Washington State Department of Ecology

Environmental Assessment Program

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

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EAP055

Approved

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SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)

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 to be followed when using a TRDI StreamPro ADCP to measure stream discharge in the field as well as evaluate measurement quality, 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 ADCPs 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. Depths should be between 1 and 14 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 ADCP 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.

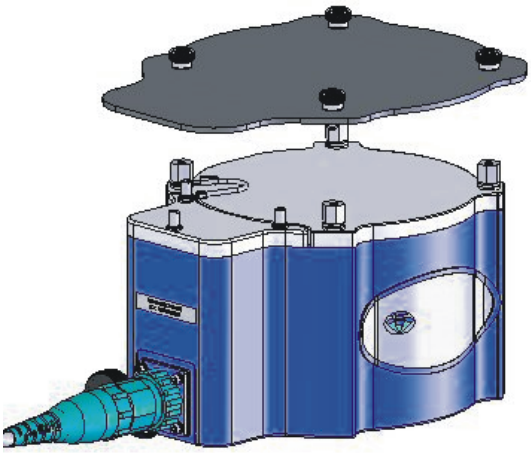


Figure 2. Electronics Housing with protective heat shield.

3. 3 StreamPro Software — The StreamPro software is stored on a Personal Digital Assistant (PDA). The software is used to collect data from the ADCP and display measurement parameters on the PDA in real-time. The program offers playback of measured transects and comparative analysis capabilities between transects.

3. 4 Bluetooth Wireless Link — StreamPro software is operated with the wireless Bluetooth link. The effective operating range between the PDA and ADCP 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 PDA and ADCP throughout the measurement.

3. 5 WinRiver II — The WinRiver II program is a desktop application designed to process data from the StreamPro. WinRiver II is used for more detailed analysis of measurements performed by StreamPro. The StreamPro data is compiled for review through the WinRiver II program.

3. 6 Section by Section Software — Section by Section Software allows for measurements at fixed locations across the transect in the same way non-acoustic equipment is used.

3. 7 ADCP — An 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.

3. 8 Cross-Section — The measurement cross-section is a vertical plane extending from either stream edge, up from the stream bottom to the surface.

3.8. 1 The cross-section of an ADCP 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. 9 Transect — The measurement transect is the course the ADCP vessel follows across the stream and defines the measurement cross-section. The transect is the basic component comprising a measurement.

3. 10 Bottom Tracking — Bottom Tracking measures instrument speed over the stream bottom as well as water depth.

3. 11 Ensembles — An ensemble is a vertical profile of velocity created by the ADCP once per second during a measurement transect. 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. 12 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. 13 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.

4.0 Personnel Qualifications/Responsibilities

4.1 Personnel using this SOP should be trained in measuring streamflow and have experience operating personal computers. 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 Personal Digital Assistant (PDA) — A PDA or palmtop computer is used to establish a wireless link with the StreamPro through Bluetooth communications. The PDA controls the operation of the ADCP, receives and stores real-time stream flow data acquired by the ADCP.

5.1.1 Most PDA's can be loaded with the basic StreamPro program and used to measure discharge. However, only one PDA per instrument is licensed and recognized by TRDI. Only licensed PDA's can operate the Section by Section program.

5.2 Raft — A raft, specially designed to deploy the ADCP, 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 Tag Line — In swift water, a tensioned tag line may be necessary to keep the raft oriented properly along the chosen transect.

5.5 Waterproof Housing — An OtterTM or PelicanTM box is used to protect the PDA from rain and moisture.

5.6 Hand Tools — A tool box 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.

5.8 StreamPro Quick Start Guide — Official TRDI operation manual.

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 that transducer beams are aligned correctly. Beam 3 should be pointed forward on the starboard side of the raft and at a 45 degree angle to the centerline of the raft.

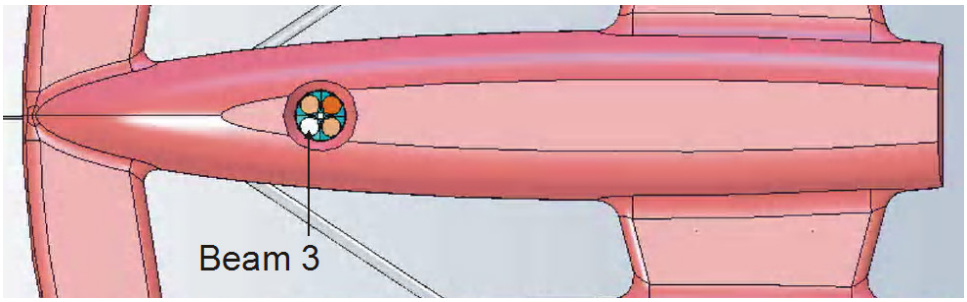


Figure 3. View of the underside of StreamPro raft. Beam 3 pointed forward on starboard side of raft.

6.1.3 The transducer head should be submerged approximately 0.1 to 0.2 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 should be replaced. 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. Always carry an extra eight-pack of AA batteries to the field.

6.1.7 To install batteries refer to page 14 of the StreamPro Quick Start Guide.

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 (Oberg, 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 ft/sec. Some of these conditions will not become apparent until preliminary depths and velocities are measured. Those procedures are described on page 13.

6.2.2 Efforts should be made to keep the StreamPro as level as possible through the course of a measurement because pitch and roll corrections are not calculated with StreamPro ADCPs.

6.3 Establishing a Bluetooth Connection — Establishing an initial Bluetooth connection on the PDA turns the activation of Bluetooth into a one step process in future StreamPro deployments.

6.3.1 To establish an initial Bluetooth connection turn on the StreamPro. Turn on the PDA by depressing the on/off button in the upper right corner of the PDA.

6.3.2 Tap the iPAQ WIRELESS icon located in the lower right of the screen. The wireless options screen will appear.

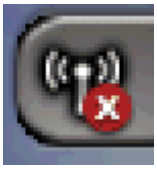


Figure 5. iPAQ wireless icon.

6.3.3 Tap the BLUETOOTH START button (). This will turn on Bluetooth. A blue light will blink in the upper left of the PDA.

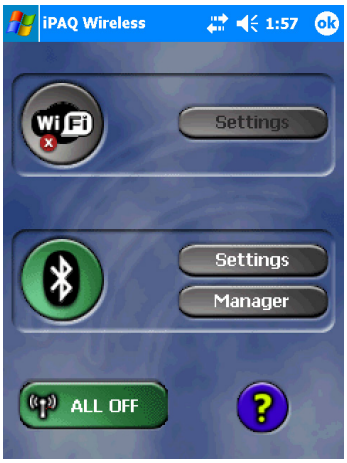


Figure 6. Bluetooth start button, located in the middle left of the wireless options screen.

