



RS5

USER MANUAL
XA00125



a **xylem** brand

Declarations of Conformity

The undersigned hereby declares that the product listed below conforms to all applicable requirements of FCC Part 15, B for the U.S. and Industry Canada (IC) ICES-003 for Canada.

Manufacturer: SonTek – a Xylem brand
9940 Summers Ridge Road
San Diego, CA 92121 USA

Equipment name: River Surveyor RS5
Model numbers: RS5

Accessories: (1) Juniper Systems, Geode (part no. 28358)
(2) SonTek RTK Rover & Base

Intentional Radiators: (RS5) FCC ID: XPYNINAB30, IC ID: 8595A-NINAB30
(RS5 RTK) FCC ID: XPYBMD345, IC ID: 8595A-BMD345

Regulations:

- FCC 47 CFR Part 15, Subpart B
- IC ICES-003
- This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions:
 1. This device may not cause harmful interference, and
 2. This device must accept any interference received, including interference that may cause undesired operation.

Standards:

- **KDB 447498 D01v06**, U.S. market SAR limits:
 1. The NINA-B3 series modules comply with FCC radiation exposure limits; having a separation distance of minimum 10 mm between the user and/or bystander and the antenna and/or radiating element ensures that the maximum output power of NINA-B3 is below the SAR test exclusion limits.
 2. The BMD-345 complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment shall be installed and operated with minimum distance 20cm between the radiator and body.
- **RSS-102 issue 5**, Industry Canada (IC) SAR limits:
 1. The NINA-B3 series modules comply with IC RSS-102 issue 5 radiation exposure limits set forth for an uncontrolled environment; having a separation distance of minimum 15 mm between the user and/or bystander and the antenna and/or radiating element ensures that the output power of NINA-B3 is below the SAR evaluation Exemption limits defined in RSS-102 issue 5 (Canadian market limits).
 2. The BMD-345 is approved for installation into mobile host platforms and must not be collocated or operating in conjunction with any other antenna or transmitter except in accordance with Industry Canada's multi-transmitter guidelines. A minimum of 20cm separation distance between any nearby person and the transmitter or antenna shall be maintained. End users must be provided with transmitter operating conditions for satisfying RF Exposure compliance.



E.J. Rollo, Compliance Engineer
April 2, 2021

The undersigned hereby declares that the product listed below conforms to all applicable Essential Requirements of the listed Directives and Standards and carry the CE mark.

Manufacturer: SonTek – a Xylem brand
9940 Summers Ridge Road
San Diego, CA 92121 USA

Equipment name: River Surveyor RS5

Model numbers: RS5

Accessory: (1) Juniper Systems, Geode (part no. 28358)
(2) SonTek RTK Rover & Base

Intentional Radiators: (RS5) FCC ID: XPYNINAB30
(RS5 RTK) FCC ID: XPYBMD345

Directives:

- EMC 2014/30/EU
- RED 2014/53/EU
- WEEE 2012/19/EU
- RoHS 2011/65/EU (includes RoHS-3 amendment 2015/863/EU)

Harmonized Standards:

- **EN 61326-1: 2013**, Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: Generic Requirements
- **EN 55011: 2009 + A1: 2010**, Electromagnetic compatibility (EMC) - Radiated disturbance
- **EN 61000-4-3: 2006 + A1: 2008 + A2: 2010**, Electromagnetic compatibility (EMC) – Electromagnetic field
- **EN 61000-4-2: 2009**, Electromagnetic compatibility (EMC) – Electrostatic discharge (ESD)
- **EN 61000-4-8: 2010**, Electromagnetic compatibility (EMC) – Power-frequency magnetic field
- **ETSI EN 301 489-1 V2.2.3 (2019-11)**, Electromagnetic compatibility (EMC) standard for radio equipment and services; Part 1 – Common technical requirements; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU
- **ETSI EN 301 489-17 V3.2.4 (2020-09)**, Electromagnetic compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for Broadband Data Transmission Systems; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU
- **ETSI EN 301 489-19 V2.1.1 (2019-04)**, Electromagnetic compatibility (EMC) standard for radio equipment and services; Part 19: Specific conditions for Receive Only Mobile Earth Stations (ROMES) operating in the 1.5 GHz band providing data communications and GNSS receivers operating in the RNSS band (ROGNSS) providing positioning, navigation, and timing data; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU
- **IEC 61010-1:2010, AMD1:2016**, Safety requirements for electrical equipment for measurement, control, and laboratory use; Part 1 – General requirements



E.J. Rollo, Compliance Engineer
April 2, 2021

The undersigned hereby declares that the product listed below conforms to all applicable Essential Requirements of the listed Directives and Standards and carry the UKCA mark.

Manufacturer: SonTek – a Xylem brand
9940 Summers Ridge Road
San Diego, CA 92121 USA

Equipment name: River Surveyor RS5
Model numbers: RS5

Accessory: (1) Juniper Systems, Geode (part no. 28358)
(2) SonTek RTK Rover & Base

Intentional Radiators: (RS5) FCC ID: XPYNINAB30
(RS5 RTK) FCC ID: XPYBMD345

Directives:

- EMC 2014/30/EU
- RED 2014/53/EU
- WEEE 2012/19/EU
- RoHS 2011/65/EU (includes RoHS-3 amendment 2015/863/EU)

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E.J. Rollo, Compliance Engineer
April 2, 2021

The undersigned hereby declares that the product listed below conforms to the Australian and New Zealand Electromagnetic Compatibility (EMC) requirements.

Manufacturer: SonTek – a Xylem brand
9940 Summers Ridge Road
San Diego, CA 92121 USA

Equipment name: River Surveyor RS5
Model numbers: RS5

Accessory: (1) Juniper Systems, Geode (part no. 28358)
(2) SonTek RTK Rover & Base

Intentional Radiators: (RS5) FCC ID: XPYNINAB30, IC ID: 8595A-NINAB30
(RS5 RTK) FCC ID: XPYBMD345, IC ID: 8595A-BMD345

Regulations:

- Australian Communications and Media Authority (ACMA) Standards, section 162 of the Radiocommunications Act 1992.
- New Zealand RSM Standards, Radiocommunications Act 1989

Standards:

- **AS/NZS CISPR 11: 2011**, Electromagnetic compatibility (EMC) standard for radiated disturbance.



E.J. Rollo, Compliance Engineer
April 2, 2021

The undersigned hereby declares that the product listed below conforms to all applicable requirements of the Radio Wave Act of Korea.

Manufacturer: SonTek – a Xylem brand
9940 Summers Ridge Road
San Diego, CA 92121 USA

Equipment name: River Surveyor RS5
Model numbers: RS5

Accessory: (1) Juniper Systems, Geode (part no. 28358)
(2) SonTek RTK Rover & Base

Intentional Radiators: (RS5) KCC ID: R-C-ULX-NINA-B30

Regulation:

- Radio Waves Act of the Republic of Korea

Standards:

- **KN 32**, Electromagnetic compatibility of multimedia equipment, Radiated emissions
- **KN 35**, Electromagnetic compatibility of multimedia equipment, Immunity
- **KN 301 489-1**, Electromagnetic compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
- **KN 301 489-17**, Electromagnetic compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for Broadband Data Transmission Systems
- **KN 61000-4-3**, Continuous RF Electromagnetic Field Disturbances
- **KN 61000-4-2**, Electrostatic Discharge (ESD)
- **KN 61000-4-8**, Power frequency magnetic field



E.J. Rollo, Compliance Engineer
April 2, 2021

The undersigned hereby declares that the product listed below conforms to all applicable requirements of the Japanese Technical Regulation Conformity Certification of Specified Radio Equipment.

Manufacturer: SonTek – a Xylem brand
9940 Summers Ridge Road
San Diego, CA 92121 USA

Equipment name: River Surveyor RS5
Model numbers: RS5

Accessory: (1) Juniper Systems, Geode (part no. 28358)
(2) SonTek RTK Rover & Base

Intentional Radiators: (RS5) MIC ID: 204-810006

Regulation:

- Japanese Technical Regulation Conformity Certification of Specified Radio Equipment (ordinance of MPT N°. 37, 1981), Article 2, Paragraph 1: Item 19 “2.4GHz band wide band low power data communication system”.



E.J. Rollo, Compliance Engineer
April 2, 2021

The undersigned hereby declares that the product listed below conforms to all applicable requirements of the NCC for the Taiwanese market.

Manufacturer: SonTek – a Xylem brand
9940 Summers Ridge Road
San Diego, CA 92121 USA

Equipment name: River Surveyor RS5
Model numbers: RS5

Accessory: (1) Juniper Systems, Geode (part no. 28358)
(2) SonTek RTK Rover & Base

Intentional Radiators: (RS5) NCC ID: CCAI18LP1970T4

Regulation:

- NCC of Taiwan

1. Without permission granted by the NCC, any company, enterprise, or user is not allowed to change frequency, enhance transmitting power or alter original characteristic as well as performance to an approved low power radio - frequency devices.
2. The low power radio - frequency devices shall not influence aircraft security and interfere legal communications; If found, the user shall cease operating immediately until no interference is achieved. The said legal communications means radio communications is operated in compliance with the Telecommunications Act. The low power radio - frequency devices must be susceptible with the interference from legal communications or ISM radio wave radiated devices.



E.J. Rollo, Compliance Engineer

April 2, 2021

The undersigned hereby declares that the product accessory listed below conforms to all applicable requirements for the handling and shipping of Li-Ion batteries and is safe to use with the model number listed.

Manufacturer: SonTek – a Xylem brand
9940 Summers Ridge Road
San Diego, CA 92121 USA

Equipment name: River Surveyor RS5
Model numbers: RS5 & SonTek RTK Base

Accessory Manufacturer: Tenenergy
Accessory Part No: 30016-04

Regulation:
• UN DOT 38.3

Standards:
• **UL 2054:2004 R9.11**
• **IEC 62133-2:2017**, Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems



E.J. Rollo, Compliance Engineer
April 2, 2021

The undersigned hereby declares that the product listed below is IP-67 rated and tested in accordance with IEC test specifications.

Manufacturer: SonTek – a Xylem brand
9940 Summers Ridge Road
San Diego, CA 92121 USA

Equipment name: River Surveyor RS5
Model numbers: RS5

Accessory: (1) Juniper Systems, Geode (part no. 28358)
(2) SonTek RTK Rover & Base

Regulation:
• IP67 ingress protection rating

Standards:
• **IEC 60529** (as a part of IEC 61010-1:2010, AMD: 2016) - This standard applies to the classification of degrees of protection provided by enclosures for electrical equipment with a rated voltage not exceeding 72.5 kV



E.J. Rollo, Compliance Engineer
April 2, 2021

The undersigned hereby declares that the product and all of its accessories are compliant with the current EU RoHS directive.

Manufacturer: SonTek – a Xylem brand
9940 Summers Ridge Road
San Diego, CA 92121 USA

Equipment name: River Surveyor RS5
Model numbers: RS5 & Accessories

Directives:
• RoHS 2011/65/EU (includes RoHS-3 amendment 2015/863/EU)

Manufacturers Statement of Compliance:

Environmental Laws restrict the use of certain hazardous substances. The manufacturer has indicated that the RS5 product, and all of its accessories, are compliant with European Union directive 2011/65/EU, which includes amendments 2015/863 & 2017/2102.



E.J. Rollo, Compliance Engineer
April 2, 2021

Release Notice

This is the August 2021 release of the RS5 User Manual. During the creation of this manual, the following were the latest versions of firmware/software. As such, if you are using different firmware/software versions, not all aspects of this manual may apply.

- RS5 firmware version 1.25
- RSQ software version 2.1

Trademarks

The term RS5 is a registered trademark of Xylem Inc. All rights are reserved. All other brand names are trademarks of their respective holders.

Warranty, Terms, and Conditions

Thank you for purchasing the RS5. The instrument was thoroughly tested at the factory and found to be in excellent working condition. If the shipping crate appears damaged, or if the system is not operating properly, please contact us immediately.

The system you have purchased is covered under a two year limited warranty that extends to all parts and labor for any malfunction due to workmanship or errors in the manufacturing process. The warranty does not cover shortcomings that are due to the design, nor does it cover any form of incidental damage as a result of errors in the measurements.

If your system is not functioning properly, first try to identify the source of the problem. If additional support is required, we encourage you to contact us immediately, and we will work to resolve the problem as quickly as possible.

If the system needs to be returned to the factory, please contact technical support to obtain a Service Request (SR) number. We reserve the right to refuse shipments without SR numbers. We require the system to be shipped back in the original shipping container using the original packing material with all delivery costs covered by the customer (including all taxes and duties). If the system is returned without appropriate packing, the customer will be required to cover the cost of a new packaging crate and material.

Contact Information

Any questions, concerns, or suggestions can be directed to SonTek by telephone, fax, or email. Business hours are 8:00 a.m. to 5:00 p.m., Pacific Standard Time, Monday through Friday.

Phone : +1 (858) 546-8327
Fax : +1 (858) 546-8150
Email : inquiry@sontek.com (General information)
sales@sontek.com (Sales information)
support@sontek.com (Support information)
Web : <http://www.sontek.com>

See our web site for information concerning new products and software/firmware upgrades.

FCC INFORMATION

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

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Section 1. Introduction

1.1. SonTek RS5 ADP

The SonTek RS5 is the newest member of the time tested RiverSurveyor family of acoustic Doppler profilers (ADPs). The RS5 builds upon the acoustic technology developed for the RiverSurveyor S5 and M9. We have drawn heavily on customer feedback and suggestions for both the hardware and software development. Using modern electronics we have built the most compact, portable, light-weight and easy to use ADP for shallow water river and stream discharge measurement.

The RS5 is the first self-contained ADP designed for open channel discharge measurement and the smallest to include a vertical beam. No need to connect to external power, radios or other electronics housings. Everything you need, including radio communication and a rechargeable battery is built into the transducer head. Don't let the size fool you. The RS5 hardware and data are, as you have come to expect from the RiverSurveyor ADPs, highly accurate and robust. Between the portability made possible by the decreased size and the intuitive interface afforded by the modern and improved software, the RS5 and accompanying RSQ software takes ease of use to a new level.

What's New?

Broadband Transducers – Robust bottom tracking, precise velocity profiling and accurate depth measurements with efficient 3 MHz, broadband transducers.

SmartPulse+ - Similar to the SmartPulse+ you know and love from the RiverSurveyor family, but even more reliable by now including broadband and coded pulse coherent processing techniques.

If you are a first time user or new to the SonTek RiverSurveyor family, SmartPulse+ is an algorithm used by the ADP while measuring that adjusts the acoustic processing, cell size and more automatically to ensure you collect the most accurate water velocity data possible. The end result of the automatic adjustments is the best measurement settings possible at all times, no matter the depth and velocity of the river.

Bluetooth Low Energy (BLE) 5 Radios – Modern, high speed, high throughput, reliable and integrated wireless communication. Because we know you don't have time to monkey with your wireless connection in the field.

Data Buffering – If you lose wireless connection momentarily, the RS5 will hold up-to 5 minutes of data in a buffer and update the data stored on the computer automatically in the background, while you continue uninterrupted with your measurement.

Rechargeable Lithium Ion Battery – The RS5 comes standard with two, 3.7V, 2600mAh, Lithium Ion rechargeable batteries. One cell will power the system with a

GNSS receiver all day on a single charge. A second battery is included with each system so you will have a backup/spare.

Enhanced Portability – The RS5 is the smallest, lightest and most portable ADP for discharge measurement available. Pair it with the HydroBoard II-Micro, equipped with folding antenna mast and board bag with backpack straps and you can travel from site to site, without disassembling, while protecting your valuable equipment.

RSQ Software – Replicates RiverSurveyor Live, but with more intuitive and modern navigation and workflow as well as many significant improvements. User adjustable, 3-beam solutions for vertical banks, transect sub-sectioning, one data file per measurement, Extrap integration and KML export to Google Earth, to name a few.

Vertical Beam – Not technically new for the RiverSurveyor line, but the RS5 is the smallest ADP ever to include a vertical beam. Measure the most accurate channel cross-section possible with a dedicated vertical beam for measuring the depth directly under the system.

1.2. SonTek RSQ Software

The RSQ Software platform is designed specifically for collecting measurements with the SonTek RS5 ADP. It includes functionality for communicating with the instrument and collecting data in real-time, as well as post-collection data viewing and processing features. Data collected with the RS5 can be exported to various data formats from the RSQ for further data processing or visualization using other software platforms.

This User Manual gives an overview of the steps required to operate the RSQ software with the SonTek-RS5, view data, and post-process measurements.

Section 2. RS5 Instrument Specifications

Hardware	Specification
Total # Of Transducers	5 X 3.0MHZ
Beam Angle	25°
Beam Width	3°
Bandwidth	25%
Vertical Beam Range	0.1-6.0m
Bottom Track Range	0.1-5.0m
Operational Range	0.1-6.0m
Resolution	0.001m
Depth Accuracy	1%±0.005m
Bottom Velocity Accuracy	1%±0.002m/s
Horizontal Velocity Range	±5m/s

Resolution			0.001m/s
Accuracy (Long Term Average)			1%±0.002m/s
Cell Size			2.5cm to 30cm
Min Profiling Depth			0.15m
Max Profiling Depth			5.0m
First Cell Start(Min) @			5cm from system tip
# Of Cells			Up To 128
Temperature Sensor			Resolution: ±0.01°C Accuracy: ±0.5°C
Compass/Tilt Sensor			Range: ±180° Pitch/Roll, 0-360° Heading Heading Accuracy: ±2° Pitch/Roll Accuracy: ±1°
Radio/Communication Protocol			Protocol: SonTek Bluetooth Range: 100m
RS5 Temperature	RS5 Operating		0° to 45°C (32°F to 113°F)
	RS5 Storage		-20° to 70°C (-4°F to 158°F)
	RS5 Storage w/ Battery		-20° to 45°C (-4°F to 113°F)
			Remove batteries from the RS5 if storage temperatures exceed the storage temperature of the Li-Ion battery.
RS5 Physical Specifications	RS5 (Instrument body + battery cover)		(L) 24.13 cm (9.5 in); (W) 5.08 cm (2.0 in)
	RS5 (Instrument body)		(L) 20.96 cm (8.3 in); (W) 5.08 cm (2.0 in)
	RS5 Weight in Air		0.45 kg (1.0 lbs)
	RS5 Weight in Water		0.15 kg (0.33 lbs)
	Waterproof Rating		IP-67
Battery Physical Specifications	Battery		19.2mm x 69.7mm
	Battery Weight		50g
Battery Power	Input Battery Voltage		3.3-4.2 VDC
	Power Source	Li-Ion	1 x size 18650, Tenenergy, Type 30016-04, 3.7VDC, 2600mAh

	Battery Life	1 x size 18650	7 hours continuous use, typical settings*
		*Defined as continuous sampling with Geode GPS	
	Power Consumption		1.0 W (Average)
GPS (Geode)	Horizontal RMS		SBAS (WAAS): <0.3 m (0.98 ft)
	2DRMS		SBAS (WAAS): <0.6m (1.96 ft)
	Frequency		L1, GNSS
Operating Altitude	Maximum operating altitude is 2000m		
Bluetooth	Compliance		FCC Part 15, FCC ID: XPYNINAB30 ISED Certification: 8595A-NINAB30

Section 3. RS5 Configuration Options and Setup

The RS5 is available in two models: the **RS5 STD** and the **RS5 Max**. Whereas the models are physically identical, the RS5 Max has an integrated GNSS option and compass while the RS5 does not.

3.1. RS5 ADP

The RS5 ADP (Figure 1) is a sequential-pinging 5-beam pulse-coherent and Broadband ADP with optional internal compass and GNSS/GPS integration. The vertical beam is used for depth measurements, and the remaining skew beams are used to calculate flow or bottom velocity in addition to depth.



Figure 1. SonTek RS5

The RS5 comes standard with a temperature sensor near the head of the instrument. It transmits data wirelessly via a Bluetooth radio connection to the RSQ software (see Section 6) for data collection and processing. The following sections describe different configurations of the RS5 available and their associated accessories.

3.2. RS5 STD – Compass Only/No GNSS

The RS5 STD model comes with the system and accessories pictured in Figure 2 and various accessories are explained below.

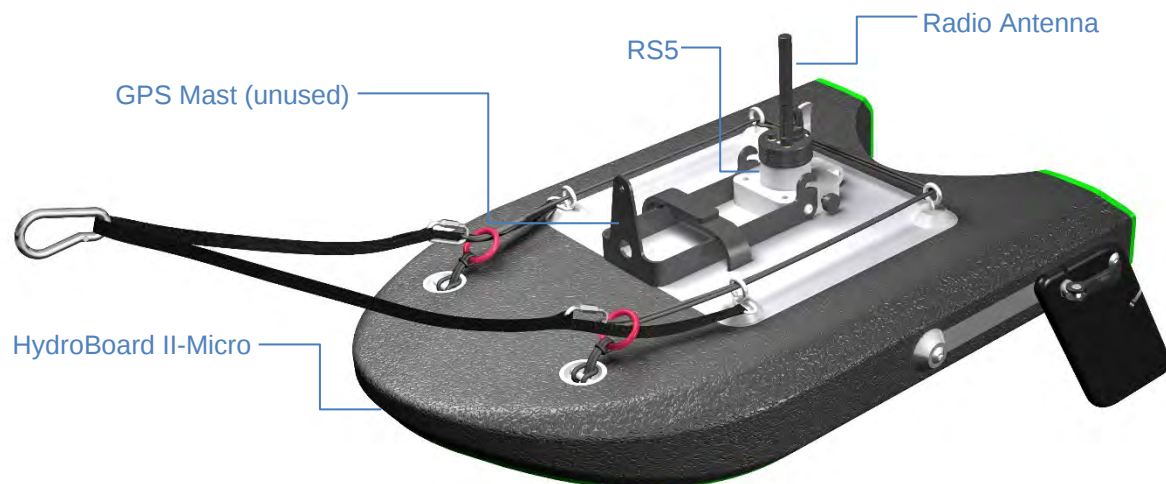


Figure 2. RS5 STD Hardware and Accessories

RS5



HydroBoard II-Micro



Radio Antenna



Radio Antenna Extension Cable
(Use this cable if elevating the radio antenna is desired)



USB + Radio Antenna



Batteries (x2 plus case)



Battery Charger



Battery Charger Wall Adapter



GPS Connector Cap



3.3. RS5 MAX – Compass and GNSS Options

3.3.1 Differential GNSS Components – Optional

The RS5 Differential GNSS option comes standard with the Geode antenna (manufactured by Juniper Systems). The RS5 Max differential solution hardware and accessories are shown in Figure 3 and are explained below.

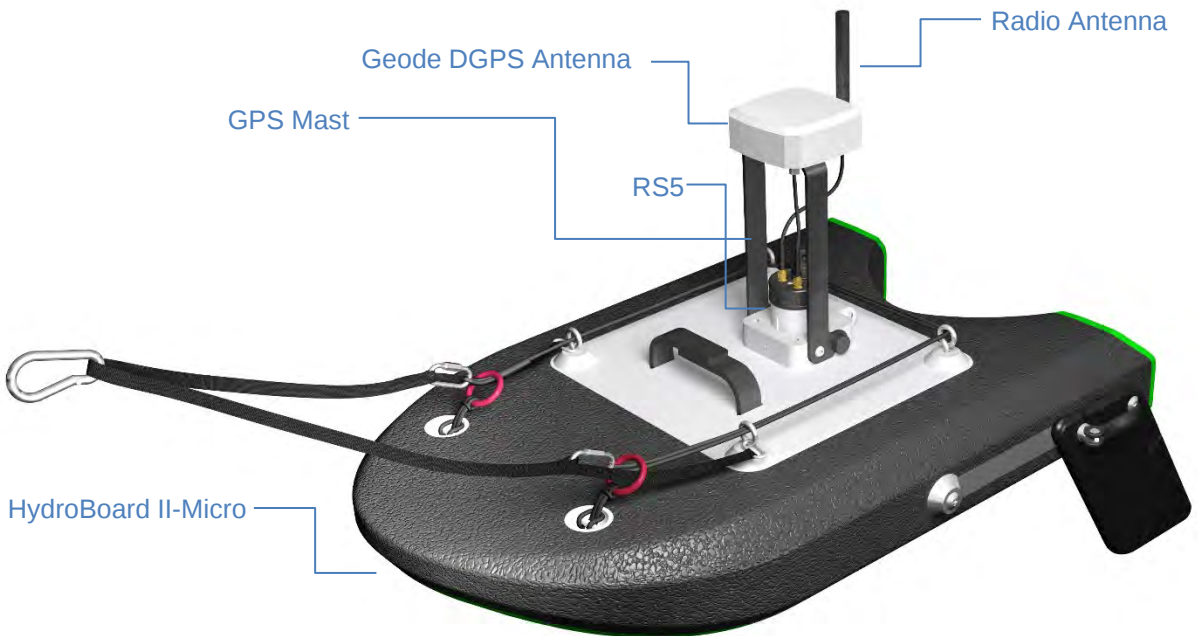


Figure 3. RS5 Max and Differential GNSS Components

RS5



HydroBoard II-Micro



Geode DGPS Antenna



Geode Antenna Bracket



GNSS/GPS cable



Radio Antenna



Radio Antenna Extension Cable

(Using this cable to elevate the radio antenna is highly recommended)



USB + Radio Antenna



Batteries (x2 plus case)



Battery Charger

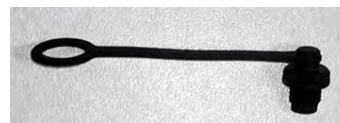


Battery Charger Wall Adapter



GPS Connector Cap

(Use this optionally when the Geode is not connected)



3.3.2 RTK GNSS Components – Optional

The RS5 RTK GNSS option comes standard with a Rover and Base Station. The RS5 Max RTK solution consists of the same hardware for the DGPS solution, but with a different rover and cable, and an additional Base Station. Hardware and accessories are shown in Figure 4 and are explained below.

