

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedure for Operation of the Teledyne RD Instruments Stream-Pro Acoustic Doppler Current Profiler

Version 1.1

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Date – 04/12/2013 04/15/2013 04/12/2013

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Date – 04/12/2013

EAP055

Approved: 04/12/2013  
RECERTIFIED: 7/29/2016

Signatures on file

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### SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
04/01/2013	1	Added procedures related to operating ADCP's with newly available compasses, GPS receivers, and Trimble® Yuma Tablets.	6	Jim Shedd, Chuck Springer
04/01/2013	1	Included new procedures for testing, analyzing, and correcting moving bed conditions.	6	Jim Shedd, Chuck Springer, Casey Clishe
07/29/2016	2	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
07/29/2016	2	Removed references to Section by Section software.	3	Jim Shedd
07/29/2016	2	Added new language describing update to WinRiver II software and related analysis and documentation of moving bed tests.	6	Jim Shedd
07/29/2016	2	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
07/29/2016	2	Made grammatical and formatting adjustments, rephrased language throughout document.		Jim Shedd
07/29/2016		Recertified	All	Bill Kammin

## **Environmental Assessment Program**

Standard Operating Procedure for the Operation of the Teledyne RD Instruments Stream-Pro Acoustic Doppler Current Profiler.

### **1.0 Purpose and Scope**

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for Operation of the Teledyne RD Instruments© (TRDI) StreamPro Acoustic Doppler Current Profiler (ADCP).

### **2.0 Applicability**

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

2.2 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).

2.3 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.

### **3.0 Definitions**

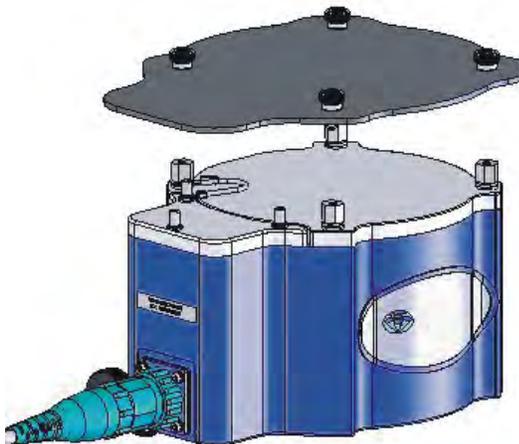
3.1 Transducer Housing — The blue cylindrical transducer housing is connected to a cable assembly which is connected to the electronics housing. The four transducer heads on the bottom of the transducer housing emit and receive sound waves used to measure water velocity, stream depth, and speed of the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

3.1.1 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.



**Figure 1. Transducer housing and cable.**

- 3.2 Electronics Housing — The blue and white electronics housing contains and protects the electronic components. The electronics housing can be submerged for short periods of time in depths up to two meters; however submersion is strongly discouraged by the manufacturer.
- 3.2.1 Covering the top of the electronics housing is a dark colored, plastic sun shield designed to prevent overheating.
- 3.2.2 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 low battery level. The activated blue LED indicates a Bluetooth link has been acquired.



**Figure 2. Electronics Housing with protective heat shield.**

3. 3        WinRiver II — The WinRiver II program is designed to process and store discharge information from the StreamPro. WinRiver II simultaneously processes GPS positions and streamflow data as well as provide\_detailed analysis of measurements performed by StreamPro.
3. 4        Bluetooth Wireless Link — A Bluetooth link facilitates data collection and processing. The Bluetooth operating range is up to 300 feet when using a Mobile Demand® tablet and a Bluetooth antenna. The effective operating range between the Yuma tablet and StreamPro is approximately 30 to 40 feet although that distance will vary depending on environmental conditions. StreamPro users must ensure continuous communication is maintained between the Tablet PC and the StreamPro throughout the measurement.
3. 5        ADCP — An acoustic Doppler current profiler (ADCP) 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 speed of the instrument over the bottom. Stream discharge is determined from these measurements. StreamPros are ADCPs.
3. 6        Cross-Section —\_The measurement cross-section is a vertical plane extending from either stream edge, up from the stream bottom to the surface. The cross-section of a StreamPro is defined as perpendicular to the average direction of flow or parallel to the average course of the vessel. The cross-section determines the cross-sectional area, width, wetted perimeter, hydraulic radius, and velocity profile.
3. 7        Transect — The measurement transect is the course the StreamPro follows across the stream and defines the measurement cross-section. The transect is the basic component comprising a measurement.
3. 8        Bottom Tracking — Bottom Tracking measures the ADCP’s speed over the stream bottom as well as water depth.
3. 9        Ensembles — An ensemble is a vertical profile of velocity created by the StreamPro. 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 is determined by vessel speed and cross-section width.
3. 10       Depth Cells — Depth cells, or bins, are arranged vertically through an ensemble. The ADCP determines the mean water velocity of each depth cell. The velocity of an ensemble is the average velocity of its depth cells. Depth cell size refers to the vertical height of the cell. The StreamPro determines cell size automatically based

on maximum cross-section depth and the maximum of 20 available depth cells. The number and size of depth cells can be adjusted by the StreamPro user.