6.3.4 If you have previously connected to the StreamPro unit you are currently using, select the MANAGER button located to the right of the Bluetooth icon. Select MY SHORTCUTS in the lower left of the screen.

Figure 7. Bluetooth Manager Screen.

6.3.5 The StreamPro Unit should appear as an icon. Hold the stylus down on the icon until a pop-up menu appears. Select CONNECT from that menu. A Bluetooth connection with the StreamPro unit should be established. A Bluetooth connection between the PDA and the ADCP is confirmed by a solid blue light on the ADCP housing near the amber colored power display.

6.3.6 If the StreamPro unit you are using does not appear in the My Shortcuts tab, add it to My Shortcuts by following the steps in the next paragraph.

6.3.7 From the My Shortcuts screen in the Bluetooth Manager, select NEW on the bottom left of the screen. Select EXPLORE A BLUETOOTH DEVICE from the connection wizard. Proceed to the next window or select NEXT to proceed to the next window if the wizard does not do so automatically. The StreamPro unit should appear as an icon in the window that follows. Select it and you should automatically proceed to the next window (if not, click NEXT). A list of services for the device should appear in the window that follows. Select BLUETOOTH SERIAL PORT and click NEXT. On the screen that follows, click FINISH. To make future connections easier, you can rename the connection. An advisable name is the StreamPro ID (i.e. SP-1, SP-2, etc.) To rename the connection, hold the stylus down on the icon until a pop-up menu appears. Select RENAME from the menu and type the desired name using the pop-up keyboard.

6.3.8 Open the StreamPro program on the PDA to establish the connection between the ADCP and the StreamPro software.

6.4 Starting StreamPro — Tap the START MENU on the PDA and select STREAMPRO from the drop down menu. In the "Select Application To Start" box tap STREAMPRO.

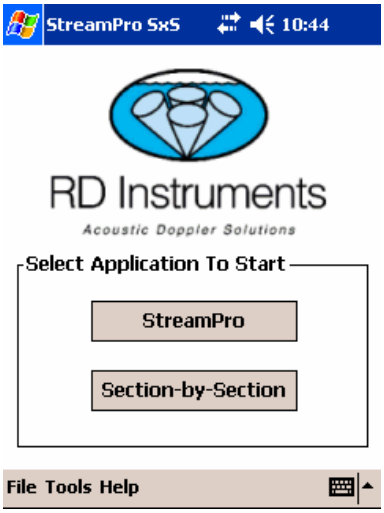


Figure 8. Tap the StreamPro button to open program.

6.4.1 The StreamPro program will default to the Setup tab on the tab bar in the upper portion of the screen.

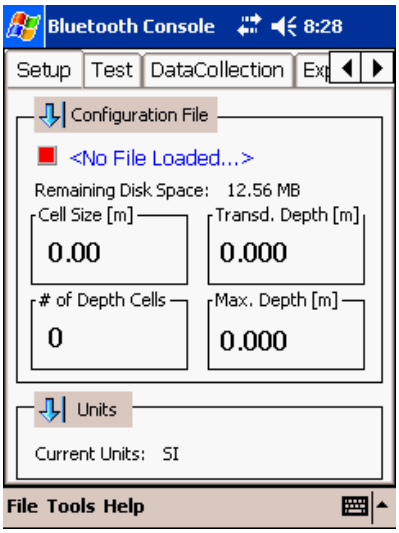


Figure 9. StreamPro Setup screen.

6.4.2 If the Setup screen is displaying metric units, tap the UNITS dropdown and select ENGLISH

6.5 Loading Factory Defaults and Instrument Self Tests — Select the CONFIGURATION FILE drop down icon and tap FACTORY DEFAULT. The screen should display "Factory Defaults Loaded". The Factory Default configuration is used to run operations tests on the instrument as well as collect preliminary depth and velocity information across the transect. Tap the TEST tab. Select SELF TEST from the Instrument drop down icon. This will initiate a series of tests to ensure electronic systems and transducers are functioning properly. This also confirms a communications link is established between the PDA and the ADCP. Run the self test out of the water for easy access in case the initial self test attempt fails.

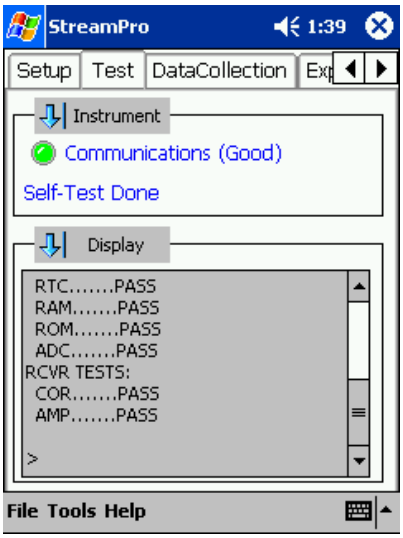


Figure 10. StreamPro Self-Test Screen.

6.5.1 A failed test almost always indicates the Bluetooth communication link has been lost. Confirm this by checking the blue lights on the PDA and the ADCP. Typically, only the blue light on the ADCP is out. If Bluetooth communication has been lost but Bluetooth is still activated at the PDA, restore communication to the ADCP by exiting and then restarting the StreamPro program. StreamPro must be closed by tapping FILE in the lower left corner of the screen and selecting EXIT STREAMPRO. Tapping the exit box in the upper right corner of the screen ( ) does not close the StreamPro program, it only minimizes it. If Bluetooth is not activated on the PDA, follow the steps in *Establishing a Bluetooth Connection* above.

6.5.2 Re-load the factory default configuration file and re-run Self Test.

6.6 Collecting Preliminary Depth and Velocity Values — if the tests are passed, the StreamPro user will now determine and record the maximum depth and velocity of the cross section. The maximum depth and velocity are then used for the measurement specific configuration file.

6.6.1 Remain in Test menu (leave Factory Defaults as the configuration in the Setup menu) and select START PINGING from the Instrument dropdown icon.

6.6.2 Begin moving the StreamPro across the stream paying attention to the output on the PDA. Note the maximum depth and maximum velocity on the field form.

