pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES
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Shale Gas Monitoring Manual

April 2017

Inventory and Monitoring Section

Table of Contents

Introduction

Scope and Purpose

With a potential 10,000 natural gas wells to be drilled on State Forest land in the next decade, Marcellus shale development has the potential to impact a wide range of environmental and social values of the state forest system including water quality and quantity, plant and animal habitats, increased fragmentation, invasive species, recreation and aesthetics, soil loss and quality, and air quality. A comprehensive and systematic program to track, detect, and report on these and other unknown impacts is critical for continued sustainable and adaptive management of Pennsylvania's State Forests. Monitoring and communicating the impacts of Marcellus shale development will aid in the development of additional best management practices for oil and gas development.

Monitoring environmental and social impacts of oil and gas development on state forest lands requires a blend of planning, on-the-ground management, data collection and analysis, research, and reporting. More specifically, monitoring includes detecting changes, tracking activities, reporting on the findings, and modifying practices where applicable.

DCNR has developed a three-tiered approach to implementing a comprehensive Oil and Gas Monitoring Program, consisting of:

1. On-the-ground management activities;
2. Research and external partner collaboration; and
3. An integrated and dedicated monitoring program.

This set of procedures outlines those components of #3, an integrated and dedicated monitoring program.

Process Overview

This manual is to be used as a field guide encompassing all the steps required for DCNR's monitoring field staff to conduct shale gas monitoring on state forest lands. It will be printed in the spring, when a majority of field work begins, updated every winter with revised and/or new procedures, and reprinted in the spring for the new field season.

Monitoring specialists will make revisions to their respective procedures as needed but all official manual updates will be made by the monitoring field staff and/or supervisor. Updates will not be incorporated into the manual until they have been piloted in the field and discussed by members of the integrated and dedicated monitoring program. The manual and all files associated with it and its management will be housed on a server local to the field staff. This can be found at \\nrford12ds1\RPI\RPI_RAID\Monitoring Protocols and Manuals. A document entitled "Manual and Protocol File Management" providing more detail on the management of this manual can be found at the above location.

Water Quality Monitoring

Field Chemistry Measurements

Purpose

Field chemistry measurement gives a discrete representation of basic water quality parameters:—like temperature, pH, conductivity, dissolved oxygen, alkalinity, and turbidity. Field chemistry procedures will be used in a variety of applications within the water monitoring program. It will be used as a stand-alone method when monitoring widespread sampling points throughout the gas districts. It will be used as a quality control check during the collection of surface water grab samples, and the maintenance of deployed water quality data loggers. Field chemistry measurements might also be used in a variety of different applications as they arise in the water monitoring program.

Equipment Needs

- YSI Pro Plus (or similar instrument)
- Meter-specific calibration log sheet
- pH and conductivity calibration solutions (for calibration)
- squirt bottle of distilled/deionized water
- Muckboots or waders
- Datasheets, field notebook, or tablet computer
- Kimwipes (for Turbidity and Alkalinity)
- Hach 2100Q Turbidity colorimeter kit
- Hanna Instruments HI 755 Checker HC Handheld Colorimeter kit (if not collecting grab samples)

When conducting work in streams with suspected or confirmed didymo populations, disinfect all applicable equipment according to procedures found in Disinfection of Didymo Infected Equipment

Calibration is preferably done in a stable, temperature controlled environment (the calibration standards should not be changing temperature). Dissolved Oxygen (DO) should be done in the field near the sampling site, and will need re-calibrated if the barometric pressure changes due to weather or to a change in elevation.

Calibration

At the beginning of each day that a YSI Pro Plus (or similar instrument) field meter is to be used, print out a blank copy of the calibration log sheet for the meter being used. Blank copies for each meter can be found at the following location: \\nrford12ds1\RPI\RPI_RAID\Water\Calibration Logs. Click on the first tab of the

spreadsheet for a "blank" copy. Fill out sheet accordingly when calibrating per the following procedures.

Turbidity calibration values need not be filled out on the calibration log sheet

Temperature

Temperature calibration is not required, nor is it available. The temperature sensor is located on the conductivity sensor (**Figure 2.1**).

Conductivity

- Fill the calibration cup with about 1/2 inch of 1000 µS/cm calibration solution. Tighten the cup. Shake the cup for several seconds, being sure that the temperature-conductivity sensor is splashed with the solution repeatedly. Open the cup and discard the solution. Repeat this process once.

- Fill the cup about 1/2 of the way to the top with calibration solution and tighten the cup. Shake the cup again and be sure after the final shake that the temperature-conductivity sensor is immersed in solution (**Figure 2.1**). Turn and gently tap the cup several times to be sure no air bubbles are trapped in the sensor.

- Press the CAL button. Select 'None' if prompted for a User ID.

- Highlight 'Conductivity' and press ENTER.

- Highlight 'Sp. Conductance' and press ENTER.

- Choose the units as 'SPC-µs/cm' and press ENTER.

- Highlight 'Calibration value' and press ENTER.

- Input the value of the calibration solution (probably 1000 µS/cm) and press ENTER.

- Wait for the specific conductance value under 'Actual Readings' to stabilize (stay the same for 5 seconds)

- Read and record the temperature and specific conductivity value in the meter's calibration log sheet as "Temp (°C)" and "Reads" respectively

- Highlight 'Accept Calibration' and press ENTER to calibrate the unit. If there is a problem with the calibration, you can press ESC at this stage to cancel the calibration, and then see the user manual for guidance on how to proceed.

- Read and record the specific conductivity value in the meter's calibration log sheet as "Adjusted"

- Next, perform a check of the calibration at 100 µS/cm. (Note: This check should not be done if using the YSI 63 Model.) You will not recalibrate nor do a two-point calibration; this is just a check to see the unit's accuracy at 100 µS/cm.
- Fill the screw-on plastic cup with about 1/2 inch of 100 uS/cm calibration solution. Tighten the cup. Shake the cup for several seconds, being sure that the temperature-conductivity sensor is splashed with the solution repeatedly. Open the cup and discard the solution. Repeat this process once.

- Fill the cup about 1/2 of the way to the top with calibration solution and tighten the cup. Shake the cup again and be sure after the final shake that the temperature-conductivity sensor is immersed in solution. Turn and gently tap the cup several times to be sure no air bubbles are trapped in the sensor.

- Without pressing any calibration buttons, read and record the specific conductivity value in the meter's calibration log sheet as "Reads." Also record temperature as "Temp (°C)". Open the cup and discard the solution.

The specific conductance reading should be within 95 to 105 µS/cm, or the meter should be recalibrated.

- Finally, perform a check of specific conductivity in air. Rinse the sensors with distilled water, shaking off excess. Blow through the conductivity sensor port holes, attempting to clear them of any excess liquid. The specific conductivity reading should settle at or near "zero". When it does, read and record the specific conductivity value in the meter's calibration log sheet as "Reads".

- Finish filling out the specific conductance section of the calibration log sheet with the calibration standard information, calibration location, and your initials.

pH

- Fill the calibration cup with about 1/2 inch of pH 7 calibration solution. Tighten the cup. Shake the cup for several seconds, being sure that the pH sensor is splashed with the solution repeatedly. Open the cup and discard the solution.

- Fill the cup about 1/2 of the way to the top with calibration solution and tighten the cup. Shake the cup again and be sure after the final shake that the pH sensor is immersed in solution (**Figure 2.1**). Turn and gently tap the cup several times to be sure no air bubbles are trapped in the sensor.

- Press the CAL button. Select 'None' if prompted for a User ID.

- Highlight 'ISE1 pH' and press ENTER.

- The instrument should automatically recognize the pH buffer value and display it at the top of the screen. If necessary, highlight 'Calibration value' and press ENTER. Then input the value of the calibration solution and press ENTER.

- Once the pH and temperature readings stabilize, read and record the temperature, pH value, and pH millivolts in the meter's calibration log sheet as "Temp (°C)", "Reads", and "Millivolts" respectively. "Adjusted" should not be filled out for pH 7 buffer.

- Highlight 'Accept Calibration' and press ENTER. The message line will then display, 'Ready for point 2.'

- Repeat the rinsing and filling of the calibration cup with pH 4 solution.

- The instrument should automatically recognize the pH buffer value and display it at the top of the screen. If necessary, highlight 'Calibration value' and press ENTER. Then input the value of the calibration solution and press ENTER.

- Once the pH and temperature readings stabilize, read and record the temperature, pH value, and pH millivolts in the meter's calibration log sheet as "Temp (°C)", "Reads", and "Millivolts" respectively. "Adjusted" should not be filled out for pH 4 buffer.

- Highlight 'Accept Calibration' and press ENTER. The message line will then display, 'Ready for point 3.'

- Repeat the rinsing and filling of the calibration cup with pH 10 solution.

- The instrument should automatically recognize the pH buffer value and display it at the top of the screen. If necessary, highlight 'Calibration value' and press ENTER. Then input the value of the calibration solution and press ENTER.

- Once the pH and temperature readings stabilize, read and record the temperature, pH value, and pH millivolts in the meter's calibration log sheet as "Temp (°C)", "Reads", and "Millivolts" respectively.

- Highlight 'Accept Calibration' and press ENTER. After accepting calibration on pH 10, press CAL to finalize the calibration. If there is a problem with the calibration, you can press ESC at this stage to cancel the calibration, and then see the user manual for guidance on how to proceed.

- After finalizing calibration, the meter will return to the main screen. While the sensor is still immersed in the pH 10 buffer, record the displayed pH value on the calibration log sheet as "Adjusted" in the pH 10 buffer row

- Finish filling out the pH section of the calibration log sheet with the buffer information, calibration location, and your initials. Ignore the "Slope" column.

Dissolved Oxygen

- Dissolved Oxygen will be calibrated (if applicable) using a water-saturated air method. The supplied screw-on plastic cup will be used for calibration (i.e., the calibration cup).

All DO calibrations should be completed onsite or very near the site where the field meter is to be used!

- Place about 1/8 inch of water in the bottom of the calibration cup.

- Make sure there are no water droplets on the DO membrane or temperature sensor. Then install the cup over the sensors. Screw the cup all the way onto the cable, and then disengage one or two threads to ensure atmospheric venting. Make sure the DO and temperature sensor is not immersed in water (**Figure 2.1**).

- Turn the instrument on and wait approximately 5-10 minutes for the cup to become completely saturated and to allow the sensors to stabilize.

- Once the readings stabilize, read and record the DO% and DO mg/L values in the meter's calibration log sheet as "Reads".

- Press the CAL button. Select 'None' if prompted for a User ID.

- Highlight 'DO' and press ENTER.

- Highlight 'DO %' and press ENTER.

- Wait for the temperature and DO% values under 'Actual Readings' to stabilize (stay the same for 5 seconds), then highlight 'Accept Calibration' and press ENTER to calibrate the unit. If there is a problem with the calibration, you can press ESC at this stage to cancel the calibration, and then see the user manual for guidance on how to proceed.

- Upon returning to the main screen, read and record the temperature and barometric pressure as "Temp (°C)" and "Baro. Pressure" respectively

- The DO mg/L value after the calibration should be compared to the chart of Dissolved Oxygen (mg/L) 100% Saturation Values found in the supporting documents section of this manual. Based on the temperature and barometric pressure read from the Pro Plus, the theoretical value is obtained from the chart. Record the theoretical value obtained from the chart in the meter's calibration log sheet as "Thero. Value"

- Read and record the final DO % and DO mg/L values in the meter's calibration log sheet as "Final".

The theoretical value should be within 0.5 mg/L of the post-calibration value on the Pro Plus. If not, the Pro Plus should be recalibrated for dissolved oxygen.

- Finish filling out the dissolved oxygen section of the calibration log sheet with the calibration location (i.e. stream name), your initials, and any additional sites for the day the preceded calibration information is relevant for (if applicable). Use additional dissolved oxygen sections at the bottom of calibration log sheet as needed.

Turbidity

- Calibrate the turbidity meter (can also be done before leaving the office or in the field).
  - Turn on the 2100Q with the blue power button.
  - Press the calibration button  . (Note: The 2100Q need only be calibrated once daily.)
  - Remove the 20 NTU calibration cell from the case. Invert it several times to ensure good mixing. Apply one drop of silicone oil and wipe with the black cloth.
  - Insert the 20 NTU calibration cell into the 2100Q, making sure that the arrow faces directly toward the front of the unit. Close the lid until it clicks. Press the Read button. Wait for the unit to stabilize. The unit will prompt you when ready for the next calibration standard.
  - Repeat these steps for the 100 NTU and 800 NTU calibration cells.
  - Press Done to review and save the results. Press Store.
  - Remove the 10 NTU verification standard cell from the case. Invert is several times to ensure good mixing. Apply one drop of silicone oil and wipe with the black cloth.
  - Insert the 10 NTU verification standard cell into the 2100Q, making sure that the arrow faces directly toward the front of the unit. Close the lid until it clicks. Press the Read button. Wait for the unit to stabilize. If the verification fails, try recalibrating the unit. If it is successful, press Done.
  - The turbidity meter is now calibrated.

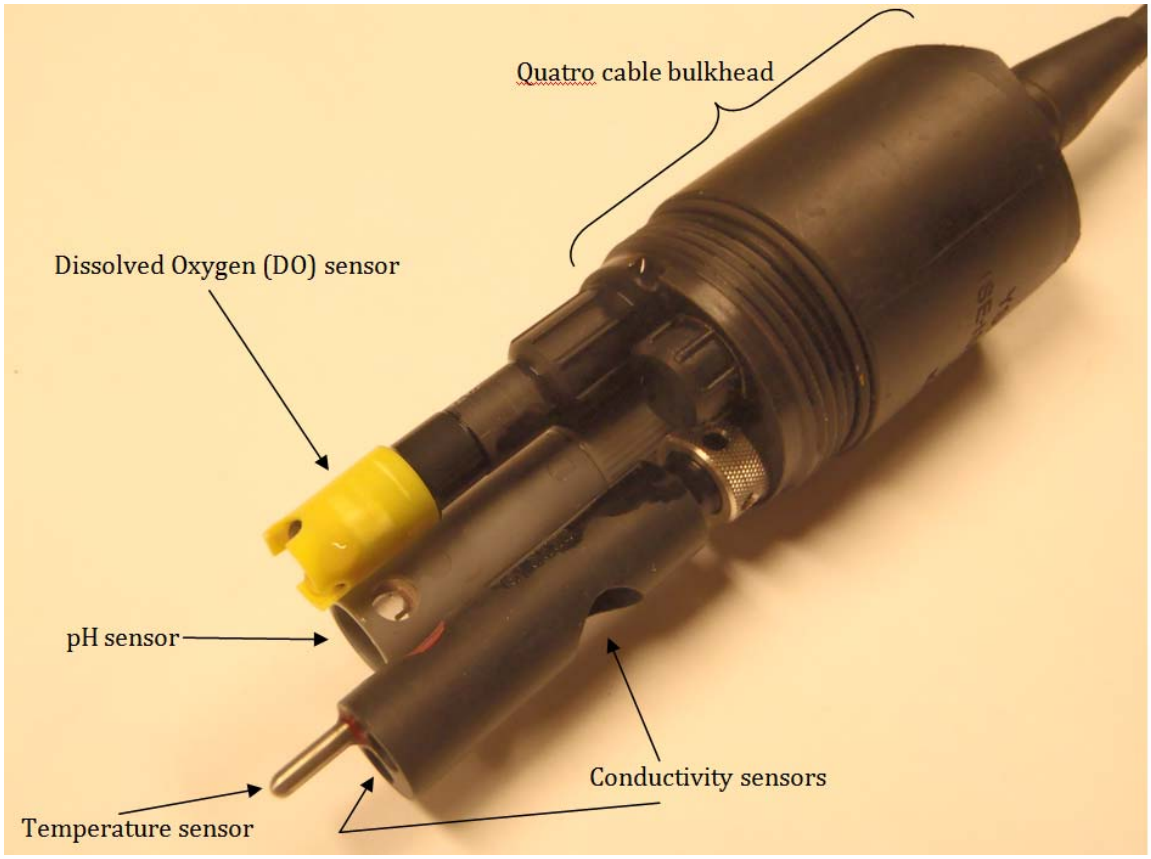


Figure 2.1 YSI Pro Plus sensors

Taking Measurements

- Turn the YSI Pro plus (or similar instrument) on. If you have moved to a new sampling location, you should recalibrate e the DO sensor, if applicable. This is because the barometric pressure may have changed from your last sampling location to the next due to change in weather or elevation.

- Install the metal sensor guard (with holes in it).

- Enter the stream downstream from your monitoring point to avoid introducing disturbed sediment to the monitoring point.

- Place the probe near the center of the current, in an area of uniform, well-mixed flow. The probe should be away from the stream bank and in the current (i.e., do not sample stagnant or non-flowing water).

- Once the probe is in place, give the cord a slight twist and shake to dislodge any air bubbles trapped in the sensors. If measuring DO, it is best to lay the sensor guard perpendicular to flow, such that water will be flowing past the tip of the DO sensor.

- Once readings stabilize (stay the same for 5 seconds), record them in a field notebook, datasheet, or tablet computer.

- At the conclusion of each day, ensure the Pro Plus is stored with a small amount of water in the bottom of the calibration cup and the cup is tightened on the Quatro cable bulkhead.

For long term storage (i.e. > 1 month), refer to user manual.

- Fill a turbidity sample vial for later reading by the Hach 2100Q turbidity meter.
  - Rinse the sample vial and cap three times with stream water in an area of good flow.
  - To fill the vial, hold the sample vial away from your body as far upstream as possible. Hold the vial upside down, dip it into the water until it is approximately at mid-depth of the water, turn the vial to face upstream, and let it fill. Take care not to disturb the stream bottom, as you may introduce sediment or debris into the sample. Be sure to fill the vial to the white line and screw on the cap.

- Read turbidity using the HACH 2100Q turbidity meter.
  - Dry the turbidity sample vial (the one with the sample water) with a kim wipe.
  - Then apply one drop of silicone oil and wipe with the black cloth.
  - Invert the sample cell several times to ensure good mixing, then insert the sample cell into the 2100Q, making sure that the arrow faces directly toward the front of the unit. Close the lid until it clicks. Press the Read button. Record the result in the appropriate place in the field notebook.
  - If the result is greater than 20 NTU, then press the Options button. Change the Read Mode to Rapidly Settling Turbidity. (***Note:*** Results below 20 NTU should use the Signal Average Read Mode.) Then re-read the sample. Record the second result in the field notebook with a notation that it was Rapidly Settling Turbidity mode.
  - Once reading is completed, empty the sample cell. Rinse it once with distilled water, fill it to the line with distilled water, and screw on the cap. The sample cell should always be stored filled with distilled water.

Alkalinity

Alkalinity testing will only be done if no grab samples will be taken, such as in Wide-Spread Monitoring, ad hoc monitoring, or incident screening.

- Turn the meter on by pressing the button, all segments will be displayed. When the display shows ''Add'', ''C.1'' with ''Press'' blinking, the meter is ready.
- Fill the cuvette with 10 mL of unreacted sample according to standard rinse fill procedures and replace the cap.
- Dry the cuvette with a kimwipe, making sure it is free of fingerprints, oil and/or dirt
- If bubbles are present in the sample, gently swirl or tap to dislodge the bubbles. DO NOT SHAKE as a higher reading can be generated.
- Place the cuvette into the meter and close the meter's cap
- Press the button. When the display shows "Add", "C.2" with "Press" blinking the meter is zeroed
- Remove the cuvette, open it, and using a 1 mL syringe carefully add exactly 1.00 mL of Alkalinity Reagent to the sample

Use the curved plastic attachment only as a protective cap; do not use it when collecting reagent. Do not let the reacted sample stand for too long after reagent is added, as accuracy will be affected.

- Replace the cap and gently invert 5 times. Place the cuvette back into the meter
- Press the button. The instrument directly displays the concentration of alkalinity in ppm of CaCO3.

After the reading it is important to discard the sample immediately, otherwise the glass might become permanently stained.

Figure 2.2 Alkalinity Handheld Colorimeter Kit

Data Management

This will vary depending on the application.

- If using a tablet computer coincident with an ArcPad application, as in the widespread sampling, refer to the supporting documents section of this manual for instructions on Checking In/Checking Out Data for ArcPad.

- Other applications may also require field chemistry data be kept in a designated field notebook, as with the surface water grab sampling and HOBO maintenance applications.

- Enter all calibration data from the calibration log sheet into the appropriate excel spreadsheet for the field meter used at the following location: \\nrford12ds1\RPI\RPI_RAID\Water\Calibration Logs. Simply make a copy of the "Place Date Here-BLANK" log sheet, place it at the end of the tabs, rename the tab with the date of calibration using the format day-month-year (e.g. 18 July 2014), fill in the information, and save the spreadsheet.

Surface Water Grab Sampling and Flow Measurement

Purpose

Surface water grab sampling and flow measurement is employed to obtain a discrete analysis of chemical constituents and flow at a given point in a stream. This information can be used to identify pollutants and/or to characterize the background chemical and hydrological characteristics of the stream. Although only representative of a point in time at a single location, these techniques provide the opportunity to accurately measure the concentrations of various parameters in a stream. Surface water grab sampling and flow measurement will be employed alongside continuous monitoring devices (e.g., sondes, Hobos) to compliment and verify the data from the continuous monitoring devices.

Equipment Needs

- YSI Pro Plus (or similar instrument)
- Conductivity and pH calibration solutions (for calibration of Pro Plus unit)
- squirt bottle of distilled/deionized water
- Ultra pure water (if collecting an equipment blank)
- Lint-free wipes (e.g., Kimwipes)
- Paper towels
- 500 mL plastic sample bottles (# needed depends on number and type of samples)
- 125 ml plastic sample bottles (# needed depends on number and type of samples)
- 1 L glass sample bottles (if doing organics)
- 40 ml VOA vials (if doing organics)
- Flow meter
- Wading rod for flow meter
- 50-foot+ measuring tape, with 1/10 foot increments
- HACH 2100Q turbidity meter
- Permanent marker (Sharpie – fine point)
- Clear packaging tape
- Bottle labels (if doing organics)
- DEP Lab sample submission sheet
- 1 gal. clear Ziploc bag
- Ice
- Cooler
- Preservatives (always nitric acid for metals, sulfuric acid if doing nutrients, and hydrochloric acid if doing organics)
- Disposable latex gloves (i.e. surgical gloves)
- Muckboots or waders
- Field notebook

- Nylon mesh bag (for keeping samples cool in stream)
- Waterproof pen or pencil

NOTE

When conducting work in streams with suspected or confirmed didymo populations, disinfect all applicable equipment according to procedures found in Disinfection of Didymo Infected Equipment

Procedures

Preparation and Staging

- Calibrate the YSI Pro Plus according to the *Calibration* procedure outlined in the *Field Chemistry Measurements* section of this manual. . REMEMBER: A calibration log sheet will need to be filled out each day a YSI Pro Plus (or similar instrument) is used

NOTE

It is recommended to calibrate the YSI Pro Plus for conductivity and pH before leaving the office, but this could also be done in the field if enough calibration solution is taken. ALWAYS CALIBRATE DISSOLVED ONSITE OR AT VEHICLE NEAR SITE.

- IF SHIPPING GRAB SAMPLES VIA COMMERCIAL COURIER, be sure to call courier service before leaving the office to set up delivery according to the Preparing Grab Samples via Commercial Carrier procedure found in the appendix of this manual.

- Calibrate the turbidity meter (can also be done before leaving the office or in the field).
  - Turn on the 2100Q with the blue power button.
  - Press the calibration button  . (Note: The 2100Q need only be calibrated once daily.)
  - Remove the 20 NTU calibration cell from the case. Invert it several times to ensure good mixing. Apply one drop of silicone oil and wipe with the black cloth.
  - Insert the 20 NTU calibration cell into the 2100Q, making sure that the arrow faces directly toward the front of the unit. Close the lid until it clicks. Press the Read button. Wait for the unit to stabilize. The unit will prompt you when ready for the next calibration standard.
  - Repeat these steps for the 100 NTU and 800 NTU calibration cells.
  - Press “Done” to review and save the results. Press “Store”.
  - Remove the 10 NTU verification standard cell from the case. Invert is several times to ensure good mixing. Apply one drop of silicone oil and wipe with the black cloth.

  - Insert the 10 NTU verification standard cell into the 2100Q, making sure that the arrow faces directly toward the front of the unit. Close the lid until it clicks. Press the Read button. Wait for the unit to stabilize. If the verification fails, try recalibrating the unit. If it is successful, press Done.
  - The turbidity meter is now calibrated.

- Upon arrival to site of interest, gather and label necessary sample bottles at vehicle.
  - If doing SAC 972: one 500 mL plastic bottle, and one 125 mL plastic bottle
  - If doing SAC 046: three 500 mL plastic bottles, and two 125 mL plastic bottle
  - If doing organics: six 40 mL glass amber vials, and two 1 L glass amber bottle
  - If ONLY doing methane: two 40ml glass amber vials

- Label sample bottles as follows:
  - For plastic bottles, use a permanent marker.
  - For glass bottles, use an ink pen and bottle labels.
  - For all sample bottles, include:
    - On the first line: your personal Collector ID, a dash, and the sequence number (the next sequential number of samples for the collector, obtained from field notebook)
    - On the second line: the type of analysis (e.g., "Gen Chem" for General Chemistry) and number of bottles if more than two (e.g., 1/2 or 2/2)
    - On the third line: the preservative, if applicable
  - If doing SAC 972:
    - Label a 500 mL bottle as Gen Chem with no preservative
    - Label a 125 mL bottle as Metals with HNO3 preservative
  - If doing SAC 046:
    - Label three 500 mL bottles as Gen Chem with no preservative
    - Label a 125 mL bottle as Metals with HNO3 preservative
    - Label a 125 mL bottle as Nutrients with H2SO4 preservative
  - If doing organics:
    - Label two 40 mL vials as VOASW with HCL preservative
    - Label two 40 mL vials as WSOL with no preservative
    - Label two 40 mL vials as METH with no preservative
    - Label two 1 L glass bottles as SV-SW with no preservative
  - Cover each label with clear packaging tape.

- Gather the following equipment, and hike to the water sampling site of interest:
  - YSI Pro Plus (or similar instrument), be sure to have metal sensor guard
  - Labeled sample bottles
  - Sample vial(s) from turbidity meter
  - Flow meter
  - Wading rod for flow meter

- 50-foot+ measuring tape, with 1/10 foot increments
- Field notebook and pen/pencil
- Nylon mesh bag

- Once onsite where the grab samples will be taken, write the date, stream name/location, time onsite (military format), and the last names of the sampling crew in the field notebook.

- Note the collector ID, sequence number, and what SAC or organics sampling are being performed [e.g. Sample 9931-114 SAC 972 (Gen Chem, Metals)]

- Record the equipment's serial number for the YSI Pro Plus (or other field meter) being used in the field notebook

For this information and subsequent information to be noted in the field notebook follow formatting previously established in the field notebook. (**Figure 2.4**)

Field Chemistry Measurement

- Measurements with the YSI Pro Plus should be taken in the mid-channel of where the grab samples will be taken. This should be done slightly downstream of the cross-section where the grab samples will be taken so as not to disturb the sampling area.

If coincident with a Hobo deployment site, take measurements as close to Hobo as possible

- From the Pro Plus, take a reading of temperature, dissolved oxygen (%), dissolved oxygen (mg/L), specific conductance, conductivity, and pH according to the *Taking Measurements* section of the Field Chemistry Measurements procedure. THE TIME (MILITARY FORMAT) OF THIS MEASUREMENT SHOULD BE RECORDED AS WELL. Record this information in the appropriate location in the field notebook.

Alkalinity need not be measured since this information will be analyzed at the DEP lab.

- Remove the Pro Plus sensor from the stream.

- Fill turbidity sample vial for later reading by the Hach 2100Q turbidity meter.
  - Rinse the sample vial and cap three times with stream water in an area of good flow.
  - To fill the vial, hold the sample vial away from your body as far upstream as possible. Hold the vial upside down, dip it into the water until it is

approximately at mid-depth of the water, turn the vial to face upstream, and let it fill. Take care not to disturb the stream bottom, as you may introduce sediment or debris into the sample. Be sure to fill the vial to the white line and screw on the cap.

- If Hach meter malfunctions or was forgotten, you can have the lab perform this test by writing "ADD TURBIDITY" in the "Additional Comments" section of the sample submission form.

Bottle Sampling

Typical Sampling (for Gen Chem, Metals, and Nutrients)

Neither SAC 046 nor SAC 972 normally test for METH, which will need collected whenever a grab sample is taken. Refer to "METH and WSOL Sampling" below for instructions on filling METH bottles. Be sure to write "ADD METH" in the "Additional Comments" section of the sample submission form

- Record the time (military format) the grab samples are taken in the appropriate place in the field notebook
- Rinse a sample bottle and cap three times with stream water in an area of good flow.
- To sample, hold the sampling bottle away from your body as far upstream as possible. Hold the bottle upside down, dip it into the water until it is approximately at mid-depth of the water, turn the bottle to face upstream, and let it fill. Take care not to disturb the stream bottom, as you may introduce sediment or debris into the sample. Each bottle should be filled to the bottom of the neck of the bottle, leaving some space at the top.
- Repeat this filling procedure for additional bottles
- Put on latex gloves. Add preservatives (if applicable) as indicated on the label by pouring one ampule (2ml) of preservative into the bottle.
- Preservative can also be added from bulk acid supply using a pipette. First use the pipette to acquire 2mL of bulk acid from the appropriate supply, then add to the appropriate sample.

Each pipette is stored its own 500ml bottle labelled HNO3 or H2SO4, respectively. The HNO3 and H2SO4 are stored in 500ml bottles supplied by the DEP lab (ask Ecological Program Specialist for water monitoring to acquire these preservatives

from the lab). Periodically clean carrier and replace pipettes frequently to help avoid contamination.

- Cap the bottle tightly and invert several times to mix the preservative into the sample water.

For sample bottles that require preservative, this can be done onsite or back at the vehicle. Back at the vehicle is recommended as it minimizes what you need to carry into the sample site. Whichever option is decided, it is important to remember that samples should be preserved and chilled as soon as possible. The integrity of the sample deteriorates the more time that elapses between sampling and preservation/chilling. This becomes increasingly important in warmer temperatures. Because you'll take grab samples before conducting other tasks like flow measurement or macroinvertebrate collection, place bottles in nylon mesh bag to keep in-stream until you are ready to leave.

VOASW Sampling

- Rinse a 1 L glass bottle and cap three times with stream water in an area of good flow.
- Fill the 1 L glass bottle as indicated above and replace cap.
- Rinse each 40 mL glass vial and cap three times with stream water.
- Put on latex gloves.
- Add one HCL ampule to each of the 40 mL vials.
- For each 40 mL vial, carefully pour water from the 1 L glass bottle into the vial, being careful not to overfill. If necessary, fill the cap of the 1 L glass bottle with sample water to gently finish the filling. Fill the vial until a slight meniscus occurs above the top of the vial, then tightly screw on the cap. Invert the vial and tap it gently on your wrist, making certain that no air bubbles appear. If air bubbles appear, unscrew the cap and gently pour additional water to create the meniscus again, then screw on cap and retest for air bubbles.

Again this procedure can be done onsite or at the vehicle. If filling 40 mL vials at the vehicle, stream water from the 1 L bottle will need to be used for rinsing. Take and fill an additional bottle with stream water onsite if needed.

SV-SW Sampling

- Rinse a 1 L bottle and cap three times with stream water in an area of good flow.

- Fill the 1 L glass bottle as indicated above in the *Typical Sampling* section, up to the neck of the bottle.

- Repeat rinsing and filling procedure for second bottle.

METH and WSOL Sampling

- Rinse a 40 mL vial and cap three times with stream water in an area of good flow.

- Fill the vial as indicated above in the *Typical Sampling* section.

- If necessary, fill the cap of the vial with stream water to gently finish the filling. Fill the vial until a slight meniscus occurs above the top of the vial, then tightly screw on the cap. Invert the vial and tap it gently on your wrist, making certain that no air bubbles appear. If air bubbles appear, unscrew the cap and gently pour additional water to create the meniscus again, then screw on cap and retest for air bubbles.

- Repeat rinsing and filling for additional bottles.

You need two of these 40ml vials for one METH sample.

Flow Measurement

- Select a cross-section of the stream that has relatively uniform, even flow. This will typically be in a straight section of the stream(usually a run). Remove any cobbles, twigs, or other obstructions that will interfere with the flow measurement. You should aim to have as uniform a stream-bottom as possible, without rocks obstructing flow immediately under, upstream, or downstream of the tagline (see next bullet). An ideal cross- section for flow would be a rectangle.

- Anchor a measuring tape (with 1/10 foot increments) across the stream. This will serve as the "tagline" for the flow measurement. The tape should be secured one foot or so above the water level and as tightly as possible. Wrapping the tape around a cobble and laying the cobble on the bank is often a good approach for securing the tape.

- Begin to prepare the flow meter by attaching the sensor to the base of the wading rod. Be sure that the metal back of the sensor is flush with the mount on the wading rod before tightening the screw on the sensor to secure it.

- Connect the sensor cable to the top of the handheld device making sure the notch inside the sensor cable end lines up with the slot on the handheld device . Hand-tighten until snug (do not use a wrench, do not overtighten).

- Attach the plastic clamp to the handheld device .

- Attach the clamp to the wading rod near the base of the yellow handle (just below the "0" mark). Be sure not to tighten clamp against the depth rod, as the rod will be not be able to slide to adjust for depth.

- Turn on the handheld, allow it to self test (with the unit out of the water), and press OK. If self test fails, call the manufacturer.

- Select PROFILER. Enter your intitials or employee number. Press OK.

- Select STREAM. Enter name of stream. Press OK.

- STAGE REFERENCE refers to an established gauging station the point where flow is taken, if one was established. Where ever a Hobo or data logger is emplaced, the STAGE REFERENCE will be the depth at the Hobo, which is found by placing the flow depth transducer on top the Hobo shroud. When prompted to enter STAGE REFERENCE, enter this value, or "0" if there is no Hobo emplaced at the site.

- Enter stream width at tagline by reading the tape where it overlaps the water's edge (the higher of the two tape values). Press OK.

- Enter tagline offset by reading the tape where it overlaps the water's edge on the other side of the stream (the lower of the two tape values). Press OK.

- Enter the number of stations. Ideally, 22 stations should be performed. If this is not reasonable, due to how narrow the stream is, then fewer stations can be performed. For streams less than 6 feet wide, use the following equation to determine the number of stations: (approximate stream width in feet *2) + 2. Press OK.

- Begin at station one. Station one will be on the lower end of the tagline. Select EDGE/OBSTRUCTION and press OK, identify this station as Left or Right Bank (as you face downstream). Press OK.

Flow will typically be "0" for the first and last stations on most cross-sections. No flow measurement is taken here.

- Select NEXT to move to Station 2.
  - Select DISTANCE TO VERTICAL. This will tell you were along the tagline to position the wading rod for Station 2. Once properly positioned, select OK to return to the previous menu.
  - Select SET DEPTH and drop the sensor to the bottom of the stream by sliding the depth rod down as far as it will go. The depth of the stream at this point will be displayed. Press OK to return to main screen.
  - Select MEASURE VELOCITY, then ONE POINT, then "0.6,"press OK.

The next screen refers to where the sensor is in the stream channel—60% off of the bottom. If stream portion is deeper than two feet, it is recommended to do a TWO POINT at 0.2 and 0.8 (20% and 80%, respectively).

  - Adjust depth rod up until the sensor is positioned in the "capture zone". When it is, the indicator will turn green, and the sensor depth should read very close to target depth indicated on the screen.
  - At this point, the meter is about to capture velocity data, so be certain the sensor is pointed directly into the direction of flow.
  - Select CAPTURE. The meter will measure an average flow over 10 seconds. When the status line near the bottom of the screen reaches the right edge of the screen, the sensor has measured flow for 10 seconds. (If the wading rod moves or the measurement is otherwise disrupted, select REPEAT to redo the measurement.)
  - Select OK, then MAIN, then NEXT to proceed to Station 3.

- Repeat the steps in the sub-bullets above for the remaining stations.

- At the last station, under the EDGE/OBSTRUCTION menu, identify the station as Left or Right Bank (as you face downstream). Press OK

- When done with the last station, select CHANNEL SUMMARY. Record the displayed flow (cfs) in the appropriate place in the field notebook. Also record the number of stations performed and stream width (to the nearest tenth foot).

- Electronically save the flow data for upload later into the stream's "target folder". Select "Save Data and Exit", enter the stream name, press OK.

- Select DONE, then power down the unit.

If the top of the sensor is exposed above the water surface, then the depth for that station should be set to "0" and no flow should be captured at that station.

When disassembling the flow meter, be certain that the lock screw on the sensor is tightened back in several turns after removing it from the wading rod, so that the screw does not fall out.

Processing and Packaging

- When leaving the site, record offsite time (military format) in the appropriate place in the field notebook.

- Upon returning to the vehicle, read turbidity using the HACH 2100Q turbidity meter.
  - Dry the turbidity sample vial (the one with the sample water) with a kim wipe.
  - Then apply one drop of silicone oil and wipe with the black cloth.
  - Invert the sample cell several times to ensure good mixing, then insert the sample cell into the 2100Q, making sure that the arrow faces directly toward the front of the unit. Close the lid until it clicks. Press the Read button. Record the result in the appropriate place in the field notebook.
  - If the result is greater than 20 NTU, then press the Options button. Change the Read Mode to Rapidly Settling Turbidity. (***Note:*** Results below 20 NTU should use the Signal Average Read Mode.) Then re-read the sample. Record the second result in the field notebook with a notation that it was Rapidly Settling Turbidity mode.
  - Once reading is completed, empty the sample cell. Rinse it once with distilled water, fill it to the line with distilled water, and screw on the cap. The sample cell should always be stored filled with distilled water.

- Prepare all sample bottles for transport according to the Preparing Grab Samples for Courier Pickup procedure found in the appendix of this manual.

- At the conclusion of each day, ensure the Pro Plus is stored with a small amount of water in the bottom of the calibration cup and the cup is tightened on the Quatro cable bulkhead.

For long term storage (i.e. > 1 month), refer to user manual.

Quality Control

- For quality control related to Field Chemistry Measurement, see the Field Chemistry Measurements procedure found in this manual.

- For quality control related to the grab samples, an equipment blank and a duplicate sample will be collected. The equipment blank will check for sampler error while the duplicate sample will ensure the lab's accuracy. BOTH will be collected every 10 samples. This means sequence numbers 001-010 would be actual samples and then sequence number 011 would be a duplicate sample of sequence number 010. Sequence number 012 would be a blank. Continuing, sequence numbers 013-022 would be actual samples and then sequence number 023 would be a duplicate sample of sequence number 022. Sequence number 024 would be a blank. This pattern should continue to ensure quality control.

Duplicate

To collect a duplicate, follow the following procedures:

This must be done in the field at the grab sampling site as you will be using the same stream water used for the "real" samples. Prepare your bottles with your other sampling bottles at vehicle before hiking in to the sampling site.

- Label the sample bottles as if they were another regular sample in the sequence at the site. Use the sequence number immediately following the number for the "real" sample.

- When recording information for the "real" sample, also record the time (military format), collector ID, and sequence number for the duplicate in the appropriate place in the field notebook (**Figure 2.3**)

- Indicate this sample as a duplicate of the "real" sample (**Figure 2.3**)

- When obtaining sample water for the "real" sample via one of the methods in the *Bottle Sampling* section above, fill the second set of sample bottles for the duplicate as well.

- Add preservative as appropriate. For VOASW samples, add the preservative before filling the vial (as would be done for normal sampling).

- When done filling sample bottles and adding appropriate preservative(s), prepare all sample bottles for transport according to the Preparing Grab Samples for Courier Pickup procedure found in Appendix B of this manual (just as you would do for a normal sample).

Equipment Blank (i.e., Rinsate Blank)

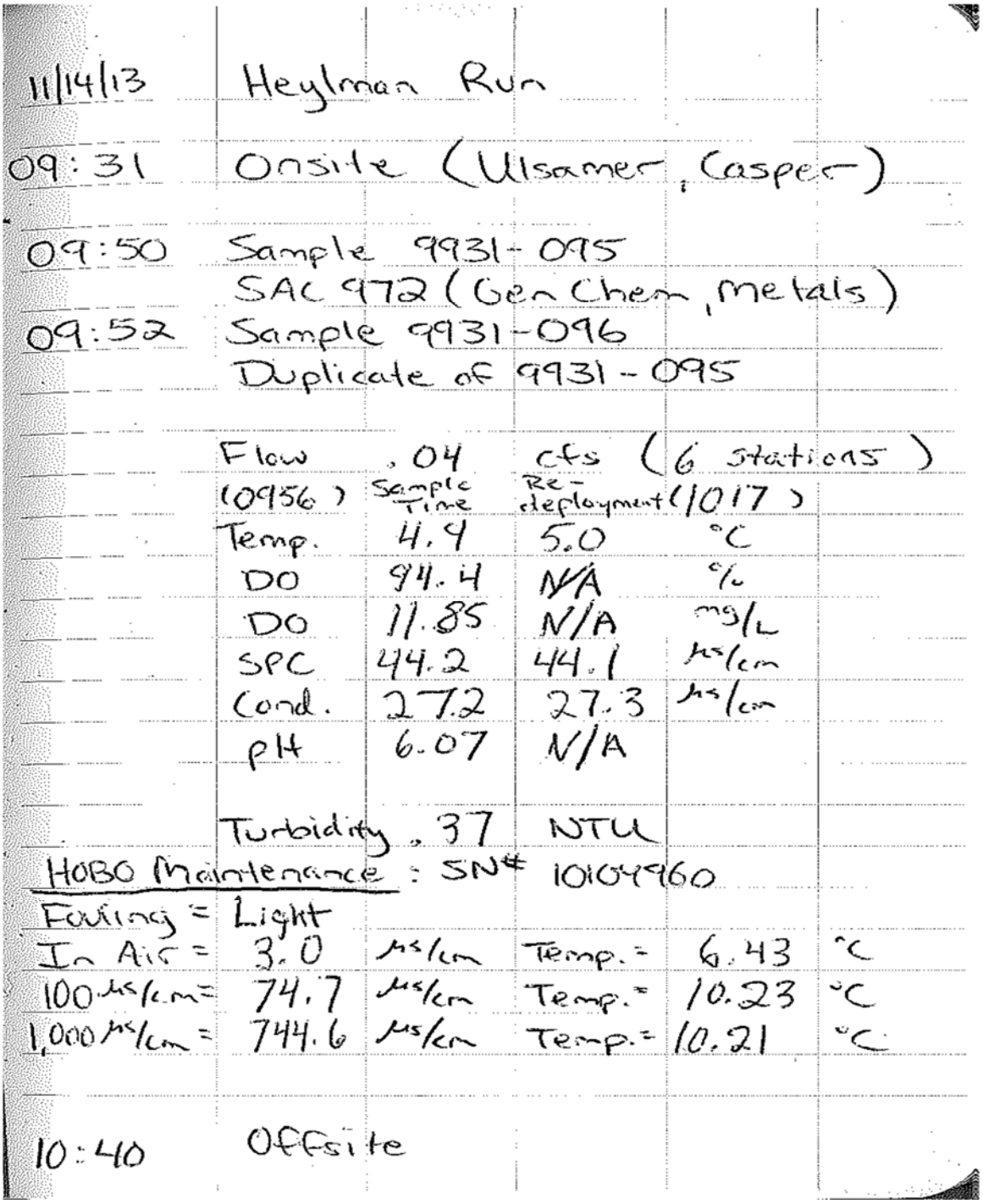
To collect an equipment blank, follow the following procedures:

This can be done in the field (recommended) or back at the office.

- Label the sample bottles as if they were another regular sample in the sequence at the site (i.e. the equipment blank should replicate the SAC code/analysis completed that day)
- Record the date, time (military format), collector ID, sequence number, SAC code the blank is replicating, and the last names of the sampling crew in the appropriate place in the field notebook.
- Indicate this sample as "Blank Ultrapure" in the appropriate place in the field notebook.
- Gather a supply of several liters of ultra-pure water.

Blanks should <u>ONLY</u> be filled with ultrapure containers specifically designated for equipment blanks <u>ONLY</u>!

- Rinse each sample bottle and cap with ultra-pure water three times. Fill the sample bottles with ultra-pure water.
- Add preservative as appropriate. For VOASW samples, add the preservative before filling the vial (as would be done for normal sampling).
- When done filling sample bottles and adding appropriate preservative(s), record the offsite time in the appropriate place in the field notebook.
- Prepare all sample bottles for transport according to the Preparing Grab Samples for Courier Pickup procedure found in the Appendix B of this manual (just as you would do for a normal sample).



11/14/13 Heylman Run

09:31 Onsite (Ulsamer, Casper)

09:50 Sample 9931-095
SAC 972 (Gen Chem, Metals)

09:52 Sample 9931-096
Duplicate of 9931-095

Flow	.04	cfs	(6 stations)	
(0956)	Sample Time	Re-deployment	(1017)	
Temp.	4.4	5.0	°C	
DO	94.4	N/A	%	
DO	11.85	N/A	mg/L	
SPC	44.2	44.1	µs/cm	
Cond.	27.2	27.3	µs/cm	
pH	6.07	N/A		
Turbidity	.37	NTU		

HOBO Maintenance : SN# 10104960

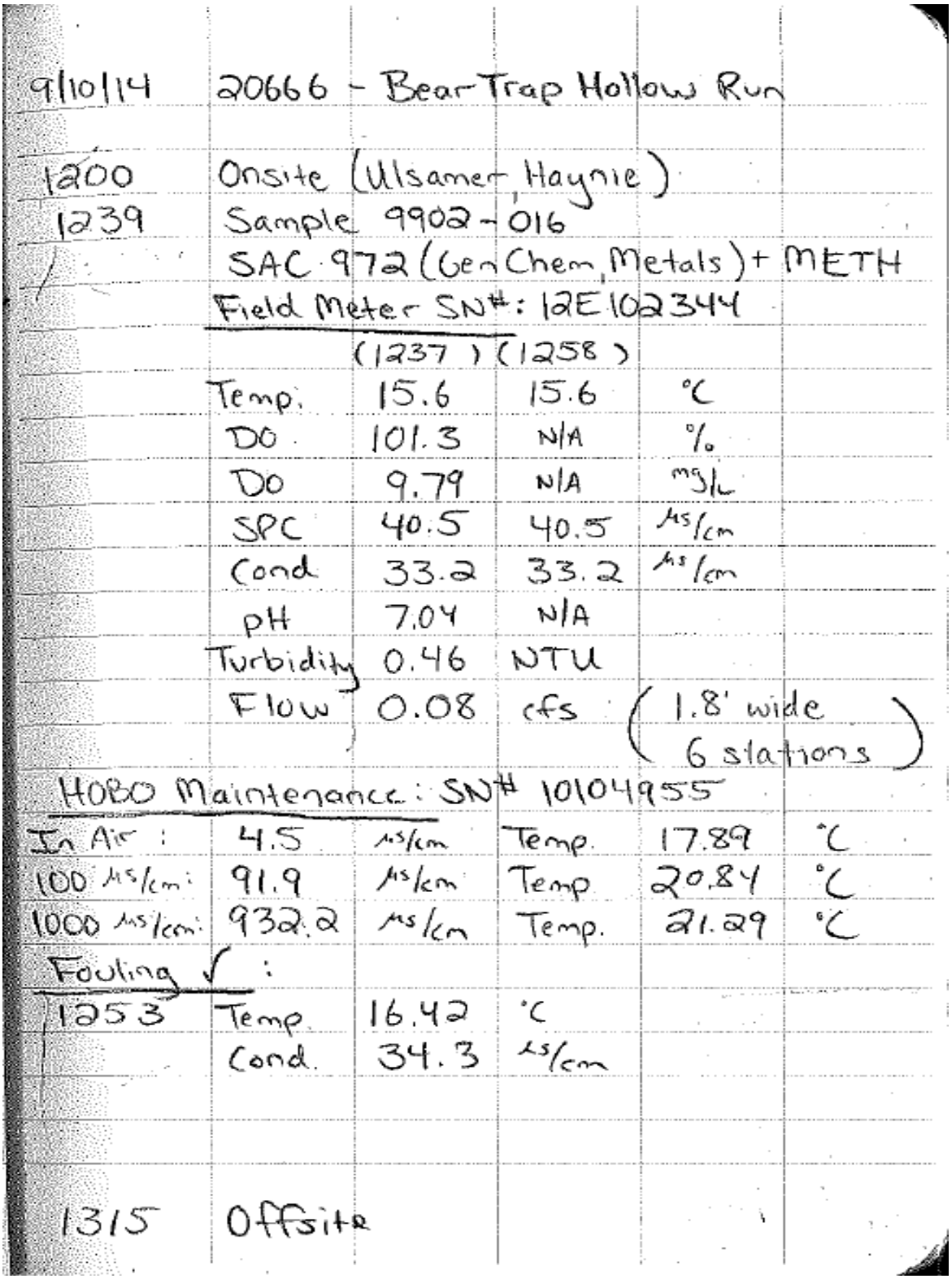
Fouling = Light

In Air =	3.0	µs/cm	Temp. =	6.43	°C
100 µs/cm =	74.7	µs/cm	Temp. =	10.23	°C
1,000 µs/cm =	744.6	µs/cm	Temp. =	10.21	°C

10:40 Offsite

Figure 2.3

* A scanned image of the field notebook when completing a duplicate (HOBO maintenance may/may not apply).



9/10/14 20666 - Bear Trap Hollow Run

1200 Onsite (Ulsamer, Haynie)
1239 Sample 9902-016
SAC 972 (Gen Chem, Metals) + METH
Field Meter SN#: 12E102344

	(1237)	(1258)	
Temp.	15.6	15.6	°C
DO	101.3	N/A	%
DO	9.79	N/A	mg/L
SPC	40.5	40.5	µs/cm
Cond	33.2	33.2	µs/cm
pH	7.04	N/A	
Turbidity	0.46	NTU	
Flow	0.08	cfs	(1.8' wide 6 stations)

HOBO Maintenance: SN# 10104955

In Air:	4.5	µs/cm	Temp.	17.89	°C
100 µs/cm:	91.9	µs/cm	Temp	20.84	°C
1000 µs/cm:	932.2	µs/cm	Temp.	21.29	°C

Fouling ✓:

1253	Temp.	16.42	°C
	Cond.	34.3	µs/cm

1315 Offsite

Figure 2.4

*Another example of the field notebook with 2014 "updates" (HOBO maintenance may/may not apply).

Data Management

- Results from the lab analyses of the grab samples will be logged in an online database to be accessed by the Bureau's Ecological Program Specialist for water quality monitoring.

- All notes from the field notebook should be scanned and saved as a PDF to the following locations: \\nrford12ds1\RPI\RPI_RAID\Water\Water Sample Field Notebook and the stream's "target folder" at the following location: \\nrforbofs06\RPI\Monitoring\MonitoringProtocols\Water\Stream Target Folders. Name the PDF's following the format presently established in the folders.

This need not be multiple times for different water procedures in a day.