3. 11 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 StreamPros 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. Sufficient 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 StreamPro will be familiar with EAP safety policies.

#### **5.0 Equipment, Reagents, and Supplies**

- 5.1 MobileDemand® and Trimble® Yuma Ruggedized Tablets— Operation of the StreamPro takes place through either MobileDemand or Trimble Yuma Ruggedized Tablet PCs. The MobileDemand and Yuma tablets establish Bluetooth communication links with the StreamPro and contains WinRiver II software through which the StreamPro operates.
- 5.2 Raft —\_A raft, specially designed to deploy the StreamPro, maintains the transducer at a constant depth while minimizing water flow disturbance. The raft is designed to accommodate several deployment methods.
- 5.3 Tow Ropes —Floating water rescue ropes are used to tow the raft across measurement transects.
- 5.4 Hemisphere© A100 GPS Unit—The GPS receiver used to collect latitude and longitude positions corresponding to each StreamPro ensemble. These units are for use with compass equipped StreamPros only. Currently only one StreamPro is equipped with a compass and available for use with a GPS receiver.
- 5.5 Parani® Bluetooth Antenna— Parani® Bluetooth antennas are used to establish a Bluetooth communication link between the Hemisphere A100 GPS receiver and the Trimble Yuma Ruggedized tablets. These antennas are programmed and dedicated to one and only one GPS receiver. Note: At this time GPS only operates through the Yuma tablets.

5.6 Tag Line — In swift water, a tensioned tag line may be necessary to keep the raft oriented properly along the chosen transect.

5.7 Hand Tools — A tool box for minor repairs and parts replacement is required on all field trips.

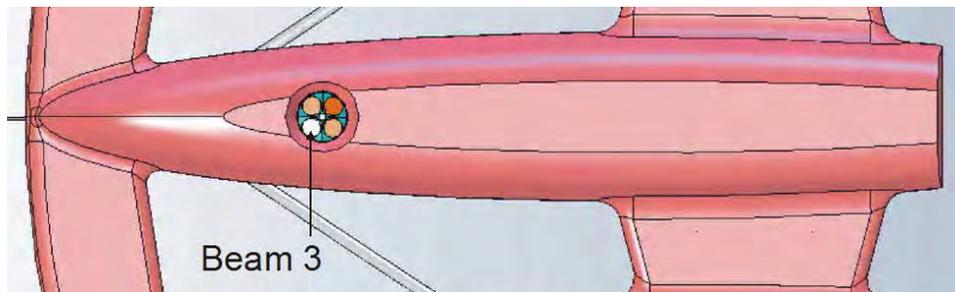
5.8 Personal Flotation Device (PFD) — Approved PFDs are required for all personnel working in or near bodies of water.

## 6.0 **Summary of Procedure**

### 6.1 Deployment Preparation

6.1.1 Prior to departure all equipment and accessories are accounted for and inspected by the field leader.

6.1.2 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 3. View of the underside of StreamPro raft. Beam 3 pointed forward on starboard side of raft.**

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

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

6.1.5 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 4. StreamPro power switch and indicator lights.**

- 6.1.6 A blinking amber light indicates the StreamPro batteries are low and need replacing. Experience has shown 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.
- 6.1.7 The StreamPro can use rechargeable batteries. Each vehicle assigned to Freshwater Monitoring Unit (FMU) Stream Hydrology staff carries a mobile AA battery charger along with an additional contingent of eight rechargeable batteries. While in transit recharge both sets of batteries so a fresh set is available for the StreamPro as well as a fully charged set for back up. The A100 GPS antenna also requires eight AA batteries. Recharge batteries for use with the Hemisphere A100 GPS antenna as well.
- 6.1.8 To install batteries in the StreamPro refer to the [StreamPro ADCP Guide](#).
- 6.1.9 If operating a StreamPro through Yuma tablets, make sure accessories such as the detachable soft-shell case with straps as well as 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.
- 6.1.10 If using the GPS receiver, confirm 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.

## 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 (Oberger, et. al., 2005). Conditions to avoid are submerged aquatic plants, abrupt changes in stream depth (boulders and/or 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.

## 6.3 Deployment Methods

6.3.1 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.

6.4 Towing StreamPro from a bridge — Towing a StreamPro from a bridge is typically the most convenient method of deployment. 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.

