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State of Washington

**Standard Operating Procedure
EAP058, Version 1.2**

**Operation of the SonTek® FlowTracker®
Handheld ADV®**

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Contact information

For more information contact:

Publications Coordinator
Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: (360) 407-6764

Washington State Department of Ecology - ecology.wa.gov
o   Headquarters, Olympia   (360) 407-6000
o   Northwest Regional Office, Bellevue   (425) 649-7000
o   Southwest Regional Office, Olympia   (360) 407-6300
o   Central Regional Office, Union Gap   (509) 575-2490
o   Eastern Regional Office, Spokane   (509) 329-3400

Purpose of this document

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

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedure for Operation of the SonTek® FlowTracker® Handheld ADV®

Version 1.2

Original Author – Tyler W. Burks, WOS FMU
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QA Approval - William R. Kammin, Ecology Quality Assurance Officer
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Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

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

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
08/10/2015	1.1	*BeamCheck* frequency and Mounting Correction update.	6.2.1 and 6.3.8	Tyler Burks
12/06/2016	1.2	Update cover page, footer	all	Bill Kammin
12/08/2016	1.2	Recertification	all	Bill Kammin

Environmental Assessment Program

Standard Operating Procedure for Measuring Stream Discharge using the SonTek® FlowTracker® Handheld ADV®

Introduction

The SonTek® FlowTracker® Handheld Acoustic Doppler Velocimeter (FlowTracker) is the primary instrument used for measuring surface freshwater discharge in wadeable streams by the Environmental Assessment Program (EAP) Freshwater Monitoring Unit (FMU). The FlowTracker ADV operates at an acoustic frequency of 10 MHz and measures the phase change caused by the Doppler shift in acoustic frequency that occurs when a transmitted acoustic signal reflects off particles in the flow of water. The magnitude of the phase change is proportional to the flow velocity. In cooperation with the United States Geological Survey, SonTek/YSI Inc. adapted this previously lab-restricted technology for use by hydrographers in wadeable streams, via a Top-set wading rod.

1.0 Purpose and Scope

1.1   This document is the Environmental Assessment Program (EAP) Freshwater Monitoring Unit (FMU) Standard Operating Procedure (SOP) for measuring stream discharge using the SonTek FlowTracker Handheld ADV.

1.2   The procedure for operation, maintenance, quality assurance, and data management for producing a surface water measurement with the FlowTracker is summarized in this document. The information hereafter is for quick reference and FMU relative supplementary information and is not a substitute for the SonTek FlowTracker Quick Start Guide, User's Manual, or the more in-depth Technical Manual.

2.0   Applicability

2.1   This procedure is followed when conditions warrant a wading discharge measurement. Certain steps in this procedure (i.e. maintenance and quality assurance) can be followed out of sequence during periodic maintenance or office processing of a discharge measurement.

3.0   Definitions

3.1   Acoustic Doppler Velocimeter (ADV): An instrument that measures stream velocity by sensing the phase change caused by the Doppler shift in acoustic frequency that occurs when a transmitted acoustic signal reflects off particles in the flow.

3.2   Boundary: An underwater obstacle that impedes the transmission or receipt of the acoustic signal by the FlowTracker. The sampling range self-adjusts to some boundaries

but may dramatically reduce recorded maximum velocity. The degree of interference is reported as the Boundary QC.

3.3 Cross section: A vertical plane oriented perpendicular to the stream flow direction that extends from bank to bank and from the channel substrate to the water surface.

3.4 Discharge: The volume of water in a stream passing a given point at a given moment in time and is determined by measuring the stream channel cross-sectional area and the water's mean velocity at the site selected.

3.5 QA Thermistor: An analytical probe comprised of thermally sensitive resistors used to measure water temperature for quality assurance purposes.

3.6 Quality control (QC) data: In addition to velocity, the FlowTracker records several quality control parameters. These include signal-to-noise ratio (SNR), standard error of velocity, boundary adjustment, the number of spikes filtered from data, and velocity angle. For details about QC data, see §8.1 of this document.

3.7 Signal-to-noise ratio (SNR): The ratio of the received acoustic signal strength to the ambient noise level. It is expressed in the logarithmic unit of decibels (dB) and is the most important QC data for the FlowTracker. Without sufficient SNR, the FlowTracker cannot measure velocity.

3.8 Standard error of velocity (σV): A direct measure of the accuracy of the mean velocity data. σV is calculated by dividing the standard deviation of one-second samples by the square root of the number of samples.

4.0 Personnel Qualifications/Responsibilities

4.1 Personnel should possess knowledge of safely conducting discharge measurements by wading methods.

4.2 Anyone tasked to make a wading discharge measurement that has secured a FlowTracker from the FMU equipment pool.

5.0 Equipment, Reagents, and Supplies

5.1 2-D ADV Probe attached to FlowTracker handheld unit (handheld unit), with firmware v3.90.
5.2 Top-set wading rod with ADV probe mount and bubble level.
5.3 Mounting bracket for handheld unit.
5.4 Hex key or Allen® wrench.
5.5 Discharge Measurement Notes Form (ECY 040-56 (Rev. 12/07)).
5.6 Personal floatation device.

5.7	Engineer's rule measuring tape (graduated in 10ths of feet to an appropriate length) and two stakes (or means to secure measuring tape).
5.8	Attire suitable for entering the stream.
5.9	RS-232 communication cable with USB adapter.
5.10	External computer with SonTek software installed (SonTek FlowTracker v2.30, SonUtils v4.20, and all versions of the manual).
5.11	Large container of turbid water (i.e. five-gallon bucket or rectangular plastic tote).

6.0   **Summary of Procedure**

6.1   Instrument Assembly

6.1.1   Remove 2-D ADV probe, handheld unit, mounting bracket, and hex key from the protective case.

6.1.2   Attach mounting bracket via thumbscrews to the two threaded holes on the back of the handheld unit.

6.1.3   Insert the mounting post of the ADV Probe into the ADV probe mount on the top-set wading rod; tighten the hex-head setscrew with the supplied hex key.

(SonTek/YSI, Inc., 2006)

6.1.4   Place the mounting bracket on the post extending from the top of the top-set wading rod; tighten the bracket using the black plastic-capped setscrew.


(SonTek/YSI, Inc., 2006)

6.2   <u>Pre-Measurement Diagnostics:</u> are performed both in the office and field environment in order to verify proper system function. *BeamCheck* is a SonTek diagnostic tool used to test and track the integrity of the ADV Probe in a controlled environment before the unit is taken to the measurement location. Additionally, there is a built-in Quality Control Test (*QCTest*) procedure that is completed in the field before each measurement is started, to assure system function.

6.2.1   *BeamCheck* is required only when (1) a new instrument is received, (2) if physical damage (e.g., dropping) may have occurred, (3) a firmware upgrade or repair is made, and (4) after any *QCTest* failures that cannot be explained by improper placement in the test environment.

6.2.1.1   Fill a container (five-gallon bucket or rectangular plastic tote) with at least 12 inches of water. This water must be turbid enough to reflect the transmitted acoustic pulses back to the receivers at the ADV probe. If using tap water, add a handful of fine-grained dirt, and stir into the container until suspended.

6.2.1.2   Connect the RS-232 communication cable to the USB adapter and between an external computer and the threaded five-pin connector COM port at the base of the handheld unit.

6.2.1.3   Start up the external computer.

6.2.1.4   Turn the handheld unit on by holding down the yellow button on the keypad.

6.2.1.5   Run the *FlowTracker* software v2.30 (click **Start** | **Programs** | **SonTek Software** | **FlowTracker**).

6.2.1.6   Click **Connect to a FlowTracker.** Select the correct COM port and click **Connect**.

6.2.1.7   Click **BeamCheck.**

6.2.1.8   Submerge ADV Probe in turbid water assuring that it is a minimum of two inches from the bottom of the container and ideally 8-12 inches from the edge of the container. It is important however that a boundary does exist.

6.2.1.9   In the upper right of the *BeamCheck* window, click **Averaging**.

6.2.1.10   Click **Start**, then quickly click **Record**.

6.2.1.10.1   The software will log the *BeamCheck* session to a file.

6.2.1.10.2   Use the following file naming convention: FT*-YYYY-MM-DD.bmc. (*Depends on the EAP-assigned number to that particular FlowTracker unit).

6.2.1.10.3   Save the file to the external computer for future archiving.

6.2.1.11   After recording a minimum of 20 pings, click **Stop**.

6.2.1.11.1   The number of recorded pings is monitored in the upper left corner of the *BeamCheck* window.

6.2.1.11.2   The following diagram is an example of a near ideal *BeamCheck* session:
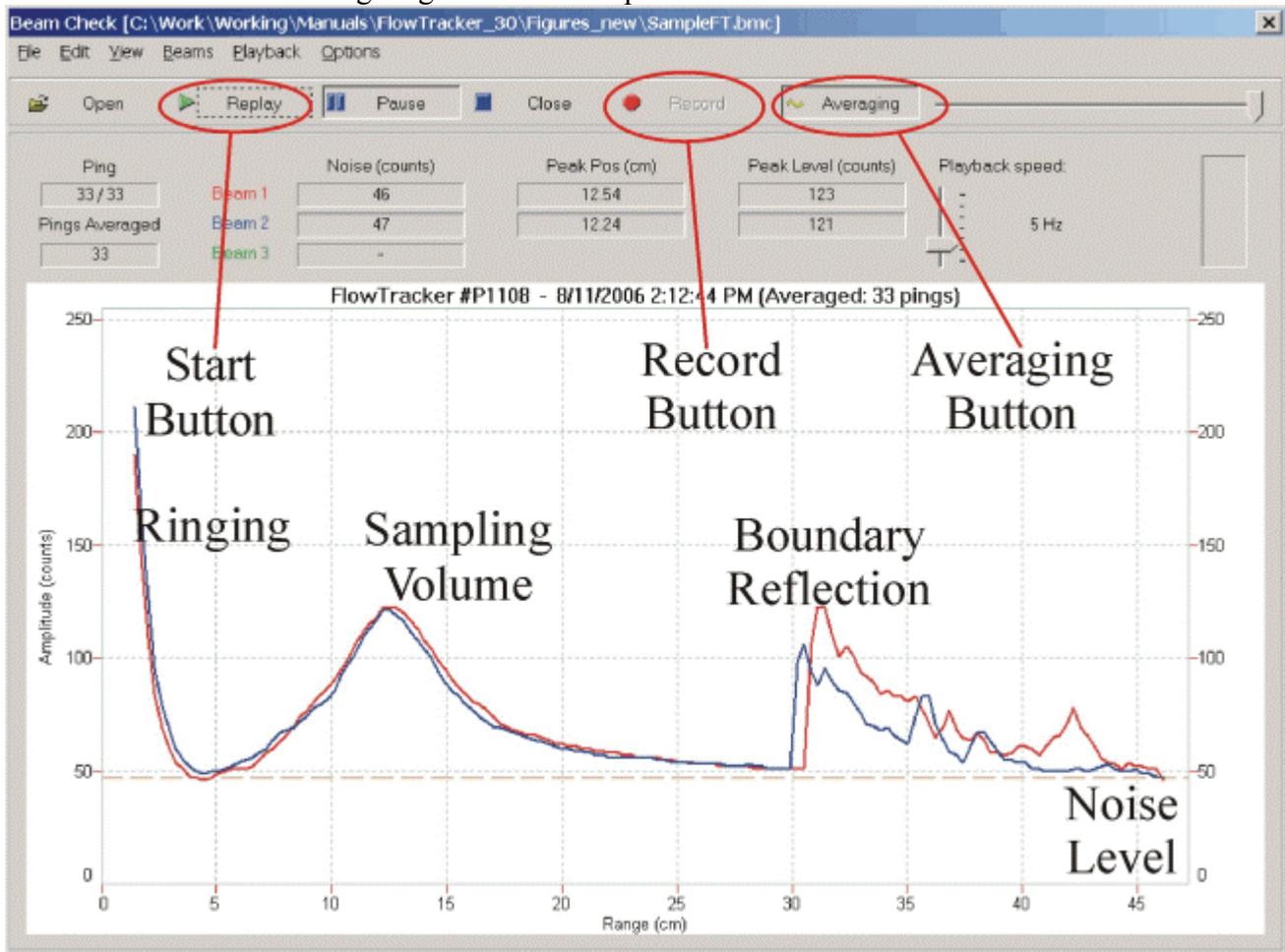
6.2.1.11.3   Refer to *SonTek/YSI FlowTracker Technical Manual* (§6.5.5) for detailed explanation of the sample diagram. Refer to *SonTek/YSI FlowTracker Technical Manual* (§6.5.6) for assistance with diagnosing potential hardware problems using *BeamCheck*.