- Offload the relevant flow files (.tsv) from the Hach flow meter into the flow data folder within the stream's "target folder" at the following location: \\nrforbofs06\RPI\Monitoring\MonitoringProtocols\Water\Stream Target Folders. Name according to format previously established in the folder.

- Enter all relevant collector, stream, and grab sample information into the "Collector ID Logbook" located at the following location: \\nrford12ds1\RPI\RPI_RAID\Water. Fill in the information for your collector I.D. and save the spreadsheet.

Temperature-Conductivity Probe (Hobo) Maintenance

Purpose

Temperature-Conductivity probes (Hobos) are deployed to measure and record stream temperature and conductivity over time. Hobos are staked into the stream bed and left for a period of time to record data, then periodically visited for maintenance and downloading of data. Data collected by Hobos can be used to characterize stream conditions, monitor for influx of high-conductivity water (such as flowback water), or monitor for influences on stream temperature (resulting from things such as cleared riparian forest). Periodic maintenance of Hobos is necessary for several reasons. Hobos can experience burial or disturbance of their staked positions. They can experience "fouling" of their sensor, which is growth of algae/bacteria on the sensor, or plugging of the sensor area with sediment.

Hobos also may experience calibration drift, whereby the calibrated value for conductivity changes over time. Although the conductivity calibration cannot be corrected or changed on Hobos, a check of their readings relative to calibration standards can be valuable in post-processing of data. Each of these potential negative effects should be checked, documented, and addressed during maintenance visits.

Equipment Needs

- YSI Pro Plus (or similar instrument)
- conductivity calibration solutions (for calibration of YSI Pro Plus and calibration checks)
- lint-free wipes (e.g., Kimwipes)
- cotton swabs (e.g., Q-tips)
- tooth brushes
- bottle brushes
- spray bottle of mild soapy water
- (2) dedicated calibration check bottles [(1) for 100µS/cm & (1) for 1,000µS/cm]
- squirt bottle of distilled/deionized water
- carabiners (several)
- Muckboots or waders
- field notebook
- pen or pencil
- Hobo Data Shuttle and USB cable
- Tablet computer with Hoboware software loaded
- GPS unit (if needed)
- Waterproof Camera

When conducting work in streams with suspected or confirmed didymo populations, disinfect all applicable equipment according to procedures found in Disinfection of Didymo Infected Equipment

Procedure

- It is recommended to calibrate the YSI Pro Plus for conductivity before leaving the office, but this could also be done in the field if enough calibration solution is taken. The solution should be at a stable temperature. Calibration should be done according to the Calibration procedure outlined in the Field Chemistry Measurements section of this manual. . REMEMBER: A calibration log sheet will need to be filled out each day a YSI Pro Plus (or similar instrument) is used

- Navigate to the site of interest where the Hobo is deployed. Hobo deployment locations can be found on FIMS in the OGIT geodatabase using the following path: *P:\Layers-Gas Program\Monitoring\Hobo Sondes Locations.*

- Fill out the field notebook according to the format previously established for Hobo maintenance visits(refer to examples in the Surface Water Grab Sampling and Flow Measurement procedure found in this manual). BE SURE TO INCLUDE THE 5-DIGIT WRDS STREAM CODE WITH THE STREAM NAME.

Side by Side Measurement

- Once on site, measurement of conductivity and temperature should be taken immediately side-by-side with the Pro Plus and Hobo. To accomplish this, the Hobo deployment location should be identified, without disturbing the area upstream or around the Hobo. (If several Hobos are deployed in series along a stream, then this process should begin with the furthest downstream Hobo.)

- Set the Pro Plus sensor in the stream as close as possible to the Hobo without disturbing the Hobo.

- From the Pro Plus, take a reading of conductivity, specific conductance, and temperature according to the Taking Measurements procedure outlined in the Field Chemistry Measurements section of this manual.

The time of this measurement should be recorded as well. Record this information in the appropriate location in the field notebook. All time records should be recorded in military format in EDT/DST (Local) time. THE HOBO SHOULD BE SET TO LOG IN UTC-5 TIME!

- Remove the Pro Plus sensor from the stream.

Retrieving Hobo

- Carefully remove any rocks covering the Hobo shroud and set them aside. Set the rocks in a place where you will remember them, so the same rocks can be used to cover the Hobo shroud once maintenance is completed. Minimize disturbance of sediment and the Hobo shroud while removing the rocks.

- Remove the Hobo from the stake by disconnecting the carabiner that holds the Hobo shroud to the stake. Attach a piece of chain to the carabiner on the stake to aid in locating the stake upon returning if desired

- Carefully open the Hobo shroud and remove the Hobo and foam insert. Use caution not to misplace the foam insert.

- Take the Hobo and shroud to a work area for cleaning and other procedures.

Hobo Cleaning

- Clean the Hobo shroud, inside and outside, with a bottle brush and stream water.

- Clean the Hobo, except for the sensor area and communication port (i.e., the clear plastic bottom), with a tooth brush and stream water (**Figure 2.5**)

- If needed, spray the entire Hobo with soapy water and, except for the sensor area and communication port, clean again with a tooth brush, then rinse in stream water.

- Rinse the sensor area and communication port with stream water (use soapy water if needed) and rub gently with a cotton swab, then rinse with stream water or distilled water.

- Wipe the Hobo with a lint-free wipe (it is OK to wipe the sensor area and communication port) and set aside for the next procedure.

Figure 2.5 HOBO sensor

Hobo Data Download

- Turn on the pad and open Hoboware. Plug the USB cord into the pad and then into the Hobo data shuttle. Hoboware should recognize that the shuttle is attached.

- Attach the data shuttle to the Hobo, aligning the Hobo properly within the shuttle. Then depress the bar on the side of the shuttle. This should cause Hoboware to recognize that the Hobo is attached. The Hobo's serial number should display at the bottom of the Hoboware screen.

- Click 'Device' from the top of the screen, then 'Readout'. Press the Enter key to select the Hobo.

- A message should appear asking if you wish to "stop the logger before reading out the logger"? Select 'Don't Stop'

- Readout status bar appears. Make sure it finishes with readout of logger to 100% complete.

- A 'Save' window will automatically pop up when readout is finished. Save file in appropriate place on your tablet computer. Hit enter or select 'Save'

- Hoboware then displays a setup window for opening the datafile. Press the Enter key

- Make sure all data from the previous visit to current time has been transferred. Close the graph.

Hobo Calibration Checks

- Prepare two calibration check bottles in the dedicated 500 mL calibration check bottles (which are labeled as such): 100 µS/cm standard, and 1000 µS/cm standard. Rinse each check bottle with a small amount of its respective calibration solution three times. Then, pour approximately 2 inches of each of the solutions into their respective calibration check bottles.

At some sites, it may be advantageous to prepare the check bottles at the vehicle, to reduce the amount of equipment needed to carry in to a site.

- Click 'Device' from the top of the screen, then 'Status'. Press the Enter key to select the Hobo. The current status of the Hobo should display.

- Read the 'Low Range Conductivity' value with the Hobo dried and sitting in air. It should be close to zero. If it is not less than 10 µS/cm, then dry it again with a lint-free wipe and recheck. The reading will not likely stay in one place, but will fluctuate around a small range. Choose the value that reads most frequently. Record the *In Air* 'Low Range Conductivity' and 'Temperature' values in the appropriate place in the field notebook.

- Place the Hobo, sensor-side down, in the 100 µS/cm calibration check bottle. Be certain that there is enough calibration solution in the bottle to cover the Hobo sensor. Swirl the Hobo several times within the bottle, and then lean the Hobo against the side of the bottle.

- Read the 'Low Range Conductivity' value once the reading has settled within a few µS/cm. The reading will not likely stay in one place, but will slowly fluctuate up or down. Choose the value that the Hobo pauses on for a few moments within a short time of placing the Hobo in solution. Record the *100 µS/cm* 'Low Range Conductivity' and 'Temperature' values in the appropriate place in the field notebook.

- Remove the Hobo from the 100 µS/cm calibration solution and squirt it down with distilled water, particularly squirting the sensor. Dry the Hobo and sensor thoroughly with a lint-free wipe.

- Place the Hobo in the 1000 µS/cm standard bottle. Repeat the process above, recording the *1000 µS/cm* 'Low Range Conductivity' and 'Temperature' values in the appropriate place in the field notebook.

- Remove the Hobo from the 1000 µS/cm calibration solution. Squirt the Hobo with distilled water, particularly squirting the sensor.

Document Fouling:

- With the Hobo still in the shuttle and attached to the tablet, put sensor into stream in an area of well mixed flow and log real-time until readings stabilize. Read and record the stabilized temperature and low range conductivity values in the appropriate place in the field notebook. Also record the time of this reading.

- Take a quick final look at the information in the 'Device Status' window and ensure that the Hobo's battery life is 'Good', time is UTC-5 time, and the logger is NOT 'Stopped'

- Close the 'Device Status' window on the Hoboware.
- Remove the Hobo from the data shuttle.
- If the last site of the day, discard the solutions left in the calibration check bottles then rinse them three times with distilled water, and then return them to storage.

If visiting multiple sites in the same day, the same calibration check bottles and solutions may be used for calibration checks. NEVER use the same solution for multiple days however.

Hobo Re-deployment

- Return the Hobo to the shroud (sensor end down), insert the foam padding, and screw on the shroud lid.
- Be certain that you return the Hobo to the proper location based on its serial number (if Hobos deployed in series). Check prior entries in the field notebook to confirm.
- Reconnect the shroud to the stake with the carabiner. Inspect carabiners and replace if "faulty" (i.e. they do not close properly).
- Replace the rocks to cover the shroud, making it barely visible to passersby, but not obstructing it from receiving stream flow.

Final Side-by-Side Measurement

- The last step is to take a final side-by-side measurement with the Pro Plus. The Pro Plus will have already been calibrated earlier in the field visit. (If several Hobos are deployed in series along a stream, then this process should begin with the furthest downstream Hobo.)
- Set the Pro Plus sensor in the stream as close as possible to the Hobo without disturbing the Hobo.
- From the Pro Plus, take a reading of conductivity, specific conductance, and temperature according to the Taking Measurements procedure outlined in the Field Chemistry Measurements section of this manual.

The time of this measurement should be recorded as well. Record this information in the appropriate location in the field notebook.

- Remove the Pro Plus sensor from the stream, and leave the Hobo deployed.

- At the conclusion of each day, ensure the Pro Plus is stored with a small amount of water in the bottom of the calibration cup and the cup is tightened on the Quatro cable bulkhead.

For long term storage (i.e. > 1 month), refer to user manual.

Data Management

- Upon returning to the office, open the Hobo file(s) and take a quick look at the data. If any anomalies or significant "spikes" are noticed in the data, particularly with conductivity, inform the Ecological Program Specialist for water monitoring via email for further inspection.

Significant spikes will be those that more than double "normal" conductivity ranges (i.e. a stream that averages 15-30 us/cm low range conductivity readings throughout the month that jumps up greater than 60 us/cm). These events should be submitted for review.

- Copy the files from the tablet computer to the appropriate place in the target folder at the following location: \\nrforbofs06\RPI\Monitoring\MonitoringProtocols\Water\Stream Target Folders. Name the files following the format previously established in the folders.

- All notes from the field notebook should be scanned and saved as a PDF to the following location: \\nrford12ds1\RPI\RPI_RAID\Water\Water Sample Field Notebook and the stream's "target folder" at the following location: \\nrforbofs06\RPI\Monitoring\MonitoringProtocols\Water\Stream Target Folders. Name the PDF's following the format presently established in the folders.

This need not be done multiple times for various water procedures in a day

Widespread Sampling

Purpose

Field chemistry measurement gives a discrete representation of basic water quality parameters including pH, temperature, conductivity, specific conductance , and alkalinity. This information is useful both as an indicator of stream quality and as a detector of potential stream impairment (e.g., low pH suggesting acid pollution, high conductivity suggesting salt pollution). Field chemistry measurement will be used at widespread sampling locations throughout the gas districts. The widespread sampling will provide some assurance to District Foresters and stakeholders that their local streams are not grossly contaminated by gas development (or will identify such contamination). The widespread sampling will also provide reference points for BOF and DEP should a pollution event occur in the vicinity of a sampling location.

Equipment Needs

- YSI Pro Plus (or similar instrument)
- Meter-specific calibration log sheet
- pH and conductivity calibration solutions (for calibration)
- squirt bottle of distilled/deionized water
- Hanna Instruments HI 755 Checker HC Handheld Colorimeter kit
- Lint-free cloth (e.g. Kimwipes)
- Widespread Sampling Datasheet or tablet computer
- GPS unit
- Measuring tape (US units)
- Laser rangefinder
- Flagging
- Pen or pencil (if using datasheet)
- Muckboots or waders

When conducting work in streams with suspected or confirmed didymo populations, disinfect all applicable equipment according to procedures found in Disinfection of Didymo Infected Equipment

Procedures

- Each day of sampling, follow the Calibration procedures outlined in the Field Chemistry Measurements section of this manual. REMEMBER: A calibration log sheet will need to be filled out each day a YSI Pro Plus (or similar instrument) is used

- If using a tablet computer, be sure to have the appropriate water sample point locations on your tablet. Refer to the supporting documents section of this manual for instructions on Checking In/Checking Out Data for ArcPad.

CAUTION: If using a tablet computer to enter new data for a water sample point, DO NOT UNDER ANY CIRCUMSTANCES OPEN A POINT IN AN EDITING SESSION THAT YOU DO NOT EVENTUALLY EDIT. This will create data management issues in the OGIT geodatabase.

- Obtain the coordinates for the sampling site of interest and drive as near as possible to the coordinates. At previously visited sites the "Notes" section will sometimes provide some guidance navigating to the site.

- Once parked, complete the following information on the datasheet or tablet computer:
  - Sample Site: the designated number of the site (SampleID)
  - Date: the date the site is being sampled
  - District: the forest district in which the sample site is located
  - Model: whether the YSI Pro Plus, YSI Model 63, or other device is being used
  - Monitor's Name(s): the name(s) of the person(s) testing the site
  - Weather and Precipitation: mark current observations on the datasheet
  - Depart from vehicle: the time you left the vehicle to hike to the sampling site

- Hike to the pre-determined coordinates. If possible, identify the previous sampling point based on flagging along the stream.

- Near the GPS coordinates, select an area of the stream that is representative of the stream. This may or may not be the point previously sampled. Choose an area that is relatively uniform in depth across the stream. Avoid obstructions (e.g., large rocks or downed trees), and avoid pools.

- Enter the stream downstream from your sampling point to avoid introducing disturbed sediment to the sampling point.

- Place the probe upstream or off to the side of your position, near the center of the current, in an area of uniform, well-mixed flow. The probe should be away from the stream bank and in the current (i.e., do not sample stagnant or non-flowing water).

- Once the probe is in place, give the cord a slight twist and shake to dislodge any air bubbles trapped in the sensors.

- Once readings stabilize (stay the same for several seconds), record them on the datasheet or tablet computer.

- Conduct an alkalinity measurement with the Hanna HI755 alkalinity tester using procedures outlined in Field Chemistry Measurements section of this manual. Read and record the alkalinity (in ppm of CaCO3) on the datasheet or tablet computer.

- Complete the following information on the datasheet or tablet computer:
  - Time: the time that measurements are taken (military format)
  - Latitude/Longitude: Recorded on re-sampled sites if the location of the sampling point needs to be moved and is different than the original coordinates. Otherwise, there is no need to fill this in.
    **This can be done real-time in the field if using a tablet computer.*
  - Sample Location: enter information that describes the sampling point location(e.g., distance from large rock or tree of certain diameter). Again, this need only be changed if the sampler feels the original sample location needs clarified or the sampling point is being moved.
  - Stream width: Using a measuring tape, measure from water edge to water edge to the nearest tenth of a foot. Avoid areas of backwater or obstructions. If the stream is large enough such that measuring with the tape is impossible, use a laser rangefinder (Careful: remember to record in feet).
  - Stream depth: Probe the stream with a stick to find, approximately, the average depth near where you sampled. Measure by marking the stick and measuring with the tape to the nearest tenth of a foot. For larger streams that cannot be waded, estimate the average depth.

- Place flagging to mark the sample location at new sites, if original flagging cannot be located, or site has been moved from the previous location. If a site's location is moved and original flagging still exists be sure to remove it. In cases where a tree is referenced in the sample location, this is usually the object that is flagged.

- Hike back to the vehicle and complete the following information on the datasheet or tablet computer:
  - Return to vehicle: the time you returned to the vehicle from the sampling site
  - Total time: the time elapsed between "Depart from vehicle" and "Return to vehicle". This should be recorded in decimal hours (e.g. 15 minutes = 0.25 hours, 1 hour 30 minutes = 1.50 hours)
  - Surrogate Stream Flow: obtained from multiplying stream width by stream depth. Round to the nearest tenth of a foot (this calculation can be calculated

at the sample site or back in the office). If using a tablet computer, this value is automatically calculated

- Once back in the office, complete the section of the datasheet "Precipitation last 48 hours" using the steps below. This is determined by the highest rate it has rained any given hour within the last 48 hours.
  - Go to the following link: http://waterdata.usgs.gov/pa/nwis/current/?type=precip&group_key=county_cd
  - Under the appropriate county, select a station that is nearest the sample location of interest
  - Be sure "00045 Precipitation" is checked under available parameters, and "Table" is checked under output format. Click "GO".
  - The resulting table will show precipitation amounts and be separated into cells of 15 minute intervals. Look through the section of the table outlining the 48 hours before you sampled the site of interest. Within that time period find the four consecutive cells that yield the highest precipitation amount (i.e. the highest rainfall total/hour). Add the four cells up for a total. *Precipitation amounts that are suspected snowfall/sleet should be ignored. ONLY do for confirmed rain events.
  - Using the total obtained, circle the appropriate precipitation class on the datasheet or select on the tablet computer using the class designations below:

    None: no measurable amounts recorded at station, or suspected snowfall
    Trace: <.05"/hour
    Light: ≥.05 and <.10"/hour
    Moderate: ≥.10 and <.40"/hour
    Heavy: ≥.40"/hour

- At the conclusion of each day, ensure the Pro Plus is stored with a small amount of water in the bottom of the calibration cup and the cup is tightened on the Quatro cable bulkhead.

For long term storage (i.e. > 1 month), refer to user manual.

Quality Control

If two different instruments are used in a field season for widespread sampling, 5% of sampling locations will be performed by both units, such that the results can be compared. Similarly, if multiple field teams perform widespread sampling, 5% of locations will have the width/depth measured by both teams, such that the results can be compared.

Data Management

- If using a tablet computer, periodically "check in" edited Water Sample point data as appropriate. Do not let edited points accumulate on your tablet without checking them back into the OGIT geodatabase as they risk being lost. Refer to the supporting documents section of this manual for instructions on Checking In/Checking Out Data for ArcPad.

- If using a datasheet, navigate to the Water Sample Point feature class in FIMS using the following path: *P:\Layers-Gas Program\Monitoring\Water Sample Point*. Start an editing session and manually enter the data from the datasheet.

- Enter all calibration data from the calibration log sheet into the appropriate excel spreadsheet for the field meter used at the following location: \\nrford12ds1\RPI\RPI_RAID\Water\Calibration Logs. Simply make a copy of the "Place Date Here-BLANK" log sheet, place it at the end of the tabs, rename the tab with the date of calibration using the format day-month-year (e.g. 18 July 2014), fill in the information, and save the spreadsheet.

Pebble Count

Purpose

Pebble counts are conducted to assess the typical particle size distribution in a streambed. When repeated over time, pebble counts can be used to detect increased levels of erosion and sedimentation in a watershed, which can be detrimental to aquatic communities.

Equipment Needs

- YSI Clipboard and pencil
- Folding measuring rule (metric)
- Long measuring tape, 200-ft or more (metric)
- Hand-held counters
- Muckboots or waders
- Flagging
- Pebble Count Datasheets
- Tablet computer and/or GPS unit (if needed)

When conducting work in streams with suspected or confirmed didymo populations, disinfect all applicable equipment according to procedures found in Disinfection of Didymo Infected Equipment

Establishing the Sample Reach

- At streams that are being re-sampled (i.e. a sample reach and pebble count has been established and conducted previously), simply navigate to the appropriate GPS coordinates, re-flag the reach and measure stream widths as outlined below, and conduct the pebble count. Previously conducted pebble count locations can be found in the OGIT geodatabase using the following path: *P:\Layers-Gas Program\OGIT_Geodatabase\OGIT.DBO.Monitoring\OGIT.DBO.Pebble_Sampling*

- Once the stream of interest has been identified, a sample reach must be established. The sample reach should be representative of the geomorphology and instream habitat typical within the stream. For example, do not select an unusually deep pool (which would skew results toward finer particles), a large island (which would skew results toward larger particles), or a sharp (i.e., >90 degree) bend (which may have an undercut bank that is difficult to sample). The sample reach should include at least two riffle and two pool habitat units, or a minimum of 200 meters (~660 feet). The downstream and upstream extent of the sample reach should coincide with the head of a riffle. Record the length of the reach on the data sheet.

- Measurement of the reach should begin at the upstream extent and proceed downstream. This will ensure that the full reach is walked and examined prior to beginning the protocol.
- The upstream and downstream extent of the sample reach should be marked with flagging on both banks.
- The GPS coordinates of the upstream and downstream extents, at centerpoint of stream, should be recorded as well.
- Place flagging every 50 meters along the reach. This flagging will serve as benchmarks during the count, ensuring that counting is progressing at the proper pace (i.e., approximately 50 pebbles per 50 meters).
- Bankfull edge should be discussed with the crew along the stream in any locations where the bankfull edge is in doubt or difficult to discern. This will ensure that each team considers the bankfull edge the same in such areas. Common indicators of bankfull edge are the edge of rooted vegetation, scourlines or small flood benches, and the tops of active point bars. (For frame of reference, the bankfull flow typically occurs every 1.5 years.)
- The width of the stream should be measured (in feet and tenths of feet), from bankfull edge to bankfull edge, at the upstream and downstream extent of the reach and at the 50-meter benchmarks. Width measurement is made perpendicular to flow. These width measurements should be recorded on the datasheet and computed for an average stream width.
- The flagging should remain in place such that the site can be revisited in the future.

Conducting the Pebble Count

- Pebble counts will be conducted with two-person teams. One person collects and measures the pebbles (the sampler), the other person tallies and counts the pebbles (the scribe). For each stream, three different teams (or samplers) should complete the pebble count along the same sample reach.
- Record the stream name, date, and last names of the survey crew on the datasheet, indicating who the sampler is and who the scribe is.
- At least 200 particles are to be sampled from the sample reach.
- Pebble counts are conducted along a zig-zag transect from bankfull edge to bankfull edge (**Figure 2.6**). The angle of the zigzag transect depends upon the meander pattern (or sinuosity) of the sample reach. A 45 degree angle is a good starting point, but the angle cannot be prescribed, because a low sinuosity reach

will require a less sharp angle than a high sinuosity reach. Thus, the angle may need adjusted as the sampler moves toward the 50-meter benchmarks.

- For a given pacing across the stream, the chosen angle should be maintained as best as possible. This is best accomplished by identifying a location on the opposite bank to walk towards, such as a rock or tree trunk.
- The zig-zag transect begins at the downstream extent of the sample reach, which should be the head of a riffle.
- Beginning at the left bank ("left" is defined as one faces downstream), the sampler paces off greater than 2.1 meters (~7 feet). This pacing distance is important to avoid correlation between particles sampled.
- A particle is selected by placing the finger at the toe of the boot, and, without looking, sliding the finger downward until it first touches a particle. If two particles are touched simultaneously, then the particle nearest to the left side of the person's fingernail should be counted. If it is possible to pick up this particle, the sampler should do so.
- This particle is then measured at the maximum length of its intermediate axis using a metric rule (**Figure 2.6**).
- If the particle cannot be picked up, it should be categorized as sand or silt/clay depending on the feel of the particle (see explanation below).
- The sampler should again pace no less than 2.1 meters to the next sampling point and repeat the process.
- If the sampler reaches the bankfull edge before pacing off the full distance to the next sampling point, then the sampler should turn away from the bank (at the same angle he/she arrived at the bank) and continue the remaining distance to establish the next point.
- The zigzag transect should continue upstream until the upstream extent is reached.
- The minimum size class to be measured should be very coarse sand (1-2 mm).
- Any sand less than 1 mm should be classified simply as medium sand (i.e., no further sub-categories of finer sand). A sand particle should feel gritty to the touch, and if a sample can be picked up, it should make a grinding sound when rubbed next to the ear.
- A clay/silt particle will not fill gritty; rather, it will have a smooth, silky, or greasy feel.

- Conversely, some particles, such as boulders, will be too large to accurately measure because they cannot be removed from the stream or are partially buried in the stream. If all 3 axes are visible, measure the maximum length of the intermediate axis as normal. If only 2 axes are visible, the sampler should do their best to measure the shortest visible axis (thus assuming that the actual shortest axis is the one buried).

- Each particle measurement is tallied by the scribe according to Wentworth size classes on the datasheet. The scribe also will use a hand counter to keep a total tally of the pebbles counted. The scribe should click the counter at the time the sampler bends over to touch a pebble. However, when working in a larger crew and there is one scribe for multiple samplers, it may be better to have each sampler keep their own tally of pebbles counted.

- Any non-native rocks (e.g. limestone rock in a sandstone stream) that are picked up by the sampler to be tallied should be tallied within the appropriate size class and indicated as “Non-native stone tally” on the data sheet.

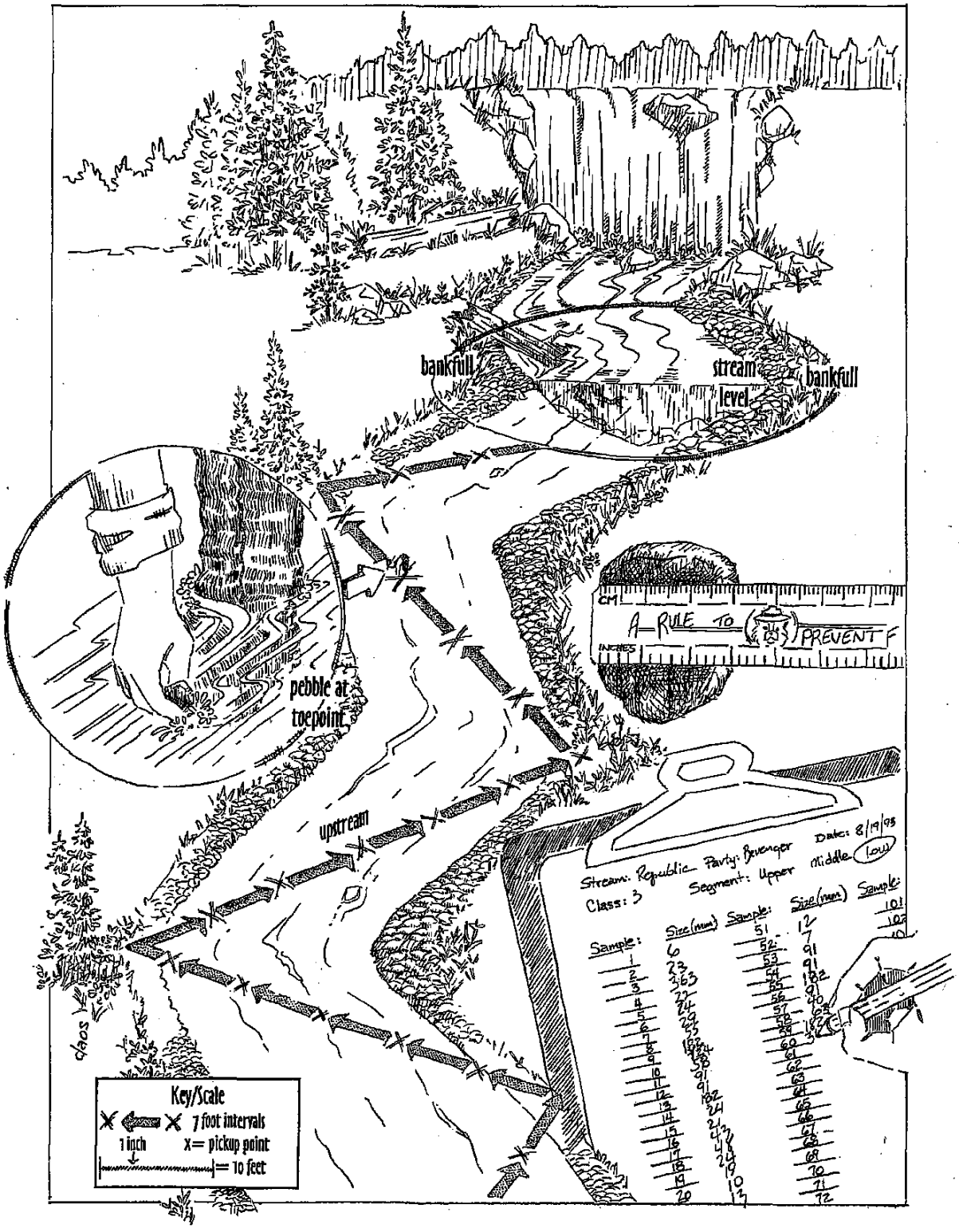


Figure 2.6 Diagram of a Pebble Count survey

Contingency Measures

- **Less than 200 pebbles counted:** If less than 200 particles have been collected, one of the following should occur. If less than 150 pebbles have been counted, then the zigzag should be repeated through the entire reach but at a less sharp angle, such that less particles are collected during the second transect. If between 150 and 200 pebbles have been counted, then the sampling reach can be extended upstream by additional riffle pool sequences (again ending at the head of a riffle). In either case, the sampling should be conducted such that at least 200 pebbles are counted.

- **Very deep pools encountered:** Very deep pools can make it difficult to sample, logistically, without getting the sampler very wet or employing submerged sampling. Both of those scenarios should be avoided. If the pools are too deep simply because the samplers are not presently equipped with sufficient length boots, then the sampling should be halted, and the reach should be resampled when adequate boots are available. If the deep pools are such that the samplers cannot reach the streambed even in adequate boots, then the following protocol should be performed. The point that cannot be reached should be counted as one tally of the finest particle encountered during the entire pebble count (i.e., probably a sand or clay/silt particle). Then, the sampler should mentally project the zig-zag walk across the pool. If the next (or several) points fall within the deep pool, then the finest particle should again be tallied. Once the projected zig-zag walk reaches a point that can be waded and sampled, the sampling should continue as before. Any pebbles counted in this manner should be specifically identified on the data sheet as "Unreachable Deep Pool Tally."

- **Caddis-Fly casings encountered:** If it can be determined that the first grain felt is the sand from a caddis fly casing, then the count should not be sand. Instead, the count should be the pebble on which the caddis fly casing was attached.

- **Vegetation clumps encountered:** If the end of a pace for counting lands on a patch of submerged or other vegetation, the particle that is the substrate for that vegetation should be counted. In other words, select the particle that is supporting the roots of the vegetation, which usually is sand, silt, or clay.

- **Silt "dusting" encountered:** If the sampler observes a dusty or light covering of silt on pebbles in the stream, this should not necessarily be counted as silt. Only if the silt covering is sufficient that it is the first thing the sampler feels, when reaching downward, should the count be tallied as silt/clay.

- **Losing hold of small pebbles:** Sometimes, due to the flowing water, the touching of a small particle with the fingertip may cause it to flow away and out of reach. If this occurs, and it is possible to estimate the size of the particle based on that brief touch, that particle should be recorded on the data sheet. If it is not possible to estimate the size of the particle, then the zig-zag should continue without tallying a particle at that location. Any pebbles counted in this manner should be specifically identified on the data sheet as "Estimated due to Drop Tally."

- **Encountering atypical geomorphology or other stream features:** Atypical backwater should be excluded from the sample reach. This is because the hydrology of backwater areas is not "typical" of the stream, and the objective is to characterize typical streambed characteristics. In addition, tributaries coming into the sample reach should be excluded from the sample reach. This is because the hydrology and bed material of the tributary may be different than the sample reach. If an island, sandbar, or clump of vegetation is encountered that is higher than the bankfull elevation, this feature should be skipped, and the zig-zag transect should continue on the other side of the feature. If the island, sandbar, or clump of vegetation is lower than bankfull elevation, then pacing should continue through the feature. When small obstructions, such as downed logs or undercut banks, are encountered, the paces can be visually projected beneath or over the obstruction, such that the zig-zag transect can be continued.

Data Management

- Once all 3 pebble counts have been conducted along the same sample reach on a given stream, the data sheets are to be scanned and sent via email to the water resource specialist for further data processing.

- The scanned data sheets should also be saved and placed in the appropriate folder on RPI_RAID \\nrford12ds1\RPI\RPI_RAID\Water\Pebble_Sampling. The files should be named using the format "Stream Name"_"Year Completed" (e.g. Bear Run_2013.pdf)

- GPS locations for new pebble counts should be added to the pebble sampling feature class in FIMS which can be found using the following path: *P:\Layers-Gas Program\OGIT_Geodatabase\OGIT.DBO.Monitoring\OGIT.DBO.Pebble_Sampling* Be sure to fill out appropriate attributes for the points. Similarly any edits to established pebble count locations can be edited in this feature class within FIMS.

Benthic Macroinvertebrate Collection

Purpose

Sampling for benthic macroinvertebrates to assess water quality has been standard practice in the global water quality monitoring industry for decades. Biometrics like the PA DEP Index of Biotic Integrity (IBI), Shannon Diversity, Hilsenhoff Biotic Index (HBI), the Index of Biotic Acidification (IBA), the Functional Feeding Reference Condition, and many others, are powerful statistical tools used to assess multiple components of a stream's long-term water quality as expressed in its biological community.

Because aquatic invertebrates are excellent indicators of water quality and are routinely sampled as part of Pennsylvania's various ongoing water quality assessment programs, the DCNR will collect benthic macroinvertebrates regularly as part of our monitoring programs to assess the attainment of aquatic life uses in areas where monitoring is deemed necessary, such as in shale gas areas or to track AMD remediation efforts, for example. The primary method used to collect these organisms is the method described below, which is based on—and identical to—PA DEP's Antidegradation and Instream Comprehensive Evaluation (ICE) surveys.

Equipment Needs

- 500µ (micron) mesh D-Frame net
- 1 to 2 Nalgene 2L Wide Mouth Bottles
- Denatured alcohol (sample preservative) 1 to 2 liters per sample, >70% alcohol concentration
- Hip or chest waders; chest waders with sturdy reinforced wading shoes are recommended
- Standard Sieve No. 35 (500 micron)
- 4L Utility Pail
- Thermo bottle labels, or other sticky label
- Permanent marker or Pen
- Clear packaging tape
- Water Quality Network Habitat Assessment Datasheet
- Neoprene gloves are recommended, but not required
- Field Notebook
- Digital Camera
- GPS unit

Procedures

Typically, water grab samples (such as SAC046 or SAC972) will be collected prior to macroinvertebrate sampling, as will discrete field chemistry values (pH, temperature, conductivity, specific conductivity, dissolved oxygen, and turbidity).

Flow measurements using a flow meter will be completed as well. **Before leaving the office, be sure to make all necessary preparations and gather all equipment needed to complete these tasks in the field as well.**

When conducting work in streams with suspected or confirmed didymo populations, disinfect all applicable equipment according to procedures found in Disinfection of Didymo Infected Equipment

Establishing the Sample Reach

The 100m reach should be homogeneous, not having any discharges, seeps, or tributaries entering into it. It should be far enough downstream of any of these inputs to allow for total mixing.

- Once onsite where the macroinvertebrate collection is to take place, write the date, 5-digit WRDS stream code, stream name/location, time onsite (military format), and the last names of the sampling crew in the field notebook.

- If establishing a new sample reach, conduct a reconnaissance of the area of interest, looking for a 100m reach with optimal riffle run type waters with a good mix of cobble sized stone.

- Whether revisiting a previously established 100m reach or establishing a new one, always walk the reach, taking a mental note of the most optimal sampling areas. Further, make mental habitat notes on bank condition, in-stream fish habitat, riparian zone, flow status, and others to facilitate the habitat assessment at the end.

- Using the GPS unit, record the coordinates of the **bottom** of the reach in the field notebook. On revisited sites, use the previously established GPS location as the bottom of the reach, if possible.

- On new sites and revisited sites, always write a short narrative describing the site and/or anything unusual (e.g. large moss covered boulders, significant bank erosion, a lot of natural wood debris in stream, low flow, etc.), as well as any recent changes/activity at the site (e.g. new pipeline, new road, recent fish structures installed, etc.). Record this narratve in the field notebook with other macroinvertebrate collection information.

- When establishing a new sample reach be sure to take pictures of the stream with a digital camera. Take 4 pictures minimum at each sample reach, (2) at the bottom of the reach (BoR), and (2) at the top of the reach (ToR). One oriented upstream and the other downstream at each location. Sometimes, an upstream and downstream picture can be taken near the middle of the reach as well

(MoR). The pictures are meant to be a snapshot of the stream area/condition so be sure to capture the stream and both banks when taking pictures.

While walking/conducting reconnaissance of the area around the 100m reach, **take special care not to walk in and disturb the stream substrate and its banks!**

Discrete Measurement, Grab Samples, and Flow Measurement

- Once the 100m reach is located, conduct a discrete measurement and collect appropriate grab samples at the bottom of the reach. Do this according to steps outlined in the Surface Water Grab Sampling and Flow Measurement procedure.

- Take a flow measurement near the bottom of the reach according to the Surface Water Grab Sampling and Flow Measurement procedure. **If the best area to measure flow falls within the 100m reach, wait for macroinvertebrate collection to be completed downstream of the flow measurement site so that you do not disturb the stream.**

- Record all information for the discrete sample, grab sample, and flow measurement in the field notebook as otherwise done.

Sampling Procedure

Sample collection consists of six D-frame kick efforts from a 100m stream reach, which are composited, preserved, and returned to a lab for further processing and identification, which is explained separately in the Benthic Macroinvertebrate Processing procedure found in this manual. Also, a PA DEP habitat assessment will be conducted following the macroinvertebrate sampling.

- In the field notebook, record information for the macroinvertbrate collection. Include the date (yyyymmdd), time (local military time to match kicking time) and the Commonwealth identifier of the collector (e.g., 20141126-1300-roryder). The short narrative described above can go here as well.

- Starting at the downstream extent of the reach, choose the best riffle and run habitat areas to kick and be certain to include areas of different depths and velocity currents (fast and slow) and substrate types.

- Spread the (6) sample kicks throughout the 100m reach, trying at least to sample three riffles (fast and shallow, with “white caps”) and three runs (slower and a little deeper, with no “white caps”).

Typically, one might sample two kicks relatively close at the bottom of the reach (BoR), two in vicinity of the middle of reach (MoR), and two at the top of reach (ToR). Stream conditions and habitat will dictate the best areas, however.

Sampling Methodology

- Once you have located the area you wish to kick, face downstream and place the net firmly on the stream bottom so that it does not rock from side to side in the area immediately downstream of the area you are targeting. Be sure there are no sizable gaps between the bottom of the net and the steam bed.

- If a second person is available, have he/she ready a timer to keep time as you progress through a "kick effort".

One "kick effort" is when the sampler vigorously kicks an approximate area of $1m^2$ (1X1m) immediately upstream of the net to a depth of 10cm (approximately 4", or as much as the embeddedness of the substrate allows) for approximately 45 to 60 seconds (

Figure 2.7).

- While holding firmly down on the net's handle to keep the net in place, begin disturbing the stream substrate with your foot in the area immediately in front of the net.

- Gradually work the entire $1m^2$ area thoroughly with your wader boots. Because each "kick effort" lasts approximately 60 seconds, try and time it so that the entire sample area is covered (i.e. all substrate in the sample area has been disturbed enough to dislodge most macroinvertebrate fauna into the water column).

All benthic dislodgement and substrate scrubbing should be done by kicks only. Substrate handling should be limited to only moving large rocks or debris out of the kick area with no "hand washing" (i.e. rubbing and scrubbing substrate with your hands to dislodge macroinvertebrate fauna) to facilitate kicking. Any handling of rocks should be done in a manner loosely imitative of kicking.

Figure 2.7 Sampling with a D-frame net

- Since the width of the kick area is wider than the net opening, the substrate material from within the $1m^2$ area should be kicked toward the center of the square meter area –above the net opening.

- While kicking, the sampler is encouraged to use his or her hands and feet as described earlier to move objects out of the path between water and net in the $1m^2$ zone. Care should be taken to not create obstructions in front of the net (typically the collector's own feet or dislodged stones) which would deflect stream flow away from the net.

- Following the first kick effort, the collector can choose to make the second kick effort after rinsing the sample to the bottom of the net, or can deposit the first kick into the 2L wide-mouth sample jar.

Because it can be somewhat easy to lose track of how many kicks one makes, and also to save time, it is recommended using the net twice (i.e. completing two "kick efforts") before depositing the kicks into the jar, unless an excessive amount of detritus has clogged the net. Caution should be taken from moving the utility pail and jar around the stream to avoid accidentally dumping either during a slip-and-fall. One effective strategy is placing (during the initial reconnaissance) the jar and pail at mid-reach near where the third and fourth kicks will occur.

- To empty net contents into the sample jar, the jar should be placed into, or held over, the 4L utility pail to catch debris and invertebrates as the net is inverted and debris composited gently into the jar.

- Care should be taken to minimize "wear and tear" on the collected organisms when compositing the materials (**Figure 2.8**).

- The reduction of large materials by careful removal, inspection, and rinsing in a bucket or using a sieve prior to field preservation or at the lab is encouraged.

Figure 2.8 Compositing kicks into sample jar. Note also sieve and pale.

NOTE

Spring samples typically do not require more than one bottle; November and December samples may, however, due to leaf fall.

- After completing the 6th and final kick, empty net contents into the sample jar as described above, leaving the net turned "inside out" with remaining net contents exposed/facing out.

- Fill the 4L utility pail half full with clean stream water and immerse the net into the water, attempting to rinse off all smaller remaining net contents from the last "kicks".

- Briefly inspect the rinsed net for any bug specimens, placing any that you find into the sample jar, then hand to a second person for a final inspection.

- Pour the remaining water in the utility pail through the sieve until you are confident the pail is free of all bug specimens.

- Next, gently dip and swipe the sieve through an area of slack water in the stream to get all remaining stone/sediment/bug specimens into one end of the sieve.

- Gently tap all contents from the sieve into the sample jar until you are confident the sieve is free of any bug specimens.

The sieve emptying procedures described above may need to be repeated several times until all stream debris is collected into the sample jar. While doing so, **take special care not to lose any bug specimens from the sample!**

- While kicking be sure to note any observations in the field notebook that you feel are important (e.g. fish sightings especially young of the year, PAFBC fish structures in reach, "No Bugs observed in net", etc.)

When doing multiple sites in a day be sure that the net, sieve, and utility pail are thoroughly rinsed in between sample sites to avoid cross contamination!

In-stream Habitat Assessment

- After macroinvertebrates are collected, the collector(s) will perform an In-stream Habitat Assessment using the Water Quality Network Habitat Assessment Datasheet.

- Fill out the header information with what information you know about the site.

- Recalling what you saw during the reconnaissance and the sampling procedure, fill out the rubric carefully, considering all variables described in the rubric. This can be done alone or with the entire sample group.

Sample Preservation and Labeling

Composited samples are preserved with no less than 70% denatured ethanol; up to 100% is also acceptable. The sample does not need to be preserved immediately after collection, but can be taken to the vehicle where the ethanol can be kept.

- Upon returning to the vehicle, dry the outside of the sample jar(s) with a paper towel

- Using a permanent marker or pen, fill out a "Thermo" or other sticky label to include the date (yyyymmdd), time (local military time to match kicking time) and the Commonwealth identifier of the collector (e.g., 20141126-1300-roryder).

- The label should also include the stream name and the numbers of sample bottles, if multiple (e.g., Lower Pine Bottom Run 1 of 2).

- Attach the label to the jar and cover with packing tape on the sample jar to avoid its loss or degradation by ethanol.

- Unscrew the lid and carefully fill the sample jar(s) with alcohol until contents of the jar are completely covered, replace and secure cap

- Gently invert and flip the sample jar(s) to thoroughly mix and distribute the alcohol throughout the contents of the jar and remove pockets of air

- Unscrew cap and check to ensure contents of the jar are completely covered with alcohol. Top off if necessary.

- Put sample jar(s) on the ground and give a heavy twist to the cap, securing the cap as tightly as possible. Check to ensure there is no leaking around the cap of the jar(s). If sample jar is leaky or otherwise faulty, replace with a newer one.

Sample Storage and Handover for Processing

Properly collected macroinvertebrate samples can be stored as collected for several years before degradation may occur. However, the samples should be processed by monitoring field staff or handed over to the Minerals Division Ecological Program Specialist for Water for ID/processing as soon as possible.

- Prior to handover/processing, they should be stored in a temperature controlled environment away from sunlight

Be sure to handle processing/packaging for all grab samples as usual and as outlined in the procedure for Preparing Grab Samples for Courier Pickup

Quality Control

To meet EPA requirements for certain Federal grants, the PA DEP must adhere to an internal quality control process that includes a field collection audit. This audit is simply the observation of discrete field chemistry data calibration and collection, water grab sampling, macroinvertebrate collection, and habitat assessment and verification memo stating the collector is proficient in these activities. The Division of Water Quality Standards overseas this audit program, and may authorize a DCNR "trusted agent" to perform the audits on their behalf.

Once a year, the Ecological Program Specialist for water monitoring will organize a field day where he or she will review and audit collection procedures with field staff. At that time, the staff will choose two to three stream habitats to evaluate and "calibrate" their habitat scoring as a group, discussing why scores were given to the various habitat criteria.

Data Management

At the conclusion of each sampling day for macroinvertebrates, complete the following procedures, or as specified by the Ecological Program Specialist for water monitoring

- Scan all field notes in the field notebook, save as a PDF, and name according to the date YYYY.MM.DD (e.g. 2014.11.26) and place a copy here:

\\nrford12ds1\RPI\RPI_RAID\Water\Water Sample Field Notebook. Place another copy in the appropriate stream target folder here: \\nrforbofs06\RPI\Monitoring\MonitoringProtocols\Water\Stream Target Folders

- Scan the Water Quality Network Habitat Assessment Datasheet as a PDF and place in the appropriate place in the stream target folder. Name following the format "Stream Name_WRDS Stream Code_Field Sheet_YYYYMMDD" (e.g. Abes Fork_23492_Field Sheet_20141126)

- Download reach pictures from the digital camera and place in appropriate place in the stream target folder

- **FOR DEP'S REFERENCE:** Place a copy of the scanned field notes as well as a copy of the Habitat Assessment Datasheet at the following location: \\Epenegfs01\Standards\DCNR_Monitoring. Place the copies into the appropriate stream folder. If the folder does not exist create one, naming it with the stream name and 5-digit WRDS stream code (e.g. Abes Fork_23492).

Benthic Macroinvertebrate Processing

Purpose

Sampling for benthic macroinvertebrates to assess water quality has been standard practice in the global water quality monitoring industry for decades. Biometrics like the PA DEP Index of Biotic Integrity (IBI), Shannon Diversity, Hilsenhoff Biotic Index (HBI), the Index of Biotic Acidification (IBA), the Functional Feeding Reference Condition, and many others, are powerful statistical tools used to assess multiple components of a stream's long-term water quality as expressed in its biological community.

Because aquatic invertebrates are excellent indicators of water quality and are routinely sampled as part of Pennsylvania's various ongoing water quality assessment programs, the DCNR will collect benthic macroinvertebrates regularly as part of our monitoring programs to assess the attainment of aquatic life uses in areas where monitoring is deemed necessary, such as in shale gas areas or to track AMD remediation efforts, for example. The method the DCNR uses to collect these organisms is described in the Benthic Macroinvertebrate Collection procedure. This procedure describes how these samples are sub-sampled and processed.

Equipment Needs

- An unprocessed macroinvertebrate sample, properly collected and stored
- 14" x 8" x 2" minimum size laboratory pan gridded into 28 2" x 2" squares
- A second large white pan; does not need to be gridded nor be the same size as first
- Wide Mouthed Funnel
- Standard Sieve No. 35 (500 micron)
- Randomized number generating system 1 to 28 (e.g. numbered paper slips)
- Forceps
- Turkey baster
- Utility type knife
- Netted scoop
- Grid cutters with inside area of $4in^2$
- (2-3) 125ml bottles
- Diluted denatured alcohol (Approx. 125mL per sample, if doing a pan scan)
- Handheld counter
- Thermo bottle labels, or other sticky label
- Clear packaging tape
- Paper/pencil
- Microscope

Procedures

Preparing Sample

The composited sample is placed in a 28-square gridded pan to prepare for sub-sampling.

When transferring bug samples and stream contents from sample jar(s) to the gridded pan for processing always take special care not to lose any bugs in the process!

Drain Sample

- Gather sample jar(s) from a given stream reach and take to a sink with a 19L carboy for storing used alcohol, wide mouthed funnel, No. 35 sieve. The sink should have some sort of nozzle type sprayer equipped on it
- Place the funnel into the used alcohol container and position sieve, centered over funnel
- Begin pouring the alcohol from the sample jar through the sieve (via the wide mouthed funnel) into the used alcohol container. Some stream material (bugs, leaf/wood debris, gravel, etc.) may fall into the sieve as well. This is OK but the main goal of this step is to remove the alcohol from the sample jar
- When most of the alcohol has been captured from the sample jar, sit the used alcohol container and funnel aside. Replace cap on carboy
- Empty majority of remaining stream debris from sample jar(s) into the sieve as it sits in the sink. Delicate use of fingers can be used to dislodge larger contents

Rinse sample and transfer to gridded pan

- When sieve becomes full, gently rinse all contents in the sieve using the sink nozzle. The goal is to remove much of the fine sediment from the sample, to aid in later bug processing

Be very careful not to use too much water pressure when rinsing, and potentially lose bug specimens

- Dump rinsed contents from sieve into gridded pan
- Continue emptying and rinsing contents from the sample jar(s) until the jars are completely empty. A small amount of water sprayed into the sample jar(s) and dumped quickly can remove the last bit of stream contents

- Once the last of the contents from the sample jar(s) are into the sieve, gently rinse as before, working the contents to one side of the sieve for a final dump into the gridded pan

- To remove last bit of contents from the sieve, flip over and gently spray through screen to dislodge last pieces into the gridded pan

- Carefully look sieve over before setting aside for any remaining bug specimens. Place any found into gridded pan.

- Top off gridded pan with enough water to just cover all sample material in the pan

Placing Grid Cutters

- Gently stir the gridded pan to disperse the contents evenly throughout as thoroughly as possible.

The goal here is to have all bug specimens equally distributed so that, as nearly as possible, each grid contains approximately the same number of bugs. If you notice several of the same type of insect clumped together, it is OK to manually disperse them throughout the pan

- On a sheet of paper, record today's date, sub-sampler name, and all information from the label on the sample jar(s). **Remember:** this should include the date (yyyymmdd), time (local military time to match kicking time) and the Commonwealth identifier of the collector (e.g., 20141126-1300-roryder)

- Randomly pull (8) numbers from 28 number random set and record these numbers on the sheet of paper as well.