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

6.4.2 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.

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

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

6.4.5 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 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.

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

6.5.1 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 5. StreamPro raft towed from shore to shore (photo by Washington Department of Ecology).**

6.5.2 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.

- 6.5.3 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.
- 6.5.4 Data quality and bottom tracking over irregular substrate are optimized at slower towing speeds. The tow speed should be less than the water velocity. In instances when velocities are less than one 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.
- 6.5.5 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.
- 6.5.6 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 that is equal to or greater than the depth of water at the vertical wall (Oberger et al., 2005).
- 6.6 Deployment Procedures
- 6.6.1 At present, Ecology 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 is used to simultaneously collect and process measured streamflow data and GPS coordinates.
- 6.6.2 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.

- 6.6.3 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 user name 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.
- 6.6.4 Once in the field, power up and log in to the Tablet PC well in advance of commencing measurements, as the boot-up process may takes several minutes. The user can choose to log on at the beginning of a day of field work, 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, simply 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 (which occurs after 10 minutes of inactivity) the user password is required upon waking the unit.
- 6.6.5 Charge Tablet PCs at the end of each field day, if needed.
- 6.6.6 Once logged on to the Tablet PC connect to the StreamPro using Bluetooth.
- 6.6.7 If using the Yuma tablet double-click the BLUETOOTH SETTINGS icon on the desktop.
- 6.6.8 If using the MobileDemand tablet, insert the Bluetooth antenna to one of the available USB ports under the hinged protective cover on the right side of the tablet.
- 6.6.9 Double click the Bluetooth icon—— located on the right side of task bar. If the Bluetooth antenna is not plugged in the Bluetooth icon is colored red. When the antenna is plugged in to the USB the icon is colored white. When connected to a device via Bluetooth the icon is green.

- 6.6.10 After clicking on the Bluetooth icon the BLUETOOTH SETTINGS window will appear.
- 6.6.11 Make sure the icon in the BLUETOOTH SETTINGS window indicates connection to the appropriate ADCP.



**Figure 6. Bluetooth Manager screen showing Bluetooth connected icon (interlocking yellow and green bars).**

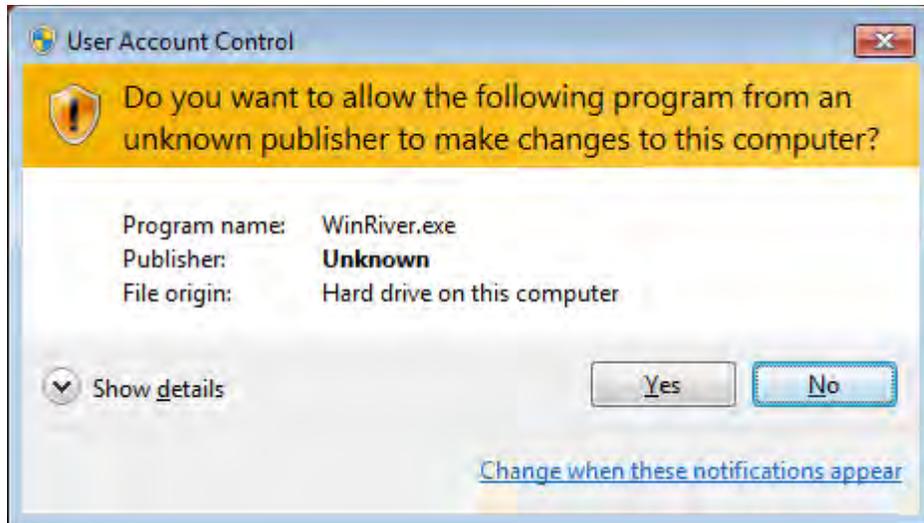
- 6.6.12 If the StreamPro is not already connected, double-tap the BLUETOOTH icon in the Bluetooth settings window for the appropriate ADCP. The connection should establish and the Bluetooth icon will change from not connected to connected. The appearance of interlocking yellow and green bars at the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