6.2.1.12   Click **File | Exit** to close *BeamCheck*.

6.2.1.13   Click **Disconnect**.

6.2.1.14   Disconnect the communication cable from the handheld unit and external computer.

6.2.1.15   Press and hold the yellow power button on the handheld unit until the screen is blank.

6.2.1.16   Disassemble the FlowTracker, and secure for departure.

6.2.2 *Field Diagnostics* are performed with the instrument assembled prior to each discharge measurement or periodically throughout the field excursion to confirm operation and capacity of the instrument.

6.2.2.1 The **Recorder Status** option checks the amount of space available on the 4-MB internal memory of the handheld unit.

6.2.2.1.1 Press and hold the yellow power button to turn on the unit.

6.2.2.1.2 Press **Enter** for the Main Menu.

6.2.2.1.3 Press **2** to access System Functions.

6.2.2.1.4 Press **2** to access Recorder Status.

6.2.2.1.4.1 The number of files recorded and the maximum number of files available will be reported. On 4MB of internal memory, approximately 64 measurements can be conducted before the memory must be reformatted (erased).

6.2.2.1.5 Press **Enter** to return to the System Functions menu

6.2.2.1.6 If you have concerns regarding the amount of space available, Press **3** to Format Recorder.

6.2.2.1.6.1 Before the internal memory is erased be sure to download the data to an external computer, or confirm with others that the data has been properly archived. Once the memory is reformatted, the previous data is non-recoverable.

6.2.2.1.7 Press **"1," "2," "3,"** and **Enter** to confirm your decision.

6.2.2.1.8 Press **Enter** after the format is complete to return to the System Functions menu. This process will take approximately 15-60+ seconds.

6.2.2.2 **Temperature Data** should be checked for accuracy, because it is used for sound speed calculations and can affect velocity data.

6.2.2.2.1 Place the ADV Probe in the water that is to be measured.

6.2.2.2.2 From the **System Functions** menu Press **4** to access temperature data.

6.2.2.2.2.1 The temperature sensor is in the probe head and is accurate to ±0.1°C. The temperature recorded is used for automatic sound speed correction.

6.2.2.2.3   This temperature value should be compared to an independent measurement of water temperature (QA thermistor) before a measurement is conducted. A difference of 5°C between the two values could result in an error of ≈2% in mean velocity determination.

6.2.2.2.4   Press **Enter** to return to the System Functions menu.

6.2.2.3   **Battery Data** should be checked prior to each measurement to confirm that there is capacity to complete the measurement.

6.2.2.3.1   From the System Functions menu Press **5** to access battery data.

6.2.2.3.1.1   The battery voltage and estimated remaining capacity (percent of total) based on voltage will be displayed for three battery types. In most cases, Alkaline or NiMH batteries are available.

6.2.2.3.1.2   Alkaline batteries have an average continuous running time of 25 hours, with a "drained" voltage of 7.0 V.

6.2.2.3.1.3   NiMH (1600mAh) batteries have an average continuous running time of 15 hours, with a "drained" voltage of 8.0V. If the alkaline voltage drops, below ≈8.0 V, the batteries should be changed. Batteries cannot be changed during a measurement without the possibility of losing data,

6.2.2.3.1.4   It is important to check the battery data at ambient temperature because capacity can vary greatly with environmental conditions.

6.2.2.3.2   Refer to *SonTek/YSI FlowTracker Technical Manual* (§7.2) for further information regarding the handheld unit power supply.

6.2.2.3.3   Press **Enter** to return to the System Functions menu.

6.2.2.3.4   The batteries are accessed from the back of the handheld unit.

6.2.2.3.4.1   Turn the system off by holding down the yellow power button.

6.2.2.3.4.1.1   **Special Note: Each time the handheld unit is turned off, it is *critical* that you do so from the Main Menu. This ensures that all information is properly saved.**

6.2.2.3.4.2   Remove the six screws holding the battery compartment lid to the main housing.

6.2.2.3.4.3   Remove the old batteries from the battery holder.

6.2.2.3.4.3.1   Place all discharged single-use alkaline batteries in a receptacle for proper recycling, or recharge NiMH batteries for later reuse.

6.2.2.3.4.4   Install the new batteries, matching the orientation shown on the battery holder.

6.2.2.3.4.5   Secure the battery compartment lid using the six screws.

6.2.2.3.4.6   Turn the system on and check the battery voltage level as described in §6.2.2.3.1 of this document.

6.2.2.3.4.6.1   New alkaline batteries will show approximately 12.0V, where NiMH will show approximately 10.5V.

6.2.2.4   Confirm that the **System Clock** displays the correct date and time (PST).

6.2.2.4.1   From the System Functions menu Press **9** to access Set System Clock.

6.2.2.4.2   If time and date are accurate Press **0** to exit back to the System Functions menu.

6.2.2.4.2.1   Change Date if not accurate.

6.2.2.4.2.1.1   Press **1** to change Date.

6.2.2.4.2.1.2   Type date on keypad YYYY/MM/DD. Use "**.**" for "/."

6.2.2.4.2.1.3   Press **Enter** to return to Set System Clock menu.

6.2.2.4.2.2   Change Time (PST) if not accurate.

6.2.2.4.2.2.1   Press **2** to change Time.

6.2.2.4.2.2.2   Type time on keypad HH:MM:SS. Use "**.**" for ":."

6.2.2.4.2.2.3   Press **Enter** to apply the set time and return to the Set System Clock menu.

6.2.2.4.2.3   Press **0** to exit back to the System Functions menu.

6.2.2.4.3   Press **0** to exit back to the Main Menu.

6.3   **Setup Parameters** determine how the FlowTracker collects data and establishes quality control criteria. In most cases, these settings will not vary from the USGS (Blanchard, 2007) recommended defaults. Instances of deviation will be mentioned below. It is however important to verify the setup parameters prior to deployment. (Special Note: Press **Enter** to scroll through the **Setup Parameters** menu)

6.3.1   The **Units System** defines the units used for display and output data.

6.3.1.1   From the Main Menu Press **1** to enter the **Setup Parameters** menu

6.3.1.2   Confirm that the Unit System is "English."

6.3.1.2.1   To change, Press **1** from the **Setup Parameters** menu.

6.3.1.2.2   Press **1** to change the **Units System** to "English."

6.3.2   The **Avg Time** (averaging time) option determines the period of sampling (in seconds) for data collection at each station.

6.3.2.1   The current averaging time will be displayed in parentheses to the right of **Avg Time**.

6.3.2.2   Confirm that the **Avg Time** is 40 seconds.

6.3.2.3   To change, Press **2** from the **Setup Parameters** menu.

6.3.2.3.1   In normal measuring conditions the averaging time is 40 seconds which conforms to EAP FMU and USGS standards.

6.3.2.3.2   In certain measurement conditions (Shedd, 2009), it is necessary to increase or decrease the averaging time. The desired time can be entered on the keypad during step 6.3.2.3.

6.3.3   The Data Collection Mode (**Mode**) option determines the procedure when collecting a series of measurement stations.

6.3.3.1   The current data-collection mode will be displayed to the right of **Mode**.

6.3.3.2   Confirm that the **Mode** is set to "Discharge."

6.3.3.3   To change, Press **3** from the Setup Parameters Menu.

6.3.3.4   Press **1** to set the mode to "Discharge," or Press **2** to set the mode to "General."

6.3.3.4.1   Typical discharge measurements require the **Mode** be set to "Discharge."

6.3.3.4.2   The "General" mode is reserved for the storage of location and velocity information without discharge calculation. This mode will not be discussed further in this document. Refer to *SonTek/YSI FlowTracker Technical Manual* §4.2.2 for further information.

6.3.4   The **QC Settings** menu sets quality control criteria for discharge measurements. To access the **QC Settings** menu Press **4** from the **Setup Parameters** menu, this grants you access to multiple criteria.

6.3.4.1   Press **1** to set the **SNR Threshold**.

6.3.4.1.1   The **SNR Threshold** should be set to 10dB, which conforms to EAP FMU and USGS standards.

6.3.4.1.2   The optimal operating range is ≥10dB; however, the FlowTracker can operate properly at a ratio as low as 4dB. Below 4dB additional seeding material may be required to collect accurate data.

6.3.4.1.3   For additional information regarding the **SNR** refer to *SonTek FlowTracker Technical Manual* §1.4.2

6.3.4.2   Press **2** to set the **σV Threshold** (Standard Error of Velocity Threshold).

6.3.4.2.1   The **σV Threshold** should be set to 0.033 feet per second (ft/sec) which conforms to EAP FMU and USGS standards.