It is important to record these numbers in the order they were pulled! This will be the order you sample the grids until you reach the targeted sub-sample of at least 220 bug specimens. Some streams (i.e. acidified streams) may require more numbers to be pulled and grids to be analyzed which can be done later, if needed.

- Place 8 grid cutters in the gridded pan, centered in the grids corresponding to the numbers pulled. Grids should be numbered on the pan sides starting at the #1 grid in the top left corner of the pan, proceeding across to the right, then down and across again until the #28 grid in the lower right corner of the pan is reached. No need to use cutter to push down through debris at this time, simply place in the pan (**Figure 2.9**)

Figure 2.9 Pan with four cutters placed

Sub-sampling

- Take a second white pan, need not be gridded, and fill with approximately 1\2" of clean tap water

- Fill a 125mL bottle approximately 1\2 way with diluted alcohol and tighten cap

NOTE

Any alcohol that bug specimens are stored in after sorting, to prep for later identification, should be less than 100% clean alcohol but greater than 70%. Bug specimens can become dehyrdrated and impossible to identify if left in pure alcohol. Used "dirty" alcohol or pure alcohol diluted with some water can be used in the 125mL sample bottles as long as the alcohol is at least 70%.

- Fill out the bug sample information from the original sample jar(s) on another sticky label. Place label on the 125mL bottle with alcohol.

- Back at the gridded pan, beginning with the first number pulled, use the grid cutter to cut down through all debris in the grid. Push straight down on the top of the grid cutter until cutter edge contacts the bottom of the pan and twist grid cutter in place

- While holding down on the grid cutter, use the utility knife to cut around the inside edge of the grid cutter, severing all stream material from the outside of the grid

- Use forceps to remove most of the stream material from inside the grid cutter. Place removed material into the un-gridded clean white pan

- Use a netted scoop and turkey baster to remove additional fine stream material

- Thoroughly inspect the inside of the grid cutter to ensure all bug specimens have been removed from the grid

- From the un-gridded pan, pick all ***identifiable*** benthic macroinvertebrates from the cut grid. Place "picked" bugs into the 125mL labeled bottle, filled approximately 1\2 way with alcohol

It is recommended to place the labeled bottle in an unused grid cutter. This will help to prevent spillage from accidently bumping the sample bottle while working.

- After each bug is dropped into the 125mL bottle, be sure to tally it on a hand counter

Include

- All benthic macroinvertebrates (entire specimen is preferred but just the head of a species does "count" and should go in the jar)
- Abdomens should be included but should not "count" towards the 220 target
- Crayfish
- Beetles, unless obviously terrestrial
- Worms
- Small fish species and salamanders DO NOT "count", but should be put into the Pan Scan bottle (see Pan Scan section below)
- When in doubt, include in the sample jar but DO NOT COUNT. Only legitimate benthic aquatic organisms should be **"counted"**

Exclude

- Terrestrials (e.g. ants, wasps, houseflies, caterpillars, spiders, etc)
- Adult aquatic insects that do not "live" in the water during their adult stage, usually with wings (if unsure, include but do not "count")
- Other non-benthic taxa such as water striders
- Exuviae or empty shells or case

When in doubt, a dissecting microscope can be used to confirm whether to include a questionable item with the sub-sample

- If possible, have another person look through the pan for bug specimens that may have been missed by initial sampler. Eye fatigue can be an issue, and a fresh set of eyes can help pick out the last remaining bug specimens from a grid sample. **MAKE SURE ALL GRIDS RECEIVE A CONISITENT LEVEL OF SCRUTINY.** (i.e. each grid should be checked by the same people if multiple people are working on a sample)

- Once the contents from one grid cutter has been thoroughly scanned for all bug specimens, discard all contents, rinse pan, and fill with approximately 1\2" of clean tap water to prepare for another grid to "pick"

Grids will continue to be "picked" according to the order numbers were pulled until 220 bug specimens are realized **AND** a minimum of four grids are analyzed. For less fertile or polluted streams, additional grids may be needed. Continue to sample grids until targeted sub-sample is reached. Less than 220 is undesirable as some specimens "picked" may be determined unidentifiable later. The **FINAL** target number of identified bugs from each stream is 190-210.

- At the conclusion of each grid, record the number of specimens "picked" next to the appropriate number for the grid on the sheet of paper. If the sample was distributed properly, grids should have similar amounts of bug specimens realized in each.

- When finished sub-sampling all necessary grids, add up the number of bugs picked from each grid and total at the bottom

If ever the amount of material composited in the sample jars exceeds the functional sorting capacity of one pan, evenly distribute the material between as many pans as necessary (Pan 1, Pan 2, etc.). From each pan (Pan 1, Pan 2, etc.), remove debris and organisms from the same four random grids and place in the second un-gridded pan as described above and proceed as normal.

- If <400 bug specimens are realized after picking the minimum 4 grids, place clear packaging tape over the label on the 125 mL bottle containing the bugs and proceed to the Packaging for Identification section below. If ≥400 bug specimens, proceed to Additional Sub-sampling section below.

Additional Sub-sampling

Should the minimum 4 grids analyzed yield ≥400 bug specimens picked, additional sub-sampling will be required for the final identification of the bug specimens to be completed. If this is the case for a sample, follow the procedures below.

- Gather an additional empty 125mL bottle with cap

- Using a screened funnel inserted into the empty 125mL bottle, pour the contents of the 125mL bottle containing the picked bugs through the screened funnel so that the bugs are collected in the funnel and the diluted alcohol is deposited into the empty bottle (if water was used in orginal bottle simply dump contents into gridded pan and fill additional empty bottle ½ way with alcohol)

- Rinse the bugs in the funnel gently with water to rinse off alcohol. RINSE WELL AS THIS WILL ENSURE LESS "BUG DRIFT" IN ADDITIONAL SUB-SAMPLE.

- Empty contents of the screened funnel into an empty 28 gridded pan and evenly distribute bugs.

There should be enough water in the pan so that the bugs can be easily distributed, but not so much that they freely move between grids. Watch your breathing and for drafts.

- From the the 28 numbered set, randomly pull a number, set aside, and begin picking the bugs from that grid, keeping a total tally of the bugs as you go and placing them in the new bottle containing the alcohol.

A bug only counts if its head is inside the grid or is touching the grid line. Work quickly to minimize bug drift. **Remember to wipe tweezers after dipping in the alcohol and before returning to the pan to minimize bug "scattering".**

- After you finish picking the first grid, assuming your tally of bugs is <220, pull another number from the 28 numbered set and continue picking from that number grid you just pulled.

- Picking will continue in this manner until the target is reached. As soon as a grid is finished being picked **AND** the number of bugs you have picked exceeds 220 you can STOP!

- Next, label the **NEW** 125mL bottle (containing the bugs you just picked). Write the sample ID, stream name, number of grids initially and then the number of grids from the second sub-sample (e.g. "Grids P1-4: P2-8"). Write this same thing on the sheet of paper containing the original sub-sample information.

- When you've picked your grids, drain the water from the extra bugs in the gridded pan using the screened funnel. Empty the bugs from the screened funnel into the **ORIGINAL** 125mL bottle by rinsing with diluted alcohol. Use the turkey baster in conjunction with alcohol if needed

- Once all bugs are rinsed from the funnel using the diluted alcohol, add additional diluted alcohol to the bottle if needed (should be ~1/4 to 1/2 way full). Write on that **ORIGINAL** bottle "Extra bugs". Add this information to the existing label if possible or apply a new one and cover with clear packaging tape.

Number of bugs picked per grid for second sub-sample need **NOT** be recorded. Just total number of grids pulled

- Place the label on the bottle and cover with clear packaging tape
- Keep these two bottles together when you provide them for ID along with the sheet of paper

Packaging for Identification

Samples will be identified by an experienced aquatic taxonomist from the PA DCNR, PA DEP, or an independent contracted expert to the appropriate taxonomic level.

- Take the sheet of paper used to record grid numbers pulled, number of bug specimens in each grid, etc and fold so that it can be wrapped around all 125mL bottles
- Tape the sheet of paper around the sub-sample bottles so that all information can be kept together for the entomologist
- Keep stored in a temperature controlled environment, away from sunlight, until the sample can be handed over to an entomologist

Quality Control

- After the picking of a grid has been completed, the pan residue should be briefly scanned by another person before discarding to assure that the sampled grids have been sufficiently "picked." **MAKE SURE ALL GRIDS RECEIVE A CONISITENT LEVEL OF SCRUTINY.** (i.e. each grid should be checked by the same people if multiple people are working on a sample)

Data Management

See Packaging for Identification above.

Chapter 3 Pad Monitoring

Pad Infrastructure and Post Construction Stormwater Management (PCSM)

Purpose

The pad infrastructure and Post Construction Stormwater Management (PCSM) procedure will be carried out on all non-conventional shale gas related pads after the pad construction is complete and for the 5 permanent sampling well pads to assess pad construction and Post Construction Stormwater Managment. Timing is 2-phase and should be coincident with the overlap of most herp breeding periods in order to capture herp impacts. The first recording should be in mid to late April. A follow up visit should check and record the presence of persistent water and the presence and condition (desiccated, absence) of eggs or larvae in late June – early July.

Equipment Needs

- Post Construction Stormwater Management Datasheet
- PCSM plan if available – check sharepoint website
- GPS, Pencil or Pen
- Laser Rangefinder
- Compass
- Clinometer
- Camera
- Slope Sticks, of equal height

Procedures

Fill out the data sheet in the following manner;

1: District (#)

- E.g. FD 09

2: Tract (#)

- Record the number of the tract which contains the pad or feature being assessed

3: Pad (ID)

- Record the Pad ID

4: Surveyors

- Record the last names of the people who are conducting the survey

5: Date

- Record the date when the survey is completed

6: Permit Type (NPDES, ESCPG1or2)

- Leave this blank

7: Pad Type

- Check the box that represents the type of pad that is being assessed
- Gas Well(s)
- Monitoring
- Compressor
- Impoundment
- Metering/Tap Site
- Storage Site
- Waste Water Treatment
- Other (write a description of the pad type)

8: Site Stage in Time

- Check the box that represents the stage of time in the development of the pad

Stage	**Description**
1.Developed Site	The site is being used for gas activities. Construction work required to prepare the site for the intended purpose has been completed; ex: Land is cleared, graded, and the stone for the working surface is in place
2.Interim Restored Site	The pad is still carrying out its intended function (ex: well pad is still producing) Not receiving active construction Topsoil around the pad is pushed back to the original grade Pad size may be reduced to a smaller size
3. Permanantly Restored Site	Brought to a use other than a natural gas pad
4.Other	Any stage that does not fit one of the previous categories – describe the stage

9: GPS Information

Pad Perimeter

- Indicate "Yes" if the current perimeter GIS layer is not accurate and is being corrected in the field
- Indicate "No" if the current perimeter layer is not being corrected in the field; whether accurate or not
- Pad Acreage – Leave this blank – it will be calculated after the survey

Pad Center **For slope related to Monitoring, Staging/Storage or Well pads only*

- Using the longest corner to corner distance on the pad, measure and find the pad center
  - Indicate "Yes" if Pad Center is GPS'd – record coordinates
  - Indicate "No" if Pad Center is not GPS'd

10: Pad Slope. **For slope related to Monitoring, Staging/Storage or Well pads only*

From the Pad Center:

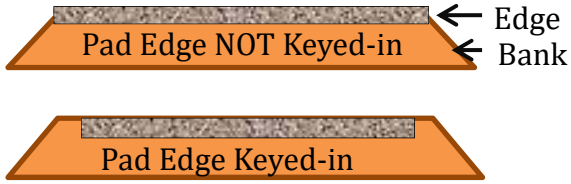
- Starting with the degree closest to "0" degrees north (PC1). Take a compass reading to the nearest degree and associated clinometer reading, to the nearest percent, from the Pad Center (PC) to the center of each of the sides at the Pad Edge (PE). Use two sticks of equal height to shoot slope.
  - Photograph this line showing the pad surface from the pad center *ONLY if* signs of pooling water are present.

- Following the same azimuth from the Pad Center, take a second clinometer reading from the Pad Edge (PE) to the edge of the modified cut or fill slope.
  - (1)Photograph this line from the Pad Edge (PE) to the edge of the modified cut or fill slope, or LOC.
  - (2)Photograph this edge (profile) from the pad corner in a clockwise direction starting from the corner left of the starting azimuth capturing the N,E,S,W edges respectively.

11-1: First (1st) Assessment of PCSM BMPs (April-May)

- Check the box in the right hand side of the page when a specific Best Management Practice (BMP) is present. Check any of the categories of BMPs that are present on the site. In the "Notes" section of the datasheet, indicate if there are any differences from the PCSM plan for the pad with what is actually on the ground. Plans can be located in the project tracking sharepoint site for newer projects. (http://nrsharepoint/parksandforestry/forestry/pads/SitePages/Home.aspx)

BMP Type		**Description**
Swale	Vegetative	A broad channel planted with vegetation designed to slow down the flow of surface runoff water and allow it to infiltrate
	Rock-lined	Same as a vegetative swale, except it is lined with rock instead of vegetation
	Check-dam	A mound of soil or rock located in the swale perpendicular to the length of the swale which serves to slow down the flow of water
	Other	Any other type of swale or feature in a swale – write a description
Swale Use	Conveyance	Feature is used primarily to "convey" or "transport" water to another infiltration structure.
	Infiltration trench	Feature is used primarily to capture and infiltrate water.
Infiltration Basin		A constructed basin designed to temporarily store and infiltrate runoff water. These may or may not contain water – indicate the condition by circling "wet" or "dry" on the data sheet.
Rain Garden		A Rain Garden (also called Bioretention) is an excavated shallow surface depression planted with specially selected native vegetation to treat and capture runoff
Channels	Diversion Channel	A long and narrow depression (ditch) which collects and re-directs surface runoff water and allows it to flow in a concentrated manner towards another runoff water feature such as an infiltration basin or a vegetative filter strip.
	Berm	A narrow and short mound of soil which functions the same as a diversion channel – it differs in that it is raised up rather than dug out
Sheetflow **ONLY indicate sheetflow if it is the only PCSM device/strat-egy for an entire side of the pad.*	Sheetflow	Sheetflow is the down-slope movement of runoff water in an even non-concentrated manner
	Rock Dissipater	A sloped area lined with stone which serves to slow down the flow of water as it passes over the rock dissipater.
	Vegetative filter Strip	A sloped area planted with vegetation – the plants act as a filter to remove any pollutants contained in the water
	Other	Any other sheetflow feature – write a description

	Keyed Edge	Cut or Fill Bank is built up to the top edge of the pad gradually rather than being an abrupt drop off. 
	Edge/bank erosion	Separation and transport of material in water from the pad edge or from bank.
Other		This list does not include all possible BMP features. If there is some other type of BMP, check this box and write a short description of what you see and take any necessary photographs.
Vegetative Cover		Visually estimate how much of the disturbed area (not including the compacted stone covered area) is vegetated. **Check the box if the vegetative cover meets DEP's 70%** requirement and select the closest percent cover: **0-10%, 10-30%, 30-50%, 50-70%, 70-90%, 90-100%**

PCSM Function

- Check the perceived function of the Feature (whether it is being used as a conveyance or for infiltration etc)
- Check whether any of the PCSM features are holding water or has recently held water and show on sketch.
- Check if the PCSM Feature was not adequate to sequester or infiltrate stormwater (overflow)

Wildlife Use

- Check wildlife use; look for signs of herps, invertebrates, egg masses, spermataphores, tracks etc. and indicate on the datasheet
- Photograph any presence or sign and include in the photo list and files.

11-2: Second (2nd) Assessment of PCSM BMPs (June-July)

- Applicable for Follow-up assessments
- ANY PADS SURVEYED DURING THE 1ST ASSESSMENT (April-May) THAT:
  a) Have PCSM features that are holding water AND
  b) Contain egg masses/spermataphores
  WILL REQUIRE A FOLLOW-UP VISIT (June-July)

- Revisit these pads and re-evaluate the PCSM BMP features that applied to the above during the first assessment. Use the same (original) datasheet to indicate findings.

12: Photos

- Photograph PCSM feature from any angle necessary to show important features such as;
  - Water entry point from pad
  - Current or past water height
  - Sediment deposits
  - Overflow features
  - Wildlife use (presence of Herps, eggs, spermataphores, tracks, etc)

- Take photographs of any features that are important, unusual, or unknown, or of features that cannot be adequately explained using words.

- On the datasheet, identify what feature the picture is of. Be sure to mark on the sketch the location and orientation of these photos.

<u>Checklist for Photos:</u>

- The following are photos needed that DO NOT need placed on sketch:
  - Pad slope line **(only if signs of pooling water exist)*
  - Bank slope from Pad Edge

- The following are photos that DO need placed on sketch:
  - Profile of Pad Edge from corners
  - PCSM features
  - Additional photos as needed

13: Notes

- Record any PCSM features "on the ground" that are not consistent with the PCSM plan.
- Record known recent rains that may affect current pooled water in PCSM and estimated days since that rainfall.
- Record any other relevant information about the pad that has not been previously documented.

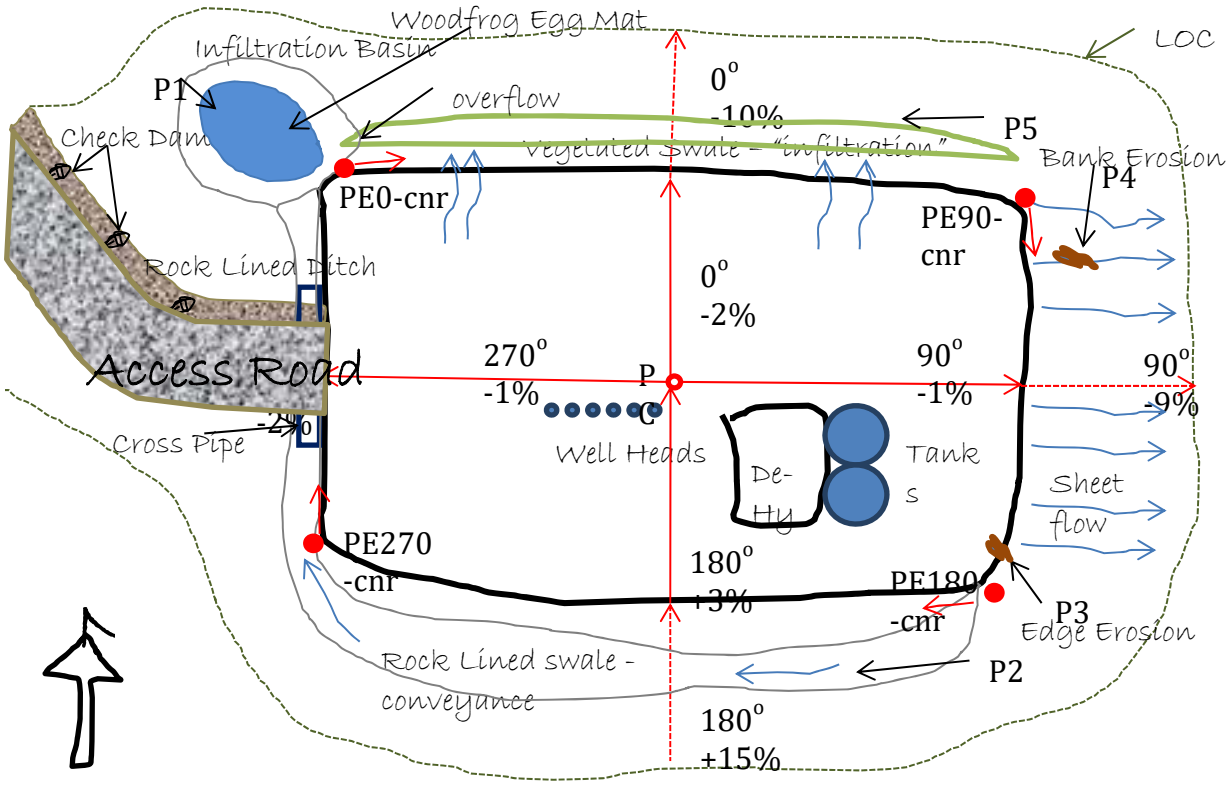
14: Sketch of Site

- Draw a sketch map of the well pad in the provided space on the Data Sheet.
- The map should be oriented so that north is at the top of the page.
- Include the Following features:
  - An outline of the pad

- A sketch of the access road and any other roads right around the well pad
- Sketch of gas infrastructure on and around the pad
- Location of any gas related signs
- Labeled representations of all BMPs you have indicated in Item 11of the Data Sheet
- Arrows indicating the direction of water flow from the pad center and through the different PCSM features
- Location of the camera for photos and the direction it was facing. ***Note: PC and PE photos do not need to be depicted on the sketch as these are known locations. Example below is for reference only.***

➢ **Example:** Photo 1 would be represented with "P1" drawn on the map in the spot where the photographer was standing and an arrow would be drawn from that spot out towards the location of the feature being photographed.

- Lines depicting azimuth and slope from the pad center point to the edge of the pad. (should depict direction of water flow as outlined above)
- Extended Lines depicting azimuth and side slope from the edge of the pad to the bottom of the fill bank or top of the cut bank. (should depict direction of water flow as outlined above)
- Any other features or notes important for the understanding of the pad



Data Management

- Scan the front and back of sheet.

- Name the file:
  - Tract_Pad ID_Year of Assessment.pdf
    - Ex: 285_C_2013.pdf

- Name the photos:
  - Tract_Pad ID_Photo Name_Year of Assessment.JPG
    - Ex: 285_C_P1_2013.JPG

  - For slope photos (Pad Center or Pad Edge) name the photo using the tract ID, pad ID, and location abbreviation and azimuth. Pad Edge will have 2 photos, one from the edge down the bank and one from the pad corner. Name the photo from the corner using the same process above with Hyphen-cnr.
    - Ex: Pad Center
      285_C_PC90 or 285_C_PC180 etc.

    - Ex: Pad Edge
      285_C_PE90 or 285_C_PE180 etc.

    - Ex: Pad Edge (from the pad corner)
      285_C_PE90-cnr or 285_C_PE180-cnr etc.

- Photos go in the folder \\nrford12ds1\RPI\RPI_RAID\Well_Pad_Sampling with the scanned copy of the datasheet and a copy of the PCSM plan for the pad if available. Be sure to place data in the folder for the relevant year.

- Give any GPS edits of existing layers to GIS specialist

Well Pad Vegetation Assessment

Purpose

The purpose of this protocol is to provide a means to collect basic, observational data on completed well pads within the state forest. Data will be collected regarding presence of invasive plant species and plant community composition. There are two types of well pad vegetation assessments:

1) Well Pad Walkabout Invasive Plant Surveys – these surveys involve canvas-style surveys only for populations of invasive species along well pad edges and well pad access roads. These surveys are designed so that every well pad on state forest land is visited on a 3 year rotation. No additional data collection besides the walkabout surveys are conducted.

2) Permanent Well Pad Vegetation Community Assessments – At 15 well pad locations, additional sampling of the vegetation communities at the well pad edge and in the adjacent forest will take place. Permanent milacre plots will be constructed and re-visited over time on a three year rotation. In addition, walkabout-style surveys will take place along three sides of the well pad to document any native species colonizing the disturbed/reclaimed edge.

Equipment Needs

- Tablet Computer
- GPS
- Data forms
- Field Guides, ID materials, and hand lens
- Compass
- 100 ft diameter tape
- Plastic bags for plant specimens
- Oak stakes, for marking plot center of permanent plots
- Mallet, for planting stakes
- Bark scribe, for marking reference trees
- Camera, for photo documentation purposes

Procedures

Record the following information at each well pad surveyed **for both** walkabouts and permanent plot assessment studies.

- District
  Record the number of the State Forest District in which the pad is located
- Tract
  Record the lease tract number in which the pad is located

*This number can be found in the attributes table of the well pad shapefile under "Tract_ID."

- Pad Number
  Record the identifying pad number for the pad
  *This number can be found in the attributes table of the well pad shapefile usually under "Pad_Label." This is usually a letter or a number.
- Surveyors
  Record the last names of the individuals performing the vegetation survey
- Date
  Record the date when the survey is completed
- Pad type
  Indicate what type of pad is being surveyed of the following categories:
  - Well
  - Compressor
  - Other
- Operator
  Record the name of the company operating the well pad
  *This can be found in the well pad shapefile under "Ownership" or on the sign at the well pad
- Number of Wells per Pad
  Record the number of wells or well heads drilled on the pad.

Well Pad Invasive Walkabout

Beginning at the entrance to the well pad, the entire edge of the well pad and any additional area of disturbance around the pad will be walked and examined for presence of invasive plant species. If the pad is being visited only for an invasive survey, be sure to use the Pad Invasives Walkabout Datasheet.

Collect and record the following items on the datasheet or tablet computer for each species present in the Well Pad Walkabout section;

- Invasive Species Found
  Record the species code of the species present
  Record "No Invasives" if no invasive species are present

- Certain ID?
  Indicate "Yes" if the species has been confidently identified
  Indicate "No" if the identity of the plant has not been positively identified

- Population Size
  Estimate the number of individual plants present at the well pad site using the following categories;
  - 1-5 (Trace)
  - 6-25

- 26-50
- 51-100
- 101-500
- 501-1000
- 1000+

Any invasive plant species found that is on the EDRR list must be documented and treated or noted for treatment based on EDRR protocols found in this manual. If any unknown species appears to be acting aggressively or is widespread at the site, a sample should be collected and pressed for further identification. All other unknown species should be collected for further identification by the field staff or specialists.

Access Road Invasive Walkabout Survey

The construction of access roads presents a vector for the introduction of invasive plant species from existing roadways onto the well pad located within interior forest tracts. To address this potential problem, the access road will be surveyed for the presence of newly established invasive plant species. This should be conducted during the course of every pad visit. The entire access road should be surveyed from the well pad edge back to the first intersection with a state forest Z1, Z2 or Z3 road.

- Collect and record the invasive species information for the access road in the Access Road Walkabout section using the same methods as the Well Pad Walkabout section. Be sure to clearly differentiate on the form each infestation that is located on an access road rather than a well pad edge.

Permanent Plot Vegetation Sampling

Milacre (1/1000 acre) plots with a 3.72 foot radius will be used to collect ground flora data around the well pads. Three sides of the well pad will be sampled, leaving out the side of the pad where the access road enters the pad

- Starting at the access road entrance, facing into the well pad, proceed clockwise around the well pad to the first pad side. This will be **"Well Pad Side A"**

- Visually locate the midpoint of the sides to be sampled. This point will serve as the location for walking off the pad to the vegetation plots.

- From the midpoint, measure and walk perpendicularly away from the edge of the pad work surface 25 feet. This becomes the plot center for the first milacre plot (side A, plot 1).

Take care not to disturb the vegetation on and around this spot.

- If visiting the plot for the first time, record the GPS coordinates of plot center, put in a stake at the plot center, then flag the stake. The distance, azimuth, DBH and species of the closest overstory tree to the plot center should also be recorded.

Once the plot center has been determined, collect and record the following vegetation data according to the Milacre Vegetation Plot Procedure described in this manual.

- Habitat / Vegetation Type

- Vegetation Data
  - Height Strata
  - Species
  - Cover Class/Stem Count

Once the milacre plot is completed, continue with the following steps;

- If plot 1 falls within Habitat/Vegetation Type 1 (Undisturbed Forest), only one milacre plot will be sampled on that side of the well pad. If plot 1 falls within a disturbed area (Habitat/Vegetation Type 2 or 3 – Native Disturbed or E & S vegetation) a second milacre plot will be established (side A, plot 2).

- To establish the plot center for plot 2, continue walking the same transect as for plot 1 until reaching the limit of clearance for the pad. From this point, measure 25 feet (continuing on the same transect into the un-disturbed forest) and establish the plot center for plot 2.

- If visiting the plot for the first time, record the GPS coordinates of plot center, put in a stake at plot center, then flag the stake. The distance, azimuth, DBH and species of the closest overstory tree to the plot center should also be recorded.

- Complete the plot using the same procedure as plot 1

- Continue this process on the other two sides of the pad to be sampled. These sides will be known as Side B and Side C, respectively, clockwise from Side A.

- General comments: Record comments on any unusual observations made at the well pad in the General Comments sections on the data sheet.

Native Species Colonization Walkabout Sampling (Disturbed edge)

At each of the three sides sampled using milacre plots, a walkabout-style survey should be conducted to locate any Pennsylvania native plant species that are colonizing the disturbed habitat at the edge of the pad.

- Upon completion of the milacre plots on each side, a walkabout of the entire well pad side should be conducted. Any native plant species found on the disturbed portions of the well pad side during the walkabout should be recorded, along with the abundance of that species on the side (1-5 (trace), 6-25, 26-50, 51-100, 101-500, 501-1000, 1000+).

Non-Native Species Colonization Walkabout Sampling (Forest edge)

At each of the three sides sampled using milacre plots, a walkabout-style survey should be conducted to locate any Pennsylvania non-native plant species that are colonizing the undisturbed forest edge and immediate forest margin at the edge of the pad.

- Upon completion of the milacre plots on each side, a walkabout of the entire well pad side should be conducted. Any non-native plant species found within the immediate undisturbed forest edge during the walkabout should be recorded, along with the abundance of that species on the side (1-5 (trace), 6-25, 26-50, 51-100, 101-500, 501-1000, 1000+).

Special Circumstances

- **Pad toe slopes:**
  - Some wellpads may have wide toe slopes that begin immediately at the edge of the pad work surface. In this case, begin the 25-foot measurement to the first milacre plot at the base of the toe slope.

- **Milacre plots placed on the edge of forest habitat:**
  - After measuring 25 feet from the edge of the pad work surface or the edge of a toe slope, it is possible that the milacre plot could consist of both undisturbed forest habitat and disturbed vegetation (either E& S planting or disturbed native vegetation). If this occurs, move the milacre plot back along the transect line towards the edge of the pad or toe slope until the entire plot is outside the undisturbed forested habitat. Record the actual distance in the appropriate comments section on the data sheet.

- **Stump or rock piles:**
  - It is possible that a milacre plot may fall within or mostly within a rock or stump pile on the outer edge of a well pad. If this occurs, simply record the percentage of the plot that is in the appropriate microhabitat class.

- On plot 2; do not complete the plot if it falls in a stump pile. Move it out into undisturbed forest. Record the new distance in the comments section for the appropriate side.

Data Management

- GPS points will be put in the forester's data backup folder in the RPIRAID and the GIS specialist will be notified of their location.

- Paper data forms will be filed until requested by the plant specialists.

Well Pad Wildlife Habitat Assessment

Purpose

The purpose of this protocol is to provide a means to collect basic, observational data on completed well pads within the state forest. Data will be collected regarding wildlife habitat.

Equipment Needs

- Tablet Computer
- GPS
- Well Pad Vegetation Assessment Datasheets
- Coverboard datasheets, if collecting coverboard data
- Field Guides, ID materials, and hand lens
- Compass
- 100 ft Tape Measure (in tenths of feet)
- Diameter Tape
- Camera with fish-eye lens(for canopy cover analysis)
- 10 BAF Prism
- Laser Rangefinder
- Reptile and Amphibian ID Guide
- 2" x 10" x 12" Cover Boards (4 per pad side, 12 total)
- Oak stakes (12 per pad – 6 for vegetation plots, 6 for wildlife habitat plots)

Procedures

- Record the following information at each well pad surveyed; ***unless completing with a Well Pad Vegetation Assessment and this information is already completed***
  - o <u>District</u>
    Record the number of the State Forest District in which the pad is located
  - o <u>Tract</u>
    Record the lease tract number in which the pad is located
    *This number can be found in the attributes table of the well pad shapefile under "Tract_ID."
  - o <u>Pad Number</u>
    Record the identifying pad number for the pad
    *This number can be found in the attributes table of the well pad shapefile usually under "Pad_Label." This is usually a letter or a number.
  - o <u>Surveyors</u>
    Record the last names of the individuals performing the vegetation survey
  - o <u>Date</u>
    Record the date when the survey is completed
  - o <u>Operator</u>
    Record the name of the company operating the well pad

*This can be found in the well pad shapefile under "Ownership" or on the sign at the well pad

- Pad type
  Indicate what type of pad is being surveyed of the following categories:
  - Well
  - Compressor
  - Other

Forest Habitat Monitoring

- Two permanent wildlife habitat points will be established on each Side A, Side B and Side C of the well pad, ignoring the side with the access road. One point 100 feet from the disturbed edge, and one point 300 feet from the disturbed edge.

- Starting at the access road entrance, facing into the well pad, proceed clockwise around the well pad to the first pad side. This will be **"Well Pad Side A"**

- Unless pad edge midpoint is already established, locate the midpoint of the sides to be sampled on the workable/paved well pad surface using the laser rangefinder. This point will serve as the location for walking off the pad to the plots.

- From the midpoint, measure and walk perpendicularly away from the edge of the pad work surface to the undisturbed edge. From this point, measure 100 feet into the undisturbed forest along the same transect. This plot will be labeled as "Plot 3" for each side.

- Once the plot center has been determined, a stake must be put into the ground at plot center and the GPS coordinates must be collected.

- At these plots, the following habitat data will be collected: species, DBH, height (ft), and health of "in" trees using the prism; forest cover type; canopy cover; mid-canopy cover; basal area (of live trees).

- Record the following information for each plot:
  - Cover type
    Record cover as either maple or oak.
  - Canopy Cover
    Using a digital camera at the plot center, determine the canopy cover percentage to the nearest percent (using camera software).
    - Photo should be taken of the canopy directly above the plot center.

- Attach the Fisheye lens to the Nikon camera, making sure to keep all dirt and dust out of the camera and lens
- Turn the camera on and put it to the "No Flash" mode by turning the dial on the top of the camera

- Hold the camera at eye level so that the lens is pointing vertically (hold camera as level as you can, it is not necessary to use a level or tripod) and so that the bottom of the camera is pointing due north.
- Take one photo
- Look at the photo and make sure that it is acceptable and that your head and your co-workers are not visible in the photo

NOTE

The best photos (most usable ones) are taken on cloudy days when there is a lot of contrast between the sky and the canopy. Days when the sky is dark blue and midday when the sun is bright in the photo are not the best times to take canopy photos. The software needs contrast between sky and the canopy to give the best results. Avoid taking photos at times that will give poor canopy photos!

- Mid-canopy Cover
  Using an ocular estimate, determine the mid canopy (woody vegetation under 15ft in height) cover percentage (0-25%, 25-50%, 50-75%, 75-100%).
- Basal area (BA)
  Count the number of **live** trees in the plot, multiply by ten, and record the result as the basal area for the plot.

- Record the following information for each tree determined as a tally tree by a 10 factor prism. The prism should be held at DBH (1.5 m above ground level) of the tree to determine the actual degree of stem displacement:
  - Tree #
    Number each tree sequentially, starting with the first "in" tree to the right of 0° North. This will be Tree #1 as it is called on the prism plot.
  - Species
    Record three-digit code using the BOF Inventory species codes.
  - DBH
    Measure all live trees 1.5 inch d.b.h. and larger that are "in". Measurement of d.b.h. should always be done from the uphill side of the tree. Measure to the nearest inch.

NOTE

In case of irregularities at d.b.h. such as swellings, bumps, depressions, branches, etc., refer to the "Special DBH Situations" section of the Overstory Plot Procedure

- Height (ft)
  Use the Criterion 400 laser to measure total tree height including the one-foot stump. Follow the laser's internal program for tree heights.
- Overstory
  Is this tree a component of the overstory of the stand (Y or N)?
- Dead or alive
  Record whether the tree is dead or alive (D or A)?

- A second plot should be put in 200 feet from Plot 3 (300' from the undisturbed edge) along the same azimuth. This plot will be labeled as "Plot 4" for each side.

Note any additional gas related disturbances encountered along the transect while measuring out plots 3 and 4. Record this with the habitat data on the Well Pad Monitoring Datasheet using the "Notes" field.

- Follow the steps taken at plot 3 above to complete data collection at plot 4.

Cover Board Installation and Monitoring (At Prism Plots)

- Cover boards should be installed at all 6 wildlife habitat permanent plots.

- Place two cover boards at each point, one on each side, perpendicular to transect. From the point center, measure 10 feet perpendicular from the transect line in both directions (parallel to the pad edge). At the measured distance, clear the area of any leaf litter or debris if present, and place the board.

- **Data Collection:**
  - Locate cover board and record the appropriate ID#. Cover boards will be named as follows: Well Pad Side_Footage from Pad Edge_Left or Right(standing on transect with back to pad). ***e.g.*** A100L, B300R, etc.

For first year (2014) permanent pads, cover boards were also placed near vegetation milacre plots 25' from the pad edge (if applicable) and 25' inside the undisturbed forest. For these cover boards, use the same ID rules except use a "D" for disturbed areas and a "U" for undisturbed areas coincident with the 25' footage to distinguish the two. ***e.g.*** A25DR, A25DL, A25UR, A25UL, etc.

  - Lift it, and record the common name and abundance of all vertebrate species present under the board on the data sheet.
  - Once the species have been recorded, place the animals at the edge of the board, and replace the board to the original location.

- Record any relevant "Notes" for the cover board.
- Repeat this process for all cover boards at the pad.

- Cover boards will be checked once per year (starting one year after placement)

- ***RECENTLY*** flipped or destroyed boards; replace cover board, note it on data sheet, and collect data next year.

Cover Board Installation and Monitoring (At Stump/Brush Piles)

- Cover boards should also be installed at 1 man made habitat feature (brush/stump pile) per permanent pad.

A minimum of 3 stumps must be present in a pile in order to evaluate the pile. The stump piles must originate from gas infrastructure, and be piled in a deliberate manner. ***If such a feature does not exist, skip installation of these coverboards.***

- Standing where access road enters the pad, find the north azimuth using a compass. The man-made habitat feature (brush/stump pile) that is nearest this azimuth should be used for this survey.

- Take a GPS point of this brush pile nearest the center as possible.

- Place 2 cover boards 1 foot from the edge of the brush pile, one on each side of the pile. Place one board centered on the pile facing the center of the well pad and one on the opposite side of the pile (facing the forest edge).

- Collect data on these coverboards just as you would with the other coverboards at the prism plots. Use an "F" to indicate data from the coverboard on the forest side of the brush pile and a "P" to indicate data from the coverboard on the pad side of the brush pile.

Data Management

- GPS points will be put in the forester's data backup folder in the RPI.RAID and the GIS specialist will be notified of their location.

- Canopy photos are filed at \\nrford12ds1\RPI\RPI_RAID\Wildlife\Permanent Pad Canopy Cover\Permanant Pad Canopy Photos and are named as follows; Tract number, Pad Id, Side of pad, plot. (i.e.100 M Side A 100ft). Refer to the Canopy Photo Software Procedure found in this manual for instructions on obtaining a canopy coverage from the photos taken.

- Paper data forms will be filed until requested by the wildlife specialist.

Soil Fertility Sampling

Purpose

The purpose of this protocol is to provide a means to collect basic soil fertility data around well pads that have been returned to the state forest.

Equipment Needs

- Tablet Computer
- GPS
- Data forms
- Compass
- 100 ft diameter tape
- Plastic bags for soil samples
- Submission forms
- Shovel/trowel
- Bucket

Procedures

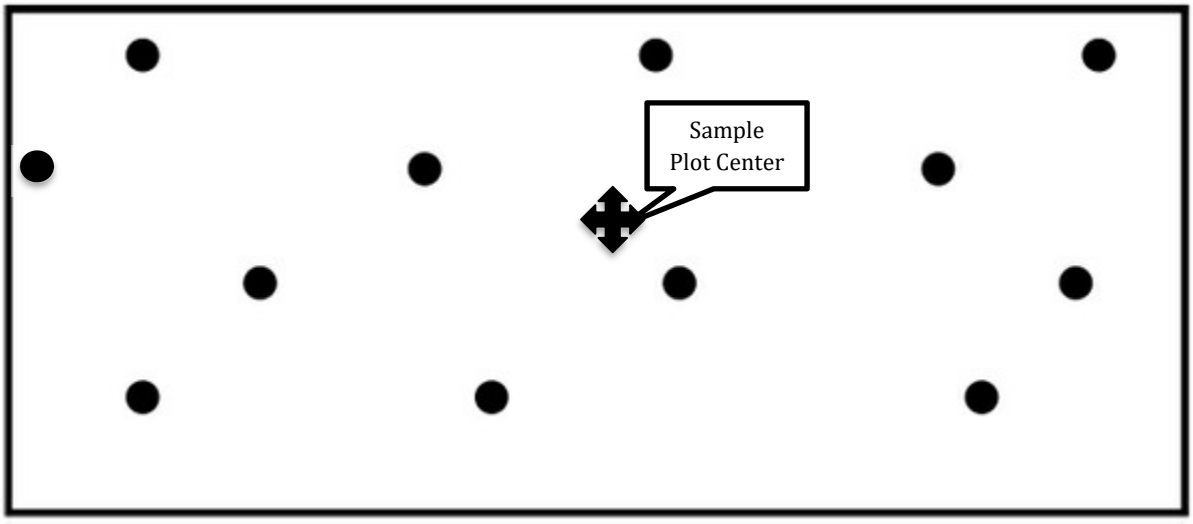
Record the following information on the submission form (use pg. 2 yellow) at each well pad surveyed.

- Grower name
  Assistant Program Managers Name
- Business name
  PA DCNR Bureau of Forestry
- Address
  10 Lower Pine Bottom Rd Waterville, PA 17776
- County name
  Lycoming
- Phone Number
  570-753-5409 ext 124
- Email
  Use the Assistant Program Managers email.
- Check box for email
  Check this box
- Field/Sample ID
  ID for each sample plot is District, Tract, Pad, side, plot# i.e. 10344BA1 or 10344Bpad for plot taken on the pad
- Serial No.
  From front of sample bag kit
- Check no till box
- Year 1 Crop Code
  1056

Soil Sampling

Three sides of the well pad will be sampled, leaving out the side of the pad where the access road enters the pad.

- Starting at the access road entrance, facing into the well pad, proceed clockwise around the well pad to the first pad side. This will be **"Well Pad Side A"**
- Visually locate the midpoint of the sides to be sampled. This point will serve as the location for walking off the pad to the sample plots.
- From the midpoint, measure and walk perpendicularly away from the edge of the pad work surface 50 feet. This becomes the central sampling location for the first sample plot (side A, plot 1).
- Once the plot center has been determined, collect the soil sample data following the diagram below to properly locate the samples.
- Using a shovel/trowel and a clean pail, obtain thin slices of soil from at least 12 places evenly spaced 5-10 feet apart in a given area.
- Sample to a depth of 6 inches.



- Mix the soil taken into one composite sample and place into labeled bag.
- To establish the plot center for plot 2, continue walking the same transect as for plot 1 an additional 50 feet and establish the plot center for plot 2.
- Complete the plot using the same procedure as plot 1

- To establish the plot center for plot 3, continue walking the same transect as for plot 1 an additional 200 feet and establish the plot center for plot 3.

- Continue this process on the other two sides of the pad to be sampled. These sides will be known as Side B and Side C, respectively, clockwise from Side A.

- The last sample location will be on the pad itself. Find a location that is representative to the pad and complete the plot using the same procedure as plot 1.

Sample Processing

- Spread each soil sample on newspaper in a warm room to air dry overnight. Do not heat.

- For each sample take 1 cup of representative sample and place in the soil mailing kit bag. Mail soil sample and submission form to The Pennsylvania State University, 111 Ag Analytical Srvcs Lab, University Park, PA 16802-1114.

Data Management

- Sample Lab results will be placed at the following location: \\nrford12ds1\RPI\RPI_RAID\Soil Samples

Chapter 4 Road Monitoring

Roadside Vegetation Community Monitoring

Purpose

The purpose of this protocol is to understand how the composition of roadside plant communities may change over time as a result of increased state forest road use. This will be carried out on individual roads by using 6 milacre (1/1000 acre) vegetation plots and by assessing areas around three culverts for invasive plants.

Two types of category Z1 (public use) roads will be identified, those with high gas traffic (HG roads) and those with no regular gas traffic (NG roads). At least two roads of each type will be selected in each core gas district based on input from the forest district and the Operations section. These will be state forest roads that are not maintained by PennDOT or municipalities. Consideration should be made to insure that the NG roads are unlikely to be utilized by new gas development in the future.

Roads chosen for the study will have the desired amount of gas traffic (high traffic or no regular gas traffic) for **at least 2.5 miles.** Any intersections within these 2.5 miles will be with another road (HG or NG) of the same type only. Attempts should be made to locate an HG and NG road pair within close proximity to each other.

Equipment Needs

- Tablet Computer
- GPS
- Roadside Vegetation Community Monitoring Datasheet
- Field Guides and ID materials and hand lens
- Compass
- Diameter tape
- Bark Scribe
- Camera

Procedures

General Data Collection

Record the following general Information on the data sheet

- District
  Record the number of the forest district the road belongs to

- Road Name
  Record the name of the road

- Surveyors
  Record the last names of the individuals who are conducting the survey

- HG / NG
  Indicate whether or not the road is being used for gas activities by circling the appropriate designation
  - HG – High gas traffic
  - NG – No regular gas traffic

- Date
  Record the date when the survey is completed

- Directions to Starting Point (mile 0.0):
  Write a short set of directions for finding the starting location for the survey (the starting point refers to the beginning of the 2.5 mile stretch of road.
  For example:
  "Starting point is 0.75 miles east from the intersection with Dry Run Road."

- General Site Observations:
  Record any notes that the crew determines would be helpful for the understanding of the data.

Establishing Vegetation Plot Locations

Three sets of two vegetation plots will be completed along each road. The first set will be located 0.25 miles from the start of the 2.5 mile survey length. (*The first and last quarter mile segments of the 2.5 mile study area serve as buffers to minimize any effects from intersections with roads of other types*.) The second set will be located 1.25 miles into the survey, and the third set at 2.25 miles. If any of these locations fall on a bridge or at any other spot such as a culvert, turnout, road intersection which would cause problems with the vegetation plots, move the set of plots down the road ten feet past the end of the obstacle and make a note describing the situation in the "Notes on Plots # and # and Closest Culvert" section for the appropriate set of plots on the data sheet.

Point A (0.25 mile) Data Collection

- Navigate to the first set of plots at mile 0.25

- Take a GPS point in the center of the road. This is called "Point A".
  (It is helpful to mark this point with a scuff or a rock so it can be re-located later in the procedure)

- Walk to the edge of the road, perpendicular from the center point that is nearest a North/East azimuth.

- Determine the point where the vegetation along the edge of the road starts. Look up and down the road to get a general (average) idea of where the vegetation

starts to grow. This general line of vegetation will determine the plot locations. The vegetation starts over a gradient on many roads, so this is not always a clean line. Ignore outlying clumps of grass or small individual plants if they are growing farther into the road than the general line of established vegetation observed (Figure 4.1).

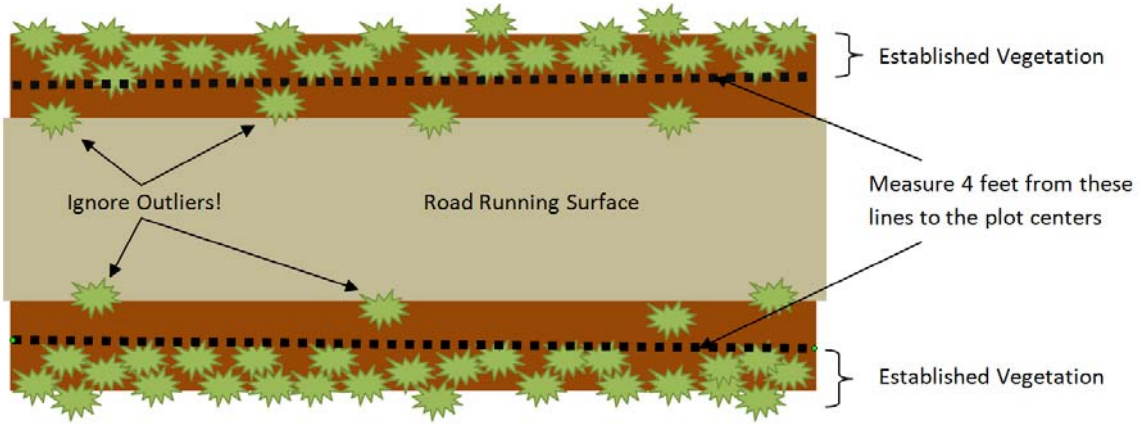


Figure 4.1

- Measure four feet off the road from the determined start of the vegetation to locate the center of the milacre plot. Mark the plot center in a non-destructive way. This is "Plot 1".

NOTE Take care not to disturb the vegetation around this point that falls on the plot.

- Measure from the center of the road to the plot center and record it on the data sheet, to the nearest tenth foot.

- Mark the closest tree
  - Locate a tree close to the milacre plot center.
    This should be a live, healthy tree of a decent size (not a sapling) which is likely to be present in future years.
  - Record the tree species, dbh, and the distance and azimuth from the plot center to the tree in the closest tree section for the appropriate plot on the data sheet.
  - Scribe the tree with one diagonal mark at chest height facing the milacre plot center.

NOTE Take care not to scribe through the bark into the cambium layer.

- Repeat the steps above directly across the road to establish a second plot, "Plot 2". **Remember:** The plot on the north or east side of the road should be the first

plot off the road centered GPS point, and the south or west side should be the second plot.

Vegetation Data

Once the plot centers have been determined, collect and record the following vegetation data on each milacre plot according to the Milacre Vegetation Plot Procedure described in the Plant Supporting Section.

- Habitat / Vegetation Type
- Vegetation Data
  - Height Strata
  - Species
  - Cover Class/Stem Count

Evaluating Closest Road Culvert

After collecting data at a pair of milacre plots, the closest culvert to those plots should also be evaluated. No closest culvert data will be collected if a culvert is not within 300 feet of the plot in either direction.

- Invasive Species Found
  - Check "yes" if invasive species are present
    Record the species code of all invasives found
  - Check "no" if there are no invasive species present

- Certain ID?
  - Indicate "Yes" if the species has been confidently identified
  - Indicate "No" if the identity of the plant has not been positively identified

- Population Size
  - Estimate the number of individual plants present at and right around the culvert on either side of the road using the following categories;
  - 1-5 (Trace)
  - 6-25
  - 26-50
  - 51-100
  - 101-500
  - 501-1000
  - 1001+

- Follow the EDRR Procedure for any EDRR target species found to be present.

Point B (1.25 miles) and Point C (2.25 miles) data collection

- Navigate to the second set of plots at 1.25 miles after all of the steps are completed at 0.25 miles.

- Repeat all of the steps done at 0.25 miles. The milacre plots off of Point B shall be called “Plot 3” (to the North/East) and “Plot 4” (to the South/West) respectively.

- Navigate to the third set of plots at 2.25 miles and repeat the steps again. The milacre plots off of Point C shall be called “Plot 5” (to the North/East) and “Plot 6” (to the South/West) respectively.

Data Management

- GPS points will be put in the forester’s data backup folder in the RPIRAID and the GIS coordinator will be notified of their location.