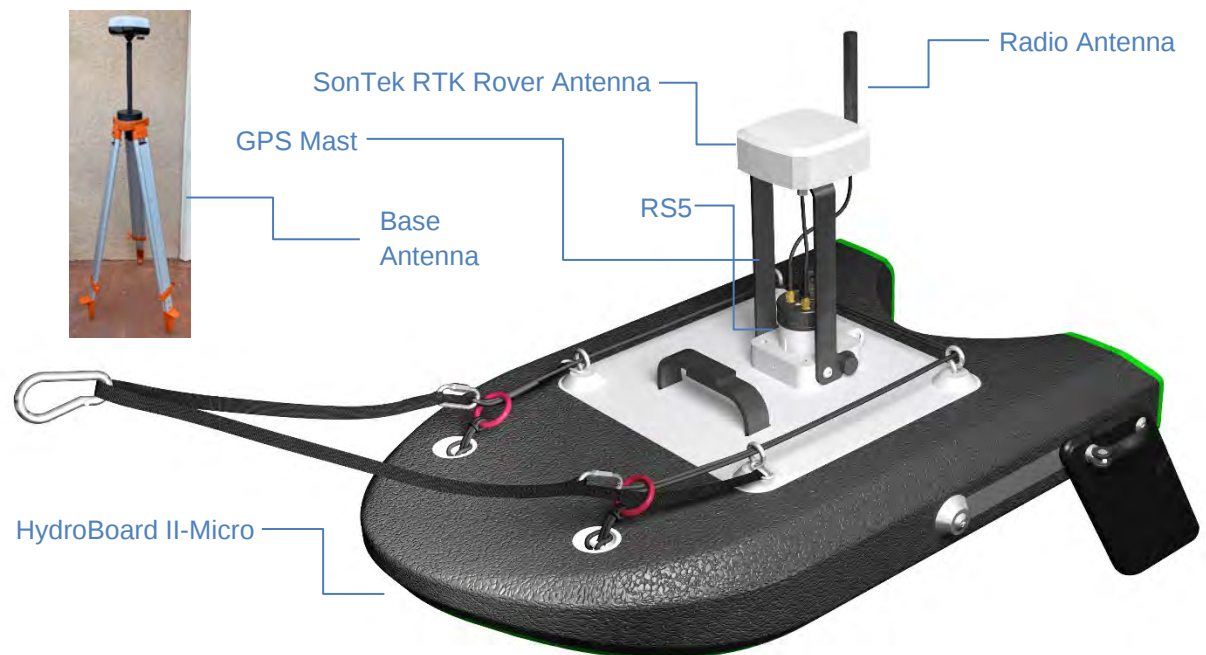


Figure 4. RS5 Max and RTK GNSS Components

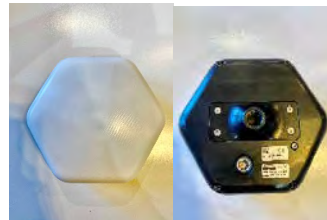
RS5



HydroBoard II-Micro



RTK Rover Antenna



RTK Base Antenna



RTK Antenna Bracket



RTK GNSS/GPS cable



Radio Antenna



Radio Antenna Extension Cable
(Using this cable to elevate the radio antenna is highly recommended)



USB + Radio Antenna



Batteries (x2 plus case)



Battery Charger



Battery Charger Wall Adapter



GPS Base Station Tripod



Base Station pole and disk (for Tripod attachment)



3.3.3 GNSS Unlock Code (for externally-supplied GNSS antenna)

For users who prefer to use their own GNSS antenna systems, a GPS unlock code can be purchased through SonTek (please contact support@sontek.com for details). This code is specific to each RS5 unit. Users will need to ensure that their GNSS antenna of choice can support the output specifications required by the RS5 (outlined in 5.2.2). A cable diagram can be provided and users will need to fabricate a cable appropriate between the RS5 and their antenna. For detailed instructions on how to enable your external GNSS antenna using the unlock code, please refer to Appendix D.

3.4. SonTek Hydroboard II-Micro

The RS5 system comes with the optional SonTek Hydroboard II – Micro, the floating platform designed specifically for the purpose of taking discharge measurements using the RS5.



Figure 5. RS5 Hydroboard II-Micro (right) with the Hydroboard Family

3.5. Carrying Case Options

3.5.1 Pelican Case (RS5 System Only)

A carrying case is available for the RS5 system and its accessories, shown in Figure 6.



Figure 6. RS5 Pelican Case

3.5.2 Backpack for HydroBoard and System - Optional

An optional convenient backpack is available to store and carry the RS5 with Hydroboard II – Micro, shown in Figure 7. The backpack allows the user to leave the RS5 assembled on the board when transporting or storing the system and provides an easy way to travel to various locations with the entire system together.



Figure 7. RS5 Backpack – Front and Back Views

The center straps on the Hydroboard II-Micro hold down the GPS stand when in storage (shown in Figure 8). The user can optionally keep the GPS cable attached to the antenna. It is highly recommended to disconnect the radio antenna from the setup when in storage and transport to avoid damaging that part.

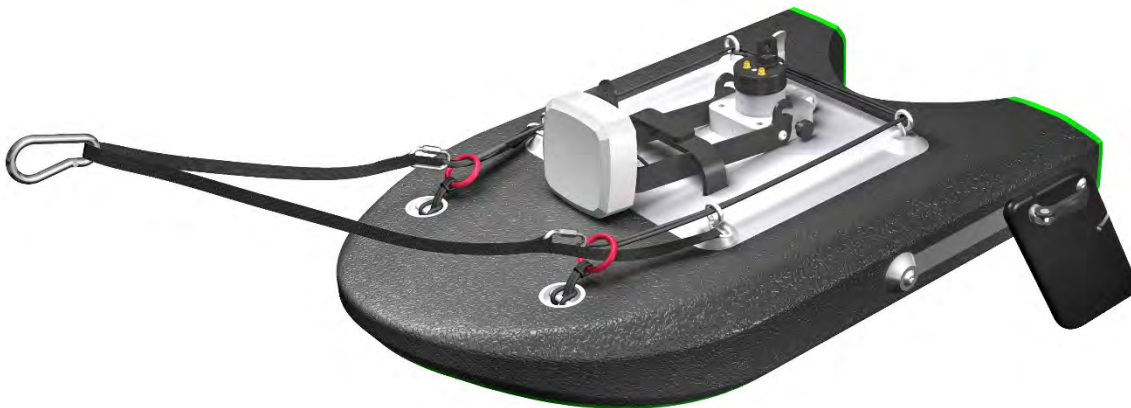


Figure 8. RS5 on HBII-Micro for Backpack Storage

Section 4. System Maintenance

Under normal conditions, the ADP requires little maintenance, while providing years of reliable performance. This section discusses some routine maintenance procedures that should be followed to ensure system longevity.

4.1. Cleaning the Transducers

Periodic cleaning of the ADP transducer face may be needed to maintain optimal performance in areas of high biological activity or mineral build-up. To remove material build-up on the transducer faces, simply clean with a stiff (non-metallic) brush or apply soapy water and clean with a sponge. The transducers themselves are protected in a hard epoxy-resin and are very durable. Minor scratches on the transducer face are normal over a period of time and will not harm them or affect their performance. Direct impacts to the face should be avoided as this might crack the face of the transducer and allow moisture into the electronics housing as well as causing damage to the transducer itself.

4.2. O-Rings

Make sure that O-ring on the battery cap is completely clean and free of debris. Be sure that the O-ring is seated correctly, and that it is not twisted or broken. It is important to maintain a water-tight seal for the integrity of the instrument.

4.3. Batteries

The RS5 is powered by a single Li-Ion cell (battery specifications can be found in Section 2). The battery contains an internal safety circuit that protects against short circuits, over-voltage, and under-voltage conditions. If purchasing these batteries from a third party, please ensure that the exact model number is obtained, as similar models without circuit protection do exist but have a different body shape.

4.4. Calibration

Each system is individually calibrated during the manufacturing process. Since there are no moving parts and the beams are built into the RS5 head, recalibration is not necessary unless the RS5 is physically damaged.

Section 5. Pre-Measurement Hardware Setup Steps

5.1. Powering on the RS5 (STD)

Unscrew the battery cap, place the battery with the positive terminal facing down into the compartment (Figure 9), and screw down the battery cap.

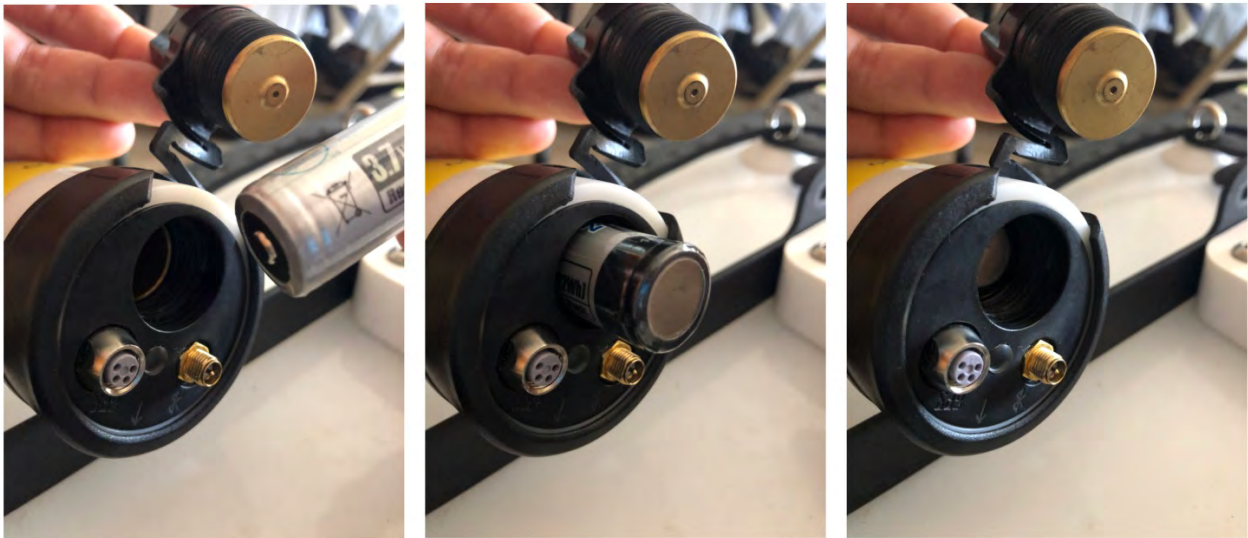


Figure 9. Place Battery Inside Compartment

The system's LED light will flash white quickly, followed by two fast red flashes. After a few seconds of delay, the LED will flash slowly red, indicating that it is powered on and in Stand-by mode and ready for connection.

5.2. Powering on GNSS Accessories (Max)

5.2.1 Differential GNSS: Geode Antenna

The RS5 Differential GNSS solution comes standard with a Geode™ antenna manufactured by Juniper Systems. The Geode antenna comes equipped with its own battery, which requires charging using its own supplied charging cable, pictured in Figure 10.



Figure 10. Geode Antenna

To turn on the Geode antenna, push the large Power button, shown in Figure 10. Various lights will flash and illuminate on the system. Please refer to the Geode manual

for a complete list of light indicators and meanings. The complete manual for the Geode antenna can be found from the Juniper Systems website at <https://junipersys.com/data/support/geode/Geode-manual-English.pdf>.

Field Note: The Geode antenna needs to be charged separately from the RS5 before taking a measurement!

The Geode system will be configured to connect directly to your RS5 (through the cable) with no other setup required, but if the user is interested in viewing antenna diagnostics (number of satellites, quality of fix, etc.) or changing settings for other purposes, Juniper Systems offers a Geode Connect app as well as a desktop software to connect to the antenna directly via Bluetooth. More information on these tools can be found in the manual mentioned above.

If the Geode antenna did not come with the RS5 or has not been configured at the factory, the commands below can be used in the Geode Connect app Terminal screen:

- 1) Send '\$jbaud,38400,other,save' (without quotes)
- 2) Send '\$jsave'
- 3) Send '\$jshow' (there is also a button for this command) and confirm that there is a line displaying \$jbaud,38400,other

Once complete, assemble the RS5 and connect to the RSQ software. Go to Hardware Utilities > Instrument Options and click the "External GNSS" button with everything connected and a clear view of the sky.

5.2.2 RTK GNSS

The SonTek RTK GNSS solution comes with the option to use a Rover antenna and a physical Base Station antenna. The Rover antenna is powered by the RS5 itself through the supplied cable. The Base Station has its own battery compartment and power button, and requires one RS5 battery, as shown in Figure 11.



Figure 11. SonTek Base Station with Battery

Both the Rover and Base have one indicator light on the side of the antenna body, as shown in Figure 12.



Figure 12. RTK Base Station Antenna with Indicator Light

Powering the Base Station Antenna

When the Base Station is set up and placed in the desired location, push the power button on the bottom of the antenna. Upon powering up, the light will go from Purple (solid) to Red (solid) to Green (slow blink). When the antenna is blinking green slowly, it is in stand-by mode and ready to pair with a Rover.

Powering the Rover

The Rover antenna is powered directly by the RS5, and does not need a separate battery. Connect the RTK GPS cable from the Rover to the RS5, and insert a battery into the RS5 instrument. **Please note: the Rover light does not come on until the user connects to the RS5 using the RSQ software!** Follow the steps to connect to the RS5 instrument using RSQ, as outlined in Section 7.3. Once connected, the Rover light will go from Purple (solid) to Red (solid) to Green (fast and slow blinking). When the Rover light is blinking green, this indicates that it is in stand-by mode and ready to pair with the Base.

Pairing the Rover and Base

The Rover will automatically search for the Base if it has already been configured to search for a specific Base antenna. The pairing information is stored with the RS5 instrument, so if a new RS5 is used with an already-paired Rover-Base pair, the antennas will need to be re-paired. To pair a Rover with a Base antenna, follow the steps below:

- 1) Ensure that the rover and base station are both powered on properly and blinking green. This means you have also connected to the RS5 using RSQ.
- 2) From RSQ, go to Tools > Hardware Utilities > Instrument Options, which will display the dialog shown in Figure 13.

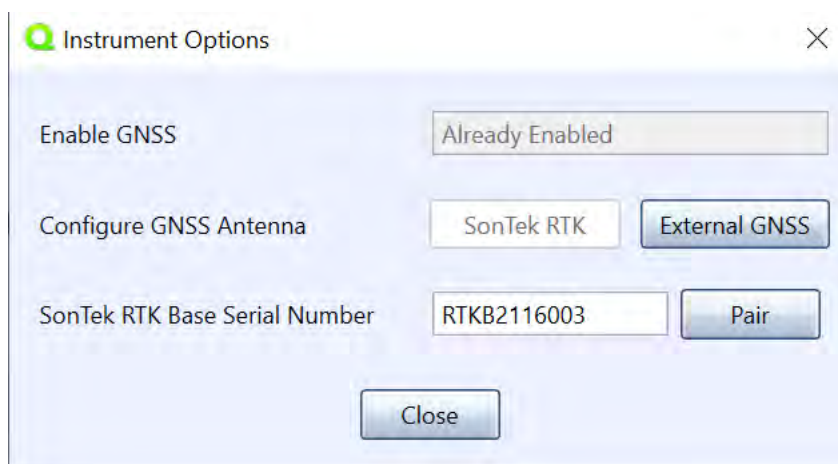


Figure 13. Instrument Options Dialog

- 3) In the “SonTek RTK Base Serial Number” field, enter the serial number of the Base station in the format RTKB##### (no spaces).
- 4) Click “Pair.” A warning will appear reminding the user to power and connect everything properly. Once ready, click “OK.”
- 5) The Rover antenna will go through a series of fast green blinks. This indicates that it is searching for the Base with the serial number entered.
- 6) Once paired successfully, a message will appear. The indicator light on both the Rover and Base will blink BLUE slowly, indicating that they are paired and connected.

5.2.3 Network RTK

Another option using the SonTek RTK solution is to use the Rover antenna as a stand-alone physical antenna, and enable Network RTK (often called NTRIP) corrections via an external base station network. The Network RTK corrections can be started at any point before or during a measurement. To set up Network RTK, click the Network RTK button from the top main menu banner of the RSQ software (shown in Figure 20). The dialog shown in Figure 14 will appear.

Connection to a Network RTK correction service in the field will require the user to have internet access at the field site. This is commonly achieved through a Mobile Hotspot or Ethernet connection, if available for a site. The internet connection is used to receive Network RTK corrections through the laptop, and these corrections are sent to the Rover antenna. A Network RTK service should be set up externally by the user with whichever service they choose. That service will provide the user with a Caster Host IP Address and Port. Enter that information, along with the user’s login credentials, into the input fields and press “Get Mount Points.”

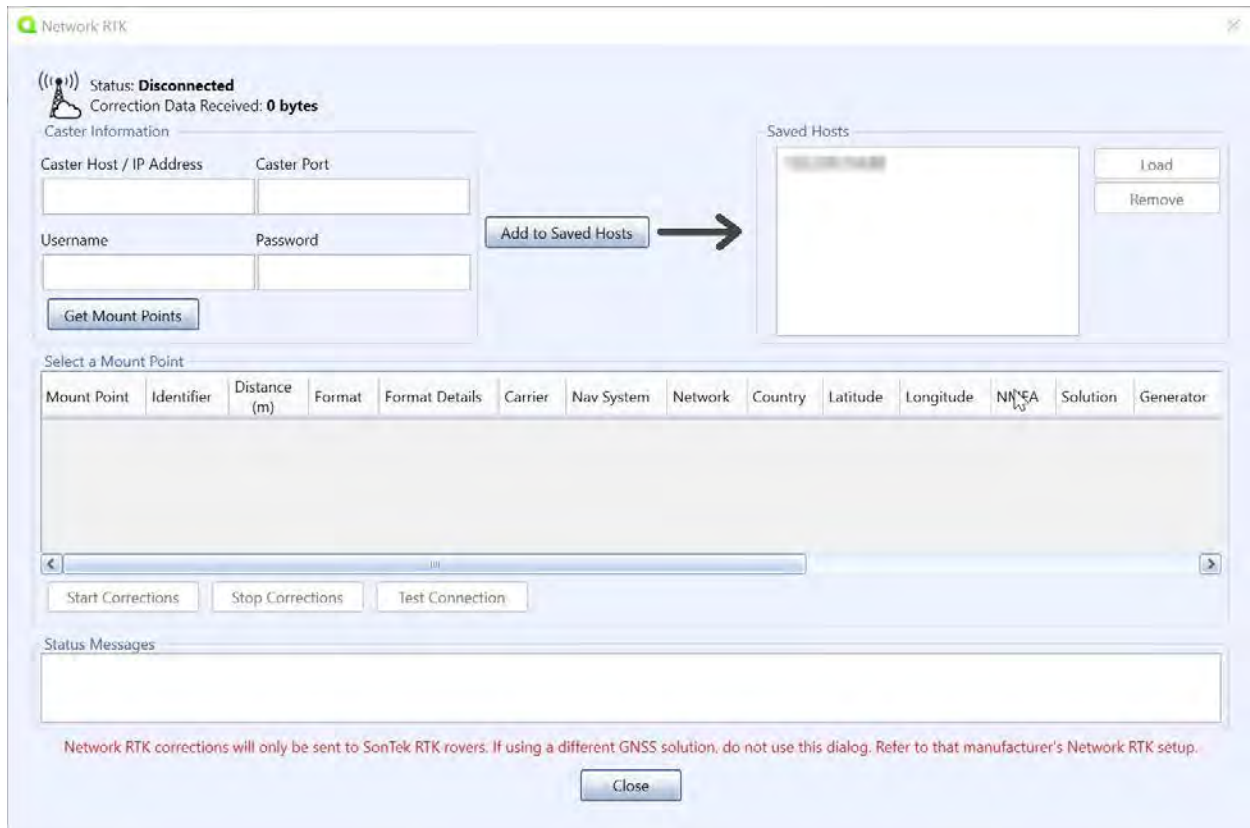


Figure 14. Network RTK Dialog

Once connected, available mount points will populate in the Mount Point table, and a Status Message will appear in the message box at the bottom of the dialog. An example of a successful connection is shown in Figure 15. If the RS5 is pinging and there are GNSS data being received, the Mount Points will be ordered from closest to farthest physical distance from the measurement.

Click on the desired Mount Point in the table. Clicking “Test Connection” will test the mount point connectivity. When ready, click “Start Corrections” to start receiving the Network corrections. When Network corrections are being received, the status icon at the top of the Network RTK dialog and the Network RTK button in the main menu banner will appear green.

To stop corrections, open the Network RTK dialog and click “Stop Corrections.”

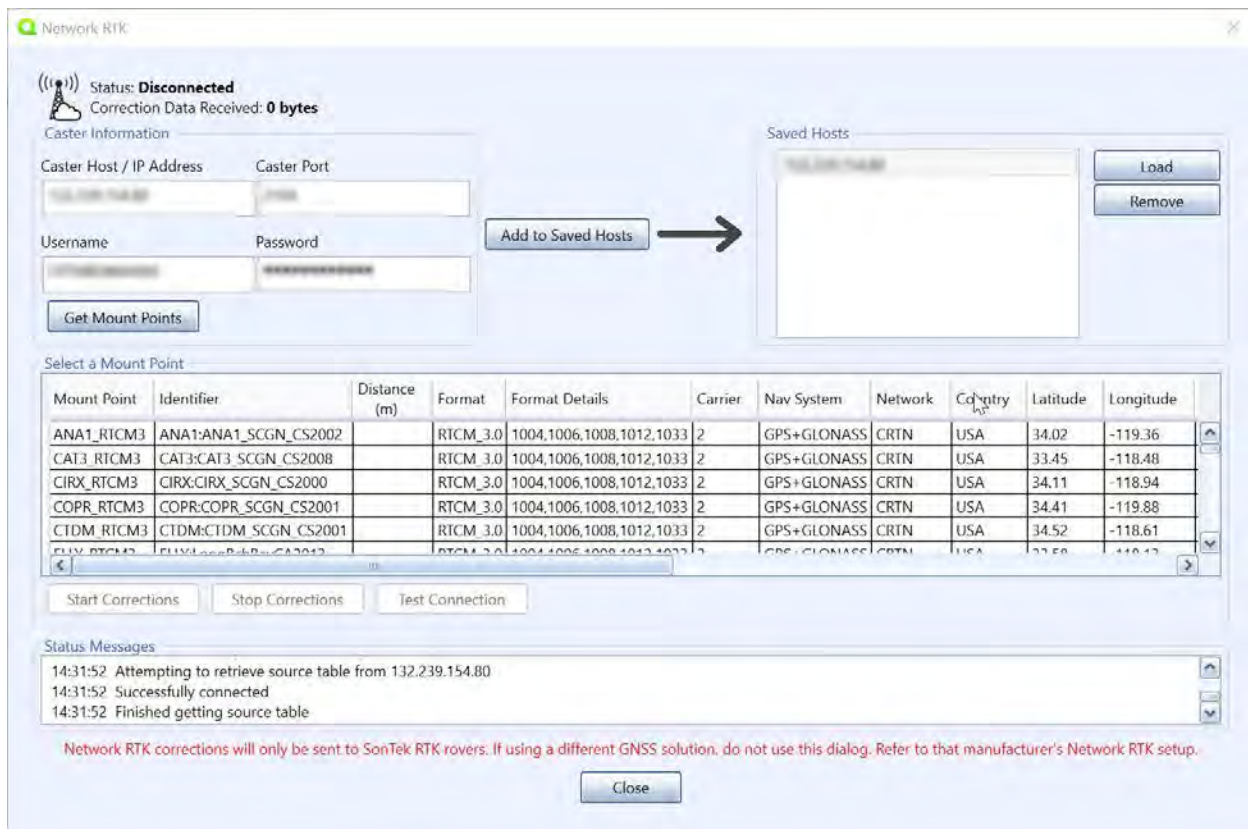


Figure 15. Example of Successful Network RTK Connection

5.2.4 External Antenna

First, ensure that the GNSS unlock code has been purchased and provided by SonTek. This is typically an 8-digit alpha-numeric code and is specific to each RS5 unit. To enable the code, please see detailed instructions in Appendix D.

The user is responsible for charging and operating their external antenna of choice, including the cable connection. The antenna/receiver must be configured prior to use with the RS5. The NMEA messages currently supported by the RS5 GNSS protocol are listed in Table 1, along with their required output rate.

Table 1. RS5 Supported NMEA GPS Messages

Message	Required Output Rate	Description
GGA	5Hz	UTC time, position, quality and DGPS diagnostics
VTG	5Hz	ground speed and direction
RMC	1Hz	UTC date and magnetic declination
ZDA	1Hz	UTC date
GSV	1Hz	detailed satellite (in view) information
GSA	1Hz	list of satellites used in fix

The receiver must be set up to communicate over **RS-232 at a Baud rate of 38400**.

Please see Appendix D for detailed instructions on how to enable an external GNSS/GPS antenna for the first time.

The external GNSS/GPS antenna must supply its own power. Please follow the antenna manufacturer's instructions on how to power their system.

5.3. Secure RS5 in Hydroboard II – Micro

Once the RS5 system is powered put the system in the Hydroboard II – Micro hole and secure the bracket. Make sure that the RS5 head is further than the bottom of the board to ensure that the transducers remain unobstructed and in the water (Figure 16).