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



**Figure 7. Windows mobility center screen on Yuma tablets. The rotate screen icon is in upper right.**

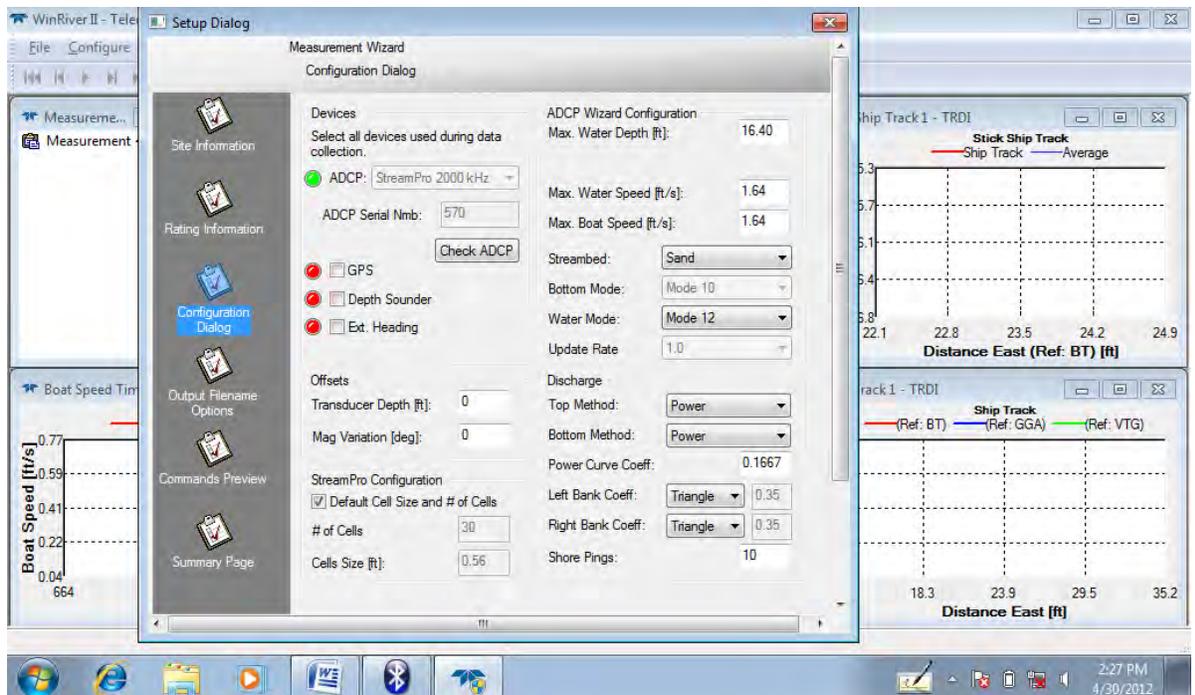
- 6.6.15 If the screen orientation is such that the USB ports face the user, double-click the WINDOWS MOBILITY CENTER icon on the desktop of the Yuma.
- 6.6.16 Find the SCREEN ORIENTATION box and click ROTATE SCREEN until the screen is oriented such that the USB ports face away from user.
- 6.6.17 Next, on either of the MobileDemand or Yuma Tablet PCs, launch WinRiver II by double-clicking the WinRiver II icon on the desktop.
- 6.6.18 A USER ACCOUNT CONTROL prompt might appear asking the user to allow the program to make changes to this computer. Tap YES.



**Figure 8.** The User Account Control prompt appears after double clicking the WinRiver II icon. Clicking YES allows WinRiver II to launch.

6.6.19

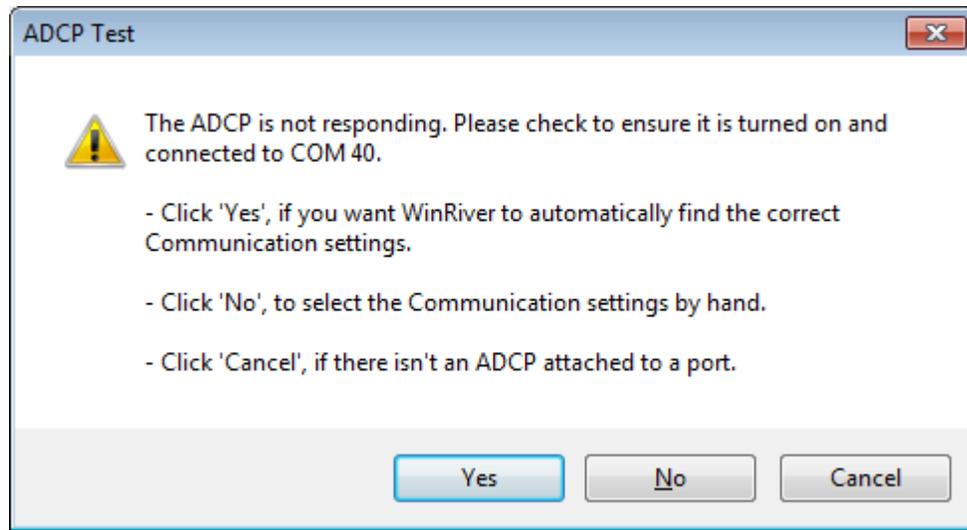
Once WinRiver II opens the user can setup the configuration of a new measurement by tapping the FILE tab and selecting NEW MEASUREMENT. This brings up the SETUP DIALOGUE, also known as the MEASUREMENT WIZARD. The Setup Dialog consists of six screens: Site Information, Rating Information, Configuration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



**Figure 9.** The Configuration Dialog is one of six screens within the Setup Dialog window.

6.6.20 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.