- Paper data forms will be filed until requested by the plant specialists.

Roadside Invasive Plant Monitoring

Purpose

State forest roads are one of the primary corridors for the introduction of invasive plants into the forested interior of our state forest system. Therefore, any attempt to manage/control the spread of these unwanted organisms must begin with an inventory of invasive plant populations established along these roads.

Equipment Needs

- GPS unit
- Roadside Invasive Plant Monitoring Datasheets
- Clipboard and pencil
- Vehicle with an odometer that measures tenths of miles
- Measuring wheel (if walking the road)
- Field guides / other ID materials and hand lens

Procedures

Road Selection

Once an area of focus is identified by the plant specialist(s), all Z1 roads located within and adjacent to the tract will be surveyed for all invasive species present. In addition, as many of the Z2 and Z3 roads should be surveyed to increase the accuracy and scope of the data. If possible, township and PennDOT maintained roads should be surveyed if they transect the state forest tract or run adjacent to a state forest boundary.

Data Collection

From the starting point, invasive plant data will be collected in one-tenth mile intervals for the entire length of the road. Special attention should be paid to culverts and newly disturbed ground along the roads. Data collection can be collected from a slowly moving vehicle or on foot (in the case that the road is undeveloped and not drivable). Vehicle data collection is most efficiently carried out by a team of three people; one to drive and watch the odometer and one person to watch the left side of the road and one to watch the right side. Two or three people can conduct a survey on foot.

Data collection is conducted using the following procedure:

1. Navigate to the pre-determined starting point of the road to be surveyed. This is usually at an intersection with another road or at the State Forest Boundary on a given road.

2. Record the following information on two datasheets (one for the left side and one for the right side):
   - <u>District #</u>
     Record the number of the forest district(s) where the road is located

- Road Name
  Record the name of the road that is being surveyed.

- Surveyors
  Record the last names of the individuals performing the invasive survey

- Date
  Record the date(s) on which the survey is conducted

- Side of road (L or R)
  Record an "L" if the datasheet represents the left side and an "R" if it represents the right side. Left and right are determined looking ahead (down the road) as you move along.

- Starting Point GPS Coordinates
  Record the GPS coordinates of the location where the survey length begins

3. Set the trip odometer to zero

4. Start driving forward slowly, looking for all invasive plant species growing around the road. Any invasive plants that are visible from the road count.

5. Stop moving once the odometer reads 0.1

6. Record the name of any invasive plants that were observed on either side of the road in the tenth mile segment in the "Invasive Species" column of their respective sheet.

7. Record a "0.0" in the "10th mile" row adjacent to the species name for each species observed to represent a presence of the particular species in the first segment of the road

8. Estimate the population of each individual species **in the 10th mile segment that was just surveyed** and record the population size code in the "Pop." row, directly under the "0.0" you just recorded

9. Continue driving and looking for invasive plant species, making sure to stop each 10th of a mile to record the invasives for each given road segment. Record invasive presence in the second tenth mile segment as 0.1, the third segment as

0.2 and so on. The datasheet should be filled out in the same manner as the following example;

Invasive Species		Population Size Code:	1-5(trace) (1)	6-25 (2)	26-50 (3)			
Multiflora Rose	10th mile	0.0	0.1	0.4	1.7			
	Pop.	1	1	2	2			
Japanese Stiltgrass	10th mile	0.0	0.1	0.2	0.4	1.0	1.5	
	Pop.	7	7	6	7	6	6	
	10th mile							
	Pop.							

Population Size / Abundance Codes

1 = 1-5 (trace)
2 = 6-25
3 = 26-50
4 = 51-100
5 = 101-500
6 = 501-1,000
7 = 1,000+

10. Once the end of the road is reached, record:
    - Ending Point GPS Coordinates
      Record the GPS coordinates of the location where the survey length ends (terminus of road or intersection with other road)

    - Total Road Survey Length
      Record the length of the road that is surveyed between the starting and ending points to the nearest tenth mile

Quality Control

Plant specialists will visit a subset of roads surveyed by the monitoring field crews to conduct checks on vegetation data collected. The specialists will recollect the vegetation data from the same location using the GIS/GPS data collected at the initial visit. A comparative analysis will be used to determine the level of accuracy, with a focus on species identification since the percent cover can be difficult to duplicate precisely.

Data Management

Paper data forms will be filed until requested by the plant specialists.

Road Condition Monitoring

Purpose

This procedure will document how state forest roads change over time due to gas development. It can also be used to collect pre-development road condition data. This procedure will also serve to capture road and trail intersections on state forest lands, to be used as a quality control measure by DCNR Bureau of Forestry's Geospatial Applications section.

Equipment Needs

- Tablet computer
- GPS unit
- Camera
- 100 ft measuring tape in tenths of feet
- Measuring wheel
- Road Condition Monitoring Datasheets (paper or electronic)
- Road Condition Monitoring_PCSM Datasheets
- Clipboard and pencil
- Safety vest

When entering data electronically, or on roads being re-measured, be sure to have the appropriate road condition monitoring points layer on your tablet computer. This will allow you to add new survey points on new roads being measured and also navigate to survey points and add new measurements on previously surveyed roads. These can be found using the following path via FIMS: P:\Layers-Gas Program\Monitoring\Road Condition Monitoring Point. Refer to the supporting documents section of this manual for instructions on Checking In/Checking Out Data for ArcPad.

Procedures

The portion of the road to be surveyed that is used for gas activity will be divided into quarter-mile sections. A survey plot is to be established at the point where gas-use begins (usually this is the beginning of the road), at each quarter-mile section, at the point in the road where gas-use ends, then at a point a quarter-mile past where gas-use ends (or at the end of the road if there is not a quarter-mile of road beyond gas use).

1. Navigate to the road to be surveyed

2. Determine from which end the gas traffic (if road is currently gas use) is entering the road

3. Go to the start of gas use (i.e. where gas traffic enters the road from the rest of the world)

4. Record the following information on the tablet computer or datasheet:
   - District #
     Record the number of the forest district the road belongs to
   - Tract #
     Record all of the leased tract numbers the road survey will encompass. Refer to the "TractID" field of the "Draft_DCNR_OG_Ownership- All" layer in ArcPad to view leased tract numbers. If no leased tracts apply, record as "N/A".
   - Road Name
     Record the name of the road that is being surveyed. This information can be found in the "Name" field of the RoadsTrails layer.
   - Surveyors
     Record the last names of the individuals performing the road survey
   - Date
     Record the date(s) the survey is completed
   - Starting Point of Survey
     Write a short description that describes the starting point for the road survey (e.g. "Intersection of Dry Run Rd with Benson Rd").

5. When the start of gas use coincides with the beginning of a road, take a GPS point at the intersection of the road being surveyed and the other road it intersects. This GPS point is taken where the centerlines of each road intersect (**Figure 4.2**).

NOTE

Any Z1, Z2, or Z3 road and "blazed" trail intersections encountered along the survey length of the road should be GPS'd, taking the GPS point where the centerlines of each feature intersect. These intersection points should be included in the same layer as survey points (Road Condition Monitoring Point).

6. If the start of the survey coincides with the beginning of a road, go to the point where the road narrows down to a uniform width representative of the road ahead (widths are usually flared out at the intersection and we do not want to capture this exaggerated width). This location becomes the first survey plot (**Figure 4.2**).

*If not, the point at which gas-use use starts ON THE STATE FOREST ROAD will be the first survey plot.

7. GPS the center of the road at the plot location. This point is added to the "Road Condition Monitoring Point" layer

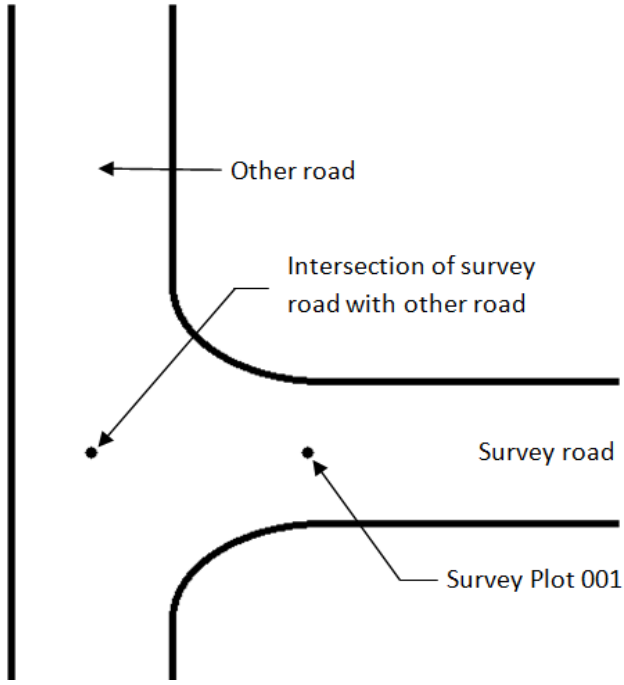


Figure 4.2

NOTE

Survey plots are named in the following fashion, formatted with the name of the road being surveyed followed by a sequential plot number. **Be sure to record the name of the survey plot in the appropriate place on the tablet computer.**

- (Survey Road) 001 - e.g. Dry Run Rd 001
- (Survey Road) 002
- (Survey Road) 003
- Continue this sequential format up to and including the last survey plot

8. Plot Data

Record the following data at each survey plot (every 0.25 miles) on the tablet computer or datasheet:

NOTE

All measurements are recorded to the nearest foot

- Plot Number
  Record the sequential plot number part of the survey plot name

- Plot Improved for OGM Use?
  Is this plot improved for gas? Yes or No

- Dust conditions
  Observe and record the amount of dust in the air that has been stirred up by passing traffic. Select one of the following categories;
  - No Dust
    Passing traffic does not produce any dust
  - Light Dust
    A minor amount of dust is produced
  - Moderate Dust
    More than Light, less than Heavy
  - Heavy Dust
    Traffic is producing a large amount of dust

- Dust control
  Indicate if the gas companies are applying any dust suppressant to the road surface OR there is evidence of such use in the past
  - None
  - Water Suppressant
  - Chemical Suppressant

- Road surface condition
  Assess the condition of the road surface for the area surrounding the survey plot and the section of road between the current and previous survey plot. Look for things such as potholes, ruts, and standing water. Select the category that best represents the road. A poor rating can be thought of in real world terms - if you have to brake or drive around a condition (potholes, ruts, erosion) on the road or if a road condition causes loss of traction (rills, washboards) then it is “poor”.

  - Good - No maintenance needed
  - Good - Recently maintained

  - Adequate, Future Maintenance Needed - Potholes
  - Adequate, Future Maintenance Needed - Rills
  - Adequate, Future Maintenance Needed - Rutted
  - Adequate, Future Maintenance Needed - Erosion
  - Adequate, Future Maintenance Needed - Berms
  - Adequate, Future Maintenance Needed - Other_____

- Poor, Needs graded- Potholing
- Poor, Needs graded- Rills
- Poor, Needs graded- Rutted
- Poor, Needs graded- Erosion
- Poor, Needs graded- Berms
- Poor, Needs graded- Other_____

Any condition not covered by a category – record a description in the "Other Notes" section of the plot data. Also note anything you feel is warranted to better describe any issues with the road surface condition.

- Road Profile
  Select the profile that best fits the survey road. Consider the cross section of the road perpendicularly to the length of the road, paying attention to the direction that water would flow off of the road surface. The 3 primary profiles are crowned, insloped and outsloped but a road can also have a flat or cupped profile. See **Figure 4.3** for an illustration of different road profiles.
  - *Insloped*
    A road built on a side hill that sheds the water to the uphill side of the road into a ditch
  - *Outsloped*
    A road built on a side hill that sheds the water to the downhill side of the road
  - *Crowned*
    Road surface sheds water to both sides of the road
  - *Flat*
    Road surface is flat and water does not have good flow to one side or the other
  - *Cupped*
    Road surface is "U" –shaped and water is trapped on the road surface acting like a ditch
  - *Other*_____
    Any other profile encountered (describe the profile in the notes section)

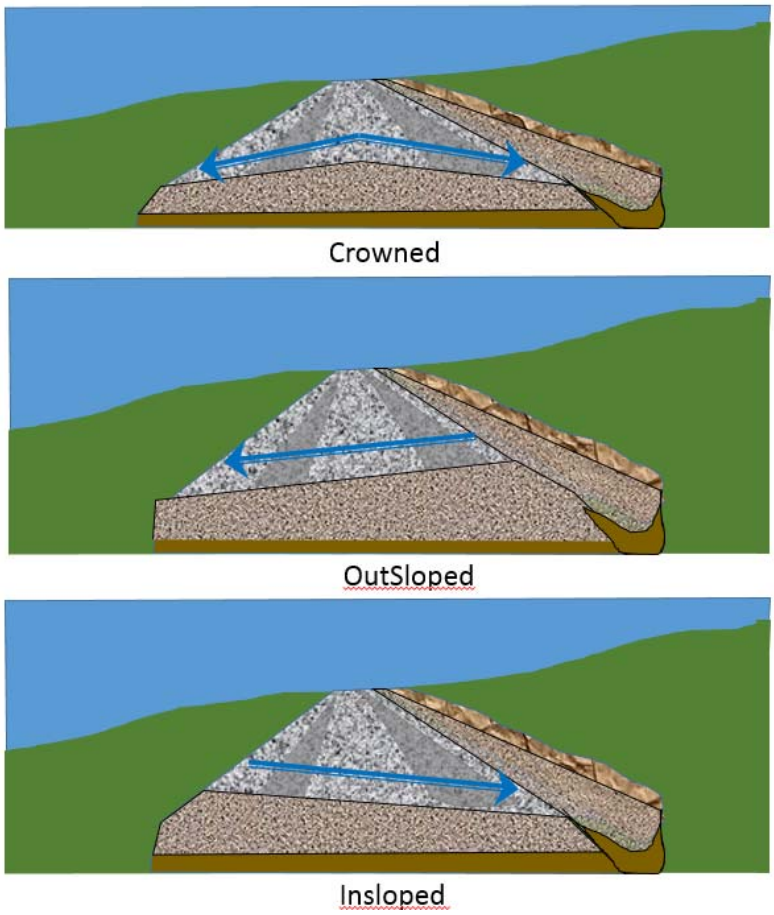


Figure 4.3 Primary Road Profiles

- PCSM
  Are Post Construction Stormwater Management (PCSM) features present? Yes or No, (*if yes complete the Road PCSM Form)

- Treadway width (ft.) (Labeled "Running Surface" pre-2016)
  - The Treadway of the road is the part of the road that receives regular traffic and shows tire wear. The edge of the road (usually covered by loose rocks and gravel) does not receive regular traffic and is not considered part of the Treadway. Refer to the boundaries of "Treadway Width" in (**Figure 4.4)**.
  - Determine where the boundary between the treadway and the road edge falls on either side of the road and measure the distance between these two boundaries.
  - It is usually helpful to look up and down the road to get a general idea of where the treadway edge is located – try to get an overall average of the area around the survey point.

- Road Surface Width (ft)
  - The road surface width is the widest point of the road surface intended for vehicular travel before it changes slope to form the shoulder or ditch. This area may have loose gravel or even encroaching vegetation if not frequently traveled.
  - Determine the boundary of the road surface width by locating the point where the road side slope changes abruptly from the crown slope (4-6%) forming the ditch (6-20%).
  - Loose Stone and vegetation may be present on the road surface particularly on wide roads where the entire surface is not driven on.

- Cross-section width (ft.) **(Only for first year OGM Measurements and remeasures for upgraded roads since last measure)*
  - The cross-section width is the extent of the material that was removed, displaced, or added during construction of the road and ditches. It is measured perpendicular to the length of the road from one side to the other. The cross-section width is bound on either side by the top of a cut bank or the toe of a fill slope (**Figure 4.7**).

- Limit of clearance (ft.) **(Only for first year OGM Measurements and remeasures for upgraded roads since last measure)*
  - The limit of clearance width is the width of the land that was cleared for the construction the road and any adjacent rights-of-way. It is measured perpendicular to the length of the road and cannot be narrower than cross-section-width (**Figure 4.4** & **Figure 4.7**).

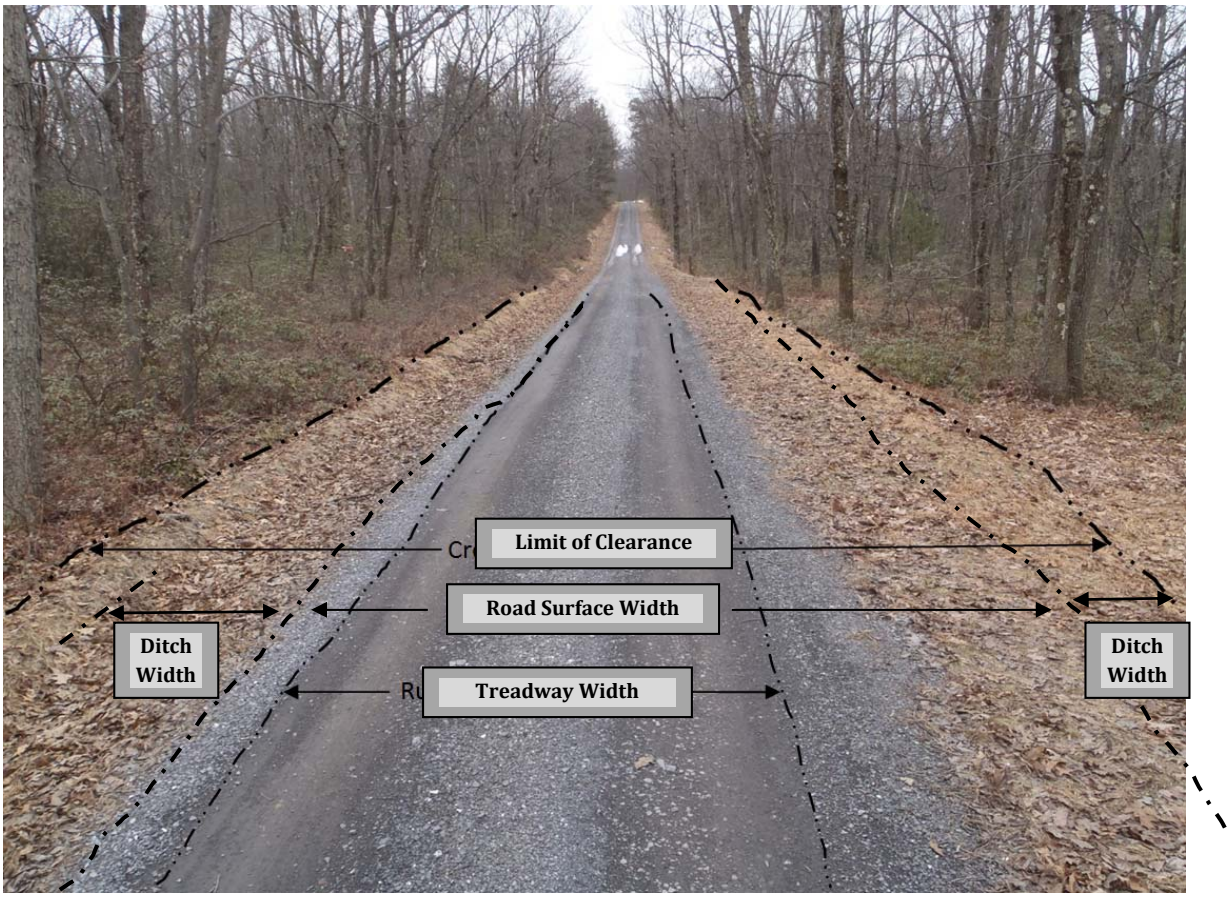


Figure 4.4

- Pipeline Adjacent
  Is a pipeline adjacent (in sight and parallel) Yes or No

- Pipeline LOC with Road (Figure 4.5)
  If Yes for Pipeline Adjacent, is the pipeline LOC measured with the road LOC (combined)? Yes, No, or Not applicable

- Road/Pipeline Buffer Width (Figure 4.6)
  If YES to "Pipeline Adjacent" and NO to "Pipeline LOC with Road" then measure the distance between the Road LOC and the Pipeline LOC (**Buffer Width**)

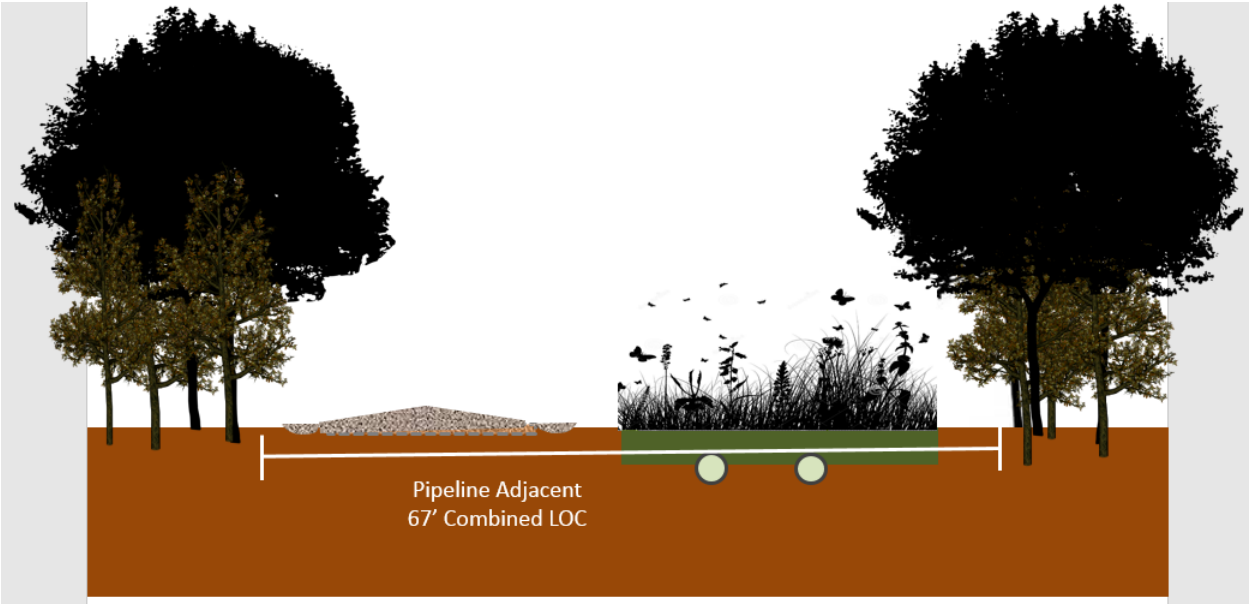


Figure 4.5 Pipeline Adjacent, LOC Combined

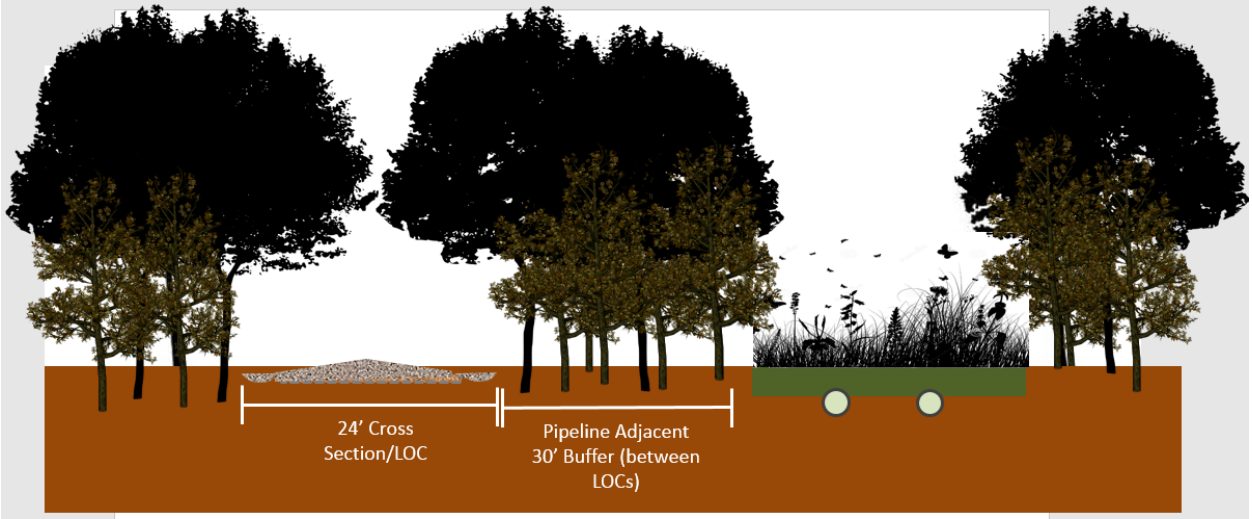


Figure 4.6 Pipeline Adjacent, Buffer

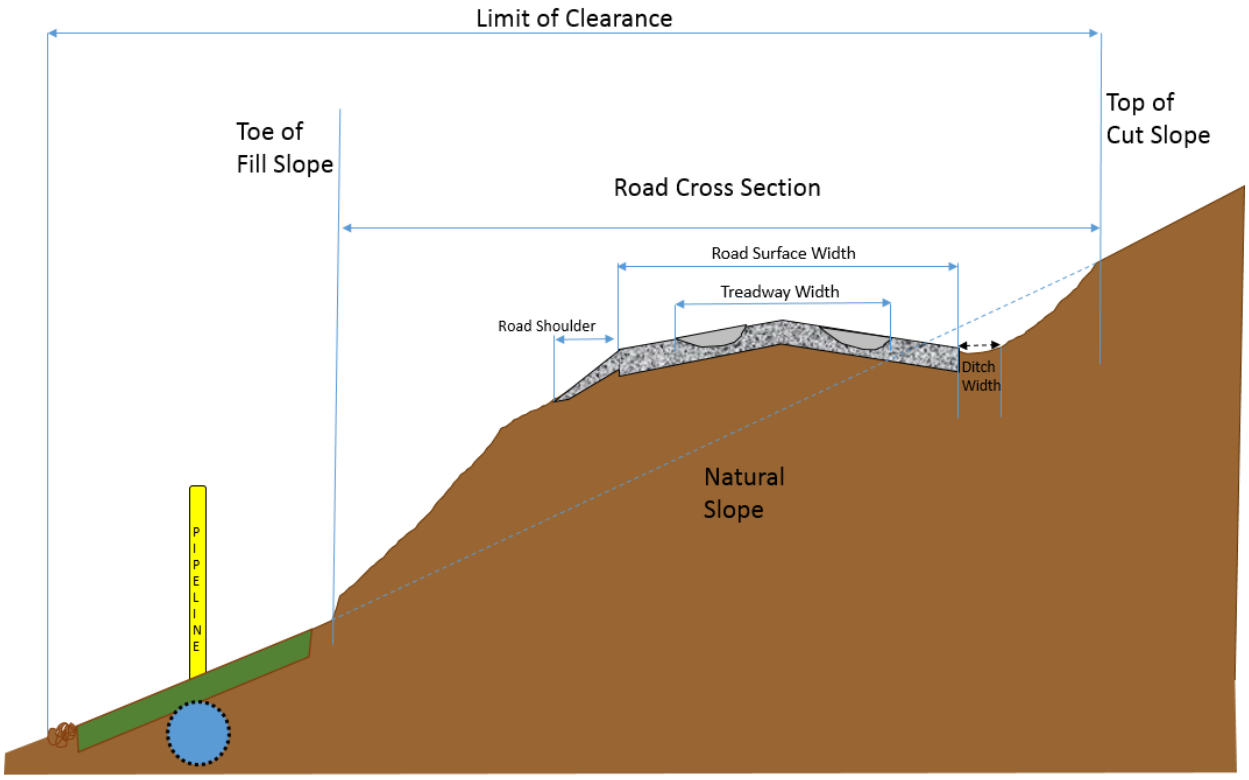


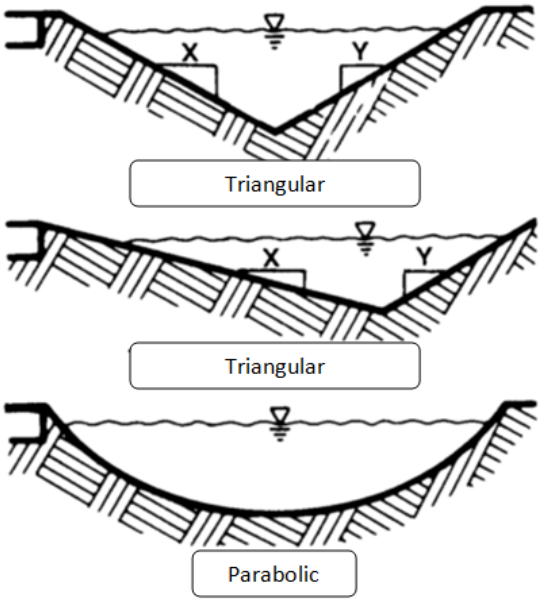
Figure 4.7 Road measurements

- Left ditch width (ft.)
  The width of a ditch is bound on the road side by the Road surface edge and on the outer side by the point where a "leveled" measurement tape from the surface width edge contacts the cut bank created during the construction of the ditch. Refer to "Ditch Width" line in **Figure 4.7**. The "left" ditch is determined as you face down the road in the direction the survey is progressing. If sheetflow is present instead of a ditch leave this field blank.

- Left Ditch Material
  Vegetated, Rock, Aggregate or Soil

- Left ditch type (ft.)
  Ditches are created features meant to direct water to a specific location such as a culvert pipe or tail ditch. For our purposes ditches are classified into two types, "parabolic" and "triangular" (**Figure 4.8**). Record as "sheetflow" if a ditch is not present.
  - Parabolic – Less common. This ditch has a curved cross-section and is usually created using a type of "scoop" from a piece of equipment. It is generally broader than a triangular ditch.

- Triangular – Common. This ditch has a triangular cross-section and is usually created from a pass with a grader blade.
- Sheetflow – Common. Present where there is no ditch. Meant to shed water off the road surface but does not direct the water to a specific location.



Ditch Cross Sections

Figure 4.8

- Left ditch condition
  The ditch (or sheetflow) should be assessed and determined if it is functioning properly and as intended. Only consider the immediate survey plot area. Select the condition that MOST applies.
  - Good – Is functioning properly and as intended with no erosion issues
  - Fair – There are minor issues with its function and/or minor erosion issues
  - Poor – There are major issues with its function and/or major erosion issues

NOTE

Note any reasoning for a "Fair" or "Poor" ditch condition that you feel is appropriate in the "Notes" section of the plot data. If water is laying in the ditch and/or the ditch has no drainage, indicate "left/right ditch has no drainage" in the "Other Notes" section of the plot data.

- Right ditch width (ft.)
  See left ditch width explanation above. The "right" ditch is determined as you face down the road in the direction the survey is progressing. If sheetflow is present instead of a ditch leave this field blank.

- Right Ditch Material
  Vegetated, Rock, Aggregate or Soil

- Right ditch type
  See left ditch type explanation above

- Right ditch condition
  See left ditch condition explanation above

- Notes
  Record any notes about the survey plot data

9. Reset the trip odometer in your vehicle and drive 0.25 miles from the plot you just completed

10. Repeat steps 7-9 (excluding the reset of the trip odometer) until you reach the end of gas use on the road or the end of the road. Include a survey plot here as well.

Notes:

- When approaching the end of the road or the end of gas use, if the end of the road or the end of gas use is within one tenth of a mile of the next quarter mile mark, the end of the road or the end of gas use becomes the point at which the survey plot is taken. If the end of the road or the end of gas use is greater than one tenth of a mile from a survey plot, another survey plot needs to be completed at the end of the road or the end of gas use.

- The quarter mile point will sometimes fall at a spot that does not represent the road as a whole (on a bridge, next to a culvert, at a wide spot like a pull-off, at an intersection). Move the survey plot to the point just after the obstacle where the road and ditches return to a representative width if the quarter mile mark falls at a spot like any of these.

11. If the road continues past gas use;
    - Travel 0.25 miles past the end of gas use and conduct one more survey plot
    - GPS center of road
    - Collect Plot Data

If the road segment beyond gas use is less than 0.25 miles, establish the last survey plot at the end of the road.

12. Finish filling out the following information on the tablet computer or datasheet:
    - Approximate Road Survey Length
      After completing the survey, record the length of road that was surveyed to the nearest quarter mile.
    - Notes
      Record anything about the entire road survey that you feel is important and/or relevant to understanding the conditions of the road and data collected. Include any of the following conditions as well as any others that come up:
        - Length and location of any asphalt applied to the survey length of the road
        - Any weather conditions that would impact dust conditions at the time of the survey
        - Amount of traffic if it impacts dust conditions at the time of the survey
        - Whether the survey is post or pre development

Road Data Management

- If entering data electronically, periodically "check in" collected road data back to the Road Condition Monitoring Point feature class via the path FIMS: P:\Layers-Gas Program\Monitoring\Road Condition Monitoring Point. This should be done frequently enough to ensure a lot of edited road data is not left on the tablet computer for an extended length of time. In general, offload data as you feel appropriate. Refer to the supporting documents section of this manual for instructions on Checking In/Checking Out Data for ArcPad.

- If using a datasheet to collect data, first "check in" new points collected (if applicable) to the Road Condition Monitoring Point feature class via FIMS: P:\Layers-Gas Program\Monitoring\Road Condition Monitoring Point. Refer to the supporting documents section of this manual for instructions on Checking In/Checking Out Data for ArcPad.Next, navigate to the feature class in FIMS, start an editing session, and add data to new or established survey plots as appropriate.

- Refer to the Infrastructure or GIS specialists for any and all questions regarding data management.

Resamples

All roads should be resampled at least once every 4-years to show change over time. For resampling roads only enter data for sections that are not asterisked*.

Road Trigger Points

If any road plot surface condition is categorized as "poor" an email notification shall be sent to the district within one week of road plot completion for that district. This would just be a notification of potential issues and not necessarily a request to act. Upon returning to the office, field crews should send an email notification to the infrastructure program specialist to be forwarded to the district.

The email should include:

1. Road Name
2. # of poor plots versus other plots for the given road (ie. 6 plots given poor rating out of 20)
3. Reason for poor rating(s)
4. Plot(s)/mileage for the plots with poor ratings (¼ mile from Road start with Some-name Rd to ¾ mile)

Post Construction Stormwater Management (PCSM) on Roads

If a road has "Structural" stormwater BMPs, a separate data sheet is used ("Road Condition Monitoring_PCSM"). Each structural BMP should be assessed for size and function.

PCSM Procedures

Moving in the same direction and utilizing the same start point for the formal road survey stop at each Structural Stormwater Feature designed to capture and infiltrate water.

Record the following:

- District #
- Tract #
- Road Name
- Road Class (Z1, Z2, Z3)
- Date
- Date of Last Rain Event
- Surveyors
- Notes (include any information deemed important to describe)

Road PCSM Plot Data:

- Plot Number (road mile #, GPS point)
- Road Profile (in-sloped, out-sloped, Crowned, Other)
- PCSM Feature Type (Rain Garden, Infiltration Basin, Infiltration Trench, Infiltration Berm, Sump, Other)
- Feature Limit of Clearance (Length and Width of the PCSM features LOC only) *additional amount of clearing over the roads LOC, do not include road LOC (**Figure 4.9**)

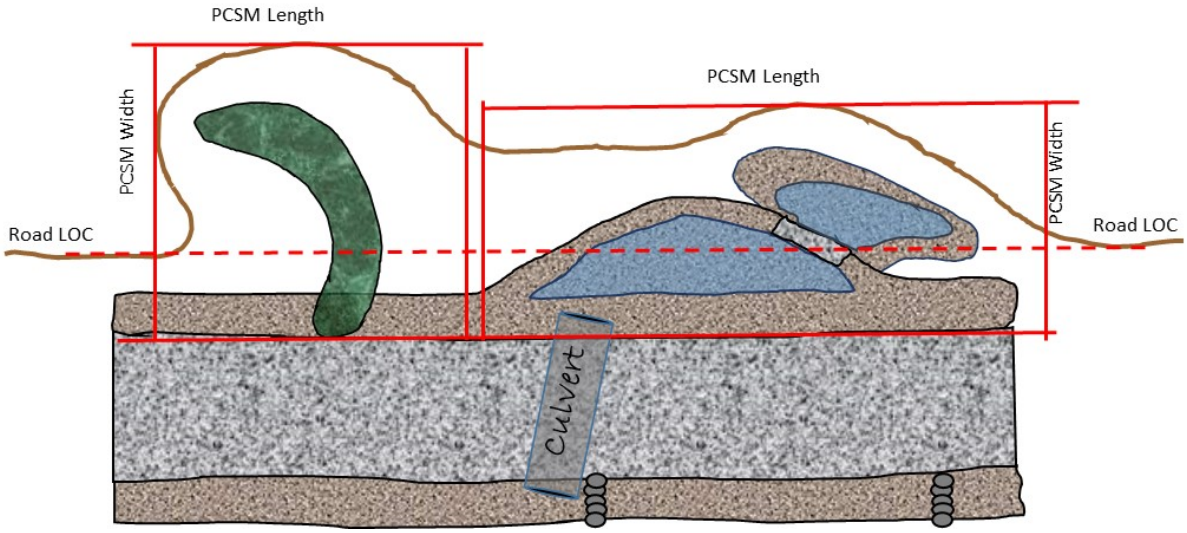


Figure 4.9 PCSM Measurements

- Channel Length (point from last outlet or infiltration point).
- Channel Armor (Rock, vegetation, aggregate etc).
- Holding water (yes or no)
- Water Overtopped (has the feature exceeded its capacity and water overflowed or bypassed the feature)
- Recently held water (signs of water being held though now dry)
- Sedimentation Present (Sediment deposit in feature) - note if needs cleaned
- Wildlife Use (note any and all wildlife use and sign)
- Other Notes (note any important information/description related to collected data or any additional information such as nearby wetlands or streams that may be or are impacted by the design)
- Sketch of site (sketch all site features and important facts such as sediment deposits or wildlife sign/use) **Figure 4.10**

NOTE **Be sure to take at least one photo (P.1) that captures the extent of the PCSM feature in relation to the road. Take additional photographs (P.2, P.3, etc.) of interesting features/issues as needed. Mark all photo locations on the sketched map!**

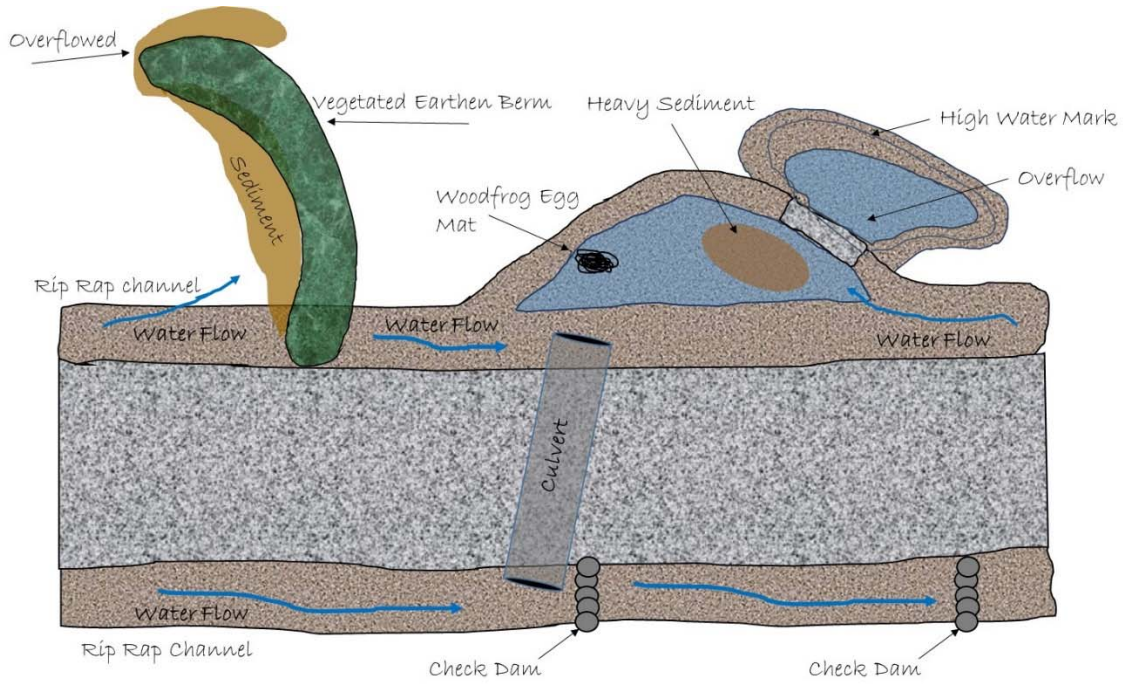


Figure 4.10 Sketch Features

PCSM Data Management

- PCSM data should be entered into the excel spreadsheet found at \\nrford12ds1\RPI\RPI_RAID\Infrastructure\Road PCSM Monitoring\Road_PCSM_Data.xlsx.
- Data sheets and photos should be placed in a folder for the respective year (e.g. Road_PCSM_2016) at the above location. A subfolder can be added for each road with district number, tract number and road name (e.g. D16_Tract_007_Matson Trl). Subfolders should contain the scanned sheets and photos for the respective roads. Follow the same naming schema already established in the folders.

PCSM Trigger Points

IF any PCSM feature is failing (eroding, overflowing, filling in with sediment (needs cleaned) or holding water beyond 72 hours (unless water garden)) then the district should be notified of the failure or maintenance need. Upon returning to the office, field crews should send an email notification to the infrastructure program specialist to be forwarded to the district.

1. Road Name
2. Plot Number/Road mile
3. Description of PCSM feature
4. Reason for failure

Road-Stream Crossing Assessment

Purpose

This protocol will provide data on the condition of stream crossings on "gas roads" on state forest land in regards to aquatic organism passage. This will help determine how gas infrastructure impacts aquatic organisms.

The Shale Gas Monitoring Team has adopted the existing procedures for assessing aquatic connectivity layed out by the North Atlantic Aquatic Connectivity Collaborative (NAACC). Information on NAACC and the protocol and data form(s) used for this assessment can be found here: https://streamcontinuity.org/resources/naacc_documents.htm

Data Management

- Datasheets and photos must be filed in the NAACC database as specified by their staff for the given year.
- Also, data sheets should be completed, scanned and placed here: \\nrford12ds1\RPI\RPI_RAID\Wildlife\Road Stream Crossings. Photos should also be placed in this location with the corresponding crossing.

Chapter 5 Plant Supporting Procedures

Baseline Vegetative Inventory

Purpose

The goal of this inventory is to obtain baseline vegetative data prior to natural gas development. To accomplish this goal it is necessary to change the sampling intensity previously used by the Bureau of Forestry to inventory forest vegetation. The objective is the assessment of community quality by quantifying its size, successional stage, disturbance, and species richness and relative density of woody and herbaceous plants in both the overstory and ground layers.

Equipment Needed

- xTablet T7000 & SX Blue II GPS
- 10 BAF Prism
- Compass
- Clinometer
- 100' Logger Diameter tape
- Paintstik Markers
- Bark Scribe
- Ribbon
- Laser
- Mil Acre Stick
- Typing Manual (PA DCNR Bureau of Forestry)
- Newcomb's Wildflower Guide
- Fern Identification Guide
- Grass Identification Guide
- Tree & Shrub Identification Guide
- Hand Lens

Procedures

Baseline vegetative data is collected in clusters. Clusters are selected by the Plant Monitoring Specialist and the GIS Forest Program Specialist. Each cluster is made up of 4 sets of plots. Each set consists of one 10 Basal Area Factor prism overstory tree plot with two milacre vegetation plots located off of the prism plot. Every cluster has a **Primary Plot** designated by a shape other than a circle (e.g. Triangle, Hexagon, etc…) and 3 subsequent plots designated by circles.

Establishing Mil Acre Plot Locations

Mil Acre plots are located 45.1' from the plot center in a cardinal direction, to the left (mil acre A) and right (mil acre B) perpendicular to the cruise line.

Make sure to record the cardinal direction travelled to each milacre plot (from plot center).

The cruise line is the direction traveled to get to the plot center from a previous plot center, with all movement in the cluster starting from the **Primary Plot Center** and always traveling in a cardinal direction (e.g. North, East, South, and West). Most commonly clusters are in squares, but can sometimes be in other configurations. When the cluster is a square, movement should always be in a **clockwise direction.** If the cluster is in another configuration start at the **Primary Plot Center** and travel outward to the consecutive plot centers establishing cruise lines. In these circumstances the mil acres for the primary plot are perpendicular to the cruise line used to go to the consecutive plot center.

Overstory Plots

Refer to the Overstory Plot Procedure for instructions on conducting the overstory tree plot.

Mil Acre Ground Plots

Refer to the Milacre Vegetation Plot Procedure for instructions on conducting the milacre plots.

Collect the following information;

- Suffix will remain 0. Unless it is necessary to take more than one set of plots.
- Enter Disturbance
- Plot Date
- Enter Species Code. When "R" is entered for regeneration, it will automatically go to Stem Count instead of Cover Rating
- Height Stratum
- Cover Rating
- Sampled ? "No" is set by default. If the species cannot be identified in the field select "Yes". If you select "Yes", collect a sample, preferably outside of the mil acre plot boundary. Put the sample into a plant specimen bag or plant press for identification later. Refer to How to Collect and Press Plants for instructions on collecting unknown plant specimens.

Ground Walk About

- After conducting the two milacre plots for a given overstory prism plot, spend 20 minutes walking around within 100' of the overstory plot center looking for any additional species that were not collected in the overstory data or in the mil acre data.

If 2 people are in the crew, spend 10 minutes per person on walk about.

- Collect the following data for each species recorded on the walk about:
  - Plant Species Code
  - Abundance
  - Date

- Remarks, if any

- Any species that cannot be identified flag with ribbon and after the walk about time is allotted, try to key out the species to identify it. Take a specimen sample if the identity cannot be determined according to the How to Collect and Press Plants procedure.

Milacre Vegetation Plot Procedure

Purpose

This procedure provides instructions for completing milacre (1/1000acre) vegetation plots.

Habitat / Vegetation Type

- 1 - **Undisturbed forest**
  Vegetation growing in a natural community class setting that has not been impacted by gas development
- 2 - **Disturbed, native vegetation**
  Area on and around the plot has been disturbed (bulldozed, trees cleared, or some other disturbance) and has not been re-planted with E&S species. At times, non-native species may volunteer into this type, but were typically not planted. This type is categorized by natural volunteer species following disturbance.
- 3 - **Disturbed, E&S vegetation**
  Area on and around the plot has been disturbed and re-planted with erosion and sedimentation species

Vegetation Data

Vegetation data is collected for every plant species growing on the milacre plot. It is collected in three parts for each species; height strata, species code, and cover class/stem count.

Height Strata

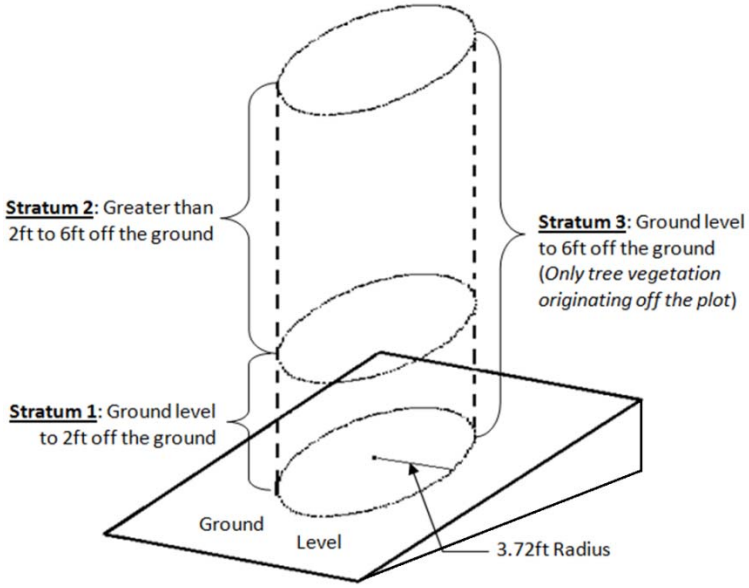
- The plot is like a 6 ft tall vertical cylinder starting at ground level with a radius of 3.72 ft. All plants growing in this space (*Only the portion of the vegetation that falls in the plot is considered)* and all tree vegetation crossing into this space from outside of the plot is recorded.

There are three height levels within the plot:

Strata Code	Definition	Height Range
1	Ground/bryophyte/low herb layer/tree seedlings	0 – 2 feet
2	High herb/low shrub layer	>2 – 6 feet
3	Tree cover originating outside of the plot	0 – 6 feet

- A single plant can be in both stratum 1 and 2. If this occurs, record it in once in stratum 1 and once in stratum 2, accounting for the amount of cover in each stratum. Disregard any foliage that is greater than six feet tall.

- On plots with slope; the strata follow the general contour of the plot. The stratum 1 boundary is always 2ft directly above the ground at any given point. See (



- Figure 5.1) below for an illustration of a plot on sloped ground.

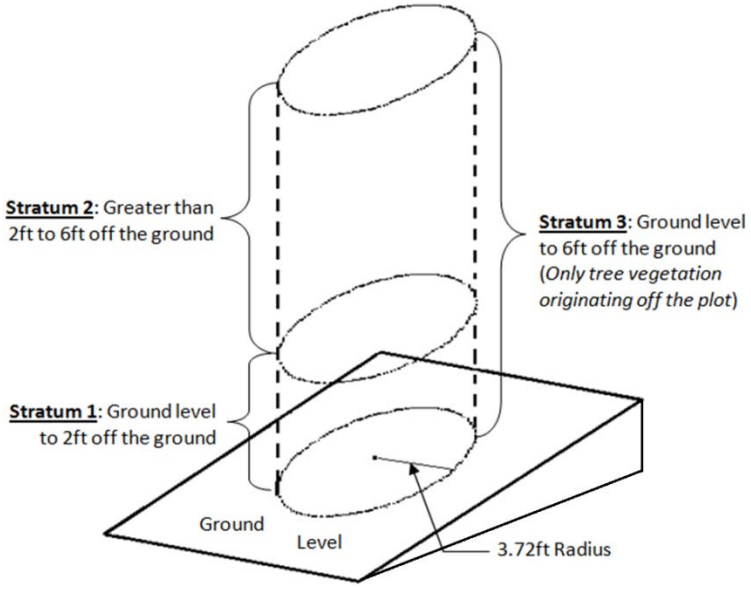


Figure 5.1

Species

Record each species present on the milacre plot as a four-character species code. The format for the code is A###, where the prefix A is an alpha character for the plant type and ### a three digit number suffix to identify individuals in each type.

Plant Type Prefix	***Plant Type***	**Examples**	**Special species codes**		
			Identified in field but not on plant list. Record name and take a sample.	**Unknown specimen of a specific plant type. Take a sample.**	**Specimen cannot be identified even with a sample.**
F	Fern cover	F006	F000	FUNK	FUID
G	Grass/sedge cover	G100	G000	GUNK	GUID
R	Trees >1ft tall and <1in. dbh	R032	R000	RUNK	RUID
S	Shrub cover	S090	S000	SUNK	SUID
T	Seedlings ≤1ft tall and any tree cover in stratum 3	T021	T000	RUNK	RUID
V	Vine Cover	V154	V000	VUNK	VUID
W	Herb cover	W010	W000	WUNK	WUID
X	Microhabitat	X014	X000	----	----

The complete list of species codes can be found in the supporting documents section of this manual. Refer to Species Codes – All.