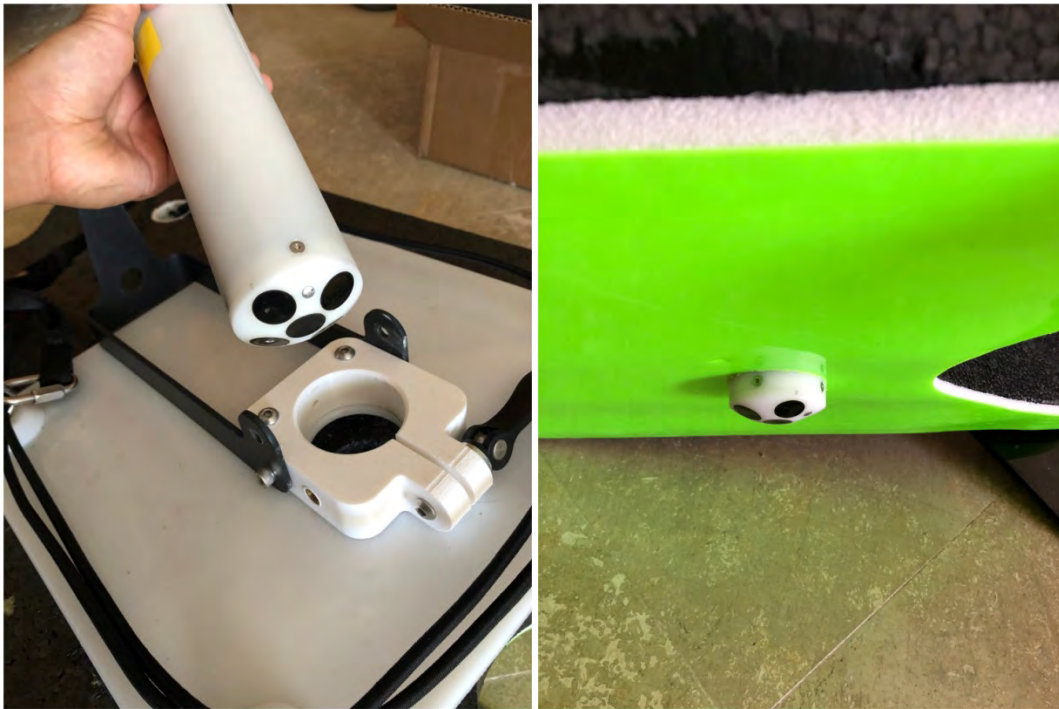


Figure 16. Installing the RS5 in the HBII-Micro: Ensure the RS5 head extends beyond the bottom of the board.

5.4. Connect Bluetooth Radio Antenna

There are two options to install the Bluetooth radio antenna on the RS5 unit: directly attached to the RS5 (no GNSS antenna) or elevated (with GNSS antenna on mount). Extensive testing has shown that elevating the Bluetooth antenna above the GNSS antenna drastically improves communications if a GNSS antenna is used. Figure 17 shows what the two configurations look like. If mounting the Bluetooth antenna above the GNSS, the radio extension cable is required (shown in Figure 2). The extension cable can be used even without a GNSS antenna if desired.

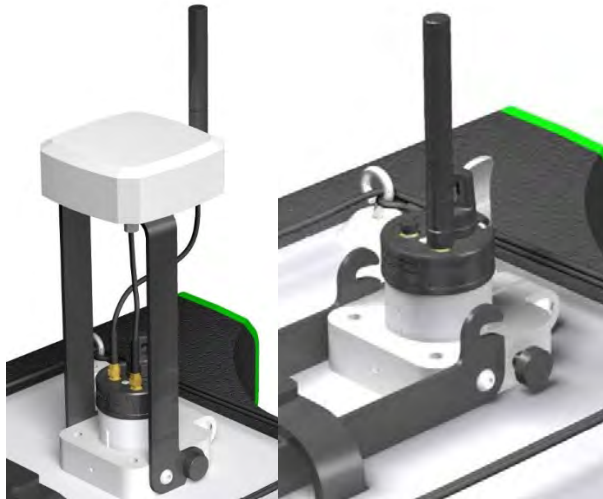


Figure 17. Radio Antenna Configuration with GPS (left) and Without (right).

Connect the second Bluetooth radio antenna to the USB dongle (described in Section 3.2), and insert the dongle into the computer.

Field Note: elevating the radio antenna as far away from the water surface as possible will give the best/most reliable communication connection!

5.5. Connect GNSS Antenna Cable

If using a GNSS solution, connect the antenna with the appropriate cable to the GPS connector of the RS5. If not using a GNSS antenna, please use the GPS connector cap supplied to keep the connector closed when in use on water (shown in Figure 18).



Figure 18. GNSS Connector Cap

Once all parts are connected and powered, the user is ready to collect a discharge measurement.



Section 6. RSQ for PC – Moving Boat

6.1. Overview – RSQ Software for PC

This section describes the RSQ software for RS5 data collection, viewing, and post-processing for Moving Boat discharge measurements. The software includes everything needed to make real-time Moving Boat discharge measurements as well as post-process the data. Additionally, RSQ is capable of post-processing RiverSurveyor M9/S5 Moving Boat data files.

6.2. PC System Requirements

Microsoft Windows 7 or newer
2Ghz processor or faster
4GB memory (8GB recommended)
1GB available disk space
1024 x 768 monitor resolution or better
USB port

6.3. Software Installation

The RSQ software installation file is included in the USB drive with your system. It can also be downloaded free of charge at:

<https://www.sontek.com/software-downloads>

The program should automatically start and display the installation menu. Follow the instructions to install the software. You will be asked to accept the Terms of Agreement. When prompted to install the driver, please proceed with the driver installation, as that will enable the USB Bluetooth dongle to work properly with the RS5.

6.4. Starting the Software

Using the Windows start menu, select RSQ, or double click the RSQ icon (shown in Figure 19) installed on the Windows desktop.



Figure 19. RSQ Software Icon

6.5. Software Layout During Data Collection

Whether in data collection or viewing/post-processing mode, the RSQ software is divided into multiple areas. When first starting RSQ, the user will have the option to either open a data file for viewing/post-processing, or to start a new measurement (shown in Figure 20). This section will give an overview of software functions for data collection, and data viewing/post-processing is covered in Section 8.

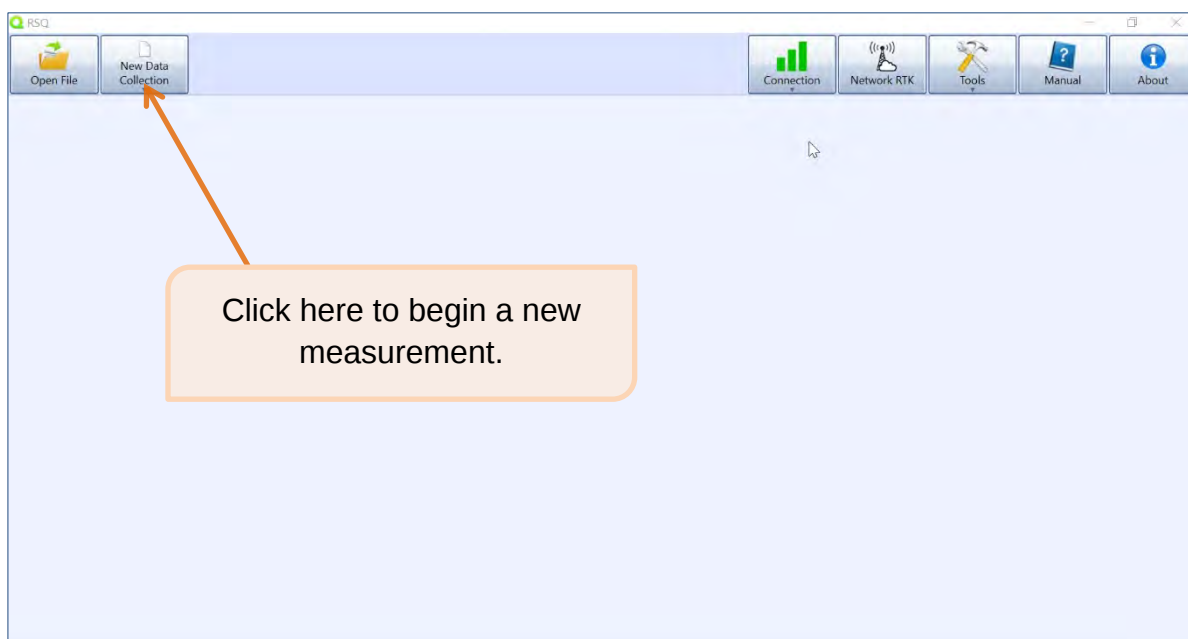


Figure 20. RSQ Main Landing Page

During data collection, the RSQ software interface is shown in Figure 21. Users familiar with the RiverSurveyor M9/S5 systems will notice that the layout of RSQ is very similar to RiverSurveyor Live.

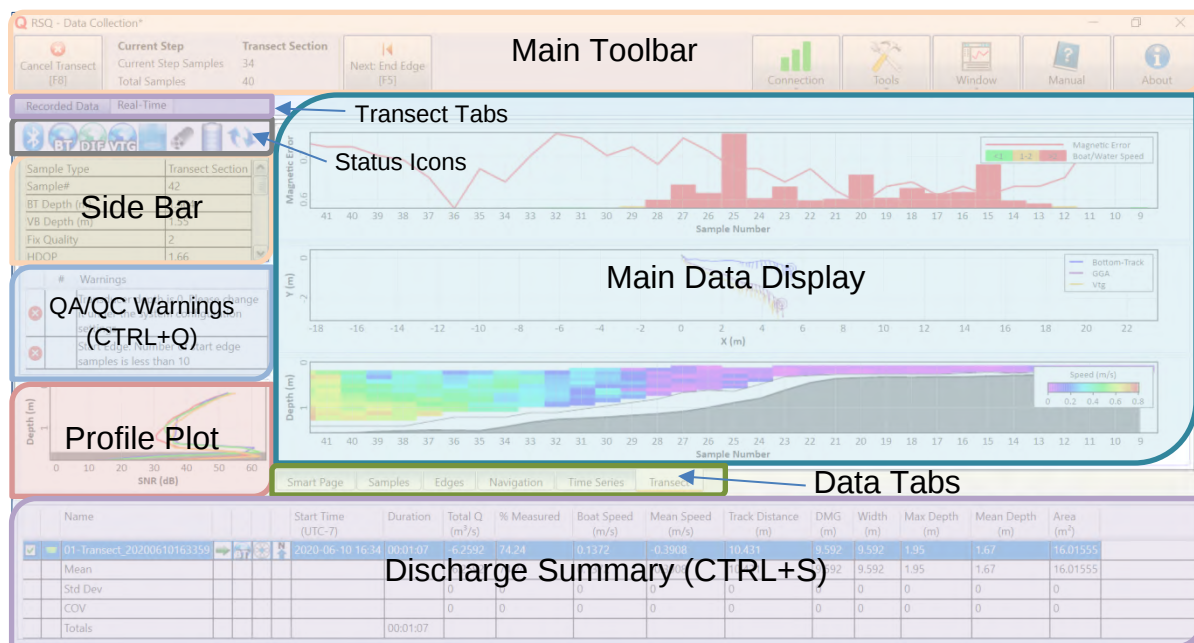


Figure 21. RSQ Interface During Active Data Collection

6.5.1 Main Toolbar

Once a new measurement is started, the main toolbar will change slightly to accommodate various options during the measurement. The main toolbar contains the main functions required during a measurement. When a measurement is first started, the main toolbar will have the buttons shown in Figure 22.



Figure 22. Main Toolbar When Starting a New Measurement

Choices on the left include:

- Cancel Transect – closes current transect
- Add Transect – add a moving boat transect
- Add Loop – add a Loop moving bed test
- Add SMBA – add a Stationary Moving Bed test

More general functions exist on the right. They include:

- Connection – use this to connect to the system and view connection status (details and instructions in Section 7.1)
- Network RTK – connect to Network RTK (when you use the SonTek RTK rover)
- Tools – various software tools including Beam Check and firmware upgrades (details and instructions in Section 6.8)
- Window – options to show the QC window (real-time and post-processing) and the Toolbox (post-processing only)

- Manual – open the RS5 User Manual (this document)
- About – view RSQ software version

When the first transect is complete, the user will see an expanded main toolbar, shown in Figure 23.



Figure 23. Main Toolbar After the First Transect

6.5.2 Transect Tabs

Transect tabs are used to select individual transects or moving bed tests for viewing. You can cycle forward through tabs by pressing **[CTRL+TAB]** or backwards with **[CTRL+SHIFT+TAB]**. This is useful when comparing transects.

6.5.3 Status Icons

Various status icons will update from sample to sample to give the user a quick visual indication of the various components of the system. From left to right, the icons represent:

- Bluetooth connection status
- Bottom track status
- GGA status
- VTG status
- Depth status
- System Status
- Battery Status
- Data Collection Status

Hovering over each icon will show a description of the status. The table shows the various status icons available and their associated meaning.

Table 2. Status Icon Meanings

Status Icon	Icon	Meaning
Bluetooth Status		Bluetooth connected
		Bluetooth Disconnecting/Disconnected
		Bluetooth Unknown
		Bluetooth Unavailable

Bottom Track Status		Bottom Track Valid
		Bottom Track Valid (Depth Only)
		Bottom Track Invalid
		Bottom Track Not Available
GPS – GGA Status		GPS GGA RTK
		GPS GGA Differential
		GPS GGA Uncorrected
		GPS GGA Invalid
		GPS GGA Not Available
GPS – VTG Status		GPS VTG RTK
		GPS VTG Differential
		GPS VTG Uncorrected
		GPS VTG Invalid
		GPS VTG Not Available
Depth Status		Depth Vertical Beam
		Depth Bottom Track
		Depth Invalid
		Depth Not Available
System Status		System OK RS5
		System Error RS5
		System OK RS (M9/S5)
		System Error RS (M9/S5)
Battery Status		Battery 100%
		Battery 80%
		Battery 60%

		Battery 40%
		Battery 20%
		Battery 10%
		Battery Not Available
Data Collection Status		Data Collection Running
		Data Collection Waiting

6.5.4 Sidebar

The sidebar can be found on the left upper portion of the software during a measurement, and is highlighted in Figure 21. The side bar is a sample-by-sample table displaying various real-time parameters. The variables displayed in the side bar can be configured by **right-clicking** on the side bar and selecting/deselecting various parameters of choice (Figure 24).

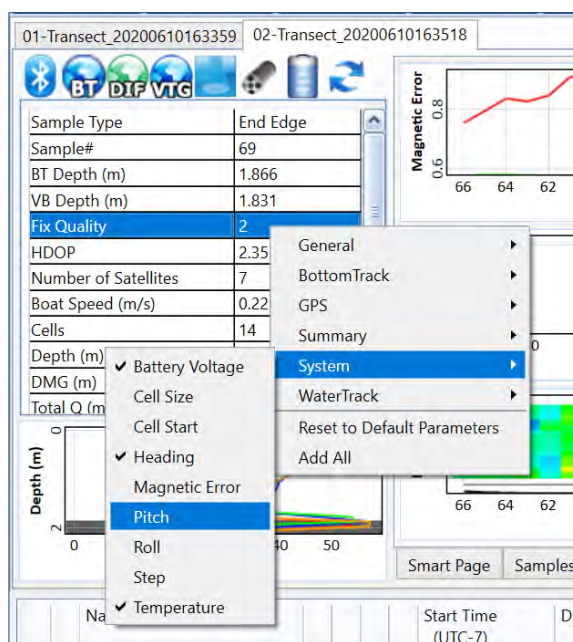


Figure 24. RSQ Side Bar Configuration

6.5.5 QA/QC Window

The QA/QC window shows various QA/QC warnings and errors during a measurement. It can be activated or deactivated through the Window button on the Main Toolbar or by using **[CTRL+Q]**. A list of warning messages can be found in Table 3. The type of

warnings displayed can be configured by **right-clicking** on the QA/QC warning window, and options are shown in Figure 25.

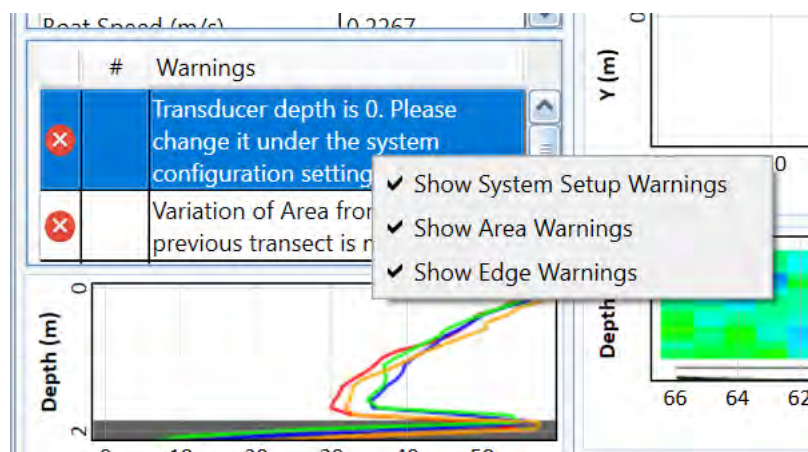


Figure 25. QA/QC Warnings Display Options

The QA/QC Process is based on international standards and well developed operational procedures from various organizations. The process is designed around system configuration, measurement components associated with moving boat measurements and system operation.

The messages supplied during the measurement process are based on the following structure:

- A warning message with a red X (✖) indicates an error that affects the measurement quality directly
- A warning message with a yellow caution symbol (⚠) indicates a potential error that should be investigated
- The “#” column refers to the individual sample number that produced the associated warning

The RSQ software uses the rules outlined in Table 3.

Table 3. QA/QC Warnings and Errors Rules and Meanings

Measurement Component	Variable	Action	Message	Criteria
System Setup Parameters	Coordinate System	Warning	Beam is selected as coordinate system	
	Track Reference	Warning	System is selected as track reference	
	Transducer Depth	Warning	Transducer depth is 0. Please set in system settings	

Measurement Component	Variable	Action	Message	Criteria
	Magnetic Declination	Warning	Magnetic declination is 0. Please set in system settings	
Compass	Pitch/Roll	Warning	Pitch/Roll exceeded calibrated value	
	Magnetic Error	Warning	Magnetic error is greater than 3.5	
Loop Method	Beam Separation	Counter / Warning	Samples with beam separation	
		Warning	9 consecutive samples with beam separation	9 Samples
	Bottom Track	Counter / Warning	Samples with bad BT	
		Warning	9 Consecutive samples with bad BT	9 Samples
	Cells	Warning	Number of cells less than 2	
SMBA Method	Beam Separation	Counter / Warning	Samples with beam separation	
		Warning	9 consecutive samples with beam separation	9 Samples
	Bottom Track	Counter / Warning	Samples with bad BT	
		Warning	9 Consecutive samples with bad BT	9 Samples
	Cells	Warning	Number of cells less than 2	
Transect	Beam Separation	Counter / Warning	Samples with beam separation	
		Warning	9 consecutive samples with beam separation	9 Samples
	Boat Speed	Warning	Boat Speed is greater than 0.7m/s	0.7m/s

Measurement Component	Variable	Action	Message	Criteria
	Bottom Track	Counter / Warning	Samples with bad BT	
		Counter / Warning	Samples with bad BT (edited)	
		Warning	9 Consecutive samples with bad BT	9 Samples
		Warning	Discharge will be biased low	
		Warning	Consider restarting the measurement using GPS reference	
	Cells	Warning	Number of cells less than 2	2 Cells
	Edge	Warning	Too shallow to collect edge data	2 Cells
		Warning	Edge Q is more than 5 percent of total Q	5%
		Warning	Please make sure that the start edge bank is entered correctly	
	Edge (Start)	Warning	Consider moving farther away from bank	2 Cells
		Warning	Number of start edge samples is less than 10	10 Samples
	Edge (End)	Warning	Consider moving farther away from bank	2 Cells
		Warning	Number of start edge samples is less than 10	10 Samples
	Depth Reference	Warning	BT was used as depth reference	
		Warning	VB was used as depth reference	
	Temperature	Warning	Significant change in temperature during transect	2°C
	Width	Warning	Variation in width from the previous transect is more than 5 percent	5%
		Warning	COV of Width is greater than 5 percent	5%
	Area	Warning	Variation in Area from the previous transect is more than 5 percent	5%

Measurement Component	Variable	Action	Message	Criteria
		Warning	COV of Area is greater than 5 percent	5%
	Discharge	Warning	Variation in Total Q from the previous transect is more than 5 percent	5%
		Warning	COV of Total Q is greater than 5 percent	5%
	Measurement Duration	Warning	Total duration of the measurement is less than 720 seconds. Please consider making 2 more transects	720s
GPS	GGA	Counter / Warning	Bad GPS-GGA samples. GPS quality is 0 or 1	
		Counter / Warning	Bad GPS-GGA samples. GPS quality changed from 4 to 2	
		Warning	HDOP is greater than 2	2
		Warning	Change in altitude from the previous sample is greater than 3 m. Check for Multi-Path	3m
	VTG	Counter / Warning	Bad GPS-VTG samples	
		Counter / Warning	Bad GPS-VTG samples. Boat Speed is less than 0.1 m/s	0.1m/s
Post Processing	Composite Tracks	Warning	System was used as track reference	
		Warning	BT was used as track reference	
		Warning	GGA was used as track reference	
		Warning	VTG was used as track reference	
	Depth Reference	Counter / Warning	Samples used substituted depth reference	
	Track Reference	Counter / Warning	Samples used substituted track reference	

Measurement Component	Variable	Action	Message	Criteria
System Operation	Battery Voltage	Warning	Replace Batteries	
	Missing Sample	Counter / Warning	Missing Samples	
		Counter	Start Edge	
		Counter	Transect	
		Counter	End Edge	
		Warning	9 consecutive missing samples. Total discharge will be biased low.	9 Samples
		Matlab Export	No automated Matlab export if missing samples are present	

6.5.6 Profile Plot

The default display shows the SNR profile for each beam for that sample. The parameter plotted and can be changed by [right-clicking](#) on the plot.

6.5.7 Main Data Display

The main data display is the large area of the software where the main data parameters in various forms are plotted. [Right-clicking](#) on plots provides options for configuring the plots.

6.5.8 Data Tabs

Data tabs offer different views of various data during the measurement. They include:

- Smart Page – view Smart Page for current setup parameters and settings
- Samples – tabular view of individual samples
- Edges – tracks, profiles, and contour plots of edge data
- Navigation – view the track(s) in a large plot with a contour plot
- Time Series – view various time series
- Transect – comprehensive view of time series, track, and contour plots

6.5.9 Discharge Summary

The discharge summary is a tool that gives a user a quick view to the files collected during the measurement session. From this display you can get a quick look at statistics and other parameters to make decisions about your data collection. The discharge summary can be shown by using [[CTRL+S](#)], and right-clicking on the header or body of the summary allows the

user to choose what parameters are displayed. See Section 7.12 for details on how to manipulate different functions from within the Discharge Summary.

6.6. Software Tools

The RSQ software provides a variety of tools which the user may need in preparation for a measurement, during data collection, or in post-processing. They can be found by clicking the **Tools** button from the main toolbar (highlighted in Figure 26).

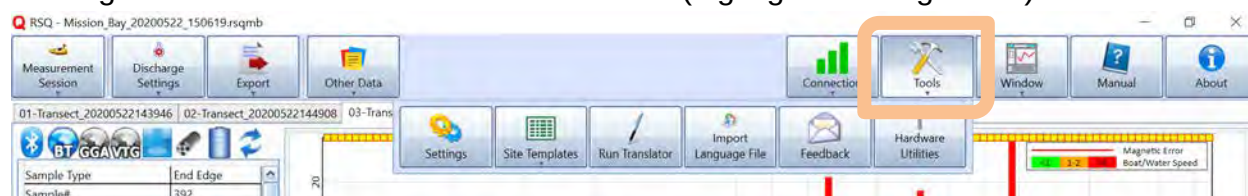


Figure 26. Software Tools From the Main Toolbar

6.6.1 Settings

Various software settings, including file naming, language, how the software displays certain parameters, and units can be configured in the Software Settings. Please refer to Appendix B for a detailed explanation of each setting option.

6.6.2 Site Templates

Site templates can be used to save time when entering setup and configuration information for sites that are frequently measured. Site templates can either be created ahead of time, or saved from an existing Smart Page. To create a new template, click the **Site Templates** button and select the desired measurement type. The example below shows a Moving Boat site template. Click the **New** button to create a new template. A dialog will appear to type a name for your template (see Figure 27), or the user has the option to copy settings from an existing template.