6.6.3 After the maximum depths and velocities have been recorded, select STOP PINGING from the Instrument drop down.

6.6.4 Return to the Setup screen and select CHANGE SETTINGS from the CONFIGURATION FILE drop down.

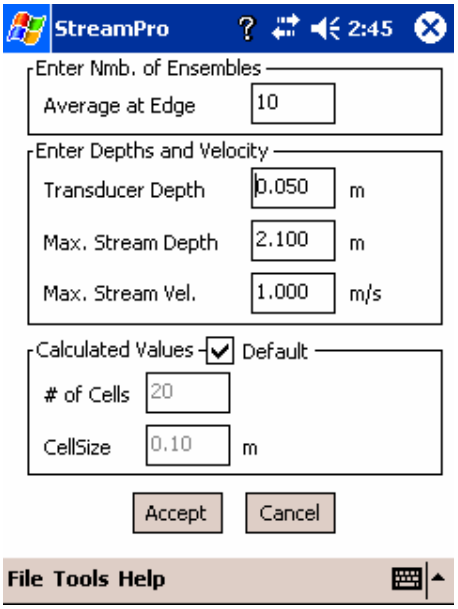


Figure 11. Change Settings screen.

6.6.5 Edit the configuration file by highlighting the respective dialog box. Tap the KEYBOARD icon in the lower right of the screen ( ) to make edits. Change maximum depth and velocity according to the noted results of the test crossing. Tap the KEYBOARD icon again to close the keyboard. Number of ensembles, transducer depth, # of cells, and cell size are rarely changed from their default settings.

6.6.6 Notice the cell size is recalculated based on the maximum stream depth. This calculation is based on the default of 20 depth cells (20 cells X depth cell size = (approximately) maximum depth). Twenty is the maximum number of depth cells the instrument will accept. By de-selecting the default check box in the calculated values area the user is free to change the number of cells to less than 20. The program only calculates cell size when the default box is checked.

6.6.7 Note: If the user changes the number of depth cells, the depth cell size will also have to be adjusted such that the product of depth cell size and number of cells is equal to or greater than maximum depth. The maximum size of a cell is 0.66 feet, the minimum cell size is 0.07 feet.

6.7 Low Noise Mode — In situations when the maximum depth is less than about 3.3 feet and the maximum velocity is less than about 0.8 feet per second, the Low Noise Mode option will appear in the Change Settings screen. This option can be activated by checking the LOW NOISE MODE checkbox.

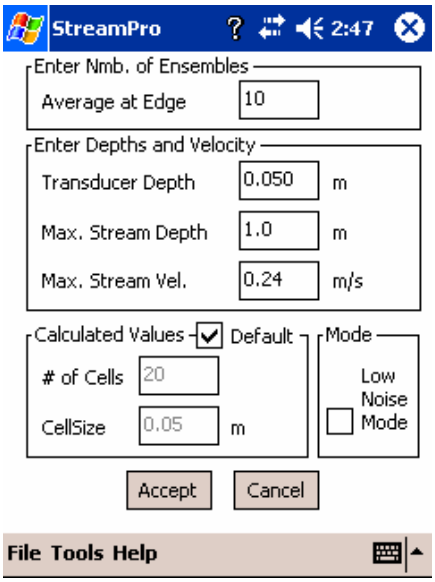


Figure 12. Change Settings screen with Low Noise Mode option.

6.7.1 Low noise mode is designed to reduce some of the ambiguity inherent in low velocity measurements. However, there can be very little pitch, roll, and yaw motion and the raft must be towed very slowly and smoothly. In velocities less than one foot per second (ft/sec) the tow speed should be one-half the water current speed. If the low noise mode is chosen, carefully watch the data being collected. If there are a high number of bad ensembles or the data is not reasonable, de-select the Low Noise Mode box and return to the standard operating mode.

6.8 Naming and Saving the Configuration File —After maximum stream depth and velocities have been entered and the number of cells and cell size have been determined and noted on the field form, tap ACCEPT.

6.8.1 Save the configuration file to the Secure Digital (SD) storage card in the PDA. By default, transect data will be saved to the same location as the configuration file. Files saved to the PDA's onboard memory (RAM) are subject to loss should there be a battery failure.

6.8.2 Tap the CONFIGURATION FILE drop down menu and select SAVE AS. The "Save Configuration File As…" screen will appear.

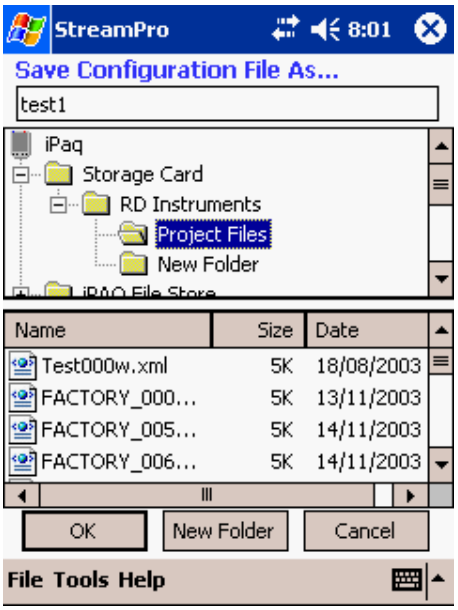


Figure 13. The Save Configuration File screen.

6.8.3 In the folder list find and open the SD CARD file folder. Select the NEW FOLDER button at the bottom center of the screen. The text box toward the top of the screen just above the folder list will be populated with the words "New Folder". Highlight this text by dragging the stylus across it, tap the KEYBOARD icon in the lower right corner of the screen, and type the name of the folder using the following naming convention:
6 Digit Station ID-4 Digit Year-2 Digit Month-2 Digit Day

Example: 01A140-2007-09-01

6.8.4 Remove the keyboard by tapping the KEYBOARD icon again. Tap OK to save the folder.

6.8.5 Find the folder just created under SD card and tap the folder to open.

6.8.6 Highlight the text "FACTORY DEFAULT" in the text box under "Save Configuration File As…", and type the name of the configuration file using the same naming convention. Tap OK to save the configuration file.

6.8.7 A file folder has now been created exclusively for this measurement and a configuration file has been saved. All transect data associated with this measurement will automatically save to this folder.

6.9 Determining Edge Distances — The ADCP can only measure above a minimum depth which is defined by the cell size. The StreamPro requires a minimum of two depth cells for edge measurements. In most situations there will be segments of the stream near both banks that cannot be measured because they are too shallow. The discharge in these segments is estimated by the StreamPro based on the depths and velocities at the predetermined end points.

6.9.1 Position the StreamPro at a point in the stream deep enough to acquire good data.

6.9.2 Tap the TEST tab, tap the INSTRUMENT drop down and select START PINGING. The number of good bins is displayed in the lower right of the test screen.