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



**Figure 10. Test prompt will appear if the StreamPro does not respond to interrogation. This prompt indicates Bluetooth connection has been lost.**

6.6.22 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:

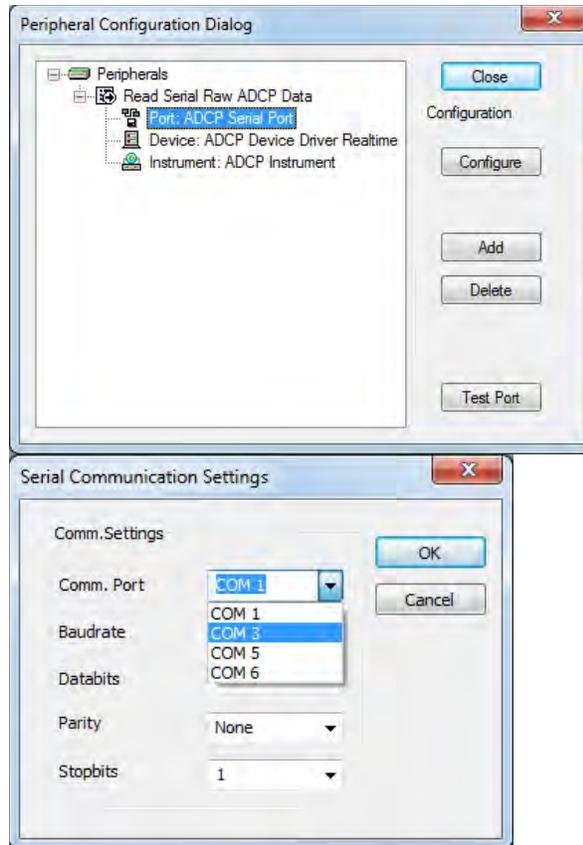
1. Baud rate is 115200.
2. Data bits is 8.
3. Parity is None.
4. Stop Bits is 1
5. Note COM Port setting.

6.6.23 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 11. Detailed settings window. Note the port name. Port name should match COM Port setting in WinRiver II.**

- 6.6.24 In the SETTING section, note the Port Name, click OK, and return to WinRiver II.
- 6.6.25 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 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.

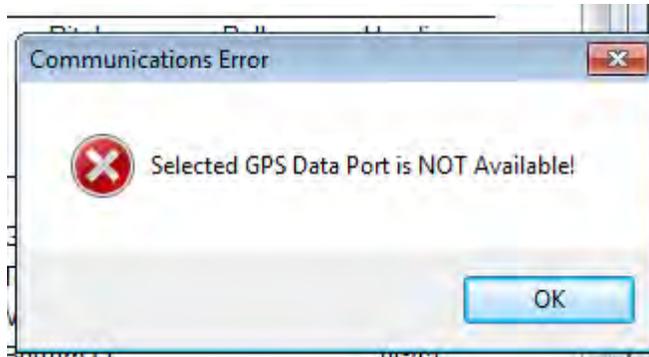


**Figure 12. Peripheral configuration Dialog box and Serial Communication Settings Com Port drop down list. Select the Com Port matching the Port Name found in Bluetooth Settings/Details.**

- 6.6.26 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.
- 6.6.27 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 simply act as 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.
- 6.6.28 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 use of GPS will appear. These warnings will typically refer to magnetic variation, compass calibration, and bottom reference settings.

- 6.6.29 Under OFFSETS set the proper transducer depth; for StreamPro ADCPs, transducer depth is 0.2 ft.
- 6.6.30 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 each year. The user can look up the current magnetic declination for specific field destinations at: <http://magnetic-declination.com>.
- 6.6.31 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.
- 6.6.32 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.
- 6.6.33 Select appropriate substrate type from the STREAMBED dropdown.
- 6.6.34 Set appropriate LEFT and RIGHT BANK COEFFICIENTS based on channel shape at each bank (i.e. square or triangular).
- 6.6.35 BOTTOM MODE, WATER MODE, and UPDATE RATE are all set automatically by WinRiver II. SHORE PING is always set at 10.
- 6.6.36 Next tap the SITE INFORMATION icon in the panel on the left side of the setup dialogue window.
- 6.6.37 Enter the Station ID number in the STATION NUMBER field.
- 6.6.38 If known, enter the measurement number (based on Hydstra Gaugings database) in the MEASUREMENT NUMBER field.
- 6.6.39 Set DEPLOYMENT TYPE based on method of measurement.
- 6.6.40 Set MEAS. LOCATION (optional).
- 6.6.41 All other fields on this screen are optional.

