



DEPARTMENT OF
ECOLOGY
State of Washington

Standard Operating Procedure EAP055, Version 2.1

**Operation of the Teledyne RD Instruments
RiverPro Acoustic Doppler Current Profiler**

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Purpose of this Document

The Washington State Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

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Although Ecology follows the SOP in most instances, there may be instances in which Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

| Revision Date | Revision History | Summary of Changes | Sections | Reviser(s) |
|---------------|------------------|---|----------|---|
| 4/1/2013 | 1.0 | Added procedures related to operating ADCPs with newly available compasses, GPS receivers, and Trimble® Yuma Tablets. | 6 | Jim Shedd, Chuck Springer |
| 4/1/2013 | 1.0 | Included new procedures for testing, analyzing, and correcting moving bed conditions. | 6 | Jim Shedd, Chuck Springer, Casey Clishe |
| 8/1/2016 | 1.1 | Removed Appendix A and all references to obsolete StreamPro software and description of use of Personal Digital Assistant devices to operate StreamPro. | 3, 5, 6 | Jim Shedd |
| 8/1/2016 | 1.1 | Removed references to Section by Section software. | 3 | Jim Shedd |
| 8/1/2016 | 1.1 | Added new language describing update to WinRiver II software and related analysis and documentation of moving bed tests. | 6 | Jim Shedd |
| 8/1/2016 | 1.1 | Updated citations and reference to 2015 edition of EAP Safety Manual. Also updated citations and reference to TRDI® StreamPro ADCP Guide (2015) and WinRiver II Users Guide (2016). | 8 | Jim Shedd |
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| 8/8/2019 | 2.0 | Updated USGS technical citations and references to the most current document. | 2, 6, 8 | Paul D. Anderson |
| 8/8/2019 | 2.0 | Added language to describe procedures for use of QRev as a post-processing tool. | 3, 6, 7 | Paul D. Anderson |
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| Revision Date | Revision History | Summary of Changes | Sections | Reviser(s) |
|----------------------|-------------------------|--|-----------------|-------------------|
| 10/28/2022 | 2.1 | Updated use of USB Bluetooth devices. Updated order in which the ADCP test and compass calibration are conducted. Added bottom velocity limit for conducting loop moving bed tests. Broke parts of section 6.8 into smaller chunks and added additional sections to improve clarity and readability. Reworked parts of collecting measurement transects to clarify parts and align procedures with the 720-second rule from USGS. Reworked parts of section 6.10 (now 6.12) to emphasize use of QRev in measurement post-processing. Adjusted language in moving bed test section to allow for performing test before or after measurement set-up. | 6 | Paul D. Anderson |
| 10/28/2022 | 2.1 | Corrected errors in terminology and added use of QRev. | 8 | Paul D. Anderson |
| 10/28/2022 | 2.1 | Updated and added references | 10 | Paul D. Anderson |

1.0 Purpose and Scope

- 1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for the Operation of the Teledyne RD Instruments (TRDI) RiverPro Acoustic Doppler Current Profiler (ADCP).
- 1.2 ADCPs have many uses, but for this document, they are used to measure discharge in deep streams and shallow rivers. To do this, the ADCP uses the movement of particles in the water through several measurement beams while moving from bank to bank.

2.0 Applicability

- 2.1 This procedure is followed when using a TRDI RiverPro ADCP (RiverPro) to measure stream discharge, evaluate measurement quality, correct biased measurements, and compile measurement data. At times it may be necessary for users to utilize a StreamPro ADCP. The StreamPro ADCP is an older piece of equipment considered a backup but not inferior. Any data generated with the StreamPro ADCP will be considered equivalent in quality as long as the SOP for Operation of the Teledyne RD Instruments StreamPro ADCP, version 1.1, is followed (Appendix A).
- 2.2 The RiverPro can be used in a wide variety of water conditions – from deep streams to shallow rivers (Teledyne RD Instruments 2020a). Waters with average velocities of less than 0.3 feet per second should be avoided (Mueller et al. 2013). In addition, the RiverPro should not be used in waters with average velocities above 66 feet per second (Teledyne RD Instruments 2020a).
- 2.3 RiverPros work best in areas with a uniform stream bottom with smaller substrate material (gravel to medium cobble) and little or no aquatic vegetation or debris. Areas of high turbulence, like standing waves and large eddies, create uncertainty and should be avoided when possible. These instruments measure discharge in depths between 0.7 feet and 66 feet (Teledyne RD Instruments 2020a).

3.0 Definitions

- 3.1 Transducer Housing — The cylindrical transducer housing is connected to a cable assembly connected to the electronics housing. The five transducer heads on the bottom of the transducer housing emit and receive sound waves used to measure water velocity, stream depth, and speed of the RiverPro across a stream channel (Figure 1, left picture).
 - 3.1.1 On the side of the transducer, embossed numbers (1–5) identify each transducer head. A thermistor embedded in the transducer measures water temperature.



Figure 1. Bottom view (left) and top view (right) of the RiverPro transducer housing.

3.2

Boat – The orange three-hulled boat is where the transducer housing is mounted, and a cable connects to a watertight compartment where the battery is stored (Figure 2). All electronic components are built into the transducer housing.



Figure 2. The three-hulled boat that houses the RiverPro head.

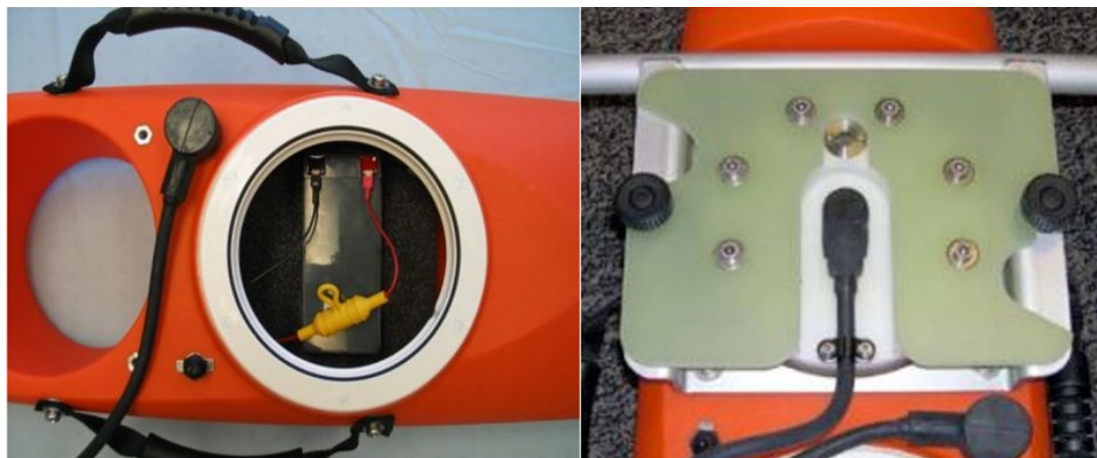


Figure 3. Left: Close-up of the center hull of the boat without RiverPro transducer housing and the battery compartment with the watertight cover removed. Right: Close-up of boat center hull with RiverPro transducer head installed.

- 3.2.1 The power switch for the RiverPro is located on the left side of the center hull between the battery compartment and the transducer housing (Figure 3). On the transducer housing's bow side (front) are three light-emitting diodes (LEDs). When the power is switched on, the left LED will be green. The middle LED will be solid blue, indicating a Bluetooth link has been acquired. The right LED is red and only turns on to indicate problems.
- 3.3 WinRiver II – WinRiver II is a software program designed to process and store discharge information from the RiverPro. WinRiver II simultaneously processes location information and streamflow data and provides detailed analysis of measurements performed by the RiverPro.
- 3.4 Bluetooth Wireless Link – A Bluetooth Wireless link facilitates data collection and processing. The Bluetooth operating range is up to 300 feet when using a computer configured with a class 1 internal Bluetooth antenna. The RiverPro users must make sure continuous communication is maintained between the computer and the RiverPro throughout the measurement.
- 3.5 USB Bluetooth device – An external Bluetooth device connected via a USB port that expands the communication capability of the Bluetooth antenna in the computer.
- 3.6 ParaniWin – ParaniWin is a software program that connects the RiverPro to a computer using a USB Bluetooth device.
- 3.7 QRev 4 –A Python-based program developed by the United States Geological Survey, Office of Surface Water, to compute ADCP measurements. QRev 4 assists the ADCP operator in post-processing by providing automated quality checks, advanced filtering, and estimates of uncertainty that can aid in the quality rating of discharge measurements.
- 3.8 ADCP – An Acoustic Doppler Current Profiler emits sound pulses into water bodies. By measuring the Doppler shift from signals reflected off particles in the water and the stream bottom, the ADCP determines water velocity, depth, and the instrument's speed over the bottom. Stream discharge is determined from these measurements. RiverPros are ADCPs.
- 3.9 Cross-Section – A measurement cross-section is a vertical plane extending from either edge up from the stream bottom to the surface. The cross-section for a RiverPro is defined as perpendicular to the average direction of flow or parallel to the average course of the boat. The cross-section determines the cross-sectional area, width, wetted perimeter, hydraulic radius, and velocity profile.
- 3.10 Transect – The measurement transect is the course the RiverPro follows across the stream and defines the measurement cross-section. The transect is the basic component comprising a measurement.
- 3.11 Bottom Tracking – Bottom tracking measures the ADCP's speed over the stream bottom and water depth.

- 3.12 Ensembles – An ensemble is a vertical profile of velocity created by the RiverPro. Ensembles are expressed in WinRiver II contour graphs as a series of columns extending across the transect. Each ensemble contains a “stack” of depth cells (bins). The width and number of ensembles in a transect are determined by vessel speed and cross-section width.
- 3.13 Bins – Bins, or depth cells, are arranged vertically through an ensemble. The RiverPro determines the mean water velocity of each depth cell. The velocity of an ensemble is the average velocity of its bins. Bin size refers to the vertical height of the bin. The RiverPro determines bin size automatically based on maximum cross-section depth and the maximum of 200 available bins. The number and size of bins can be adjusted by the RiverPro user.
- 3.14 Side Lobe Interference – Side lobe interference contaminates returning signals used to determine water velocity. Side lobe interference is caused by an in-stream boundary, typically a vertical stream edge, boulder, or log. Recent upgrades have reduced the effects of side lobe interference; however, personnel operating RiverPros should remain aware of in-stream boundaries and attempt to avoid them.

4.0 Personnel Qualifications/Responsibilities

- 4.1 Users of this document will typically work in the Hydrogeologist job classification. Training in streamflow measurement procedures and experience operating personal computers is required to perform the operations in this SOP. No certifications are required for users of this SOP.
- 4.2 Operators of the RiverPro will be familiar with EAP safety policies.

5.0 Equipment, Reagents, and Supplies

- 5.1 Computer - Operation of the RiverPro takes place through a computer using a Windows-based operating system. The computer establishes Bluetooth communication links with the RiverPro and contains WinRiver II software through which the RiverPro operates. Ideally, this computer will be ruggedized to be used in any weather condition encountered in the field.
- 5.2 Boat - A three-hulled boat (Figure 2) designed to deploy the RiverPro, maintains the transducer at a constant depth while minimizing water flow disturbance. The boat is designed to accommodate several deployment methods.
- 5.3 Tow Ropes – Floating water rescue ropes are used to tow the raft across measurement transects when wading is not possible.
- 5.4 USB Bluetooth Device – A USB Bluetooth device connects the computer to the RiverPro. The manufacturer recommends an SD1000U for use with the RiverPro.
- 5.5 Tag Line – In swift water, a tensioned tag line may be necessary to keep the raft oriented properly along the chosen transect.
- 5.6 Hand Tools – A toolbox for minor repairs and parts replacement is required on all field trips.

- 5.7 Personal Flotation Device (PFD) – Approved PFDs are required for all personnel working in or near bodies of water.

6.0 Summary of Procedure

6.1 Deployment preparation

- 6.1.1 Before departure, check that all equipment and accessories are accounted for and inspected by the field leader to ensure they are operational.
- 6.1.2 Check for correct transducer beam alignment on the RiverPro. Beam 3 is pointed forward on the starboard (right) side of the boat and at a 45° angle to the boat's centerline. It is unlikely that misalignment would occur. However, if there is misalignment, it must be corrected before use, or any measurements made would likely be useless.
- 6.1.3 The transducer head is submerged to 0.25 feet in the water. This depth is measured from the water surface to the center of the ADCP transducer faces. Transducer depth should be checked periodically to make sure the transducer head has not moved.
- 6.1.4 Inspect the power supply cable for damage. If the cable is disconnected, make sure the cable connector pins are straight and not broken. Before plugging in the cable, grease the pins with the product recommended in the RiverPro & RioPro ADCP Guide (Teledyne RD Instruments 2022).
- 6.1.5 Check for sufficient battery power. Turn the RiverPro on by pushing the switch to the 'On' position located on the port (left) side of the center hull between the transducer housing and the battery compartment. The center LED will illuminate green if there is sufficient battery power and the RiverPro passes its start-up test. (Figure 1).
- 6.1.6 If the right LED light illuminates red, there is a system error or low battery. If the battery is low, then the right LED will blink slowly. If the low battery condition is indicated on the transducer housing, a fully charged battery must be installed before proceeding with the measurement. For other system conditions, the red LED will behave differently. For a description of these behaviors, consult the RiverPro & RioPro ADCP Guide (Teledyne RD Instruments 2022).
- 6.1.7 The RiverPro uses a 12-volt, 7-amp hour rechargeable battery that fits in the watertight compartment aft (behind) of the transducer housing (Figure 3). Lead acid gel cells or lithium iron rechargeable batteries can power the RiverPro. A fully charged second battery must be carried in the field vehicle while using the RiverPro. In addition, the field vehicle must have a portable charging system for the batteries. If the battery in use falls below 12 volts, then the second battery will be used, and the low battery will be charged while in transit between stations to become the backup battery.
- 6.1.8 To install the battery in the RiverPro, refer to the RiverPro & RioPro ADCP Guide (Teledyne RD Instruments 2022).