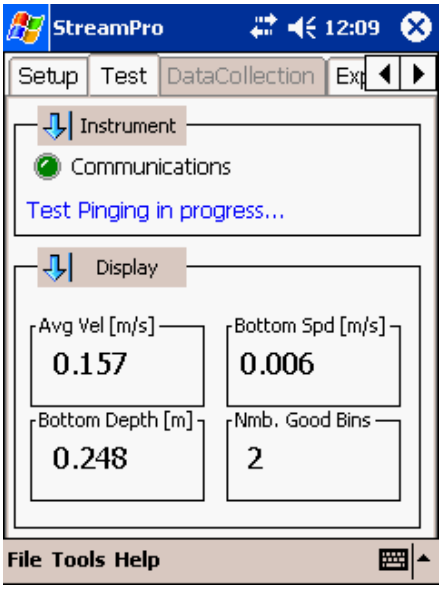


Figure 14. Test screen while Test Pinging is in progress.

6.9.3 Slowly move the StreamPro toward the bank paying close attention to the Number of Good Bins displayed on the PDA 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. In cross-sections with steep banks the number of good bins at the transect end points may be greater than two.

6.9.4 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 (Oberg, et. al., 2005).

6.9.5 If possible, stake or somehow mark the end point location. Measure the distance from the ADCP transducer head to the edge of water using one of the methods detailed below:

6.9.6 Bank measurements: Measure the distance from the center of the ADCP transducer head to the edge of water using an engineer's tape measure, which is incremented in tenths of feet rather than inches.

6.9.7 Bridge measurements: Extend a fiberglass tape along the bridge railing, covering at least the width of the channel. Lower a weighted fiberglass tape, such as those used for taking "tape down" measurements, to the edge of water and note the distance on the tape run along the railing. Then lower the weighted tape to the ADCP transducer head and note that distance. The difference between the two distances should be noted as the edge distance for the transects.

6.9.8 Repeat the procedure for the opposite bank.

6.10 Confirming StreamPro Water Temperature — The water temperature measured by the ADCP is used to compute the speed of sound through water. The computed speed of sound is used to determine 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).

6.10.1 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 ADCP water temperature by using Expert mode in StreamPro to compare the measured and recorded temperatures. Expert mode is described in more detail on page 25.

6.10.2 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.

6.11 Moving Bed Test — TRDI ADCP's determines its 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 StreamPro's speed over ground. This bias results in errors to water velocity calculations which adversely effect accurate flow measurements. The moving bed test is used to determine if bed movement is present.

6.11.1 In the case of the StreamPro ADCP, an accurate moving bed test is difficult to accomplish because of the lack of a compass. TRDI is working on solutions to these issues. A standard operating procedure will be made available as a revision to this document after TRDI finds a solution.

6.11.2 If a moving bed is suspected or observed relocate to a new measurement site.

6.12 Deployment Methods

6.12.1 There are two primary methods of StreamPro deployment; towing from a bridge and towing from shore. It is recommended two tow lines be used with one person handling each. Better control of the raft is maintained through higher velocities, shear zones, and areas of turbulence.

6.13 Towing StreamPro from a bridge — Towing the 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 the best for measuring stream discharge. Always attempt to find the most favorable measurement cross-section that is safe and practical.

6.13.1 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.

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

6.13.3 One person will have to operate the PDA in addition to one of the tow lines.

6.13.4 The person operating the PDA must ensure a Bluetooth connection is maintained throughout the measurement. The PDA operator directs the positioning of the ADCP to the pre-determined endpoints.

6.13.5 It is best in most bridge measurement applications to measure on the downstream side of the bridge. When measurements are done from the upstream side of a bridge the raft is usually pushed under the bridge by the current and cannot be seen. It is difficult to maintain a Bluetooth connection when the StreamPro and PDA do not have a good line of sight, particularly when there is a concrete barrier between the PDA and the StreamPro. A disadvantage of deploying the ADCP from a bridge is the difficulty of the operators to see and avoid floating debris coming from upstream.

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

6.14.1 The towing process is as follows: Two tow lines are clipped to the carabiners located at either side of the StreamPro raft. One person pulls the raft across the stream, while the person on the opposite bank pays out line keeping adequate counter-tension on the raft.

Figure 15. StreamPro raft towed from shore to shore (photo by Washington Department of Ecology).

6.14.2 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 be difficult and unsafe. If the situation is unsafe, abandon the measurement and attempt to find a more suitable location.

6.14.3 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.

6.14.4 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 the tow speed should be one-half of the water speed.

6.15 Collecting Discharge Data With The StreamPro

6.15.1 Position the StreamPro at the predetermined starting point. Tap the DATA COLLECTION tab. Tap the TRANSECT START button located in the middle left of the screen.

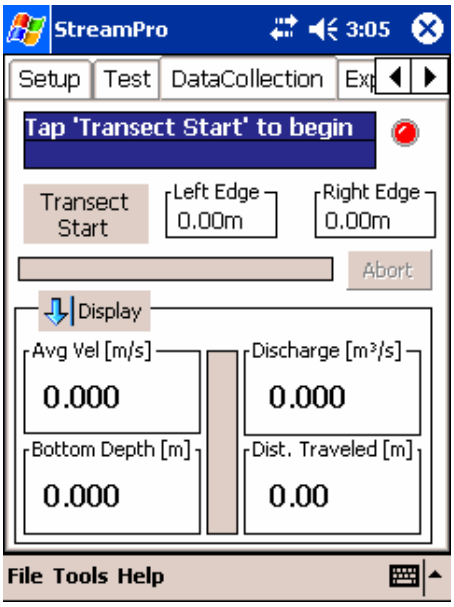


Figure 16. Data Collection screen.

6.15.2 The edge distance screen will appear. Highlight the edge of the stream on which the StreamPro is positioned. Stream edges are determined while facing downstream. Using the numbered key pad, enter the distances from each edge to the respective pre-determined endpoints in the text boxes immediately to the right of the Left Edge/Right Edge buttons. StreamPro will automatically toggle between edges at the beginning and end of subsequent transects. After the edge distances are entered, tap OK.

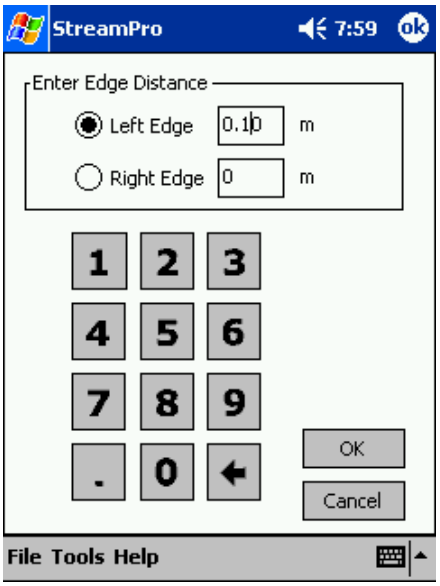


Figure 17. Edge Distance screen.