Cover class/stem count

- The abundance of all herbaceous plants and tree seedlings will be estimated in terms of the percent of the area of the milacre plot occupied by each species. Ocular estimates of abundance have been chosen as the most effective and expedient means of quantification. For this inventory the Domin-Krajina cover-abundance scale for forest communities will be used to quantify herbaceous plants and tree seedlings.

  The code and scale is as follows:

Code	**Cover % of the Species**
10	100
9	>75, but <100
8	>50 to 75
7	>33 to 50
6	>25 to 33
5	>10 to 25
4	>5 to 10

3	1 to 5
2	<1
1	2 or 3 plants
+	1 small plant

- ALL COVER CLASSES ARE DETERMINED BY LOOKING DOWN ON THE PLOT FROM ABOVE

- It can be used in the following manner
  1. Determine the boundary of the plot (3.72ft radius circle around the plot center)
  2. Identify a single plant species
  3. Locate all of the individuals or vegetation of that species present in the 6ft cylinder
  4. Determine in which stratum the vegetation is found
  5. Estimate what percentage of the plot is covered by the vegetation of that species in Stratum 1 and record the stratum, species code, and cover class code
  6. Repeat step 5, estimating the amount of cover for Stratum 2
  7. If the species is a tree, repeat step 5 for Stratum 3
  8. Identify another species of plant on the plot and repeat the process from step 3 to 7.
  9. Continue this process until all of the species of plants on the plot have been covered
  10. Identify any items on the plot covered by the X-codes (Microhabitat)
  11. Estimate the cover for each of these items

- Trees greater than 1ft tall and less than 1in. dbh are considered regeneration. These are tallied with the code prefix "R." Write down the number of individual stems instead of the cover class code in the Cover class/Stem count column.

How to classify tree species on the plot (here red maple is used as an example).

Size	Stratum	Species Code	Cover Class/Stem Count
≤ 1ft tall	1	T021	% cover of green
>1 to 2ft tall	1	R021	Stem Count
>2ft tall and <1in dbh	2	R021	Stem Count
Any leaves whose stem originates off plot	3	T021	% cover of green
Any tree ≥1in dbh	1	X011 (Live Bole/Root Code)	Cross sectional area of stem and exposed roots at ground level

- Microhabitat tips (X-codes);
  - Should only be used in spaces not occupied by vegetation. For example; do not record leaf litter(X014) if you cannot see any leaf litter through the vegetation when looking down on the plot.
  - Do not record X-codes with the + or 1 cover classes

- Cover % code tips
  - The + code is only used for a small single plant such as a newly germinated seedling. Use a higher percentage class for a single plant if it covers an area great enough to meet that class.
  - The code of 1 (2 or 3 plants) is used for 2 or 3 small plants. Use a higher code if these plants cover enough area.
  - 5%of the plot is roughly the size of an 8.5" x 11" sheet of paper
  - Cover percentages are based off of vegetation. Woody stems do not contribute to the amount of cover when estimating cover class.
  - It is common for one species to have vegetation completely overtopped by more vegetation of the same species. In this case only consider the vegetation that is visible when looking down on the plot when determining the cover class for that species.
  - It is okay to count overlapping vegetation of different species. This makes it possible to have more than 100% cover if the cover classes for all of the species on the plot would be combined together.

Overstory Plot Procedure

Purpose

The objective of this procedure is the assessment of forest community quality by quantifying its size, successional stage, disturbance, species richness, and relative density of woody plants in the overstory.

Equipment Needs

- Tablet computer (e.g. xTablet T7000)
- GPS unit (e.g. SX Blue II GPS)
- 10 BAF Prism
- Compass
- Clinometer
- 100' Logger tape in tenths of feet
- Paintstik markers
- Bark scribe
- Flagging ribbon
- Laser (tree height)
- Typing Manual (PA DCNR Bureau of Forestry)
- Tree & Shrub Identification Guide
- Hand Lens

When entering data electronically, be sure to have the appropriate GPS points and electronic forms loaded on the tablet. Points are selected by the Plant Monitoring Specialist and the GIS Forest Program Specialist. Refer to the supporting documents section of this manual for instructions on Checking In/Checking Out Data for ArcPad.

Establishing Plot Center

- Using the tablet computer and GPS unit, get as close as you can to the GPS coordinates representing plot center.

- Mark your plot center by pushing a stick into the ground and tie a piece of flagging to the top of the stick.

- Standing on plot center select a witness tree and use the compass to determine the azimuth from the plot center to the center of the tree. Using the bark scribe, mark the tree with a single slash facing plot center at your face height on the tree. Measure the diameter of the tree to the nearest tenth of an inch, and measure the distance from the front of the tree to plot center to the nearest tenth of a foot.

Witness trees should be relatively close to the plot center and should be healthy, notable trees (not small, dead, dying, etc…).

- Within the appropriate tab on the tablet computer, enter crew members last names, the date, and in "Remarks" enter the following witness tree data: species code, diameter at breast height (dbh, measured 4.5' from the ground), distance from plot center, and azimuth (e.g. spp. 040, dbh. 22.3", dist. 8.6', Az. 270).

Plot Data

The following information should be assessed and recorded within the appropriate tab on the tablet computer.

Vegetative Condition

Select the code that most applies to the **acre** surrounding the plot center. Full descriptions of these terms can be found in the typing manual.

Code	Vegetative Condition
1	**Forested** (terrestrial and palustrine forests)
2	**Non Forested** (woodland, shrub land, or herbaceous openings)
3	**Non Vegetated**
4	**Aquatic Systems, Anthropologic sites, or Mineral sites**

Plot Condition

Select the code that most applies to the **area** surrounding the plot center.

Code	Plot Condition
1	Surrounding area of the plot is clearly within the classic definition of a plant community type.
2	Surrounding area of the plot is within a transition area between two or more plant community types (includes aquatic, anthropogenic and mineral). A hole in a stand is not a transition, neither is a small under stocked area. The minimum surrounding area is the area contained within a 45.1 foot radius of the plot center (the maximum distance a 16.4 inch DBH tree can still be called as "in" the prism plot). The maximum surrounding area will depend upon the occurrence of trees larger than 16.4 inches DBH that lie further than 45.1 feet from plot center and are called as "in" the prism plot.
3	Surrounding area is Non-Vegetated.
4	Surrounding area is in an Aquatic System, Anthropogenic or Mineral site.

Stand Structure

Select the code that best describes the basic form of the trees in the stand in which the plot resides.

Code	Stand Structure
0	**Non-Forested or Non-Vegetated**
1	**Single Storied:** Stands characterized by an even canopy of uniform height with close competition between trees. The smaller trees are usually members of the stand that were stressed or overtopped and have fallen behind their associates. Regeneration and/or tall relics from a previous stand may be present. Most of the trees in the stand are within the height class of the average stand height.
2	**Two Storied:** Stands composed of two relatively even but distinct canopy layers, such as a mature overstory with an understory sapling layer, possibly from seed tree or shelterwood operations, or an overstory of tall conifers with an understory of low hardwoods. Neither canopy is necessarily continuous or closed, but both canopy levels tend to be uniformly distributed across the stand. Each canopy level must cover at least 25% of the stand.
3	**Multi-Storied:** Stands generally containing trees from every size group on a continuum from seedlings to mature trees and are characterized by a broken or uneven canopy layer. Usually the largest number of trees is in the smaller diameter classes. Consider any stand with three or more layers as multi-storied is each of the three or more layers covers at least 25% of the stand.
4	**Mosaic:** Stands contain at least two distinct size classes each of which covers at least 25% of the stand; however, these classes are not uniformly distributed but are grouped in small repeating aggregations, or occur in stringers less than 120 feet wide, throughout the stand. Each size class aggregation is too small to be recognized and mapped as an individual stand; the aggregations may not be single-storied.

Percent Slope

Measure according to the following procedure:

- Standing on plot center, imagine someone of your same height standing downhill 100 feet.
- Using the clinometer, aim about where their eyes would be and remember the % slope.

- Repeat this procedure uphill.

- Add both numbers together and divide by two. The result is the percent slope.

Anything under 5% is entered as 0

Forest Community Type by District:

This can be found in the appropriate tab within the attributes for the plot, under "Veg Code". Simply refer to this and select the plant community type already defined by the forest district.

The "Veg Code" will contain letters and numbers. The letters represent the plant community type while the numbers represent site, size, and stocking classes. Currently, for our purposes, we are only concerned with the letters, therefore these will be the only options you see in the selectable drop down list.

Forest Community Type by Monitoring Crew:

Refer to the Typing Manual and select the plant community type that best represents the stand that the plot is located in. This does not have to be the same type that the district chose to represent the stand.

Aspect

To avoid micro-site conditions, a distance of 100 feet along the contour is the minimum span over which aspect should be determined. Measure aspect according to the following procedure:

- Stand at the plot center with your shoulders parallel to the slope face, looking downhill.

- Using the compass, determine the azimuth, perpendicular (90 degrees) from the slope face.

Use a three digit integer to record aspect to the nearest degree. Record "Null" when there is no aspect (slope of less than 5%) and record "360" for a north aspect.

Terrain Position

Terrain position is the location of the plot along the slope profile. To avoid micro-site conditions, a distance of 100 feet around plot center is the minimum span to consider. Select the terrain position that best relates to the acre surrounding the plot center to the slope profile.

Code	Terrain Position	
1	**Top of Slope**	(convex region)
2	**Upper Slope**	(convex region at upper edge of slope)
3	**Mid-Slope**	(fairly uniform angle)

Code	Terrain Position	
4	**Bench**	(slope deviation, level land with slope above and below)
5	**Lower Slope**	(concave region at lower edge of slope)
6	**Bottomland**	(horizontal region at low-lying areas, may be subject to flooding)
7	**Flatland**	(areas not part of or related to the slope)

NOTE Bottomland is generally associated with drainages and flatland is not.

Refer to **Figure 5.2** below for a visual representation of these terrain positions.

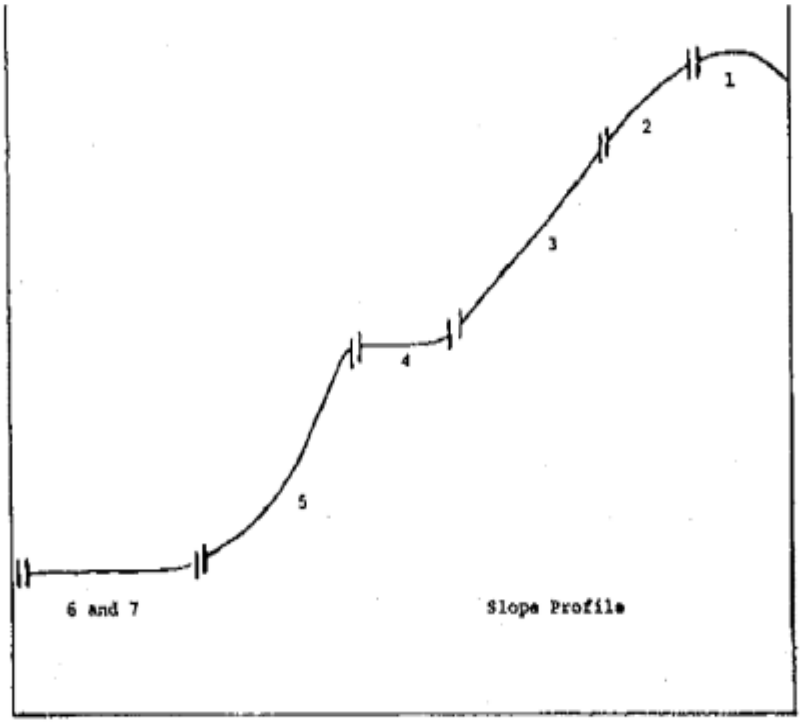


Figure 5.2

Establishing Prism Plot Trees

- Standing on plot center, use the compass to determine north.
- Starting at north, proceed through the plot in a clockwise direction, assessing trees encountered at their DBH (4.5') to determine if they are "in" or "out" of the plot with the 10 BAF prism.

NOTE Make sure the prism is always held directly over plot center.

- Mark all trees 1.5" DBH and larger, determined to be "in" by the prism, with a Paintstik marker. All living and dead trees that are standing on their own should be assessed (trees that are leaning into and supported by another tree are not tallied).

NOTE

Borderline trees need to be verified as "in" or "out" by using the limiting factor distance appropriate for the dbh of the tree. The limiting factor distance is determined by multiplying the dbh by 2.75, or by using the 10 BAF Prism Cruise distance table (Figure 5.3). If the limiting factor distance is ≥ the actual distance from plot center to the pith of the tree, the tree is "in". If the limiting factor distance is < the actual distance, it is "out" and should not be tallied.

NOTE

Measure to the pith (estimate the pith's location) at the tree's base when measuring the distance from plot center to the tree.

10 BAF Prism Cruise Distances

10 BAF Prism Cruise Distances										
Diam.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1	2.75	3.025	3.3	3.575	3.85	4.125	4.4	4.675	4.95	5.225
2	5.5	5.775	6.05	6.325	6.6	6.875	7.15	7.425	7.7	7.975
3	8.25	8.525	8.8	9.075	9.35	9.625	9.9	10.175	10.45	10.725
4	11	11.275	11.55	11.825	12.1	12.375	12.65	12.925	13.2	13.472
5	13.75	14.025	14.3	14.575	14.85	15.125	15.4	15.675	15.95	16.225
6	16.5	16.775	17.05	17.325	17.6	17.875	18.15	18.425	18.7	18.975
7	19.25	19.525	19.8	20.075	20.35	20.625	20.9	21.175	21.45	21.725
8	22	22.275	22.55	22.825	23.1	23.375	23.65	23.925	24.2	24.475
9	24.75	25.025	25.3	25.575	25.85	26.125	26.4	26.675	26.95	27.225
10	27.5	27.772	28.05	28.325	28.6	28.875	29.15	29.425	29.7	29.975
11	30.25	30.525	30.8	31.075	31.35	31.625	31.9	32.175	32.45	32.725
12	33	33.275	33.55	33.825	34.1	34.375	34.65	34.925	35.2	35.475
13	33.75	36.025	36.3	36.575	36.85	37.125	37.4	37.675	37.95	38.225
14	38.5	38.775	39.05	39.325	39.6	39.875	40.15	40.425	40.7	40.975
15	41.25	41.525	41.8	42.075	42.35	42.625	42.9	43.175	43.45	43.725
16	44	44.275	44.55	44.825	45.1	45.375	45.65	45.925	46.2	46.475
17	46.75	47.025	47.3	47.575	47.85	48.125	48.4	48.675	48.95	49.225
18	49.5	49.775	50.05	50.325	50.6	50.875	51.15	51.425	51.7	51.975
19	52.25	52.525	52.8	53.075	53.35	53.625	53.9	54.175	54.45	54.725
20	55	55.275	55.55	55.825	56.1	56.375	56.65	56.925	57.2	57.475
21	57.75	58.025	58.3	58.575	58.85	59.125	59.4	59.675	59.95	60.225
22	60.5	60.775	61.05	61.325	61.6	61.875	62.15	62.425	62.7	62.975
23	63.25	63.525	63.8	64.075	64.35	64.625	64.9	65.175	65.45	65.725
24	66	66.275	66.55	66.825	67.1	67.375	67.65	67.925	68.2	68.475
25	68.75	69.025	69.3	69.575	69.85	70.125	70.4	70.675	70.95	71.225
26	71.5	71.775	72.05	72.325	72.6	72.875	73.15	73.425	73.7	73.975
27	74.25	74.525	74.8	75.075	75.35	75.625	75.9	76.175	76.45	76.725
28	77	77.275	77.55	77.825	78.1	78.375	78.65	78.925	79.2	79.475
29	79.75	80.025	80.3	80.575	80.85	81.125	81.4	81.675	81.95	82.225
30	82.5	82.775	83.05	83.325	83.6	83.875	84.15	84.425	84.7	84.975
31	85.25	85.525	85.8	86.075	86.35	86.625	86.9	87.175	87.45	87.725
32	88	88.275	88.55	88.825	89.1	89.375	89.65	89.925	90.2	90.475
33	90.75	91.025	91.3	91.575	91.85	92.125	92.4	92.675	92.95	93.225
34	93.5	93.775	94.05	94.325	94.6	94.875	95.15	95.425	95.7	95.975
35	96.25	96.525	96.8	97.075	97.35	97.625	97.9	98.125	98.45	98.725
36	99	99.275	99.55	99.825	100.1	100.375	100.65	100.925	101.2	101.475
37	101.75	102.025	102.3	102.575	102.85	103.125	103.4	103.675	103.95	104.225
38	104.5	104.775	105.05	105.325	105.6	105.875	106.15	106.425	106.7	106.975
39	107.25	107.525	107.8	108.075	108.35	108.625	108.9	109.175	109.45	109.725
40	11.0	110.275	110.55	110.825	111.1	111.375	111.65	111.925	112.2	112.475

Figure 5.3 Limiting Factor Distances by DBH

Prism Plot Tree Data

For each tree that is to be tallied, the following information should be assessed and recorded within the appropriate tab on the tablet computer.

NOTE Make sure you save the data periodically as you go to prevent the loss of data.

Species Code

Record the three-digit code, **excluding the letter**, using the species codes found in the supporting documents section of this manual. Refer to Species Codes – All.

Diameter at Breast Height

Record the DBH, rounding to the nearest 1/10th of an inch. Measurement of DBH should always be done from the uphill side of the tree.

NOTE For unique DBH situations refer to the Special DBH Situations section below.

Tree Height

Using the laser, shoot the total tree height (i.e. the top of the green on a live tree and the top of the dead wood on a dead tree, Refer to **Figure 5.4** for exceptions). Stand approximately the distance of the tree's height away when using the laser (avoid being on the downhill side, or under the lean of the tree). Although not preferred, a clinometer can also be used for this.

Crown Class

Select the code that best represents the crown class of the tree.

Code	Crown Class
1	OPEN GROWN Trees with crowns that have received full light from above and from all sides throughout most of the life of the tree, particularly during its early development period, their forms or crown shapes have not been and are not likely to be influenced by other trees.
2	DOMINANT Trees with crowns extending above the general level of the crown cover and receiving full light from above and partly from the sides, larger than average trees in the stand, and with crowns well developed, but possibly somewhat crowded on the sides.
3	CODOMINANT Trees with crowns forming the general level of the crown canopy and receiving full light from above, but comparatively little from the sides, usually with medium-sized crowns, more or less crowded on the sides. (In stagnated stands, includes trees with small-sized crowns crowded on the sides.)

Code	Crown Class
4	INTERMEDIATE Trees shorter than those in the two preceding classes, but with crowns either below or extending into the crown cover formed by codominant and dominant trees, receiving little direct light from above and probably crowded on the sides.
5	OVERTOPPED Suppressed trees with crowns entirely below the general level of the crown cover, receiving no direct light either from above or from the sides.
6	DEAD All dead trees.

In multiple-age stands with understory trees of younger age classes, crown classification is often difficult. As a general rule, the crown class for each tree should be judged in the context of its immediate environment; that is, those trees affecting it or being affected by it in terms of crown competition. For example, the intermediate and overtopped crown classes are intended to include only trees seriously affected by direct competition from adjacent trees. As another example, a dominant tree is one that generally stands head and shoulders above all other trees in its vicinity. However, there may be a young, vigorous tree nearby, but not overtopped by a dominant tree. This smaller tree may be considerably shorter than the dominant, but still be receiving full light from above and partly from the sides. In its own immediate environment, it is dominant and should be recorded as such. Only understory trees immediately adjacent to the overstory trees will be assigned subordinate crown classes.

Wind-thrown trees, if still alive, are to be classified in the context of their immediate environment as described above.

Tree Condition Class

Record one of the following condition class codes for the tree. Broken tops must be significant enough to introduce rot into the main stem.

Code	Description	Comments
1	Live tree, intact top	
2	Live tree, broken top	
3	Live tree, intact dead top	Tops may merely be defoliated – use with caution.
4	Dead tree, intact top layer.	Use scribe to check for moisture in cambium

Code	Description	Comments
5	Dead tree, broken top layer.	Use scribe to check for moisture in cambium
6	Dead tree, down (punky).	Do not tally if advanced decay is present
7	Snag, intact top	
8	Snag, broken top	

Dead trees are trees that have recently died (within the last several years) but still retain many branches (including some small branches and possibly some small twigs) and have bark that is generally tight and hard to remove from the tree.

Snags are dead trees, or what remains of a dead tree, that is at least 4.5 feet tall and is missing most of its bark. This category includes trees covered with bark that is very loose. This bark can usually be removed, often times in big strips, with very little effort, snags are not recently dead trees. Most often they will have been dead for several years, sometimes for more than a decade.

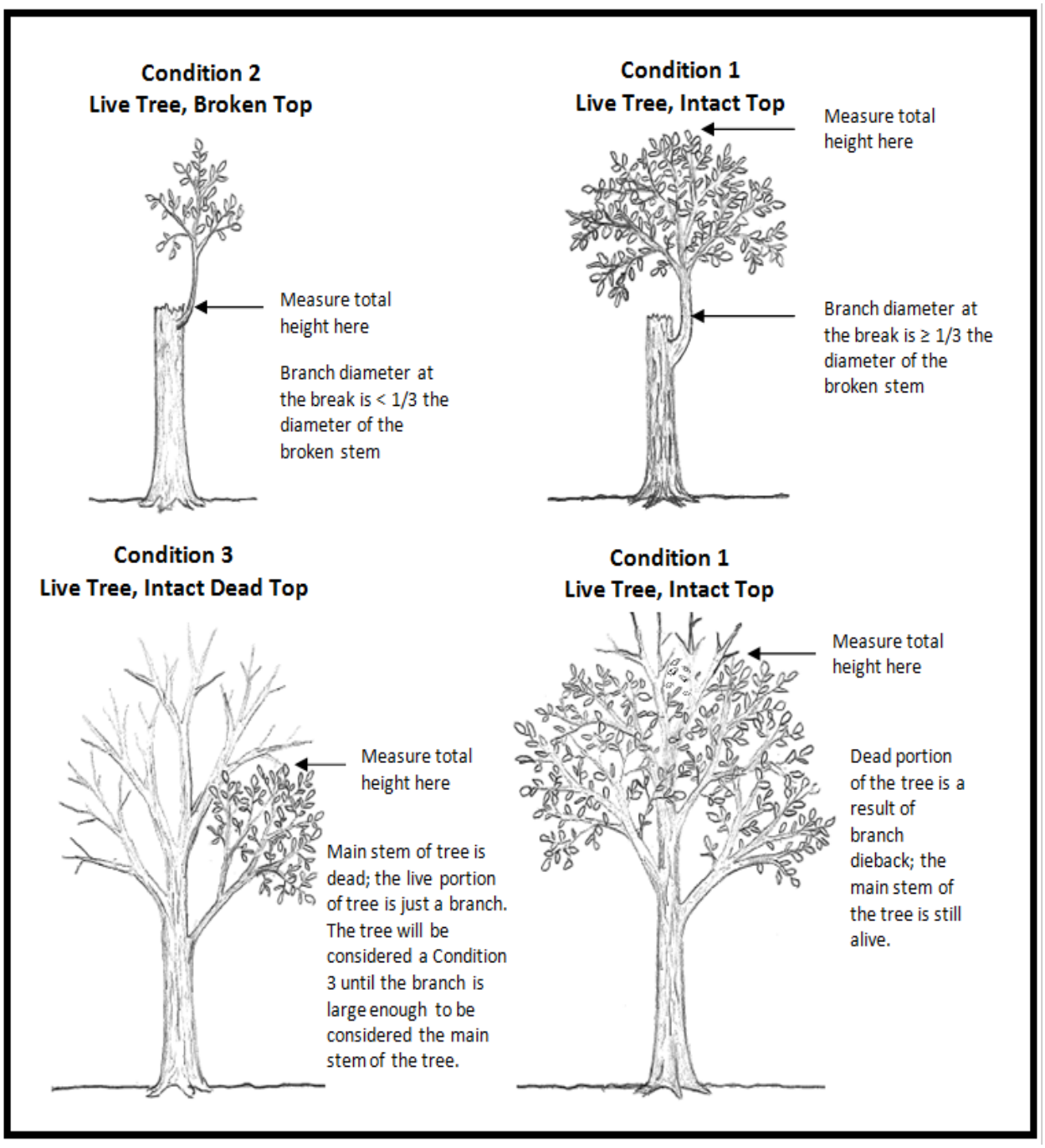


Figure 5.4 Special tree height situations

Cavities

Indicate "yes" if the tree contains a cavity suitable for use by wildlife and/or would be considered as a defect. Trees can be alive or dead, but must be standing.

Defoliation

Select the code that best represents the percentage of defoliation observed in the crown of the tree. Defoliation in this context refers to that caused by insect, disease, or climate. No cause needs to be assessed, but can be added in remarks if discernible.

Code	Defoliation (%)
0	No defoliation
1	1% - 60%
2	>60%

Remarks

Use for additional notes on individual trees.

Record "Witness Tree" in this field when tallying the witness tree used to reference plot center

Special DBH Situations

Forked tree

In order to qualify as a fork, the stem in question must be at least 1/3 the diameter of the main stem and must branch out from the main stem at an angle of 45° or less. **Forks originate at the point on the bole where the piths intersect**. Forked trees are handled differently depending on whether the fork originates below 1.0 ft, between 1.0 and 4.5 ft, or above 4.5 ft.

- Trees forked below 1.0 ft. Trees forked in this region are treated as distinctly separate trees. DBH is measured for each stem at 4.5 ft above the ground (**Figure 5.5**). When stems originate from pith intersections below 1 ft, it is possible for some stems to be within the limiting distance of the plot and others to be beyond the limiting distance. If stems originating from forks that occur below 1.0 ft and fork again between 1.0 and 4.5 ft, the DBH of each fork is measured at a point 3.5 ft above the pith intersection (**Figure 5.8-B**).

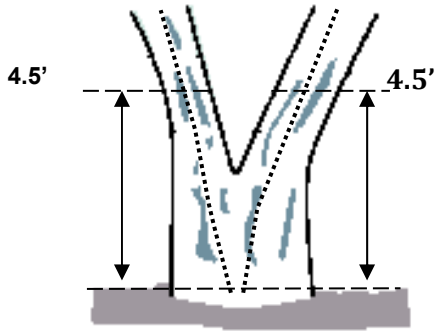


Figure 5.5 Trees forked below 1 ft

- Trees forked between 1.0 ft and 4.5 ft. Trees forked in this region are also counted as separate trees (Figure 5.6).The DBH of each fork is measured at a point 3.5 ft above the pith intersection. When forks originate from pith intersections between 1.0 and 4.5 ft, the limiting distance is the same for all forks--they are either all "in", or all "out" of the plot.

NOTE

Multiple forks are possible if they all originate from approximately the same point on the main stem. In such cases, measure DBH on all stems at 3.5 ft above the common pith intersection (Figure 5.8-F).

NOTE

Once a stem is tallied as a fork that originated from a pith intersection between 1.0 and 4.5 ft, do not recognize any additional forks that may occur on that stem. Measure the diameter of such stems at the base of the second fork as shown in Figure 5.8-E (i.e., do not move the point of diameter the entire 3.5 ft above the first fork).

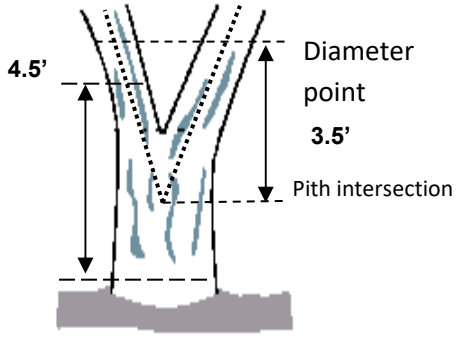


Figure 5.6 Trees forked between 1 ft and 4.5 ft

- Trees forked at or immediately above 4.5 ft. If a fork occurs at or immediately above 4.5 ft, measure diameter below the fork just beneath any swelling that would inflate DBH. (**Figure 5.7**)

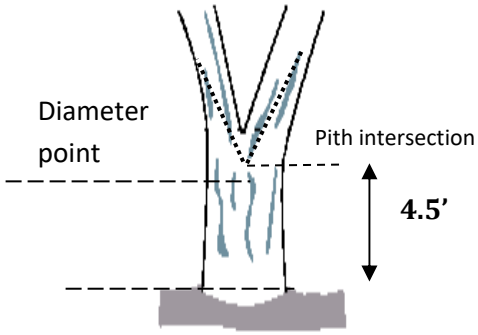


Figure 5.7 Tree forked at 4.5 ft

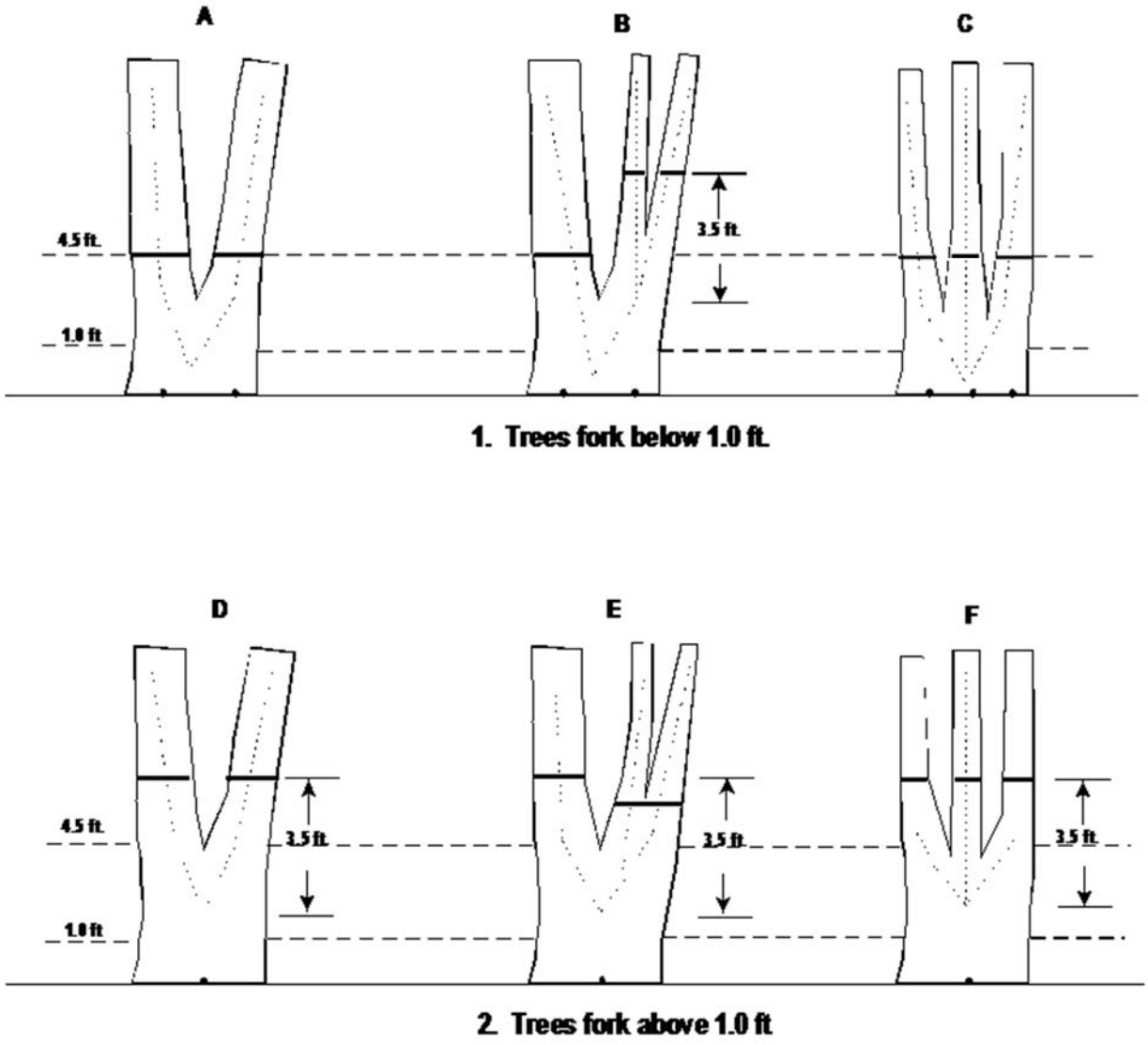


Figure 5.8 Special DBH situations for forked trees

Stump sprouts

Stump sprouts originate between ground level and 4.5 ft on the boles of trees that have died or been cut. Stump sprouts are handled the same as forked trees, with the exception that stump sprouts are not required to be 1/3 the diameter of the dead bole. Stump sprouts originating below 1.0 ft are measured at 4.5 ft from ground line. Stump sprouts originating between 1.0 ft and 4.5 ft are measured at 3.5 ft above their point of occurrence.

Tree with butt-swell or bottleneck

Measure these trees 1.5 ft above the end of the swell or bottleneck if the swell or bottleneck extends 3.0 ft or more above the ground (Figure 5.9).

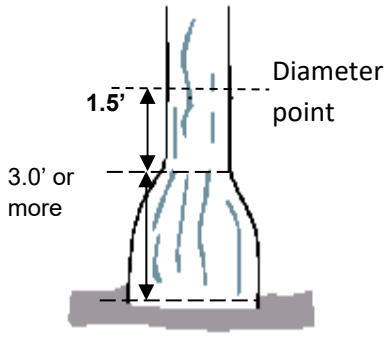


Figure 5.9 Tree with butt-swell

Tree with irregularities at DBH

On trees with bumps, depressions, and branches (Figure 5.10) or swellings (Figure 5.11) at DBH, diameter will be measured immediately above the irregularity at the place it ceases to affect normal stem form.

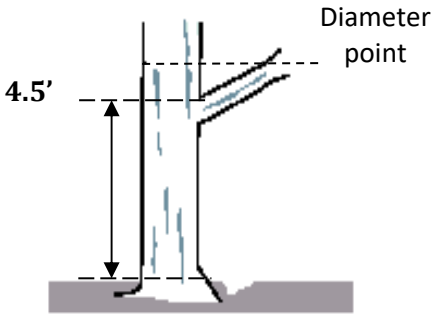


Figure 5.10 Tree with branch

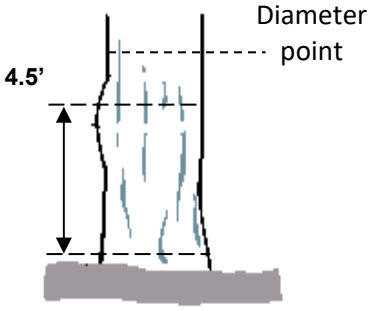


Figure 5.11 Tree with swelling

Tree on slope

Measure these trees at 4.5 ft from the ground, along the bole, on the uphill side of the tree (Figure 5.12).

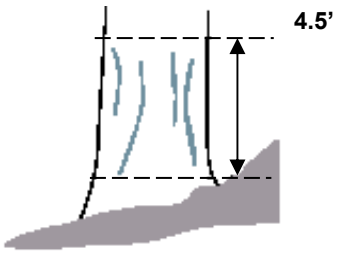


Figure 5.12 Tree on slope

Leaning tree

Measure these trees at 4.5 ft from the ground along the bole. The 4.5 ft distance is measured along the underside face of the bole (Figure 5.13).

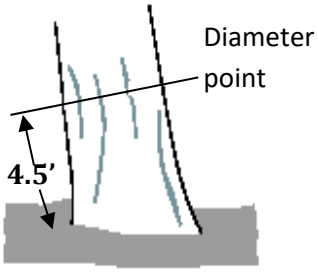


Figure 5.13 Leaning tree

Independent trees that grow together

If two or more independent stems have grown together at or above the point of DBH, continue to treat them as separate trees. Estimate the diameter of each and explain the situation in the notes.

Missing wood or bark

Do not reconstruct the DBH of a tree that is missing wood or bark or at the point of measurement. Record the diameter of the wood and bark that is still attached to the tree (Figure 5.14). If a tree has a localized abnormality (gouge, depression, etc.) at the point of DBH, apply the procedure described for trees with irregularities at DBH (Figure 5.11).

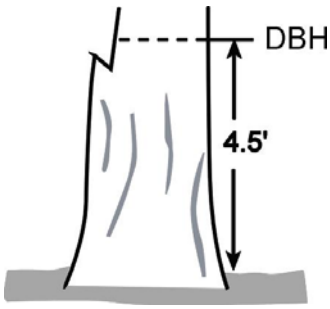


Figure 5.14 Tree missing wood or bark

Down live tree with tree-form branches growing vertical from main bole

When a down live tree, touching the ground, has vertical (<45° from vertical) tree-like branches coming off the main bole, first determine whether or not the pith of the main bole (averaged along the first log of the tree) is above or below the duff layer.

- If the pith of the main bole is above the duff layer, use the same forking rules specified for a forked tree, and take all measurements accordingly (**Figure 5.15**).

    - If the pith intersection of the main down bole and vertical tree-like branch occurs below 4.5 ft from the stump along the main bole, treat that branch as a separate tree, and measure DBH 3.5 ft above the pith intersection for both the main bole and the tree-like branch.

    - If the intersection between the main down bole and the tree-like branch occurs beyond the 4.5 ft point from the stump along the main bole, treat that branch as part of the main down bole.

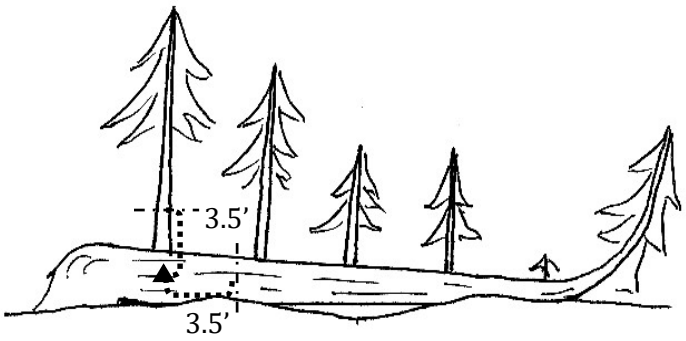


Figure 5.15 Tree above duff layer

- If the pith of main tree bole is below the duff layer, ignore the main bole, and treat each tree-like branch as a separate tree; take DBH and length measurements from the ground, not necessarily from the top of the down bole (**Figure 5.16**). However, if the top of the main tree bole curves out of the ground towards a vertical angle, treat that portion of that top as an individual tree originating where the pith leaves the duff layer.

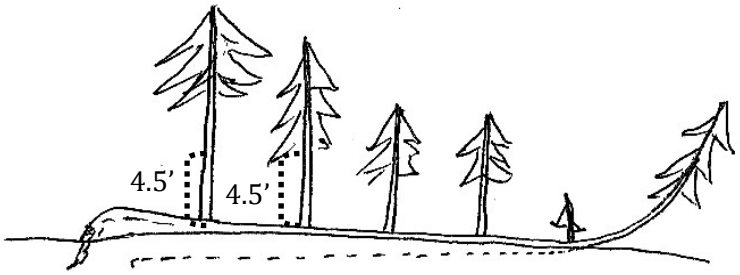


Figure 5.16 Tree below duff layer

Data Management

- For data entered electronically on a tablet computer, be sure to "check in" collected data periodically to the appropriate location in the OGIT geodatabase. Do not let overstory data build up on the tablet as you risk losing the data. Refer to the supporting documents section of this manual for instructions on Checking In/Checking Out Data for ArcPad

- If entering data on a datasheet refer to appropriate specialist for instructions on filing and entering data.

Invasive Plant Species Early Detection and Rapid Response (EDRR)

Purpose

This protocol provides a brief (less than 5 minutes) reporting procedure that can be carried out by all monitoring program personnel. It allows not only for opportunistic sampling, but also timely (sometimes instant) treatment of invasive plant species.

The focus of this protocol is on high priority species that are either new or uncommon to a district or are currently found outside a district, but have the potential to move in. Tracking these novel populations and treating them promptly is essential for slowing the spread of invasive plants and allows the Bureau to understand if these species are colonizing new areas or becoming more widespread due to gas development. Secondly, keeping careful record of how new invasive plant populations are treated and the success or failure of these treatments is essential to better management of these species across all Bureau of Forestry lands.

Invasive Species High Priority List

The following species are targets for Early Detection and Rapid Response as of March 1, 2016. This list will be re-evaluated annually based on the latest survey data. At this time, this list applies to all districts currently utilized for gas development in northern Pennsylvania (Moshannon, Sproul, Tiadaghton, Elk, Susquehannock, Tioga, and Loyalsock state forests).

- Tree-of-heaven (*Ailanthus altissima*)
- Japanese angelica tree (*Aralia elata)*
- Poison hemlock (*Conium maculatum*)
- Glossy buckthorn (*Frangula alnus*)
- Goatsrue (*Galega officinalis*)
- Mile-a-minute (*Persicaria perfoliata*)
- Common reed (*Phragmites australis* ssp. *australis*)
- Japanese and Giant knotweed (*Polygonum cuspidatum & P. sachaliense*)
- Black swallow-wort (*Vincetoxicum nigrum*)
- Pale swallow-wort (*V. rossicum*)
- Porcelain-berry (*Ampelopsis brevipedunculata*)

Equipment Needs

- Tablet Computer and GPS
- Shale Gas Monitoring: Invasive Plant Species Early Detection and Rapid Response Data Collection Form
- Camera

- PPE Gear (Gloves, Mask, etc.)
- Herbicide Application Equipment (Backpack Sprayer, Spray bottle, etc.)
- Applicable Herbicide Solutions
- Field Guides and Identification Materials
- Plastic bags (for specimens)
- Plant Press (for specimens)
- Mattock, shovel, trowel, or other hand tools
- Large Garbage bags (for plant material removal)

Procedures

Conducting Surveys for High Priority Species

One defining characteristic of EDRR protocols is the opportunistic nature of the sampling. Monitoring staff should be familiar with all species listed on the High Priority list and be able to adequately identify all these species at both their peak and at the beginning and end of the growing season. During all monitoring protocols, regardless of topic or location, monitoring staff should be aware of surrounding vegetation and be able to differentiate these invasive plant species from surrounding vegetation when present. Invasive plant species identification materials should be referenced as necessary to help identify species that are unknown. If not very confident of the species ID, a voucher specimen should be collected along with additional descriptive photos of the plant including leaves, flowers, or fruit.

Initial Visit & Population Description

If an invasive species is found that is on the High Priority list, a GPS point should be taken at the center of the population and the coordinates noted on the field data sheet. The GPS data will be entered into the EDRR data in the FIMS system by the specialists. Surveyor's last name(s), date of survey, district number, leased tract number, closest road, and species should also be noted on the data sheet. Be sure the "New Occurrence" box is checked as well.

Appropriate photo documentation is essential to the long-term viability of this protocol. Photos should be taken to adequately capture the entire population, as well as the state of the individual plants. Special attention should be given to photos that provide identification examples of first year growth and plant "seedlings" that are just becoming established. If possible, please try to take a "landscape" style picture that captures the population and the associated/adjacent gas infrastructure.

Additional data such as certainty of identity, abundance, infested area, reproductive state, and any information in regards to the perceived vector of infestation should also be included on the data sheet. The "Population General Comments" is for any other information that is site-specific or pertinent to the population being surveyed.

Notification

When a High Priority population is found, upon returning to the office, the plant monitoring specialists should be notified of what was found. Send appropriate photographs, data sheets, and a short explanation describing what was found via email. In the case of high risk or novel species encountered, the monitoring team may contact the gas forester responsible for the area so that they can be aware of said species being found in his/her district.

If a population of a High Priority species is found on the well pad paved surface and needs to be dug and removed, the gas operator should be contacted prior to digging. If the population can be easily hand-pulled or sprayed with herbicide, this contact can occur following treatment. The gas operators will be notified by either the plant monitoring specialist(s) or gas foresters if necessary.

If more than a very small amount of herbicide is necessary, the district in which the population occurs should be contacted prior to herbicide treatment. In addition to discussing herbicide treatment, also discuss whether Monitoring staff or district staff will enter treatment data into the herbicide tracking database following treatment.

Following treatment, it is necessary for the monitoring team to submit herbicide tracking information to the district. All applicable data should be collected during treatment and submitted to the plant specialists for inclusion with each district's herbicide tracking data.

Referring Treatment to Districts or Gas Operators

In the course of EDRR surveys, it is possible that large populations of high-priority species may be encountered. Due to limitations in manpower, it may be prudent to transfer treatment responsibilities of these large populations to district staff, or in the case of leased tracts, the lessee or Surface Use Agreement holder. Generally, if the treatment of a high-priority population is going to take more than one day's work, it is likely outside of the scope of Monitoring Team responsibility. However, each species and each population creates unique situations which must be evaluated carefully before the decision to transfer treatment responsibility is reached.

A standardized decision-making process has been established to facilitate making the determination of when to transfer treatment responsibility (**Figure 5.17**). This chain of questions is meant to duplicate the assessment made by experienced field foresters and specialists. This process is based on answering the following four questions. If the answer to any of these questions is 'No' then the population should be transferred.

Is this an isolated population?

This question attempts to determine if the population seeded in from an adjacent seed source that may have been present prior to development of any gas infrastructure.

Will continued treatments eradicate the population?

If targeted, effective treatments have a high likelihood of eradicating the population in question; it may be most efficient for the monitoring team to conduct these treatments.

Can all required treatments over the course of a field season be completed in a total of one day's time or less?

EDRR protocols are meant to be opportunistic and require minimal time to complete. If a population size necessitates more than one day's time for treatment, it is likely too large to remain an efficient use of the monitoring team's time and resources.

Do we have or can we obtain the resources required to effectively treat the population?

If a population requires large amounts of chemicals or specialized equipment, it may be outside of the scope of the work carried out by the monitoring team and better handled by the district or gas lessee.

If the decision is made to transfer responsibility of treatment to a district, the monitoring eam is still responsible to aid the district in the following ways:

- Teaching or explaining the appropriate survey and treatment techniques for the species.

- Plant Monitoring Specialists will work with the appropriate district staff to prepare a treatment plan.

- Monitoring team staff can provide assistance in surveying the area immediately surrounding the transferred population for smaller satellite populations.

When the decision is made to transfer treatment responsibilities of population to a district, the monitoring forester who first encountered the population is responsible for notifying the district of the decision and serving as the follow-up contact between the district and monitoring staff. At the time of notification, the monitoring team will provide all location data and recommended treatment protocols. Contact should first be made to the applicable Gas Forester, Assistant District Forester, District Forester and (if named) the district Invasive Species Coordinator. Plant monitoring specialists, the Monitoring Field Manager, Ecological Services Botanist, and Monitoring Team Coordinator should also be notified. Follow-up to confirm initiation of treatment by district staff should take place 15 days following initial notification.

If the decision is made to transfer treatment to an applicable Lessee or Surface Use Agreement-holder, the monitoring staff should work closely with Minerals Staff and district Gas Foresters to provide the appropriate notification and treatment protocols to the operator.

Treatment of Populations

After all information has been collected and all photographs have been taken, the invasive species population should be evaluated for treatment. Depending on the time of year, species and size of the population, this treatment could be conducted immediately or at some time in the near future.

Evaluating treatment options:

Consider the population size and perceived age of infestation. If the population is small and it appears unlikely that the species has been present for more than one or two growing seasons, then hand-pulling or digging may be the most effective means of removal. If the population is extensive or has a larger number of individuals, herbicide treatments should be considered. If the population found is too large to efficiently treat, the district should be contacted.

If the population is found in an area subject to invasive plant provisions on a gas lease, the operator may be responsible for treatment. If EDRR species are found in areas subject to these provisions, collect the data and determine the feasibility of treatment. Please contact a plant specialist for how best to proceed.

Conducting treatments:

- **Tree-of-heaven:**
  Unless the seedling is extremely small (less than 6-8 inches tall), cutting or breaking of Ailanthus stems should not be considered an effective treatment for the infestation. Herbicide applications should take place from July 1st until Ailanthus leaves turn colors in the fall. One potential treatment method is basal bark application of triclopyr (garlon) and oil (pre-mixed sold as Pathfinder II). Hack and squirt can also be effective, given that each stem is not entirely girdled or damaged (a small portion should be left intact) while treating.

- **Japanese angelica tree:**
  Angelica tree can only be certainly differentiated from Hercules' club during the flowering season (August). Angelica tree should be treated by basal bark application of triclopyr (garlon) and oil (pre-mixed sold as Pathfinder II). Each seedling/stem should be treated. If the population is found late in the season, consider removing the flower/fruits from the stems if the population is small.

- **Poison hemlock:**
  Special care should be taken while handling poison hemlock, all parts of this plant are toxic. The most effective treatment of poison hemlock is to target the 1st year or early spring basal rosettes with glyphosate. This treatment is much more effective than treating bolted, flowering stems. During the summer, the drying dead adult plants are observed. If this is the case, this site should be documented and treatment of the rosettes can take place in fall or the next growing season.

- **Phragmites**:
  - If the population is small (less than 20 individuals), it may be possible to hand-dig the population. Extreme care should be taken to ensure that the rhizome system is removed intact and all new off-sprouts are found and removed. All plant material and rhizome should be bagged and removed from the site.

  - If herbicide is deemed necessary due to the size of the population, consider first cutting the stems and applying herbicide eight weeks later, depleting reserves in the rhizomes. Consider using imazapyr (Habitat), imazamox (Clearcast), or glyphosate to treat *Phragmites*. If cutting prior to treatment is not utilized, treatment should be conducted after July 1.

- **Glossy buckthorn:**
  If only a few individuals are present, hand pulling or digging can be effective if the roots are removed. This site would still have to be monitored for any additional seedlings from the seed bank. For larger populations, cut-stump treatments with glyphosate or tryclopyr should take place in summer (after July 1st) or fall.

- **Goats-rue**:
  Any goat's-rue found needs to be reported to the PA Department of Agriculture. If populations are small and have only been established for one or two growing seasons, hand pulling of plants appears to be an effective treatment as long as the root system is removed. *Using Garlon 3A in summer as a foliar application can be an effective herbicide for treating goat's-rue.*

- **Mile-a-minute:**
  This species is best controlled with pre-emergent application during March or April. However, it is likely that a population will be found during the growing season. For very small populations, hand pulling and digging may be effective. Both tricolpyr (Garlon 3A) and glyphosate (Glyphomate 41) can be used as a foliar application during the growing season. A surfactant should be used as well. Garlon 3A targets only broadleaf plants, which may be more desirable if

mile-a-minute is growing with other non-target species. The extent of the population should be flagged and considered for pre-emergent treatment the following growing season.

- **Japanese knotweed:**
  - Small populations of knotweed (1-5 plants) can be considered for digging and hand removal. Be advised that the taproots of knotweed are very extensive and often branch, exercise caution while digging these plants. Consider an herbicide application to the roots if they break off when pulling or become difficult to remove.