6.1.9 While operating the RiverPro using a computer, make sure the wall charger or spare computer batteries are on hand. To operate the RiverPro with any computer via Bluetooth, a USB Bluetooth device or equivalent device internal to the computer is required. The USB Bluetooth device (if needed) is stored with each tablet. Also, make sure a body harness for suspending the tablet from one's chest and shoulders is available for measurements requiring both hands.

6.2 Measurement Preparation

6.2.1 Upon arrival at the measurement site, determine the location of the best cross-section and the safest method of deployment. Optimal operating conditions are straight channels of uniform shape with small, consistent substrate (Mueller et al. 2013). Conditions to avoid are submerged aquatic plants, abrupt changes in stream depth (boulders and bedrock ledges), large standing waves, entrained air, and substantial upwelling of water in the channel (as evidenced by "boils"). Some of these conditions will not become apparent until preliminary depths and velocities are measured.

6.3 Deployment Methods

6.3.1 There are two primary methods of RiverPro deployment: towing from a bridge and towing from shore to shore. Better control of the boat is maintained through higher velocities, shear zones, and areas of turbulence with two tow lines, each handled by a separate person.

6.3.2 A secondary method is deployment by wading. This method is not preferred and should only be used when towing from shore to shore or a bridge is not possible or practical. If this method is used, care should be taken to stay as far away from the boat as possible. In addition, the field lead should consider downgrading the measurement quality.

6.4 General deployment – The factors to consider when choosing a deployment method and location are more numerous than described in this SOP. Several factors of greatest importance are described here.

6.4.1 Tie either a bowline (with a single overhand to finish) or a double figure eight knot with a loop at the end of each tow line and clip into carabiners located at either side of the RiverPro boat. These two knots are strong and are easy to tie with a loop.

6.4.2 One person will operate the computer in addition to one of the tow lines. The computer operator directs the positioning of the RiverPro to the pre-determined endpoints. In addition, the computer operator must make sure a Bluetooth connection is maintained throughout the measurement.

6.4.3 The person with the other tow line must communicate boat positioning issues to the computer operator and watch for water debris that could damage or cause a complete loss of the RiverPro. Note: When measuring in extreme high flow conditions, having a third person on site increases safety. This person can look out for debris in the water, provide additional help in an emergency, man a throwable rope, etc.

6.4.4 Typically, the RiverPro boat will follow the path of an arc across the transect rather than a straight line because of current drag on the boat. At wide cross-sections, consider not only the width of the cross-section but also the amount of line needed to compensate for current drag.

- 6.4.5 In general, the tow speed of the boat should be approximately equal to or less than the average water velocity. When irregular substrate is encountered, data quality and bottom tracking are optimized at slower towing speeds. Maintaining smooth operation of the boat throughout the measurement is critically important.
- 6.4.6 Slowly move the RiverPro toward the bank paying close attention to the number of good bins displayed on the computer screen. As the stream becomes shallower, the number of good bins will decrease.
- 6.4.7 Due to the potential for side lobe interference, the RiverPro should not measure against vertical walls. The RiverPro should be at a distance from a vertical wall equal to or greater than the water depth at the vertical wall (Mueller et al. 2013).
- 6.5 Towing RiverPro from a bridge – Towing a RiverPro from a bridge is typically the most convenient deployment method. However, cross-sections located beneath or immediately downstream of a bridge often are not optimal for measuring stream discharge. Always attempt to find the most favorable measurement cross-section remaining mindful of safety and practicality.
 - 6.5.1 Carefully lift the RiverPro over the bridge railing and slowly lower it into the stream or river. Avoid dragging or striking the transducer head on the bridge or bridge railing while lowering the RiverPro. If the boat is lowered into the water carelessly, capsizing may occur. If practical, walk the RiverPro to the edge of the stream and lower the lines from the bridge.
 - 6.5.2 It is best in most bridge measurement applications to measure on the downstream side of the bridge. When measuring from the upstream side, the raft is usually pushed under the bridge by the current, obscuring the orientation and location of the RiverPro. It is difficult to maintain a Bluetooth connection when the RiverPro and computer do not have a good line of sight, particularly when a concrete barrier separates the computer and the RiverPro.
 - 6.5.3 One disadvantage of deploying the RiverPro from the downstream side of a bridge, and always something to remain mindful of, is the difficulty of the operators to see and avoid floating debris coming from upstream.
- 6.6 Towing the RiverPro from shore to shore – Towing the RiverPro from shore to shore requires two people handling lines on opposite sides of the stream or river.
 - 6.6.1 Two tow lines are clipped to the carabiners located at either side of the boat. One person pulls the boat across the stream or river, while the person on the opposite bank pays out line while keeping adequate counter-tension.
 - 6.6.2 Wide cross-sections with higher velocities can result in significant drag on the tow lines. Towing the boat and controlling orientation in these situations can prove difficult and unsafe. If an unsafe situation exists, abandon the measurement, and attempt to find a more suitable location.
- 6.7 Measurement Set-up

- 6.7.1 At present, Ecology has two RiverPros equipped with a compass. A computer and the WinRiver II application are used to simultaneously collect and process the measured streamflow data.
- 6.7.2 Once in the field, power on the computer and log in using the local login credentials. This should be one of the first tasks completed at a site where the RiverPro is to be used to measure flow due to the length of time the startup process can take. Powering off the computer after each measurement is recommended to conserve battery power. Charging should be done as needed and at the end of each day so that it does not become a critical issue. If available, extra computer batteries should also be brought into the field.
- 6.7.3 If a USB Bluetooth device is needed, follow 6.7.4. Otherwise, skip to 6.7.5.
- 6.7.4 Once logged on to the computer, insert the USB Bluetooth device into an open USB port to connect to the RiverPro via Bluetooth. Once the USB Bluetooth device is inserted into a USB port, ParaniWin will automatically make the connection. If the connection is successful, the middle LED light will illuminate blue on the RiverPro transducer housing.
- 6.7.5 Launch the WinRiver II application by double-clicking on the icon on the desktop or selecting the icon in the taskbar.
- 6.7.6 Once WinRiver II opens, the user can set up the configuration of a new measurement by selecting the 'File' menu and then selecting 'New Measurement.' This brings up the 'SETUP DIALOG, also known as the MEASUREMENT WIZARD. The Setup Dialog includes six screens: Site Information, Rating Information, Configuration Dialog, Output Filename Options, Commands Preview, and Summary Page.

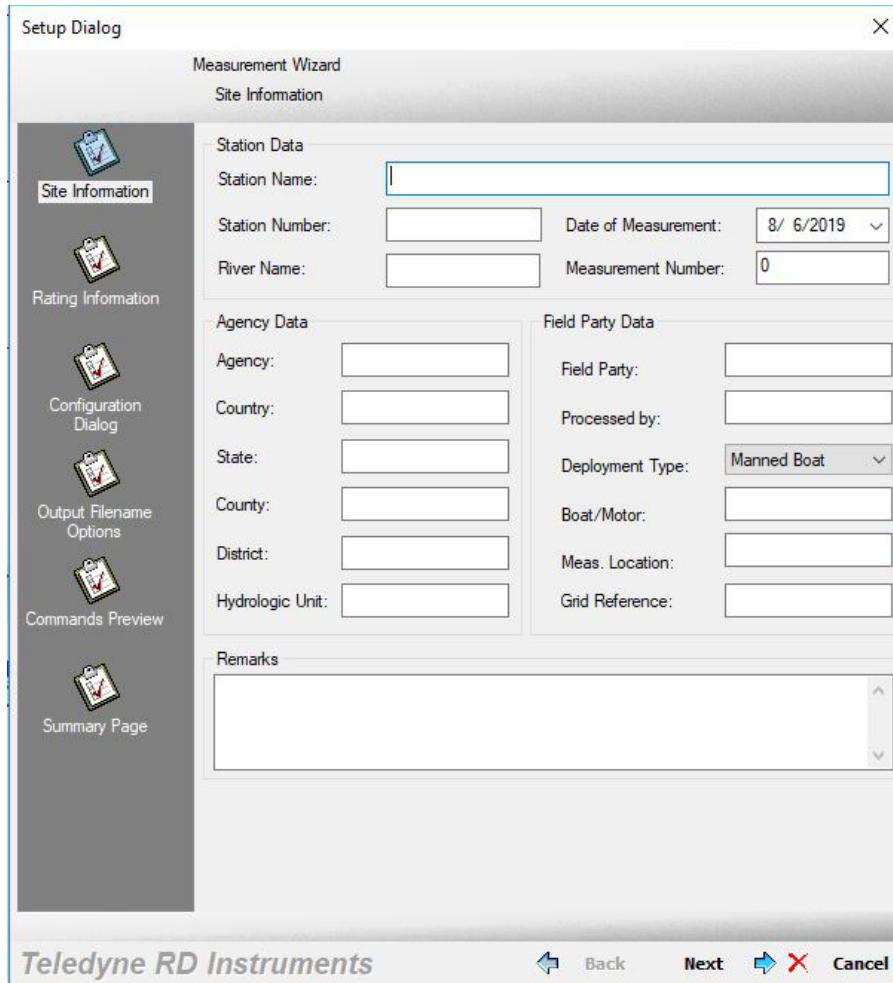


Figure 4. Site Information Screen for the MEASUREMENT WIZARD.

- 6.7.7 The MEASUREMENT WIZARD opens to the ‘Site Information’ screen (Figure 4). At the top of the screen, under ‘Station Data’, fill out ‘Station Name’ and ‘Station Number’ (station number refers to Station ID) and make sure the ‘Date of Measurement’ is correct. Under ‘Field Party Data’, only the ‘Deployment Type’ needs to be set. The default type is “Manned Boat.” To set the proper type, select the down arrow and a drop-down menu will appear with the available selections. Of the five available choices, only “Manned Boat” and Tethered Boat” apply. Most deployments will be “Tethered Boat.” All other fields on this screen are optional.
- 6.7.8 Select ‘Rating Information’ on the left of the MEASUREMENT WIZARD screen or select ‘Next’ at the bottom to continue. If desired, enter rating information on this screen.
- 6.7.9 Select ‘Configuration Dialog’ on the left of the MEASUREMENT WIZARD screen or select ‘Next, to continue.

- 6.7.10 The 'Configuration Dialog' screen will open with a message that tells you that WinRiver II is interrogating the ADCP. This means that WinRiver II is trying to communicate with the RiverPro. If the communication is successful, the red circle next to ADCP under 'Devices' will turn green, and the information in the boxes will auto-populate with the RiverPro information and serial number. A dialog box with a warning about offsets will also appear. Close the dialog box. For computers with internal USB Bluetooth devices, this is also when the Bluetooth connection is made automatically.
- 6.7.11 Under 'Offsets' set the transducer depth to the verified distance from the water surface to the center of the ADCP transducer faces (0.25 feet unless measured differently) and the 'Magnetic Variation' (declination) specific to the area that the RiverPro is being used. Magnetic declination for Washington State currently ranges from 13.9° to 16.0° and changes yearly. The user can look up the magnetic declination for specific field destinations at: <https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml>. WinRiver II only accepts decimal degrees. Users must convert any magnetic declination that is not in decimal degrees format. There are also smartphone apps that can get this information for specific locations.
- 6.7.12 Set the appropriate Left and Right bank coefficients based on channel shape at each bank (i.e., square or triangular) in the 'Discharge' section of the 'Configuration Dialog.'
- 6.7.13 All other information is set automatically.
- 6.7.14 Select 'Output Filename Options' on the left of the MEASUREMENT WIZARD screen or select 'Next' at the bottom to continue.
- 6.7.15 Set the filename prefix per the adopted Freshwater Monitoring Unit file name convention (i.e., Station Number-YYYY-MM-DD). Example 05A105-2019-08-06
- 6.7.16 'Output Directory' should be C:\Measurements\

6.7.17 Under the 'Include Filename Options' section, uncheck 'Measurement Number.' All other information should remain as defaulted.

6.7.18 Select 'Commands Preview' on the left of the MEASUREMENT WIZARD screen or select 'Next' at the bottom to continue.

6.7.19 WinRiver II pre-sets this part of the MEASUREMENT WIZARD. Only CR1 should be shown in the 'Fixed' field.

6.7.20 Select 'Summary Page' on the left of the MEASUREMENT WIZARD screen or select 'Next' at the bottom to continue. The 'Summary Page' gives you one last chance to make changes before continuing with the measurement.

6.7.21 Select 'Finish' to complete the MEASUREMENT WIZARD.

6.7.22 Select the 'Acquire' menu and select 'Set ADCP Clock' from the drop-down. In the pop-up window, select 'Set using PC Clock' and select ok.