6.3.4.2.2   **σV** is normally dominated by real variations in the flow and will vary depending on the measurement environment.

6.3.4.2.3   If the threshold is exceeded the observation can be repeated, with an adjustment of location in the cross section if desired. In certain measurement environments threshold exceedances are unavoidable.

6.3.4.2.4   For additional information regarding the **σV** refer to *SonTek FlowTracker Technical Manual* §1.4.3

6.3.4.3   Press **3** to set the **Spike Threshold**.

6.3.4.3.1   The **Spike Threshold** should be set to 10%, which conforms to EAP FMU and USGS standards.

6.3.4.3.2   Spikes in velocity data are inherent in all acoustic Doppler velocity sensors. Spikes have many causes, but typically include: boundaries, highly aerated water, or acoustic anomalies.

6.3.4.3.3   A warning is given after a velocity observation if the percentage of spikes relative to the total number of points exceeds 10%. In the case of a 40-second averaging time this threshold would be five spikes.

6.3.4.3.4   If the threshold is exceeded, the observation can be repeated, with an adjustment of location in the cross section if desired. In certain measurement environments threshold exceedances are unavoidable.

6.3.4.3.5   For additional information regarding the **Spike Threshold** refer to *SonTek FlowTracker Technical Manual* §1.4.5

6.3.4.4   Press **4** to set the **Max Velocity Angle**.

6.3.4.4.1   The **Max Velocity Angle** should be set to 20°, which conforms to EAP FMU and USGS standards.

6.3.4.4.2   Velocity angle is defined as the water flow direction relative to the FlowTracker's X measurement component.

6.3.4.4.3   The following diagram by Rehmel (2007) illustrates the probe coordinate system relative to the channel cross section.
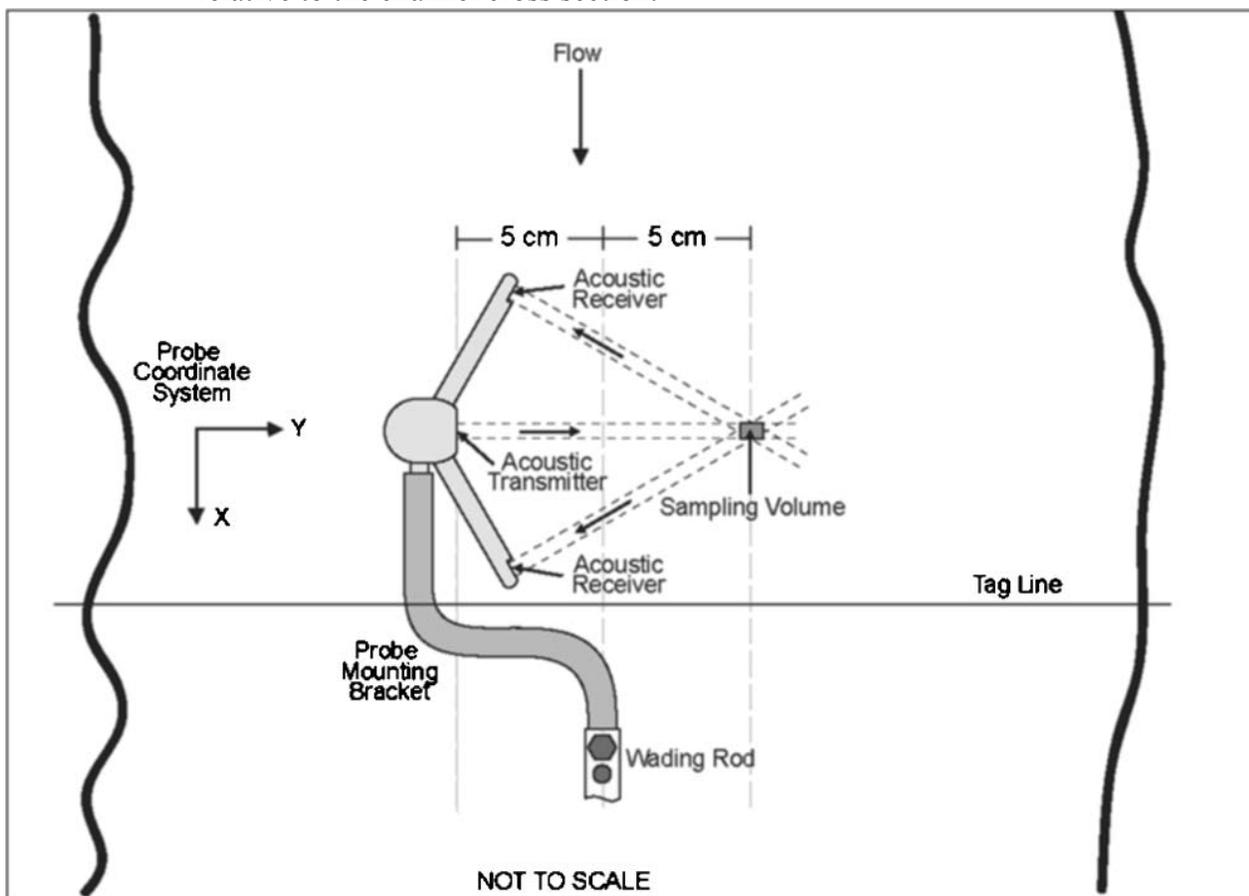
(Rehmel, 2007)

6.3.4.4.4   The FlowTracker's ability to measure two components of velocity eliminates the requirement for the individual to measure and document flow angles at each station for later use in discharge computation of wading measurements.

6.3.4.4.5   If the threshold is exceeded, the observation can be repeated with an adjustment of location in the cross section, if desired. If, however, a majority of the channel flow is beyond 20-30° in a single direction (positive or negative) a new location for the measurement cross section should be considered.

6.3.4.4.6   For additional information regarding the **Max Velocity Angle** refer to *SonTek FlowTracker Technical Manual* §1.4.6.

6.3.5   The **Discharge Settings** menu specifies settings for the discharge calculations and the quality-control criteria used for **Discharge** measurements. To access the **Discharge Settings** menu, Press **5** from the **Setup Parameters** menu.

6.3.5.1   From the **Discharge Settings** menu Press **1** to confirm the **Equation** used for discharge calculation. The current equation used is in parentheses next to the word **Equation**.

6.3.5.1.1   The **Equation** should be set to **Mid Section**, which conforms to EAP FMU and USGS standards.

6.3.5.1.2   If the **Equation** differs, Press **1** to set to the **Mid Section** method.

6.3.5.1.3   By selecting the **Mid Section** method this sets **Repeat Depth** and **Repeat Velocity** to "NO." **Repeat Depth** and **Repeat Velocity** are only used in measurement methods nonstandard to the EAP FMU and USGS.

6.3.5.2   From the **Discharge Settings** menu, Press **4** to confirm the **Max Section Discharge**, which is the percentage of the total discharge allowed in each section.

6.3.5.2.1   The **Max Section Discharge** should be set to **10%.** This conforms to EAP FMU and USGS standards.

6.3.5.2.2   The default **Max Section Discharge** is **10%**.

6.3.5.2.3   The operator is given an alert during the measurement if a **Rated** discharge is entered or after the entire measurement is complete. For additional information regarding the **Max Section Discharge,** refer to *SonTek FlowTracker Technical Manual* §1.4.7.

6.3.5.3   From the **Discharge Settings** menu, Press **5** to confirm the **Max Depth Change** (default 50%), which is intended to alert the operator of potential depth entry errors.

6.3.5.3.1   If the entered depth differs from the previous or adjacent section by 50%, the operator is alerted and prompted to re-enter or accept the value.

6.3.5.3.2   For additional information regarding the **Max Depth Change** refer to *SonTek FlowTracker Technical Manual* §1.4.8.

6.3.5.4   From the **Discharge Settings** menu, Press **6** to confirm the **Max Location Change** (default 100%), which is intended to alert the operator of potential location entry errors.

6.3.5.4.1   With a setting of 100%, an alert will be given to the operator if the station spacing changes by two times or if a station is simply out of order. Stations can be entered out of order. However, an alert is given to confirm the entry prior to sorting the location to the correct order.

6.3.5.4.2   For additional information regarding the **Max Location Change**, refer to *SonTek FlowTracker Technical Manual* §1.4.9.

6.3.5.5   From the **Discharge Settings** menu, Press **7** to confirm the discharge **Reference** value.

6.3.5.5.1   The discharge **Reference** value is used to compute percent discharge (**%Q**) at each station.

6.3.5.5.2   The operator has the option to compute **%Q** using a **Rated** or **Measured** discharge.

6.3.5.5.3   **Rated** is the default option. However, if a value is not supplied, the **Measured** discharge is used.

6.3.5.5.4   One benefit of entering a **Rated** discharge is that the operator is able to monitor the **%Q** of each section as the measurement progresses; adding additional sections if necessary.

6.3.5.6   From the **Discharge Settings** menu Press **8** to select the **Methods Displayed**. This allows the operator to select the options available to measure mean velocity at a section.

6.3.5.6.1   The EAP FMU only uses a limited number of the total methods available. The unused methods can be turned off to reduce the number of methods toggled through during a measurement if a method change is required. Special Note: To the right of each method the word ON or OFF will be displayed.

6.3.5.6.2   Based on current techniques employed by the EAP FMU the following **Methods** should be toggled to the ON position: **2-6-8 Methods**, and **Multi Methods**.

6.3.5.6.3   Press **1** to toggle ON **2-6-8 Methods.**

6.3.5.6.4   Press **5** to toggle ON **Multi Methods**.

6.3.5.6.5   For additional information regarding the methods available for the measurement of mean velocity in a section, refer to *SonTek FlowTracker Technical Manual* §5.2.4.

6.3.5.7   From the **Discharge Settings** menu, Press **9** to confirm the **Uncertainty** calculation.

6.3.5.7.1   The **Uncertainty** calculation should be set to **Stats** (abbreviated from **Statistical**), which conforms to EAP FMU standards. The **Stats** calculation provides an estimate of measurement uncertainty for each discharge calculation.

6.3.5.7.2   In addition to an overall statistical uncertainty calculation, uncertainty is split into the following components: accuracy, depth, velocity, and width.

6.3.5.7.3   The **Stats Uncertainty** calculation incorporates measurement uncertainty, natural stream conditions (e.g., different bottom types), and the assumption that depth and velocity change linearly between stations.

6.3.5.7.4   For detailed information regarding the **Stats Uncertainty** calculation refer to *SonTek FlowTracker Technical Manual* §5.2.5 and Appendix C.

6.3.6   **Salinity**

6.3.6.1   The salinity of the water being measured can affect the sound speed, which is used for mean velocity determination.