  - The most effective means to treat knotweed is to cut the plants and treat with glyphosate eight weeks later. Typically this cutting occurs in late May or June and treatment is conducted eight weeks later, this helps to reduce root/rhizomes reserves prior to spraying. If there is no mowing or cutting, treatments should take place after July 1st and end by mid-September, this should be a high volume application. Depending on the glyphosate formulation, a surfactant may be necessary (Glyphomate 41 does not need an additional surfactant).

- **Black and Pale swallow-worts:**
  If populations are small, digging of plants and root material can be effective, but is difficult and all material must be removed from the site. Glyphosate can be effective against swallow-worts, but must be applied twice in a season, first in June then again in August. When using glyphosate, a surfactant is required. Triclopyr can also be used as a foliar application once per growing season, and has the advantage of only targeting broadleaf plants.

Follow-up Visits

Each population found, documented and potentially treated using these protocols should be re-visited, at a minimum, during the following field season. The purpose of these re-visits is to complete any re-treatments as well as evaluate the efficacy of EDRR treatments. Not only is the re-treating of populations essential to their eradication, but evaluating the success of treatments better establishes treatment protocols moving forward.

The same data sheet used during the initial treatment should be used again. Check the box next to “Follow-up Visit” and indicate how many times this population has been visited. If this is not known leave blank. Please mark if the population has been completely eradicated by checking the appropriate box under “Abundance”. Portions of the datasheet are provided for comments in regards to the prior treatment and details regarding any follow-up treatments. Populations need to be visited until eradicated and not present on site for two consecutive growing seasons before being removed from the EDRR database.

Photos should be taken of the site and/or population during all follow-up visits as described above in the initial treatment section. Even if the population is dead or no longer present, a photo of the site of original infestation must be taken.

Data Management

- A copy of the datasheet and applicable photos should be placed here: \\nrford12ds1\RPI\RPI_RAID\Plants\EDRR in the folder corresponding to the population. If a new population a new folder will need to be created. Follow the naming/ordering scheme already established when adding new folders.

- Notify the plant monitoring specialists and appropriate gas forester of new populations via email including applicable photos. Please see the notification section above for other necessary contacts. Plant monitoring specialists are responsible for data entry and coordination with the GIS specialist.

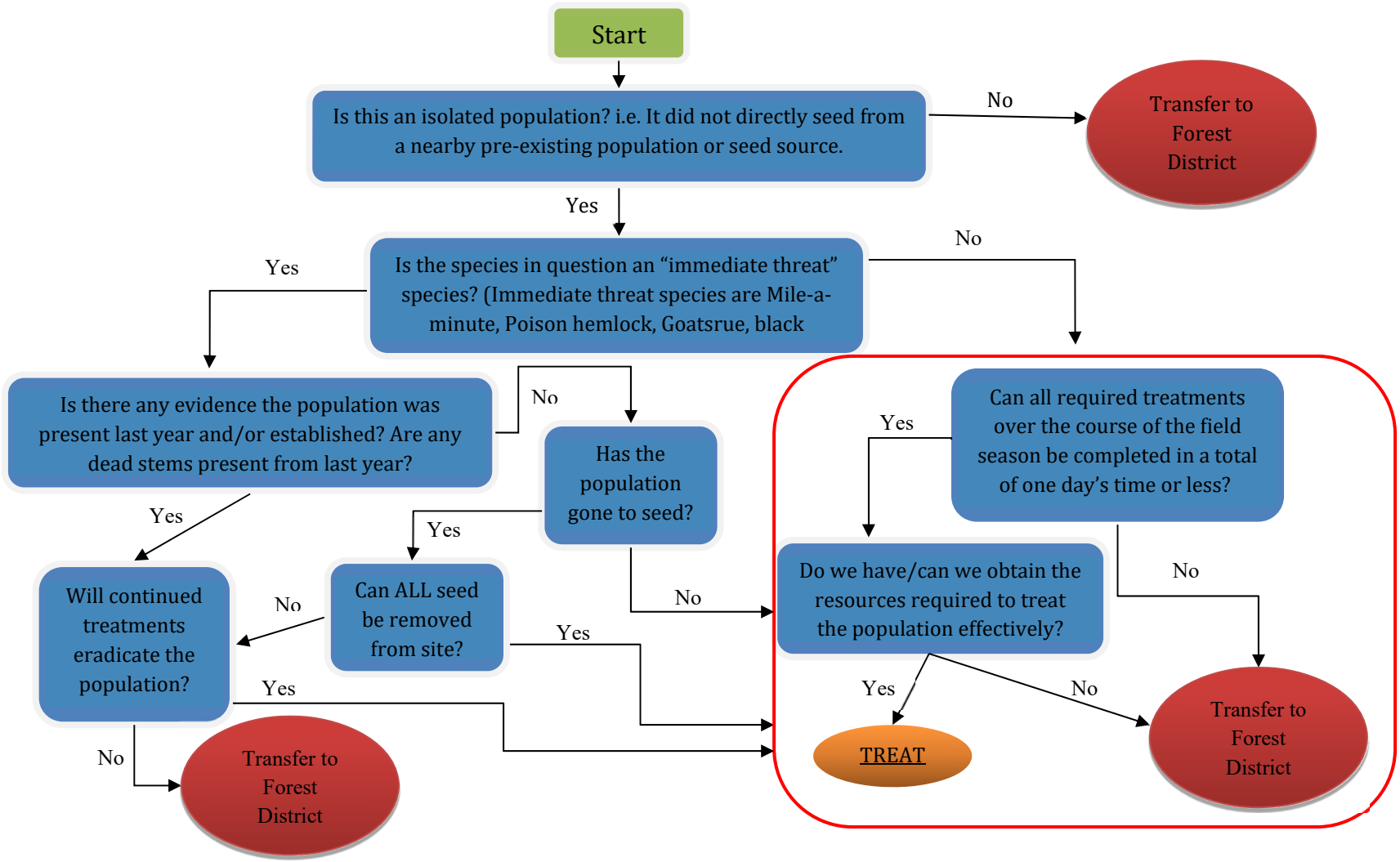


Figure 5.17 Decision-Making Flowchart for EDRR Populations

Chapter 6 Pipeline ROW Monitoring

Grassland Bird Nest Surveys

Purpose

The data collected will determine use of pipeline right-of-ways (ROW) as nesting habitat by grassland birds. Comparisons can be made based on management practices of the ROW such as the mowing regime, seed mix, and ROW width. The habitat data collected at each end of the transect can be used as input in an HSI model for the Eastern Meadowlark and Bobwhite to determine habitat suitability for these two grassland birds. The transect surveys must be conducted between the first week in June – First week in July.

Equipment Needs

- GPS
- Data sheet
- 6' long stick
- Laser rangefinder
- Robel pole
- String (4 meters long)

Procedures

- Locate transect start point (one chain from an intersecting road, staying centered in the ROW)

- GPS start point (first milacre plot)

- Collect habitat data utilizing a milacre plot (3.72' radius around the established point)

- Determine how much of the milacre plot is covered by the following vegetation types.

    - Total herbaceous cover percentage
    - Percent grass
    - Percent forbs
    - Percent ferns
    - Percent shrub (including tree seedlings)
    - Percent duff (must be softball sized to count)
    - Percent bare ground/mineral soil (must be softball sized to count)

The percentage estimates will be recorded in the following classes;

Code	Cover % of the Species
10	100
9	>75, but <100
8	>50 to 75
7	>33 to 50
6	>25 to 33
5	>10 to 25
4	>5 to 10
3	1 to 5
2	<1
1	2 or 3 plants
+	1 small plant

- Calculate average height at milacre;
  Determine the dominant vegetation and estimate and record the average height of this vegetation in inches

- Use the Robel pole to collect visual obstruction data.
  The graduated Robel pole is placed at the center of the milacre and a reading is taken in four different directions;
  - perpendicular to the ROW to the left
  - perpendicular to the ROW to the right
  - parallel to the ROW back to the starting point
  - parallel to the ROW forward towards the survey

- **Readings are taken in the following manner;**
  - One person holds the graduated pole vertically on the plot center
  - The surveyor holds the 1m pole four meters from the graduated pole in the appropriate direction and holds their eye at the top of the pole
  - Sight with the eye on the pole towards the graduated pole
  - Determine the lowest stripe on the graduated pole that is not completely obscured by vegetation
  - Record the measurement number representing this stripe

- Next, Start Transect, 6 feet wide by 726 feet long (0.1 acre)
  - Transect should parallel pipeline ROW, and be centered in ROW
  - Record the number of grassland nests observed on transect
  - Record whether the nest is small mammal or bird
  - Record ht of nest (inches) and ht of adjacent vegetation (inches) in notes section

- Repeat habitat data collection at the midpoint and end of the transect

- If milacre plot falls in a non-vegetated area, offset 15 feet from non-vegetated area into the closest vegetated area along the transect

- **The following pieces of data will be obtained by the wildlife specialist in the office prior to or after the field data is collected;**
  - Record ROW width (FIMS)
  - Record frequency of mowing (Gas Forester)
  - Record timing of mowing (Gas Forester)
  - Record Native / Conventional seed mix

Data Management

For now, the data should be collected and recorded on paper forms. Field personel should file datasheets until requested by the wildlife specialist. The data will then be entered into spread sheets, and analyzed to evaluate ROW conditions as grassland bird habitat.

Pipeline ROW Vegetation Monitoring

Purpose

Current rights-of-way on state forest land account for approximately **3,000** acres and **760** miles of linear disturbance. The recent Shale Gas development has the potential to add **104** miles of additional disturbance. These rights-of-way have the potential to provide ideal habitat conditions for the establishment and further spread of invasive plant populations within interior forested landscapes. Additionally, the right-of-way could act as a vector for further movement of established invasives outside of the existing corridor. Areas of concern that intersect rights-of-way include; stream crossings, timber sales, burned areas, road/trail crossings, wetlands and any other sensitive ecosystems. We will refer to these areas as "hot spots" later in this document. The initial scope of this protocol is the current and future disturbed areas of development related to shale gas on state forest lands. Due to the limited access and remote locations of some of these corridors, it is important to monitor for invasive populations before they are able to establish a viable population and spread into stream crossings, wetlands, and other sensitive landscape features.

Equipment Needs

- Tablet Computer/GPS
- ROW Vegetation Monitoring Datasheet
- Camera
- Field Guides and ID materials
- Pencil
- D-tape or Other Measuring Tape
- Snake Gaiters
- UTV, Trailer, and Radio (Optional)

Procedures

*****Before going afield load appropriate ROW segments and points on the tablet computer via path "FIMS:P:\Layers-Gas Program\Monitoring"**

General Data Collection

Record the following general information on the data sheet:

- District #
  Record the number of the forest district the pipeline is located in

- Tract #
  Record all of the leased tract numbers the Pipeline ROW survey will encompass. Refer to the "TractID" field of the "Draft_DCNR_OG_Ownership- All" layer in ArcPad to view leased tract numbers. If no leased tracts apply, record as "N/A".

- ROW Name
  Record the name of the pipeline given by the operator(s)

- Surveyors
  Record the last names of the individuals performing the pipeline survey

- Date
  Record the date(s) the survey is completed

- Operator
  Record the name of the gas company(s) associated with the pipeline.

Section Data

Once a right-of-way has been established for monitoring, a GIS layer will be created with 0.25 mile sections overlaid onto the ROW. All sections will be numbered.

- Use the tablet to navigate to the first section of the pipeline to be surveyed.

A survey can be started at any section as long as the section is properly identified in the "segment ID" field on the datasheet.

- Starting at the end of a section, thoroughly walk the cleared pipeline area looking for invasive species. When invasive species are found they are added to the species list for that 0.25 mile section, as well as population size (number of plants), and appropriate vegetative state. Selected ROW sections can be surveyed on foot by a minimum of 3 staff members. Special attention should be paid to the outer most edges of the ROW, as this is where the likelihood of invasives becoming established is highest. However, the entire cross section of the ROW should be thoroughly examined.

If a high-priority species is found, surveyors will defer to the EDRR protocol.

- When the end of the ROW section has been reached, the surveyors will tally results from all surveyors and record.

This process can be performed using an UTV if desired, as long as the entire ROW is thoroughly assessed. A second pass may be needed to cover the entire section.

Section Data Collection

- Species
  Record the name of each invasive species found in the section

- Population Size
  Estimate the number of individual invasive plants encountered in the section and circle the appropriate category

- Vegetative State
  Circle the appropriate vegetative state for the latest vegetative state observed

- Adjacent Road?
  Indicate if a state forest road is immediately adjacent the section or not. If YES, record on the datasheet the class of road (Z1, Z2, or Z3) and if the road is adjacent the section for its entire or partial length.

- General Section Notes
  Record any significant information for the section, such as wildlife encountered within the section

Hotspots

A hotspot is a disturbance within the ROW being surveyed. These areas have high potential to harbor invasives and can include roads, trails, and streams. Culverts will not be considered hotspots, unless they are associated with a stream/intermittent stream. If applicable, a survey will be conducted at every hotspot that is perpendicular to the ROW corridor. Surveyors will walk 100' out the hotspot perpendicular to the ROW looking for any invasive species. These data will be recorded at the bottom of the datasheet for the 0.25 section.

Invasives found on hotspots that are parallel to the ROW, such as hiking trails and deer fences will be included and tallied with the invasives found in that 0.25 mile section. Be sure to indicate them in the "General Section Notes" on the datasheet to account for "inflated" population sizes.

Hotspot areas that are normally covered in other walkabout protocols are excluded, but noted in the "General Section Notes".

Hotspot Data Collection

- Type
  Circle the appropriate description for the disturbance being surveyed
  - Road
  - Stream
  - Trail
  - Fence
  - Other (Describe)

- Species
  Record the name of each invasive plant species encountered in the hotspot

- Population Size
  Estimate the number of individual invasive plants encountered on the hotspot and circle the appropriate category

- Vegetative State
  Record the appropriate latest vegetative state for each species found
  - Vegetative
  - Flowering
  - Fruiting/Seeding

Intensive Swath

An intensive portion of the ROW survey will be conducted on a randomly selected one mile section of the survey length. There will be five points set at quarter mile increments, within that section. The intensive points will be shown on the GIS layer for ROW Vegetation Monitoring. The five points will be assigned alphabetical letters A through E, with "A" corresponding to the lowest numbered section in the intensive portion.

At each intensive point, a one meter wide swath perpendicular to the length of the right-of-way will be carefully examined.

Intensive Swath Data Collection

Record the following general information on the data sheet using the "New ROW" section for Marcellus pipelines and the "Historic ROW" section for pre-existing gas pipelines, if noticeable.

- Swath Alphabetical Code
  Circle the letter that corresponds to the point being surveyed based on the number of the section

- Width
  Record Width of the ROW **for the pipeline**, to the nearest foot (excluding adjacent disturbed locations such as roads or log landings)

- Species
  Record the three dominant plant species for the one meter swath

- Percent of Cover

Record the percentage cover class codes for each the three dominant species of plants using the Domin-Krajina Cover Abundance Scale provided at the bottom of the data sheet.

- Total Vegetation Coverage
  Record the total percentage of the swath covered by vegetation

Additional Data Collection

While conducting surveys, the presence of wildlife or erosion issues should be noted. Tree plantings and the success of them along with mortality and maintenance issues with fencing should also be recorded. If any EDRR species are encountered, follow the EDRR procedure as appropriate.

Routine UTV Cleaning

If the UTV was driven through large infestations of invasive plant species, or is moving between districts, the surveyors will thoroughly clean the vehicle, including the tires and undercarriage to ensure seed or other vegetative materials are not transmitted across districts or tracts.

Quality Control

Plant specialists will visit a subset of right-of-way sections visited by the monitoring field crews to conduct "cold checks" on vegetation data collected. The specialist will recollect the vegetation data from the same location using the GIS/GPS data collected at the initial visit. A comparative analysis will be used to determine the level of accuracy, with a focus on species identification since the percent cover will be difficult to duplicate due to specificity of locating plot center on the quality control visit. In addition, the plant specialists will conduct "hot checks" on site to determine if plot location procedures are being followed and data collected is accurate.

Data Management

Paper data sheets will be filed in the Monitoring filing cabinet until requested by the plant specialist.

Pipeline-Stream Crossing Monitoring

Purpose

Pipeline crossings represent a significant impact on streams and rivers in state forests. The pipeline crossings are typically constructed by an open-cut trench across the stream or by horizontal directional drilling (HDD) beneath the stream. The open-cut trench represents a direct impact on the riparian vegetation, stream bed, and water. The HDD can affect riparian vegetation, depending on the details of the operation, and can affect nearby water bodies through the occurrence of inadvertent returns. Post Construction Stormwater Management (PCSM) Best Management Practices (BMPs) are constructed in order to ensure that construction activities do not impact receiving waters with erosion and sedimentation for the life of the project. Through this monitoring effort, we will be able to determine the success of installed BMPs through time. We will also be able to make recommendations to improve guidelines and vegetative species planting lists in regards to erosion and sedimentation control.

This protocol has been designed to provide an efficient means to characterize and assess forest stream crossings by pipelines on State Forest lands. It is our assumption that following construction and site rehabilitation many of these stream crossing sites will remain fairly stable, thus eliminating the need for an exhaustive assessment of every site. However, it is important to evaluate these sites and identify "at-risk" or "impacted" stream crossings that require follow-up by the district and/or operators.

Equipment Needs

- Clipboard and pencil
- Measuring tape (logger's 100' tape)
- clinometer
- digital camera
- GPS unit
- Infrastructure Monitoring Pipeline Crossing Datasheet

Procedures

For the purposes of this protocol, the **"centerpoint"** is the center of the intersection between the right-of-way (ROW) and the stream. **"Left bank"** and **"right bank"** are determined as one faces downstream. Useful acronyms are included at the top of the datasheets.

- Once onsite record the District #, Tract #, Operator (on the lease) , ROW crossing ID # (obtained from the crossing's attributes in FIMS), Surveyors, and the Date at the top of the datasheet
- Also record if a pre-existing (historical) ROW was present AND if any synthetic matting can be seen anywhere in the study area

ROW Measurements

ROW width measurements will be taken with a logger's tape or other suitable device measured ***to the nearest whole foot***. These measurements will be taken 25 feet from the stream bank on BOTH the left and right sides of the stream.

- Measure the total ROW width and temporary workspace width if a deferential determination can be made in the field between the temporary and permanent ROW. If a determination between temporary and permanent width cannot be made, note on the field sheet in the temporary width block "unknown".

The permanent ROW is the area maintained in herbaceous cover for the life of the ROW either through cutting or herbicide application. The temporary ROW is the area that was used as a workspace during the pipeline construction, and it will be allowed to recover with tree and shrub species. Over time, this measurement will become more defined as the temporary workspace is reclaimed with tree and shrub species. If there is temporary right-of-way on each side closest to the undisturbed forest and permanent ROW in the middle, these two temporary ROW sides may be summed.

If there is an existing (historical) ROW where the new ROW is co-located, the widths of the historical ROW should be added to the "Temporary ROW" depending on vegetation composition and inferred maintenance history. If maintained in herbaceous cover like the new pipeline ROW, simply include with the "Total ROW" and do not add to "Temporary ROW" measurements.

Slope Measurements

The slope (%) of BOTH sides of the pipeline will be measured in two ways using a clinometer.

- First, measure the percent slope from the centerpoint to a point 25 feet from the stream bank and record on the datasheet

- Next, measure the percent slope, along the same bearing, from the centerpoint to the end of a straight line-of-sight and record on the datasheet

If the stream is too deep, these measurements can be made from the stream bank.

Photo-Documentation

Eight photographs will be taken from the centerpoint of the stream-pipeline intersection. The photographs will be: ***upstream, downstream, left bank upstream, left bank ROW, left bank downstream, right bank downstream, right bank ROW, right bank upstream***. Generally, these should be landscape-type photos, not zoomed-in at the portion of the stream bank.

In addition, **any notable features will be photographed and commented on** in detail, such as eroding banks, failing PCSM structures, unsuccessful re-vegetation, or algae in the stream. If needed, extra space on the datasheet is provided to number photos to facilitate the matching and naming of photos later when downloading.

Bank Assessment

The structure of each bank area will be recorded based on the composition observed. When evaluating these stream bank areas, surveyors will only consider to a point ~25ft upstream/downstream of the ROW corridor and the area from the surface of the stream or stream bottom to the point at which the slope changes from vertical to horizontal. This is typically only a few feet up from the stream itself.

- Categorize each bank area as ***Rock Armored, Erosion Control Materials*** (mat, sock, etc), ***Non E&S Vegetation*** (any vegetation that is not an E&S planting)***, E&S Vegetation, Dense Root Coverage*** (may or may not be undercut), ***Exposed Bank with little or no root coverage, or Other***. The number code corresponding with the category should be recorded on the data sheet.

If "other" is chosen, please specify what conditions are present at that location. More than one category can be selected for each area.

- In addition, for each bank area that is categorized as either "Non E&S Vegetation" (3), or "E&S Vegetation" (4), evaluate the coverage/success of the vegetation in close proximity to the stream as ***Good*** (A), ***Moderate*** (B), or ***Poor*** (C). *For example, a bank area that was seeded and is nearly 100% covered with very little bare ground would be recorded as "4A" in the blank next to the appropriate bank area.*

Erosion Survey

- Record the type of erosion observed at each bank area as ***None observed, sheet, rill/gulley, or bank/sloughing***. The number code corresponding with the erosion type should be recorded on the datasheet.

Sheet	→occurs when water flows along the soil surface causing erosion or deposition along that surface. This may be evident where erosion control matting has been washed downslope or vegetation has been worn away.
Rill/Gulley	→erosion occurs when water begins to concentrate in small or large channels, causing an incision in the soil surface.
Bank/Sloughing	→erosion occurs along exposed banks and may be evident from sloughing of the soil into the stream or as freshly exposed soil surface along the banks.

- The severity of the erosion at each bank area should also be recorded: ***Light, Moderate or Severe***. The letter corresponding to each severity should be recorded on the datasheet in the appropriate bank area.

If a material has been hauled in to line the channel bottom, then this should be indicated in the comments section at the bottom of the datasheet.

Quality Control

No less than twice per field season, a pipeline stream crossing monitoring event will be observed by a Vegetation Specialist and Infrastructure Specialist, who will verify that the method is being implemented according to this procedure.

Data Management

- Paper data sheets should be scanned and filed at the following location: \\nrford12ds1\RPI\RPI_RAID\Pipeline Stream Crossings

- All applicable photos should be downloaded and placed in the appropriate folder at the above location

Chapter 7 Social Monitoring

Sound Monitoring

Purpose

The guidelines for oil and gas related activity on State Forest Lands recommend that the operating noise level of compressor stations shall not exceed 55 db(A) L_{dn} at any distance greater than 100 yards (300 feet) from any infrastructure on the pad that is capable of producing noise. Sound monitoring is conducted by the monitoring staff at compressor sites, permanent well pad vegetation assessment sites, and other sites on State Forest Land as scheduled by the Social Monitoring Specialist or as requested by district personnel and other stakeholders.

Equipment Needs

- Infrastructure Extech Sound Level Meter, Model HD600 (SLM)
- USB cable
- Software CD
- 9V battery
- Laser Range Finder
- GPS
- Digital Camera
- Tablet & Pen

Calibration

- Attach the Model HD600 Sound Level Meter to the Sound Level Calibrator. This is done by removing the foam windscreen and inserting the SLM into the calibrator.

- Turn on the power to both devices.

- **SETUP:** Use the A/C button to select db(A), the FAST/SLOW button to select slow, and the LEVEL button to select 30 – 130.

This is what we set the SLM to when collecting data.

- The SLM should read 94.0 db(A). If it does not (which it is normally off by a few tenths) use the small flathead screwdriver to turn the set screw on the SLM until it reads 94.0 db(A). (Clockwise to increase, and Counter Clockwise to decrease db(A)).

- Once the SLM is set to 94.0 db(A) unhook and turn the power off on both devices.

- Fill out the Sound Monitor Calibration form in RPI_RAID in the Compressors Folder and "Save As" ***Sound Monitor Calibration.yyyymmdd.xlsx***.

Deployment

Developed Site

- Be sure to have the foam windscreen on the SLM for deployment.
- Check the weather online before going afield do not deploy if wind speeds are greater than 15mph or if there is a greater than 30% chance of rain. Since these factors will distort the data.
- Install a new 9V battery for each deployment. If not the power will die during the consecutive deployment and all of the data will be lost.
- Follow instructions in the EXTECH user's guide supplied in the plastic carrying case to set the time and date.
- Turn the power on and follow the steps for SETUP above in Calibration.
- Walk a complete lap around the perimeter, periodically using the laser range finder, trying to keep a distance of 100 yards. Continuously monitor the db(A) level on the display screen while walking the perimeter.
- Return to where the SLM displayed the highest db(A) reading. Try to stay away from roads or any noise source other than the compressor that may distort the data.
- Select a tree to place the SLM on, use the laser range finder to make sure the location is 100 yards or greater. Use the strap and install the SLM onto a tree at ear level height (if there is no tree available, improvise and make something to mount the SLM to).
- Take a GPS point.
- Take 2 photos of the SLM placement (try to capture identifying features of the placement site in the photos so the exact same site can be used for redeployments). Take at least one photo with an angle to include the compressor in the background of the photo.
- In a notebook write down the date, compressor and tract #, distance, and time deployed so the SLM can be retrieved 24 hours later. Also take any notes that could be important for the Social Monitoring Specialist that could explain other noises being recorded by the SLM (e.g. Heavy equipment being operated at the site, snowmobiles riding by, etc.) .

- If recording ambient noise levels of a site before a compressor is built and there is a pad present, deploy the SLM 100 yards from the edge of a pad.

- To setup and start recording proceed to *Setup for Recording* section below.

Undeveloped Site

When collecting ambient noise levels at sites that do not yet have pads built, follow the same procedures outlined for a developed site with the following deviations:

- When there is not a pad present the Social Monitoring Specialist will send a map of the proposed site where the ambient noise level is to be recorded.

- For ambient noise level recordings photos and GPS points are not required. Since these locations will most likely not be reused after the site is developed and the compressor is built.

Setup for Recording

- With the SLM turned **off**, press and hold the LIGHTBULB and press the power button (simultaneously). "0001" and "Int" will appear on the display screen. Use the LEVEL button and set the SLM to "0015". Press HOLD to save interval settings and return to the main display screen. Follow SETUP steps above in Calibration.

- Press the REC button to start recording and walk away trying not to make any unnecessary noise.

Retrieval

- For undeveloped and developed compressor stations: 24 hours later, return to the SLM and press REC to stop recording. For permanent well pad vegetation assessment sites: retrieve when the permanent well pad vegetation assessment is complete

- Press the power button to power off the SLM.

- Return to the vehicle and place the SLM in the plastic carrying case.

Software Communications

- Use a computer that has the CP210X driver installed on it or download from the internet. (https://www.silabs.com/support/pages/support.aspx?ProductFamily=USB+to+UART)

- Use a computer with the HD600 disc already installed on it or load it from the disc provided in the plastic carrying case.

- Connect the SLM to the computer using the provided USB cable from the plastic carrying case.
- Launch the HD600 application.
- Turn the power on to SLM and press the SETUP button to establish communication.
- If the data does not appear on the screen, communication is not established. If so, select the COMport which has the CP210X driver installed. (Data will appear on the computer screen when communication is established).

Process Recorded Data

- Click Datalogger (D)
- Double click the DATETIME for the data you want to view/export/save.
- Click export to Excel (E)
- File the data as according to the File Management Appendix.
- Download the photos of the SLM placement along with the Data file. The files should be named using the format "Tract #_ Compressor pad"(e.g. 289_ Comp_P#.JPG).

Clearing Data

- After all the steps from above have been followed you can clear the stored reading from the SLM to ready it for the next deployment.
- With the SLM turned off. Press and hold the REC button and press the power button.
- When "CLR" appears on the display screen release the REC button
- All of the readings that were stored on the SLM are now erased.

Additional Data Management

- Enter data into the Compressor Sound database at \\nrford12ds1\RPI\RPI_RAID\Sound Monitoring.
- Open the database and fill out all header information:
  - Tract #
  - Infrastructure I.D. (At this time there is only one compressor per tract and they are named "A" with the exception of Tract 100 which has "Hagermans Run" and "Bodine Mtn")
  - Select "Measure Type" from dropdown
  - Select "Noise Type" from dropdown
  - Year

  - Leaf ON/OFF
  - Notes

- “Select File” from folder
- “Import” file
- Check to make sure the file was inported into the database

Chapter 8 Appendix A Supporting Documents

Observed Pollution or Suspected Pollution Events

Introduction

Monitoring field staff should be alert at all times for pollution events or suspected pollution events. Pollution events may vary in nature and severity, but are generally defined as the unintended release of hazardous, regulated, or other substances with the potential to cause negative environmental effects. Examples of such substances are diesel fuel and other petroleum products, hydraulic fracturing fluid prepared prior to well injection (frack fluid), chemical additives for preparing frack fluid, flowback water recovered from the drilling process, and other brine waters used during drilling operations. In addition, inadvertent returns (the unintentional discharge of drilling mud, primarily water and bentonite) and major failures of erosion and sedimentation control measures, which pollute or imminently threaten to pollute a water body, are also considered pollution events. Pollution events may occur at a pad site or at some ancillary feature related to gas development, such as a compressor station, meter site, roadway, or pipeline.

If a pollution event is discovered, the first concern should be for the safety of all involved and the public. Appropriate actions and notifications should proceed as described below.

Observer Actions and Notifications

Upon discovering a pollution event, monitoring field staff should promptly assess the severity of the pollution event to determine any potential safety issues before further inspection or documentation. If a pollution event causes an imminent safety threat, do not engage in event documentation and immediately notify the Forest District. If it is determined there is no immediate safety threat, follow the outlined procedure for documenting the observed event below.

- If no imminent safety danger exists, access the site and photo-document the pollution event. Include evidence of the event and any interim remedial measures being taken.

- Begin filling out the "Pollution Event Documentation Form" to document the event. This form can be found in the Guidelines for Administering Oil and Gas Activity on State Forest Lands on page 81.

- Assuming the conditions at the site are safe, and the staff present have been trained in sampling protocols and have the proper sampling containers or field meters, take samples of substances at the pollution site and along transport pathways.

- Upon returning to the office, promptly brief the Monitoring Assistant Program Manager in the Resource Inventory and Monitoring Section of the observations.

If the Assistant Program Manager is unavailable, contact the Section Chief for the Resource Inventory and Monitoring Section.

- Review and finish filling out the "Pollution Event Documentation Form" as completely as possible.

- Compile additional notes and photographs so they are readily available for distribution if requested.

Resource Inventory and Monitoring Assistant Program Manager Roles

Upon being notified of the observations, the Assistant Program Manager will promptly review the details of the observation and begin the notification process. The first contact will be made to the appropriate district point of contact (POC) via telephone regarding the observations and any actions that were taken.

The BOF Minerals section maintains the district POC list.

This will be followed-up with an e-mail to document the call. CC'ed on the e-mail are the following:

- District Forester (unless this is the POC).
- The Ecological Program Specialist for water monitoring in the BOF Minerals Division (if samples were collected).
- The Program Manager for the Resource Inventory and Monitoring Section.
- The Assistant State Forester.

Follow-up Documentation and Monitoring

Following the event notification, the Resource Inventory and Monitoring Section will provide additional documentation and coordinate additional monitoring efforts as requested.

Disinfection of Didymo (*Didymosphenia geminata*) Infected Equipment

Purpose

The proper disinfection of equipment used in the monitoring of riparian areas known or suspected to have Didymo is prudent to prevent the spread of this diatom. Didymo only requires one cell to reestablish itself in another freshwater stream and can survive outside a stream in a cool, damp, dark environment for up to 40 days. It is the responsibility of monitoring personnel to insure they are not spreading any invasive species while performing their work. There are a few approved methods of treatment to remove Didymo from equipment. Choose the most practical treatment for the situation which will not adversely affect your gear.

Equipment Needs

Bleaching Method:

- Large Rubbermaid-type bin, or 5 gallon bucket
- Large stiff bristle brush
- Spray bottle
- Graduated cylinder or measuring cup
- Bleach
- Tap or stream water

Cleaning Agent Method:

- Large Rubbermaid-type bin, or 5 gallon bucket
- Large stiff bristle brush
- Measuring cup
- Cleaning agent such as Simple Green, Snot Off, or disinfectants such as Formula 409 or Fantastic (must contain the quaternary ammonium compound alkyl dimethyl benzyl ammonium chloride)
- Tap or stream water

Procedures

Preparation

- **Remember:** Disinfect Didymo infected clothing and equipment before relocating the work site to another water body, watershed, or another site within the same water body.

- **Check**: Before leaving an infested river, stream, or lake, check items and leave debris at site. (Any obvious clumps of algae, hidden clumps of vegetation, mud, etc.)

Disinfection Methods

Only equipment that is most likely to harbor Didymo need be disinfected. Some equipment, such as the YSI Pro Plus and digital cameras can be excluded because of the potential damage to the functionality of the instruments. Items such as muck boots, waders, or any other footwear are ALWAYS to be disinfected. Other items may or may not be disinfected at the discretion of the field staff. Remember, hardened, non-porous surfaces do not pose as much of a concern as soft, porous surfaces.

- **Bleaching Method**: In a large tote or 5 gallon bucket, soak all surfaces for at least one minute in 2% household bleach (2.5 oz with water added to make one gallon.) Use a large stiff bristle brush to remove debris from surfaces while being soaked. In the field, after all surfaces have been scrubbed and soaked, dispose of the solution on the ground away from any water body. At the office, solution can be discarded down a sink drain.

- **Cleaning Agent Method:** Cleaning agents should be diluted for soaking with two parts water to one part disinfectant. For all materials, follow label instructions and be sure to soak equipment for a minimum of 10 minutes. Use a large stiff bristle brush to remove debris from surfaces while being soaked. In the field, after all surfaces have been scrubbed and soaked, dispose of the solution on the ground away from any water body. At the office, solution can be discarded down a sink drain.

- **Drying Method:** Drying will kill Didymo. To ensure Didymo cells are dead by drying, the item must be completely dry to the touch, inside and out, then left for at least another 48 hours before use.

When disinfecting equipment, it is recommended you:

- Soak porous materials longer than the specified times to ensure saturation with solution
- Follow manufacturer's instructions when using products
- Use all cleaning procedures on dry land away from waterways
- It is preferable to drain used solutions into treated wastewater (e.g. pour down sink drain)

Preparing Grab Samples for Courier Pickup

Purpose

Grab samples taken must be properly cared for prior to shipment to DEP Bureau of Labs. Arrangements must be made in advance for Quick Courier Service to pickup and deliver the samples to the lab. Proper care and timely shipment are essential in retaining sample quality.

Equipment Needs

- Paper towels
- Bubble wrap protectors (for organics)
- Cooler
- Ice
- One gallon Ziploc bags
- Clear packaging tape
- DEP Lab – Multiple Sample Submission Sheet
- Ink pen
- Quick Courier ticket

Procedures

Arranging for Quick Courier Pickup

Call the Quick Courier to arrange for sample pickup one day prior to sampling or the day of sampling, prior to 10:00AM. The Quick Courier number is **1-800-355-1004**. Use the information below to direct the courier and obtain a confirmation number for transport. It is important to use "Bureau of Forestry Building" for the location. Quick Courier has us filed under this title and broken down by address.

Call Information:

- Request to have cooler(s) picked up
- Grab Sampling Code **PA-DEP69** (not West Nile)
- Pickup Location – Bureau of Forestry building in Waterville
- Address – 10 Lower Pine Bottom, Waterville, PA 17776
- Time – after 4:30PM
- Give number of coolers
- Record confirmation number on DEP-Bureau of Labs, Quick Courier Service Ticket. The ticket will be secured to the top of the cooler when ready for pickup. A sample copy of the ticket is shown at the end of this procedure (**Figure 8.1**).

Completing the DEP Sample Submission Sheet

***Sample Submission Sheets should be filled out with blue or black ink pen for demonstrating proper chain of custody.**

- The top of the sample submission form should be completed with the collector ID number, Reason Code (01 for Routine Sampling), Cost Center (035 for Bureau of Forestry) and Program Code (0021 for Bureau of Forestry).

- The row should include the sequence number, date, time (in military format), sample location(stream name), and SAC code.

Two bottlescan be written on the same row so long as they share the same sequence #, and SAC code.

- The total number of inorganic (plastic) and organic (glass) bottles should be entered in the boxes. Nutrients bottles get marked as "#of N/P".

- The sample collector name and phone number should be added.

- Check "Commercial Courier" for shipping method, unless hand delivering.

- The chain of custody line for "Relinquished by Sample Collector" should be filled out at the end of the day when the cooler is either left for the courier or dropped off at the lab.

- A sample copy can be found at the end of this procedure (**Figure 8.2**).

Preparing Bottles for Transport

- Bottle caps should be tight to prevent contamination/spillage

- Put all 40 mL glass bottles used for organics in a bubble wrap protector, if applicable

- Place all sample bottles in a Ziploc bag to prevent cross-contamination from melted "dirty" ice

- Pack all sample bottles in the cooler amongst ice, keeping the bottles upright if possible.

- Fill the remaining area of the cooler with ice and replace lid.

Preparing the Cooler for Pickup

- The completed sample submission form should be placed in a Ziploc bag. Fold ~1/2" of the short edge of the form to fit in the Ziploc bag.

- Place the bag on top of the secured cooler lid.

- Secure the Ziploc bag to the cooler top using the clear packaging tape.

NOTE

When taping begin several inches below cooler lid and bring the tape up over the bag, allowing slack over the bag, and continue down the other side of the cooler. It is important to leave slack so the submission form can easily be removed and replaced without removing the tape. Two strips should be sufficient to hold the lid and submission form in place. Use more as needed.

- Tape the Quick Courier ticket on top of the Ziploc bag.

- Place the cooler in the vestibule of the Resource Management Center, on the right hand side, just before the second set of doors. The courier has a key to the outer door.

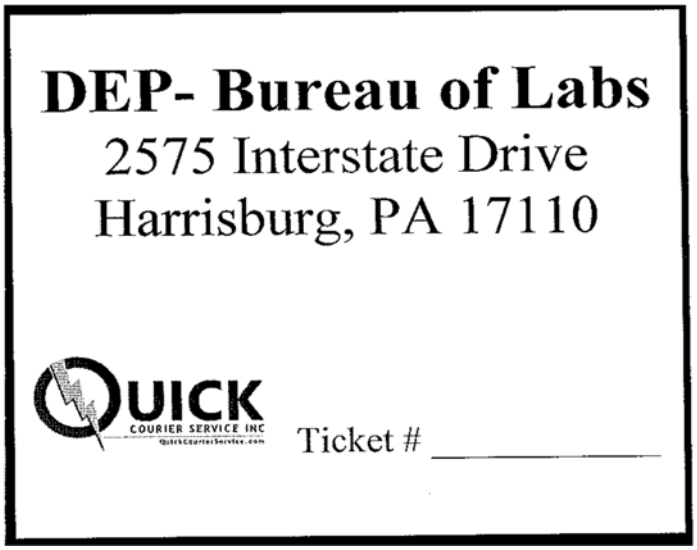
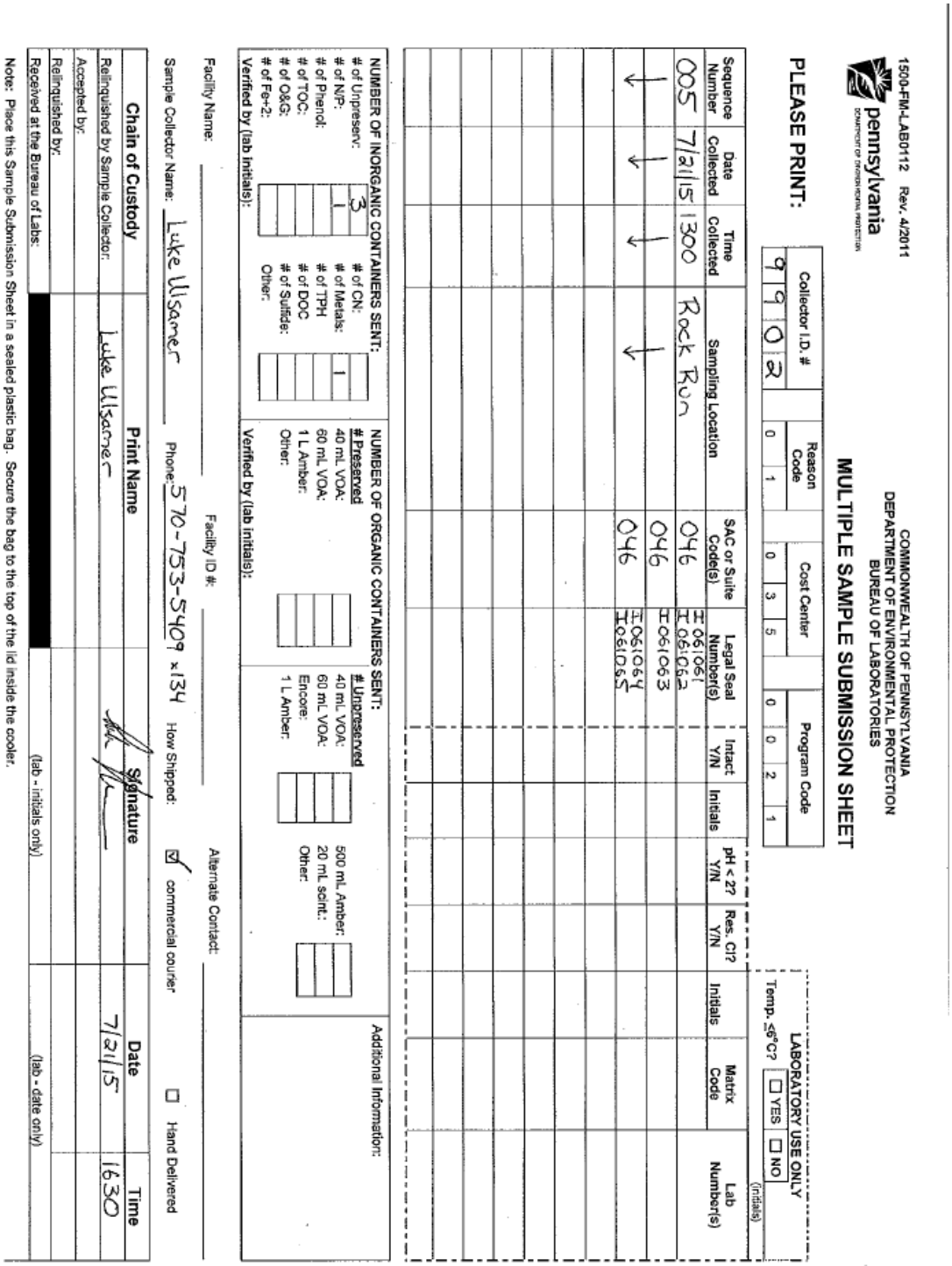


Figure 8.1 Sample Quick Courier ticket



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pennsylvania

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF LABORATORIES

MULTIPLE SAMPLE SUBMISSION SHEET

PLEASE PRINT:

Collector I.D. #: 9 9 0 2

Reason Code: 0 1

Cost Center: 0 3 5

Program Code: 0 0 2 1

LABORATORY USE ONLY
Temp. ≤6°C? ☐ YES ☐ NO (Initials)

Sequence Number	Date Collected	Time Collected	Sampling Location	SAC or Suite Code(s)	Legal Seal Number(s)	Intact Y/N	Initials	pH < 2? Y/N	Res. Cl? Y/N	Initials	Matrix Code	Lab Number(s)
005	7/21/15	1300	Rock Run	046	H061061							
↓	↓	↓	↓	046	H061062							
					H061063							
				046	H061064							
					H061065							

NUMBER OF INORGANIC CONTAINERS SENT:
# of Unpreserv: 3
# of N/P: 1
# of Phenol:
# of TOC:
# of O&G:
# of Fe+2:
# of CN:
# of Metals: 1
# of TPH
# of DOC
# of Sulfide:
Other:

NUMBER OF ORGANIC CONTAINERS SENT:

# Preserved	# Unpreserved
40 mL VOA:	40 mL VOA:
60 mL VOA:	60 mL VOA:
1 L Amber:	Encore:
Other:	1 L Amber:

500 mL Amber:
20 mL scint.:
Other:

Additional Information:

Verified by (lab initials):

Verified by (lab initials):

Facility Name:

Facility ID #:

Alternate Contact:

Sample Collector Name: Luke Ulsamer

Phone: 570-753-5409 x134

How Shipped: ☑ commercial courier ☐ Hand Delivered

Chain of Custody	Print Name	Signature	Date	Time
Relinquished by Sample Collector:	Luke Ulsamer		7/21/15	1630
Accepted by:				
Relinquished by:				
Received at the Bureau of Labs:		(lab - initials only)	(lab - date only)	

Note: Place this Sample Submission Sheet in a sealed plastic bag. Secure the bag to the top of the lid inside the cooler.

Figure 8.2 Example of a completed DEP Lab Multiple Sample Submission Sheet

***NOTE: Legal Seal Number(s) filled in **if applicable**

How to Collect and Press Plants

Purpose

To preserve plant specimens for future identification or to be used as a reference species in a herbarium.

Equipment Needs

- Clippers
- Shovel
- Plastic bag
- Plant press
- Newspaper or blotting papers
- Cardboard
- Writing implement
- Water
- Paper towels
- Plant Collection Data Sheet
- Compass
- Clinometer
- Camera
- Typing Manual (PA DCNR Bureau of Forestry)
- Masking tape

Collecting Ethics

Before you pick any part of any plant remember to consider:

- Are there enough plants to justify your action? In general, follow the 1 in 20 rule - only take one if you can see 20 other good plants of the same kind.

- Weeds, particularly noxious weeds, can be collected without limit, but minimize the disruption you cause. Don't leave holes in the ground.

- Do you have a good reason for killing or damaging the plant? Whether it is a good enough reason will vary with location.

Collection Procedure

The collection procedure is used for plant species that you are unable to identify in the field, however you feel it can be identified with further research at the office. The pressing procedure will be used for unknown plant species that will require additional assistance.

Selection Criteria

Grasses and Grass-like Plants:

- If possible, select specimens with seedheads fully emerged from the sheath.
- If possible, select specimens that are still green including the seedhead.
- Collect the whole plant, when possible, including a good sample of the roots.
- Be sure that rhizomes or stolons are attached to the plant if they are typical for that species.

Shrubs and Other Woody Plants:

- Select a branch about 12 to 14 inches in length and not over 10 inches in width. The branch should contain as many identifying features as possible (i.e. buds, leaves, seeds/fruit etc.).
- If possible collect the plant when it is in bloom.
- It is often useful to include a sample of both the current years and the older bark of woody plants.
- Roots of large woody plants should not be dug up for collection.
- Since some plants bloom in early spring and others bloom in the late fall, you may not always have the best "state" of a specimen for I.D. purposes. Collection at a later date may be necessary if possible.
- Choose plant specimens carefully. Select one, or preferably two, of each plant species to be collected.
- Avoid plants that are off-color, grazed, over-mature, diseased or otherwise not normal.

Plant Extraction

- If a plant specimen can be identified from just a piece (i.e. a shrub), simply clip and bag the branch section.
- If a plant specimen is to be removed, dig about 6 inches straight down around the plant, about 3 inches out from the stem. Carefully lift out the chunk of sod. If

the soil is dry, shake the soil gently from the roots. If the soil is moist, use water to wash away the soil from the roots.

- Remove all soil particles from the roots. Don't be afraid to wash the roots thoroughly on all the plants collected. In fact, it may take more than one washing. Excess moisture after washing the roots can be removed by firmly pressing the plant between paper towels.

- Remove the excess plant material from the roots, stems, leaves and seedheads. For example, by removing several stems from a large bunchgrass or shrub, it is easier to collect and bag a specimen. If plants are very large and bulky, collect a sample of the stem, leaf arrangement, roots and flower or seed head.

- Take several plastic bags with you when collecting plants. Put the plant(s) in the bag with a few drops of water (don't overdo it), then seal the bag and the specimens will stay fresh. The bags should be kept out of direct sunlight. Another option is to moisten a paper towel with water and place it in the sealable plastic bag. Only put one kind of plant in a bag and label the bag to match your field notes.

- While at the site, record the identification number in your field notes. Be sure that once the specimen is identified it can be linked back to the data. This can be done several ways but it is recommended to use the "UNK'' species code followed by a sequential number.

    - When a specimen is collected as part of a vegetative procedure, such as a milacre plot, simply mark "UNK #" in the appropriate place on the data sheet and somehow tag the bag/specimen. Masking tape may be useful for this. Your name, the date, and location should already be recorded on the datasheet for the procedure.

    - If the collected specimen is not part of a vegetative procedure, it is a good idea to mark the bag/specimen with your name, the date, and location for later reference.

Pressing Procedure

The pressing procedure is used for unknown plant species, which will require additional assistance for identification. The objective is to quickly dry the plants under firm pressure to retain plant colors and the plant arrangement. It is important to follow the pressing instructions precisely. Well preserved plants aid in the identification process and may be used as herbarium mounts. Photo documentation of the live specimen is required by the plant specialist.

Photo Documentation

- Photograph the whole plant and any unique identifying features.

- Record the photo numbers on the plant collection data sheet (**Figure 8.4**).

Plant Extraction

- Have your press ready to go before you extract a specimen. Cut a supply of corrugated cardboard sheets to fit your press. Fold newspaper lengthwise with about a quarter of the upper and lower edges folded toward the center. This will help keep your specimens from sliding out (**Figure 8.3**). Open the press by removing the ratchet straps. Fill the press by placing alternating layers of the cardboard and the folded newspaper, beginning and ending with a sheet of cardboard. Although it is not necessary, blotter sheets can be placed between the newspaper and cardboard to speed the drying process.

- To remove a plant from the soil, dig about 6 inches straight down around the plant about 3 inches out from the stem. Carefully lift out the chunk of sod. If the soil is dry, shake the soil gently from the roots. If the soil is moist, use water to wash away the soil from the roots.

- Remove all soil particles from the roots. Don't be afraid to wash the roots thoroughly on all the plants collected. In fact, it may take more than one washing. Excess moisture after washing the roots can be removed by firmly pressing the plant between paper towels.

- Remove the excess plant material from the roots, stems, leaves and seedheads. For example, by removing several stems from a large bunchgrass or shrub, it is easier to dry. If plants are very large and bulky, collect a sample of the stem, leaf arrangement, roots and flower or seed head.

Plant Pressing

- Press the plants immediately after extracting and cleaning. Once a plant wilts, it will not make an attractive mount.