- 6.8 Compass Calibration – After setting the clock, the compass of the RiverPro must be calibrated. The compass must be calibrated before measuring discharge at each station. Make sure to calibrate the compass as far from magnetic materials or things that can create magnetic fields as possible (e.g., metal bridges and power lines). There are several ways to calibrate the compass. All the methods require that the RiverPro is level and that two 360° rotations are completed. For this SOP, there are two recommended methods. The use of one of these methods is preferred but not required. One method uses a survey tripod equipped with a cradle that holds the RiverPro level while being rotated 360° in either direction. The second method is placing the RiverPro in a calm part of the river or stream with enough room to rotate the boat 360° in either direction.
- 6.8.1 Select the ‘Acquire’ menu and select ‘Execute Compass Calibration.’ In the pop-up window, select ‘Start Calibration.’ Once the calibration starts, rotate the RiverPro in a circle making sure to keep the on-screen color green. After the first full rotation is complete, a second rotation will be needed for verification. Once the calibration is complete, a window will come up with the calibration results. If the results are 1.0° or less, the test is complete. If it is greater than 1.0°, the calibration must be repeated. Close the calibration window when it is complete.
- 6.8.2 ADCP Test - After completing the compass calibration, an ADCP test must be completed to make sure all systems are working properly. This test should be performed in the water as near as possible to the selected measurement location. This will make sure the test is completed in conditions similar to the acoustic and magnetic conditions of the actual measurement location.
- 6.8.3 Select the ‘Acquire’ menu and select ‘Execute ADCP Test’ from the drop-down. This is the standard ADCP self-test. A screen will show the results of each test in real-time. The last test to run is a PC20. Several columns of data are displayed with a count on the left. Let this test run until the count reaches 100, select ‘Stop PC20,’ then select “Close” right away. The self-test will take several seconds to complete. Results are logged and available for review in the ‘MeasurementCtrl’ window under the QA/QC dropdown on the main WinRiver II screen. Note: If the PC20 test stops before 100 counts, restart the ADCP test.
- 6.9 Moving Bed Test – RiverPros determine their relative position and speed by bottom tracking. Accurate bottom tracking is reliant on a stable, non-moving stream bed. Moving bed situations result in a bias to the determination of the RiverPros speed over the ground. This bias results in errors (underestimations) in water velocity calculations, adversely affecting accurate flow measurements. The moving bed test determines if bed movement is present and the degree to which the condition exists.
- 6.9.1 A moving bed test must be conducted with all ADCP measurements. Even when the bed appears stationary, sediment transport near the bed can affect bottom track pulses. In addition, sediment transport characteristics can vary at the same discharge, meaning a moving bed may be detected at a discharge where previously none was detected (Mueller et al. 2013).

- 6.9.2 There are several ways to test for a moving bed, but only two apply to RiverPros used by Ecology’s EAP. One is a stationary moving bed test, and the other is a loop moving bed test. The stationary test must be conducted in a location with the highest potential for a moving bed (Mueller et al. 2013). The loop moving bed test requires a calibrated compass, average water velocities greater than or equal to 0.79 ft/sec, and the exact same start and stop location (Mueller et al. 2013). The loop moving bed test is recommended because it accounts for changes in moving bed conditions across the entire measurement cross-section.
- 6.9.3 There are many specific details associated with each type of moving bed test that are beyond the scope of this SOP. General procedures for conducting the tests are described below. Detailed information about each moving bed test can be found in Mueller et al. (2013) and Mueller and Wagner (2006).
- 6.9.4 Loop moving bed test – A loop moving bed test consists of starting at a marked location near one of the channel banks, moving to a location near the other channel bank, and returning to the marked location. This test should take at least three minutes (180 seconds). It is important to maintain a consistent boat speed during the loop test. Do not linger or pause at the edges. Return to the exact starting location. Bottom tracking must be maintained throughout the test. The bad ensemble threshold for a valid loop moving bed test is 5%.
- 6.9.5 To start the test, select the ‘Acquire’ menu and select ‘Start Pinging.’ Once pinging starts, the ‘Acquire Control’ window will indicate that pinging has commenced, but data is not being recorded.
- 6.9.6 Next, select the ‘Acquire’ menu and select ‘Select Moving Bed Test’ from the drop-down. From the pop-up box, select the ‘Loop Moving Bed Test’ radio button and select the OK button. The test will begin immediately.
- 6.9.7 Move the boat from its pre-positioned location at the starting mark to the opposite bank and back. Begin moving the boat immediately upon the start of the test, do not linger at the far edge, and maintain a steady rate of movement. Upon returning to the marked location on the starting bank, select ‘Acquire’ and then select ‘Stop Moving Bed Test’ from the drop-down menu.
- 6.9.8 Stationary moving bed test – A stationary moving bed test consists of positioning the RiverPro in the thalweg of the channel or the location with the greatest potential for a moving bed. The test duration should be no less than five minutes (300 seconds) if the RiverPro is kept in a stationary position. If it is impossible to keep the RiverPro boat stationary, then the test should be no less than 10 minutes (Mueller et al. 2013). Bottom tracking, boat, and water velocities must be maintained throughout the test period.
- 6.9.9 Pre-position the RiverPro in the location selected for the stationary moving bed test.
- 6.9.10 To start the test, select the ‘Acquire’ menu and select ‘Start Pinging.’ Once pinging starts, the ‘Acquire Control’ window will indicate that pinging has commenced, but data is not being recorded.

- 6.9.11 Next, select the ‘Acquire’ menu and select ‘Select Moving Bed Test’ from the drop-down. From the pop-up box, select the ‘Stationary Moving Bed Test’ radio button and select the OK button. The test will begin immediately.
- 6.9.12 Hold the RiverPro in the pre-positioned location for the selected duration based on boat movement. The test duration can be found at the bottom of the ‘Composite Tabular’ window on the WinRiver II main screen.
- 6.9.13 At the end of the required time, select the ‘Acquire’ menu and then select ‘Stop Moving Bed Test’ from the drop-down menu.
- 6.9.14 After each moving bed test, the ‘Test Result’ window appears in the WinRiver II workspace. The moving bed test results are presented and indicate if a moving bed sufficient to warrant correction to the measurement is present. The test results also present reasons why the test was invalid or any warnings to consider when analyzing test results.
- 6.9.15 For a loop moving bed test, a correction is warranted if the moving bed velocity is greater than 0.04 feet per second and greater than 1% of the water velocity.
- 6.9.16 A correction is warranted for a stationary moving bed test with no boat movement (five minutes) if the moving bed velocity is greater than 1% of the mean water velocity. A correction is warranted if a stationary moving bed test with boat movement (10 minutes) has a moving bed velocity greater than 2% of the mean water velocity (Mueller et al. 2013). However, at this time WinRiver II does not distinguish between the five- and 10-minute stationary moving bed tests. Instead, it applies the 1% rule to all stationary moving bed tests. It is left up to the user to determine if there is a moving bed when a stationary moving bed test is conducted.
- 6.9.17 Close the window by selecting the ‘Close’ button. After post-processing, the RiverPro measurement, copy and paste the test results into the Hydstra Gaugings comments.
- 6.9.18 Only stationary moving bed test results are automatically applied to measurements conducted in WinRiver II. When a loop moving bed test recommends a correction, the collected transects must be reprocessed to apply the correction. Reprocessing will be covered later in this SOP.
- 6.10 Collect measurement transects
- 6.10.1 Position the RiverPro boat at one edge of the selected cross-section. Move the RiverPro out from the bank until there is sufficient depth that the ‘Composite Tabular’ window consistently shows at least two good bins.
- 6.10.2 Measure and note the distance from the center of the transducer head to the bank. This marks the start and return point at this bank for each transect.
- 6.10.3 Select the ‘Acquire’ menu and then select ‘Start Transect’ from the drop-down. This brings up the ‘Start Transect’ window.
- 6.10.4 In the ‘Start Transect’ window, enter the measured distance (feet) into the ‘Distance From Shore’ box and set the ‘Bank’ radio button to the proper starting bank. The bank of the stream is determined by looking downstream. For example, the left bank of the stream is the bank on your left when looking downstream. Select ‘Ok.’

- 6.10.5 As soon as ‘Start Transect’ is selected, WinRiver II starts recording transect data. Keep the RiverPro stationary for at least ten good ensembles before starting the transect. The number of good ensembles is indicated by ‘Nmb. of Ens.’ minus ‘Bad Ens.’ in the ‘Composite Tabular’ window.
- 6.10.6 As the RiverPro approaches the far bank, note the number of good bins indicated in the ‘Composite Tabular’ window. Once the RiverPro reaches a location with a steady count of two bins, hold steady in that location. Collect at least ten good ensembles at this location before selecting the ‘Acquire’ menu and then selecting ‘End Transect’ from the drop-down menu to stop recording. After ending the transect, mark and measure the ending location.
- 6.10.7 In the ‘End Transect’ window, enter the noted distance (feet) from this bank to the center of the transducer head in the ‘Distance From Shore’ box. There is no need to set the ‘Bank’ radio button to the proper ending bank as it is automatically set based on your selection at the start of the transect. Select ‘Ok.’
- 6.10.8 The final measured discharge for the transect will appear in blue in the ‘Composite Tabular’ window.
- 6.10.9 Make sure the boat is in the proper position (i.e., the position that ended the previous transect) and continue measuring transects, following steps 6.10.1 to 6.10.8. Collect transects until the total measurement time is at least 12 minutes (720 seconds), and there are an even number of reciprocal transects (USGS, Office of Surface Water Technical Memorandum 2011.08, 2011). Total measurement time only includes time spent measuring transects and does not include the time between transects, doing the moving bed test, or other tasks. It is allowable to reposition the RiverPro between transects if the chosen transect location turns out to be unsuitable. If the cross-section location changes, the edge distances must be updated accordingly.
- 6.10.10 After the 720 seconds is reached, select the ‘View’ menu and then select ‘Discharge Summary’ in the drop down. This brings up the ‘Discharge Summary’ window that displays summary statistics for each transect. Note: If a loop moving bed test detected a moving bed, reprocess all measured transects before viewing discharge summary statistics. To reprocess the transects, select the ‘Playback’ menu and select ‘Reprocess Checked Transects’ from the drop-down (pinging must be stopped to reprocess).
- 6.10.11 If there are transects that the field lead feels are outliers in the ‘Discharge Summary’ window, they can be replaced by a transect collected in the same direction. Additional reciprocal transects can be collected if the field lead, using professional judgment, feels that collecting more data will improve the overall quality and or accuracy of the measurement.
- 6.10.12 After all transects have been collected, select the ‘Acquire’ menu and then select ‘Stop Pinging.’ Once pinging has stopped, turn off the RiverPro and stow all equipment in the field vehicle.
- 6.10.13 Before leaving the measurement site, note all relevant field conditions (e.g., stream substrate, edge descriptions, flow location in cross-section, and gage pool control type) and fill out the measurement notes using data from the ‘Discharge Summary’ window.

- 6.11 Confirming RiverPro Water Temperature – The water temperature measured by the RiverPro is used to compute the speed of sound through water. The computed speed of sound determines velocities, depths, and discharge. A 5-degree Celsius (°C) error in measured temperature at a water temperature of 20°C will result in a 3% bias in the measured discharge (Mueller et al. 2013).
- 6.11.1 Measure water temperature using a calibrated thermistor for comparison with the RiverPro temperature sensor. View the water temperature in the ‘Composite Tabular’ window to compare the measured and recorded temperatures.
- 6.11.2 If the water temperature difference is greater than 2°C, TRDI should be consulted, and the temperature sensor should be considered for repair or replacement. Note the measured water temperature on the measurement field sheet.
- 6.12 Viewing and Compiling Data in WinRiver II and QRev 4 – Typically, post-processing and analysis of RiverPro measurements occur in the office. Transfer all RiverPro measurement files to the appropriate network drive as soon as possible.
- 6.12.1 After transferring the files, start WinRiver II on a computer and open and reprocess a measurement following the procedure in the WinRiver II Software User's Guide (Teledyne RD Instruments 2020b). Also, start QRev 4 on an office computer and open a measurement following the procedure in the QRev User's Manual (USGS 2022).
- 6.12.2 View summary data in WinRiver II and QRev 4. Summary statistics for all checked transects are displayed. Any transect that needs to be discarded can be unchecked, and the summary statistics will be automatically recomputed. The reason(s) must be documented if a transect is unchecked and discarded.
- 6.12.3 QRev 4 and WinRiver II data are copied into a discharge summary report template and saved on a network drive for review. The template is stored in a shared location on the network drive.
- 6.12.4 With the template open, copy the required data into the QRev 4 and WinRiver II tabs following the instructions provided in the instructions tab.
- 6.12.5 If desired, choose a representative transect and copy images of the WinRiver II Velocity Contour and Stick Ship Track windows to the summary report template.
- 6.12.6 To do this, click on the window being copied, click on the “Configure” menu, and click “Screen Capture.” In the “Capture Setup” window, select the radio button for “Window” and click on ‘Capture Now.’ Return to the ‘Misc’ tab of the summary report and paste the copied window in the appropriate cell by right-clicking and selecting ‘Paste.’ Repeat the process for the other window.
- 6.12.7 The final step in post-processing is to copy QRev 4 data onto the front of the ADCP discharge measurement notes sheet and enter it into the Hydstra Gaugings database. QRev 4 data is also used for finalizing the quality rating assigned to the measurement.
- 6.12.8 The full capability and use of QRev 4 are beyond the scope of this SOP. However, detailed information can be found on the United States Geological Survey, Office of Surface Water, and Hydroacoustics webpage at the following link.
<https://hydroacoustics.usgs.gov/movingboat/QRev.shtml>

7.0 Records Management

- 7.1 RiverPro transect files (.PDO), post-processed WinRiver II measurement files (.mmt), and QRev 4 files (.mat) are saved in Windows file system folders exclusive to a particular RiverPro measurement.
- 7.2 The folders containing these files are located on the Stream Hydrology Group's shared server.
- 7.3 Original field notes are saved in central filing locations at respective Ecology offices.
- 7.4 Reviewed discharge summary reports are kept in the possession of the principal investigator for each flow monitoring station.
- 7.5 A record of peer reviews of all discharge measurements is located on the Stream Hydrology Group's shared server.