6.3.6.2   Freshwater has a salinity of <0.5 ppt (parts per thousand) and seawater has a salinity of 35-50 ppt.

6.3.6.2.1   For the purposes of the EAP FMU, it is rare that the FlowTracker will be used in water with a salinity that will affect the sound speed. However, salinity may affect sound speed in estuarine (brackish) or polluted waters.

6.3.6.2.2   **IMPORTANT: When using the FlowTracker in salt water, a sacrificial zinc anode should be installed on the probe for corrosion protection.**

6.3.6.3   It has been determined that an error of 12 ppt in salinity creates a ≈2% error in mean velocity.

6.3.6.4   From the **Setup Parameters Menu** press **6** to change the **Salinity** value (in ppt).

6.3.7   **Language**

6.3.7.1   The FlowTracker firmware can be operated in five different languages: English, French, German, Spanish, and Italian.

6.3.7.2   From the **Setup Parameters Menu** press **7** to change the **Language**.

6.3.7.3   Press **1** to set the firmware to **English**.

6.3.7.4   Consult the FlowTracker Technical Manual §2.4.7 if another language is desired.

6.3.8   **Mounting Correction**

6.3.8.1   SonTek/YSI reports that a potential bias of 1 to 2 percent was identified in the x-velocity component (streamwise component) during tests conducted using a FlowTracker in a tow tank with a standard wading rod and offset mount. This condition prompted SonTek/YSI to release new versions of firmware (3.9) and software (2.30) for the FlowTracker to allow a setting called "mounting correction" that may be used to adjust the measured x-velocity component for flow disturbance in the sample volume caused by the mounting bracket and wading rod. Based on careful investigation and analysis by the USGS Office of Surface Water, EAP FMU conforms to the policy that the "mounting correction" must <u>NOT be applied</u>. Follow-up USGS field comparisons, flowing water numerical simulations, and lab comparisons in flowing water did not indicate a consistent bias of this magnitude for expected field applications (Rehmel, 2010).

6.3.8.2   From the **Setup Parameters Menu** press **8** to change the **Mounting Correction**.

6.3.8.3   Press **1** to set the firmware to **No Correction** (the default setting).

6.3.8.4   Consult the FlowTracker Technical Manual §2.4.8 and §8.1.4 if a nonstandard mounting correction is necessary. The non-standard correction must also be set in FlowTracker software v2.30 under the **Program Settings** dialog.

6.4   Discharge Measurement Procedure

6.4.1   <u>Summary of Site Selection Criteria</u>

6.4.1.1   The first and often most critical step in determining the discharge of a watercourse is selecting a representative cross section. The following is a brief summary of site-selection criteria that are specific to producing the best results with the SonTek FlowTracker. For a full description of measurement-site-selection criteria review (Shedd, 2009).

6.4.1.2   The channel is relatively straight for a distance (≈10-20 channel widths upstream and downstream of the measurement site) to provide uniform flow through the measuring section.

6.4.1.3   Streamflow is perpendicular to the measurement cross section and tagline.

6.4.1.4   The channel is free of obstructions (e.g., vegetation, woody debris, and variable substrate sizes) and excessive turbulence that create negative velocity, uneven velocity distribution across the measurement cross section or that interfere with the acoustic signal.

6.4.1.4.1   In some cases, especially shallow streams with variable substrate sizes, minor channel modification may be necessary to improve a measurement site.

6.4.1.4.2   Modifications should be minor and conducted prior to the start of the flow measurement. Be mindful of the potential for salmonid redds during appropriate seasons.

6.4.1.5   The water to be measured has sufficient particulate matter (fine sediment, organics, and air) entrained to carry an acoustic signal.

6.4.2   Summary of the Mid-Section Method

6.4.2.1   The following is a brief summary of the mid-section method for determining stream discharge. A full explanation can be found in Shedd (2009).

6.4.2.2   The default method (§6.3.5.1) used by the FlowTracker for discharge calculation is the mid-section method. This discharge setting organizes the entered measurement information for the operator and applies the mid-section equation to the data to calculate discharge. Therefore, only working knowledge of the mid-section method is necessary.

6.4.2.3   In order to accurately define the area and mean velocity of the channel, the cross section is divided into multiple segments. A discharge measurement is the summation of the products of the partial areas of the stream cross section and their respective average velocities.

6.4.2.4   In the mid-section method of computing a discharge measurement, it is assumed that the velocity sample at each point represents the mean velocity in a rectangular subsection. The subsection area extends laterally from half the distance from the preceding observation point to half the distance to the next, and vertically from the water surface to the sounded depth (Buchanan and Somers, 1969; Rantz et al., 1982).

6.4.3   Data Collection Procedure

6.4.3.1   Assemble the FlowTracker as described in §6.1 of this document.

6.4.3.2   Select the cross-section location, and stretch the tagline perpendicular to the prominent flow direction.

6.4.3.3   Begin filling out Discharge Measurement Notes Form (ECY 040-56 (Rev. 12/07)).

6.4.3.4   Read and record all primary, secondary, and auxiliary gage indices (where applicable).

6.4.3.5   Read and record water temperature for future comparison to both station data and the FlowTracker water temperature sensor.

6.4.3.6   <u>Measurement Header Information</u>

6.4.3.6.1   From the **Main Menu**, Press **3** to **Start Data Run**

6.4.3.6.2   Press **1** to **Name** the data file.

6.4.3.6.2.1   Enter the station number (e.g., 45F110) using the keypad. It is similar to a touch-tone phone keypad, where numbers are displayed first, then letters. Press the individual key multiple times to reach the desired number or letter.

6.4.3.6.2.2   Press **Enter** when finished.

6.4.3.6.3   Press **2** to add an extension to the **Data File Name**. The extension should consist of the three-digit date as an identifier. Press **Enter** when finished.

6.4.3.6.4   Review the **Data File Name**, displayed in parentheses, for accuracy.

6.4.3.6.5   Press **9** to accept the **Data File Name**.

6.4.3.6.6   Press **1** to enter the **Site** name; this name will be imported during post-processing into the Hydstra database.

6.4.3.6.6.1   Enter the station number (e.g., 45F110) using the keypad. In this case, the letters are displayed first, and then numbers. If a key is needed for a consecutive letter/number combination, wait for the cursor to move to the next space before pressing the keypad.

6.4.3.6.6.2   Press **Enter** when finished.

6.4.3.6.7   Press **2** to enter **Operator Name** (initials). Enter your initials using the keypad. In this case the letters are displayed first, and then numbers. Press **Enter** when finished.

6.4.3.7   <u>Pre-measurement QC Data</u>

6.4.3.7.1   Press **9** to **Start.**

6.4.3.7.2   Press **8** or **QC Menu** (in yellow text) to enter gage height, rated discharge, location, and site condition information. This button can be pressed at any point during the measurement to better document conditions throughout the site. For example, multiple entries of **Height** may be required during a rapidly changing stage. Up to 20 different entries can be added to each measurement file.

6.4.3.7.2.1   Press **1** to enter gage **Height** in feet. This value should be the most recent recorded observation of the primary gage index.

6.4.3.7.2.2   Press **2** to enter the **RatedQ** in ft³/s. A current rating table is required to enter this information. This value is used for comparison to measured discharge both in **%Q** calculation during the measurement (aides in adjusting width spacing) and a quality control feature at the end of the measurement, showing departure from the current rating. Press **Enter** when finished.

6.4.3.7.2.3   Press **3** to enter the **Time** of the observation if it differs from the current time displayed. Press **Enter** when finished.

6.4.3.7.2.4   Press **4** to enter the **Location** of the observation on the tag line in feet. Press **Enter** when finished.

6.4.3.7.2.5   Press **5** to enter text **Comments** about the measurement cross section or a particular location in the cross section. The "-" button is used to put a space between words. It is advised that this feature only be used for limited text entry. Document additional notes on Discharge Measurement Note Sheet (ECY 040-56 (Rev. 12/07)). Press **Enter** when finished.

6.4.3.7.2.6   By pressing **6** or **7** you are able to navigate between specific observation entries.

6.4.3.7.2.7   Once you have completed pertinent entries press **0** to exit. This will either continue with the beginning of the measurement or return to the present measurement location.

6.4.3.7.3   The operator will next be prompted to **Run** or **Skip** the **Auto QC Test**. The **Auto QC Test** is essentially a field version of *BeamCheck*, but is particular to the present measurement environment. This information is stored with each discharge measurement file and is displayed on the discharge measurement summary.

6.4.3.7.3.1   It is a requirement of all EAP FMU members to conduct an **Auto QC Test** prior to each discharge measurement.

6.4.3.7.3.2   Press **1** to **Run Test**.

6.4.3.7.3.3   The operator will be prompted to put the FlowTracker probe in moving water, away from obstructions. It is suggested that the operator place the probe in a location within the cross section that is representative of the stream to be measured. Set the probe at the 6/10ths depth on the wading rod, and Press **Enter**.

6.4.3.7.3.4   The FlowTracker will collect 20 pings and either report that "All Results are Good" or that the test completed with warnings.

6.4.3.7.3.5   If a warning exists, Press **1** to **End Test** or Press **2** to **Repeat Test**. If the test is being repeated, move to a different place in the cross section free of potential boundary interference.

6.4.3.7.4   At this point of the procedure you are prompted to enter the **Starting Edge** of the cross section to be measured and will soon be collecting velocity data.

6.4.3.7.4.1   All discharge measurements conducted by EAP FMU members begin at the right edge of water (REW). However, the default is the left edge.

6.4.3.7.4.2   Press **LEW/REW** (#4) to toggle between the edges, and set the starting edge to **REW**.

6.4.3.7.4.3   Press **Set Location** to enter the distance on the tagline for the starting **REW**. Press **Enter** when finished.

6.4.3.7.4.4   Some cases exist where the edge of the cross section has a depth (Shedd, 2009), e.g., at a bridge abutment.

6.4.3.7.4.5   Press **Set Depth** to enter the depth of water at the particular location on the tagline. Refer to Shedd (2009) for instructions on the use of a top-set wading rod. Press **Enter** when finished.

6.4.3.7.4.6   Press **Next Station** (#2) to continue the measurement.

6.4.3.7.4.7   The following sequence will occur at each successive location of the cross section. Generally, 25-30 observations per cross section are sufficient to define the natural variability of the channel. Narrow channels will have fewer observations, due to the fact that spacing between observations is limited to 0.3 feet.

6.4.3.7.4.7.1   Press **Set Location** to enter the location on the tagline of the velocity observation. Press **Enter** when finished. The default observation spacing is one foot. Each successive observation sends you to the next point on the tagline based on the spacing of previous observations.

6.4.3.7.4.7.2   Press **Set Depth** to enter the depth of water at the observation point. Press **Enter** when finished. Each successive observation copies the depth of the previous point.