6.15.3 The Data Collection screen will return with the message "Taking Edge Measurements. Hold Position" displayed in the blue text box near the top of the screen. Hold the StreamPro as still as possible while the depths and velocities used to estimate edge discharges are collected. After ten good edge ensembles have been recorded, the blue text box prompt will change to "Transect in progress. Move to the far edge." The StreamPro software allows up to 20 bad ensembles to be collected during the edge measurements. Bad ensembles can occur when aquatic vegetation intermittently enters the field of the transducer beams, or when the ADCP is not held in a stable position. It is important that the ADCP is able to collect 10 good ensembles at the edge before a total of 20 bad ensembles are collected, or the transect will automatically be aborted.

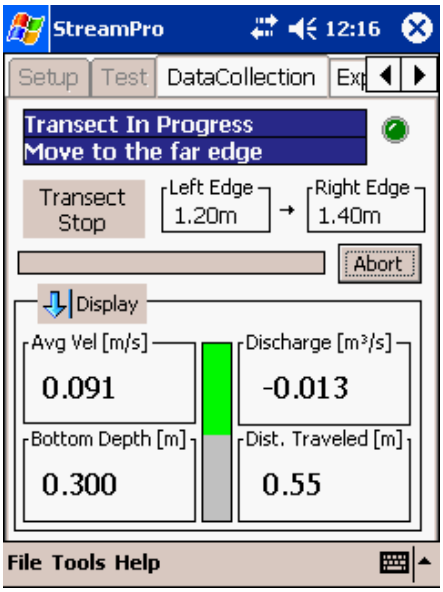


Figure 18. Data Collection screen with Transect In Progress. Note Good Bins Indicator Bar graph in center of Digits Display.

6.15.4 Slowly and steadily move the StreamPro toward the opposite bank. As the StreamPro proceeds across the transect the four parameters in Digits Display are in real time. The discharge is the accumulated discharge to the present point in the measurement.

6.15.5 Notice the "Good Bins Indicator" vertical bar graph in the Digits Display. If the bar is green, three or more good bins are being measured. A yellow bar indicates two good bins. A red bar indicates one good bin. If no good bins are being collected, the "Good Bins Indicator" bar will appear grey, and the numeric display of average velocity will say "Bad". Although the StreamPro will operate with only one good bin in any given ensemble (with the exception of edge ensembles, which require two good bins), the manufacturer recommends selecting measurement cross-sections and bin sizes such that a minimum of two good bins are obtained. The "Good Bins Indicator" graph is useful as the StreamPro approaches the edges. Just prior to reaching the opposite edge slow the raft so as not to overshoot the pre-determined endpoint.

6.15.6 When the StreamPro reaches the opposite edge tap TRANSECT STOP. The edge distance screen will reappear. Verify the edge distance from the shore and tap OK. Once again hold the StreamPro still while the instrument collects edge data. After the edge discharge estimate is calculated, recording stops and the data file is closed.

6.15.7 Keep the ADCP in the same position to start the next transect. In the Data Collection screen tap TRANSECT START. The edge distances previously entered are saved so there should be no need to re-enter edge distances unless the measurable edge distance changes in the course of the measurement, such as during rising or falling stage conditions. Repeat this process until four good transects are measured.

6.15.8 If a transect must be aborted, re-start the transect at the same side of the stream as the aborted one. Be sure to note the circumstances of any aborted transects on the field form for the measurement. Each transect should have a reciprocal pair to reduce directional biases, i.e., of the four transects, two originate from the right side and two from the left side. Directional biases occur when right to left transects yield consistently greater or lesser discharges than transects measured right to left. (Oberg, et. al., 2005)

6.16 Comparing Transects — Tap the HISTORY tab to compare results of the four measured transects. The mean values of discharge, velocity, distance, and area are displayed in the upper part of the screen. Record the mean values in the space provided on the field sheet.

6.16.1 In the Transect Display in the lower portion of the screen, parameters of all transects are displayed. Included in this display is Delta Q, the difference (expressed as a percentage) between the measured discharge of a particular transect and the mean of all measured transects.

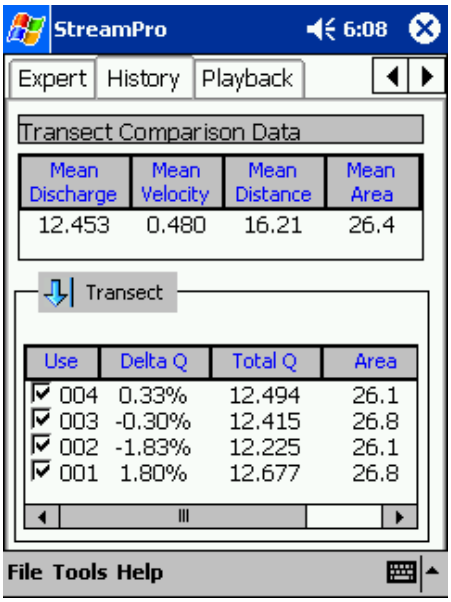


Figure 19. StreamPro History screen.

6.16.2 Verify all four transects are within five percent of the mean. If Delta Q of any transect is greater than five percent, four additional transects are measured. If Delta Q exceeds the five percent tolerance after eight transects use professional judgment to determine if more transects are necessary.

6.16.3 If data quality problems exist due to equipment malfunctions, computer problems, configuration errors, or other identifiable difficulties, discard the bad transects and measure additional transects as required. Transects measured to replace bad transects start at the same edge as the discarded transect. In situations where stage has changed such that the rated discharge has changed by greater than 5 percent between the time of the original transect and the replacement transect, a new set of transects should be measured. All transect discards should be documented in the field notes.

6.17 Playing Back Data On The PDA — Tap the PLAYBACK tab. Tap FILE dropdown in the lower right corner of the screen and select LOAD…

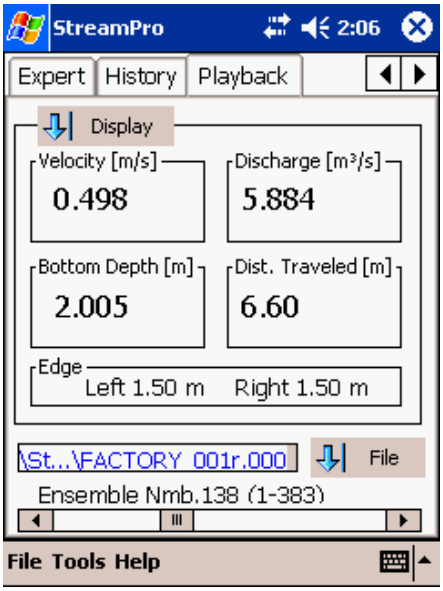


Figure 20. StreamPro Playback mode screen.