8.0 Quality Control and Quality Assurance

- 8.1 Since ADCP data and results are collected and processed in the field, the largest share of Quality Assurance and Quality Control (QA/QC) is performed in the field. Most equipment and deployment problems adversely affecting a measurement are identified during the measurement or through cursory reviews after the measurement.
- 8.2 Addressing data collection problems in the field may require changing cross-sections, repairing equipment, alternative deployment methods, adjusting configuration file setting(s), and additional transects.
- 8.3 After the measurement, all transects comprising the measurement are assessed to identify data quality problems and assign a preliminary quality rating. To do this, RiverPro operators will use QA/QC data from WinRiver II and, if time allows QRev 4.
- 8.4 As a general guide, if the coefficient of variance percent (COV %) for discharge of the measurement is less than 3%, the measurement is considered excellent. If the COV % is between 3% and 5%, the quality of the measurement is good. A COV % between 5% and 8% is considered fair. The measurement is regarded as poor if the COV % is greater than 8%.
- 8.5 In addition to the COV % statistics, area, width, and velocities should be consistent between transects. The field investigator should also consider factors such as the quality of the gage height measurement, cross-section quality, and flow conditions as part of the quality assignment.
 - 8.5.1 QRev 4 provides a great deal of additional data to help assign measurement quality; RiverPro operators should use the estimated 95% uncertainty output and pay special attention to any quality messages when assigning measurement quality ratings. Details about quality messages and sections of the QRev 4 output can be found in the QRev User's Manual (USGS 2022).
- 8.6 Consider downgrading the measurement quality if one or more transects contain greater than 10% bad ensembles. This especially applies when less than 10% of the bad ensembles are concentrated in one part of the cross-section (Mueller et al. 2013).

- 8.7 Downgrade measurement quality with 25% or more bad bins in one or more transects. Pay attention to the distribution of the bad bins across the transect. If bad bins are distributed uniformly, downgrading the quality may not be necessary (Mueller et al. 2013).
- 8.8 Any changes in quality assignments are documented and included with materials submitted for measurement review.
- 8.9 Measurement Review
- 8.9.1 All RiverPro measurements are peer-reviewed. Reviewed materials include completed field forms and notes, the discharge summary table, photos, and other pertinent information. Before review, the measurement is entered into the Hydstra Gaugings database.
- 8.9.2 The reviewer checks measurement notes to make sure proper measurement procedures were followed and that the data reflects the assigned quality code. The Hydstra Gaugings database is checked to verify that measurement statistics, stage height, quality assignments, and notes are entered correctly. After the Gaugings database is verified, the reviewer enters their initials in the designated location.
- 8.9.3 The reviewer examines the discharge summary table to evaluate the variability between all parameters of the measured transects. Measurements are also checked for starting bank reciprocity and measurement duration. Velocity contours are checked for high numbers of bad ensembles and depth cells, as well as ensuring the velocity profile extends to the full depth of the channel.
- 8.9.4 The reviewer enters COV% for Total Q, Area, and Velocity into the Stream Hydrology Group's Quality Assurance Database.
- 8.9.5 When the review is complete, the reviewer initials the field note sheet in the space provided in the upper right corner and returns the submitted materials along with any written comments to the lead investigator.

9.0 Safety

- 9.1 Personal Flotation Devices are required for persons working in or near bodies of water.
- 9.2 All EAP safety policies are followed, and safety is always the top priority when operating this instrument.
- 9.3 In all measurement situations, unsafe deployments that may result in injury to staff or loss/damage to equipment are not to be attempted. Refer to the EAP Safety Plan for further information about working in and around streams (Ecology 2019).
- 9.4 Always consider the safety and traffic situations when measuring from a bridge and take appropriate actions, including suspending the measurement if unsafe conditions exist. Consult the EAP Safety Plan (Ecology 2019) for further guidance regarding bridge safety.
- 9.5 Crossing the stream is done safely and by the guidelines for working in and around rivers and streams established in the EAP Safety Plan (Ecology 2019).

10.0 References

- 10.1 Ecology [Washington State Department of Ecology]. 2019. Environmental Assessment Program Safety Plan. Washington State Department of Ecology, Olympia.
 - 10.2 Mueller, D. S., C. R. Wagner, M.S. Rehmel, K. A. Oberg, and F. Rainville. 2013. Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat, version 2.0, December 2013. U.S. Geological Survey Techniques and Methods, book 3, chapter A22, 95 p.
 - 10.3 Mueller, D. S. and C. R. Wagner. 2006. Application of the Loop Method for Correcting Acoustic Doppler Current Profiler Discharge Measurements Biased by Sediment Transport. U.S. Geological Survey Scientific Investigations Report 2006-5079, 26p.
 - 10.4 Teledyne RD Instruments. 2022. RiverPro & RioPro ADCP Guide. P/N 95B-6097-00 (April 2022).
 - 10.5 Teledyne RD Instruments. 2020a. RiverPro ADCP: Intelligent River Discharge Measurement System Datasheet. WR-1030, August 2020.
 - 10.6 Teledyne RD Instruments. 2020b. WinRiver II Software User's Guide. P/N 957-6231-00 (February 2020).
 - 10.7 USGS. 2011. Office of Surface Water Technical Memorandum 2011.08: Exposure time for ADCP moving-boat discharge measurements made during steady flow conditions. U.S. Geological Survey, Office of Surface Water. September 2011.
 - 10.8 USGS, 2022 QRev User's Manual. U.S. Geological Survey.
- (Unless otherwise noted, all photos and images used in this document are courtesy of Teledyne RD Instruments©.)

11.0 Appendix A

- 11.1 Appendix A contains the previous version of the current SOP EAP055 v2.1 that will be followed when using the StreamPro ADCP. The StreamPro ADCP is only to be used when the RiverPro is unavailable.

Applicability

This procedure is followed when using a TRDI StreamPro ADCP to measure stream discharge, evaluate measurement quality, correct biased measurements, and compile measurement data.

The StreamPro ADCP is most reliable when used in low to moderate velocities (1 – 5 feet/second) with little turbulence. Variability increases dramatically in discharge measurements when the mean velocity is less than 0.8 feet/second (Blachard 2005).

StreamPros work best in areas with a uniform stream bottom with smaller substrate material (gravel to medium cobble) and little or no aquatic vegetation or debris. These instruments measure discharge in depths between 1 and 20 feet.

Definitions

Transducer Housing — The blue cylindrical transducer housing is connected to a cable assembly connected to the electronics housing. The four transducer heads on the bottom of the transducer housing emit and receive sound waves used to measure water velocity, stream depth, and speed of the StreamPro across a stream channel.

On the side of the transducer, embossed numbers (1 through 4) identify each of the transducer heads. A thermistor embedded in the transducer measures water temperature.

Electronics Housing — The blue and white electronics housing contains and protects the electronic components. The electronics housing can be submerged for short periods in depths up to two meters; however, submersion is strongly discouraged by the manufacturer.

Covering the top of the electronics housing is a dark-colored, plastic sun shield designed to prevent overheating.

The power switch for the StreamPro is located on the left front of the electronics housing. Immediately above the power switch are two LED lights. The activated amber LED indicates power on. A blinking amber LED indicates a low battery level. The activated blue LED indicates a Bluetooth link has been acquired.

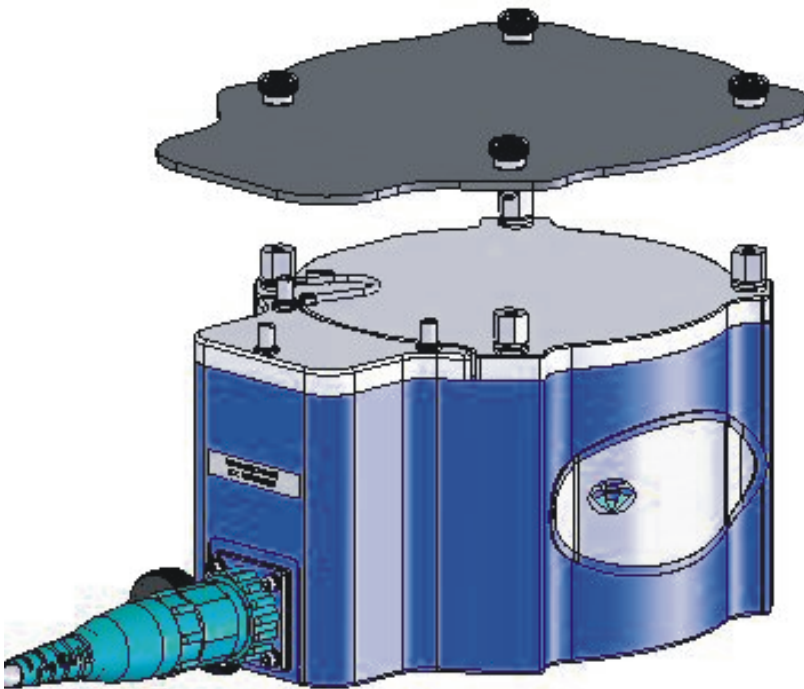


Figure A1. Electronics housing with protective heat shield.

Summary of Procedure

Deployment Preparation

Before departure, all equipment and accessories are accounted for and inspected by the field leader.

Check for correct transducer beam alignment. Beam 3 is pointed forward on the starboard side of the raft and at a 45-degree angle to the centerline of the raft.

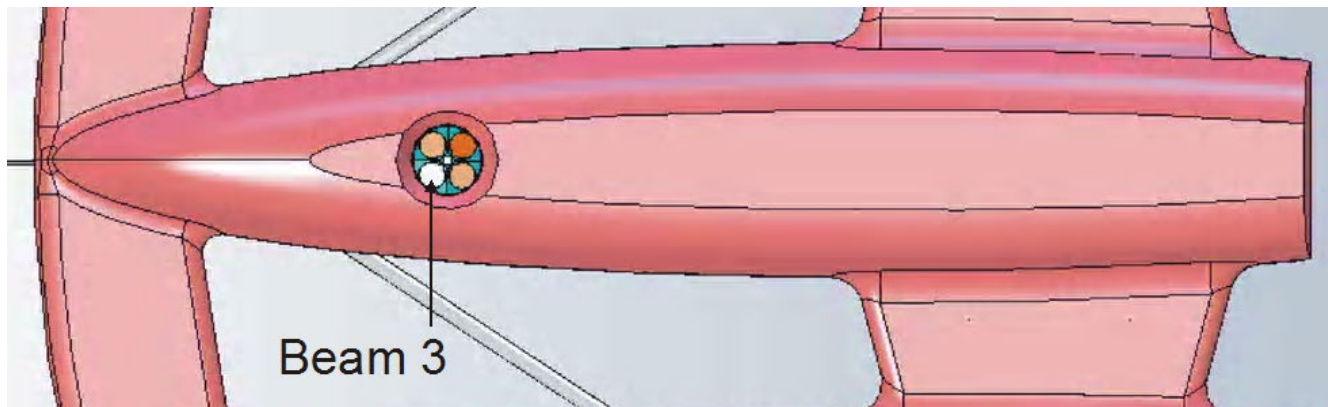


Figure A2. View of the underside of StreamPro raft. Beam 3 pointed forward on the starboard side of the raft.

The transducer head is submerged approximately 0.1 to 0.25 feet in the water.

Inspect the transducer cable for damage. Make sure the transducer cable connector pins are straight and not broken.

Check for sufficient battery power. Turn the ADCP on by depressing the white power button located on the side of the unit. The amber LED light should come on.



Figure A3. StreamPro power switch and indicator lights.

A blinking amber light indicates the StreamPro batteries are low and need replacing. Experience has shown that as battery power diminishes, Bluetooth communication becomes erratic and eventually lost before the amber light begins blinking. The StreamPro requires eight double-A (AA) batteries to operate.

The StreamPro can use rechargeable batteries. Each vehicle assigned to Freshwater Monitoring Unit (FMU) Stream Hydrology staff carries a mobile AA battery charger and an additional contingent of eight rechargeable batteries. While in transit, recharge both sets of batteries so a fresh set is available for the StreamPro and a fully charged set for backup. The A100 GPS antenna also requires eight AA batteries. Recharge batteries for use with the Hemisphere A100 GPS antenna as well.

To install batteries in the StreamPro, refer to the [StreamPro ADCP Guide](#).

If operating a StreamPro through Yuma tablets, make sure accessories such as the detachable soft-shell case with straps, 120-volt wall charger, and 12-volt car charger are on hand. Make sure the wall charger is on hand if using the MobileDemand tablet. The MobileDemand requires a Bluetooth antenna to facilitate Bluetooth communication with the StreamPro. A four-point body harness is also available with the MobileDemand tablets to suspend the tablet from one's chest and shoulders.

If using the GPS receiver, confirm that the dedicated Parani® Bluetooth antenna is available to connect to the Yuma and establish a Bluetooth link between the computer and the GPS antenna. The Parani Bluetooth antenna that attaches to the Yuma is stored in the blue Pelican® case attached to the boat deck of the StreamPro equipped with GPS.

Measurement Preparation

Upon arrival at the measurement site, determine the location of the best cross-section and the safest method of deployment. Optimal operating conditions are straight channels of uniform shape with small, consistent substrate (Oberg et al. 2005). Conditions to avoid are submerged aquatic plants, abrupt changes in stream depth (e.g., boulders and bedrock ledges), large standing waves, substantial upwelling of water in the channel (as evidenced by “boils”), and velocities greater than 6-7 feet/second. Some of these conditions will not become apparent until preliminary depths and velocities are measured.

Deployment Methods

There are two primary methods of ADCP deployment; towing from a bridge and towing from shore. Better control of the raft is maintained through higher velocities, shear zones, and areas of turbulence with two tow lines, each handled by a separate person.

Towing StreamPro from a bridge — Towing a StreamPro from a bridge is typically the most convenient deployment method. However, cross-sections located beneath or immediately downstream of a bridge often are not optimal for measuring stream discharge. Always attempt to find the most favorable measurement cross-section remaining mindful of safety and practicality.

Tie either a bowline or a double figure eight knot with a loop at the end of each tow line and clip into carabiners located at either side of the StreamPro raft.

Carefully lift the StreamPro over the bridge railing and slowly lower it into the stream. If the raft is lowered into the water carelessly, capsizing may occur. If practical, walk the StreamPro to the stream edge and lower the lines from the bridge.