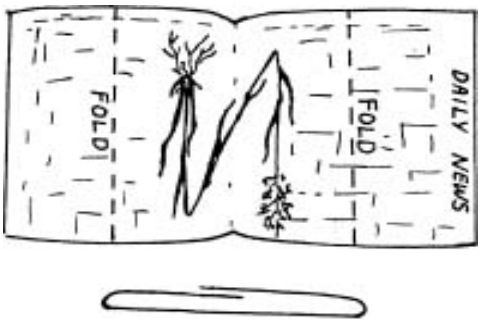


Figure 8.3 Newspaper layout

- When ready to press a specimen, flip open a folded newspaper layer within the press layers. If the plant is less than 12 inches long, place it in the folded newspaper. Arrange the stems, leaves, roots and flowers exactly as you want them to appear on the mount. Flowers should be pressed open. Both the upper and lower surfaces of flowers and leaves should be displayed.

- If the plant is longer than 12 inches, it will be necessary to fold the plant in the shape of a V, N or W (**Figure 8.3**). If the plant is still too large, press a sample of each part: stem, leaf, root and flower or seed head. For hard-to-handle plants, hold it at the stem base firmly and slowly move the plant up and down against the newspaper a few times, stopping with an upward stroke. This will help separate and straighten out the branches and leaves.

- Hold the plant in place and fold the upper and lower parts of the newspaper over the plant. While applying pressure to keep the plant in position, write the assigned plant voucher number on the edge of the newspaper where it is noticeable [see **Voucher (#)** in "Completing the Plant Collection Data Sheet" section below]. Place a cardboard layer above the newspaper containing your specimen. Replace the top press board and replace the ratchet straps perpendicular to the long ribs of the press. Position the straps approximately three inches from each end. Pull the straps taunt until the contents of the press are firmly compressed.

- If possible, examine the plant after it has been pressed for 24 hours. This is your last opportunity to do some rearranging while the plant is still flexible. Be sure both upper and lower leaf surfaces show. Change the newspaper or blotter paper every day until the plant is thoroughly dry as needed. Remember that succulent (fleshy) plants will take much longer to press.

- Plants can be removed from the press in seven to 10 days. Keep the plants in folded newspaper until you are ready to give to a plant specialist for assistance in identification.

Completing the Plant Collection Data Sheet

- A completed plant collection data sheet must be submitted with each pressed plant specimen. This form will assist the plant specialist in identification of the species. It also identifies the person who requires identification of the submitted specimen. For a completed example of the plant collection data sheet, see **Figure 8.4**. A blank copy is provided in Appendix B.

- After pressing the plant specimen, record the following information in the field on the plant collection datasheet.

  - **Date of Collection** - Record the date
  - **Voucher (#)** - Record your initials followed by the sequential number for your pressed plants
  - **Forest District** - Record the district number where the specimen was taken
  - **Ecoregion** - Not applicable
  - **Tract/Pad (#)** - Record the leased tract number and pad ID, if applicable
  - **Plot ID -** Provide if applicable
  - **Photo Number(s)** - List the digital photo number(s), if not already done
  - **Slope** - Refer to the *Percent Slope* instructions in the "Plot Data" section of the Overstory Plot Procedure found in this manual
  - **Aspect** - Refer to the *Aspect* instructions in the "Plot Data" section of the Overstory Plot Procedure found in this manual
  - **Adjacent Forest Type** - Refer to the BOF typing manual and record the plant community type that best represents the stand the specimen was taken in
  - **Physical Habitat/Substrate** - Briefly describe habitat/soil type
  - **Genus/Species OR Brief Description** - Record the genus if known, if unknown leave blank and give a brief description of the specimen

- **Add'l Field Notes** - Record any unique circumstances

Plant Collection Data Sheet

DATE OF COLLECTION: 6-12-14 VOUCHER #: DC1

FOREST DISTRICT: 16 ECOREGION: — TRACT/PAD # 587/A

PLOT ID: — PHOTO NUMBER(S): Canon 267, 268, 269

SLOPE: 10 ASPECT: 240 (ADJACENT) FOREST TYPE: AH

PHYSICAL HABITAT/SUBSTRATE: edge of well pad / limestone grave

GENUS/SPECIES: ?

OR

BRIEF DESCRIPTION: Grass species, no inflorescence, bright green leaves w/ reddish base

ADD'L. FIELD NOTES: was growing in a drainage ditch w/ standing water

Figure 8.4 Plant Collection Data sheet

Data Management

- Upon returning to the office, post your photos in RPI RAID so they can be reviewed by the Plant Specialist.

- Navigate to \\nrford12ds1\RPI\RPI_RAID\Plants\Plant Press Specimens and create a new folder and name it with the voucher number (e.g. Voucher LN1).

- Move your photos and datasheet to the corresponding folder.

- Give pressed specimens, along with corresponding plant collection data sheet to the plant specialist(s) as requested, or able to.

- If collected (bagged) specimens cannot be identified by field personnel back at the office, then transfer contents to a plant specialist for identification. Depending on timing, an additional specimen may need to be collected and pressed according to the pressing instructions within this procedure.

Canopy Photo Software Procedure

Purpose

This procedure outlines the process of determining the level of canopy cover documented in a canopy photo taken with an aspherical fish eye lens. The software used for this process (Gap Light Analyzer version 2.0) can be downloaded from the internet for free. It can be found simply by searching for "gap light analyzer." There is also a manual that covers this program; also a free download from the internet. The purpose of the following procedure is to show the way that the Gas Monitoring field crews use this software.

Equipment Needs

- Computer installed with Gap Light Analyzer version 2.0
- Digital canopy photos to analyze
- Datasheet for the Well Pad Vegetation Assessment for the appropriate pad

Procedures

- Open the Gap Light Analyzer program
- Open the photo file that you want to analyze
  - Open Image – click the  icon
  - Navigate to the image file
    Photos for the Permanent Pad Wildlife Assessment can be found in the following path;
    RPI_RAID – Wildlife – Permanent Pad Canopy Photos

Make sure to search for "Other Graphics" in the Files of Type field

  - Select and open the file you want to analyze

Directions for the next step can be found at the bottom of the screen (at this stage in the process is says "Register Image")

- Register Image
  - Click the  icon

Photos are taken with the bottom of the camera facing north, so north will be at the bottom of the image and south at the top.

- Click just inside the edge of the image at the middle of the screen at the north side
- Drag the cursor to the middle of the south facing side and release the mouse This draws a circle on the image
- If you like the circle you drew, click "OK" in the Image Registration box This makes the image a square around the circle and brings two copies of the image up on the screen

- Threshold the image
  - Click the  icon

This makes the Working Image black and white while the registered image stays in color. This gives you a reference picture to compare the two images. The software assigns a value of each pixel of the color image; dark colors a low number and light colors a high number and makes the high values white (sky) and the low values black (canopy).

- Visually compare the two images and ask yourself, "Is the sky represented as white and the canopy represented as black in the working image?"

If you do not like the working image representation, drag the sliding bar in the Threshold box one way or another. This changes the definition of what is sky and what is canopy. Shifting the bar will make more of the photo sky or more of the photo canopy. Make sure the two images agree as to what is what. The default value of 128 is usually a good representation and it is not usually necessary to monkey with the values.

The sun will put a bright spot on the canopy part of the image and this can't be fixed by changing the values. It is best not to take canopy photos when the sun is in the photo!

- Click "Ok" when you are happy with the image
- Run Calculations
  - Click the  icon
  - A Calculations box pops up, click "Calculate"
  - Look at the value for "% Canopy Openness"
  - Take this number and subtract it from 100% to get the percentage of the canopy that is closed.

- Record this new value in the datasheet for the Well Pad Vegetation Assessment in the "Canopy Cover" field for the appropriate plot in the Wildlife Habitat section.

Data Management

Refer to the Well Pad Wildlife Habitat Assessment protocol for data management instructions.

Checking In/Checking Out Data for ArcPad

Purpose/Background

ArcMap/ArcPad allows you to "check out" data from ArcMap feature classes. These checked out features can be edited in the field using ArcPad and then checked back into the ArcMap features classes. When the data is checked back in, ArcMap looks for new features and features that have been edited. The new features are added to the feature class and features that have been changed overwrite the previous version of the feature.

This all sounds great but there are some things we need to watch out for:

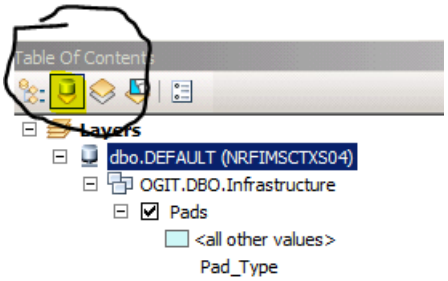
- ArcPad does not check for topological correctness. The feature created or edited in ArcPad may overlap with an existing feature that it's not supposed to. The new feature may also have gaps between it and an existing feature that are not supposed to exist. Either way, we need to inspect each new feature that is checked back into ArcMap to make sure topology rules are not being violated.
- ArcPad check-in is "last one in wins". In other words, two people may use the same checked-out data. The first person may edit feature A and then check it back in. The second person may open the attributes in feature A while edited in ArcPad and not make any edits. ArcPad notes that the second person opened the attribute table in edit mode. It marks the feature as being edited. The second person then checks in their copy of the data (after the first person). ArcPad/ArcMap copies the marked feature back into the ArcMap feature class. The edits made by the first person are overwritten (lost).
- Once edits are checked in ArcMap, they cannot be checked in again. In the case above, the first person cannot check their data back in again to recover the lost edits. There may be some ways to work around this but it is very inconvenient and the error may not be caught.

It's safer to check data into a child "version" of the database rather than the "default" version. Any edits can be checked for correctness before writing them to the default version. A "version" acts like a copy of the database.

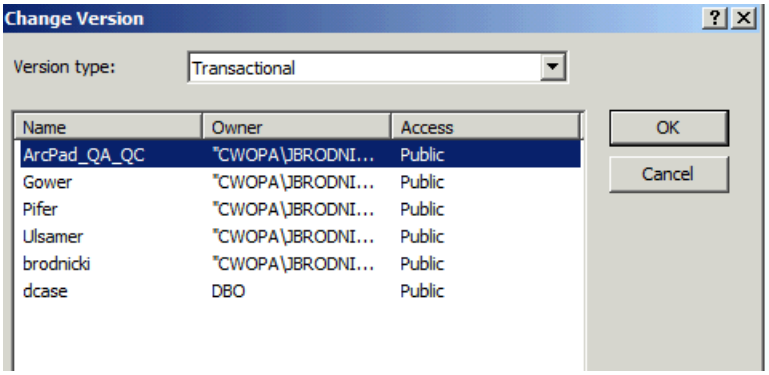
"Checking Out" Data for ArcPad

1. Open FIMS
2. Add data that you want to check out.
3. Zoom to extent of data you want to check out.
4. If you only want to check-out certain features, use one of the select tools to select them now.
5. There are several "versions" of the OGIT database. Most ArcPad related work can be done in the "ArcPad_QA_QC" version.
6. Change the version to ArcPad_QA_QC by:

a. Going to the "List by Source" tab for the feature you want to check out in the table of contents.

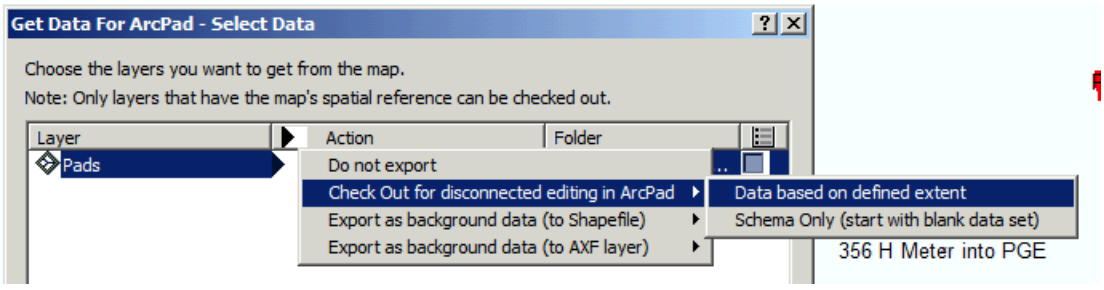


b. Right click on the source(in this case- dbo.Default)
c. Click on "Change Version"
d. Click on "ArcPad_QA_QC" and click "OK".

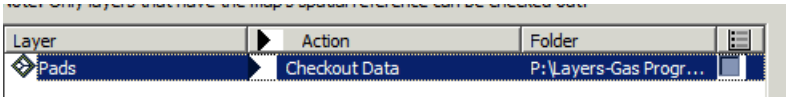


7. Go to the "ArcPad Data Manager" toolbar.
   a. Click on the "Get Data for ArcPad" button.

   b. For the layers you want to check out:
      i. Under "Action"- click on "do not export". A drop down list will appear.
      ii. Select "Check Out for disconnected editing in ArcPad"->"Data based on defined extent"



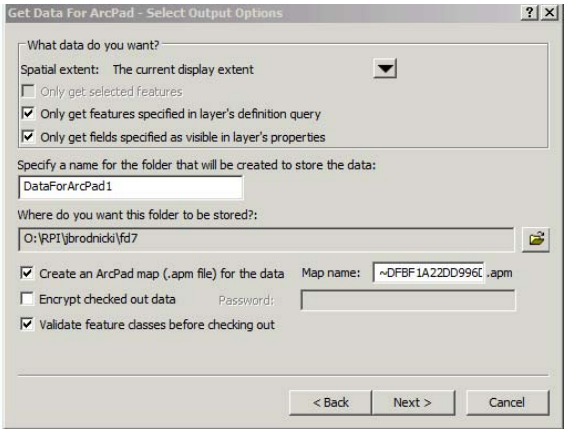
      iii. The menu will now look like:



iv. If you have a customized form, click the check box to the right. A window will pop up where you can select the axf file with the customized form. Once you select the axf file, another box will pop up where you select the layer associated with the form. Select the layer and click "OK". See John Brodnicki if you plan to use a customized form in checked-out data.

c. Click "Next"; then click "Next" again.

d. You are now at the "Get Data for ArcPad- Select Output Options" window.

i. 

ii. Under "Spatial Extent" select the current display extent or the entire extent of the data.

iii. You will probably want to make sure the "Only get features specified in the layer's definition" and "Only get fields specified as visible in layer's properties" are checked. If you really want to limit the check-out to certain features, use "Only get selected features"- You have to select the features before opening the "Get Data for ArcPad" dialog.

iv. Give the check-out folder a meaningful name.

v. Select the folder where you want the checked-out data to be saved. You can save it on the "O" drive or put your flash card in your computer and save the folder directly to your flash card.

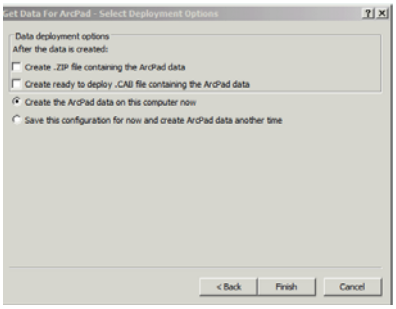
vi. If you want an ArcPad "map", enter the name and check the box.

vii. Do not encrypt the data.

viii. Make sure the "Validate feature classes before checking out" box is checked. If the check-out fails because of the validation, figure out why and then decide whether to check-out the data without validation or fix the problem before you check it out (fixing it first is the preferred choice!).

ix. Click "Next"

e. Make sure "Create the ArcPad data on this computer now" button is checked.

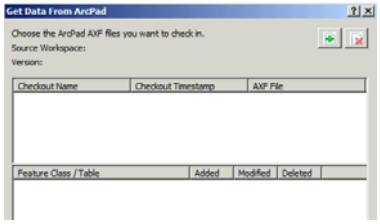


f. Click "Finish"

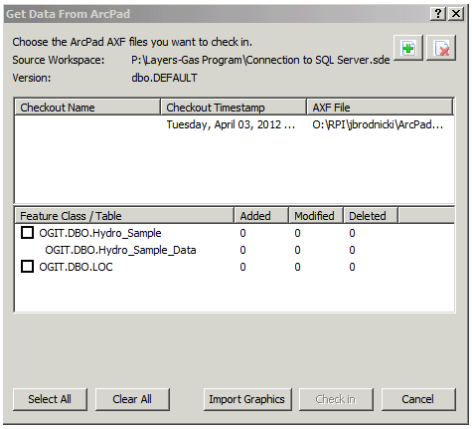
8. It will take several minutes to check-out the data. After it's done, open it in ArcPad to make sure there aren't any problems.

"Checking In" Data for ArcPad

1. Open ArcMap.
2. Add the feature class you will be checking data into.
3. Change the version to "ArcPad_QA_QC"- see step 6 above.
4. Start an edit session.
5. Copy the ArcPad axf file with the edits to your folder on the "O" drive or insert your flash card in your computer.
6. Click the "Get Data from ArcPad" button on the "ArcPad Data Manger" toolbar.



a. Click the button with the green plus sign.
b. Navigate to the folder with the axf file and select the file.
c. The form will be automatically filled in.



i. Make sure the source and version match the data you added to ArcMap.

ii. The form will show how many new features were created and how many existing feature were edited. If these don't look right, make sure you have the right axf file selected!
iii. Check the feature classes and tables that you want to check-in. Related tables with edits will automatically be checked-in if the parent feature is checked-in.
iv. Click "Check-in".
v. This will take a few minutes. A box will eventually pop up saying whether it was successful or what errors occurred.

"Reconcile and Post" Edits

The data has now been checked-in to the ArcPad_QA_QC version. You now need to make sure the data is okay and then move it up to the "default" version that everyone uses.

1. Find your new or edited features in ArcMap. Check:
    a. Topology- Are pads, roads, pipelines still on LOC? If not, adjust the LOC or correct the feature you just checked-in.
    b. Make sure there aren't any gaps or overlaps where there shouldn't be any.
    c. Look for any glaring errors in the attributes. Some features have auto-populated fields for district number, township, etc. If these weren't auto-calculated during the check-in, you can make a minor edit in the attributes (type in a district number- even if it's wrong) and the code should run to auto-populate them.
    d. When done, save your edits.
2. Add the "Versioning" toolbar to ArcMap if it isn't already there.

3. Click the "Reconcile" button.  This writes any changes in the "default" version to the "ArcPad_QA_QC" version. If there are conflicts, you will probably want to use the target (ArcPad_QA_QC) version to reconcile the differences. This may or may not be the best option. If someone has made or posted edits to the "default" version since you checked out data, you may want to use the "default" version to reconcile differences. See John Brodnicki if you have questions.
4. You now need to "post" your edits to the "default" version. The "post" button should no longer be grayed out since you have done a reconcile.

    a. Click the "post" button.
    b. You shouldn't receive any conflict notifications. If you do, try to see why. Get help if in doubt.

Your edits have now been checked-in. You wrote your edits to the "ArcPad_QA_QC" version, checked them for errors and then moved the edits into the "default" version that everyone else uses. Save your edits and stop editing.

Remember to change the version in ArcMap back to "default" if you are going to do any additional editing in ArcMap. It's much safer to check-out a new copy of the data if you are going back in the field to collect more information rather than using your old axf file again.

The new copy will have any edits made by other users. Remember to ask for help if you have any questions or doubts about what you're doing. The steps described here are pretty complex but they help insure that we don't import junk into the version of the data used by the entire Monitoring program.

Species Codes – All

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
F130	Adiantum	pedatum	Maidenhair	NATIVE
F110	Asplenium	platyneuron	Ebony spleenwort	NATIVE
F105	Athyrium	filix-femina	Lady fern	NATIVE
F115	Athyrium	thelypteroides	Silvery spleenwort	NATIVE
F142	Botrychium	spp.	Grape fern species	NATIVE
F140	Botrychium	virginianum	Rattlesnake fern	NATIVE
F150	Cystopteris	fragilis	Fragile fern	NATIVE
F060	Dennstaedtia	punctilobula	Hayscented Fern	NATIVE
F010	Dryopteris	marginalis	Marginal wood fern	NATIVE
F020	Dryopteris	spinulosa	Spinulose wood fern	NATIVE
F201	Equisetum	arvense	Field horsetail	NATIVE
F090	Gymnocarpium	dryopteris	Common oak fern	NATIVE
F006	Lycopodium	annotinum	Bristly clubmoss	NATIVE
F005	Lycopodium	clavatum	Staghorn clubmoss	NATIVE
F002	Lycopodium	complanatum	Running-pine	NATIVE
F155	Lycopodium	inundatum	Bog clubmoss	NATIVE
F003	Lycopodium	lucidula	Shining clubmoss	NATIVE
F004	Lycopodium	obscurum	Tree clubmoss	NATIVE
F001	Lycopodium	spp.	Clubmoss species	NATIVE
F085	Matteuccia	struthiopteris	Ostrich fern	NATIVE
F080	Onoclea	sensibilis	Sensitive fern	NATIVE
F040	Osmunda	cinnamomea	Cinnamon fern	NATIVE
F050	Osmunda	claytoniana	Interrupted fern	NATIVE
F053	Osmunda	regalis	Royal fern	NATIVE
F125	Polypodium	vulgare	Common polypody	NATIVE
F100	Polystichum	acrostichoides	Christmas fern	NATIVE
F030	Pteridium	aquilinum	Bracken fern	NATIVE
F064	Thelypteris	hexagonoptera	Broad beech fern	NATIVE
F070	Thelypteris	noveboracensis	New York fern	NATIVE
F066	Thelypteris	palustris	Marsh fern	
F065	Thelypteris	phegopteris	Long beech fern	NATIVE
F145	Woodwardia	virginica	Virginia chain fern	NATIVE
G194	Agrostis	gigantea	Redtop	
G285	Agrostis	hyemalis	Hairgrass	NATIVE
G190	Agrostis	perennans	Upland bent	NATIVE
G192	Agrostis	stolonifera var. palustris	Carpet Bentgrass	
G195	Agrostis	spp.	Agrostis species	

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
G350	Andropogon	gerardii	Big bluestem	NATIVE
G080	Anthoxanthum	odoratum	Sweet vernalgrass	
G600	Avena	spp.	Oats species	
G100	Brachyelytrum	erectum	Long-awned Wood Grass	NATIVE
G103	Bromus	ciliatus	Fringed Brome	NATIVE
G102	Bromus	inermis	Smooth brome	
G104	Bromus	japonicus	Japanese brome	
G106	Bromus	sterilis	Poverty brome	
G105	Bromus	tectorum	Cheatgrass	
G107	Calamagrostis	canadensis	Canada bluejoint	NATIVE
G130	Carex	abscondita	Sedge	NATIVE
G135	Carex	aestivalis	Sedge	NATIVE
G152	Carex	baileyi	Sedge	NATIVE
G025	Carex	communis	Sedge	NATIVE
G050	Carex	crinita	Short hair sedge	NATIVE
G154	Carex	debilis	Sedge	NATIVE
G155	Carex	digitalis	Sedge	NATIVE
G157	Carex	folliculata	Sedge	NATIVE
G156	Carex	gracillima	Sedge	NATIVE
G039	Carex	hirsutella	Sedge	NATIVE
G040	Carex	intumescens	Sedge	NATIVE
G147	Carex	lanuginosa	Sedge	NATIVE
G020	Carex	laxiflora	Sedge	NATIVE
G260	Carex	leptonervia	Sedge	NATIVE
G128	Carex	lupulina	Sedge	NATIVE
G262	Carex	lurida	Sedge	NATIVE
G151	Carex	mesochorea	Midland sedge	NATIVE
G265	Carex	novae-angliae	Sedge	NATIVE
G030	Carex	pensylvanica	Sedge	NATIVE
G290	Carex	plantaginea	Plantain sedge	NATIVE
G150	Carex	radiata	Sedge	NATIVE
G140	Carex	rosea	Sedge	NATIVE
G158	Carex	scoparia	Broom sedge	NATIVE
G015	Carex	spp.	Carex species	NATIVE
G145	Carex	stricta	Tussock sedge	NATIVE
G129	Carex	swanii	Sedge	NATIVE
G159	Carex	vulpinoidea	Sedge	NATIVE
G280	Cinna	latifolia	Drooping woodreed	NATIVE
G110	Dactylis	glomerata	Orchardgrass	
G160	Danthonia	compressa	Northern oatgrass	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
G295	Danthonia	spicata	Poverty-grass	NATIVE
G165	Deschampsia	flexuosa	Common hairgrass	NATIVE
G630	Dichanthelium	spp.	Dichanthelium species	NATIVE
G610	Digitaria	sanguinalis	Northern crabgrass	
G620	Echinochloa	crusgalli	Barnyard-Grass	
G060	Eleocharis	acicularis	Spike-rush	NATIVE
G070	Eleocharis	obtusa	Spike-rush	NATIVE
G242	Elymus	canadensis	Canada wild-rye	
G240	Elymus	repens	Quackgrass	
G245	Elymus	virginicus	Virginia wild-rye	NATIVE
G300	Eriophorum	virginicum	Cotton-grass	
G178	Festuca	elatior	Tall Fescue	
G180	Festuca	obtusa	Nodding fescue	NATIVE
G177	Festuca	rubra	Red fescue	
G175	Festuca	spp.	Fescue species	
G169	Glyceria	spp.	Mannagrass species	NATIVE
G172	Glyceria	melicaria	Mannagrass	NATIVE
G170	Glyceria	striata	Fowl meadowgrass	NATIVE
G500	Holcus	lanatus	Velvetgrass	
G075	Hystrix	paluta	Bottlebrush-grass	NATIVE
G311	Juncus	canadensis	Canada rush	NATIVE
G312	Juncus	effusus	Soft rush	NATIVE
G310	Juncus	spp.	Rush species	NATIVE
G313	Juncus	tenuis	Path rush	NATIVE
G252	Leersia	oryzoides	Rice cutgrass	NATIVE
G251	Leersia	spp.	Cutgrass	NATIVE
G250	Leersia	virginica	Cutgrass	NATIVE
G336	Lolium	multiflorum	Ryegrass	
G335	Lolium	perenne	Perennial ryegrass	
G090	Luzula	multiflora	Woodrush	NATIVE
G340	Microstegium	vimineum	Japanese stilt grass	
G200	Milium	effusum var. cisatlanticum	Milletgrass	NATIVE
G400	Miscanthus	sinensis	Miscanthus	
G270	Oryzopsis	asperifolia	Mountain rice	NATIVE
G222	Panicum	lanuginosum	Panic grass	NATIVE
G220	Panicum	clandestinum	Deer-tongue grass	NATIVE
G230	Panicum	spp.	Panic-grass species	NATIVE
G225	Panicum	virgatum	Switchgrass	NATIVE
G325	Phalaris	arundinacea	Reed canary-grass	

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
G330	Phleum	pratense	Timothy	
G379	Phragmites	australis ssp. americanus	Native common reed	
G380	Phragmites	australis ssp. australis	Common reed	
G271	Piptatherum	pungens	Slender mountain ricegrass	NATIVE
G255	Poa	alsodes	Woodland bluegrass	NATIVE
G121	Poa	compressa	Canada bluegrass	
G120	Poa	pratensis	Kentucky bluegrass	NATIVE
G125	Poa	spp.	Poa species	
G123	Poa	trivialis	Rough bluegrass	
G210	Schizachne	purpurascens	Grass	NATIVE
G351	Schizachyrium	scoparium var. scoparium	Little bluestem	NATIVE
G013	Scirpus	americanus	Three-square	NATIVE
G012	Scirpus	atrovirens	Dark-green bulrush	NATIVE
G010	Scirpus	cyperinus	Wool-grass	NATIVE
G011	Scirpus	validus	Soft-stem bulrush	NATIVE
G236	Secale	cereale	Rye	
G315	Setaria	pumila	Yellow foxtail	
G314	Setaria	spp.	Foxtail species	
G360	Sorghastrum	nutans	Indian-grass	NATIVE
G356	Sorghum	bicolor ssp. x drummondii	shattercane	
G358	Sorghum	halepense	Johnsongrass	
G320	Sparganium	androcladum	Branching bur-reed	NATIVE
G238	Tridens	flavus	Purpletop	NATIVE
G235	Triticum	aestivum	Wheat	
G717	Typha	angustifolia	Narrowleaf cat-tail	
G716	Typha	latifolia	Common cat-tail	NATIVE
G718	Typha	x glauca	Hybrid cattail	
R005	Abies	balsamea	Balsam fir	NATIVE
R024	Acer	negundo	Ashleaf maple	NATIVE
R113	Acer	pensylvanicum	Striped maple	NATIVE
R023	Acer	platanoides	Norway maple	
R302	Acer	pseudo-platanus	Sycamore maple	
R021	Acer	rubrum	Red maple	NATIVE
R022	Acer	saccharinum	Silver maple	NATIVE
R020	Acer	saccharum	Sugar maple	NATIVE
R114	Acer	spicatum	Mountain maple	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
R079	Aesculus	flava	Yellow buckeye	NATIVE
R112	Ailanthus	altissima	Tree-of-heaven	
R240	Albizia	julibrissin	mimosa	
R305	Alnus	glutinosa	European black alder	
R100	Alnus	spp.	Alder species	
R091	Amelanchier	arborea	Downy juneberry	NATIVE
R191	Amelanchier	laevis	Smooth juneberry	NATIVE
R195	Amelanchier	spp.	Serviceberry species	NATIVE
R101	Asimina	triloba	Pawpaw	NATIVE
R050	Betula	alleghaniensis	Yellow birch	NATIVE
R051	Betula	lenta	Black birch	NATIVE
R053	Betula	papyrifera	Paper birch	NATIVE
R093	Betula	populifolia	Gray birch	NATIVE
R090	Carpinus	caroliniana	Hornbeam	NATIVE
R263	Carya	cordiformis	Bitternut hickory	NATIVE
R260	Carya	glabra	Pignut hickory	NATIVE
R261	Carya	laciniosa	Shellbark hickory	NATIVE
R262	Carya	ovata	Shagbark hickory	NATIVE
R264	Carya	spp.	Hickory species	NATIVE
R060	Carya	tomentosa	Mockernut hickory	NATIVE
R073	Castanea	dentata	American chestnut	NATIVE
R109	Catalpa	bignonioides	Catalpa	
R074	Celtis	occidentalis	American hackberry	NATIVE
R105	Cercis	canadensis	Redbud	NATIVE
R080	Cornus	alternifolia	Alternate-leaved dogwood	NATIVE
R081	Cornus	florida	Flowering dogwood	NATIVE
R307	Euodia	hupehensis	Bee-bee tree	
R054	Fagus	grandifolia	American beech	NATIVE
R055	Fraxinus	americana	White ash	NATIVE
R056	Fraxinus	nigra	Black ash	NATIVE
R057	Fraxinus	pennsylvanica	Red Ash	NATIVE
R070	Gleditsia	triacanthos	Honey-locust	NATIVE
R083	Ilex	opaca	American holly	NATIVE
R071	Juglans	cinerea	Butternut	NATIVE
R068	Juglans	nigra	Black walnut	NATIVE
R012	Juniperus	virginiana	Eastern red-cedar	NATIVE
R016	Larix	laricina	American larch	NATIVE
R059	Liriodendron	tulipifera	Tulip-tree	NATIVE
R084	Magnolia	acuminata	Cucumber-tree	NATIVE
R206	Malus	spp.	Apple species	

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
R094	Morus	alba	White mulberry	
R066	Nyssa	sylvatica	Blackgum	NATIVE
R092	Ostrya	virginiana	Hop-hornbeam	NATIVE
R110	Paulownia	tomentosa	Princess-tree	
R306	Phellodendron	spp.	Corktree spp.	
R019	Picea	abies	Norway spruce	
R003	Picea	glauca	White spruce	NATIVE
R004	Picea	mariana	Black spruce	NATIVE
R002	Picea	rubens	Red spruce	NATIVE
R014	Pinus	banksiana	Jack pine	
R007	Pinus	nigra	Austrian pine	
R018	Pinus	pungens	Mountain pine	NATIVE
R011	Pinus	resinosa	Red pine	NATIVE
R009	Pinus	rigida	Pitch pine	NATIVE
R001	Pinus	strobus	Eastern white pine	NATIVE
R015	Pinus	sylvestris	Scotch pine	
R010	Pinus	virginiana	Virginia pine	NATIVE
R075	Platanus	occidentalis	Sycamore	NATIVE
R063	Populus	grandidentata	Bigtooth aspen	NATIVE
R064	Populus	tremuloides	Quaking aspen	NATIVE
R078	Prunus	avium	Sweet cherry	NATIVE
R077	Prunus	cerasus	Sour cherry	
R095	Prunus	pensylvanica	Fire cherry	NATIVE
R076	Prunus	serotina	Black cherry	NATIVE
R107	Prunus	spp.	Cherry tree species	NATIVE
R215	Pyrus	americana	American mountain-ash	NATIVE
R200	Pyrus	calleryana	Callery pear	
R040	Quercus	alba	White oak	NATIVE
R032	Quercus	coccinea	Scarlet oak	NATIVE
R036	Quercus	imbricaria	Shingle oak	NATIVE
R098	Quercus	muhlenbergii	Yellow oak	NATIVE
R037	Quercus	phellos	Willow oak	NATIVE
R048	Quercus	prinus	Chestnut oak	NATIVE
R030	Quercus	rubra	Northern red oak	NATIVE
R045	Quercus	stellata	Post oak	NATIVE
R031	Quercus	velutina	Black oak	NATIVE
R069	Robinia	pseudoacacia	Black locust	NATIVE
R087	Salix	spp.	Willow species;except Black	
R096	Sassafras	albidum	Sassafras	NATIVE
R058	Tilia	americana	Basswood	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
R006	Tsuga	canadensis	Eastern hemlock	NATIVE
R061	Ulmus	americana	American elm	NATIVE
R304	Ulmus	pumila	Siberian elm	
R062	Ulmus	rubra	Slippery elm	NATIVE
S610	Alnus	rugosa	Speckled alder	NATIVE
S605	Alnus	serrulata	Smooth alder	NATIVE
S645	Amelanchier	canadensis	Oblong-leaf juneberry	NATIVE
S495	Aralia	elata	Japanese angelica-tree	
S490	Aralia	spinosa	Hercules'-club	NATIVE
S160	Berberis	thunbergii	Japanese barberry	
S900	Berberis	vulgaris	European barberry	
S914	Buddleja	davidii	Butterfly-bush	
S240	Comptonia	peregrina	Sweet-fern	NATIVE
S400	Cornus	amomum	Silky Dogwood	NATIVE
S430	Cornus	racemosa	Red-panicle dogwood	NATIVE
S440	Cornus	stolonifera	Red-osier dogwood	NATIVE
S170	Corylus	americana	American hazlenut	NATIVE
S175	Corylus	cornuta	Beaked hazlenut	NATIVE
S191	Crataegus	punctata	Dotted hawthorn	NATIVE
S190	Crataegus	spp.	Hawthorn species	NATIVE
S380	Diervilla	lonicera	Northern bush-honeysuckle	NATIVE
S351	Elaeagnus	angustifolia	Russian olive	
S350	Elaeagnus	umbellata	Autumn-olive	
S700	Euonymus	alatus	Burning-bush	
S915	Frangula	alnus	Glossy buckthorn	
S050	Gaylussacia	baccata	Black huckleberry	NATIVE
S060	Gaylussacia	frondosa	Tall huckleberry	NATIVE
S120	Hamamelis	virginiana	Witch-hazel	NATIVE
S390	Hydrangea	arborescens	Wild hydrangea	NATIVE
S395	Hypericum	prolificum	Shrubby St. John's-wort	NATIVE
S625	Ilex	montana	Large-leaf holly	NATIVE
S623	Ilex	spp.	Holly species	NATIVE
S620	Ilex	verticillata	Winterberry holly	NATIVE
S080	Kalmia	angustifolia	Sheep laurel	NATIVE
S070	Kalmia	latifolia	Mountain laurel	NATIVE
S710	Lespedeza	bicolor	Shrubby bushclover	
S712	Lespedeza	cuneata	Chinese bushclover	
S650	Ligustrum	spp.	Privet species	
S130	Lindera	benzoin	Spicebush	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
S360	Lonicera	spp.	Honeysuckles	
S910	Lonicera	tatarica	Tartarian honeysuckle	
S375	Lyonia	ligustrina	Maleberry	NATIVE
S201	Malus	coronaria	Sweet crabapple	NATIVE
S630	Nemopanthus	mucronatus	Mountain holly	NATIVE
S560	Physocarpus	opulifolius	Ninebark	NATIVE
S655	Prunus	americana	American plum	NATIVE
S656	Prunus	virginiana	Choke cherry	NATIVE
S210	Pyrus	arbutifolia	Red chokeberry	NATIVE
S220	Pyrus	floribunda	Purple chokeberry	NATIVE
S230	Pyrus	melanocarpa	Black chokeberry	NATIVE
S200	Pyrus	spp.	Chokeberry species	NATIVE
S580	Quercus	ilicifolia	Scrub oak	NATIVE
S911	Rhamnus	cathartica	Common buckthorn	
S912	Rhamnus	frangula	European buckthorn	
S460	Rhamnus	spp.	Buckthorn species	
S090	Rhododendron	maximum	Rosebay	NATIVE
S100	Rhododendron	nudiflorum	Pink azalea	NATIVE
S110	Rhododendron	roseum	Early azalea	NATIVE
S095	Rhododendron	spp.	Azalea/Laurel spp.	NATIVE
S105	Rhododendron	viscosum	Swamp azalea	NATIVE
S720	Rhodotypos	scandens	Jetbead	
S311	Rhus	glabra	Smooth sumac	NATIVE
S310	Rhus	spp.	Sumac species	NATIVE
S312	Rhus	typhina	Staghorn sumac	NATIVE
S526	Ribes	cynosbati	Prickly gooseberry	NATIVE
S525	Ribes	hirtellum	Smooth gooseberry	NATIVE
S530	Ribes	lacustre	Bristly black currant	NATIVE
S540	Ribes	rotundifolium	Roundleaf gooseberry	NATIVE
S520	Ribes	spp.	Currant/Gooseberry species	NATIVE
S635	Rosa	multiflora	Multiflora rose	
S637	Rosa	setigera	Prairie rose	
S640	Rosa	spp.	Rose species	
S270	Rubus	allegheniensis	Common blackberry	NATIVE
S302	Rubus	idaeus	Wild red raspberry	NATIVE
S300	Rubus	occidentalis	Black raspberry	NATIVE
S301	Rubus	odoratus	Flowering raspberry	NATIVE
S285	Rubus	pensilvanicus	Blackberry	NATIVE
S290	Rubus	phoenicolasius	Wine raspberry	
S280	Rubus	pubescens	Dwarf raspberry	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
S245	Rubus	spp.	Blackberry/Raspberry species	NATIVE
S485	Salix	sericea	Silky willow	NATIVE
S484	Salix	spp.	Willow shrub species	NATIVE
S470	Sambucus	canadensis	Common elderberry	NATIVE
S480	Sambucus	pubens	Red-berried elder	NATIVE
S452	Spiraea	corymbosa	Dwarf spiraea	NATIVE
S913	Spiraea	japonica	Japanese spiraea	
S450	Spiraea	spp.	Spiraea species	NATIVE
S451	Spiraea	tomentosa	Steeplebush spirea	NATIVE
S454	Spirea	latifolia	Meadowsweet	NATIVE
S515	Taxus	canadensis	Canadian yew	NATIVE
S010	Vaccinium	angustifolium	Late low blueberry	NATIVE
S030	Vaccinium	corymbosum	Highbush blueberry	NATIVE
S035	Vaccinium	myrtilloides	Velvet-leaf blueberry	NATIVE
S020	Vaccinium	pallidum	Southern low blueberry	NATIVE
S005	Vaccinium	spp.	Blueberry species(low)	NATIVE
S040	Vaccinium	stamineum	Deerberry	NATIVE
S140	Viburnum	acerifolium	Maple-leaved viburnum	NATIVE
S150	Viburnum	alnifolium	Hobblebush	NATIVE
S156	Viburnum	cassinoides	Wild-raisin	NATIVE
S152	Viburnum	dentatum	Southern arrow-wood	NATIVE
S158	Viburnum	dilatatum	Linden viburnum	
S151	Viburnum	lentago	Nannyberry	NATIVE
S145	Viburnum	opulus	Guelder-rose	
S159	Viburnum	plicatum	Doublefile viburnum	
S154	Viburnum	prunifolium	Black-haw	NATIVE
S153	Viburnum	recognitum	Northern arrow-wood	NATIVE
S157	Viburnum	sieboldii	Siebold viburnum	
S135	Viburnum	spp.	Viburnum species	
S500	Zanthoxylum	americanum	Prickly-ash	NATIVE
T005	Abies	balsamea	Balsam fir	NATIVE
T024	Acer	negundo	Ashleaf maple	NATIVE
T113	Acer	pensylvanicum	Striped maple	NATIVE
T023	Acer	platanoides	Norway maple	
T302	Acer	pseudo-platanus	Sycamore maple	
T021	Acer	rubrum	Red maple	NATIVE
T022	Acer	saccharinum	Silver maple	NATIVE
T020	Acer	saccharum	Sugar maple	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
T114	Acer	spicatum	Mountain maple	NATIVE
T079	Aesculus	flava	Yellow buckeye	NATIVE
T112	Ailanthus	altissima	Tree-of-heaven	
T240	Albizia	julibrissin	Mimosa	
T305	Alnus	glutinosa	European black alder	
T100	Alnus	spp.	Alder species	
T091	Amelanchier	arborea	Downy juneberry	NATIVE
T191	Amelanchier	laevis	Smooth juneberry	NATIVE
T195	Amelanchier	spp.	Serviceberry species	NATIVE
T101	Asimina	triloba	Pawpaw	NATIVE
T050	Betula	alleghaniensis	Yellow birch	NATIVE
T051	Betula	lenta	Black birch	NATIVE
T053	Betula	papyrifera	Paper birch	NATIVE
T093	Betula	populifolia	Gray birch	NATIVE
T090	Carpinus	caroliniana	Hornbeam	NATIVE
T263	Carya	cordiformis	Bitternut hickory	NATIVE
T260	Carya	glabra	Pignut hickory	NATIVE
T261	Carya	laciniosa	Shellbark hickory	NATIVE
T262	Carya	ovata	Shagbark hickory	NATIVE
T264	Carya	spp.	Hickory species	NATIVE
T060	Carya	tomentosa	Mockernut hickory	NATIVE
T073	Castanea	dentata	American chestnut	NATIVE
T109	Catalpa	bignonioides	Catalpa	
T074	Celtis	occidentalis	American hackberry	NATIVE
T105	Cercis	canadensis	Redbud	NATIVE
T080	Cornus	alternifolia	Alternate-leaved dogwood	NATIVE
T081	Cornus	florida	Flowering dogwood	NATIVE
T307	Euodia	hupehensis	Bee-bee tree	
T054	Fagus	grandifolia	American beech	NATIVE
T055	Fraxinus	americana	White ash	NATIVE
T056	Fraxinus	nigra	Black ash	NATIVE
T057	Fraxinus	pennsylvanica	Red Ash	NATIVE
T070	Gleditsia	triacanthos	Honey-locust	NATIVE
T083	Ilex	opaca	American holly	NATIVE
T071	Juglans	cinerea	Butternut	NATIVE
T068	Juglans	nigra	Black walnut	NATIVE
T012	Juniperus	virginiana	Eastern red-cedar	NATIVE
T016	Larix	laricina	American larch	NATIVE
T059	Liriodendron	tulipifera	Tulip-tree	NATIVE
T084	Magnolia	acuminata	Cucumber-tree	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
T206	Malus	spp.	Apple species	
T094	Morus	alba	White mulberry	
T066	Nyssa	sylvatica	Blackgum	NATIVE
T092	Ostrya	virginiana	Hop-hornbeam	NATIVE
T110	Paulownia	tomentosa	Princess-tree	
T306	Phellodendron	spp.	Corktree spp.	
T019	Picea	abies	Norway spruce	
T003	Picea	glauca	White spruce	NATIVE
T004	Picea	mariana	Black spruce	NATIVE
T002	Picea	rubens	Red spruce	NATIVE
T014	Pinus	banksiana	Jack pine	
T007	Pinus	nigra	Austrian pine	
T018	Pinus	pungens	Mountain pine	NATIVE
T011	Pinus	resinosa	Red pine	NATIVE
T009	Pinus	rigida	Pitch pine	NATIVE
T001	Pinus	strobus	Eastern white pine	NATIVE
T015	Pinus	sylvestris	Scotch pine	
T010	Pinus	virginiana	Virginia pine	NATIVE
T075	Platanus	occidentalis	Sycamore	NATIVE
T063	Populus	grandidentata	Bigtooth aspen	NATIVE
T064	Populus	tremuloides	Quaking aspen	NATIVE
T078	Prunus	avium	Sweet cherry	NATIVE
T077	Prunus	cerasus	Sour cherry	
T095	Prunus	pensylvanica	Fire cherry	NATIVE
T076	Prunus	serotina	Black cherry	NATIVE
T107	Prunus	spp.	Cherry species	
T215	Pyrus	americana	American mountain-ash	NATIVE
T200	Pyrus	calleryana	Callery pear	
T040	Quercus	alba	White oak	NATIVE
T032	Quercus	coccinea	Scarlet oak	NATIVE
T036	Quercus	imbricaria	Shingle oak	NATIVE
T098	Quercus	muhlenbergii	Yellow oak	NATIVE
T037	Quercus	phellos	Willow oak	NATIVE
T048	Quercus	prinus	Chestnut oak	NATIVE
T030	Quercus	rubra	Northern red oak	NATIVE
T045	Quercus	stellata	Post oak	NATIVE
T031	Quercus	velutina	Black oak	NATIVE
T069	Robinia	pseudoacacia	Black locust	NATIVE
T087	Salix	spp.	Willow tree species	
T096	Sassafras	albidum	Sassafras	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
T058	Tilia	americana	Basswood	NATIVE
T006	Tsuga	canadensis	Eastern hemlock	NATIVE
T061	Ulmus	americana	American elm	NATIVE
T304	Ulmus	pumila	Siberian elm	
T062	Ulmus	rubra	Slippery elm	NATIVE
V115	Adlumia	fungosa	Allegheny-vine	NATIVE
V280	Akebia	quinata	Five-leaf akebia	
V285	Ampelopsis	brevipedunculata	Porcelain-berry	
V080	Amphicarpa	bracteata	Hog-peanut	NATIVE
V021	Celastrus	orbiculatus	Asiatic bittersweet	
V020	Celastrus	scandens	American bittersweet	NATIVE
V145	Clematis	virginiana	Virgin's-bower	NATIVE
V110	Convolvulus	arvensis	Field bindweed	
V100	Convolvulus	sepium	Hedge bindweed	NATIVE
V180	Dioscorea	quaternata	Wild yamroot	NATIVE
V150	Dioscorea	villosa	Wild yam	NATIVE
V260	Euonymus	fortunei	Wintercreeper	
V250	Hedera	helix	English ivy	
V240	Lonicera	japonica	Japanese honeysuckle	
V040	Parthenocissus	quinquefolia	Virginia-creeper	NATIVE
V120	Phaseolus	polystachios	Wild kidney bean	NATIVE
V170	Polygonum	cilinode	Fringed bindweed	NATIVE
V135	Polygonum	convolvulus	Black bindweed	
V136	Polygonum	perfoliatum	Mile-a-minute weed	
V137	Polygonum	scandens	Climbing false-buckwheat	NATIVE
V230	Pueraria	lobata	Kudzu	
V105	Rhus	radicans	Poison-ivy	NATIVE
V201	Rubus	flagellaris	Dewberry	NATIVE
V200	Rubus	hispidus	Swamp dewberry	NATIVE
V154	Smilax	bona-nox	Bullbriar	
V050	Smilax	glauca	Catbrier	NATIVE
V060	Smilax	rotundifolia	Greenbrier	NATIVE
V049	Smilax	spp.	Smilax species	
V160	Smilax	tamnoides var. hispida	Bristly greenbrier	NATIVE
V190	Solanum	dulcamara	Bittersweet nightshade	
V290	Vincetoxicum	nigrum	Black swallow-wort	
V292	Vincetoxicum	rossicum	pale swallow-wort	
V010	Vitis	spp.	Grape	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
V270	Wisteria	floribunda	Japanese wisteria	
V275	Wisteria	sinensis	Chinese wisteria	
W315	Abutilon	theophrastii	Indian mallow	
W656	Achillea	millefolium	Yarrow	
W922	Acorus	calamus	Sweet flag	
W589	Actaea	pachypoda	White baneberry	NATIVE
W670	Actinomeris	alternifolia	Wingstem	NATIVE
W900	Aegopodium	podograria	Goutweed	
W280	Agrimonia	gryposepala	Agrimony	NATIVE
W281	Agrimonia	parviflora	Small-flowered agrimony	NATIVE
W745	Alliaria	officinalis	Garlic-mustard	
W320	Allium	spp.	Garlic/onion species	NATIVE
W325	Allium	tricoccum	Wild leek	NATIVE
W573	Ambrosia	artemisiifolia	Common ragweed	NATIVE
W575	Amianthium	muscaetoxicum	Fly Poison	NATIVE
W474	Anaphalis	margaritacea	Pearly everlasting	NATIVE
W586	Anemone	lancifolia	Mountain Anemone	NATIVE
W585	Anemone	quinquefolia	Wood anemone	NATIVE
W587	Anemone	spp.	Anemone species	NATIVE
W490	Anemonella	thalictroides	Rue anemone	NATIVE
W477	Antennaria	neglecta	Field pussytoes	NATIVE
W479	Antennaria	neodioica	Smaller pussytoes	NATIVE
W475	Antennaria	parlinii	Smooth pussytoes	NATIVE
W478	Antennaria	plantaginifolia	Plantain-leaved pussytoe	NATIVE
W657	Anthemis	arvensis	Corn chamomile	
W663	Anthriscus	sylvestris	wild chervil	
W476	Apocynum	androsaemifolium	Pink dogbane	NATIVE
W482	Apocynum	cannabinum	Indian-hemp	NATIVE
W820	Aquilegia	canadensis	Wild columbine	NATIVE
W857	Arabis	canadensis	Sicklepod	NATIVE
W207	Arabis	laevigata	Smooth rock cress	NATIVE
W442	Aralia	hispida	Bristly sarsaparilla	NATIVE
W440	Aralia	nudicaulis	Wild sarsaparilla	NATIVE
W830	Aralia	racemosa	Spikenard	NATIVE
W444	Arctium	minus	Common burdock	
W310	Arisaema	spp.	Jack-in-the-pulpit species	NATIVE
W403	Aristolochia	serpentaria	Virginia snakeroot	NATIVE
W400	Asarum	canadense	Wild ginger	NATIVE
W750	Asclepias	spp.	Milkweed species	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
W751	Asclepias	syriaca	Common milkweed	NATIVE
W535	Aster	acuminatus	Sharp-leaved aster	NATIVE
W950	Aster	cordifolius	Blue wood aster	NATIVE
W082	Aster	divaricatus	White wood aster	NATIVE
W081	Aster	junciformis	Rush aster	NATIVE
W536	Aster	lateriflorus	Calico aster	NATIVE
W078	Aster	macrophyllus	Large-leaved Aster	NATIVE
W077	Aster	prenanthoides	Crooked-stem aster	NATIVE
W076	Aster	radula	Rough aster	NATIVE
W080	Aster	spp.	Aster species	NATIVE
W534	Aster	umbellatus	Flat-topped white aster	NATIVE
W079	Aster	undulatus	Wavy-leaved aster	NATIVE
W951	Aster	vimineus	Small white aster	NATIVE
W772	Baptisia	tinctoria	Wild indigo	NATIVE
W205	Barbarea	vulgaris	Common wintercress	
W498	Belamcanda	chinensis	Blackberry-lily	
W215	Bidens	connata	Swamp beggar-ticks	NATIVE
W217	Bidens	frondosa	Beggar-ticks	NATIVE
W200	Boehmeria	cylindrica	False nettle	NATIVE
W203	Brassica	rapa	Field mustard	
W712	Cabomba	caroliniana	Carolina fanwort	
W255	Caltha	palustris	Marsh-marigold	NATIVE
W454	Cardamine	impatiens	Narrowleaf bittercress	
W257	Cardamine	pensylvanica	Pennsylvania bittercress	NATIVE
W681	Carduus	acanthoides	Thistle	
W683	Carduus	nutans	Musk thistle	
W895	Carum	carvi	Caraway	
W260	Caulophyllum	thalictroides	Blue cohosh	NATIVE
W930	Centaurea	jacea	Brown knapweed	
W901	Centaurea	maculosa	Spotted knapweed	
W931	Centaurea	nigra	Black knapweed	
W465	Cerastium	vulgatum	Common mouse-ear chickweed	
W870	Chamaechrista	fasciculata	Partridge-pea	NATIVE
W068	Chamaelirium	luteum	Devil's-bit	NATIVE
W902	Chelidonium	majus	Celandine	
W025	Chelone	glabra	Turtlehead	NATIVE
W020	Chimaphila	maculata	Striped wintergreen	NATIVE
W021	Chimaphila	umbellata	Pipsissewa	NATIVE
W626	Chrysanthemum	leucanthemum	Oxeye daisy	