6.17.1 The ADCP File Selection screen will appear. Find the correct file folder and select a raw data file. A pop up box displaying "Loading File Completed" will appear. Tap OK in the upper right corner of the pop up box. The loaded file can be played back by moving the sliding tab at the bottom of the screen. The Display dropdown box in the upper left of the screen offers graphic display options.

6.18 Expert Mode — Expert mode can be accessed during Test Pinging, Data Collection, or Data Playback modes. Expert mode is used to view the water temperature and perform advanced data quality evaluations during or after a measurement.

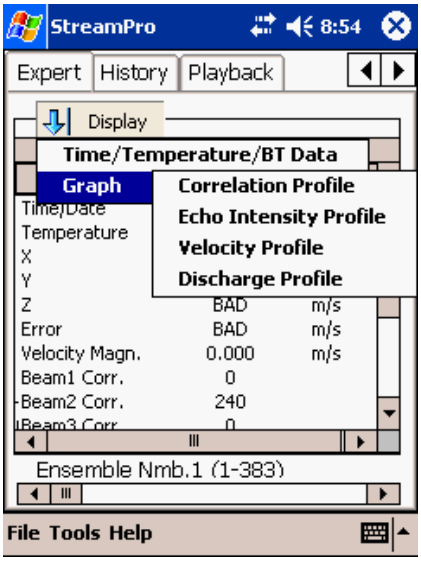


Figure 21. StreamPro Expert mode screen.

6.18.1 Tap the EXPERT tab. Use the scroll bar on the right side of the screen to scroll through the tabular data. The slide tab on the bottom of the screen scrolls through each ensemble of the transect. The Display dropdown box in the upper left of the screen offers graphic display options.

6.19 Post Processing StreamPro Measurements

6.20 Copying Data Files From PDA to PC — Microsoft Active Sync must be loaded on the PC in order to download data from the PDA.

6.20.1 After returning to the office place the PDA in the cradle. Active Sync should automatically start on the PC.

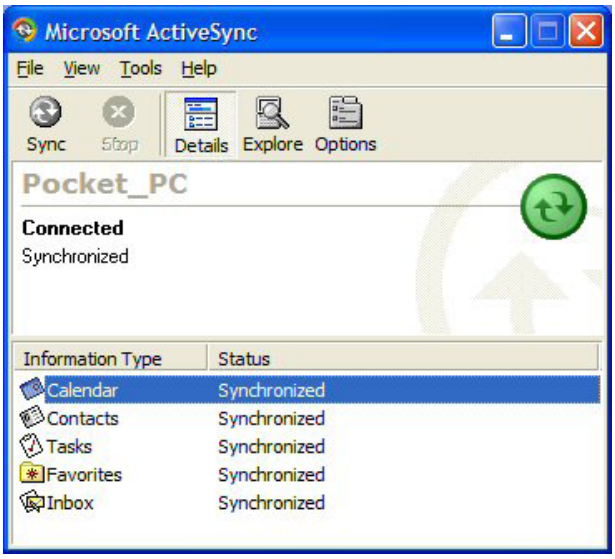


Figure 22. Microsoft ActiveSync screen.

6.20.2 When docked, the PDA will show up on the drive list in My Computer or Windows Explorer as "Mobile Device". Click on this icon to activate the connection. Then navigate to the SD card within the "Mobile Device" folder listing. You can then copy and paste or "drag and drop" the folder for the ADCP measurement to its destination location on Ecology's network.

6.21 Viewing And Compiling Data In WinRiverII — WinRiver II is the TRDI software package used to post-process StreamPro data.

6.21.1 After measurement files have been copied to the PC start WinRiver II. Select the FILE tab in the upper left of the screen and select CREATE MEASUREMENT and navigate to the desired raw data files in the "Select ADCP Raw Data File" pop up window.

