check"
16. Where it is known which event the error check corresponds to, change the EventName in tlu_Errorcheck to that event. Where it is not known which event or the error check corresponds to multiple events change the event name in tlu_Errorcheck to "To Be Determined."
17. Click the finalize button.
18. Append the tables to the master and make a certified copy of the yearly data.

In Situ Water Physiochemistry Logger Processing Procedure: Certification

1. Move all raw files into:

Z:\MONITORING\Loggers\Data\Certified\FY##\RawData\InSituYSI_WaterQuality

2. Copy the yearly water chemistry databases from:

Z:\MONITORING\Loggers\Data\Certified\FY##\Databases

3. Paste them into the following places. FY## refers to the fiscal year to which the data correspond.

Z:\MONITORING\Wetlands\Data\Certified\FY##\Databases

Z:\MONITORING\Streams\Data\Certified\FY##\Databases

4. In each of the protocol-specific certified copies, remove any records that do not correspond to that protocol. Link Import_Logger_[Insitu/YSI]_Data and Import_Logger_[Insitu/YSI]_Metadata in the certified protocol database.
5. Ensure the data have been appended to the Data and Metadata tables in the InSituYSI_WaterQuality_MASTER database in:

Z:\MONITORING\Loggers\Data\Certified

Once the tables are in the master water quality database, summary queries can be run to produce the final summary tables.

WEI SOP 19: Data Analysis

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

As of publication, this SOP was under development. Future revisions will include updated background and methods.

WEI SOP 20: Revising the Protocol

Version 1.0, June 2015

Change History

Previous Version Number	Date	Author	Change Description	Reason	New Version Number

Introduction

This SOP explains how to make and track changes to the WEI Protocol, including its accompanying SOPs. While this protocol has been developed using current standardized methodology, all long-term monitoring programs need to be flexible to adapt to changes. As new technologies, methods, and equipment become available, this protocol will be updated as appropriate. Current best practices will be weighed against the continuity of protocol information in determining revisions. Project staff should refer to this SOP whenever edits are necessary and should be familiar with the protocol versioning system in order to identify and use the most current versions of the protocol documents. All changes will be made in a timely manner with the appropriate level of review.

All edits require review for clarity and technical soundness. Small changes to existing documents (e.g., formatting, simple clarification of existing content, small changes in the task schedule or project budget, or general updates to information management handling SOPs) may be reviewed in-house by ROMN staff. However, major changes to data collection or analysis techniques, sampling design, or response design will trigger an outside review.

Update Procedure

1. Discuss proposed changes with other project staff prior to making modifications. It is imperative to consult with the Data Manager prior to making changes because certain types of changes may jeopardize dataset integrity unless they are planned and executed to avoid this. Also, because certain changes may require altering the database structure or functionality, advance notice of changes is necessary to help minimize disruptions to project operations. Consensus should be reached regarding who will be making the changes and in what timeframe.

2. Make the agreed-upon changes in the appropriate protocol document. A change in one document may necessitate other changes elsewhere in the protocol. For example, a change in the narrative may require changes to several SOPs. Similarly, renumbering an SOP may mean changing document references in several other documents. Also, the project task list and other appendices may need to be updated to reflect changes in timing or responsibilities for the various project tasks.
3. Document all edits in the Change History Log embedded in the protocol narrative and each SOP. Log changes only in the document being edited (e.g., if there is a change to an SOP, log those changes only in that document). Record the previous version number, the date of the changes (i.e., the date when all changes were finalized), author of the revision, the change and the paragraph(s) and page(s) where changes are made, the (brief) reason for making the changes, and the new version number. Version numbers increase incrementally by hundredths (e.g., version 1.01, 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0).
4. Circulate the changed document for internal review among project staff and cooperators. Minor changes and clarifications will be reviewed in-house. When significant changes in methodology are suggested, revisions will first undergo internal review by the project staff. Additional external review including, but not limited to, National Park Service staff with appropriate water quality, aquatic communities, and statistical expertise will be required.
5. Upon ratifying and finalizing changes:
 - a. Ensure that the version number and date (in the document header) is updated properly throughout the document.
 - b. Make a copy of each changed file to the protocol archive folder (i.e., a subfolder under the Protocol folder in the project workspace).
 - c. The copied files should be renamed by appending the revision date in YYYYMMDD format. In this manner, the revision date becomes the version number and this copy becomes the “versioned” copy to be archived and distributed.
 - d. The current, primary version of the document (i.e., not the versioned document just copied and renamed) does not have a date stamp associated with it.
 - e. To avoid unplanned edits to the document, reset the document to read-only by right-clicking on the document in Windows Explorer and checking the appropriate box in the Properties popup.
 - f. Inform the Data Manager so the new version number(s) can be incorporated into the project metadata.

6. As appropriate, create PDF files of the versioned documents to post to the Internet and share with others. These PDF files should have the same name and be made from the versioned copy of the file.
7. Send a digital copy of the revised monitoring plan to the Network Contact and Network Data Manager. The revised monitoring plan will be forwarded to project and park staff who had been using a previous version of the affected document. Ensure that field staff have a hardcopy of the new version.
8. The Network Data Manager will place a copy of the revised protocol in the proper folder on the ROMN shared drive. In addition, the Network Data Manager will archive the previous version in the ROMN archive drive.
9. The Network Data Manager will post the revised version and update the associated records in the proper I&M databases, including but not limited to NatureBib, NPS Data Store, ROMN Intranet and Internet web sites, and the Protocol database.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 960/129020, June 2015

National Park Service
U.S. Department of the Interior



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