6.4.3.7.4.7.3   Depending on the depth of water at the observation point, the measurement method (§6.3.5.6) may differ in order to calculate mean velocity. To toggle between the various methods press **Method+**. The actual velocity observation depth (referenced from the bottom-up) is displayed in parentheses. This depth changes with method.

6.4.3.7.4.7.4   When all values are correctly set and the probe is located as desired, press **Measure** to start velocity data collection. Make sure you keep the probe's X direction perpendicular

to the tag line being used to define the stream cross section (see §6.3.4.4.3 of this document).

6.4.3.7.4.7.5 It is possible to recover if you mistakenly press **Measure** with an incorrect parameter or **Method**. Press **Abort** to terminate the measurement (or let the measurement finish), and press **2** to repeat the measurement. Until one measurement is accepted at a station, you have the ability to change all parameters. After one measurement has been accepted, **Method** can no longer be changed (although other parameters can still be changed).

```
Loc 2.00  MDep .6D
Vel    2.23
SNR    14.3
Time   19
```

6.4.3.7.4.7.6 An updating display (right) shows velocity and SNR data. Displayed values represent the running mean of data at that station.

6.4.3.7.4.7.7 Once the measurement time has elapsed, a series of quality-control-criteria warnings may be displayed, depending on the measurement environment. Below is a series of tables that describes the quality-control warnings and recommend action. Sections in this table refer to the FlowTracker Technical Manual.

Warning	QC Criteria	Description	Suggested Action
Low SNR (§1.4.2)	None	SNR < 4 dB	• Improve SNR (§8.6)
Beam SNR (§1.4.2)	SNR Threshold	Difference in SNR for any 2 beams is > SNR Threshold.	• Look for underwater obstacles; repeat measurement. • Check probe operation (§6.5).
SNR Variation (§1.4.2)	None	One-second SNR data varies more than expected during a measurement. May indicate underwater interference or a highly aerated environment.	• Look for underwater obstacles; repeat measurement. • Look for environmental sources (e.g., aerated water).
SNR Change (§1.4.2)	SNR Threshold	SNR more than SNR Threshold different previous measurements; major change in measurement conditions.	• Look for underwater obstacles or other changes in river condition. • Repeat measurement
High σV (§1.4.3)	σV Threshold	σV > σV Threshold; adjusted based on previous data and measured velocity. May indicate interference or a highly turbulent environment.	• Look for underwater obstacles or a change in conditions. • Consider real turbulence levels in river. • Repeat measurement.
Bad Boundary QC (§1.4.4)	None	Boundary QC is FAIR or POOR. Indicates possible interference from underwater obstacles.	• Consider re-locating probe and repeating test. • Measurement can proceed if results are consistent.
High Spikes (§1.4.5)	Spike Threshold	Spikes > Spike Threshold percent of samples. May indicate poor measurement conditions.	• Look for underwater obstacles or unusual conditions (e.g., aerated water). • Repeat measurement.
High Angle (§1.4.6)	Max Velocity Angle	Angle > Max Velocity Angle. May only indicate non-ideal measurement environment.	• Consider if measured angle is realistic. • Repeat measurement if needed.
High %Q (§1.4.7)	Max Section Discharge	%Q > Max Section Discharge. Station contains a large portion of the total discharge.	• Consider adding more stations.
Suspect Depth Value (§1.4.8)	Max Depth Change	Station depth differs from adjacent stations by more than Max Depth Change %. This may indicate a data entry problem.	• Verify station depth value. • Re-enter if needed.
Suspect Location Value (§1.4.9)	Max Location Change	Spacing between stations has changed by more than Max Location Change %. This may indicate a data entry problem.	• Verify station location value. • Re-enter if needed.
Location Out of Order / Location Outside Edge (§1.4.9)	None	Station location out of sequence or outside river edge. This may indicate a data entry problem.	• Verify station location value. • Re-enter if needed.

6.4.3.7.4.7.8   Following the potential quality control warnings, a summary of velocity and quality control data is shown. Below is an example of a summary screen.

```
Vel 2.25     σV 0.04
Ang 5°       SNR 15.1
Spikes 0     Bnd BEST
1:Accept     2:Repeat
```

6.4.3.7.4.7.9   Press **1** to **Accept** the data and move to the next station or location in the measurement series (e.g., advancing from the 2/10^{ths} to 8/10^{ths} observation depth). Record location, depth, and mean velocity in the Discharge Measurement Notes after each accepted observation.

6.4.3.7.4.7.10   Press **2** to **Repeat** the measurement, especially if quality-control issues arise. When a measurement is repeated, data are not lost. However, you will no longer be able to view the *old* data from the keypad interface. The *old* data are still recorded. Later, the data can be extracted in the raw data file (*.dat) and the measurement summary file (*.sum), but not in the discharge summary file (*.dis).

6.4.3.7.4.7.11   Once a station is completed, the FlowTracker displays the next station. Location, depth, and method data for new stations are predicted using previous stations. If a multiple measurement method was used (e.g., 2/10^{ths} and 8/10^{ths} water depth), the next station will use the same method in the opposite order (i.e.; 8/10^{ths} then 2/10^{ths} depth).

6.4.3.7.4.7.12   Depending on the width and flow characteristics of the stream being measured, steps encompassed in §6.4.3.7.4.7 (through *7.10) will be repeated for approximately 25-30 locations across the cross section.

6.4.3.7.4.7.13   At the end of the cross section, or when an individual station is complete, the operator can review summary data for stations by pressing **Next Station** and **Previous Station**. Below is an example of summary information that is displayed.

```
Stn 1        Loc 2.00      Stn 1        Loc 2.00
0.6          0.6(0.54)     Npts 40      0.6(0.54)
             Dep 1.35      Vel 2.25
             Enter=More    Ang 5°       Enter=More

Stn 1        Loc 2.00      Stn 1        Loc 2.00
SNR 14.5     0.6(0.54)     StnQ 2.523 cfs
σV 0.04      Bnd BEST      StnV 2.25 ft/s
Spikes 0     Enter=More    %Q 4.5%      Enter=More
```

6.4.3.7.4.7.14   After initial review of the collected data the operator has the option to return to a station and either delete or repeat the observation. This station can be navigated to by pressing **Previous Station** or **Next Station**.

6.4.3.7.4.7.15 Whether you are going to repeat or delete a completed station, press **Delete** and the digits **1-2-3** to confirm.

6.4.3.7.4.7.16 If the operator must repeat or "redo" a station enter the location, depth, and measurement method of the station. Follow standard measurement procedures for that station. In most cases, the operator will get a warning that the entered location is out of sequence. Press **1** to **Accept Value**, the new station data will automatically be sorted into the correct position so that discharge calculations are accurate. Data from a deleted station is not lost. However, you will no longer be able to view the *old* data from the keypad interface.

6.4.3.7.4.7.17 Once all measurement stations are completed, press **End Section**. Depending on the measurement environment the operator is then presented with the summary of all data that has exceeded quality control criteria. Press **Enter** to review stations with quality control warnings.

6.4.3.7.4.7.18 After the review of stations, the operator has the option to either press **1** to end the section or to press **2** to not end the section. If quality-control warnings exist and the measurement can be improved, press **2** to return to the cross section for modification.

6.4.3.7.4.7.19 If the section is not ended, the operator is returned to the last station. At this point, press **Set Location** to add stations. If the operator has not advanced (**Next Station**) to the current last station of the measurement, pressing **Set Location** will modify the location of the present station on the display. In order to avoid confusion, advance to the last station before adding any additional stations.

6.4.3.7.4.7.20 Once satisfied, press **End Section**, and then press **1** to end the collection of velocity observations.

6.4.3.7.4.7.21 Press **QC Menu** (#8) to enter the ending gage height from the primary gage index, and any additional observations as described in §6.4.3.7.2 of this document.

6.4.3.7.4.7.22 The operator will then be prompted to enter the ending (LEW) edge of water, enter the respective depth and location.

6.4.3.7.4.7.23 Press **Calculate Disch.** to finish the measurement. Below is an example of the final measurement summary screens. Press **Enter** to advance through the multiple screens. While reviewing this information, populate the necessary fields of form ECY 040-56 (Rev. 12/07). It is also suggested that V Max, Depth Mean, SNR Mean, σV Mean, and H_2O Temperature be written in the remarks portion of the form.

```
┌─────────────────────────┐ ┌─────────────────────────┐ ┌─────────────────────────┐
│ TotalQ 44.234 cfs       │ │ Q Uncertainty 3.5%      │ │ Num Stations 27         │
│ RatedQ 45.000 cfs       │ │ Largest Source          │ │ V Mean 1.43 ft/s        │
│ Difference -1.7%        │ │   Num Stations          │ │ V Max 2.21 ft/s         │
│ 0=Exit or Enter=More    │ │ 0=Exit or Enter=More    │ │ 0=Exit or Enter=More    │
└─────────────────────────┘ └─────────────────────────┘ └─────────────────────────┘
┌─────────────────────────┐ ┌─────────────────────────┐ ┌─────────────────────────┐
│ Width 23.000 ft         │ │ Depth Mean 2.77 ft      │ │ SNR Mean 16.5 dB        │
│ Area 47.350 ft^2        │ │ Depth Max 3.15 ft       │ │ σV Mean 0.05 ft/s       │
│                         │ │                         │ │ Temperature 61.2°F      │
│ 0=Exit or Enter=More    │ │ 0=Exit or Enter=More    │ │ 0=Exit or Enter=More    │
└─────────────────────────┘ └─────────────────────────┘ └─────────────────────────┘
┌─────────────────────────┐ ┌─────────────────────────┐ ┌─────────────────────────┐
│ Start Height 4.900      │ │ File 555312.100         │ │ Site                    │
│ End Height 5.000        │ │ Mode: Discharge         │ │ Poudre River FC         │
│ Change 0.100 ft         │ │ 2001/06/25  14:24:15    │ │ Operator Billy Bob      │
│ 0=Exit or Enter=More    │ │ 0=Exit or Enter=More    │ │ 0=Exit or Enter=More    │
└─────────────────────────┘ └─────────────────────────┘ └─────────────────────────┘
```

6.4.3.7.4.7.24   Press **0** to **Exit** and return to the **Main Menu**. Once data collection is complete, press and hold the yellow power button until the display goes dark. This *must* be done from the **Main Menu**, or otherwise there is a risk of losing data.

6.4.3.7.4.7.25   After each completed measurement disassemble the FlowTracker and return it to its protective case. Extra attention should be given to protecting the integrity of the sensor cable.