One person will operate the Tablet PC in addition to one of the tow lines.

The person operating the tablet must make sure a Bluetooth connection is maintained throughout the measurement. The Tablet PC operator directs the positioning of the StreamPro to the pre-determined endpoints.

It is best in most bridge measurement applications to measure on the downstream side of the bridge. Then measuring from the upstream side, the raft is usually pushed under the bridge by the current obscuring the orientation and location of the StreamPro. It is difficult to maintain a Bluetooth connection when the StreamPro and Tablet PC do not have a good line of sight, particularly when a concrete barrier separates the Tablet PC and the StreamPro. One disadvantage of deploying the StreamPro from a bridge, and always something to remain mindful of, is the difficulty of the operators to see and avoid floating debris coming from upstream.

Towing the StreamPro from shore — Towing the StreamPro from shore requires two people handling lines on opposite sides of the stream.

Two tow lines are clipped to the carabiners located at either side of the raft. One person pulls the raft across the stream, while the person on the opposite bank pays out line while keeping adequate counter-tension.



Figure A4. StreamPro raft towed from shore to shore (photo by Washington Department of Ecology).

Wide cross-sections with higher velocities can result in significant drag on the tow lines. Towing the raft and controlling orientation in these situations can prove difficult and unsafe. If an unsafe situation exists, abandon the measurement and attempt to find a more suitable location.

Typically, the StreamPro raft will follow the path of an arc across the transect rather than a straight line because of current drag on the raft and tow lines. At wide cross-sections, consider not only the width of the cross-section but also the amount of line needed to compensate for current drag. The tow lines are about 150 feet in length.

Data quality and bottom tracking over irregular substrate are optimized at slower towing speeds. The tow speed should be less than the water velocity. When velocities are less than 1 ft/sec, reduce the tow speed to one-half of the water speed. Make efforts to keep the StreamPro as level as possible through the course of a measurement.

Slowly move the StreamPro toward the bank paying close attention to the “Number of Good Bins” displayed on the tablet screen. As the stream becomes shallower, the number of good bins will decrease. When the display begins to oscillate between one and two good bins, slowly move the StreamPro back toward the center of the stream until there are consistently two good bins.

Because of the potential for side lobe interference, the StreamPro should not measure against vertical walls. The StreamPro should be at a distance from a vertical wall equal to or greater than the depth of water at the vertical wall (Oberg et al. 2005).

Deployment Procedures

Ecology currently has one StreamPro equipped with a compass and GPS capabilities. An ADCP equipped with a GPS receiver must operate with a calibrated compass. In addition, only the Yuma tablets are capable of processing GPS data. The WinRiver II program simultaneously collects and processes measured streamflow data and GPS coordinates.

Ecology’s Environmental Assessment Program uses MobileDemand and Trimble Yuma Ruggedized Tablet PCs loaded with WinRiver II and other ancillary programs to collect simultaneous streamflow and GPS information.

Anytime a Tablet PC is physically in a Department of Ecology office and turned on, it connects automatically to the Ecology network (either wired or wireless). Before leaving the office for the field, turn on the Tablet PC and sign on with your Ecology username and password (same name and password used on your agency desktop or laptop computer). If the user’s password has changed since last logged in to a Tablet PC, the password may be out of sync. If the user’s current password is not successful, try previous passwords, starting with the most recent. Once logged in, allow any Windows updates to complete, then reboot the Tablet PC. Again, let any updates run to completion. This procedure accomplishes two things: First, it applies any outstanding Windows updates to the computer that otherwise would have consumed valuable time in the field (and likely prove unsuccessful in the absence of an internet connection), and it also synchronizes the user’s password which, if not updated, can frustrate the user if she or he is forced to find their correct password while in the field.


Once in the field, power up and log in to the Tablet PC well before commencing measurements, as the boot-up process may take several minutes. The user can choose to log on at the beginning of a day of fieldwork, then place the unit in sleep mode by pressing the power button. Sleep mode keeps the processor running but uses minimal battery. The Yuma tablets can remain in sleep mode for a day or two without completely discharging the battery. The Mobile Demand tablets require more power, so attention must be given to power consumption, even in sleep mode. MobileDemand tablets may require recharging after a few hours. To wake up the Tablet PC from sleep mode, press the power button. The user’s password is not required when waking up the Tablet PC from sleep mode. However, if the Tablet PC falls asleep on its own (after 10 minutes of inactivity), the user password is required upon waking the unit.

Charge Tablet PCs at the end of each field day, if needed.

Once logged on to the Tablet PC, connect to the StreamPro using Bluetooth.

If using the Yuma tablet, double-click the BLUETOOTH SETTINGS icon on the desktop.

If using the MobileDemand tablet, insert the Bluetooth antenna into one of the available USB ports under the hinged protective cover on the right side of the tablet.

Double-click the Bluetooth icon——located on the right side of the taskbar. If the Bluetooth antenna is not plugged in, the Bluetooth icon is colored red. When the antenna is plugged into the USB, the icon is colored white. When connected to a device via Bluetooth, the icon is green.

After clicking the Bluetooth icon, the BLUETOOTH SETTINGS window will appear.

Make sure the icon in the BLUETOOTH SETTINGS window indicates connection to the appropriate ADCP.



Figure A5. Bluetooth Manager screen showing Bluetooth connected icon (interlocking yellow and green bars).

If the StreamPro is not already connected, double-tap the BLUETOOTH icon in the Bluetooth settings window for the appropriate ADCP. The connection should establish, and the Bluetooth icon will change from not connected to connected. The appearance of interlocking yellow and green bars at the bottom of the connection icon indicates the StreamPro is connected. After Bluetooth is connected, minimize the Bluetooth Settings window.

If the ADCP is equipped with a GPS receiver, remove the red USB Bluetooth antenna from the Pelican box and plug it into one of the USB ports on the Yuma tablet. Turn on power to the GPS using the toggle switch on the Pelican box. The LED next to the cable plug on the GPS antenna should turn on, and the LEDs on the serial Bluetooth antenna inside the Pelican box should start flashing. The Bluetooth antennas in each Pelican box are a matched pair. They will connect automatically and only

to each other (not to any other antennas). Return the USB Bluetooth antenna to the pelican box from which it was removed at the end of each measurement to avoid damage to the antenna. Recall that Ecology has only one StreamPro equipped with a compass and GPS capabilities. Only the Yuma tablets are capable of processing GPS data.

The USB ports on the Yuma tablet are on the bottom of the unit, which puts them facing toward the user. This makes using the plug-in USB Bluetooth antenna with the default screen orientation difficult. Fortunately, the screen can easily rotate 90 degrees at a time using the WINDOWS MOBILITY CENTER icon.

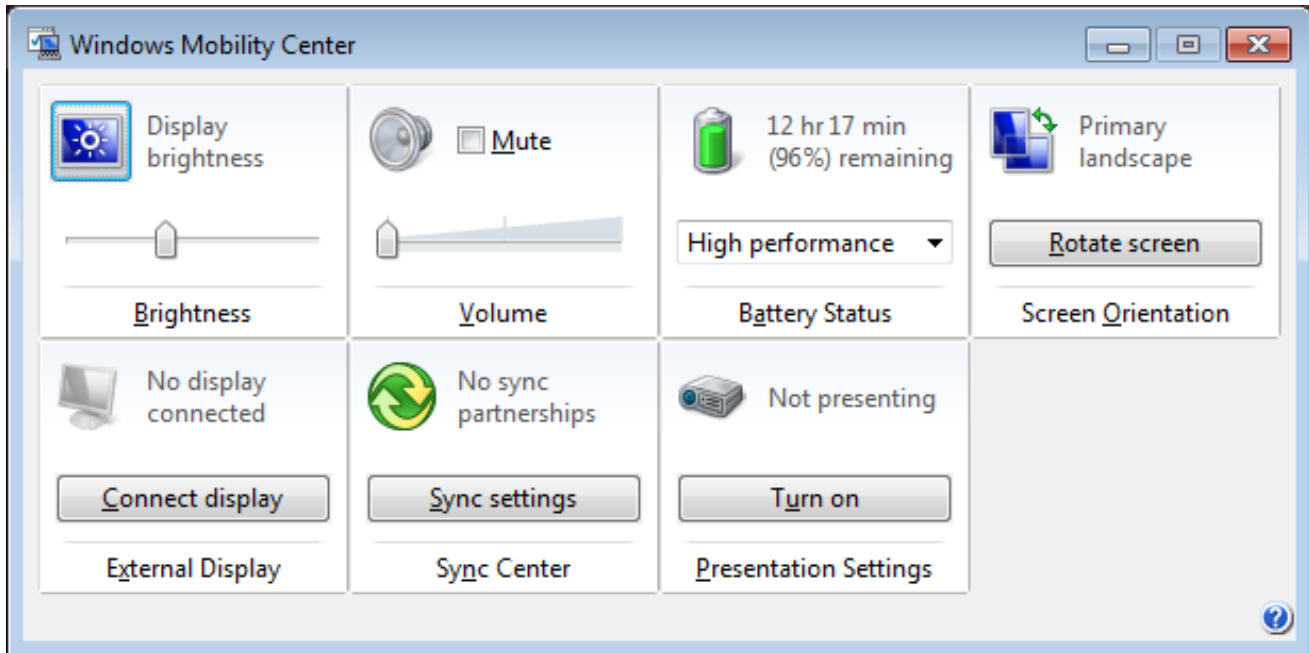


Figure A6. Windows mobility center screen on Yuma tablets. The rotate screen icon is in the upper right.

If the screen orientation is such that the USB ports face the user, double-click the WINDOWS MOBILITY CENTER icon on the desktop of the Yuma.

Find the SCREEN ORIENTATION box and click ROTATE SCREEN until the screen is oriented such that the USB ports face away from the user.

Next, on either of the MobileDemand or Yuma Tablet PCs, launch WinRiver II by double-clicking the WinRiver II icon on the desktop.

A USER ACCOUNT CONTROL prompt might appear, asking the user to allow the program to make changes to this computer. Tap YES.

Once WinRiver II opens, the user can set up the configuration of a new measurement by tapping the FILE tab and selecting NEW MEASUREMENT. This brings up the SETUP DIALOGUE, also known as the MEASUREMENT WIZARD. The Setup Dialog consists of six screens: Site Information, Rating Information, Configuration Dialog, Output Filename Options, Commands Preview, and Summary Page.

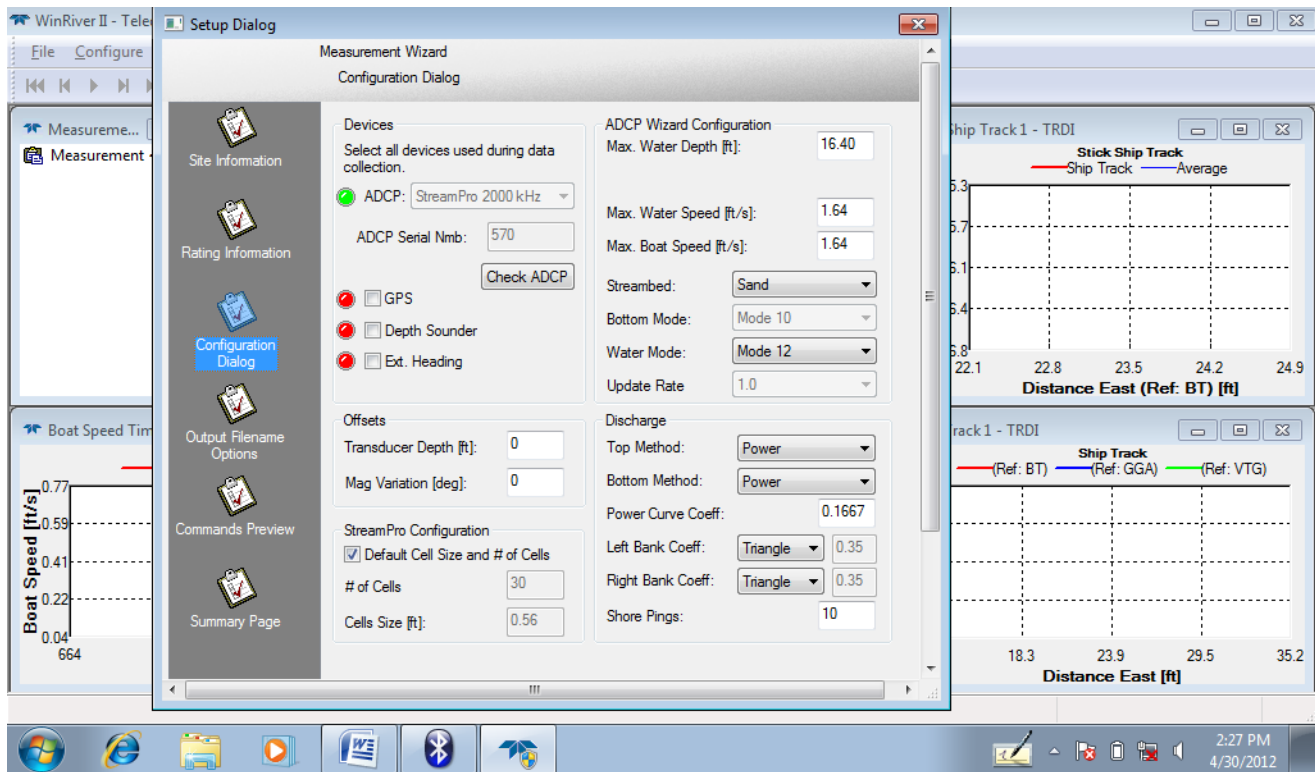


Figure A7. The Configuration Dialog is one of six screens within the Setup Dialog window.

On the left panel of the Setup Dialog screen, tap the CONFIGURATION DIALOG icon. WinRiver will interrogate the StreamPro, and after a few seconds, the model and serial number of the ADCP will populate. The red dot next to the ADCP model should turn green, indicating WinRiver has recognized the ADCP.