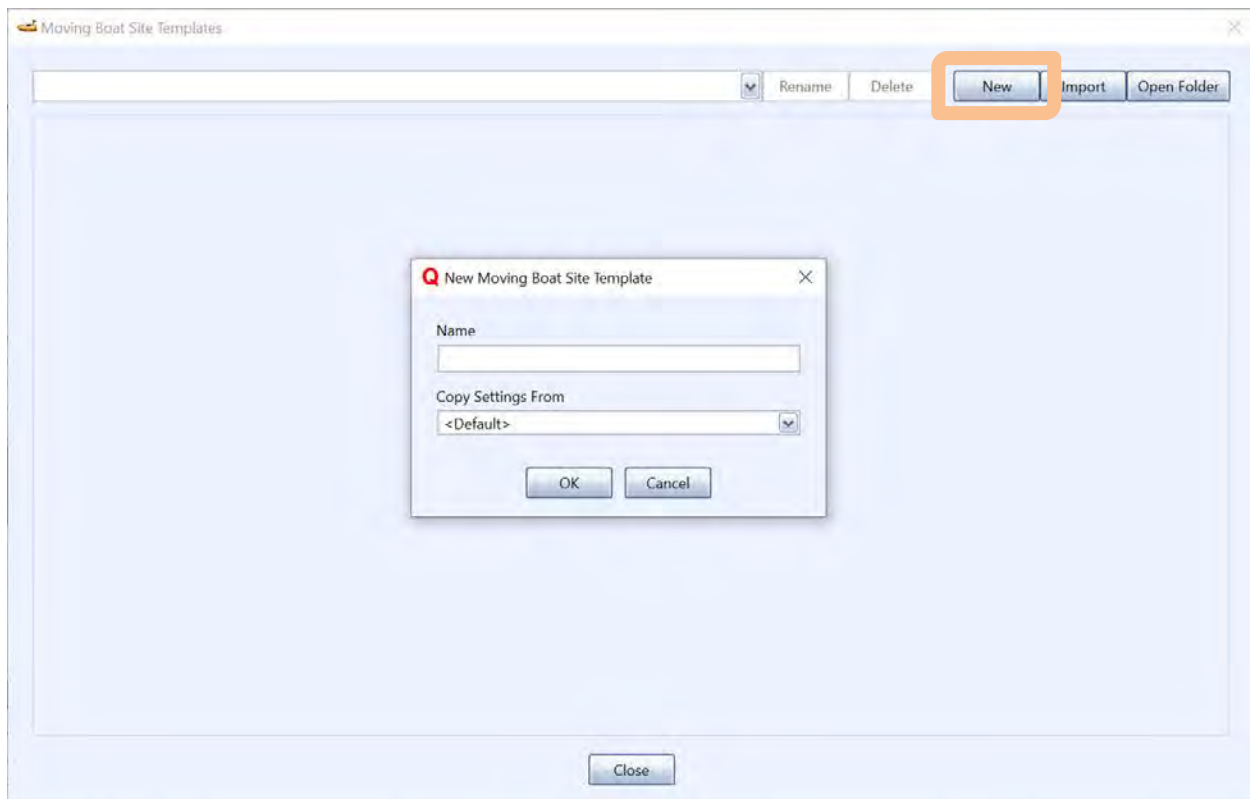


Figure 27. Create a new site template

Clicking **OK** will bring up the Smart Page, where the desired configuration and settings can be entered (Figure 28).

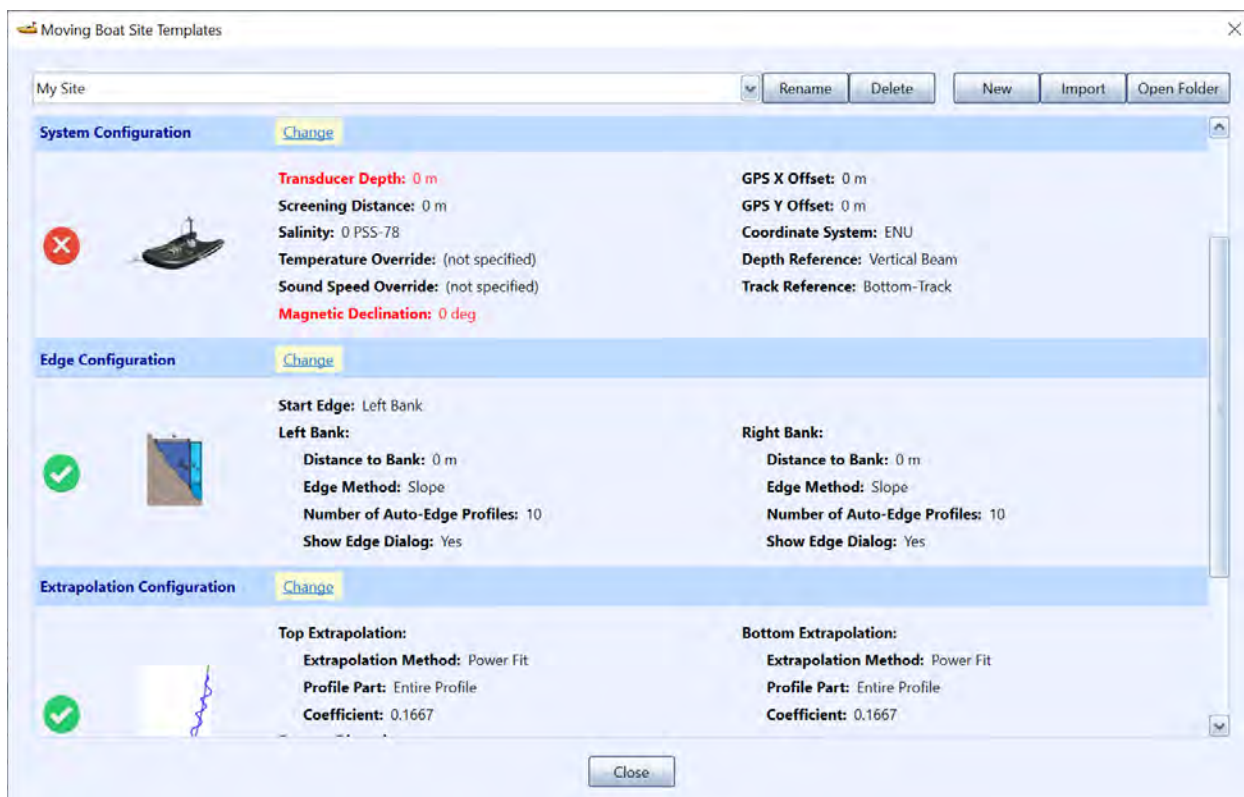


Figure 28. Enter configurations and settings for a site template

Clicking **Close** will save the current template. All templates are saved in a Site Templates folder which can be opened by clicking the **Open Folder** button. The **Rename** button will allow the user to rename the current template, and the **Delete** button will delete the current template. For site templates not saved in the RSQ template folder, use the **Import** button to save the template to the database.

All templates in the appropriate folder will be available to load when starting a measurement from the Smart Page. Details can be found in Section 7.9.

6.6.3 Run Translator

The Translator tool can be used to configure wording displayed in the RSQ software according to localized or agency standards. It can also be used to translate the RSQ software into a language not available in the default language choices (see Appendix B for general language settings).

When the Translator tool is open, the user has the option of configuring individual phrases or words by entering their desired phrase in the “Translated Value” in the right column. Choosing “New from existing” offers the option to start a translation template from an existing language template. The user can then save their new template language file and use it during RSQ operation. To use a custom language file, please see the following section, Section 6.6.4.

RSQ Translator v0.7.7 (2020-06-09): (new file)

New New from existing Open Save Save as Language: Filter: Clear

Id	Original Value	Translated Value
Android_AdcpData_PleaseFinishOrUseTheCancelContextMenuItem	Please complete the measurement. To cancel - please use the context menu.	
Android_Charting_ChartConfiguration	Chart Configuration	
Android_CloseAndReopenThisWindowToSeeExternalChangesApplied	Close and reopen the active window to see any external changes.	
Android_Connect_BluetoothLESupportMissing	BluetoothLE support missing	
Android_ErrorTakingPhoto	Error taking a photo	
Android_HardwareUtilities_ConfigurationSavedTo	Configuration saved to	
Android_HardwareUtilities_UserSuppliedFirmwareOrIniFileInstructions	To provide additional firmware or configuration files, please use one of these two options: 1. Download the firmware (.bin) or configuration (.ini) files using the Chrome web-browser on your mobile device or 2. Download the firmware (.bin) or configuration (.ini) files on your PC and using a USB cable copy the downloaded files to your mobile device under the following folder	
Android_LocationServicesNotEnabled	Location Services are not currently enabled on this device. Please click 'OK' and enable Location Services to be able to continue.	
Android_Main_BackButtonDisabledInSettings	Back button disabled in Settings	
Android_Permissions_RequestToAllow	To be able to function properly, the application requires access to certain Android services like Camera, Bluetooth, File Storage and GPS. Please click OK and allow these services on the next screen or manually open the Android Settings app -> Apps -> click on the application icon -> Permission and enable access to all listed services.	
Android_Settings_DisableBackButtonInMainActivity	Disable Back Button on Main Screen	
Android_Settings_ExpandOnEdit	Expand on Edit	
Android_Settings_ExpandOnView	Expand on View	
Android_Settings_LargeTableDisplay	Large Table Display	
Calibration_CompassCalibrationFailed	Compass calibration failed. No changes were applied. Please try again.	

Figure 29. Run Translator Tool

6.6.4 Import Language File

To import a custom language file (other than the RSQ defaults, described in Appendix B), use the Import Language File tool. The Import tool will prompt the user to locate the desired language file.

6.6.5 Feedback

The built-in feedback tool allows the user to easily open their desired email interface to send an email to support@sontek.com.

6.6.6 Hardware Utilities

The Hardware Utilities tool offers a variety of diagnostic tools and advanced system tools that may be needed, including Beam Check, Compass Calibration, System Test, Terminal Emulator, Firmware Upgrade, Instrument Options, and Load/Save Configuration. Each of these items are described in detail in Appendix C.

6.7. Hot Keys/Accelerators

A list of hot keys/accelerators is provided in Table 4. Hot Keys/Accelerators and provide keyboard shortcuts to speed up measurements in the field.

Table 4. Hot Keys/Accelerators

Keys highlighted in **BLUE** are also available in Data Collection and Post-Processing. Keys highlighted in **ORANGE** are only available in Post-Processing.

Hot Key/Accelerator	Action
F5	Move forward action (refers to active button)
F8	Stop System
CTRL+N	Open connection dialog
CTRL+O	Open file
CTRL+T	Open toolbox
CTRL+S	Show/Hide Discharge Summary
CTRL+F4	Close file when viewing
Z	Zoom in
SHIFT+Z	Zoom out
CTRL+Tab	Move to next tab
Up	Move up samples
Down	Move down samples
CTRL+Up	Move up every 20 samples
CTRL+Down	Move down every 20 samples
CTRL+1	Open Site Information dialog
CTRL+2	Open System Configuration dialog
CTRL+3	Open Edge Configuration dialog
CTRL+4	Open Extrapolation Configuration dialog
CTRL+5	Open Calculation Thresholds dialog

6.8. General Plot/Display Functionality Features

6.8.1 Zoom on Mouse Wheel (Scroll)

Zooming in and out on a plot can be achieved by using the scroll wheel of the user's mouse or the scrolling function of the keypad.

6.8.2 Zoom to all

Right-clicking on a plot gives the user the ability to 'Zoom to all' which automatically sets the axes so that all data are displayed.

6.8.3 Right-Click on Plots and Tables

Generally, **right-clicking** on plots or tables in the software will bring up various viewing parameters for the data displayed.

6.8.4 Double-Click on Axis Labels

Double-clicking on axis labels on plots will bring up the ability to set limits for that axis manually or choose to display the limits automatically.

6.8.5 Double-Click on Legend

Double-clicking on a legend allows the user to manually change the limits of the colors plotted.

6.8.6 Copy to Clipboard

Generally, **right-clicking** on plots or tables in the software will bring up the ability to copy the plot or table to the clipboard in your laptop to paste onto a separate document.

6.8.7 Change Horizontal Axis

Generally, **right-clicking** on plots or tables in the software will bring up various choices for the horizontal axis.

6.8.8 Remember Axis Setting for Next Time RSQ Opens

The RSQ software settings will be stored and when newly opened, will display with the same settings that existed from the last software close.

Section 7. Collecting a Measurement – Moving Boat

This section is a general guide to prepare for and conduct discharge measurements in the field. The information presented here will discuss pre-measurement tests as well as the general procedure for making a discharge measurement. Please note that guidelines for Acoustic Doppler discharge measurements vary among agencies and countries.

7.1. Moving Boat Discharge Measurement Principles

Total discharge is the volume of water moving past a known point per unit time. In open channels, discharge (Q) is computed as water velocity (V) multiplied by the cross-sectional area of the channel (A):

$$Q = V * A$$

The RS5 can be used following the moving boat methodology in which the RS5 is mounted on boat (or floating platform) with the transducers pointed downward into the water column and then moved laterally across the channel from edge to edge. A single discharge measurement can be broken into three key components: the start edge, transect, and end edge (Figure 30).

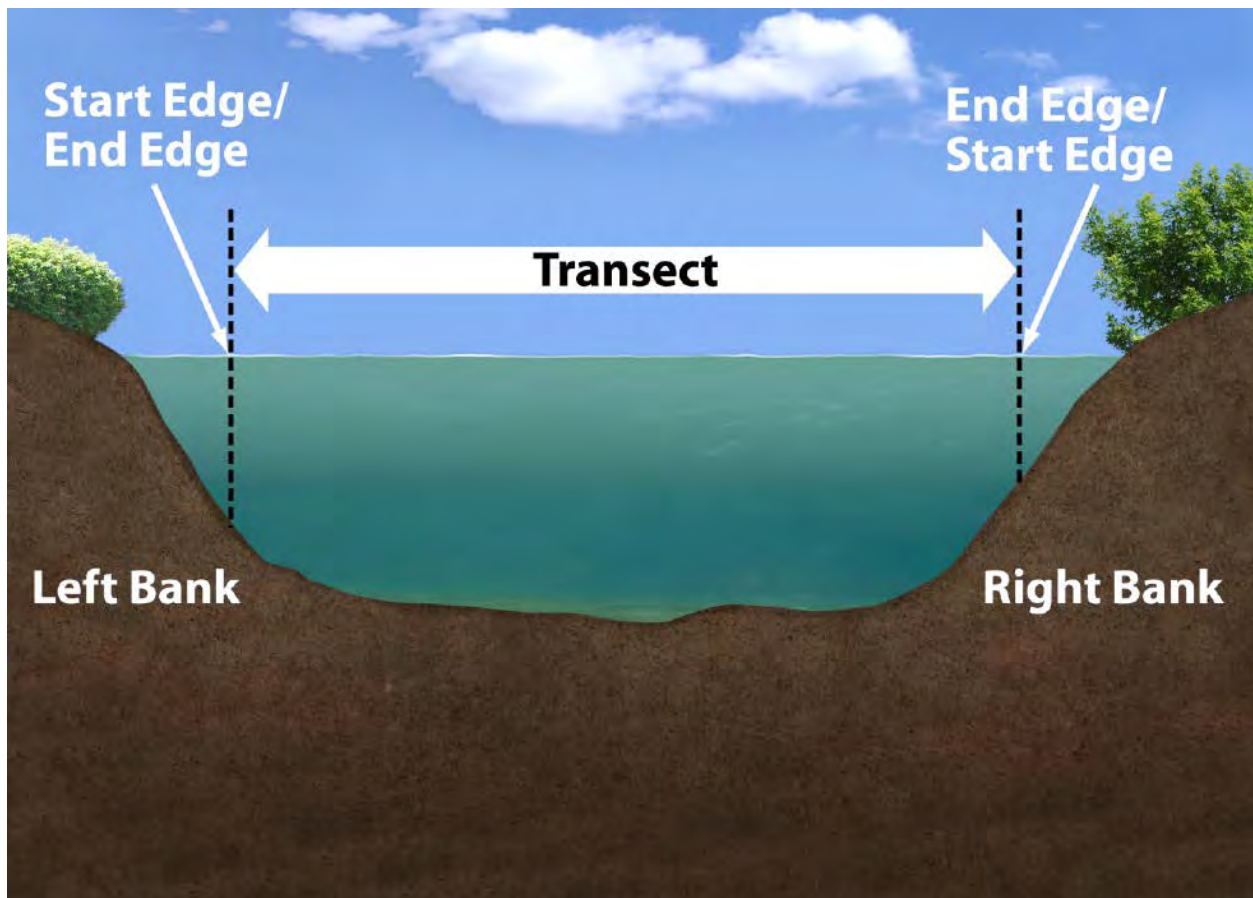


Figure 30. A Measurement Section Break Down

The middle area of the transect is measured by the RS5. The top and bottom areas are estimated by various means of extrapolation, and the edge areas are estimated by an average measurement. This further division of regions is shown in Figure 31.

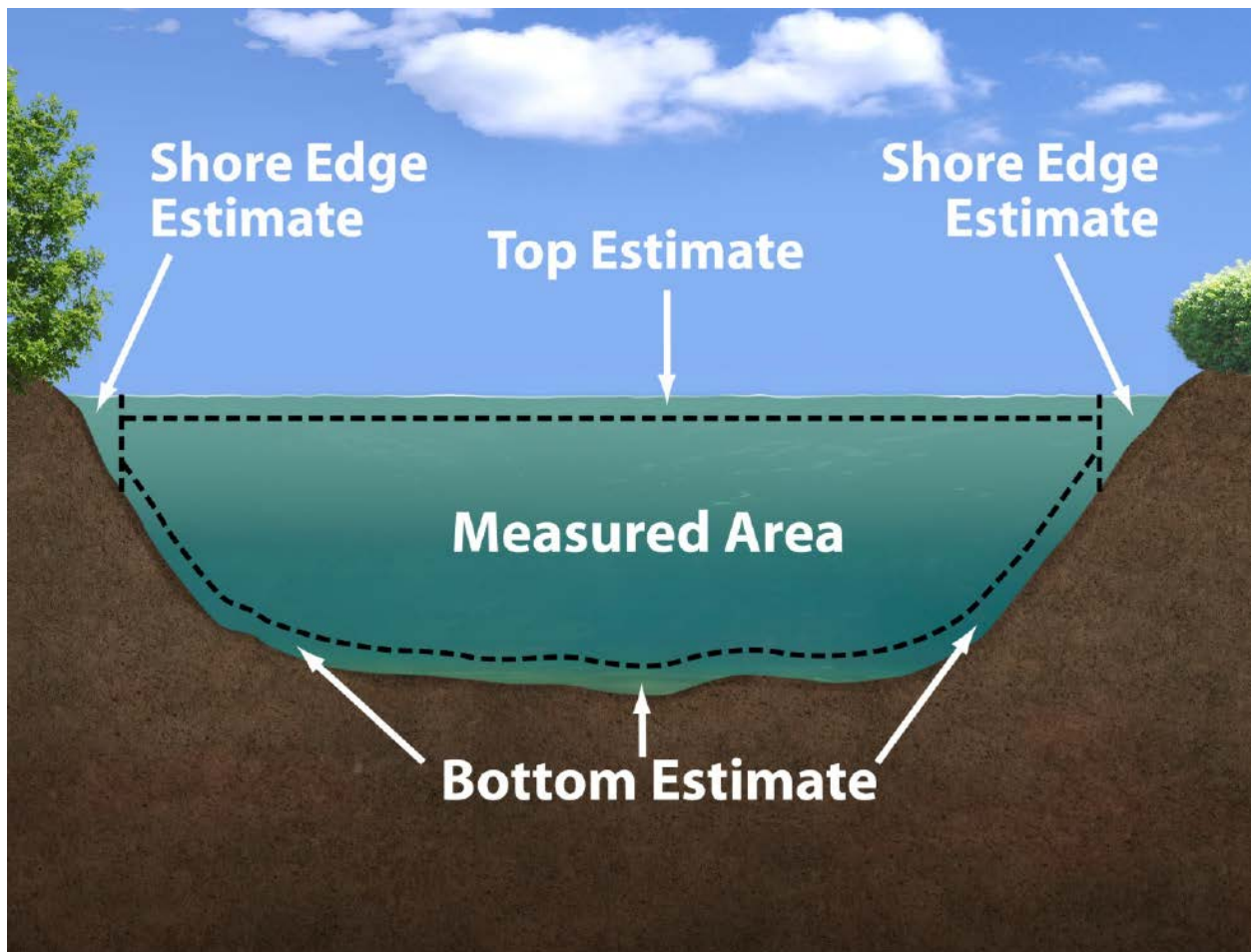


Figure 31. Measured Areas Versus Top/Bottom Estimates

Discharge is calculated by summing the edge, measured, and estimated areas. Only the measured area and edge estimates are measured by the acoustic Doppler profiler. The top and bottom regions are determined using industry-standard calculations for extrapolation.

The reasons for dividing the discharge calculation into components result from the inherent limitations of all acoustic Doppler profilers, and include:

- The profiler has a minimum operating depth. At depths lower than this minimum, the water velocity and therefore the discharge must be estimated based on the velocity and depth measurements on the edges. The Start and End Edges are measured in this way.
- The mounting depth plus a short distance (referred to as the blanking distance) from the profiler to the start of the measured velocity profile leave a section of the water at the surface unmeasured. This area is referred to as the Top Estimate.
- Potential data contamination in the last cell (i.e., the cell is partially or fully “touching” the riverbed), or potential side-lobe interference at the end of the profile, leaves a section of water at the bottom unmeasured. This area is referred to as the Bottom Estimate.

Velocity Profile Extrapolation is used to estimate the unmeasured areas at the top and bottom of the water column. The standard method uses a power law velocity profile proposed by Simpson and Oltmann (1990) and Chen (1991) to calculate velocities above and below the measured area according to Equation 1:

$$\frac{u}{u_*} = 9.5 \bullet \left(\frac{z}{z_0} \right)^b$$

Equation 1. Velocity Profile Power Law

where u is the velocity at height z measured from the river bottom, u_* is the bottom shear velocity, z_0 is the bottom roughness height, and b is a constant, typically 1/6 (Chen, 1991).

Use of this equation assumes that flow is moving in approximately the same direction. In situations where this may not be the case, (e.g., stratified or multi-directional flow), one of the other extrapolation methods, available in the RSQ software should be used. By default, the RSQ software uses the “1/6th power law velocity profile” (described above) using the measured velocity profile to calculate velocities in the top and bottom unmeasured areas.

The portion of discharge in the start and end edges is calculated from a mean velocity profile measured at the edge locations by maintaining a (relatively) fixed position at each edge. The discharge calculation at the edge is based on the selection of a constant sloped bank or vertical wall and uses a combination of the mean depth and velocity profile at each edge.

In the transect, discharge is calculated from multiple samples of the depth, distance traveled across the transect, and velocity of the water column. During collection of transect data, the system automatically compensates for changes in the vessel course and speed.

Finally, total discharge is the sum of the transect discharge, the edge discharge, and the top and bottom estimates. The RSQ software processing will perform these calculations automatically and guide the user through the discharge measurement process.

7.2. Starting the System

To start the system, please refer to Section 5 on how to power on the RS5 and all of its components before attempting to connect to the system.

7.3. Connecting to the System

RSQ offers a few different choices for connecting to an RS5 system. To open the Connect dialog, click the **Connect** button from the Main Toolbar. Please ensure that your RS5 system is powered on, and the Bluetooth USB dongle is inserted into your laptop. The Connect dialog is shown in Figure 32.

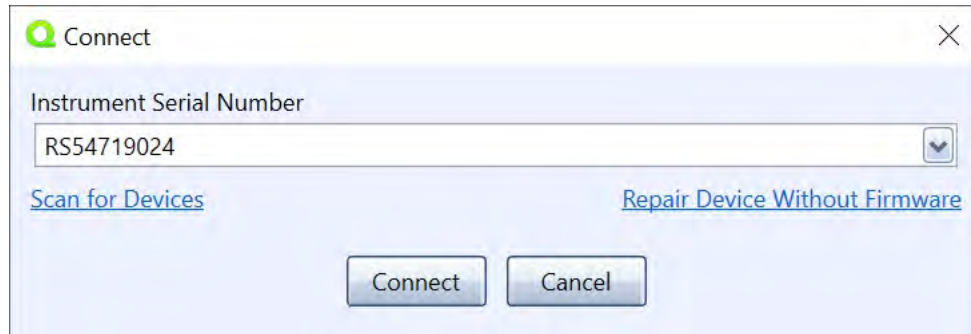


Figure 32. Default Connection Window

If the 'Allow Simulated Connections' function is enabled in the software settings, then the user must ensure that the Connection Type is SonTek BLE Dongle. See Appendix B for information about Simulated Connections.

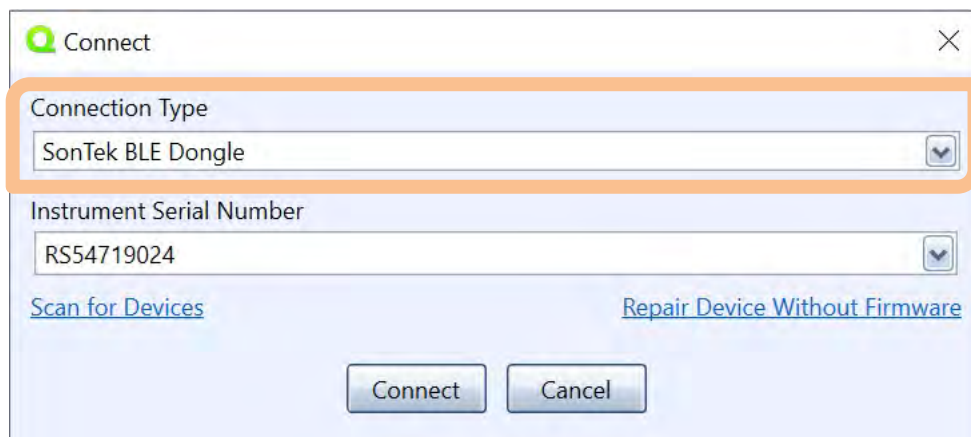


Figure 33. Connection Type: SonTek BLE Dongle

7.3.1 Automatic Device Scanning

Choosing Scan for Devices from the Connect dialog (highlighted in Figure 34) brings up a list of active RS5 systems that are within detection range of the Bluetooth dongle.