6.5   Discharge Measurement Processing

6.5.1   Discharge measurements conducted with the FlowTracker are processed using the software SonTek FlowTracker v2.30. For instructions on acquiring and installing this software, refer to the *SonTek FlowTracker Technical Manual* §6.1.

6.5.2   Discharge-measurement processing and software utilization requires connecting the FlowTracker to an external computer. Connect the RS-232 communication cable to the USB adapter and between an external computer and the threaded five-pin connector COM port at the base of the handheld unit.

6.5.3   Start up the external computer.

6.5.4   Turn the handheld unit on by holding down the yellow button on the keypad.

6.5.5   Run the FlowTracker software v2.30 (click **Start** | **Programs** | **SonTek Software** | **FlowTracker**). Below is the FlowTracker software start-up window:

6.5.6   Click **Connect to a FlowTracker.** Select the correct COM port, and click **Connect**. The operator will be notified if a connection was established. If a connection is not established, a red circle will appear in the "connect to serial port" dialog box.

6.5.7   Each FlowTracker measurement is saved to a master file (*.wad), which is composed of many extractable file types that can be used in different settings. Each file type can be extracted at any time from the *.wad. **Important:** *FlowTracker* **software does NOT prompt before overwriting the ASCII output files. Be sure any modified files, or files using the same file name, have been moved to a different folder before extracting the ASCII data.**

6.5.7.1   From the main software window review the current file export settings.

6.5.7.2   For the proper export settings check the box next to the following three statements: "Show Discharge Summary Report," "Export ASCII Discharge file (DIS)," and "Put Headers on ASCII files."

6.5.7.3 "Show Discharge Summary Report" displays the final discharge calculation and measurement summary report in tabular and graphic form. This includes automatic quality-control analysis to flag measurements that may include suspect data. Below is an example of a discharge summary report:

DEPARTMENT OF ECOLOGY
State of Washington

Discharge Measurement Summary   Date Generated: Wed Feb 11 2009

File Information

File Name	45C060-2008-05-14.WAD
Start Date and Time	2008/05/14 15:03:50

Site Details

Site Name	45C060
Operator(s)	TWB

System Information

Sensor Type	FlowTracker	
Serial #	P1783	
CPU Firmware Version	3.2	
Software Ver	2.11	

Units (English Units)

Distance	ft
Velocity	ft/s
Area	ft^2
Discharge	cfs

Discharge Uncertainty

Category	ISO	Stats
Accuracy	1.0%	1.0%
Depth	0.2%	2.1%
Velocity	1.0%	2.5%
Width	0.1%	0.1%
Method	1.7%	
# Stations	2.0%	
Overall	3.0%	3.4%

Summary

Averaging Int.	40	# Stations	26
Start Edge	REW	Total Width	12.400
Mean SNR	41.1 dB	Total Area	11.939
Mean Temp	53.45 °F	Mean Depth	0.963
Disch. Equation	Mid-Section	Mean Velocity	1.5174
		Total Discharge	18.1160

Supplemental Data (Gauge Height Change = 0.000ft)

#	Time	Location	Gauge Height	Rated Flow	Comments
1	Wed May 14 15:02:07 PDT 2008	0.000	5.560		
2	Wed May 14 15:45:40 PDT 2008	17.000	5.560		

Measurement Results

St	Clock	Loc	Method	Depth	%Dep	MeasD	Vel	CorrFact	MeanV	Area	Flow	%Q
0	15:03	4.60	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0
1	15:03	5.00	0.6	0.320	0.6	0.128	0.3635	1.00	0.3635	0.144	0.0523	0.3
2	15:06	5.50	0.6	1.000	0.6	0.400	0.0997	1.00	0.0997	0.500	0.0499	0.3
3	15:07	6.00	0.6	0.980	0.6	0.392	0.4072	1.00	0.4072	0.490	0.1995	1.1
4	15:08	6.50	0.6	1.200	0.6	0.480	0.7703	1.00	0.7703	0.600	0.4623	2.6
5	15:09	7.00	0.6	1.230	0.6	0.492	1.3179	1.00	1.3179	0.615	0.8105	4.5
6	15:10	7.50	0.6	1.300	0.6	0.520	2.2530	1.00	2.2530	0.650	1.4643	8.1
7	15:11	8.00	0.6	1.050	0.6	0.420	2.8333	1.00	2.8333	0.525	1.4873	8.2
8	15:13	8.50	0.6	1.070	0.6	0.428	2.5764	1.00	2.5764	0.535	1.3782	7.6
9	15:14	9.00	0.6	1.200	0.6	0.480	1.6158	1.00	1.6158	0.600	0.9696	5.4
10	15:16	9.50	0.6	1.080	0.6	0.432	0.9833	1.00	0.9833	0.540	0.5310	2.9
11	15:17	10.00	0.6	1.130	0.6	0.452	0.7933	1.00	0.7933	0.565	0.4482	2.5
12	15:19	10.50	0.6	1.030	0.6	0.412	0.8343	1.00	0.8343	0.515	0.4296	2.4
13	15:20	11.00	0.6	1.080	0.6	0.432	0.9052	1.00	0.9052	0.540	0.4888	2.7
14	15:21	11.50	0.6	1.280	0.6	0.512	1.2159	1.00	1.2159	0.640	0.7781	4.3
15	15:22	12.00	0.6	1.300	0.6	0.520	1.4777	1.00	1.4777	0.650	0.9604	5.3
16	15:23	12.50	0.6	1.150	0.6	0.460	1.7615	1.00	1.7615	0.575	1.0128	5.6
17	15:24	13.00	0.6	0.950	0.6	0.380	2.2178	1.00	2.2178	0.475	1.0536	5.8
18	15:25	13.50	0.6	0.980	0.6	0.392	2.3110	1.00	2.3110	0.490	1.1324	6.3
19	15:26	14.00	0.6	0.850	0.6	0.340	2.1273	1.00	2.1273	0.425	0.9042	5.0
20	15:28	14.50	0.6	0.800	0.6	0.320	2.5292	1.00	2.5292	0.400	1.0115	5.6
21	15:29	15.00	0.6	0.750	0.6	0.300	2.1355	1.00	2.1355	0.375	0.8008	4.4
22	15:30	15.50	0.6	0.720	0.6	0.288	2.2448	1.00	2.2448	0.360	0.8083	4.5
23	15:31	16.00	0.6	0.780	0.6	0.312	1.5118	1.00	1.5118	0.390	0.5895	3.3
24	15:33	16.50	0.6	0.680	0.6	0.272	0.8615	1.00	0.8615	0.340	0.2930	1.6
25	15:33	17.00	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0

Rows in italics indicate a QC warning. See the Quality Control page of this report for more information.
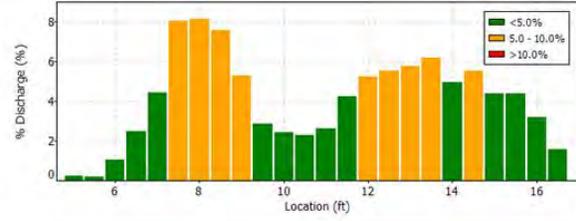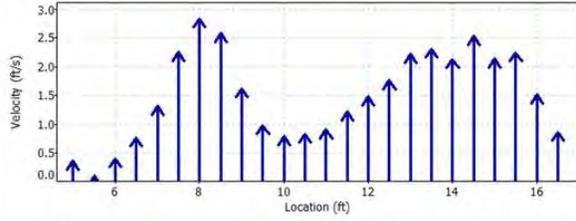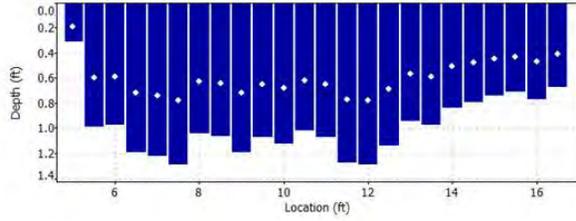
Quality Control

St	Loc	%Dep	Message
5	7.00	0.6	High standard error: 0.112
9	9.00	0.6	High standard error: 0.116
18	13.50	0.6	High angle: -21
19	14.00	0.6	High angle: -21
23	16.00	0.6	High standard error: 0.096
24	16.50	0.6	High standard error: 0.087

Automatic Quality Control Test (BeamCheck)

Wed May 14 15:02:24 PDT 2008

Legend: Beam1, Beam2
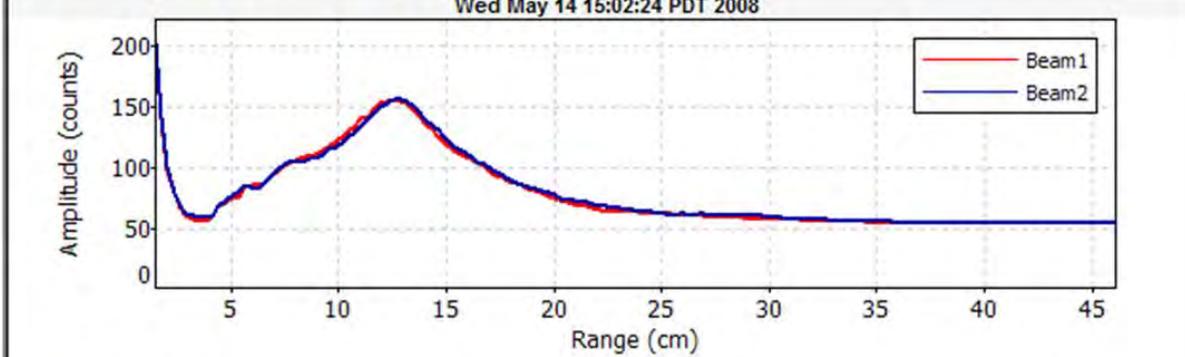
- ✔ Noise level check - Pass
- ✔ SNR check - Pass
- ✔ Peak location check - Pass
- ✔ Peak shape check - Pass