If WinRiver cannot find or does not recognize the StreamPro, an ADCP Test prompt will appear, indicating that the ADCP is not responding.

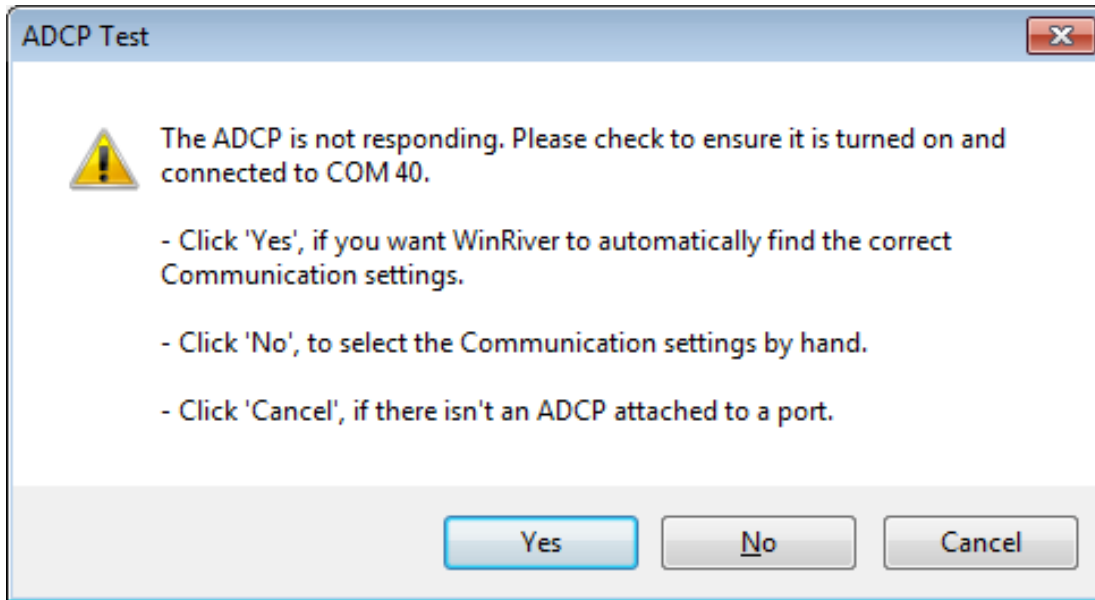


Figure A8. Acoustic Doppler Current Profiler (ADCP) Test prompt will appear if StreamPro does not respond to interrogation. This prompt indicates Bluetooth connection has been lost.

Note the COM port on which WinRiver II is searching for the StreamPro (COM 40 in the sample screenshot above). Click 'NO' to select communication settings by hand. A Serial Communication Settings prompt will appear. Verify the following:

- Baud rate is 115200.
- Data bits is 8.
- Parity is None.
- Stop Bits is 1
- Note COM Port setting.

Open the BLUETOOTH SETTINGS window from the Windows Task Bar at the bottom of the screen (the Bluetooth window was previously minimized after initially establishing the Bluetooth connection between the StreamPro and Tablet PC). With the appropriate Bluetooth Connection icon highlighted, tap the DETAILS button at the bottom of the window. A Detailed Settings window will appear.

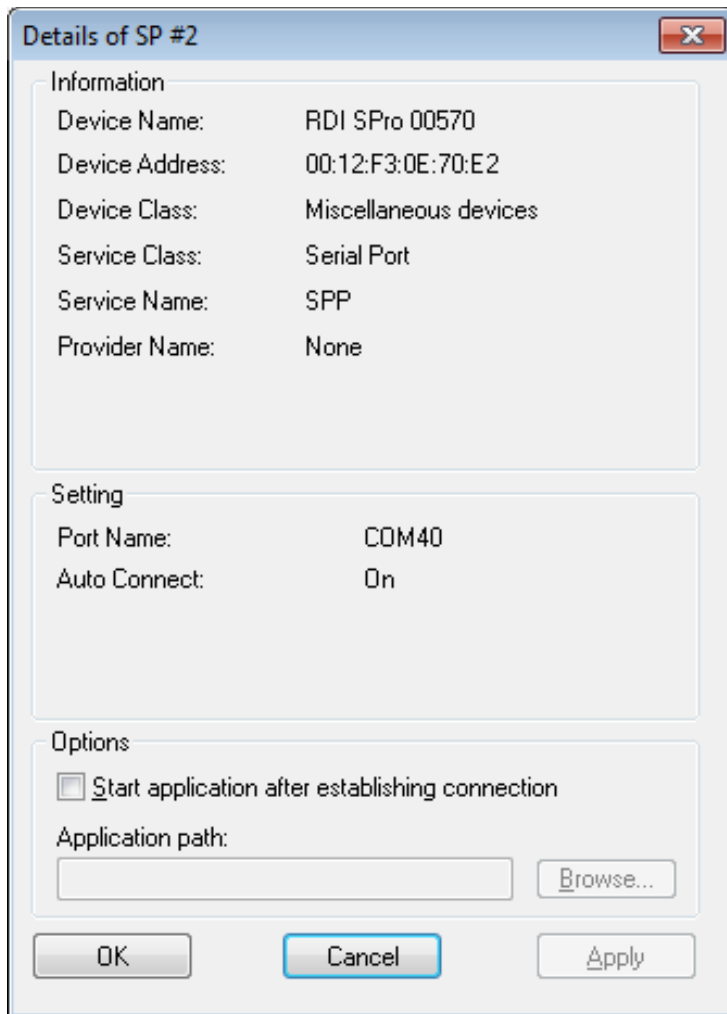


Figure A9. Detailed settings window. Note the port name.

The port name should match the COM Port setting in WinRiver II.

In the SETTING section, note the Port Name, click OK, and return to WinRiver II.

Click on CONFIGURE in the upper left of the WinRiver II workspace. When the drop-down appears, click PERIPHERALS. In the PERIPHERAL CONFIGURATION DIALOG box, click the plus (+) sign under the PERIPHERALS heading. When the dropdown menu appears, double-click on PORT: ADCP SERIAL PORT. In the SERIAL COMMUNICATION SETTINGS dialog, change the WinRiver II COM port setting to match the Port Name in BLUETOOTH SETTINGS/ DETAILS by selecting the appropriate COM port from the dropdown list and tap OK.

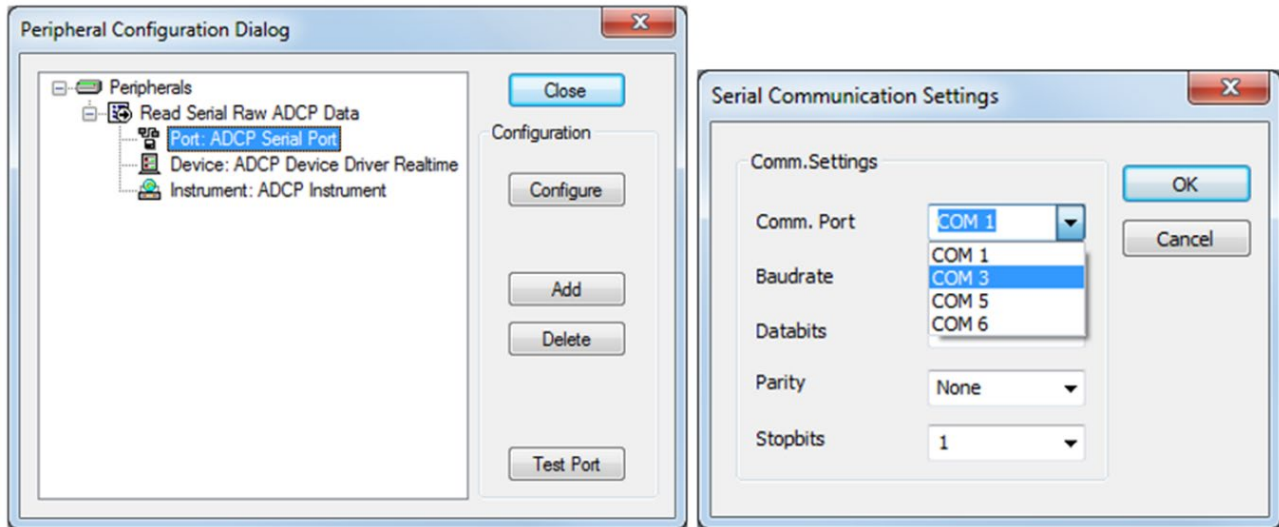


Figure A10. Peripheral Configuration Dialog box (left) and Serial Communication Settings Com Port drop-down list (right). Select the Com Port matching the Port Name found in Bluetooth Settings/Details.

The StreamPro should now connect via Bluetooth to the Tablet PC, as evidenced by the green light next to the ADCP model number in the Configuration Dialog screen.

Once the ADCP is connected, several warnings may appear in the Configuration Wizard about transducer depth setting, magnetic variation, boat speed, and moving bed. These warnings are reminders to set the appropriate parameters in the Configuration Wizard. Most will quit occurring once the appropriate parameters are set. However, the GPS warning is quite persistent throughout the Configuration Wizard.

Navigate back to the Configuration Dialog in the Setup Dialog window. If the StreamPro is equipped with a GPS antenna, select the check box next to GPS. The red dot next to GPS should turn green, and a warning about settings requirements related to the use of GPS will appear. These warnings typically refer to magnetic variation, compass calibration, and bottom reference settings.

Under OFFSETS, set the proper transducer depth; for StreamPro ADCPs, transducer depth is 0.2 ft.

If using the StreamPro equipped with a compass, set the MAGNETIC VARIATION (declination). Magnetic declination for Washington State currently ranges from 14.8° to 17.2° and changes yearly. The user can look up the current magnetic declination for specific field destinations at: <http://magnetic-declination.com/>.

Approximate maximum water depth and water velocity visually and populate MAX. WATER DEPTH (FT) and MAX. WATER SPEED (FT/S) fields. The user can refine these entries later.

Set MAX. BOAT SPEED field equal to maximum water speed. Actual boat speed during transects and loop moving bed tests should not exceed half the water velocity.

Select the appropriate substrate type from the STREAMBED dropdown.

Set appropriate LEFT and RIGHT BANK COEFFICIENTS based on channel shape at each bank (i.e., square or triangular).

BOTTOM MODE, WATER MODE, and UPDATE RATE are all set automatically by WinRiver II. SHORE PING is always set at 10.

Next, tap the SITE INFORMATION icon in the panel on the left side of the setup dialogue window.

Enter the Station ID number in the STATION NUMBER field.

If known, enter the measurement number (based on the Hydstra Gaugings database) in the MEASUREMENT NUMBER field.

Set DEPLOYMENT TYPE based on the method of measurement.

Set MEAS. LOCATION (optional).

All other fields on this screen are optional.

Tap the RATING INFORMATION icon on the left panel of the Setup Dialogue window or tap NEXT at the bottom of the Site Information window. Enter rating information on this screen.

Next, navigate to the OUTPUT FILENAME OPTIONS icon in Setup Dialog.

Set the filename prefix per the adopted FMU file naming convention (i.e., STATION NUMBER-YYYY-MM-DD). Example: 18A050-2016-05-05

OUTPUT DIRECTORY should be C:\Measurements\

Under the INCLUDE FILENAME OPTIONS section, uncheck all options except TRANSECT NUMBER

Filename Preview will show a sample of the resulting filename.

COMMANDS PREVIEW settings are set in part by WinRiver II based on information entered by the user in CONFIGURATION DIALOG. Find more information regarding coded commands in the StreamPro ADCP Guide.

If, at any time during the measurement, it becomes necessary to change settings from the Setup Dialog|ConfigurationWizard, the user may select CONFIGURATION WIZARD from the ACQUIRE tab on the menu bar. Some settings, such as filename information, are no longer editable after initial configuration, but others, such as bottom depth, etc., can be edited anytime.

From the menu bar, select ACQUIRE, then choose SET ADCP CLOCK. If GPS is available, the user can set the ADCP clock using GPS time. Make sure the CORRECT WITH PC TIME ZONE box is checked. If GPS is unavailable, use PC time. Since Tablet PCs are frequently connected to and synced with the Ecology network, PC times are quite accurate. Note that if there is no GPS present, a warning that the selected GPS port cannot be found will be displayed before the SET ADCP CLOCK DIALOG is displayed. This usually means the Bluetooth antenna is not plugged into the Yuma tablet. Click OK to proceed to the SET ADCP CLOCK DIALOG window.

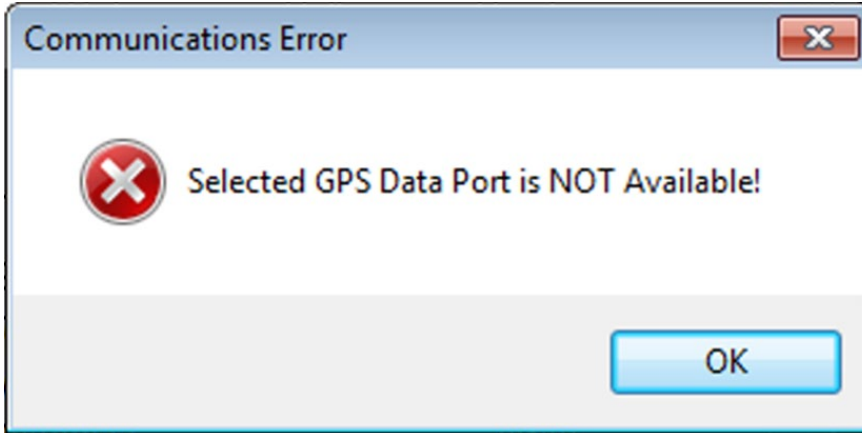


Figure A11. Warning Display indicating GPS data port is unavailable.