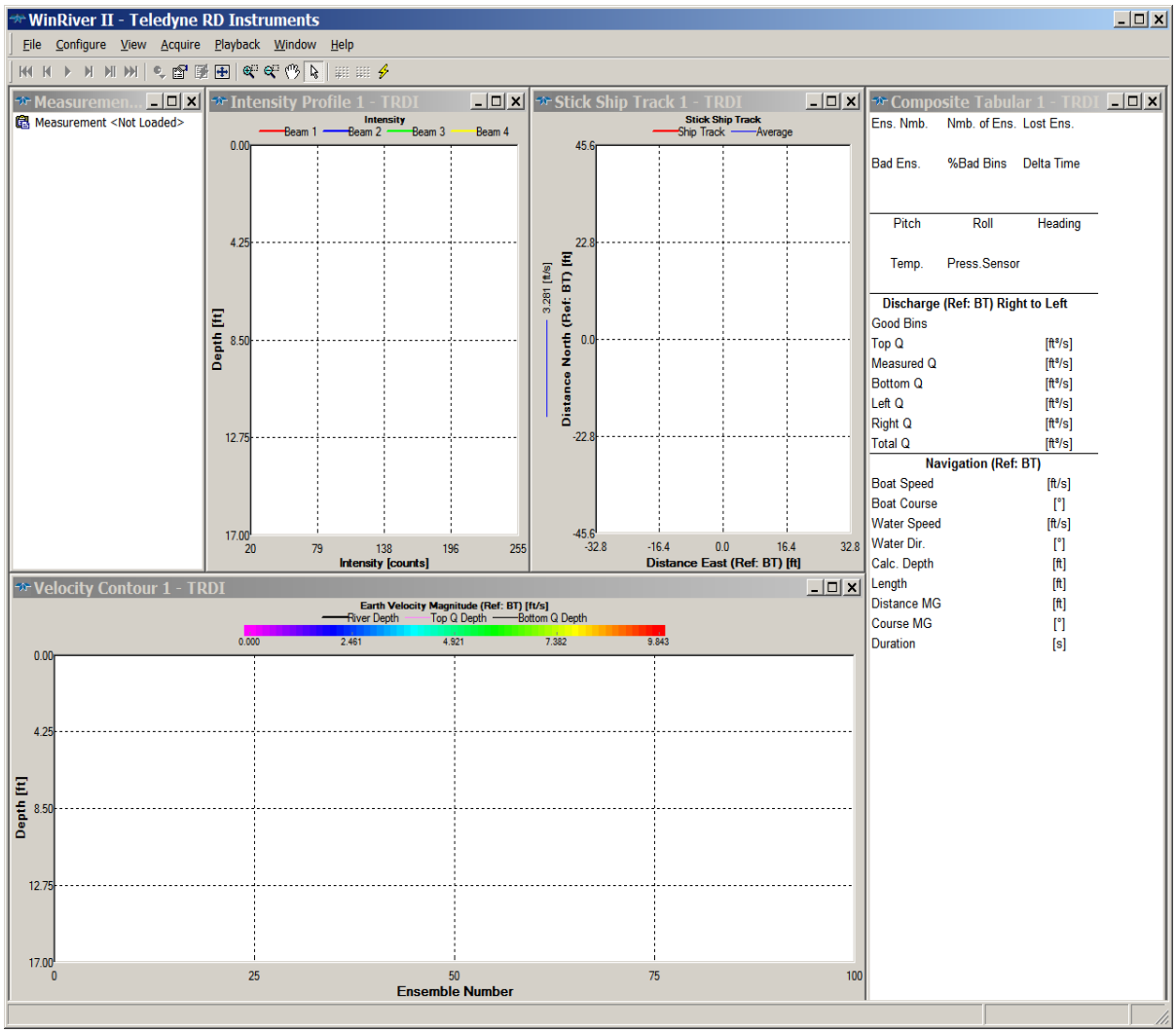


Figure 23. Opening WinRiver II screen.

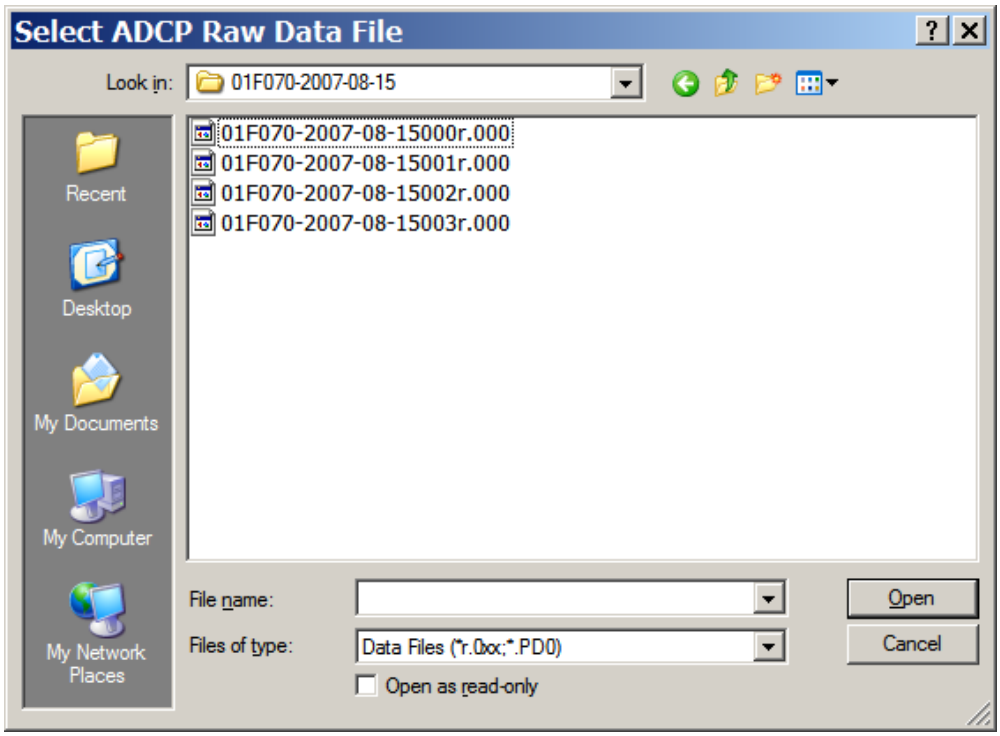


Figure 24. Select ADCP Raw Data File pop up window.

6.21.2 Navigate to the folder containing the StreamPro measurement files, highlight all of the files (<CTRL>-A will select all files in a folder) and select OPEN. The created measurement will appear in the Measurement Management window with the numbered transects checked.

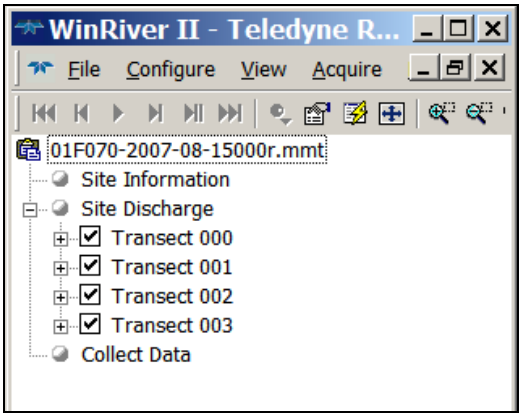
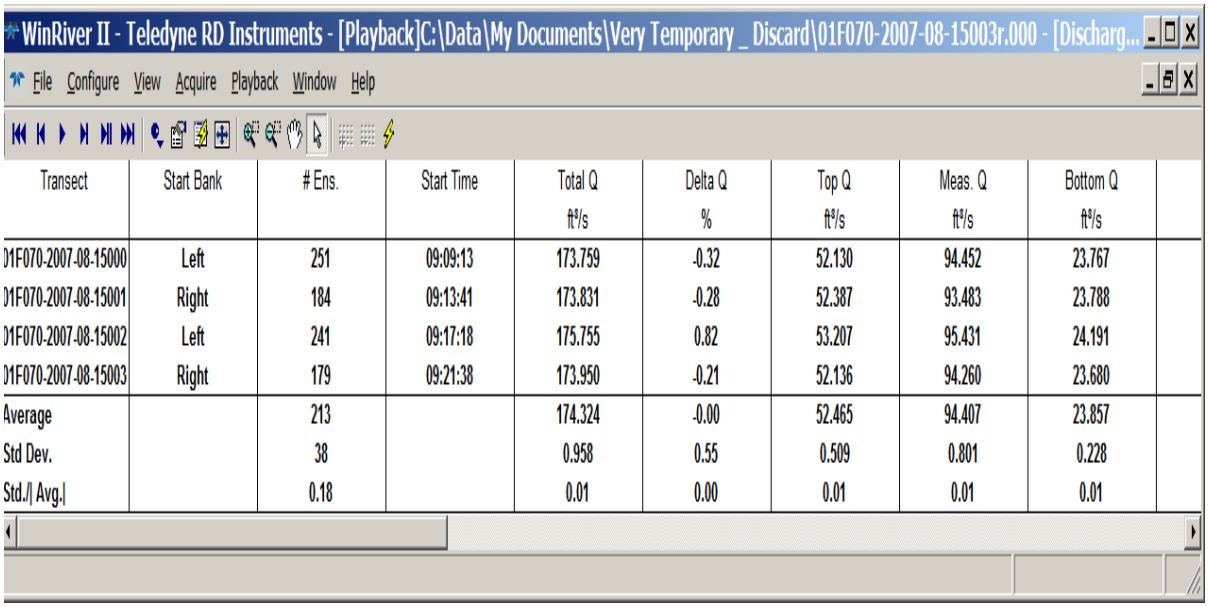


Figure 25. Measurement Management window.