6.5.7.4   "Export ASCII Discharge file (DIS)" displays final discharge calculation data and overall measurement summary. The most widely used output file, especially for database integration. It also displays mean temperature, SNR, and flow angle of each vertical. In the instance that a data entry error was discovered prior to database import; this is the only file that is editable. See example below:

```
File_Name                     45C060-2008-05-14.WAD
Start_Date_and_Time           2008/05/14 15:03:50
Site_Name                     45C060
Operator(s)                   TwB
Sensor_Type                   FlowTracker_Handheld_ADV
Serial_#                      P1783
Software_Ver                  2.11 (Build 48 - Nov 29 2006)
CPU_Firmware_Version          3.2
Averaging_Interval            40 sec
Unit_System                   English Units
Discharge_Equation            Mid-Section
Start_Edge                    REW
#_Stations                    26
Total_Width                   12.400 ft
Total_Area                    11.939 ft^2
Total_Discharge               18.1160 cfs
Mean_Depth                    0.963 ft
Mean_Velocity                 1.5174 ft/s
Mean_SNR                      41.1 dB
Mean_Verr                     0.0644 ft/s
Mean_Temp                     53.45 deg F
Mean_Bnd                      0 Best
Boundary_Condition_(Bnd)      0 Best
                              1 Good
                              2 Fair
                              3 Poor

Discharge_Uncertainty_(ISO)
Overall                       3.0 %
Accuracy                      1.0 %
Depth                         0.2 %
Velocity                      1.0 %
Width                         0.1 %
Method                        1.7 %
#_Stations                    2.0 %

Discharge_Uncertainty_(Statistical)
Overall                       3.4 %
Accuracy                      1.0 %
Depth                         2.1 %
Velocity                      2.5 %
Width                         0.1 %

Supplemental_Data
Gauge_Height_Change               0.000 ft
 Record            Time    Gauge_Height(ft)  Rated_Flow(cfs)  Comments
   01   2008/05/14 15:02:07       5.560                     ()
   02   2008/05/14 15:45:40       5.560                     ()

Automatic_Quality_Control_Test_(BeamCheck)
05/14/2008 15:02:24
        Noise level check - Pass
        SNR check - Pass
        Peak location check - Pass
        Peak shape check - Pass
```

```
St  Clock   Loc  Depth  IceD  %Dep  MeasD  Npts Spike   Vel   SNR Angle  Verr  Bnd   Temp  CorrFact MeanV   Area   Flow    %Q
()   ()    (ft)  (ft)   (ft)  (*D)  (ft)    ()   ()    (ft/s) (dB)(deg)  (ft/s)  ()  (degF)   ()    (ft/s) (ft^2)  (cfs)   (%)
00  15:03  4.60  0.000  0.000  0.0  0.000    0    0   0.0000   0.0    0  0.0000   0   0.00   1.00   0.0000  0.000  0.0000   0.0
01  15:03  5.00  0.320  0.000  0.6  0.128   40    0   0.3635  38.9  -17  0.0479   0  53.28   1.00   0.3635  0.144  0.0523   0.3
02  15:06  5.50  1.000  0.000  0.6  0.400   40    3   0.0997  40.0    8  0.0341   0  53.28   1.00   0.0997  0.500  0.0499   0.3
03  15:07  6.00  0.980  0.000  0.6  0.392   40    2   0.4072  40.0    0  0.0509   0  53.28   1.00   0.4072  0.490  0.1995   1.1
04  15:08  6.50  1.200  0.000  0.6  0.480   40    4   0.7703  40.2    1  0.0574   0  53.29   1.00   0.7703  0.600  0.4623   2.6
05  15:09  7.00  1.230  0.000  0.6  0.492   40    0   1.3179  40.8   -4  0.1122   0  53.31   1.00   1.3179  0.615  0.8105   4.5
06  15:10  7.50  1.300  0.000  0.6  0.520   40    0   2.2530  40.8   -3  0.0906   0  53.33   1.00   2.2530  0.650  1.4643   8.1
07  15:11  8.00  1.050  0.000  0.6  0.420   40    0   2.8333  41.9   -1  0.1033   0  53.35   1.00   2.8333  0.525  1.4873   8.2
08  15:13  8.50  1.070  0.000  0.6  0.428   40    0   2.5764  41.3   -1  0.1273   0  53.37   1.00   2.5764  0.535  1.3782   7.6
09  15:14  9.00  1.200  0.000  0.6  0.480   40    0   1.6158  41.3    0  0.1165   0  53.40   1.00   1.6158  0.600  0.9696   5.4
10  15:16  9.50  1.080  0.000  0.6  0.432   40    1   0.9833  41.3    1  0.0505   0  53.42   1.00   0.9833  0.540  0.5310   2.9
11  15:17 10.00  1.130  0.000  0.6  0.452   40    2   0.7933  40.4   -7  0.0266   0  53.44   1.00   0.7933  0.565  0.4482   2.5
12  15:19 10.50  1.030  0.000  0.6  0.412   40    0   0.8343  41.1  -13  0.0358   0  53.46   1.00   0.8343  0.515  0.4296   2.4
13  15:20 11.00  1.080  0.000  0.6  0.432   40    1   0.9052  41.5  -11  0.0436   0  53.47   1.00   0.9052  0.540  0.4888   2.7
14  15:21 11.50  1.280  0.000  0.6  0.512   40    2   1.2159  41.7  -13  0.0436   0  53.47   1.00   1.2159  0.640  0.7781   4.3
15  15:22 12.00  1.300  0.000  0.6  0.520   40    1   1.4777  42.1  -17  0.0358   0  53.49   1.00   1.4777  0.650  0.9604   5.3
16  15:23 12.50  1.150  0.000  0.6  0.460   40    2   1.7615  42.1  -13  0.0413   0  53.51   1.00   1.7615  0.575  1.0128   5.6
17  15:24 13.00  0.950  0.000  0.6  0.380   40    3   2.2178  42.4  -15  0.0597   0  53.53   1.00   2.2178  0.475  1.0536   5.8
18  15:25 13.50  0.980  0.000  0.6  0.392   40    1   2.3110  41.9  -20  0.0686   0  53.55   1.00   2.3110  0.490  1.1324   6.3
19  15:26 14.00  0.850  0.000  0.6  0.340   40    4   2.1273  42.1  -20  0.0466   0  53.55   1.00   2.1273  0.425  0.9042   5.0
20  15:28 14.50  0.800  0.000  0.6  0.320   40    2   2.5292  41.9  -15  0.0653   0  53.56   1.00   2.5292  0.400  1.0115   5.6
21  15:29 15.00  0.750  0.000  0.6  0.300   40    3   2.1355  41.3  -18  0.0577   0  53.58   1.00   2.1355  0.375  0.8008   4.4
22  15:30 15.50  0.720  0.000  0.6  0.288   40    1   2.2448  41.5  -14  0.0482   0  53.58   1.00   2.2448  0.360  0.8083   4.5
23  15:31 16.00  0.780  0.000  0.6  0.312   40    0   1.5118  41.6  -14  0.0961   0  53.60   1.00   1.5118  0.390  0.5895   3.3
24  15:33 16.50  0.680  0.000  0.6  0.272   40    0   0.8615  39.8  -19  0.0866   0  53.62   1.00   0.8615  0.340  0.2930   1.6
25  15:33 17.00  0.000  0.000  0.0  0.000    0    0   0.0000   0.0    0  0.0000   0   0.00   1.00   0.0000  0.000  0.0000   0.0
```

6.5.8   From the main software menu click on the "Program Settings" hyperlink. This dialog box allows the operator to specify the output units system, mounting correction, language settings, and, if desired, a fixed output directory for all ASCII output files. See the example below:

6.5.8.1   Set the Unit System and Language to **English**.

6.5.8.2   The *.dis file is electronically archived in the same location as the *.wad master file. Therefore, all files should be exported to the same directory as the master file.

6.5.8.3   It is suggested that an official Department of Ecology logo be placed on the discharge summary report header. Click **Browse** and navigate to H:\FLOWS\Instrumentation\SonTek_FlowTracker\Ecology Logo\LOGO_color_FT.jpg for the current pre-formatted logo.

6.5.8.4   Once satisfied with the Program Settings, click **OK** to exit. These settings will now be valid for all measurements opened using the software.

6.5.9   While the FlowTracker is connected to an external computer, the operator has access to the *Recorder* dialog box via a hyperlink. See an example of the Recorder dialog box below:
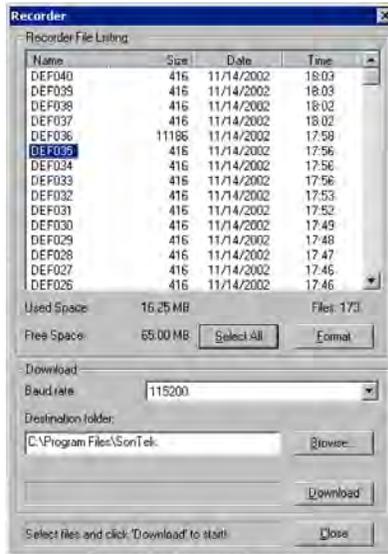
6.5.9.1   Completed discharge measurements are selected using several different methods. The operator can click one file to select it, hold **Control** or **Shift** and click a series of files, or click **Select All** to select all files on the recorder.

6.5.9.2   The default download rate for the *Recorder* is 57,600 baud. Faster or slower download rates are selectable, depending on the external computer. If difficulty arises, select a lower baud rate.

6.5.9.3   In most cases, the operator will complete batch downloads of measurements. Later, these processed measurements will be electronically archived to a gaging-station-specific directory. It is suggested that an intermediate **Destination folder** be established on a Department of Ecology (personal or network) drive in which all preprocessed discharge measurements be stored. Click **Browse** and navigate to this location.

6.5.9.4   Click **Download** to copy all the selected files to the specified folder. Note: A **Cancel** control will appear to let the operator abort the download process. Watch the status area at the bottom of the dialog box to view the download progress.

6.5.9.5   From the *Recorder* dialog box the operator can **Format** (erase) the internal memory of the FlowTracker, as discussed in §6.2.2.1.5 of this document. The previous discussion outlines how to **Format** the internal memory using the Keypad. The following steps outline how to **Format** the internal memory using the software.

6.5.9.5.1   Once it has been confirmed that all measurements have been properly downloaded and are in the proper directory, click **Format** and then **OK** to confirm the decision to format/erase discharge measurements from the internal memory. As a reminder, once the measurements have been deleted from the FlowTracker's internal memory, the data is **<u>non-recoverable</u>**.

6.5.9.5.2   Depending on the number of measurements this process could take several minutes. When finished, **Close** the *Recorder* dialog box and **Disconnect** the FlowTracker from the external computer.

6.5.9.6   An electronic and hard-copy archive of all FlowTracker discharge measurements is required by the EAP FMU. The following steps outline how to generate a hard copy.

6.5.9.6.1   Run the FlowTracker software v2.30 (click **Start | Programs | SonTek Software | FlowTracker**).

6.5.9.6.2   Click the **Open a FlowTracker file** hyperlink. Browse to the particular discharge measurement that will be processed.

6.5.9.6.3   Prior to opening the *.wad file the file must be renamed. This file name is displayed on the Discharge Measurement Summary and is used to name subsequent export files, such as the *.dis. The *.wad can be renamed by right-clicking on the measurement icon. The electronic file naming convention places station identification number, 4-digit year, 2-digit month, and 2-digit day; all separated by hyphen (e.g., 45F110-2007-07-26.wad).