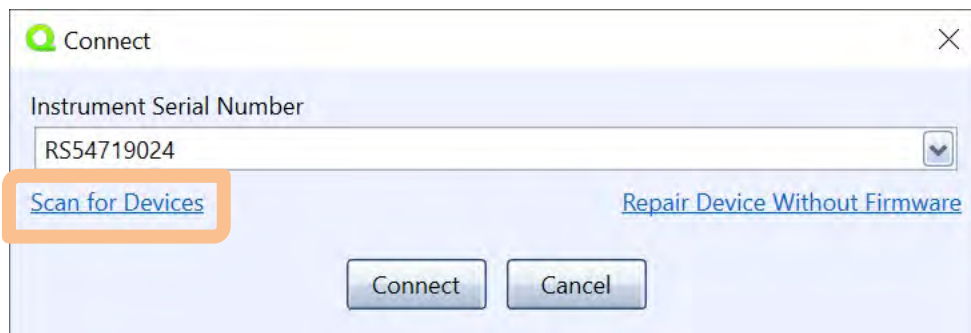


Figure 34. Scan for Devices

From the list of devices, **double-click** on the desired serial number to connect (shown in Figure 35).

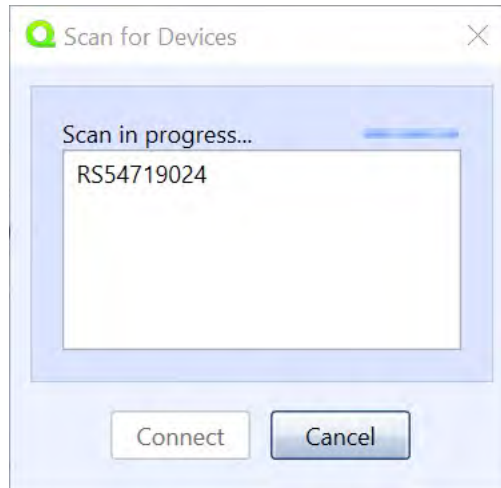


Figure 35. Double-Click on the Serial Number to Connect

Updates on the connection progress will appear in the Connect dialog, as shown in Figure 36. Any connection errors or failures will also appear in this screen.



Figure 36. Connection Progress

7.3.2 Manual Device Connection (serial number)

To manually connect to an RS5 from the Connect dialog, simply type in the serial number (in the format RS5#####) in the space highlighted in Figure 37.

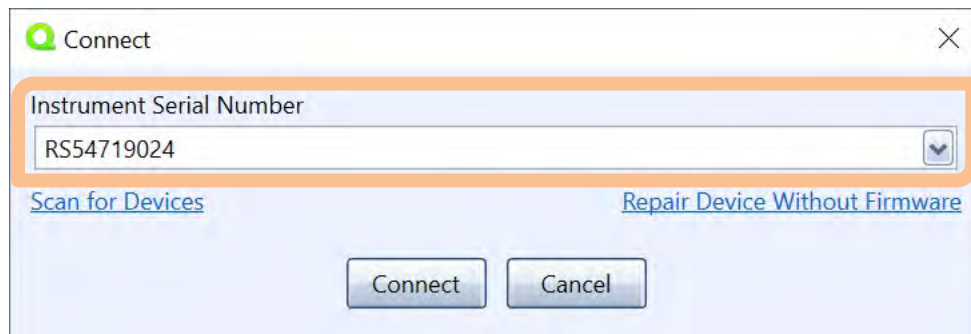


Figure 37. Connect to Instrument via Serial Number

The same connection progress messages will appear as shown in Figure 36.

7.3.3 Manual Device Connection for Windows 7 (COM port selection)

For users operating computers on Windows 7, a manual COM port option will appear in the Connection dialog, shown in Figure 38.

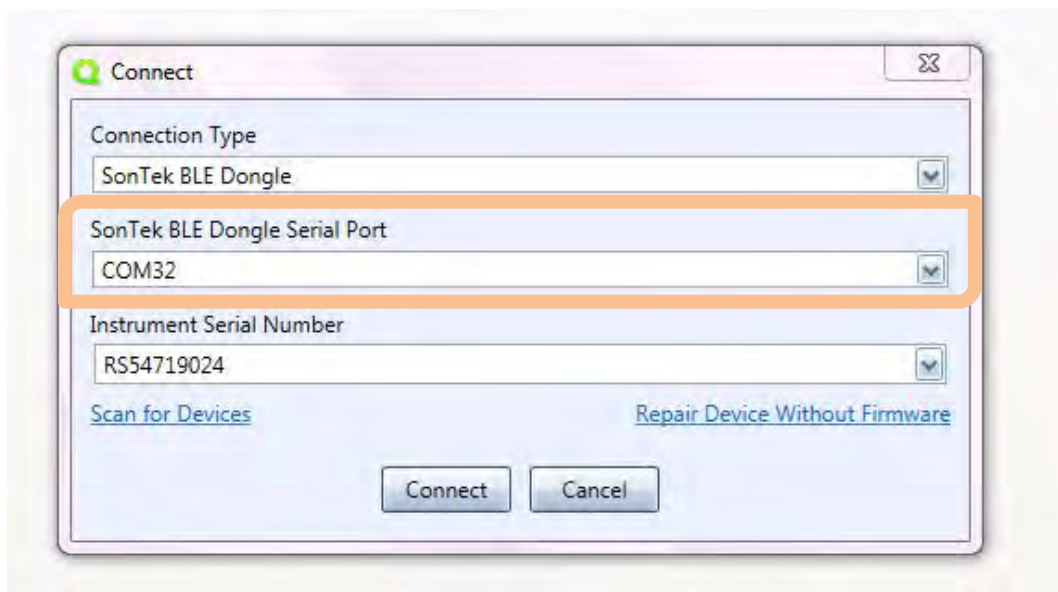


Figure 38. Connection Dialog for Windows 7

The user must ensure that the COM number appearing in the Device Manager for SonTek BLE (see Figure 39) matches the COM number indicated in the serial port dialog highlighted in Figure 38. Note: the COM port numbers in Figure 32 and 33 do not match.

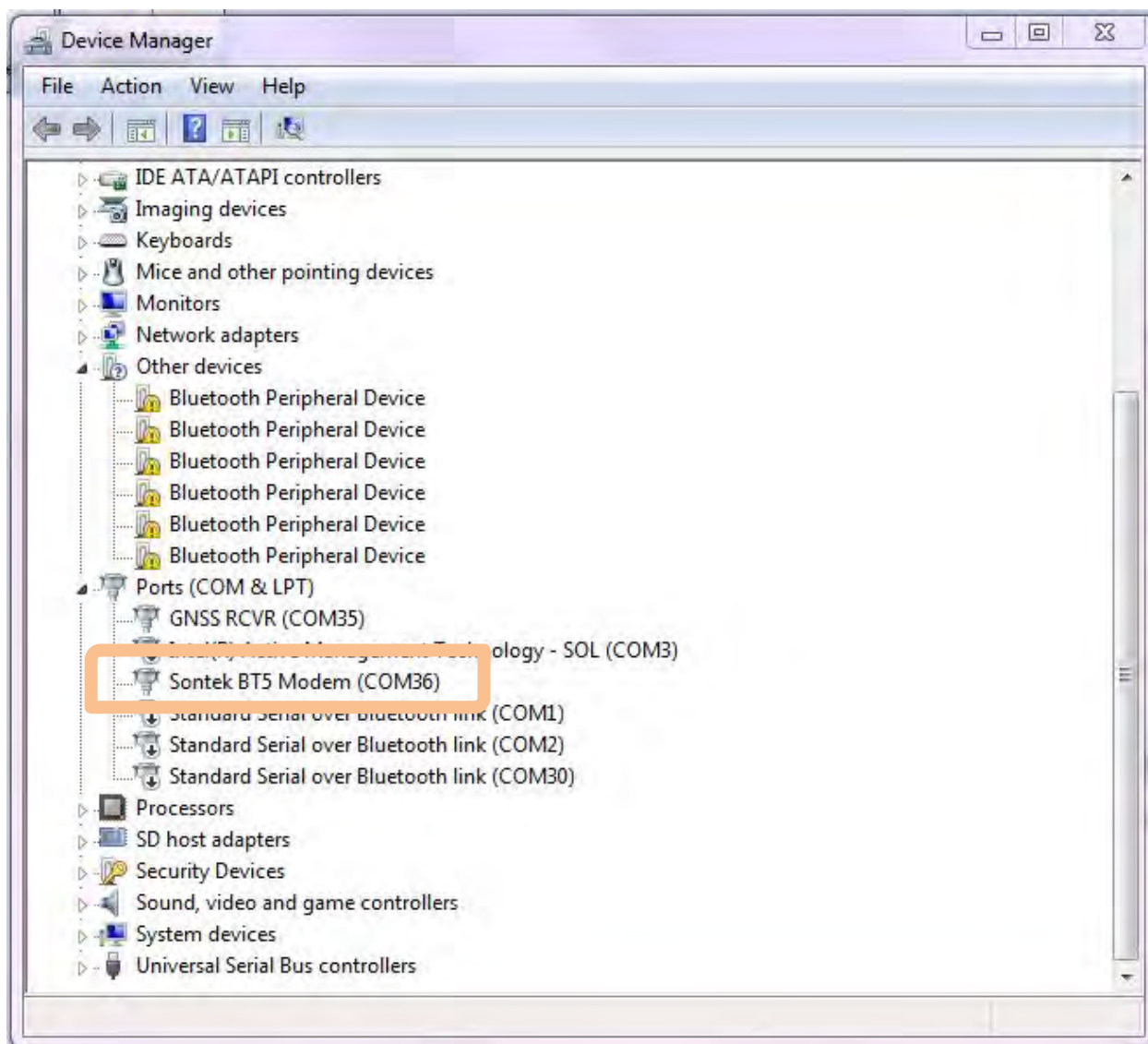


Figure 39. Device Manager

7.3.4 Connection Status

The status of the connection is indicated by the icon on the Connect button. Table 5 shows the various connection status icons and their associated meanings.

Table 5. Connection Status Icons

Icon	Status
	Excellent (>-70 dBm)

	Good (-70 to -85 dBm)
	Poor (<-85 dBm)
	Attempting to reconnect
	Disconnected

Details on the connection can be viewed by clicking the **Connect** button, as shown in Figure 40. Clicking the **Connect** button while connected also offers the option to Disconnect.



Figure 40. Connection Details

Typically, RSSI values will range from -20 dBm (maximum) to -85 dBm (minimum) for the most reliable connection. As RSSI decreases, chances of dropping communications increases.

The RS5 system employs a data buffer where data will be recovered by the software if a connection is lost and reconnected within 5 minutes during data sampling. More details on the data buffer can be found in the RS5 Technical Manual (coming soon).

7.3.5 Repair Device without Firmware

Certain situations could require forcing the system to load new firmware without accessing the current firmware on the RS5. Please contact SonTek Technical Support

(support@sontek.com) before using this option. This can be done through the Repair Device Without Firmware feature from the Connect dialog, highlighted in Figure 41.

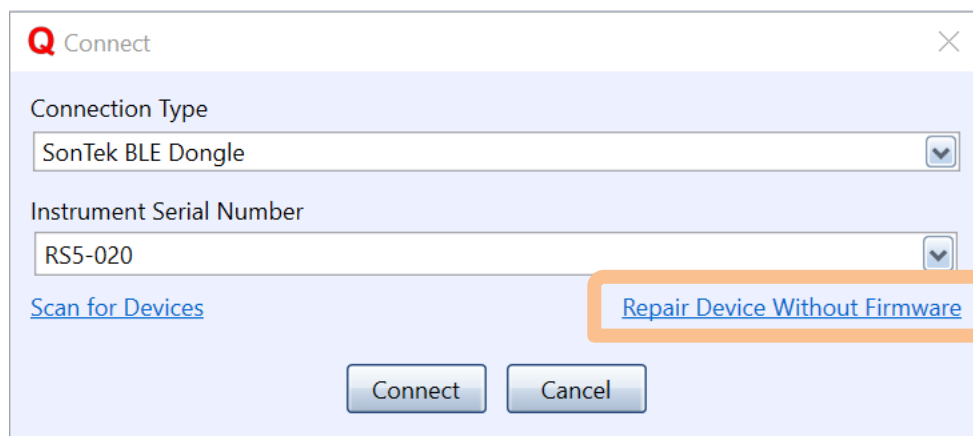


Figure 41. Repair Device Without Firmware

The Repair Device Without Firmware dialog (Figure 42) will prompt the user for the instrument serial number and the firmware file the user wishes to use. Please select the appropriate file and click **OK**.

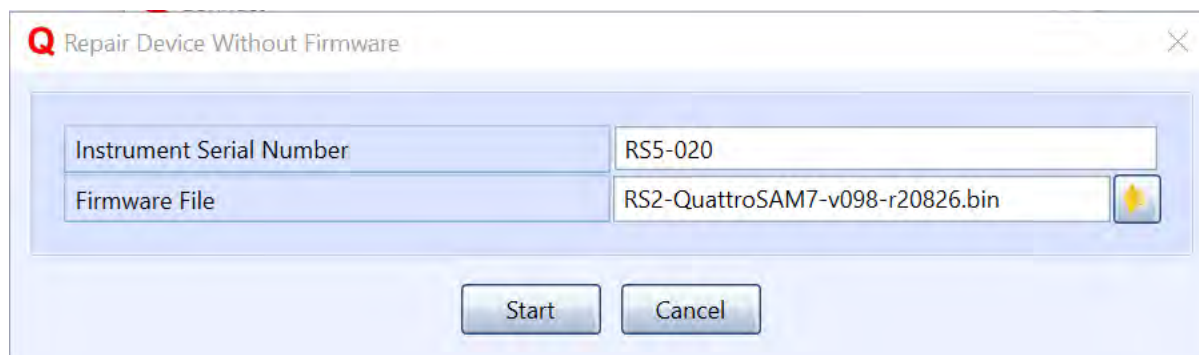


Figure 42. Repair Device Without Firmware Dialog

The software will prompt the user to power cycle the RS5 system. Be sure to click **Continue** before powering on the system.



Figure 43. Repair Device Without Firmware Prompt to Power Cycle

The new firmware will then be loaded onto the system.

7.4. Starting a Moving Boat Measurement

Once the RS5 is connected in the RSQ software, click the **New Data Collection** button (Figure 44). Click the **Moving Boat** button. The Stationary option will be coming soon.



Figure 44. New Data Collection

7.5. Smart Page (Pre-measurement Setup Checklist)

The RSQ Smart Page (top portion shown in Figure 45) is the landing page where a measurement starts. It guides the user through the proper steps for pre-measurement tests and setup that should occur prior to each discharge measurement to ensure both the functionality of the RS5 hardware for proper data collection as well as proper configuration of setup parameters. Each section is described in detail in the following sections.



Figure 45. Smart Page

In general, sections with a red X must be addressed before starting a new measurement. Sections with a green check mark indicate those items are ready for a measurement to begin. Aside from the System Test and Compass Calibration, entries in the Smart Page can be changed in Post-processing (see Section 8).

7.5.1 System Information

The System Information section (Figure 46) lists the information for the RS5 instrument currently connected, including the type of instrument (RS5), Serial Number, Firmware Version, and the current RSQ software version used.



Figure 46. Smart Page: System Information

The System Information section is also where the user can load an existing template by clicking the Load Template link (highlighted in Figure 46). Once selected (Figure 47), the user can use the drop-down menu at the top of the dialog to select an existing template. The selected template will appear in the dialog to guide the user. Click **Select** to choose the active template.



Figure 47. Load Template Dialog

From the System Information section, the user also has the option to save their existing Smart Page settings to a template by clicking the [Save as Template](#) link.

7.5.2 System Test

A system test should be done prior to each discharge measurement to ensure the functionality of the RS5 hardware for proper data collection. It verifies the battery voltage, compass, and temperature sensor are all functioning properly. A system pass would indicate that the RS5 is ready for a measurement, while a fail would require user action in order to conduct reliable discharge measurements.

To run a System Test, click the Run New Test link (highlighted in Figure 48) in the System Test section.

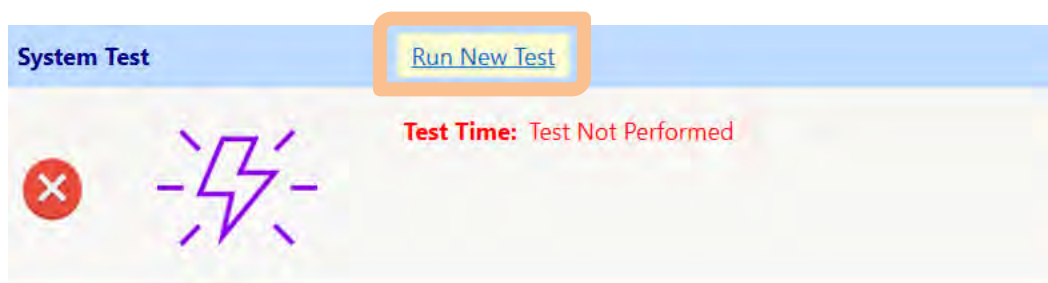


Figure 48. System Test

The test typically takes 12.5 seconds and will present a dialog window indicating a system test Pass or Fail (Figure 49). If the System Test fails, the reason for the failure will be displayed. A failure indicates that user action is required to ensure proper functionality of the system.

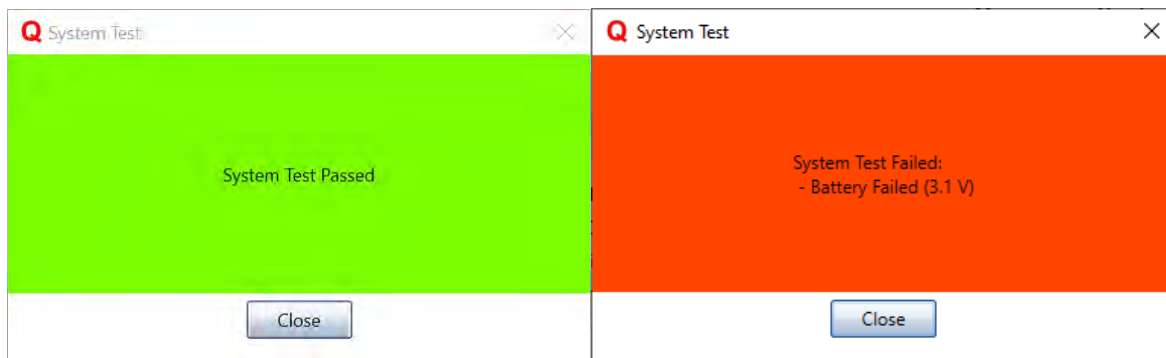


Figure 49. System Test Pass (left) and System Test Fail (right)

Once the connected RS5 system passes the System Test, the System Test section will have a green check mark, and the time at which the last System Test was performed will be indicated.

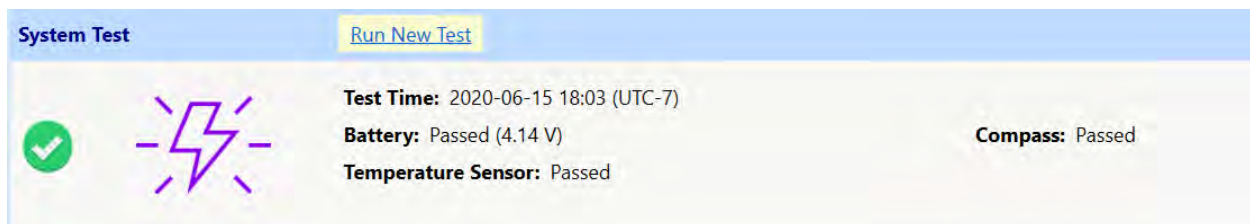


Figure 50. System Test Section After Pass

7.5.3 Site Information

The Site Information section (Figure 51) contains user-input information about the site and the operator for the measurement.

Site information includes:

- Site name
- Station number
- Location
- Operator
- Vessel
- Measurement number
- Gauge Height Information
- Comments

To change the Site Information entries, click the Change link, highlighted in Figure 51

Site Information

Change

Site Name:

Station Number: asdf

Location:

Operator:

Vessel:

Measurement Number:

Gage Height Info:

Comments:

Figure 51. Site Information

7.5.4 Compass Calibration

When making a discharge measurement using the RS5, the system's internal compass is used to provide the instrument's heading as it moves across the channel. The RS5 internal (magnetic) compass must be calibrated prior to data collection. Users familiar with the M9/S5 compass calibration will recognize the steps outlined below, as the procedure for calibrating the compass for those systems is the same as for the RS5.

A proper user-performed compass calibration at the field measurement site prior to collecting data is a critical step for avoiding heading errors during the measurement, as the compass calibration is used to compensate for localized magnetic interference in the vicinity of the instrument. If heading errors are observed during the measurement, then a review should be performed of the methodology used for the compass calibration, and of the local surroundings where the calibration was performed for potential sources of magnetic interference, in order to locate the cause(s) of the heading errors.

A primary consideration is that the internal (magnetic) compass calibration is designed to be representative of the conditions that will be experienced during the actual measurement. When calibrating the compass, the RS5 should be rotated through two complete circles while varying the pitch and roll smoothly through the greatest tilt angles possible and practical. The keys to a proper compass calibration are slow rotations in a relatively low magnetic field, using pitch and roll angles similar to what will be experienced on the boat or floating platform during the actual data collection. For example, if the measurement will be performed at a site with flat surface water conditions, then a compass calibration using smaller pitch and roll angles may be sufficient (but NOT totally flat). However, if the boat or floating platform will be experiencing large pitch and roll angles during the measurement, then the calibration needs to be performed using large pitch and roll angles during the rotations. If smaller pitch and roll angles are used during the compass calibration procedure than what will be experienced during the actual measurement, there will be the potential for significant heading errors. Conversely, calibrating the compass using significantly large pitch and roll angles and then making the actual measurement where very small pitch and roll angles will be experienced could also lead to heading errors.

In addition, the pitch and roll angles applied during the calibration should be done at a relatively slow rate (such as what one might use when operating/panning a video camera). Varying the pitch and roll angles too quickly or erratically will cause the RS5's internal accelerometers to report unrealistic heading values for a given calibration point, resulting in significant calibration errors.

It is important that the compass calibration be performed in the same environment as where the actual measurement will be performed. For example, it is not adequate to perform a calibration in a parking lot far from the water's edge, or on a concrete bridge deck far above the water surface, etc. In addition, prior to the calibration it is important to look around to ensure that there are not any sources of magnetic interference in the area where the compass calibration will be performed. Potential sources of interference include large ferrous metal objects, metal hulled vessels, concrete structures with rebar, power transmission lines, automobiles, etc.

Warning: A new compass calibration MUST be performed each time the battery is changed in the RS5!

Compass Calibration Steps:

1. Prior to the calibration, all magnetic material or sources of interference should be removed from the immediate vicinity, such as cell phones/mobile electronic devices, wristwatches, keys, hand tools, etc.
2. If the RS5 will be mounted on a floating platform, the compass calibration must be performed with the system installed on the platform along with the other components. If the RS5 will be used from a manned boat, the compass calibration must be performed using the entire boat with the RS5 mounted in the exact place and orientation in which it will be used during the actual measurement. Everything that will be physically attached to the RS5 system during the actual measurement must be treated as part of the system and therefore rotated along with the RS5.
3. The RS5 internally stores the results (not raw data) from the last good compass calibration and if it exists on the system, its information will be displayed in the Compass Calibration section.

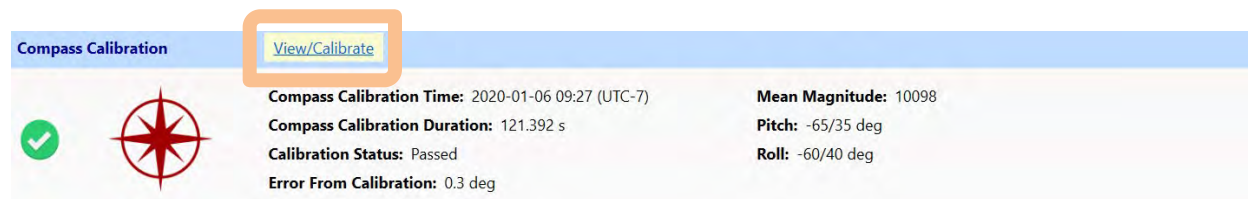


Figure 52. Compass Calibration

To begin a Compass Calibration, click the View/Calibrate link (highlighted in Figure 52) in the Compass Calibration section of the Smart Page. The Compass Calibration dialog will appear (Figure 53). The results from the last good calibration will be displayed.