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
W628	Chrysanthemum	spp.	Chrysanthemum species	
W625	Chrysosplenium	americanum	Golden saxifrage	NATIVE
W682	Cichorium	intybus	Blue chicory	
W480	Cimicifuga	racemosa	Black snakeroot	NATIVE
W551	Circaea	alpina	Dwarf enchanter's-nightshade	NATIVE
W550	Circaea	quadrisulcata	Enchanter's-nightshade	NATIVE
W903	Cirsium	arvense	Canada thistle	
W686	Cirsium	discolor	Field thistle	NATIVE
W684	Cirsium	pumilum	Pasture thistle	NATIVE
W689	Cirsium	spp.	Thistle species	
W685	Cirsium	vulgare	Bull-thistle	
W525	Claytonia	caroliniana	Carolina spring-beauty	NATIVE
W526	Claytonia	virginica	Spring-beauty	NATIVE
W326	Clintonia	umbellulata	White Clintonia	NATIVE
W904	Conium	maculatum	Poison hemlock	
W620	Conopholis	americana	Squaw-root	NATIVE
W240	Convallaria	majalis	Lily-of-the-valley	
W224	Conyza	canadensis	Horseweed	NATIVE
W680	Coptis	groenlandica	Goldthread	NATIVE
W377	Corallorhiza	maculata	Spotted coralroot	NATIVE
W118	Cornus	canadensis	Bunchberry	NATIVE
W770	Coronilla	varia	Crown-vetch	
W780	Corydalis	sempervirens	Pale corydalis	NATIVE
W740	Cryptotaenia	canadensis	Honewort	NATIVE
W800	Cunila	origanoides	Dittany	NATIVE
W645	Cuphea	petiolata	Blue waxweed	NATIVE
W275	Cynoglossum	virginianum	Wild comfrey	NATIVE
W650	Cypripedium	acaule	Pink lady's-slipper	NATIVE
W655	Dalibarda	repens	Dewdrop	NATIVE
W880	Datura	stramonium	Jimsonweed	
W730	Daucus	carota	Queen Anne's-lace	
W455	Dentaria	diphylla	Toothwort	NATIVE
W258	Dentaria	heterophylla	Toothwort	NATIVE
W777	Desmodium	glutinosum	Pointed-leaved tick trefoil	NATIVE
W776	Desmodium	paniculatum	Panicled tick-trefoil	NATIVE
W775	Desmodium	rotundifolium	Prostrate tick-trefoil	NATIVE
W778	Desmodium	spp.	Trefoil species	NATIVE
W235	Dianthus	armeria	Deptford pink	
W530	Dicentra	canadensis	Squirrel-corn	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
W529	Dicentra	cucullaria	Dutchman's-breeches	NATIVE
W531	Dicentra	eximia	Wild bleeding-heart	NATIVE
W457	Disporum	lanuginosum	Fairy-bells	NATIVE
W458	Drosera	rotundifolia	Round-leaved sundew	NATIVE
W562	Duchesnea	indica	Indian-strawberry	
W277	Echium	vulgare	Viper's bugloss	
W921	Egeria	densa	Brazilian waterweed	
W290	Epifagus	virginiana	Beechdrops	NATIVE
W420	Epigaea	repens	Trailing-arbutus	NATIVE
W416	Epilobium	ciliatum	Northern willow-herb	NATIVE
W418	Epilobium	coloratum	Purple leaved willow herb	NATIVE
W417	Epilobium	hirsutum	Hairy willow-herb	
W935	Epilobium	parviflorum	Smallflower hairy willow-herb	
W419	Epipactis	helleborine	Helleborine	
W220	Erechtites	hieraciifolia	Pilewort or Fireweed	NATIVE
W225	Erigeron	annuus	Daisy fleabane	NATIVE
W226	Erigeron	philadelphicus	Common fleabane	
W228	Erigeron	strigosus var. strigosus	Prairie fleabane	NATIVE
W858	Erysimum	cheiranthoides	Wormseed-mustard	
W520	Erythronium	albidum	White trout-lily	NATIVE
W521	Erythronium	americanum	Trout-lily	NATIVE
W355	Eupatorium	maculatum	Spotted joe-pye-weed	NATIVE
W358	Eupatorium	perfoliatum	Boneset	NATIVE
W356	Eupatorium	purpureum	Sweet-scented Joe-pye-weed	NATIVE
W360	Eupatorium	rugosum	White-snakeroot	NATIVE
W359	Eupatorium	sessilifolium	Upland boneset	NATIVE
W365	Euphorbia	maculata	Upright spotted spurge	NATIVE
W367	Euphorbia	vermiculata	Hairy spurge	NATIVE
W195	Fagopyrum	sagittatum	Buckwheat	NATIVE
W459	Fragaria	spp.	Wild strawberry species	NATIVE
W460	Fragaria	vesca	Wood strawberry	NATIVE
W885	Galega	officinalis	Goat's-rue	
W374	Galeopsis	bifida	Hemp-nettle	
W361	Galinsoga	ciliata	Quickweed	NATIVE
W126	Galium	aparine	Cleavers	NATIVE
W122	Galium	asprellum	Rough bedstraw	NATIVE
W124	Galium	boreale	Northern Bedstraw	NATIVE
W125	Galium	circaezans	Wild licorice	NATIVE
W121	Galium	palustre	Marsh bedstraw	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
W123	Galium	pilosum	Hairy Bedstraw	NATIVE
W120	Galium	spp.	Bedstraw species	NATIVE
W127	Galium	triflorum	Sweet-scented bedstraw	NATIVE
W012	Gaultheria	hispidula	Creeping snowberry	NATIVE
W010	Gaultheria	procumbens	Wintergreen	NATIVE
W500	Geranium	maculatum	Wild geranium	NATIVE
W660	Geranium	robertianum	Herb-robert	NATIVE
W566	Geum	aleppicum	Yellow avens	
W565	Geum	canadense	White avens	NATIVE
W338	Gillenia	trifoliatus	Bowman's-root	NATIVE
W375	Glechoma	hederacea	Ground-ivy	
W473	Gnaphalium	obtusifolium	Sweet everlasting	NATIVE
W380	Goodyera	pubescens	Downy rattlesnake-plantain	NATIVE
W381	Goodyera	repens	Dwarf rattlesnake-plantain	NATIVE
W382	Goodyera	tesselata	Checkered rattlesnake Plantain	NATIVE
W719	Habenaria	clavellata	Green-wood orchis	NATIVE
W615	Habenaria	orbiculata	Large round-leaved orchis	NATIVE
W718	Habenaria	spp.	Rein Orchid species	NATIVE
W278	Hackelia	virginiana	Beggar's-lice	NATIVE
W016	Hedeoma	pulegioides	American pennyroyal	NATIVE
W363	Heliopsis	helianthoides	Ox-eye daisy	NATIVE
W907	Hemerocallis	fulva	Day lily	
W506	Hepatica	acutiloba	Sharp-lobed hepatica	NATIVE
W505	Hepatica	americana	Round-lobed hepatica	NATIVE
W908	Heracleum	mantegazzianum	Giant hogweed	
W259	Hesperis	matronalis	Dame's-rocket	
W840	Heuchera	americana	Alum-root	NATIVE
W084	Hieracium	aurantiacum	Orange hawkweed	NATIVE
W086	Hieracium	paniculatum	Panicled hawkweed	NATIVE
W085	Hieracium	pratense	Field hawkweed or King-devil	
W560	Hieracium	spp.	Hawkweed species	NATIVE
W083	Hieracium	venosum	Rattlesnake-weed	NATIVE
W783	Houstonia	caerulea	Bluets	NATIVE
W786	Houstonia	serpyllifolia	Creeping bluets	NATIVE
W784	Houstonia	spp.	Bluets species	NATIVE
W785	Houstonia	tenuifolia & longifolia	Narrow-leaved Houstonia	NATIVE
W916	Humulus	japonicus	Japanese hops	
W917	Hydrilla	verticillata	Hydrilla	
W790	Hydrocotyle	americana	Water pennywort	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
W792	Hydrophyllum	canadense	Broad-leaved Waterleaf	NATIVE
W793	Hydrophyllum	virginianum	Virginia waterleaf	NATIVE
W302	Hypericum	canadense	Canadian St.John's-wort	NATIVE
W301	Hypericum	mutilum	Dwarf St. John's-wort	NATIVE
W303	Hypericum	perforatum	Common St. John's-wort	
W300	Hypericum	punctatum	Spotted St. John's-wort	NATIVE
W299	Hypericum	spp.	St.John's-wort species	NATIVE
W305	Hypericum	virginicum	Marsh St. Johns-wort	NATIVE
W485	Hypoxis	hirsuta	Yellow star-grass	NATIVE
W335	Impatiens	capensis	Spotted Touch-me-not	NATIVE
W333	Impatiens	pallida	Pale jewelweed	NATIVE
W330	Impatiens	spp.	Touch-me-not species	NATIVE
W370	Ipomoea	spp.	Morning-glory species	NATIVE
W926	Iris	Pseudacorus	Yellow iris	NATIVE
W555	Isotria	verticillata	Whorled-pogonia	NATIVE
W825	Krigia	virginica	Dwarf dandelion	NATIVE
W264	Lactuca	biennis	Blue lettuce	NATIVE
W265	Lactuca	scariola	Prickly lettuce	
W266	Lactuca	spp.	Lactuca species	
W767	Lamium	purpureum	Purple dead-nettle	
W210	Laportea	canadensis	Wood-nettle	NATIVE
W263	Lapsana	communis	Nipplewort	
W410	Lathyrus	latifolius	Everlasting-pea	
W850	Lepidium	campestre	Fieldcress	
W851	Lepidium	virginicum	Wild peppergrass	NATIVE
W768	Lespedeza	repens	Creeping bush-clover	NATIVE
W538	Leucanthemum	vulgare	Ox-eye daisy	
W725	Lilium	canadense	Canada lily	NATIVE
W724	Lilium	spp.	Lily species	
W607	Linaria	vulgaris	Butter-and-eggs	
W835	Linum	virginianum	Wild yellow flax	NATIVE
W619	Listera	cordata	Heartleaf twayblade	NATIVE
W726	Lobelia	inflata	Indian-tobacco	NATIVE
W163	Lotus	corniculatus	Birdsfoot trefoil	
W860	Ludwigia	palustris	Marsh-purslane	NATIVE
W862	Ludwigia	peploides	Floating seedbox	
W169	Lycopus	americanus	Water-horehound	NATIVE
W170	Lycopus	uniflorus	Northern Bugleweed	NATIVE
W171	Lycopus	virginicus	Virginia Bugleweed	NATIVE
W426	Lysimachia	ciliata	Fringed loosestrife	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
W940	Lysimachia	nummularia	Moneywort	
W425	Lysimachia	quadrifolia	Whorled loosestrife	NATIVE
W424	Lysimachia	spp.	Loosestrife species	NATIVE
W941	Lythrum	salicaria	Purple loosestrife	
W130	Maianthemum	canadense	Canada mayflower	NATIVE
W642	Malaxis	unifolia	Green adder's-mouth	NATIVE
W160	Medeola	virginiana	Indian cucumber-root	NATIVE
W165	Medicago	lupulina	Black medick	
W605	Melampyrum	lineare	Cow-wheat	NATIVE
W866	Melilotus	alba	White sweet-clover	
W865	Melilotus	officinalis	Yellow sweet-clover	
W755	Mentha	arvensis	Wild mint	NATIVE
W604	Mimulus	ringens	Allegheny monkey-flower	NATIVE
W040	Mitchella	repens	Partridge-berry	NATIVE
W446	Mitella	diphylla	Miterwort or Bishop's-cap	NATIVE
W445	Mitella	nuda	Naked miterwort	NATIVE
W175	Monarda	didyma	Bee-balm or Oswego tea	NATIVE
W271	Monotropa	hypopithys	Pinesap	NATIVE
W270	Monotropa	uniflora	Indian-pipe	NATIVE
W273	Myosotis	scorpioides	Forget-me-not	
W905	Myriophyllum	aquaticum	Parrot feather watermilfoil	
W906	Myriophyllum	spicatum	Eurasian water-milfoil	
W690	Nasturtium	officinale	Watercress	
W691	Nepeta	cataria	Catnip	
W548	Oenothera	perennis	Small Sundrops	NATIVE
W640	Orchis	spp.	Orchis species	
W909	Ornithogalum	nutans	Star-of-Bethlehem	
W910	Ornithogalum	umbellatum	Star-of-Bethlehem	
W658	Osmorhiza	claytonii	Sweet-cicely	NATIVE
W659	Osmorhiza	longistylis	Anise root	NATIVE
W103	Oxalis	grandis	Great wood sorrel	NATIVE
W102	Oxalis	montana	Common wood-sorrel	NATIVE
W100	Oxalis	spp.	Wood sorrel species	NATIVE
W101	Oxalis	stricta	Yellow wood-sorrel	NATIVE
W918	Pachysandra	terminalis	Japanese pachysandra	
W438	Panax	quinquefolius	Ginseng	NATIVE
W590	Panax	trifolius	Dwarf ginseng	NATIVE
W805	Paronychia	canadensis	Forked chickweed	NATIVE
W911	Pastinaca	sativa	Wild parsnip	
W606	Pedicularis	canadensis	Wood-betony	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
W912	Perilla	frutescens	Beafsteak plant	
W714	Persicaria	longiseta	Bristled knotweed	
W875	Phlox	paniculata	Summer phlox	NATIVE
W057	Physalis	subglabrata	Ground-cherry	NATIVE
W250	Phytolacca	americana	Pokeweed	NATIVE
W190	Pilea	pumila	Clearweed	NATIVE
W723	Plantago	lanceolata	English plantain	
W721	Plantago	major	Common plantain	
W720	Plantago	rugelii	Red-stemmed plantain	NATIVE
W616	Platanthera	psycodes	Purple-fringed orchid	NATIVE
W614	Platanthera	spp.	Orchid species	
W390	Podophyllum	peltatum	Mayapple	NATIVE
W610	Polygala	paucifolia	Fringed polygala or gaywings	NATIVE
W611	Polygala	senega	Seneca snakeroot	NATIVE
W112	Polygonatum	biflorum	Smooth solomon's-seal	NATIVE
W111	Polygonatum	pubescens	Hairy solomon's-seal	NATIVE
W110	Polygonatum	spp.	Solomon's-seal species	NATIVE
W187	Polygonum	arifolium	Halberd-leaved tearthumb	NATIVE
W180	Polygonum	aviculare	Prostrate knotweed	
W188	Polygonum	cuspidatum	Japanese knotweed	
W183	Polygonum	hydropiper	Common smartweed	
W186	Polygonum	hydropiperoides	Mild water-pepper	NATIVE
W184	Polygonum	persicaria	Lady's-thumb	
W189	Polygonum	sachalinense	Giant knotweed	
W182	Polygonum	sagittatum	Arrow-leaved tearthumb	NATIVE
W185	Polygonum	spp.	Knotweed/Smartweed species	NATIVE
W914	Potamogeton	crispus	Curly pondweed	
W340	Potentilla	canadensis	Dwarf cinquefoil	NATIVE
W345	Potentilla	norvegica	Rough cinquefoil	NATIVE
W348	Potentilla	simplex	Common cinquefoil	NATIVE
W349	Potentilla	spp.	Cinquefoil species	NATIVE
W470	Prenanthes	alba	White lettuce	NATIVE
W469	Prenanthes	altissima	Rattlesnake-root	NATIVE
W050	Prenanthes	spp.	Rattlesnake-root species	NATIVE
W471	Prenanthes	trifoliata	Gall-of-the-earth	NATIVE
W450	Prunella	vulgaris	Selfheal or Heal-all	
W766	Pycnanthemum	incanum	Hoary mountain-mint	NATIVE
W765	Pycnanthemum	verticillatum	Torrey's mountain-mint	NATIVE
W600	Pyrola	spp.	Pyrola species	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
W509	Ranunculus	abortivus	Small-flowered crowfoot	NATIVE
W513	Ranunculus	acris	Common meadow buttercup	
W510	Ranunculus	fascicularis	Early buttercup	NATIVE
W512	Ranunculus	ficaria	Lesser celandine	
W515	Ranunculus	recurvatus	Hooked Crowfoot	NATIVE
W516	Ranunculus	repens	Creeping buttercup	
W511	Ranunculus	septentrionalis	Swamp buttercup	NATIVE
W519	Ranunculus	spp.	Ranunculus species	
W537	Rudbeckia	hirta	Black-eyed-susan	NATIVE
W665	Rumex	acetosella	Field sorrel	
W666	Rumex	obtusifolius	Bitter dock	
W669	Rumex	spp.	Rumex species	
W635	Sagittaria	latifolia	Common arrowhead	NATIVE
W760	Sanguinaria	canadensis	Bloodroot	NATIVE
W245	Sanicula	canadensis	Short-styled snakeroot	NATIVE
W247	Sanicula	odorata	Fragrant snakeroot	NATIVE
W234	Saponaria	officinalis	Bouncing-bet	
W350	Satureja	vulgaris	Wild basil	
W353	Saxifraga	virginiensis	Early saxifrage	NATIVE
W694	Scutellaria	epilobiifolia	Marsh Skullcap	NATIVE
W695	Scutellaria	lateriflora	Mad-dog skullcap	NATIVE
W675	Sedum	telephioides	Wild Live-forever	NATIVE
W630	Sedum	ternatum	Wild stonecrop	NATIVE
W696	Senecio	aureus	Golden ragwort	NATIVE
W697	Senecio	obovatus	Round-leaved ragwort	NATIVE
W232	Silene	latifolia	White campion	
W848	Sisymbrium	altissimum	Tumble-mustard	
W699	Sisyrinchium	angustifolium	Stout blue-eyed-grass	NATIVE
W925	Sisyrinchium	montanum	Blue-eyed-grass	NATIVE
W698	Sisyrinchium	spp.	Blue-eyed-grass species	NATIVE
W150	Smilacina	racemosa	False solomon's-seal	NATIVE
W152	Smilacina	spp.	False solomon's-seal species	NATIVE
W545	Smilacina	stellata	Star-flowered Solomon's Seal	NATIVE
W055	Solanum	carolinense	Horse-nettle	NATIVE
W056	Solanum	dulcamara	Trailing bittersweet	
W059	Solidago	altissima	Late goldenrod	NATIVE
W064	Solidago	bicolor	Silver-rod	NATIVE
W061	Solidago	caesia	Blue-stemmed goldenrod	NATIVE
W062	Solidago	canadensis	Canada Goldenrod	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
W065	Solidago	flexicaulis	Zigzag goldenrod	NATIVE
W058	Solidago	graminifolia	Grass-leaved goldenrod	NATIVE
W063	Solidago	rugosa	Rough-stemmed goldenrod	NATIVE
W060	Solidago	spp.	Goldenrod species	NATIVE
W812	Sonchus	arvensis	Field sow-thistle	
W813	Sonchus	asper	Spiny-leaved sow-thistle	
W815	Sonchus	oleraceus	Common sow-thistle	
W795	Specularia	perfoliata	Venus's looking-glass	NATIVE
W145	Spiranthes	spp.	Ladies'-tresses species	NATIVE
W231	Stellaria	alsine	Bog chickweed	
W230	Stellaria	media	Common chickweed	
W432	Streptopus	amplexifolius	Twisted-stalk	NATIVE
W430	Streptopus	roseus	Rosy-bells	NATIVE
W952	Symphyotrichum	lowrieanum	Smooth heart-leaved aster	NATIVE
W415	Symplocarpus	foetidus	Skunk cabbage	NATIVE
W580	Taraxacum	spp.	Dandelion species	
W583	Tephrosia	virginiana	Goat's-rue	NATIVE
W710	Thalictrum	dioicum	Early meadow-rue	NATIVE
W711	Thalictrum	polygamum	Tall meadow-rue	NATIVE
W855	Thlaspi	arvense	Field pennycress	
W435	Tiarella	cordifolia	Foamflower	NATIVE
W715	Tovara	virginiana	Jumpseed	NATIVE
W845	Tragopogon	pratensis	Yellow goat's-beard	
W915	Trapa	natans	Water chestnut	
W030	Trientalis	borealis	Star-flower	NATIVE
W867	Trifolium	arvense	Rabbit's-foot clover	
W166	Trifolium	hybridum	Alsike clover	
W168	Trifolium	pratense	Red clover	
W167	Trifolium	repens	White clover	
W072	Trillium	erectum	Wake-robin	NATIVE
W073	Trillium	grandiflorum	Large-flowered trillium	NATIVE
W070	Trillium	spp.	Trillium species	NATIVE
W075	Trillium	undulatum	Painted trillium	NATIVE
W716	Tussilago	farfara	Coltsfoot	
W140	Urtica	dioica	Stinging nettle	NATIVE
W141	Urtica	spp.	Nettle species	NATIVE
W495	Uvularia	perfoliata	Bellwort	NATIVE
W496	Uvularia	sessilifolia	Sessile-leaved bellwort	NATIVE
W494	Uvularia	spp.	Bellwort species	NATIVE
W700	Veratrum	viride	False or White hellebore	NATIVE

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
W810	Verbascum	thapsus	Common mullein	
W890	Verbena	hastata	Blue vervain	NATIVE
W735	Vernonia	noveboracensis	New York ironweed	NATIVE
W571	Veronica	officinalis	Common speedwell	NATIVE
W570	Veronica	spp.	Speedwell species	NATIVE
W873	Vicia	cracca	Cow vetch	
W705	Vinca	minor	myrtle or periwinkle	
W541	Viola	affinis	LeConte's violet	NATIVE
W091	Viola	blanda	Sweet white violet	NATIVE
W089	Viola	canadensis	Canada violet	NATIVE
W093	Viola	hastata	Halberd-leaved violet	NATIVE
W092	Viola	incognita	Large-leaved white violet	NATIVE
W088	Viola	labradorica	American dog violet	NATIVE
W094	Viola	pallens	Northern white violet	NATIVE
W095	Viola	palmata	Early blue violet	NATIVE
W098	Viola	papilionacea	Common blue violet	NATIVE
W540	Viola	pensylvanica	Smooth yellow violet	NATIVE
W542	Viola	primulifolia	Primrose-leaved violet	NATIVE
W099	Viola	rostrata	Long-spurred violet	NATIVE
W097	Viola	rotundifolia	Round-leaved violet	NATIVE
W543	Viola	sagittata	Arrow-leaved violet	NATIVE
W090	Viola	spp.	Violet species	NATIVE
W096	Viola	striata	Pale violet	NATIVE
W595	Waldsteinia	fragarioides	Barren strawberry	NATIVE
W920	Yucca	filamentosa	Yucca	
X001	Rocky	MicroHabitat	Rocky Coverage	
X002	Water	MicroHabitat	Standing Water - Wet	
X003	Soil	MicroHabitat	Mineral Soil/Sediment	
X004	Moss	MicroHabitat	Moss Coverage	
X005	Burned	MicroHabitat	Burned Coverage	
X006	MechDisturb	MicroHabitat	Mech Disturbance	
X007	Snow	MicroHabitat	Snow Covered	
X008	ConiferDuff	MicroHabitat	Pine/Hemlock Duff	
X009	Stream	MicroHabitat	Flowing Water - Stream	
X010	DeadWood	MicroHabitat	Dead Wood	
X011	BoleRoot	MicroHabitat	Live Bole/Root	
X012	Dung	MicroHabitat	Dung/Scats	
X013	Trash	MicroHabitat	Trash/Junk	
X014	LeavesHumus	MicroHabitat	Empty except leaves/humus	

Code	KeyGenus	KeySpecies	KeyCommonName	Origin
X015	ForestryStuff	MicroHabitat	Forestry Stuff (tree tubes, etc.)	
X016	SpringSeep	MicroHabitat	Spring seep	
X021	Limestone gravel	MicroHabitat	Limestone gravel coverage	
X022	E & S Materials	MicroHabitat	Silt socks, netting, hay/straw	
X030	Vegetative Tree Cover	MicroHabitat	VegetativeTreeCover-Live Bole	

Species Codes – Invasives

DCNR - Bureau of Forestry INVASIVES LIST 2016		
CODE	**Common Name**	**Scientific Name**
W900	Goutweed	Aegopodium podagraria
W745	Garlic mustard	Alliaria petiolata
W663	Wild chervil	Anthriscus sylvestris
W454	Narrowleaf bittercress	Cardamine impatiens
W683	Musk thistle	Carduus nutans
W930	Brown knapweed	Centaurea jacea
W931	Black knapweed	Centaurea nigra
W901	Spotted knapweed	Centaurea stoebe
W902	Greater celandine	Chelidonium majus
W903	Canada thistle	Cirsium arvense
W685	Bull thistle	Cirsium vulgare
W904	**Poison hemlock**	**Conium maculatum**
W770	Crown-vetch	Coronilla varia
W880	Jimsonweed	Datura stramonium
W417	Hairy willow herb	Epilobium hirsutum
W935	Smallflower hairy willowherb	Epilobium parviflorum
W188	**Japanese knotweed**	**Fallopia japonica**
W189	Giant knotweed	Fallopia sachalinensis
W885	**Goat's-rue**	**Galega officinalis**
W907	{Orange daylily}	{Hemerocallis fulva}
W908	Giant hogweed	Heracleum mantegazzianum
W259	Dames rocket	Hesperis matronalis
W926	Yellow flag iris	Iris pseudacorus
W940	Moneywort	Lysimachia nummularia
W941	Purple loosetrife	Lythrum salicaria
W909	Nodding Star-of-Bethlehem	Ornithogalum nutans
W910	Star-of-Bethlehem	Ornithogalum umbellatum
W918	{Japanese pachysandra}	{Pachysandra terminalis}
W911	Wild parsnip	Pastinaca sativa
W912	Beefsteak plant	Perilla frutescens
W714	Bristled knotweed	Persicaria longiseta
W512	Lesser celandine	Ranunculus ficaria
V280	Chocolate vine	Akebia quinata
V285	Porcelain berry	Ampelopsis brevipedunculata
V021	Oriental bittersweet	Celastrus orbiculatus
V260	{Wintercreeper}	{Euonymus fortunei}
V250	{English ivy}	{Hedera helix}
W916	Japanese hops	Humulus japonicus

CODE	Common Name	Scientific Name
V240	Japanese honeysuckle	Lonicera japonica
V136	**Mile-a-minute**	**Persicaria perfoliata**
V230	Kudzu	Pueraria lobata
W000	{Bigleaf Periwinkle}	{Vinca major}
W705	{Common Periwinkle}	{Vinca minor}
V290	**Black swallow-wort**	**Vincetoxicum nigrum**
V292	**Pale swallow-wort**	**Vincetoxicum rossicum**
V270	{Chinese Wisteria}	{Wisteria sinensis}
V275	{Japanese Wisteria}	{Wisteria floribunda}
T/R000	Amur maple	Acer ginnala
T/R023	Norway maple	Acer platanoides
T/R302	Sycamore maple	Acer pseudoplatanus
T/R240	Mimosa	Albizia julibrissin
T/R305	European black alder	Alnus glutinosa
T/R112	**Tree-of-heaven**	**Ailanthus altissima**
S495	**Japanese angelica-tree**	**Aralia elata**
T/R000	{Paper mulberry}	{Broussonetia papyrifera}
T/R000	{White mulberry}	{Morus alba}
T/R110	Empress tree	Paulownia tomentosa
T/R306	{Cork-trees}	{Phellodendron species}
T/R200	Callery pear	Pyrus calleryana
T/R307	{Bee-bee tree}	{Tetradium daniellii}
T/R304	Siberian elm	Ulmus pumila
S160	Japanese barberry	Berberis thunbergii
S900	European barberry	Berberis vulgaris
S914	{Butterfly Bush}	{Buddleja davidii}
S351	Russian olive	Elaeagnus angustifolia
S350	Autumn olive	Elaeagnus umbellata
S700	Winged Euonymus	Euonymus alata
S915	**Glossy buckthorn**	**Frangula alnus**
S710	Shrubby bushclover	Lespedeza bicolor
S712	Chinese bushclover	Lespedeza cuneata
S650	Japanese privet	Ligustrum japonicum
S650	Border privet	Ligustrum obtusifolium
S650	Chinese privet	Ligustrum sinense
S650	Common privet	Ligustrum vulgare
S360	Amur honeysuckle	Lonicera mackii
S360	Morrow's honeysuckle	Lonicera morrowii
S360	Bell's honeysuckle	Lonicera xbella
S360	Standish honeysuckle	Lonicera standishii
S910	Tartarian honeysuckle	Lonicera tatarica

CODE	Common Name	Scientific Name
S911	Common buckthorn	Rhamnus cathartica
S720	Jetbead	Rhodotypos scandens
S635	Multiflora rose	Rosa multiflora
S290	{Wineberry}	{Rubus phoenicolasius}
S913	Japanese spiraea	Spiraea japonica
S159	{Doublefile viburnum}	{Viburnum plicatum}
S158	{Linden viburnum}	{Viburnum dilatatum}
S157	{Siebold viburnum}	{Viburnum sieboldii}
S145	Guelder rose	Viburnum opulus
G000	{Small carpetgrass}	{Arthraxon hispidus}
G106	Poverty brome	Bromus sterilis
G105	Cheatgrass	Bromus tectorum
G500	Common velvet grass	Holcus lanatus
G340	Japanese stiltgrass	Microstegium vimineum
G000	{Chinese silvergrass}	{Miscanthus sinensis}
G000	{Wavyleaf basketgrass}	{Oplismenus hirtellus}
G325	Reed canary grass	Phalaris australis
G380	**Common reed**	**Phragmites australis ssp. australis**
G000	{Golden bamboo}	{Phyllostachys aurea}
G123	Rough bluegrass	Poa trivialis
G000	{Ravenna Grass}	{Saccharum ravannae}
G178	Tall fescue	Schedonorus arundiaceus
G356	Shattercane	Sorghum bicolor ssp. drummondii
G358	Johnsongrass	Sorghum halepense
W712	Carolina fanwort	Cabomba caroliniana
NO CODE	Didymo	Didymosphenia geminata
W921	Brazilian water-weed	Egeria densa
W917	Hydrilla	Hydrilla verticillata
W862	Floating seedbox	Ludwigia peploides
W905	Parrot feather watermilfoil	Myriophyllum aquaticum
W906	Eurasian water-milfoil	Myriophyllum spicatum
W914	Curly pondweed	Potamogeton crispus
W915	Europan water chestnut	Trapa natans
G717	Narrow-leaved cattail	Typha angustifolia
G718	Hybrid cattail	Typha x glauca
*Species without a CODE should be collected as a voucher specimen, EXCEPT Didymo (do NOT collect)		
**Watch List Species are denoted by the {….} and should be recorded the same as invasives.		
***EDRR Species are highlighted on this list. If encountered, must follow EDRR reporting process.		

Species Codes – Well Pad Species

CODE	Scientific Name	Common Name	PAGE
	ANADARKO Less than 15% Slope		
G330	Phleum pratense	Timothy	328
G242	Elymus canadensis	Canada wild-rye	345
G351	Schizachyrium scoparium	Little bluestem	392
G350	Andropogon gerardii	Big bluestem	392
W167	Trifolium repens	White clover	593
G220	Panicum clandestinum	Deer-tongue grass	373
W870	Chamaechrista fasciculata	Partridge-pea	572
W537	Rudbeckia hirta	Black-eyed-susan	941
	ANADARKO Greater than 15% Slope		
G360	Sorghastrum nutans	Indian-grass	391
G225	Panicum virgatum	Switchgrass	385
	ERNST Seed Mixes/Kugel Mix		
G110	Dactylis glomerata	Orchardgrass	333
G238	Tridens flavus	Purpletop	350
G245	Elymus virginicus	Virginia wild-rye	347
G177	Festuca rubra	Red fescue	320
G336	Lolium multiflorum	Ryegrass	329
G159	Carex vulpinoidea	Fox sedge	280
G190	Agrostis perrennans	Autumn bent-grass	325
G194	Agrostis gigantea	Redtop	324
W166	Trifolium hybridum	Alsike clover	592

CODE	Scientific Name	Common Name	PAGE
G335	Lolium perenne	Perennial ryegrass	329
W163	Lotus corniculatus	Bird's-foot trefoil	588
G178	Schedonorus arundinaceus	Tall fescue	329
G103	Bromus cillatus	Fringed brome	341
G620	Echinochloa crusgalli	Barnyard grass	369
G315	Setaria pumila	Yellow foxtail	387
G235	Triticum aestivum	Common wheat	347
S400	Cornus ammomum	Silky dogwood	716
W723	Plantago lanceolate	Narrowleaf plantain	793
W180	Polygonum aviculare	Prostrate knotweed	452
W416	Epilobium ciliatum	Northern willow-herb	511
W168	Trifolium pratense	Red clover	593
G120	Poa pratensis	Kentucky bluegrass	339
X021	Limestone Gravel	Limestone Gravel Cover	
X022	E & S Materials	E & S Materials Cover	

Dissolved Oxygen (mg/L) 100% Saturation Chart for Fresh Water

Temp °C	Barometric Pressure (mm Hg)														
	700	705	710	715	720	725	730	735	740	745	750	755	760	765	770
0.0	13.46	13.56	13.65	13.75	13.85	13.94	14.04	14.14	14.23	14.33	14.43	14.52	14.62	14.72	14.81
0.5	13.27	13.37	13.46	13.56	13.65	13.75	13.84	13.94	14.03	14.13	14.23	14.32	14.42	14.51	14.61
1.0	13.09	13.18	13.28	13.37	13.46	13.56	13.65	13.75	13.84	13.93	14.03	14.12	14.22	14.31	14.40
1.5	12.91	13.00	13.09	13.19	13.28	13.37	13.46	13.56	13.65	13.74	13.84	13.93	14.02	14.11	14.21
2.0	12.73	12.82	12.91	13.01	13.10	13.19	13.28	13.37	13.46	13.56	13.65	13.74	13.83	13.92	14.01
2.5	12.56	12.65	12.74	12.83	12.92	13.01	13.10	13.19	13.28	13.37	13.46	13.55	13.64	13.73	13.82
3.0	12.39	12.48	12.57	12.66	12.75	12.84	12.93	13.02	13.10	13.19	13.28	13.37	13.46	13.55	13.64
3.5	12.23	12.31	12.40	12.49	12.58	12.67	12.75	12.84	12.93	13.02	13.11	13.19	13.28	13.37	13.46
4.0	12.07	12.15	12.24	12.33	12.41	12.50	12.59	12.67	12.76	12.85	12.93	13.02	13.11	13.20	13.28
4.5	11.91	11.99	12.08	12.17	12.25	12.34	12.42	12.51	12.59	12.68	12.77	12.85	12.94	13.02	13.11
5.0	11.75	11.84	11.92	12.01	12.09	12.18	12.26	12.35	12.43	12.52	12.60	12.69	12.77	12.86	12.94
5.5	11.60	11.69	11.77	11.86	11.94	12.02	12.11	12.19	12.27	12.36	12.44	12.52	12.61	12.69	12.78
6.0	11.46	11.54	11.62	11.70	11.79	11.87	11.95	12.04	12.12	12.20	12.28	12.37	12.45	12.53	12.61
6.5	11.31	11.39	11.48	11.56	11.64	11.72	11.80	11.88	11.97	12.05	12.13	12.21	12.29	12.37	12.46
7.0	11.17	11.25	11.33	11.41	11.49	11.58	11.66	11.74	11.82	11.90	11.98	12.06	12.14	12.22	12.30
7.5	11.03	11.11	11.19	11.27	11.35	11.43	11.51	11.59	11.67	11.75	11.83	11.91	11.99	12.07	12.15
8.0	10.90	10.98	11.06	11.14	11.21	11.29	11.37	11.45	11.53	11.61	11.69	11.76	11.84	11.92	12.00
8.5	10.77	10.84	10.92	11.00	11.08	11.16	11.23	11.31	11.39	11.47	11.54	11.62	11.70	11.78	11.86
9.0	10.64	10.71	10.79	10.87	10.94	11.02	11.10	11.18	11.25	11.33	11.41	11.48	11.56	11.64	11.71
9.5	10.51	10.59	10.66	10.74	10.81	10.89	10.97	11.04	11.12	11.19	11.27	11.35	11.42	11.50	11.57
10.0	10.39	10.46	10.54	10.61	10.69	10.76	10.84	10.91	10.99	11.06	11.14	11.21	11.29	11.36	11.44
10.5	10.26	10.34	10.41	10.49	10.56	10.64	10.71	10.78	10.86	10.93	11.01	11.08	11.16	11.23	11.30
11.0	10.15	10.22	10.29	10.37	10.44	10.51	10.59	10.66	10.73	10.81	10.88	10.95	11.03	11.10	11.17
11.5	10.03	10.10	10.17	10.25	10.32	10.39	10.47	10.54	10.61	10.68	10.76	10.83	10.90	10.97	11.05
12.0	9.91	9.99	10.06	10.13	10.20	10.27	10.35	10.42	10.49	10.56	10.63	10.71	10.78	10.85	10.92
12.5	9.80	9.87	9.94	10.02	10.09	10.16	10.23	10.30	10.37	10.44	10.51	10.58	10.66	10.73	10.80
13.0	9.69	9.76	9.83	9.90	9.97	10.04	10.11	10.19	10.26	10.33	10.40	10.47	10.54	10.61	10.68
13.5	9.59	9.65	9.72	9.79	9.86	9.93	10.00	10.07	10.14	10.21	10.28	10.35	10.42	10.49	10.56
14.0	9.48	9.55	9.62	9.69	9.76	9.82	9.89	9.96	10.03	10.10	10.17	10.24	10.31	10.37	10.44

Temp °C	Barometric Pressure (mm Hg)														
	700	705	710	715	720	725	730	735	740	745	750	755	760	765	770
14.5	9.38	9.44	9.51	9.58	9.65	9.72	9.78	9.85	9.92	9.99	10.06	10.13	10.19	10.26	10.33
15.0	9.27	9.34	9.41	9.48	9.54	9.61	9.68	9.75	9.81	9.88	9.95	10.02	10.08	10.15	10.22
15.5	9.18	9.24	9.31	9.38	9.44	9.51	9.58	9.64	9.71	9.78	9.84	9.91	9.98	10.04	10.11
16.0	9.08	9.14	9.21	9.28	9.34	9.41	9.47	9.54	9.61	9.67	9.74	9.80	9.87	9.94	10.00
16.5	8.98	9.05	9.11	9.18	9.24	9.31	9.37	9.44	9.50	9.57	9.64	9.70	9.77	9.83	9.90
17.0	8.89	8.95	9.02	9.08	9.15	9.21	9.28	9.34	9.41	9.47	9.54	9.60	9.66	9.73	9.79
17.5	8.80	8.86	8.92	8.99	9.05	9.12	9.18	9.24	9.31	9.37	9.44	9.50	9.57	9.63	9.69
18.0	8.70	8.77	8.83	8.90	8.96	9.02	9.09	9.15	9.21	9.28	9.34	9.40	9.47	9.53	9.59
18.5	8.62	8.68	8.74	8.80	8.87	8.93	8.99	9.06	9.12	9.18	9.24	9.31	9.37	9.43	9.50
19.0	8.53	8.59	8.65	8.72	8.78	8.84	8.90	8.96	9.03	9.09	9.15	9.21	9.28	9.34	9.40
19.5	8.44	8.50	8.57	8.63	8.69	8.75	8.81	8.87	8.94	9.00	9.06	9.12	9.18	9.25	9.31
20.0	8.36	8.42	8.48	8.54	8.60	8.66	8.73	8.79	8.85	8.91	8.97	9.03	9.09	9.15	9.21
20.5	8.28	8.34	8.40	8.46	8.52	8.58	8.64	8.70	8.76	8.82	8.88	8.94	9.00	9.06	9.12
21.0	8.19	8.25	8.31	8.37	8.43	8.49	8.55	8.61	8.67	8.73	8.79	8.85	8.92	8.98	9.04
21.5	8.11	8.17	8.23	8.29	8.35	8.41	8.47	8.53	8.59	8.65	8.71	8.77	8.83	8.89	8.95
22.0	8.04	8.09	8.15	8.21	8.27	8.33	8.39	8.45	8.51	8.57	8.63	8.68	8.74	8.80	8.86
22.5	7.96	8.02	8.08	8.13	8.19	8.25	8.31	8.37	8.43	8.48	8.54	8.60	8.66	8.72	8.78
23.0	7.88	7.94	8.00	8.06	8.11	8.17	8.23	8.29	8.35	8.40	8.46	8.52	8.58	8.64	8.69
23.5	7.81	7.86	7.92	7.98	8.04	8.09	8.15	8.21	8.27	8.33	8.38	8.44	8.50	8.56	8.61
24.0	7.73	7.79	7.85	7.90	7.96	8.02	8.08	8.13	8.19	8.25	8.30	8.36	8.42	8.48	8.53
24.5	7.66	7.72	7.77	7.83	7.89	7.94	8.00	8.06	8.11	8.17	8.23	8.28	8.34	8.40	8.45
25.0	7.59	7.65	7.70	7.76	7.81	7.87	7.93	7.98	8.04	8.10	8.15	8.21	8.26	8.32	8.38
25.5	7.52	7.58	7.63	7.69	7.74	7.80	7.85	7.91	7.97	8.02	8.08	8.13	8.19	8.24	8.30
26.0	7.45	7.51	7.56	7.62	7.67	7.73	7.78	7.84	7.89	7.95	8.00	8.06	8.11	8.17	8.22
26.5	7.38	7.44	7.49	7.55	7.60	7.66	7.71	7.77	7.82	7.88	7.93	7.99	8.04	8.10	8.15
27.0	7.32	7.37	7.43	7.48	7.53	7.59	7.64	7.70	7.75	7.81	7.86	7.91	7.97	8.02	8.08
27.5	7.25	7.30	7.36	7.41	7.47	7.52	7.57	7.63	7.68	7.74	7.79	7.84	7.90	7.95	8.01
28.0	7.19	7.24	7.29	7.35	7.40	7.45	7.51	7.56	7.61	7.67	7.72	7.77	7.83	7.88	7.93
28.5	7.12	7.18	7.23	7.28	7.33	7.39	7.44	7.49	7.55	7.60	7.65	7.71	7.76	7.81	7.87
29.0	7.06	7.11	7.16	7.22	7.27	7.32	7.38	7.43	7.48	7.53	7.59	7.64	7.69	7.74	7.80
29.5	7.00	7.05	7.10	7.15	7.21	7.26	7.31	7.36	7.42	7.47	7.52	7.57	7.62	7.68	7.73
30.0	6.94	6.99	7.04	7.09	7.14	7.20	7.25	7.30	7.35	7.40	7.46	7.51	7.56	7.61	7.66

Chapter 9 Appendix B Datasheets

Datasheets

DEP Lab Sample Submission Sheet

Macroinvertebrate Collection Habitat Field Form

Widespread Sampling

Pebble Count

Post Construction Stormwater Management (PCSM)

Well Pad Vegetation Assessment

Pad Invasives Walkabout

Roadside Vegetation Community Monitoring

Roadside Invasive Plant Monitoring

Road Condition Monitoring

Invasive Plant Species Early Detection and Rapid Response (EDRR)

Plant Collection

Coverboards

Grassland Bird Nest Surveys

Pipeline ROW Vegetation Monitoring

Pipeline-Stream Crossing Monitoring

Road-Stream Crossing Assessment

***All datasheets can be found via the following path:**

\\nrford12ds1\RPI\RPI_RAID\Monitoring Protocols and Manuals\Current Manual and Protocols\Datasheets for Manual

Chapter 10 Definitions

Definitions

Calibrate
To adjust or mark (something, such as a measuring device) so that it can be used in an accurate and exact way.

Core Gas Districts
The entire state forest holdings of districts 9, 10, 12, 13, 15, 16, & 20.

Corridor
A narrow tract of land forming a passageway or route identified by a specific common purpose.

Development
Permanent or temporary earth disturbance activities related to oil and gas exploration and production not including seismic exploration.

Dissolved Oxygen
The amount of oxygen gas that is dissolved in water. Just like humans, most living creatures in our watersheds need oxygen to survive. Instead of using lungs to breathe oxygen in the air, many aquatic animals get oxygen from water, using gills to breathe. As the DO level rises, the gills work more efficiently, but as the DO level decreases, it is much harder for the fish and other aquatic life to get the oxygen they need to live. Dissolved oxygen conditions in streams change over the course of the day, because plants and algae produce oxygen only during the daytime, while fish, algae and other aquatic life constantly remove oxygen from the water, day and night. Streams with an unhealthy overabundance of algae and aquatic life may have very severe fluctuations in DO. At night or very early in the morning, DO concentrations may drop to levels that result in fish kills or ecosystem disturbances.
(Units of measure = mg/L or %DO)

Earth Disturbance Activity
(ESCGP-2) A construction or other human activity which disturbs the surface of the land, including land clearing and grubbing, grading, excavations, embankments, land development, agricultural plowing or tilling, operation of animal heavy use areas, timber harvesting activities, road maintenance activities, oil and gas activities, well drilling, mineral extraction, and the moving, depositing, stockpiling, or storing of soil, rock, or earth materials.

Extraction
Production of oil or natural gas after a well has been drilled and completed.

Exuviae
Sloughed off natural animal coverings (as in the skins of snakes, bugs, etc.)

Gas Districts
Districts that have been recognized for the potential of unconventional gas development (districts 2, 4, 6, 8, 9, 10, 12, 13, 14, 15, 16, 19, & 20)

Hardened Surface
To cover uniformly with materials that form a compacted working surface that is impervious as defined by DEP.

Impact
To have a direct effect or influence.

Infrastructure
Facilities and transportation arteries associated with gas extraction and transport (i.e. – well pads, compressor stations, pipeline right-of-ways, impoundments.

Limit of Clearance
BOF designation that is negotiated between the district and gas company that falls within the LOD where actual removal of predominant vegetation cover, including overstory, midcanopy or understory vegetation, and/or original soil substrate will occur.

Limit of Disturbance(LOD)
Line that designates the separation between the areas that can be disturbed and those that will not be disturbed based on the specifications of the DEP approved permit.

PAD
Infrastructure sites that include well pads, compressor stations, freshwater impoundments, storage pads, stone pits and meter, valve or tap stations and refers to the actual space the designated infrastructure occupies.

Pad Edge
The extent of the hardened surface, the edge of what could be considered usable workspace. This does not include toe slope of material.

pH
pH measures how acidic or how alkaline a solution is on a scale from 0-14, with 7 being "neutral" (neither acidic or alkaline). Smaller values indicate greater acidity while larger values indicate greater alkalinity. Stream pH may fluctuate over the course of the day because of biological activity. Most plants and animals do best in fairly neutral water with a pH range of 6.5-8.0, and more extreme values (either high or low) are undesirable. Some streams in Pennsylvania are affected by acid mine drainage (AMD), and have very low pH, creating inhospitable conditions for fish and other aquatic life.
(Units of measure = standard pH units)

Post Construction Stormwater Management (PCSM)
Refer to DEP §102.8.

Results
To end in a particular way.

ROW Temporary Workspace
Cleared area outside of the permanent footprint which is legally defined within the permit and is utilized only during construction of a facility.

Sinuosity

The tendency of a stream to move back and forth across the floodplain, in an S-shaped pattern, over time. As the stream moves back and forth across the flood plain, it may leave behind scars of where the river channel once was. A stream that doesn't meander at all has a sinuosity of 1(Sinuosity = actual path length between two points/shortest straight line distance between two points). The more meanders in a stream, the higher the sinuosity will be.

Specific Conductance

Specific conductance or conductivity is the ability of water to carry an electrical current. Pure water is actually a fairly good insulator, but substances dissolved in water, such as salt (sodium chloride, or NaCl), can help allow electrical current to flow. When the salt dissolves, the individual Na and Cl atoms split apart. The chlorine atom tends to "steal" a negatively charged electron from sodium, giving the chlorine a negative (-) electric charge and sodium a positive (+) electric charge. These charged atoms are called ions. It becomes much easier for electricity to flow when there are lots of positively and negatively charged ions dissolved in the water. Conductivity depends on the total number and type of ions in the water, not just Na and Cl from table salt. Conductivity may increase during winter, when ions from snow melt salts can run off into the stream.
[Units of measure : microsiemens(µs)/centimeter(cm)]

Turbidity

Turbidity is a measure of clarity, or the light scattering ability of water. Light is scattered (reflected in random directions) by particles that are suspended or dissolved in water. Turbidity is measured by a light source shining through the water while a very sensitive light sensor measures the amount of light reflected at a 90 degree angle. If there are lots of small particles suspended in the water, such as clay and silt from streambank erosion, much of the light will not shine straight through the water sample, but be scattered off in different directions. It is natural for turbidity to increase somewhat, along with stream discharge, in response to wet weather. Severe increases in turbidity may indicate sediment pollution from stream erosion, and this fine sediment can be harmful to fish and other aquatic life.
(Units of measure = National Turbidity Units or NTU)

State Forest Reclamation

To change an area used for gas development to another district approved condition, e.g. recreation parking infrastructure, herbaceous opening or forested habitat.

State Forest Restoration

To bring back to the original contour/grade, land use and function.

Well Pad

(DEP ESCGP-2) The area surrounding an oil or gas wellhead that is subject to earth disturbance and that is used or planned for use for the drilling, production or plugging of the well, including associated support activities (such as storage of chemicals, wastewater, drill cutting, and equipment). The well pad does not include roads, pipelines, and facilities for the withdrawal, storage, and conveyance of freshwater.

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