- 6.6.42 Tap the RATING INFORMATION icon on the left panel of the Setup Dialogue window or tap NEXT at the bottom of Site Information window. Enter rating information in this screen.
- 6.6.43 Next, navigate to the OUTPUT FILENAME OPTIONS icon in Setup Dialog.
- 6.6.44 Set the filename prefix per the adopted FMU file naming convention (i.e. STATION NUMBER-YYYY-MM-DD). Example: 18A050-2016-05-05
- 6.6.45 OUTPUT DIRECTORY should be C:\Measurements\- 6.6.46 Under INCLUDE FILENAME OPTIONS section, uncheck all options except TRANSECT NUMBER
- 6.6.47 Filename Preview will show a sample of the resulting filename.
- 6.6.48 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.
- 6.6.49 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 at any time.
- 6.6.50 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 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 prior to the SET ADCP CLOCK DIALOG being displayed. In most cases this means the Bluetooth antenna is not plugged in to the Yuma tablet. Simply click OK to proceed to the SET ADCP CLOCK DIALOG window.



**Figure 13. Warning Display indicating GPS data port is unavailable.**

- 6.6.51 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.
- 6.6.52 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.
- 6.6.53 Next, ascertain 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 at this time.
- 6.6.54 If the clock is properly set, the ACQUIRE CONTROL window will appear indicating the instrument is pinging but not recording.

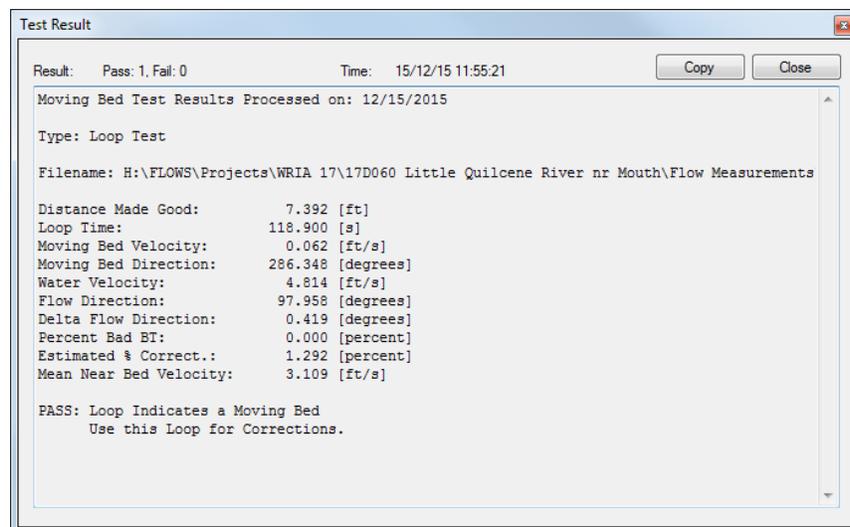


**Figure 14. Acquire Control window indicating ADCP is pinging but not recording.**

- 6.6.55 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.
- 6.6.56 After moving the StreamPro over the cross-section and noting maximum depth and water speed, select ACQUIRE then STOP PINGING from the menu bar.
- 6.6.57 Again from the menu bar select ACQUIRE then CONFIGURATION WIZARD.
- 6.6.58 In the Configuration Wizard select the CONFIGURATION DIALOG page from the pane on the left side of the window.
- 6.6.59 Set the MAX. WATER DEPTH and MAX. WATER SPEED (in the upper right side of the window) to that noted during pinging
- 6.6.60 Set MAX. BOAT SPEED to roughly half the water speed. Do not exceed this speed during measurement transects.
- 6.6.61 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.
- 6.7 Moving Bed Test — StreamPros determine their own 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 ground. This bias results in errors (underestimations) to water velocity calculations which adversely affect accurate flow measurements. The moving bed test is used to determine if bed movement is present and the degree to which the condition exists.
- 6.7.1 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).
- 6.7.2 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, thereby eliminating the bias in water speed calculation caused by moving bed. Using this method requires continuous collection of valid DGPS data, which can be difficult at sites with riparian tree cover or other obstructions, such as bridges or overhead power lines.