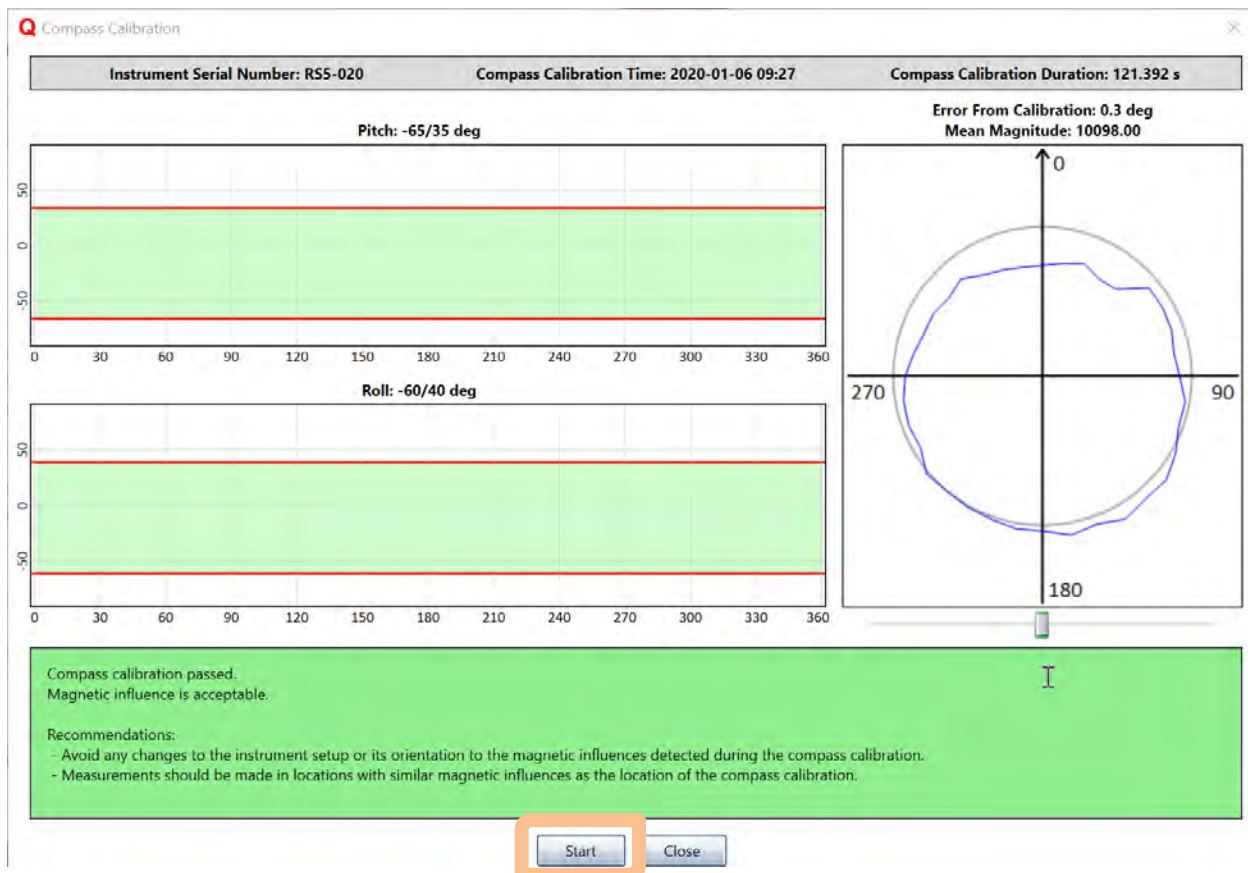


Figure 53. Compass Calibration Dialog

- To begin a Compass Calibration, press the Start button, highlighted in Figure 53. Once the calibration begins, the dialog will provide real-time feedback on the heading (x-axis), pitch, and roll, shown in Figure 54.
- The pitch and roll angles should be varied during the rotations. For the best calibration results, the angles used should be similar to what will be experienced during the measurement transects. When making a measurement, it is important to keep in mind that the calibration will only be valid over the same pitch and roll angles experienced during the compass calibration procedure. **It is critical that the variation in pitch and roll be done SLOWLY. The internal compass uses accelerometers (similar to those used in modern video-game consoles) and as such can generate erroneous tilt angles should the system's tilt be varied too fast during the calibration routine. A typical rate is about 2-3 seconds to go from one tilt limit (e.g. high positive roll) to another (e.g. high negative roll).**

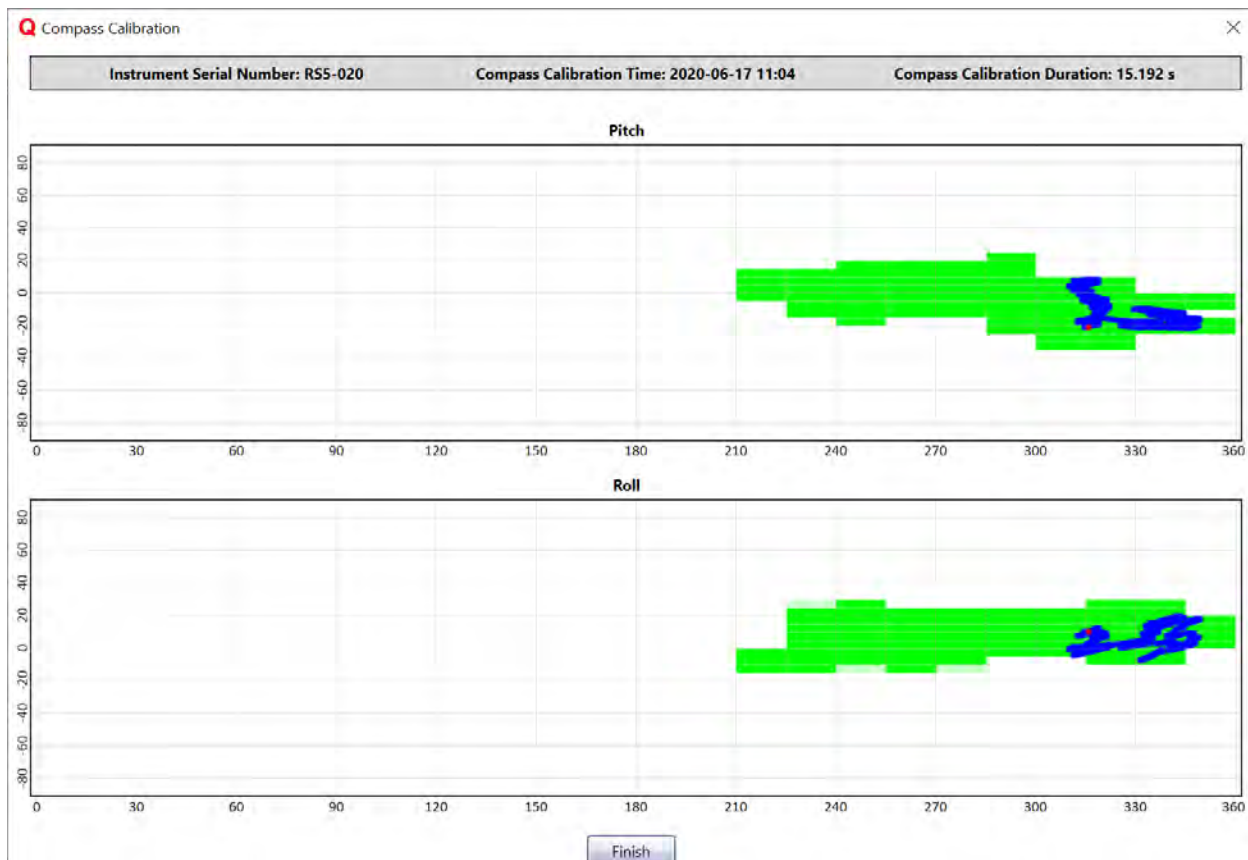


Figure 54. Compass Calibration Procedure

6. The RS5 and boat/floating platform should be rotated through two complete circles, taking 60 seconds for each rotation. The RSQ software will limit the calibration routine to a maximum of 120 seconds, so the operator should try to perform one rotation per minute. The duration of the calibration is shown in the top right corner of the calibration screen. Once done, press **Finish** at the bottom of the dialog.
7. Once finished, the calibration results will be displayed. Figure 53 shows an example of a passed compass calibration, whereas Figure 55 shows an example of a failed compass calibration. If failed, the user has the option to choose to save the calibration to the system. Under normal circumstances, it is best to avoid saving a failed calibration to the system and to restart the calibration. Compass calibration failures can be caused by a variety of factors, and the following two parameters (both highlighted in Figure 55) can be used to diagnose the failure:
 - **Error from Calibration (degrees)** - a statistical measure of calibration quality. Lower values correspond to lower error and vice-versa. Compass calibration errors larger than **0.5 degrees** will produce a failed compass calibration.

- Mean Magnitude** - This is the mean value of the magnetic field measured during calibration. The units are internal to the compass itself and values are unique to instrument and location at time of calibration. For 3D calibrations (including pitch/roll), this value depends on the magnetic field strength both from the instrument and from the surrounding environment. Values resulting from two consecutive RS5 calibrations should be about the same. If a user deploys an RS5 at same site every week, s/he should see about the same mean magnitude each time. If the value substantially changes, sources of magnetic interference should be investigated.

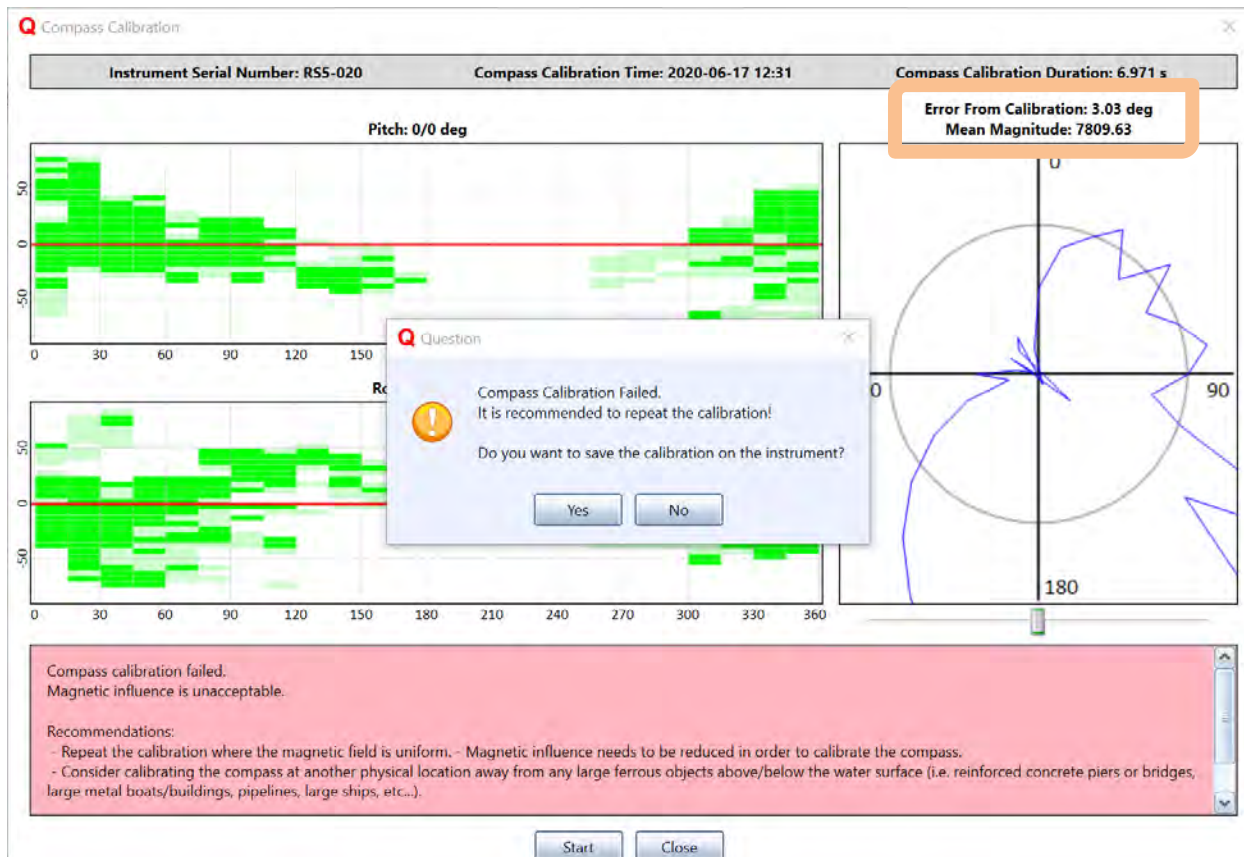


Figure 55. Compass Calibration Fail

- After a passed calibration, there must not be any changes made to the position of engines or mounts, or any other metal components on the boat, such as toolboxes, electronic devices, etc, when taking the actual measurement. If any position changes are made, the compass calibration should be repeated so that the system can account for the new, current, magnetic field affects prior to proceeding with the measurement.

7.5.5 System Configuration

System configuration settings are specific to each measurement, location, and hardware setup. Information is entered by clicking the Change link highlighted in Figure 56.

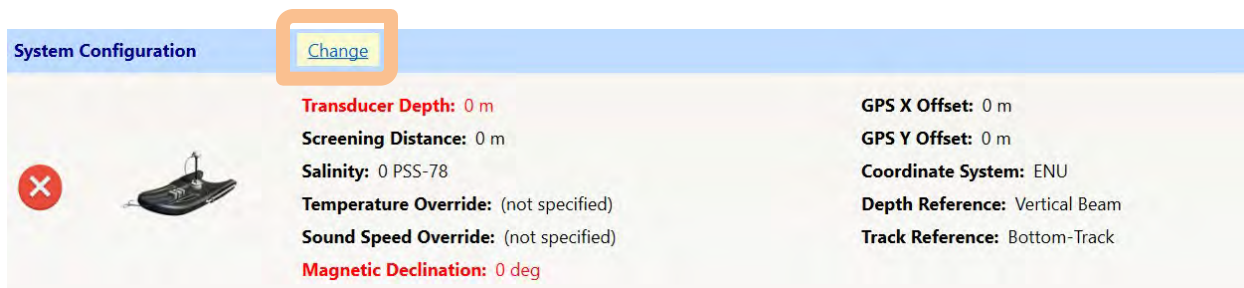


Figure 56. System Configuration

A dialog will pop up allowing the user to enter various configuration parameters (see Figure 57). These items must be entered with care, as they directly affect the final discharge calculations.

Figure 57. System Configuration Dialog

If the System Configuration section has not been completed, a red X will remain visible in that section. The Transducer Depth and Magnetic Declination fields are highlighted in red if not completed – if they are not completed, the user will receive multiple QA/QC warnings associated with these values. If values are not known before beginning the measurement, they can be entered as “0” as long as the user is aware that their

discharge calculations will be affected in the field. These values can then be modified in post-processing. Each setting in the System Configuration is described in detail in the following sections.

7.5.5.1 Transducer Depth

Transducer depth is the distance that the vertical beam transducer is submerged below the water surface. Figure 58 shows a basic diagram that depicts an ADP's transducer face submerged in water. Transducer depth corresponds to the depth of water that the transducer face is submerged.

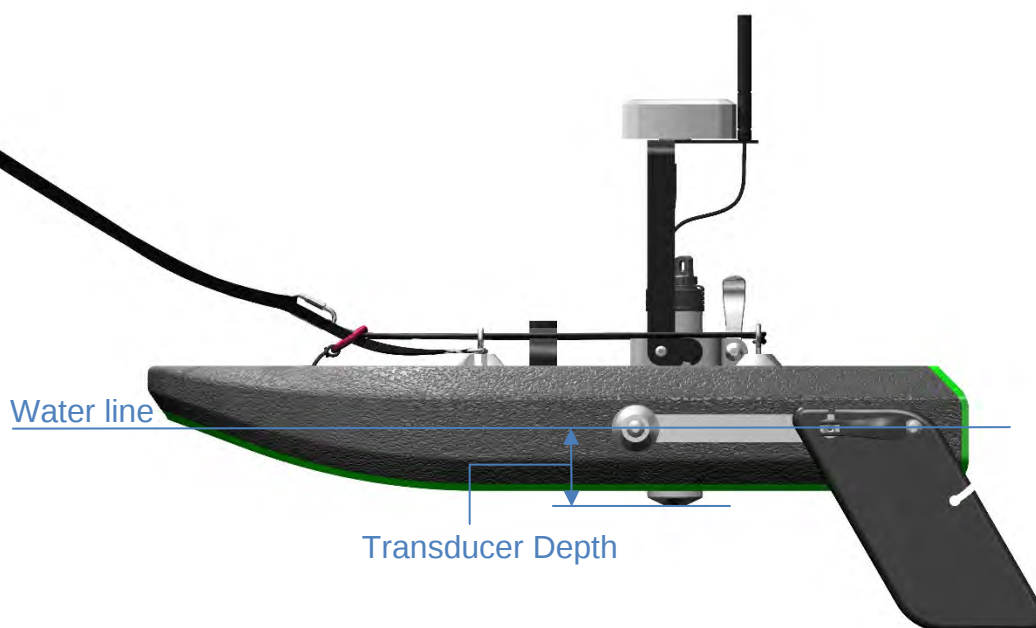


Figure 58. Transducer Depth

7.5.5.2 Screening Distance

Screening distance is the distance below the ADP face at which the user wishes to begin the velocity profile rather than using the default setting of the instrument. This is primarily used for boat mounted applications where the screening distance can be set to avoid flow disturbance from the wake of the boat. An accurate Transducer Depth is required, and the final depth for the instrument to begin profiling is:

$$\text{Profile Starting Depth} = \text{Transducer Depth} + \text{Screening Distance}$$

7.5.5.3 GPS X/Y Offset

When the RS5 is mounted on the Hydroboard II-Micro (described in Section 3.4), the GNSS/GPS antenna is located directly above the RS5 system. In the case where the antenna is not located directly above the RS5, a GPS X/Y offset must be entered to ensure proper location of the track with respect to the instrument and the site geometry.

The GPS antenna is often forced to be mounted off-center when using a manned boat. The X and Y axis definitions are shown in Figure 59.

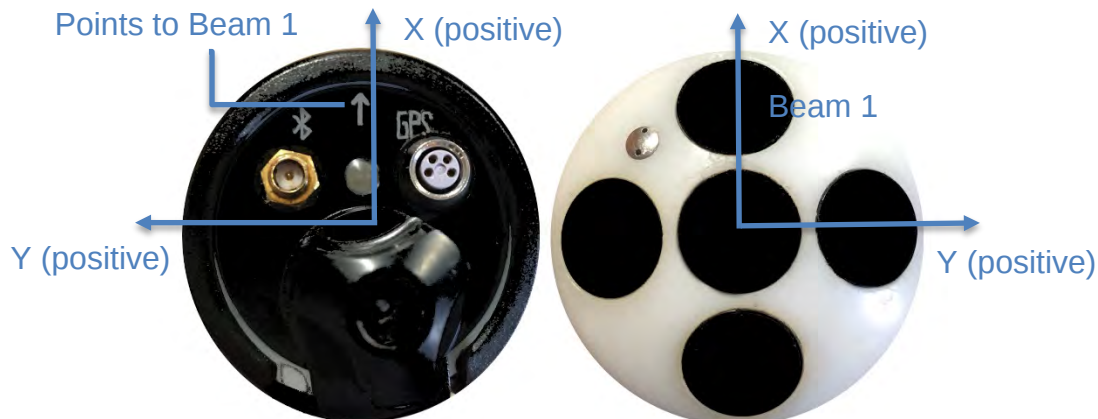


Figure 59. GPS X/Y Offset Axis Definition

7.5.5.4 Salinity

Salinity (PSS-78) generally refers to the concentration of the minerals dissolved in water.

Typical values include:

- 0-0.5 (freshwater)
- 0.5-30 (brackish)
- 30-50 (saline water, typical for large inland seas and oceans, with average ocean salinity at 35)
- >50 (brine – not advised for ADP measurement)

Salinity affects the speed of sound in water; high salinity values increase the speed of sound. Manual entry of an accurate salinity value enables correction of the speed of sound in water which is required for the velocity calculation. Because speed of sound corrections using the PSS-78 convention are only valid up to 42, a maximum salinity of 42 is allowed in the RSQ software. It is not recommended to collect ADP measurements in brine water that has a higher salinity. Corrections are recommended in any aquatic environment not considered freshwater. Reference values can be obtained from published sources or determined in situ with an appropriate meter.

7.5.5.5 Temperature Override

Temperature affects the speed of sound in water in a similar way as salinity: an increase in temperature increase the speed of sound. The RS5 is equipped with a temperature sensor built into the transducer housing. The system is designed to automatically calculate the velocity with the measured temperature. In the case where the user wishes to use an external temperature measurement, the temperature can be

entered in the Temperature Override variable, which will be used over the measured temperature.

7.5.5.6 Sound Speed Override

As with the Temperature Override feature, the sound speed measured by an external measurement can be entered here to override the automatic calculation using the measured temperature by the RS5.

7.5.5.7 Magnetic Declination

When using GNSS/GPS as a track reference, it is essential to enter a correct magnetic declination to ensure that the velocity vectors and components have the correct heading. On the earth's surface, a calibrated compass indicates magnetic north rather than geographic north. The angular difference between these two directions defines the magnetic declination (also known as variation, magnetic variation, or compass variation). Magnetic declination varies across the earth's surface and over time. The magnetic declination angle (θ) can be found on maps or referenced online from nearby stations such as airports. Avoid using old maps, as magnetic declination can change substantially over time. A good source now is using Apps (e.g. Compass in Google Play or Declination in App Store).

7.5.5.8 Coordinate System

The Coordinate System defines the axes by which the velocity vectors and profiles are plotted and reported. This drop down menu has three options. All options are available for post processing; however you can set the default for the measurement.

- **Beam:** Beam coordinates are relative to the orientation of the transducers on the head of the ADP. Beam coordinates are typically used for diagnostics purposes only.
- **XYZ:** Transforms beam velocities into a typical right-hand XYZ Cartesian coordinate system. The positive X axis is in the direction of beam 1, marked by an arrow next to the transducer. The positive Z axis is up. This choice is also rarely used.
- **ENU:** Applies the ENU (East, North, Up) coordinate system to the data. Local ENU coordinates are formed from a plane tangent to the Earth's surface fixed to a specific location. This is the most common choice for standard measurements.

7.5.5.9 Depth Reference

Two options exist for determining water depth. Both options are available for post-processing and the user can choose the default reference.

- **Vertical Beam:** Applies data from the vertical transducer to determine water depth for the cross-sectional area. This choice is often preferred as it applies to the depth directly below the instrument.
- **Bottom-Track:** This option averages depth values measured by the four angled beams to determine water depth.

7.5.5.10 Track Reference

The ADP measures water velocity using multiple acoustic pulses transmitted and received throughout the water column (see RS5 Technical Manual for more details, coming soon). When the ADP is in motion, the apparent velocity measured by the ADP is a combination of boat velocity and water velocity. In order to determine true water velocity the boat speed must be determined and then subtracted from the apparent velocity. The RS5 moving boat application offers four methods, known as tracking references, to determine boat velocity.

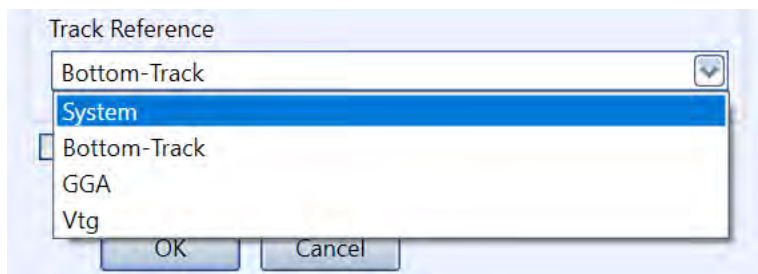


Figure 60. Track Reference Options

An appropriate track reference should be selected when setting up a measurement, but can be changed during post-processing, if necessary.

1. System

The ADP references velocity data only to itself. This option should only be used in specialized applications by experienced users. It is not recommended for discharge measurements from a moving vessel.

2. Bottom Tracking (Default)

Boat velocity is calculated using signals received from multiple acoustic pulses reflected from the channel bed and banks. If the channel bed is stationary (i.e. no bedload flux), then the apparent velocity will consist entirely of boat and water motion, so water velocity can be determined by removing bottom-tracked boat motion. If the channel bed is in motion (i.e, active bedload flux) the apparent velocity will involve a combination of boat, water, and channel-bed velocities. In this case, the user can proceed in one of two ways: (1) use a moving-bed test to measure and correct for the effects of bed motion on the bottom tracking (loop or SMBA, discussed in Sections 7.11.1 and 7.11.2), or (2) use GPS/GNSS to measure the boat track. Bottom tracking is the only reference available for the RS5 STD model.

As a general note, users can also opt to use a third option of taking a measurement in Stationary mode (coming soon).

3. GGA

GP GGA (GGA) refers to a specific NMEA-0183 protocol for outputting GPS position data. In this case, the GGA “string” contains actual position (latitude/longitude) along with several other GPS parameters. Boat velocity is calculated by measuring the distance between two successive GGA positions divided by the travel time between those two positions. Differential corrections are required for the GGA data to reduce the amount of position error associated with each measurement. The RS5 currently uses one type of differential correction: sub-meter “differential” or “DGPS” corrections with its standard Max options. “Real-Time Kinematic” (RTK) capability for the RS5 will produce coordinates with survey-grade (c. +/- 1 to 10 cm) precision – this option will be coming soon, but can also be achieved using an external GPS system capable of RTK corrections.

GGA is susceptible to incorrect position data due to multi-pathing when near tree-cover or bridges.

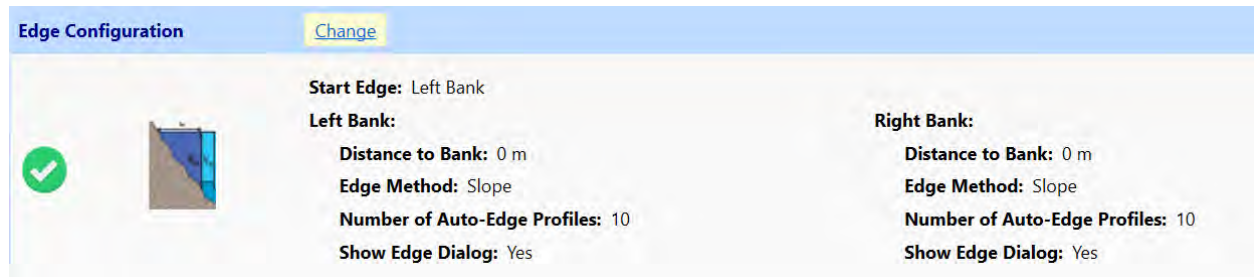
4. VTG

GP VTG (VTG – Velocity Traveled over Ground) refers to a specific NMEA-0183 protocol for outputting GPS velocity data. In this case, the VTG string contains the actual boat speed information along with several other GPS parameters. The GPS velocity is calculated based on the Doppler shift of the received satellite signals. This method requires additional review of data quality parameters to verify data quality.