6.5.9.6.4   Double-click on the measurement icon 45F110-2007-07-26.WAD. This will load measurement data and display the Discharge Measurement Summary.

6.5.9.6.5   Review summary information for the measurement, paying particular attention to the **Discharge Uncertainty** statistics, and **Quality Control** messages. This information is useful for evaluating the overall quality rating more the measurement. Also, assure that the information contained on the Discharge Measurement Notes Form (ECY 040-56 (Rev. 12/07)) and the Discharge Measurement Summary is consistent.

6.5.9.6.6   In the upper right corner of the Discharge Measurement Summary is the **Print** icon . Clicking this icon will bring up the print dialog box, which varies depending on the printer being used. In an effort to reduce paper consumption, it is suggested that the printer be configured to print two color pages per double-sided sheet. The Discharge Measurement Summary is not editable; therefore, printing configuration is the only option for paper reduction.

6.5.9.7   Submit the printed Discharge Measurement Summary and the completed Discharge Measurement Notes form for peer review.

6.5.10   Located on the lower left corner of the main software screen are three hyperlinks to the three versions of the FlowTracker manual. These include the User's Manual, Technical Manual, and Quick Start Guide all in *.pdf format.

7.0   Records Management

7.1   Recorded *BeamCheck* files are saved using the following file naming convention: FT*-YYYY-MM-DD.bmc. (*Depends on the EAP assigned number to that particular FlowTracker handheld unit). BeamCheck files are archived on the EAP FMU shared server (H:\FLOWS\Instrumentation\SonTek_FlowTracker\BeamCheck\FT*).

7.2   Field data for discharge measurements are recorded on form ECY 040-56 (Rev. 12/07): Discharge Measurement Notes.

7.3   Master (*.wad) and auxiliary (*.dis) files are saved using the standard file-naming convention, e.g., 45F110-2009-02-18.wad.

7.4   Both file types for each measurement are electronically archived on the EAP FMU shared server (H:\FLOWS\Projects) under the specific station name and water year in which the measurement was conducted.

7.5   Once returned from peer review (discussed in §8.7), the Discharge Measurement Summary, Discharge Measurement Notes, and all original field-discharge-measurement notes are stored in central locations at Ecology Headquarters, Regional, and Field Offices.

7.6   A record of peer reviews of all discharge measurements is located in the EAP FMU shared server (H:\FLOWS\QAData).

8.0   Quality Control and Quality Assurance Section

8.1   The FlowTracker records quality control (QC) data with each measurement. QC parameters are automatically reviewed with each measurement and at the completion of a discharge cross section. Below is a summary table of QC parameters, all section hyperlinks are inactive, but refer to the FlowTracker Technical Manual:

Parameter	Description	Expected Values
SNR (§1.4.2)	**SNR** is the most important QC parameter. • It measures the strength of the acoustic reflection from particles in the water. • Without sufficient SNR, the FlowTracker cannot measure velocity.	Ideally > 10 dB Minimum ≥ 4 dB
σV (§1.4.3)	σV (standard error of velocity) is a direct measure of the accuracy of velocity data. • It includes the effects of turbulence in the river and instrument uncertainty.	Typically < 0.01m/s (0.03 ft/s). Higher in turbulent environment.
Boundary QC (§1.4.4)	Boundary QC evaluates the measurement environment for interference from underwater obstacles. • FAIR or POOR results may indicate significant interference from an underwater obstacle.	BEST or GOOD
Spikes (§1.4.5)	Spikes in FlowTracker velocity data are removed using a spike filter. • Some spikes are common and no cause for concern. • Too many spikes indicate a problem in the measurement environment (e.g., interference from underwater obstacles or highly aerated water).	Typically < 5% of total samples. Should be < 10% of total samples.
Angle (§1.4.6)	Angle is the direction of the measured velocity relative to the FlowTracker X-axis. • Used for discharge measurements only. • A good site should have small velocity angles. • Large angles may be unavoidable at some sites.	Ideally < 20°
%Q (§1.4.7)	%Q is the percentage of the total discharge in a single measurement station. • Most agencies have criteria for the maximum %Q.	Typical criteria: Ideally < 5% Maximum < 10%

8.2   If any value exceeds expected criteria, a warning is given. §6.4.3.7.4.7.7 of this document lists different QC warning messages and gives guidelines for interpreting these messages. All QC review criteria can be adjusted or disabled.

8.3   Avoidance of all QC warnings for a particular discharge measurement is difficult and strictly dependent on the stream environment available. However, the feedback given by the FlowTracker allows the operator to address potential QC issues at the measurement site. Addressing QC warnings at the measurement site may require modification of the measurement cross section, repeating velocity observations, adjusting the spacing of observations, adding observations to better define the channel, or choosing a different measurement cross section.

8.4   Upon completion of the measurement (**Calc. Discharge**) the FlowTracker reports a calculation of overall statistical discharge uncertainty and the largest contributing source. The **Stats Uncertainty** calculation incorporates measurement uncertainty, natural stream conditions (e.g., different bottom types), and the assumption that depth and velocity change linearly between stations. This uncertainty percentage should be used as guidance to assign a preliminary quality rating

8.5   As a general guide, if the Overall Uncertainty of the discharge measurement is within two percent the measurement is considered excellent. If Overall Uncertainty is within five percent the quality of the measurement is good. An Overall Uncertainty between five and eight percent is considered fair. The measurement is regarded as poor if the Overall Uncertainty is greater than eight percent.

8.6   In addition to the discharge uncertainty statistics, the relative amount of QC warnings incurred during the measurement should be considered. The operator should also consider factors such as cross-section quality and flow conditions as part of the quality assignment.

8.7   <u>Measurement Review</u>

8.7.1   All FlowTracker measurements are peer reviewed. Reviewed materials include completed Discharge Measurement Notes and the Discharge Measurement Summary. Before review, the measurement is entered to the Hydstra Gaugings database.

8.7.2   The reviewer checks measurement notes to ensure proper measurement procedures were followed and that 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.

8.7.3   The reviewer compares the Discharge Measurement Summary to the Discharge Measurement Notes to evaluate potential discrepancies of location, depth, and velocity. Measurements are also checked for the completion of the Auto QC Test and a review of QC warnings present. Though it is the decision of the Basin Lead, the reviewer may suggest an alternative quality rating for the measurement.

8.7.4   The reviewer enters the Overall discharge uncertainty, including the uncertainty in velocity and depth into the EAP FMU Quality Assurance Database (H:\FLOWS\QAData).

8.7.5   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 Basin Lead.

8.8   Troubleshooting

8.8.1   If problems persist and solutions cannot be found in this document, consult the *SonTek FlowTracker Technical Manual* (particularly §8.7) for further assistance. If necessary contact SonTek at (858) 546-8327 or via e-mail at support@sontek.com.

8.8.2   *BeamCheck* is the same diagnostic tool that the manufacturer uses and is available to all users. *BeamCheck* methods are outlined in §6.2.1 of this document.

8.8.3   If SonTek is contacted via e-mail, it is suggested that you send the *.wad file for the measurement in which difficulties were experienced and any previous *.bmc files for the FlowTracker that was used for the measurement. This may prevent the need to send the handheld unit to SonTek.

9.0   Safety

9.1   Personal flotation devices are required for persons working in or near bodies of water.

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

9.3   In all measurement situations, unsafe deployments that may result in injury to staff or loss or damage to equipment are not attempted. Refer to the EAP Safety Manual, beginning on pages 43 and 65 (EAP, 2016) 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 37 (EAP, 2016) 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 43 (EAP, 2016).

10.0 References

10.1 Blanchard, S.F., 2007. SonTek/YSI FlowTracker firmware version 3.10 and software version 2.11 upgrades and additional policy on the use of FlowTrackers for discharge measurements. United States Geological Survey, Office of Surface Water. Technical Memorandum 2007.01.

10.2 Buchanan, T.J., and Somers, W.P., 1969. "Discharge measurements at gaging stations." *Techniques of water-resources investigations*, Book 3, U.S. Geological Survey, Reston, Va., Chapter A8.

10.3 Environmental Assessment Program, 2016. Environmental Assessment Program Safety Manual, March 2016. Washington State Department of Ecology, Olympia, WA.

10.4 Rantz, S. E., et al., 1982. "Measurement and computation of streamflow." *U.S.Geological Survey Water-Supply Paper No. 2175*, Vol. 1, Reston, Va.

10.5 Rehmel, M., 2007. Application of acoustic doppler velocimeters for stream flow measurements. *Journal of Hydraulic Engineering*, **133(12):**1433-1438.

10.6 Rehmel, M., 2010. FlowTracker diagnostic test policy. United States Geological Survey, Office of Surface Water. Technical Memorandum 2010.06.

10.7 Shedd, J.R., 2009. Standard Operating Procedure for Measuring and Calculating Stream Discharge, Version 1.0. Washington State Department of Ecology, Olympia, WA.SOP Number EAP056. www.ecology.wa.gov/quality

10.8 SonTek/YSI, Inc., 2009. FlowTracker Handheld ADV Technical Manual Firmware Version 3.7, Software Version 2.30 featuring SmartQC. P/N 6054-60050--D

10.9 SonTek/YSI, Inc., 2009. FlowTracker Handheld ADV User's Manual Firmware Version 3.7 featuring SmartQC. P/N 6054-60051--D

10.10 SonTek/YSI, Inc., 2009. FlowTracker- Quick Start Guide. P/N 6054-60211--D

10.11 SonTek/YSI, Inc., 2009. SonTek FlowTracker, version 2.30 [program]. San Diego, California, SonTek/YSI, Inc.

10.12 Unless otherwise noted, all photos and images used in this document courtesy of SonTek/YSI, Inc.

11.0 Appendices

Appendix A
Discharge Measurement Notes (ECY 040-56 (Rev. 12/07))

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

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...................
Max Depth................... Hor. angle coef................... Wetted Perim................... Meter No...................

| Time | GAGE READINGS | | | |
	TD/WT	Logger	Staff	+/-

Type of meter ....
Calibration Pre: .... Post: ....
QA form attached   Y/N
Vel Unc ....
Depth Unc ....
Overall Unc ....
Wading, cable, ice, boat, upstr., downstr.,
side bridge ..... feet, mile, above, below
gage, and ....
Check-bar, found .... at ....
changed to .... at ....

Cell Width | WW | LEW | REW

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%), based on following
conditions: ....

Cross section ....
Control ....
Flow ....
Remarks ....
Other .... Photo taken   Y / N
Weather ....
Gage ....

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

ECY 040-56 (Rev. 12/07)

Dist. from initial point	Depth								
1	REW @								
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15 ●									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

River at --
VELOCITY