- 6.7.3 The second way to account for moving bed is through an analysis of the moving bed test and subsequent correction of discharge values based on results of the moving bed test.
- 6.7.4 Currently two methods test for moving bed; the Loop and Stationary methods. The loop test requires an ADCP equipped with a calibrated compass.
- 6.7.5 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 edges. Return to exact starting location. Bottom track must be maintained throughout the test (bad ensemble threshold is 5%). During loop test, note maximum channel depth and maximum velocity for later entry to Configuration Wizard.
- 6.7.6 From the menu bar, select ACQUIRE then START PINGING.
- 6.7.7 Again from the menu bar, select ACQUIRE then select MOVING BED TEST.
- 6.7.8 Select LOOP TEST, tap OK, and test will begin immediately.
- 6.7.9 Move boat slowly from marked location to 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.
- 6.7.10 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.
- 6.7.11 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 period of the test. In a tethered deployment, try to minimize “swimming”. Bottom tracking, boat, and water velocities must be maintained throughout the test period.
- 6.7.12 Position the StreamPro in the thalweg of the channel or the location with the greatest potential for moving bed.
- 6.7.13 From the menu bar, select ACQUIRE then START PINGING.
- 6.7.14 From the menu bar, select ACQUIRE then select MOVING BED TEST.

- 6.7.15 Select STATIONARY, tap OK, and the test will begin immediately.
- 6.7.16 Hold the StreamPro as stationary as possible for at least 5 minutes. Duration of the test can be found at the bottom of the Composite Tabular window.
- 6.7.17 At the end of the test, select ACQUIRE from the menu bar then STOP MOVING BED TEST.
- 6.7.18 At the conclusion of a moving bed test, the Test Result window appears in the WinRiver II workspace. 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 results of the test also present reasons why the test was not valid or any warnings to consider when analyzing test results.
- 6.7.19 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 test results into the Hydstra GAUGINGS comments.



**Figure 15. Moving Bed Test results window.**

6.7.20

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 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.

The screenshot shows a window titled 'MBT Summary - TRDI'. It contains two tables. The first table, 'Selected MB Tests', has columns for MB Test, Used in Correction, Distance US/MG, Duration s, MB Vel ft/s, MB Dir °, Water Vel ft/s, Flow Dir °, Diff in Flow Dir °, Average Depth ft, % Bad Bottom Track, and Potential MB Error %. The second table, 'Applied Corrections', has columns for Transect ID, Bottom-Track Discharge ft³/s, MB Corrected Discharge ft³/s, Correction Difference %, Correction Type, and Average MB Velocity ft/s.

MB Test	Used in Correction	Distance US/MG	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

Transect ID	Bottom-Track Discharge ft³/s	MB Corrected Discharge ft³/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 16. Moving Bed Test summary window. Moving bed corrections are applied to the flow value of each measured transect and the results averaged.**

6.8

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 14).

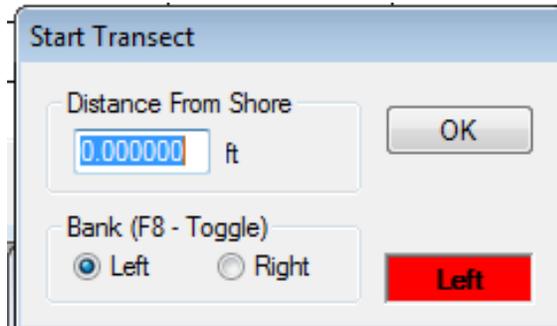
6.8.1

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 were entered and saved in SETUP DIALOG, users can only change those settings in CONFIGURATION WIZARD under the ACQUIRE tab.

6.8.2

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.

- 6.8.3 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.
- 6.8.4 From the menu bar select ACQUIRE then START TRANSECT. This will bring up the START TRANSECT dialog.



**Figure 17. Start (and End) Transect dialog window.**

- 6.8.5 Enter the noted distance (in feet) from the bank to the transducer head in DISTANCE FROM SHORE field, and set the BANK TOGGLE to the correct bank (left or right), and tap OK.
- 6.8.6 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.
- 6.8.7 As the StreamPro approaches the far bank, note the number of good bins, as 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.
- 6.8.8 In the END TRANSECT dialogue, enter the noted distance (in feet) from this bank to the transducer head in DISTANCE FROM SHORE field, and set the BANK TOGGLE to the correct bank (left or right), and tap OK.
- 6.8.9 Final statistics for the completed transect will appear in blue in the COMPOSITE TABULAR window.

- 6.8.10 Ensure the StreamPro is in proper position (i.e. the position that ended the previous transect) and measure three more transects.
- 6.8.11 After a total of four transects, select DISCHARGE SUMMARY in the SITE DISCHARGE section of the MEASUREMENTCTRL window.
- 6.8.12 Assess the total variability as indicated by the DELTA Q column in the DISCHARGE SUMMARY window
- 6.8.13 If any of the transects show a Delta Q greater than  $\pm 5\%$ , measure an additional four transects.
- 6.8.14 After all transects have been collected, select ACQUIRE then 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.
- 6.9 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-percent bias in the measured discharge (Oberg, et. al., 2005).
- 6.9.1 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 at the conclusion of determining edge distances while the instrument is still testing pinging. View the water temperature in COMPOSITE TABULAR window to compare the measured and recorded temperatures.
- 6.9.2 If the water temperature difference is greater than 2° C, TRDI should be consulted and the temperature sensor considered for repair or replacement. Note both water temperatures on the measurement field sheet.
- 6.10 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.