After setting the ADCP clock, select ACQUIRE, then EXECUTE ADCP TEST from the menu bar. This is the standard ADCP self-test, which takes several seconds to complete. Results are logged and available for review in the MEASUREMENTCTRL window under the QA/QC dropdown.

If using the StreamPro with a compass, from the menu bar, select ACQUIRE, then EXECUTE COMPASS CALIBRATION. Follow the prompts in the compass calibration window. Attempt to keep the StreamPro as level as possible while rotating the instrument during calibration. The calibration can take place in a calm part of the river or stream. A swiveled, rotating platform on which the StreamPro can be rotated is available at the EAP Operations Center.

Next, ascertain the maximum channel depth for the selected cross-section. From the menu bar, select ACQUIRE, then START PINGING. If the ADCP Clock was not set, a window will appear prompting the user to do so now.

If the clock is properly set, the ACQUIRE CONTROL window will appear, indicating the instrument is pinging but not recording.

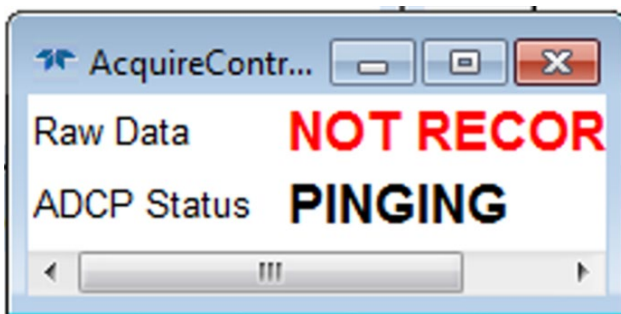


Figure A12. Acquire Control window indicating Acoustic Doppler Current Profiler (ADCP) is pinging but not recording.

Slowly move the StreamPro from one bank to the other in the intended cross-section. Note the maximum depth and water speed encountered visually in the VELOCITY CONTOUR window or noted from the COMPOSITE TABULAR screen.

After moving the StreamPro over the cross-section and noting the maximum depth and water speed, select ACQUIRE, then STOP PINGING from the menu bar.

Again from the menu bar, select ACQUIRE, then CONFIGURATION WIZARD.

In the Configuration Wizard, select the CONFIGURATION DIALOG page from the pane on the left side of the window.

Set the MAX. WATER DEPTH and MAX. WATER SPEED (in the upper right side of the window) to that noted during pinging

Set MAX. BOAT SPEED to roughly half the water speed. Do not exceed this speed during measurement transects.

Select SUMMARY PAGE from the panel at the left side of the Configuration Wizard, then scroll to the bottom of the page and tap FINISH.

Moving Bed Test — StreamPros determine their relative position and speed by bottom tracking. Accurate bottom tracking is reliant on a stable, non-moving stream bed. Moving bed situations result in a bias to the determination of the StreamPros speed over the ground. This bias results in errors (underestimations) in water velocity calculations, adversely affecting accurate flow measurements. The moving bed test determines if bed movement is present and the degree to which the condition exists.

Conduct a moving bed test prior to all ADCP measurements. Even in conditions where the bed appears stationary, sediment transport near the bed can affect bottom track pulses. In addition, sediment transport characteristics can vary at the same discharge, meaning moving bed may be detected at a discharge where previously none was detected (Oberg et al. 2005).

If a moving bed condition exists, there are two ways to account for it. The first involves collecting valid GPS coordinates for every ensemble. GPS coordinates replace bottom tracking as the ADCP positional reference, eliminating the bias in water speed calculation caused by moving bed. This method requires continuous collection of valid GPS data, which can be difficult at sites with riparian tree cover or other obstructions, such as bridges or overhead power lines.

The second way to account for the moving bed is through an analysis of the moving bed test and subsequent correction of discharge values based on the results of the moving bed test.

Currently, two methods test for moving bed; the Loop and Stationary methods. The loop test requires an ADCP equipped with a calibrated compass.

A loop moving bed test consists of starting at a marked location near one of the channel banks, moving to a location near the other channel bank, and returning to the marked location. This test should take at least 3 minutes. Do not linger or pause at the edges. Return to the exact starting location. Bottom track must be maintained throughout the test (bad ensemble threshold is 5%). During the loop test, note the maximum channel depth and maximum velocity for later entry to Configuration Wizard.

From the menu bar, select ACQUIRE, then START PINGING.

Again from the menu bar, select ACQUIRE, then select MOVING BED TEST.

Select LOOP TEST, tap OK, and the test will begin immediately.

Move the boat slowly from the marked location to the opposite bank and back. Begin moving the boat immediately upon the start of the test, and do not linger at the far edge. Upon returning to the marked location on the starting bank, select ACQUIRE, then STOP MOVING BED TEST from the menu bar.

The stationary method is conducted when a StreamPro with a calibrated compass is not available, or bottom tracking is not adequately maintained through a loop test.

A stationary moving bed test consists of positioning the StreamPro in the thalweg of the channel or the location with the greatest potential for moving bed. The test duration is at least 5 minutes, and the StreamPro raft should remain as stationary as possible for the test period. In a tethered deployment, try to minimize “swimming.” Bottom tracking, boat, and water velocities must be maintained throughout the test period.

Position the StreamPro in the thalweg of the channel or the location with the greatest potential for moving bed.

From the menu bar, select ACQUIRE, then START PINGING.

From the menu bar, select ACQUIRE, then select MOVING BED TEST.

Select STATIONARY, tap OK, and the test will begin immediately.

Hold the StreamPro as stationary as possible for at least 5 minutes. The duration of the test can be found at the bottom of the Composite Tabular window.

At the end of the test, select ACQUIRE from the menu bar, then STOP MOVING BED TEST.

After a moving bed test, the Test Result window appears in the WinRiver II workspace. The test result presents the parameters of the test and indicates if a moving bed sufficient enough to warrant correction to the measurement is present. If the moving bed velocity is greater than 0.04 feet per second and greater than 1% of the water velocity, then the moving bed warrants correction to the discharge measurement. The test results also present reasons why the test was invalid or any warnings to consider when analyzing test results.

Close the test results by tapping the CLOSE button in the upper right of the test results window. The COPY button to the left of the close button copies the test results in text format. One can access test results in the MEASUREMENTCTRL window in the WinRiver II workspace. Select QA/QC or tap the plus (+) sign to the left. Select MOVING BED TEST. Select LOOP or STATIONARY depending on the type of test conducted, and finally, select TEST RESULT. After post-processing, the ADCP measurement, copy and paste the test results into the Hydstra GAUGINGS comments.

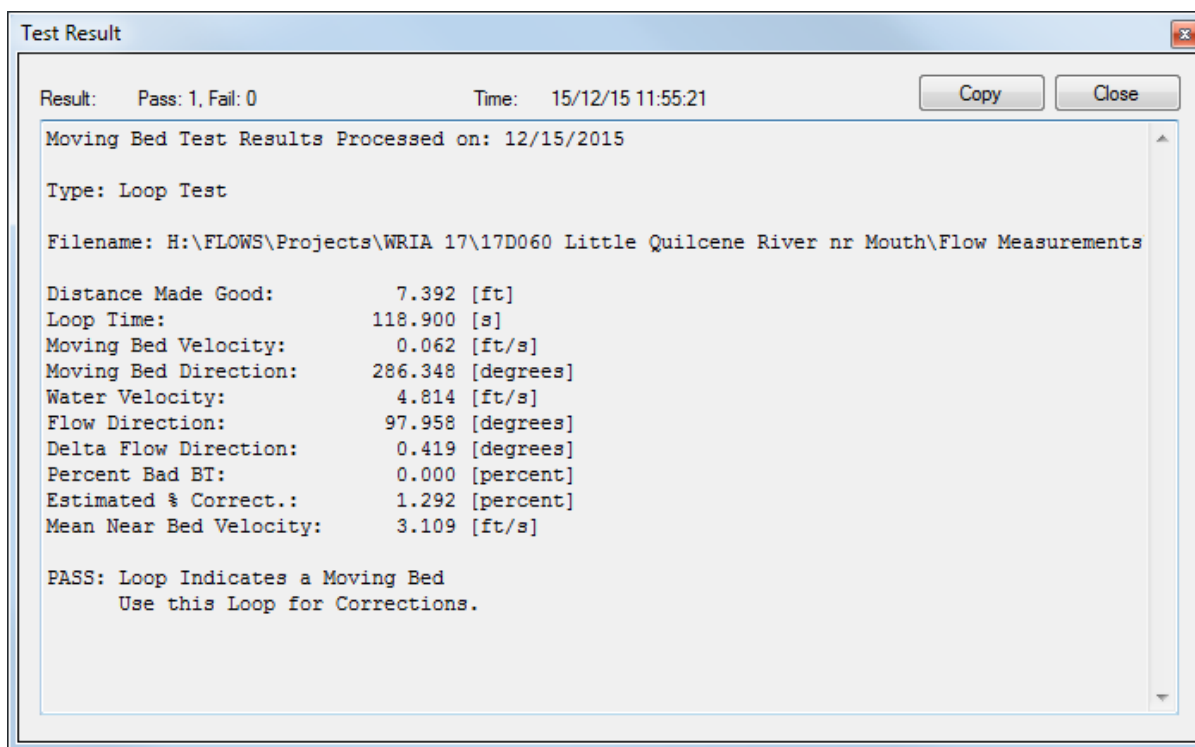


Figure A13. Moving Bed Test results window.

Corrections to flow measurement values based on moving bed tests occur automatically in WinRiver II after the measurement is complete. WinRiver II applies corrections to the flow values of each transect, and the results are averaged. These corrections are displayed in the MBT SUMMARY. Access MBT SUMMARY in the MEASUREMENTCTRL window in the WinRiver II workspace. Select QA/QC or tap the plus (+) sign to the left. Select MOVING BED TEST, then select MBT SUMMARY.

| Selected MB Tests | | | | | | | | | | | |
|-------------------|--------------------|-------------------|------------|-------------|----------|----------------|------------|--------------------|------------------|--------------------|----------------------|
| MB Test | Used in Correction | Distance US/MG ft | Duration s | MB Vel ft/s | MB Dir ° | Water Vel ft/s | Flow Dir ° | Diff in Flow Dir ° | Average Depth ft | % Bad Bottom Track | Potential MB Error % |
| Loop 000 | YES | 7.392 | 118.90 | 0.062 | 286.35 | 4.814 | 97.96 | 0.42 | | 0.00 | 1.29 |

| Applied Corrections | | | | | |
|---------------------|---|---|-------------------------|-----------------|--------------------------|
| Transect ID | Bottom-Track Discharge ft ³ /s | MB Corrected Discharge ft ³ /s | Correction Difference % | Correction Type | Average MB Velocity ft/s |
| 000 | 330.791 | 339.167 | 2.53 | Distributed | 0.062 |
| 001 | 377.666 | 383.893 | 1.65 | Distributed | 0.062 |
| 002 | 354.186 | 359.538 | 1.51 | Distributed | 0.062 |
| 003 | 387.058 | 393.468 | 1.66 | Distributed | 0.062 |
| 004 | 369.437 | 373.738 | 1.16 | Distributed | 0.062 |
| 005 | 357.631 | 362.694 | 1.42 | Distributed | 0.062 |
| 006 | 355.358 | 359.596 | 1.19 | Distributed | 0.062 |
| 007 | 350.197 | 354.710 | 1.29 | Distributed | 0.062 |
| Average | 360.291 | 365.850 | 1.55 | Distributed | 0.062 |

Figure A14. Moving Bed Test summary window. Moving bed corrections are applied to the flow value of each measured transect, and the results are averaged.

Collect measurement transects—After executing the moving bed test, select ACQUIRE, then START PINGING from the menu bar. This will bring up the ACQUIRE CONTROL window, indicating the instrument is pinging but not recording (figure A14).

If maximum depth, water speed, and boat speed need updating after the moving bed test, the user can do so in CONFIGURATION WIZARD as described on pages 21 and 22. Note: Once the initial depth, water, and boat speeds are entered and saved in SETUP DIALOG, users can only change those settings in CONFIGURATION WIZARD under the ACQUIRE tab.

Position the ADCP at one edge of the intended cross-section. Move the ADCP out from the bank until there is sufficient depth that the COMPOSITE TABULAR window consistently shows at least two good bins.

Note the measured distance from the transducer head to the bank. This marks the start from and return point at this bank for each transect.

From the menu bar, select ACQUIRE, then START TRANSECT. This will bring up the START TRANSECT dialog.

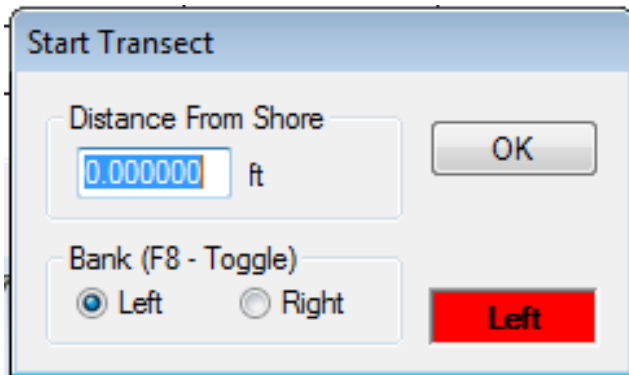


Figure A15. Start (and End) Transect dialog window.

Enter the noted distance (in feet) from the bank to the transducer head in the DISTANCE FROM SHORE field, set the BANK TOGGLE to the correct bank (left or right), and tap OK.

As soon as START TRANSECT is selected, WinRiver starts recording transect data. However, keep the StreamPro stationary, as at least 10 good ensembles must be collected as indicated by NUMB. OF ENS minus BAD ENS. in the COMPOSITE TABULAR window. After at least 10 good ensembles are obtained at the edge location, proceed steadily across the channel at a speed no greater than half the water velocity.