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

6.21.4 Select the DISCHARGE SUMMARY node from the Measurement Management window. The Discharge Summary displays all checked transects and presents a comprehensive comparison between transects. Transect statistics in red font indicates the transect's Delta statistic for discharge is greater than plus or minus five percent.



Transect	Start Bank	# Ens.	Start Time	Total Q ft³/s	Delta Q %	Top Q ft³/s	Meas. Q ft³/s	Bottom Q ft³/s
01F070-2007-08-15000	Left	251	09:09:13	173.759	-0.32	52.130	94.452	23.767
01F070-2007-08-15001	Right	184	09:13:41	173.831	-0.28	52.387	93.483	23.788
01F070-2007-08-15002	Left	241	09:17:18	175.755	0.82	53.207	95.431	24.191
01F070-2007-08-15003	Right	179	09:21:38	173.950	-0.21	52.136	94.260	23.680
Average		213		174.324	-0.00	52.465	94.407	23.857
Std Dev.		38		0.958	0.55	0.509	0.801	0.228
Std./| Avg.|		0.18		0.01	0.00	0.01	0.01	0.01

Figure 26. Discharge Summary window.

6.21.5 Un-checking the transect in the Measurement Management window removes the transect from the summary. Transects should not be permanently removed 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 of the transect. All transect removals are documented.

6.21.6 Downgrading the measurement quality should be considered if one or more transects contains 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).

6.21.7 The measurement quality should also be downgraded 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).

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

6.21.9 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 Report Summary Template* Excel file located at the Stream Hydrology group's shared server folder (H:\FLOWS\QAData).

STATION NUMBER: **DATE OF MEASUREMENT:** **ADCP NUMBER:**

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
											#DIV/0! #DIV/0! #DIV/0! #DIV/0! #DIV/0! #DIV/0! #DIV/0! #DIV/0! #DIV/0! #DIV/0!	
Mean Stdev ***Stdev/Mean***											**#DIV/0!** #DIV/0! ***#DIV/0!***	

Figure 27. Discharge Summary Template (Table by Washington Department of Ecology).

6.21.10 Open the template file and paste the Discharge Summary below the template. Copy and paste the respective parameters including Mean, Standard Deviation, and Stdev/Mean to the correct locations in the template.

6.21.11 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.

7.0 Records Management

7.1 StreamPro configuration files (.xml), raw transect files (r.000), 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 StreamPro data and results are collected and presented to the field investigator in real-time, 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 Measurement Review

8.6.1 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. Additional WinRiver II contour graphs, photos, or any other pertinent information may also be included. Before review, the measurement is entered to the Hydstra Guagings database.

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

8.6.3 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.

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

8.6.5 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.

8.6.6 Additional quality assurance practices involving the periodic comparison of discharge measurements collected by other instruments are described in a Standard Operating Procedure document currently under development.

8.7 Troubleshooting

8.7.1 If problems persist and solutions cannot be found in this document consult the "StreamPro Quick Start Guide" for further assistance. If necessary call TRDI at (858) 842-2600.

Problem	Solution
BlueTooth connection is not established	Make sure BlueTooth is turned on at PDA. Make sure StreamPro is powered on. Exit StreamPro program (Tap FILE/EXIT STREAMPRO). Restart StreamPro. BlueTooth connection should restore. More details at page(s): 9-11
BlueTooth connection is erratic or fails during measurement.	The range of most BlueTooth devices is approximately 30 feet. Although experience has shown the StreamPro can communicate at ranges of 100 feet or more, in some environments the range can be substantially shorter. Make sure BlueTooth is turned on at PDA. Make sure StreamPro is powered on. Exit StreamPro program (Tap FILE/EXIT STREAMPRO). Restart StreamPro. BlueTooth connection should restore. More details at page(s): 9-11
StreamPro icon does not appear under my shortcut tab.	Follow procedure on pages 10-11.
StreamPro screen displays metric units.	Tap SETUP tab in StreamPro program, tap UNITS dropdown, and select ENGLISH. More details at page(s): 12
Velocities and/or bottom depth show as "BAD" during measurement.	Bad ensembles can be caused by excessive turbulence, aquatic vegetation, or inadequate transect depth. Consider conducting the measurement in a different location. More details at page(s): 9

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 (pages 1-35 and 2-17) 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, 2006. Environmental Assessment Program Safety Manual.

10.3 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.

10.4 Teledyne RD Instruments. StreamPro Quick Start Guide. 2005. P/N 95B-60045-00.

10.5 Teledyne RD Instruments. StreamPro Software User's Guide. 2005. P/N 95B-6008-00.

10.6 Teledyne RD Instruments. StreamPro ADCP Operation Manual. 2005. P/N 95B-6003-00.

10.7 Unless otherwise noted all photos and images used in this document courtesy of Teledyne RD Instruments©.

Attachment A.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

ADCP
Discharge Measurement Notes

Meas. No ____
Comp. by ____
Check by ____
Prop. No ____

Sta. No. ....
Name: ....
Date ...., 20 .... Party ....
Width .... Area .... Vel. .... G.H .... Disch. ....
Method .... No. secs. .... G.H. change .... in .... hrs. Susp. ....
Max Depth .... Hor. angle coef. .... Wetted Perim. .... Meter No. ....

GAGE READINGS

Time	TD/WT	Logger	Staff	+/-
REW				
LEW				

Type of meter ....
$Q\ \sigma / \bar{x}$ ....
$V\ \sigma / \bar{x}$ ....
$A\ \sigma / \bar{x}$ ....
Wading, cable, ice, boat, upstr., downstr, side bridge........ feet, mile, above, below gage, and..........
Check-bar, found .... changed to .... at ....

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%), based on following conditions:
Cross section..........
Flow..........
Control..........
Gage..........
Weather..........
Other..........
Remarks..........

Zero flow = GH ________ -depth at control ________ = ________ ft.

ECY 070-298 (10/07)

Measurement Notes

Test Ping Transect:
Right Edge Dist. ________
Left Edge Dist. ________
Max Depth ________
Max Velocity ________
Cell Size ________

File Name: ________________
Water Mode: ________________ Profiler depth ________________
Location on SD Card: ________________________
Moving Bed Test: Yes No __________ Ft. in __________ Seconds
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	
Averages											

Notes
____
____
____
____