- 6.10.1 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.

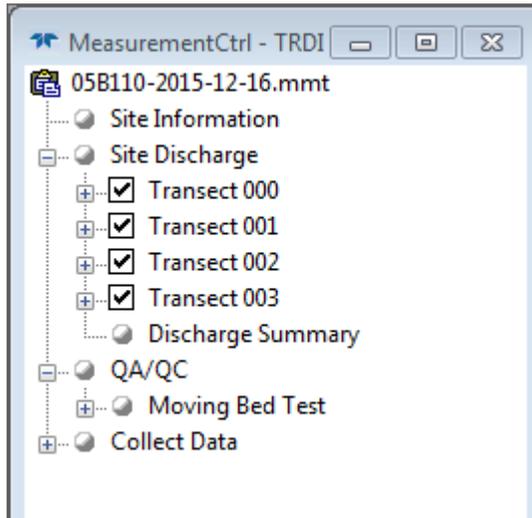


Figure 18. MeasurementCtrl window.

- 6.10.2 To playback all the transects, select REPROCESS CHECKED TRANSECTS from the PLAYBACK Menu.
- 6.10.3 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 font indicates the transect's discharge Delta statistic is greater than plus or minus five percent from the average discharge of all the processed transects.

Transect	Start Bank	# Ens.	Start Time	Total Q ft <sup>3</sup> /s	Delta Q %	Top Q ft <sup>3</sup> /s	Meas. ft <sup>3</sup> /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 19. Discharge Summary window.

6.10.4 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 a data quality problem exists due to equipment malfunction, computer problem, configuration errors, or other difficulties occurring during the measurement. Document all transect removals.

6.10.5 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 at the Stream Hydrology group's shared server folder (H:\FLOWS\QADData).

Transect Number	Total Q ft <sup>3</sup> /s	Delta Q %	Meas. Q ft <sup>3</sup> /s	Top Q ft <sup>3</sup> /s	Bottom Q ft <sup>3</sup> /s	Left Q ft <sup>3</sup> /s	Right Q ft <sup>3</sup> /s	Width ft	Total Area ft <sup>2</sup>	Q/Area ft <sup>3</sup> /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 20. Discharge Summary Report Template (Table by Washington Department of Ecology).

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

6.10.7 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.

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

**7.0 Records Management**

7.1 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.

7.2 The folders containing these files are located in 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 possession of the principle investigator of the particular flow monitoring station.
- 7.5 A record of peer reviews of all discharge measurements is located in the Stream Hydrology Group's shared server.

**8.0 Quality Control and Quality Assurance Section**

- 8.1 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 at the conclusion of the measurement.
- 8.2 Addressing data collection problems in the field may require changing cross sections, repairing equipment, alternative deployment methods, adjusting configuration file settings, and/or additional transects.
- 8.3 At the conclusion of the measurement all transects comprising the measurement are assessed to identify data quality problems and assign a preliminary quality rating.
- 8.4 As a general guide, if the Delta Q of the discharge of all transects is within two percent the measurement is considered excellent. If Delta Q is within five percent the quality of the measurement is good. A Delta Q within eight percent (with at least eight transects measured) is considered fair. The measurement is regarded as poor if there are transects with Delta Q greater than eight percent.
- 8.5 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.
- 8.6 Consider downgrading the measurement quality if one or more transects contain greater than 10 percent bad ensembles. This especially applies, even when less than 10 percent of the bad transects are concentrated in one part of the cross-section (Oberg, et. al., 2005).
- 8.7 Downgrade measurement quality with 25 percent 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).

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 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 to the Hydstra Gaugings database.

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

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 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.

8.9.4 The reviewer enters coefficient of variation of Total Q, Area, and Velocity to 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, loss or damage to equipment are not attempted. Refer to the EAP Safety Manual for further information about working in and around streams.

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 Manual (page 1-37) for further guidance regarding bridge measurement safety.

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

## **10.0 References**

- 10.1 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.
- 10.2 Environmental Assessment Program, 2015. Environmental Assessment Program Safety Manual.
- 10.3 Oberg, Kevin A.; Morlock, Scott E.; Caldwell, William S. 2005. Quality-Assurance
- 10.4 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.
- 10.5 Teledyne RD Instruments. StreamPro ADCP Guide. 2015. P/N 95B-6003-00.
- 10.6 Teledyne RD Instruments. WinRiver II User's Guide. 2016. P/N 957-6231-00.

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