As the StreamPro approaches the far bank, note the number of good bins indicated in the COMPOSITE TABULAR window. Once the StreamPro reaches a location with a steady count of 2 bins, hold steady in that location while marking this location and measuring the distance from the transducer head to that bank. Collect at least 10 good ensembles at this location before selecting ACQUIRE, then END TRANSECT from the menu bar to stop recording.

In the END TRANSECT dialogue, enter the noted distance (in feet) from this bank to the transducer head in the DISTANCE FROM SHORE field, set the BANK TOGGLE to the correct bank (left or right), and tap OK.

Final statistics for the completed transect will appear in blue in the COMPOSITE TABULAR window.

Make sure the StreamPro is in the proper position (i.e., the position that ended the previous transect) and measure three more transects.

After four transects, select DISCHARGE SUMMARY in the SITE DISCHARGE section of the MEASUREMENTCTRL window.

Assess the total variability indicated by the DELTA Q column in the DISCHARGE SUMMARY window.

If any transects show a Delta Q greater than $\pm 5\%$, measure four additional transects.

After all transects have been collected, select ACQUIRE, then select STOP PINGING, close WinRiver II, turn off the StreamPro, and GPS if so equipped, and place the Tablet PC in sleep mode by pressing the power button.

Confirming StreamPro Water Temperature — The water temperature measured by the StreamPro computes the speed of sound through water. The computed speed of sound determines velocities, depths, and discharge. A 5°C error in measured temperature results in a 2% bias in the measured discharge (Oberg et al. 2005).

Measure water temperature using a calibrated thermistor for comparison with the StreamPro temperature sensor. The independent temperature measurement should be conducted adjacent to the StreamPro after determining edge distances while the instrument is still testing pinging. View the water temperature in the COMPOSITE TABULAR window to compare the measured and recorded temperatures.

If the water temperature difference is greater than 2°C, TRDI should be consulted, and the temperature sensor should be considered for repair or replacement. Note both water temperatures on the measurement field sheet.

Viewing and Compiling Data in WinRiverII—Typically, post-processing and analysis of ADCP measurements occur in the office. As stated earlier, the Tablet PCs connect automatically to the Ecology network once inside an Ecology office. As soon as possible, transfer all ADCP measurement files to the appropriate network drive.

Start WinRiver II on an office PC. Select the FILE tab in the upper left of the screen and select OPEN MEASUREMENT. From the SELECT MEASUREMENT FILE DIALOGUE, navigate to the folder created in SETUP DIALOGUE and select the file with the appropriate station name ending in the suffix .mmt and click OPEN. The created measurement will appear in the MEASUREMENTCTRL window with the numbered transects checked.

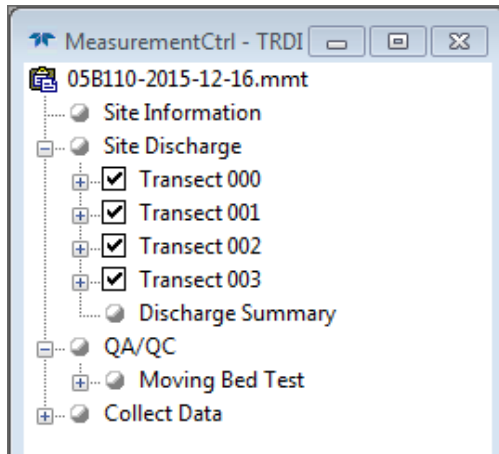


Figure A16. MeasurementCtrl window.

To playback all the transects, select REPROCESS CHECKED TRANSECTS from the PLAYBACK Menu.

Select the DISCHARGE SUMMARY node from the MEASUREMENTCTRL window. The Discharge Summary displays all checked transects and presents a comprehensive comparison between transects. Transect statistics in red indicate the transect’s discharge Delta statistic is greater than plus or minus 5% from the average discharge of all the processed transects.

| Transect | Start Bank | # Ens. | Start Time | Total Q ft ³ /s | Delta Q % | Top Q ft ³ /s | Meas. ft ³ /s |
|----------------------|------------|--------|------------|-------------------------------|--------------|-----------------------------|-----------------------------|
| 05B110-2015-12-16000 | Right | 134 | 09:04:35 | 697.591 | -0.74 | 68.918 | 540.4 |
| 05B110-2015-12-16001 | Left | 99 | 09:07:33 | 733.732 | 4.41 | 73.461 | 569.2 |
| 05B110-2015-12-16002 | Right | 131 | 09:10:04 | 683.210 | -2.78 | 66.886 | 528.8 |
| 05B110-2015-12-16003 | Left | 108 | 09:12:43 | 696.549 | -0.89 | 69.528 | 538.0 |
| Average | | 118 | | 702.770 | 0.00 | 69.698 | 544.1 |
| Std Dev. | | 17 | | 21.654 | 3.08 | 2.751 | 17.48 |
| Std./ Avg. | | 0.14 | | 0.03 | 0.00 | 0.04 | 0.03 |

Figure A17. Discharge Summary window.

Un-checking the transect in the Measurement Management window removes the transect from the summary. Do not permanently remove transects from the summary unless there is certainty that a data quality problem exists due to equipment malfunction, computer problems, configuration errors, or other difficulties occurring during the measurement. Document all transect removals.

In the Discharge Summary window in WinRiver II, place the mouse pointer at any location in the window, right-click, and select COPY. Navigate to the ADCP Discharge Summary Report Template Excel file located in the Stream Hydrology group's shared server folder (H:\FLOWS\QAData).

| Transect Number | Total Q ft ³ /s | Delta Q % | Meas. Q ft ³ /s | Top Q ft ³ /s | Bottom Q ft ³ /s | Left Q ft ³ /s | Right Q ft ³ /s | Width ft | Total Area ft ² | Q/Area ft/s | Wetted Perimeter ft | Duration s |
|-----------------|-------------------------------|--------------|-------------------------------|-----------------------------|--------------------------------|------------------------------|-------------------------------|-------------|-------------------------------|----------------|------------------------|---------------|
| 00 | 339.17 | -7.29 | 175.56 | 123.09 | 28.78 | 7.34 | 4.41 | 48.46 | 80.70 | 4.20 | 51.79 | 120.17 |
| 01 | 383.89 | 4.93 | 200.84 | 139.73 | 32.03 | 7.32 | 3.98 | 52.95 | 88.49 | 4.34 | 56.29 | 101.84 |
| 02 | 359.54 | -1.73 | 188.02 | 128.77 | 31.38 | 7.48 | 3.88 | 47.66 | 78.43 | 4.58 | 50.95 | 97.96 |
| 03 | 393.47 | 7.55 | 204.26 | 143.35 | 34.64 | 7.86 | 3.36 | 53.19 | 88.16 | 4.46 | 56.50 | 89.26 |
| 04 | 373.74 | 2.16 | 197.15 | 133.95 | 30.87 | 8.19 | 3.49 | 48.97 | 80.92 | 4.62 | 52.27 | 100.30 |
| 05 | 362.69 | -0.86 | 193.43 | 132.31 | 25.53 | 8.18 | 3.25 | 52.64 | 88.30 | 4.11 | 55.99 | 109.20 |
| 06 | 359.60 | -1.71 | 183.69 | 135.95 | 28.85 | 7.53 | 3.57 | 49.36 | 80.79 | 4.45 | 52.63 | 91.39 |
| 07 | 354.71 | -3.05 | 188.76 | 130.68 | 23.86 | 7.76 | 3.66 | 49.93 | 81.84 | 4.33 | 53.21 | 92.56 |
| Mean | 365.85 | 0.00 | 191.46 | 133.48 | 29.49 | 7.71 | 3.70 | 50.40 | 83.45 | 4.39 | 53.71 | |
| Stdev | 17.22 | 4.71 | 9.42 | 6.35 | 3.52 | 0.35 | 0.38 | 2.20 | 4.14 | 0.18 | 2.22 | |
| Stdev/Mean | 0.05 | 0.00 | 0.05 | 0.05 | 0.12 | 0.05 | 0.10 | 0.04 | 0.05 | 0.04 | 0.04 | |

Figure A18. Discharge Summary Report Template (Table by Washington Department of Ecology).

Open the template file. Select the INSTRUCTIONS tab and follow the instructions.

Print a copy of the template and a color copy of the Velocity Contour Window from a representative transect. Submit these printed copies and the ADCP Field Measurement sheets for review.

For information on more detailed analytical tools in WinRiver II, consult the WinRiverII User's Guide.

Records Management

StreamPro transect files (.PDO) and post-processed WinRiver II measurement files (.mmt) are saved in Windows file system folders exclusive to a particular StreamPro measurement.

The folders containing these files are located in the Stream Hydrology Group's shared server.

Original field notes are saved in central filing locations at respective Ecology offices.

Reviewed discharge summary reports are kept in possession of the principal investigator of the particular flow monitoring station.

A record of peer reviews of all discharge measurements is located in the Stream Hydrology Group's shared server.

Quality Control and Quality Assurance Section

Because ADCP data and results are collected and processed in the field, the largest share of Quality Control and Assurance is performed in the field. Most equipment and deployment problems adversely affecting a measurement are identified during the measurement or through cursory reviews after the measurement.

Addressing data collection problems in the field may require changing cross-sections, repairing equipment, alternative deployment methods, adjusting configuration file settings, and additional transects.

After the measurement, all transects comprising the measurement are assessed to identify data quality problems and assign a preliminary quality rating.

As a general guide, if the Delta Q of the discharge of all transects is within 2%, the measurement is considered excellent. If Delta Q is within 5%, the quality of the measurement is good. A Delta Q within 8% (with at least eight transects measured) is considered fair. The measurement is regarded as poor if there are transects with Delta Q greater than 8%.

In addition to the Delta Q statistics, area, width, and velocities should be consistent between transects. The field investigator should also consider factors such as cross-section quality and flow conditions as part of the quality assignment.

Consider downgrading the measurement quality if one or more transects contain greater than 10% bad ensembles. This especially applies even when less than 10% of the bad transects are concentrated in one part of the cross-section (Oberg et al. 2005).

Downgrade measurement quality with 25% or more bad bins in one or more transects. Pay attention to the distribution of the bad bins across the transect. If bad bins are distributed uniformly, downgrading the quality may not be necessary (Oberg et al. 2005).

Any changes in quality assignments are documented and included with materials submitted for measurement review.

Measurement Review

All StreamPro measurements are peer-reviewed. Reviewed materials include completed field forms and notes, the discharge summary table, and a copy of the velocity contour graph. Also, include photos or any other pertinent information. Before review, the measurement is entered into the Hydstra Gaugings database.

The reviewer checks measurement notes to make sure proper measurement procedures were followed, and the data reflects the assigned quality code. The Hydstra Gaugings database is checked to verify that measurement statistics, stage height, quality assignments, and notes are entered correctly. After the Gaugings database is verified, the reviewer enters their initials in the check box provided.

The reviewer examines the discharge summary table to evaluate the variability between all parameters of the measured transects. Measurements are also checked for starting bank reciprocity and transect duration. Velocity contours are checked for high numbers of bad ensembles and depth cells, as well as ensuring the velocity profile extends to the full depth of the channel.

The reviewer enters the coefficient of variation of Total Q, Area, and Velocity into the Stream Hydrology Group's Quality Assurance Database.

When the review is complete, the reviewer initials the field note sheet in the space provided in the upper right corner and returns the submitted materials along with any written comments to the lead investigator.

Safety

Personal Flotation Devices are required for persons working in or near bodies of water.

All EAP safety policies are followed, and safety is always the top priority when operating this instrument.

In all measurement situations, unsafe deployments that may injure staff or cause loss or damage to equipment are not attempted. Refer to the EAP Safety Manual for further information about working in and around streams.

Always consider the safety and traffic situations when measuring from a bridge and take appropriate actions, including suspending the measurement if unsafe conditions exist. Consult the EAP Safety Manual (pages 1-37) for further guidance regarding bridge measurement safety.

Crossing the stream is done safely and in accordance with the guidelines for working in and around streams established in the EAP Safety Manual (pages 1-35).

Appendix A. References

Blachard, Stephan F. 2005. Guidance on the use of RD instruments StreamPro Acoustic Doppler Profiler. United States Geological Survey, Office of Surface Water. Technical Memorandum 2005.05.

Environmental Assessment Program, 2015. Environmental Assessment Program Safety Manual, March 2015. Washington State Department of Ecology, Olympia, WA.

Oberg, Kevin A.; Morlock, Scott E.; Caldwell, William S. 2005. Quality-Assurance Plan for Discharge Measurements Using Acoustic Doppler Current Profilers. United States Geological Survey In cooperation with the U.S. Army Corps of Engineers, Detroit District. Scientific Investigations Report 2005-5183.

Teledyne RD Instruments. StreamPro ADCP Guide. 2015. P/N 95B-6003-00.

Teledyne RD Instruments. WinRiver II User's Guide. 2016. P/N 957-6231-00.

(Unless otherwise noted, all photos and images used in this document are courtesy of Teledyne RD Instruments©.)

Measurement Notes

Test Ping Transect: _____
 Right Edge Dist. _____ File Name: _____
 Left Edge Dist. _____ Water Mode: _____ Profiler depth _____
 Max Depth _____ Location on SD Card: _____
 Max Velocity _____ Moving Bed Test: Yes No _____ ft. in _____ Seconds
 Cell Size _____ No. of Cells _____ Deployment _____

| Transect Number | Start Bank R/L | Start Time PST | Distance to Right Edge | Distance to Left Edge | Discharge | | | Velocity | Width | Area | |
|-----------------|----------------|----------------|------------------------|-----------------------|-----------|--|--|----------|-------|------|--|
| | | | | | | | | | | | |
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| Averages | | | | | | | | | | | |

Notes

Back of ADCP discharge measurement sheet where staff transcribe measurement information generated by WinRiver II.