VTG is not susceptible to the multi-pathing that GGA experiences, but it does normally require a minimum boat speed in order to obtain a reliable signal.

7.6. Edge Configuration

Edge Settings can be entered by clicking **Change** in Edge Settings section on the Smart Page (Figure 61). Default settings are pre-populated for transects to begin on the left bank, but this setting can be changed before starting data collection.



Edge Configuration	
Start Edge: Left Bank	
Left Bank:	Right Bank:
Distance to Bank: 0 m	Distance to Bank: 0 m
Edge Method: Slope	Edge Method: Slope
Number of Auto-Edge Profiles: 10	Number of Auto-Edge Profiles: 10
Show Edge Dialog: Yes	Show Edge Dialog: Yes

Figure 61. Edge Configuration

Edge configuration settings are also entered at the beginning and end of each transect (if selected) and can be changed in post-processing. The RSQ software will alternate starting banks on subsequent transects based on the starting edge selected for the first transect, but this can also be changed during the transect.

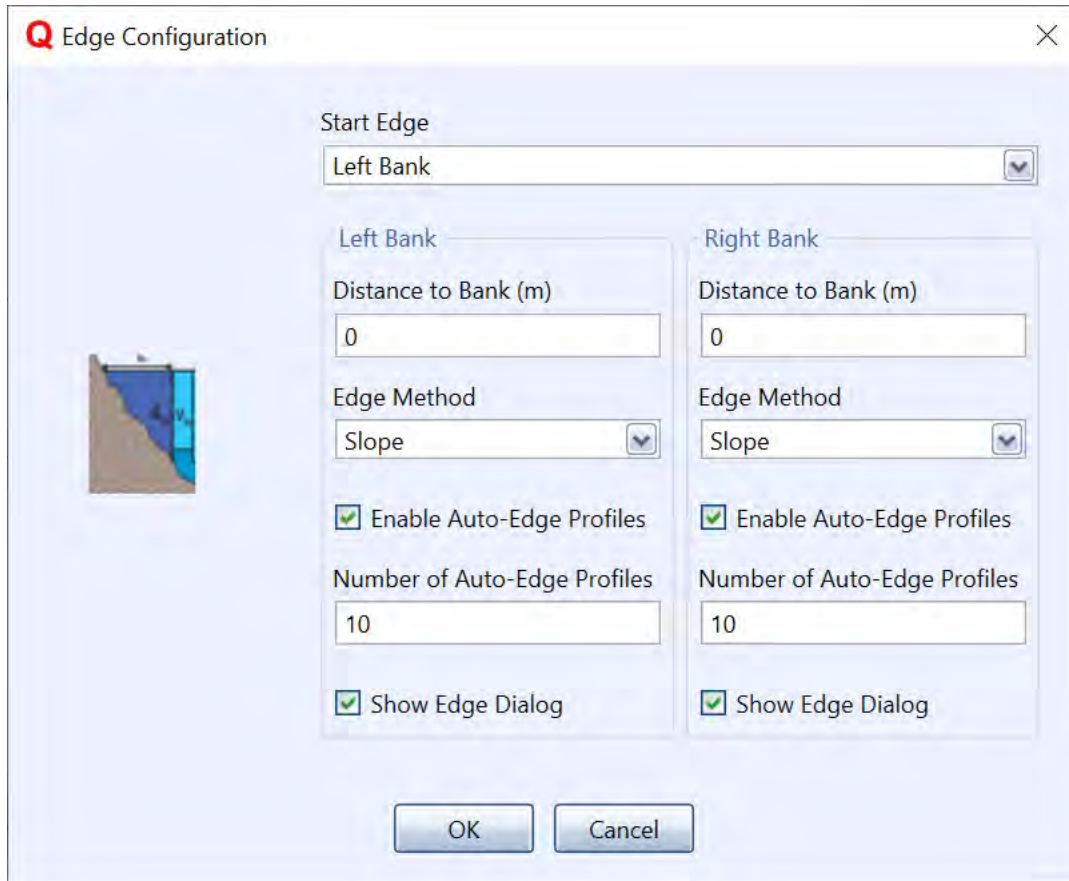


Figure 62. Edge Configuration Dialog

Settings in the Edge Configuration Dialog (Figure 62) include:

- **Start Edge** – the starting bank for the transect
- **Distance to Bank** – the distance from the start or end edge position of the RS5 instrument to the edge of the water. This distance can be manually measured or visually estimated.
- **Edge Method** – the bank geometry type for calculating the edge discharge
- **Enable Auto-Edge Profiles** – When this box is checked, the value in the subsequent box (Number of Auto-Edge Profiles) is used for the edge sampling before moving automatically to the transect section. When this box is not checked, moving to the Transect Section must be done manually by clicking the button (or pressing [F5])
- **Number of Auto-Edge Profiles** – the number of samples collected at the edge if the Auto-Edge feature is enabled. Default and recommended number of samples is 10. After 10 samples the software will automatically switch to the Transect Section and the boat can start traversing the channel

- **Show Edge Dialog** – this setting enables the edge dialog to appear at the start and end edge of each transect despite having filled out the edge configuration section in the Smart Page.

7.7. Extrapolation Configuration

The Extrapolation Configuration section allows the user to change extrapolation settings for the top and bottom sections of the channel not measured by the RS5 (described in Section 7.1)

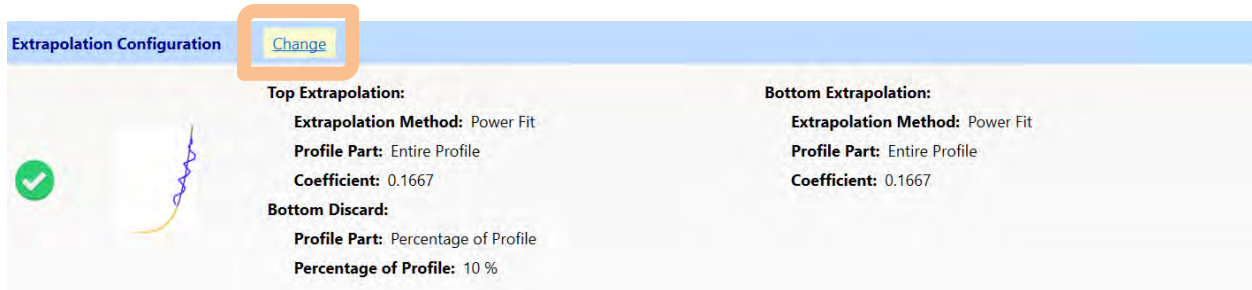


Figure 63. Extrapolation Configuration

The default choice for top and bottom extrapolation methods is the Power Fit. To change these settings, click the **Change** link (highlighted in Figure 63). This will bring up the Extrapolation Dialog in Figure 64.

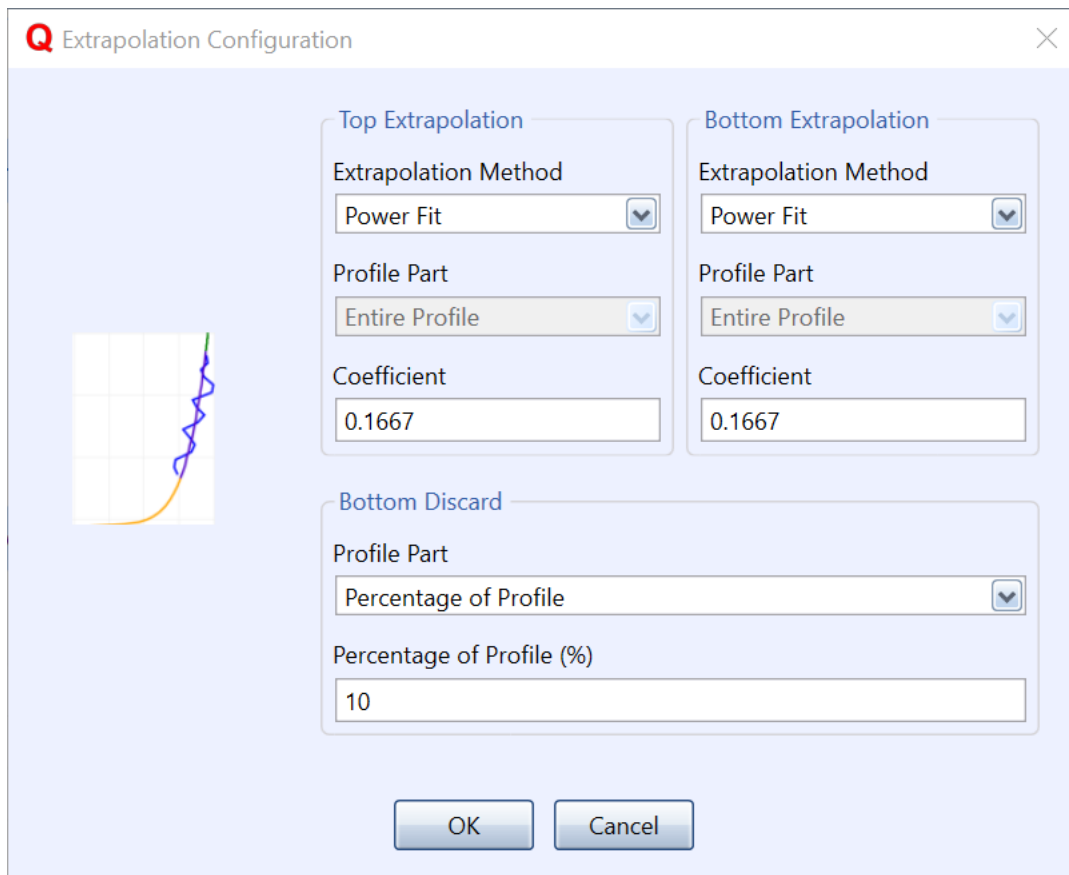


Figure 64. Extrapolation Configuration Dialog

Extrapolation choices follow Mueller (2013). Options for the top extrapolation method are:

- Constant - Assumes the velocity or discharge is constant from the average of the top cells defined by the 'Number of Cells' parameter
- Power Fit – uses a power law with the associated coefficient (default is 1/6, or 0.1667)
- 3-point Fit - Uses a linear least squares extrapolation through the uppermost three depth cells to the water surface.

Extrapolation choices for the bottom extrapolation are:

- Power Fit - uses a power law with the associated coefficient (default is 1/6, or 0.1667)
- No Slip - fits a power curve with the chosen coefficient through zero at the bottom and through depth cells in the lower chosen percentage (default 20%) of the flow or the last valid depth cell, if no valid bins are in the bottom chosen percentage of the water column

The user also has the option here to discard the chosen bottom percentage of profile (default 10%) or number of cells before extrapolation is performed.

7.8. Calculation Thresholds

The Calculation Thresholds section (Figure 65) shows several options for using or filtering certain types of data.

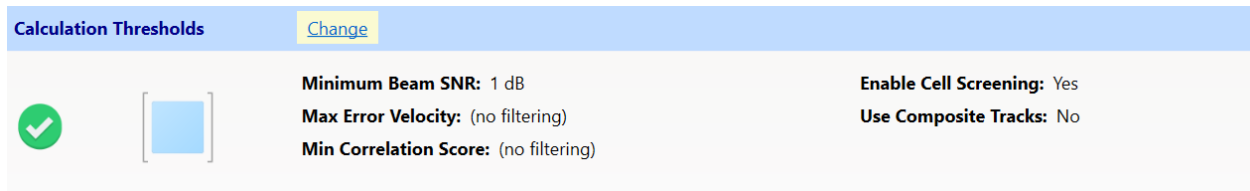


Figure 65. Calculation Thresholds

Clicking the [Change](#) link will allow the user to edit these options (dialog shown in Figure 66).

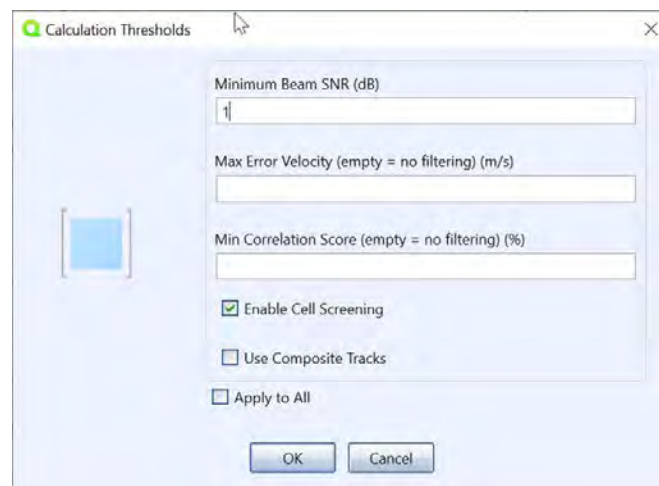


Figure 66. Calculation Thresholds Dialog

These options include:

- **Minimum Beam SNR (dB)** – Sets the minimum Beam SNR for velocity allowed to be used for calculations and shown in data. Default is 1 dB.
- **Max Error Velocity** – sets the maximum error velocity used as a filter. Any error velocities beyond this maximum value will not be used for calculations or shown in data plots.
- **Min Correlation Score** – Sets the minimum correlation score for velocity data allowed to be used for calculations and shown in data.
- **Enable Cell Screening** – if checked, the selection in “Minimum Beam SNR (dB)” will be used as a filter. Any cells with SNR less than the value in “Minimum Beam SNR (dB)” will be filtered out of the dataset and not displayed.
- **Use Composite Tracks** – If checked, the composite tracks feature will work as follows:

- o **If bottom track is the selected track reference:** automatically use a GNSS/GPS track when a bottom track sample is invalid. If the GGA sample has quality 4, the GGA track reference will be used, otherwise the VTG track reference will be used, if valid.
- o **If GGA is the selected track reference:** automatically use VTG track when a GGA sample is less than quality 2. If no valid VTG data exist, bottom track will be used as the track reference.
- o **If VTG is the selected track reference:** automatically use GGA track if the GGA track has quality 4 and the VTG sample is invalid. If GGA data is less than quality 4, bottom track will be used as the track reference.

7.9. Advanced Data Collection



Figure 67. Advanced Data Collection

The Advanced Data Collection setup in the Smart Page (shown in Figure 67) will appear when the 'Show diagnostic parameters' choice is checked in the Settings dialog. These settings allow the user to modify certain parameters for advanced data collection. When **Change** is clicked, the user will see the dialog shown below.

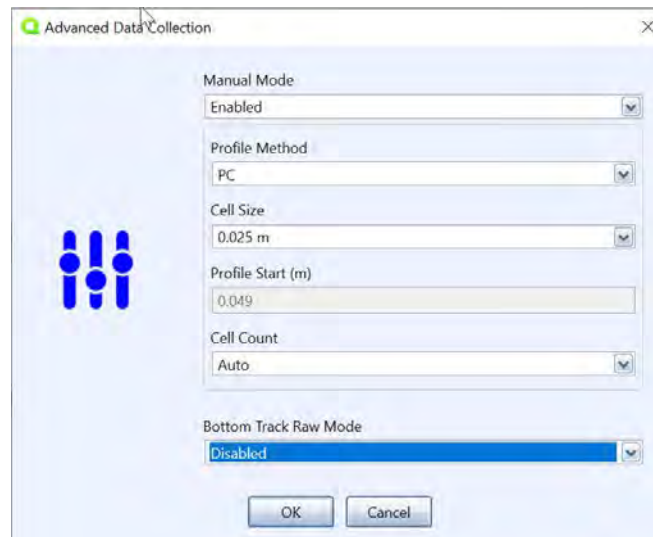


Figure 68. Advanced Data Collection Dialog

7.9.1 Manual Mode

Manual mode forces the RS5 to ping in a specific user-defined manner. When enabled, the choices for these items are outlined in Table 6. Manual Mode Settings, below.

Table 6. Manual Mode Settings

Profile Method	Cell Size	Profile Start	Cell Count
PC	Auto 0.012 m 0.025 m 0.05 m 0.1 m	- 0.042 m 0.049 m 0.059 m 0.154 m	Auto 1-127
BB	Auto 0.05 m 0.075 m 0.1 m 0.15 m 0.2 m 0.3 m	- 0.099 m 0.107 m 0.139 m 0.159 m 0.244 m 0.296 m	Auto 1-127

Please note that cell sizes are tied to specific profile start values (table values should be read across the corresponding row. The user has the choice to force the RS5 to sample in either PC (Pulse Coherent) or BB (Broadband) mode. When those are selected, the user can further select to automatically determine cell sizes and counts using that part of the SmartPulse algorithm, or force a manual cell size. Only when a cell size is selected can the user select a cell count. If 'Auto' is selected for cell count, the RS5 will automatically fill the profile with as many cells as possible before hitting the bottom. If a cell count is entered, the RS5 will calculate velocity for that number of cells unless the number of cells exceeds what will fit for a given detected depth. Any cells beyond the detected depth will not have velocity calculated.

7.9.2 Bottom Track Raw Mode

This mode should be used only when troubleshooting with Technical Support. Please do not attempt to use this mode if not necessary, as this mode creates very large data files.

7.10. Templates from Smart Page

Once all settings have been entered in the Smart Page, the user has the option to save the current settings to a Template by clicking the [Save as Template](#) link at the top of the Smart Page, highlighted in orange in Figure 69. This will make the Template available when loading a Template, and allows for quicker setup at sites where the user measures often. To load a Template that is already created, click the [Load Template](#) link highlighted in blue in Figure 69. This will open a drop-down menu where a Template can be chosen.

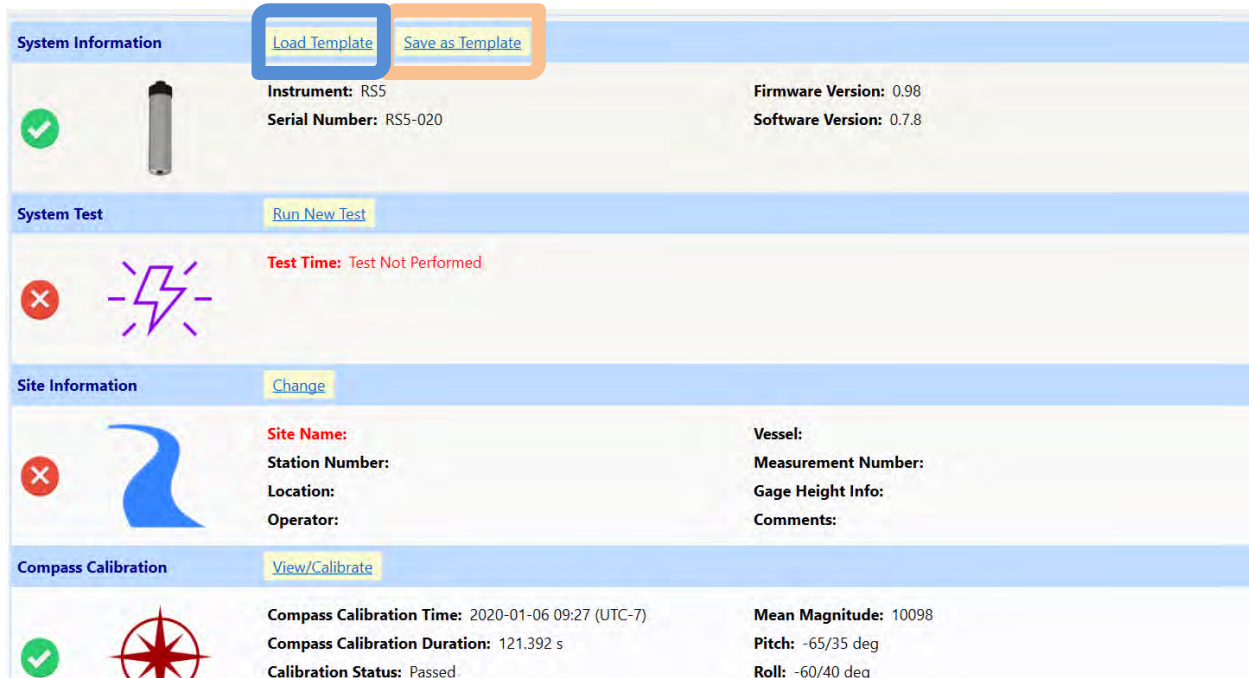


Figure 69. Save as Template from Smart Page

7.11. Data Collection

After completing the Pre-measurement tests and initial site specific entries to configure the System from the Smart Page, begin the measurement procedure. From the Smart Page screen, the main toolbar will offer various choices to begin a measurement, as shown in Figure 70. Depending on the measurement procedure, the user may be required to perform a moving bed test (Loop or SMBA) prior to collecting transects, or they may proceed to start the main measurement directly. The software provides a step-by-step procedure outlined below. Each step is explained in detail in the following sections.

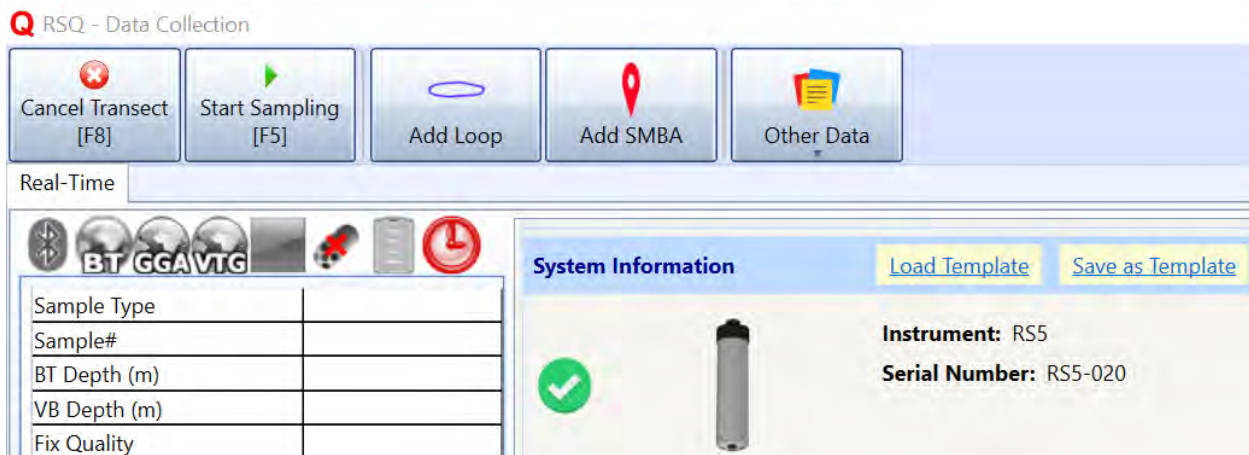


Figure 70. Options for Beginning Data Collection

7.11.1 Add Loop (Optional)

The Loop moving bed test is commonly used to identify a moving bed and correct for its effects in the final discharge. The Loop Method is documented in Mueller and Wagner (2006), and the procedure described here follows this document step-by-step. The loop methods consists of an out-and-back transect loop across the section that should start and end at the same position.

1. Make sure a successful compass calibration has been performed, described in Section 7.5.4. A compass calibration is **required** for a Loop test.
2. Establish a starting point near the bank. It will be helpful to select this location such that the boat can easily be controlled when starting and ending a measurement. The starting point does not need to be located as close to the bank as a regular discharge measurement. To guarantee a common start and end position, users can mark the location on their cable, tape, or anything else being used to assist.
3. To start a Loop, click the Add Loop button. The Loop Preview dialog will appear, as shown in Figure 71. At any point beyond this, pressing the Cancel Loop button will cancel the Loop measurement.

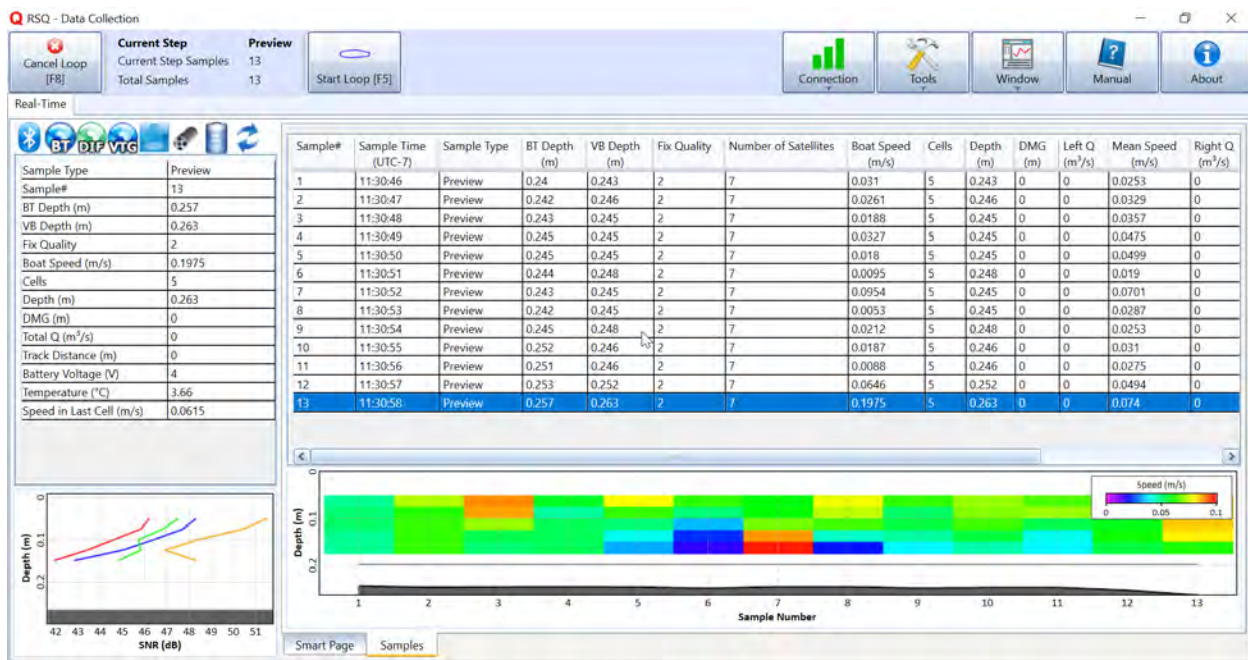


Figure 71. Add Loop Preview

4. Ensure that the RS5 is stationary and at the starting point of the loop measurement. The preview dialog allows the user to view profiling data before recording the loop measurements – please ensure that valid data cells appear and that the data conform to expectations at that site before proceeding. If data

look satisfactory, press the Start Loop button (or use the [F5] key) to begin the loop measurement.

5. Once started, the Loop measurement data will appear, as shown in Figure 72, and the user should begin moving the RS5 across the section. By default, the Boat Speed and Boat/Water Speed Ratio will be plotted on top. It is essential that the user maintain a steady, slow boat speed throughout the out-and-back transect. Per the recommendation from Mueller and Wagner (2006), the boat speed should be the lesser of a.) the boat speed that requires no less than 3-minutes to complete the loop or b.) the boat speed that is less than 1.5 times the mean water speed. The ship track and velocity profile are also plotted.

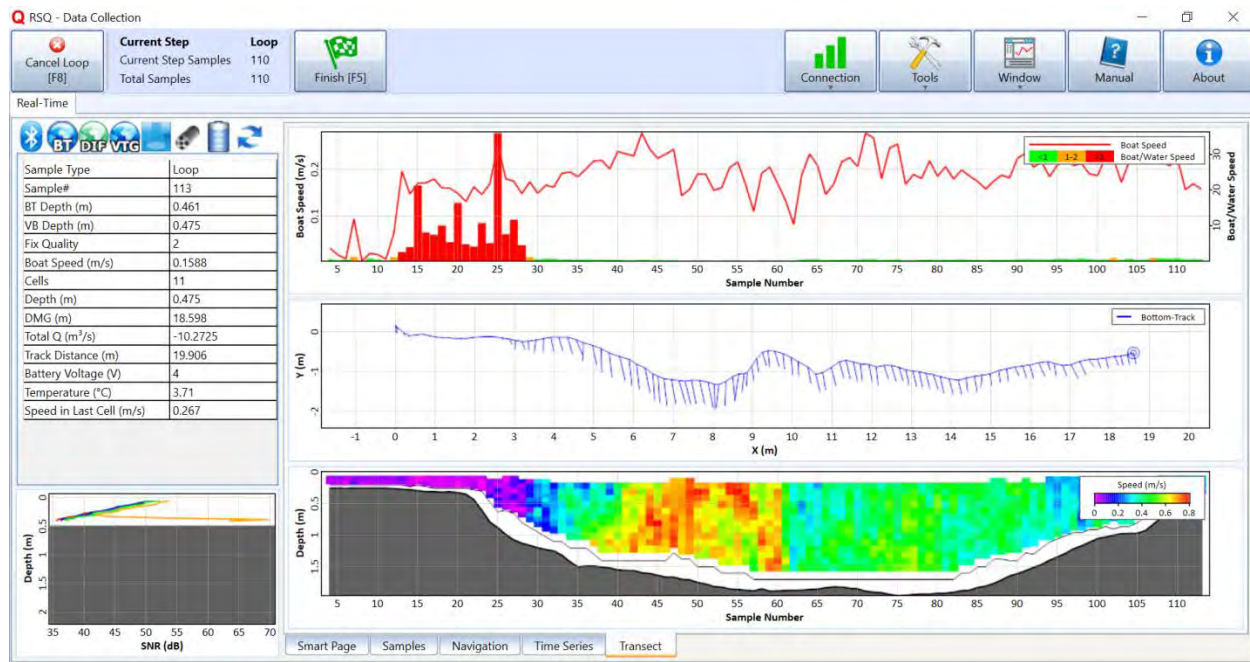


Figure 72. Loop Measurement Dialog

6. When approaching the far channel bank, do not spend any extra time along the edge. Rather, gently turn the boat and return to the starting stream bank.
7. After returning to the starting position, press the Finish button (or use [F5]) to stop the Loop measurement.
8. The results of the Loop measurement will be displayed automatically (shown in Figure 73).

The screenshot shows a software window titled "Loop Method" with a close button (X) in the top right corner. The window contains several input fields for measurement data, a text area for warnings, and a final recommendation box.

Field	Value
Loop Method Files	01-Loop_20200129115206
Distance Made Good (m)	1.321
Loop Time (seconds)	370
Moving Bed Velocity (m/s)	0.0036
Flow Velocity (m/s)	0.8828
Moving Bed Direction (deg)	156.36
Flow Direction (deg)	26
Estimated Percent Correction (%)	0
Percent Bad Bottom Track (%)	17.03

Below the input fields, there is a text area containing the following information:

- Difference in flow direction between out and back sections: 6.53 deg.
- Warning: Percentage of bad bottom track value exceeds 5. Loop may not be accurate. Please review your data.

At the bottom of the dialog, a box contains the final recommendation:

Moving-bed Velocity (MBV) < Minimum MBV Criteria - no correction recommended.

A "Close" button is located at the bottom center of the dialog.

Figure 73. Loop Measurement Results

Loop Measurement warnings and information are displayed near the bottom, and the final recommendation for a correction is displayed at the bottom. Figure 73 shows the results of a Loop Measurement with no correction recommended.

From the Loop Measurement Results dialog, the user can choose to repeat the Loop Measurement, or proceed to the Start Edge.

7.11.2 Add SMBA (Optional)

The Stationary Moving Bed Analysis (SMBA) moving bed test is an alternative way to identify a moving bed and correct for its effects in the final discharge. The SMBA method is documented in Mueller (2007) and Mueller and Wagener (2006), and the procedure described here follows these documents. The SMBA method does not require a compass, and is better suited for sites where there is large magnetic

interference, or when the compass is thought to be unreliable. The SMBA requires at least one measurement at a stationary location ideally located in the location of highest flow (where the probability of having a moving bed is greatest). Follow the steps below to perform an SMBA moving bed test.

1. To begin an SMBA moving bed test, press the Add SMBA button from the Smart Page (shown in Figure 70). The dialog shown in Figure 74 will appear.

Figure 74. Start SMBA Dialog

2. The user must enter the number of measurements desired (default is 1) and the number of samples per measurement (default is 300). Click OK to enter the preview screen shown in Figure 75.

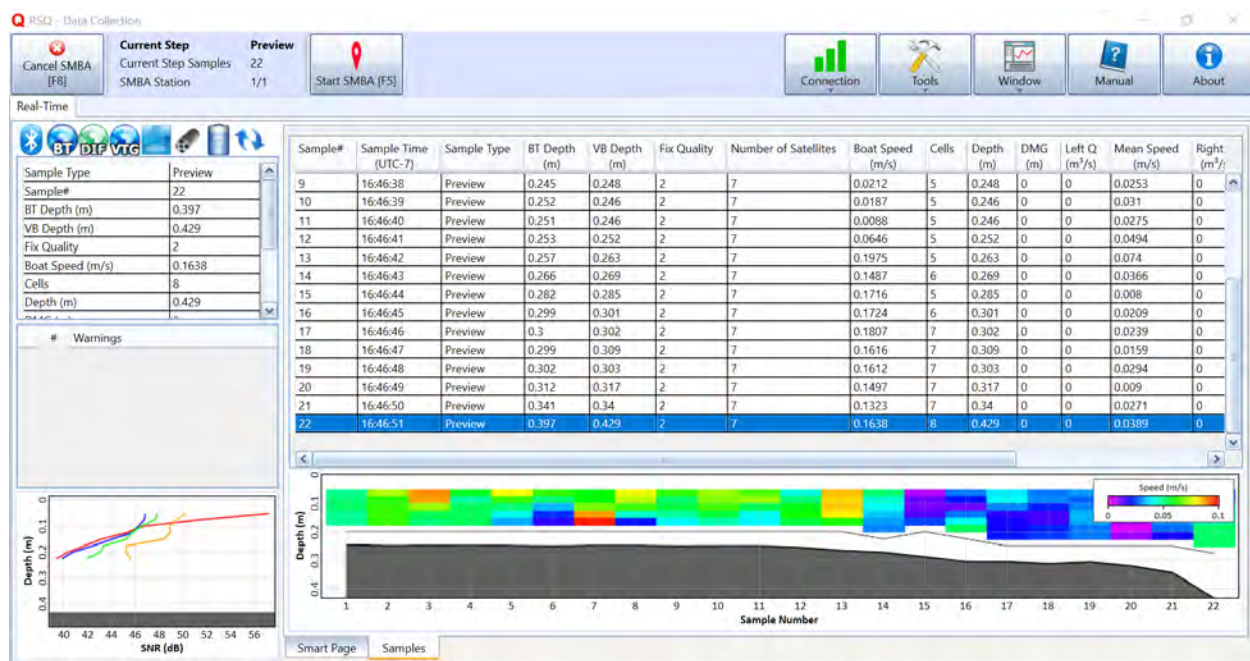


Figure 75. SMBA Preview

3. Ensure that the RS5 is held at a stationary location in the channel where the highest flow is located, and that the profile data look reasonable for the site. Click Start SMBA (or use [F5]).
4. The SMBA data collection will begin, and the same data will appear as shown for the Loop measurement (Figure 72). To track the progress of the measurement, the top left area of the RSQ software will display the current number of samples (shown in Figure 76).

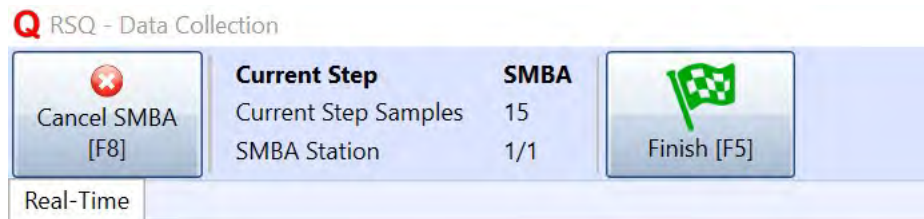


Figure 76. SMBA Status

5. After the selected number of samples has been reached, results will automatically be displayed, as shown in Figure 77.

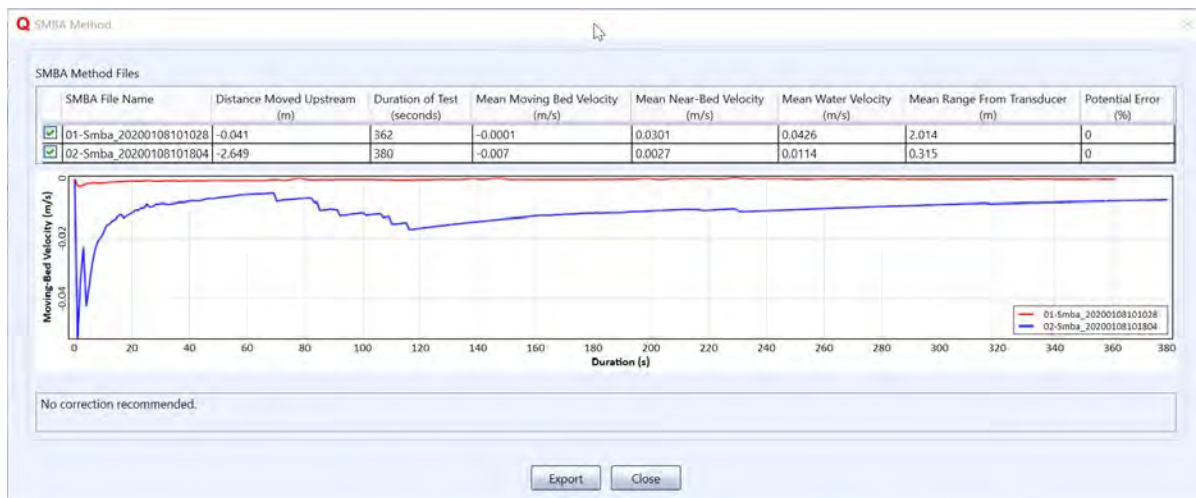


Figure 77. SMBA Results

6. After the user examines the summary, they will have the option here to either add an additional station or continue to the start edge. We recommend the user adheres to the rules of their agency regarding how many SMBA stations to measure before beginning a measurement in the case that a moving bed is detected.
7. Additionally, the user has the ability to export the data to a CSV file by click the Export button.

7.11.3 Start Sampling

From the Smart Page, click the Start Sampling button (or use [F5]) to begin data collection (Figure 70). Alternatively, sampling can begin from the Loop or SMBA dialogs by choosing to proceed to the Start Edge. The data preview display will appear (Figure 78).

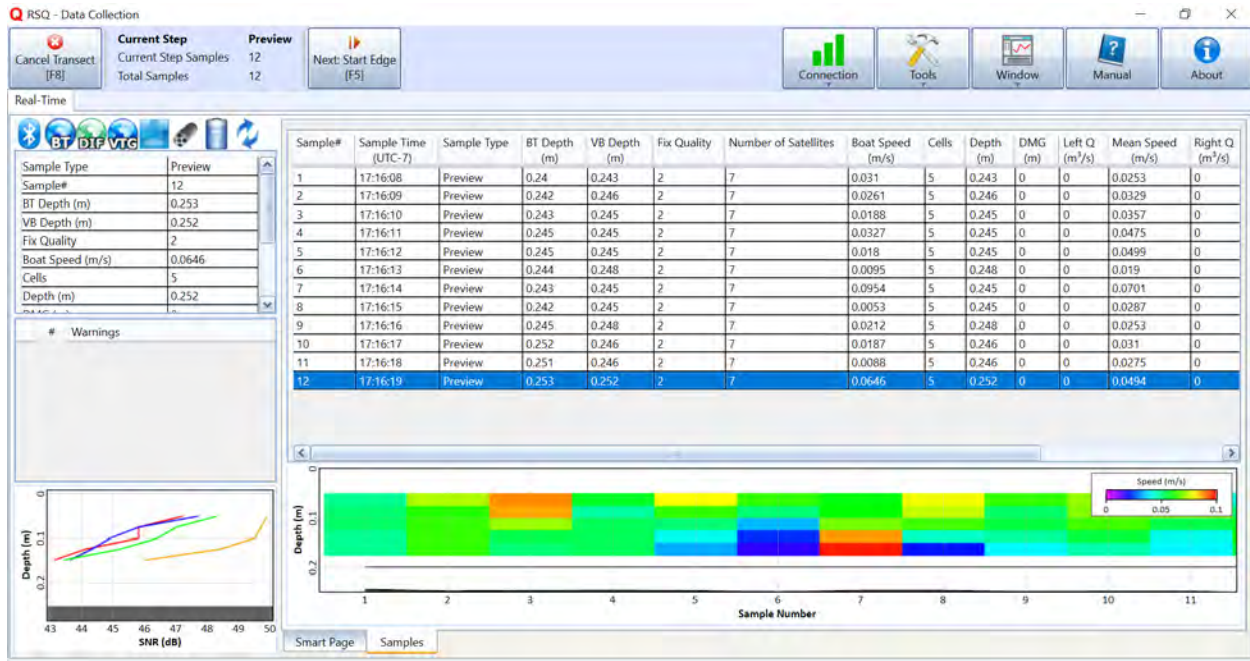


Figure 78. Start Sampling Preview

Ensure that all status icons and data appear reasonable for the site. Position the vessel at the start edge of the transect. In general, edge data should contain at least 2 vertical cells of valid data in order to proceed. Once the user is satisfied with the data preview, they can proceed to begin the Start Edge collection.

7.11.4 Start Edge

Click the Next: Start Edge button (or use [F5]), highlighted in Figure 79.

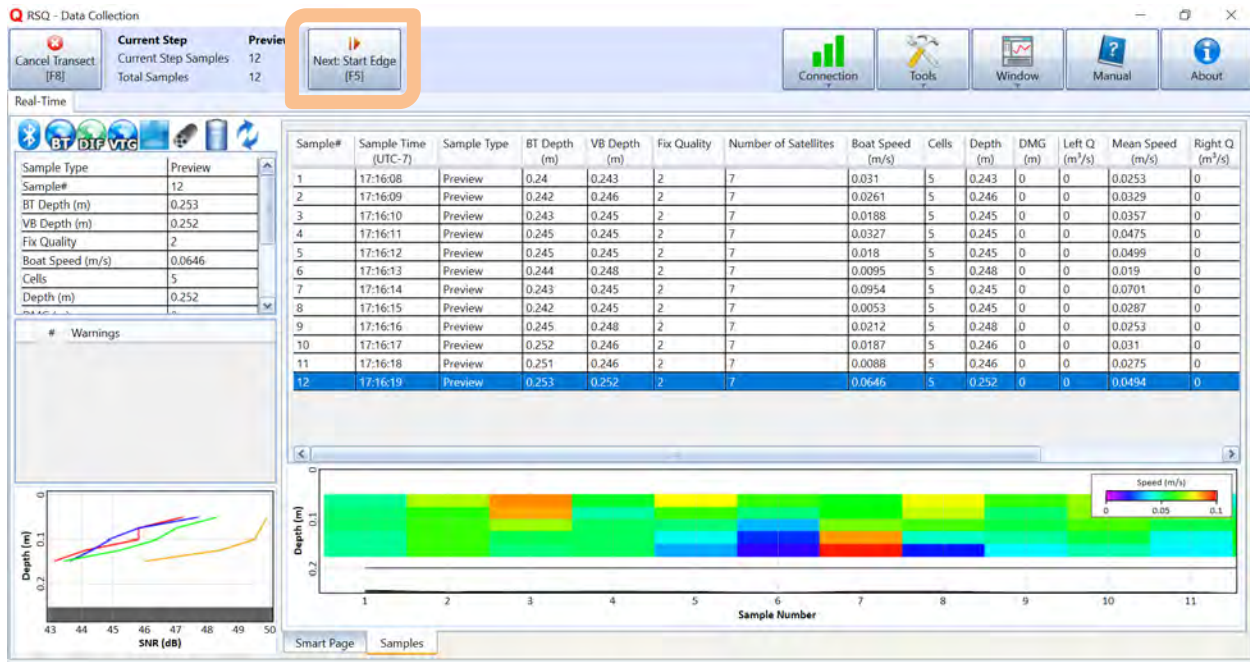


Figure 79. Proceed to Start Edge

A pop-up Edge Dialog window (shown in Figure 80) will appear if this option is checked (see Section 7.6).

The screenshot shows the Edge Configuration dialog box. The 'Start Edge' dropdown is set to 'Left Bank'. The 'Distance to Bank (m)' is set to 0. The 'Edge Method' dropdown is set to 'Slope'. The 'Enable Auto-Edge Profiles' checkbox is checked. The 'Number of Auto-Edge Profiles' is set to 10.

Figure 80. Edge Dialog

Any Edge settings from the Smart Page (described in Section 7.6), and any modifications to these settings can be made here. The distance to bank can be either measured or estimated. Click **OK** to begin the Start Edge data collection.

The Edge data collection tab will appear, as shown in Figure 81. Keep the RS5 as stationary as possible during the edge data collection. It is recommended that the user collect at least 10 good samples with at least 2 vertical cells during the edge measurement. If the user selected to use the auto-edge feature, the RSQ software will automatically switch to measuring the Transect after that number of samples is done. Alternatively, when the Edge measurement is satisfactory, the user can manually proceed to the Transect measurement.

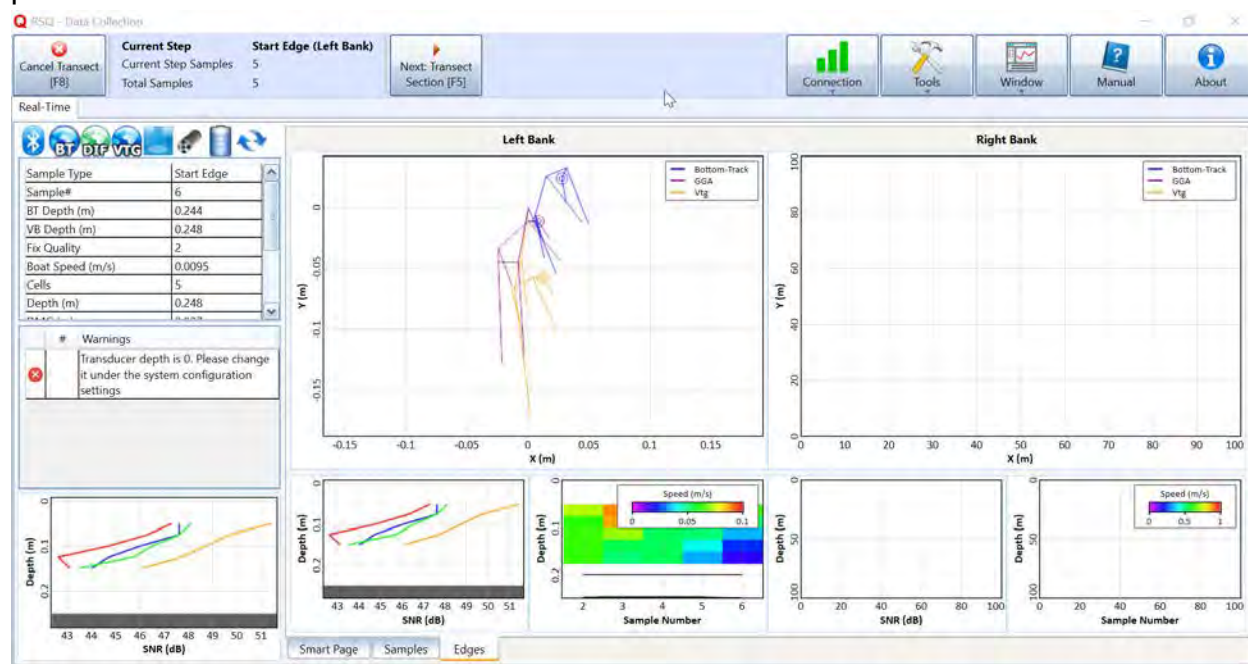


Figure 81. Start Edge Data Collection Dialog

7.11.5 Transect Section

If proceeding to the Transect measurement manually, click the Next: Transect Section button (or use [F5]), highlighted in Figure 82.

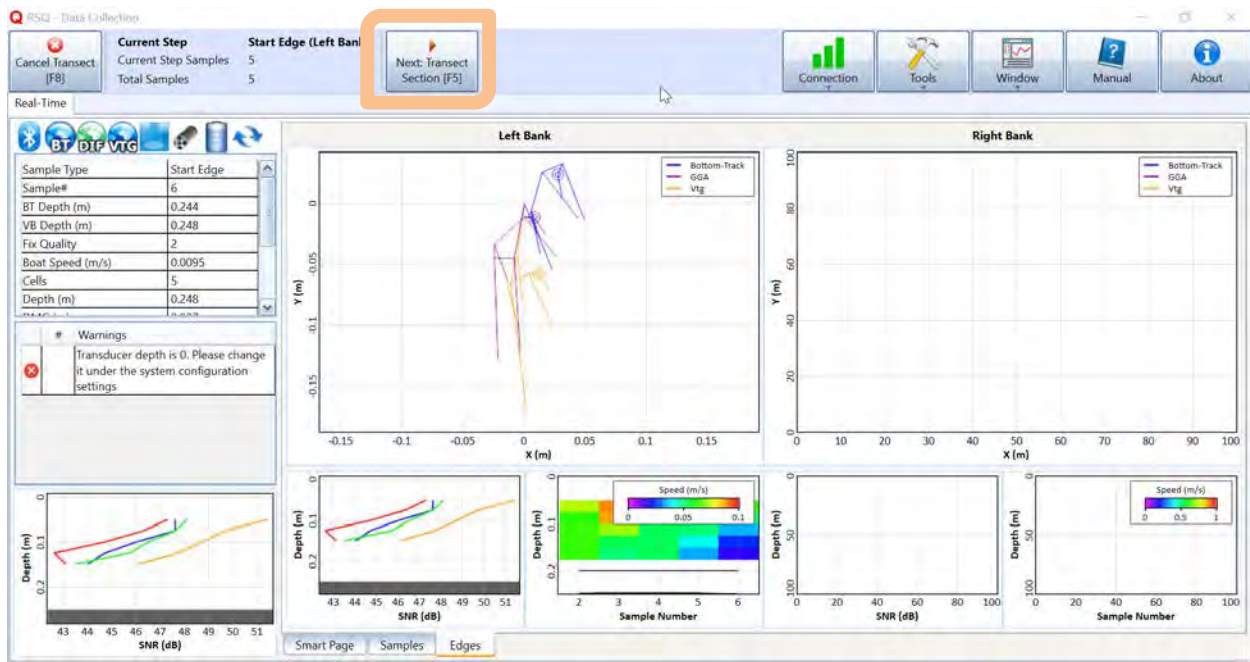


Figure 82. Proceed to Transect Section

The Transect data tab will activate automatically, as shown in Figure 83.

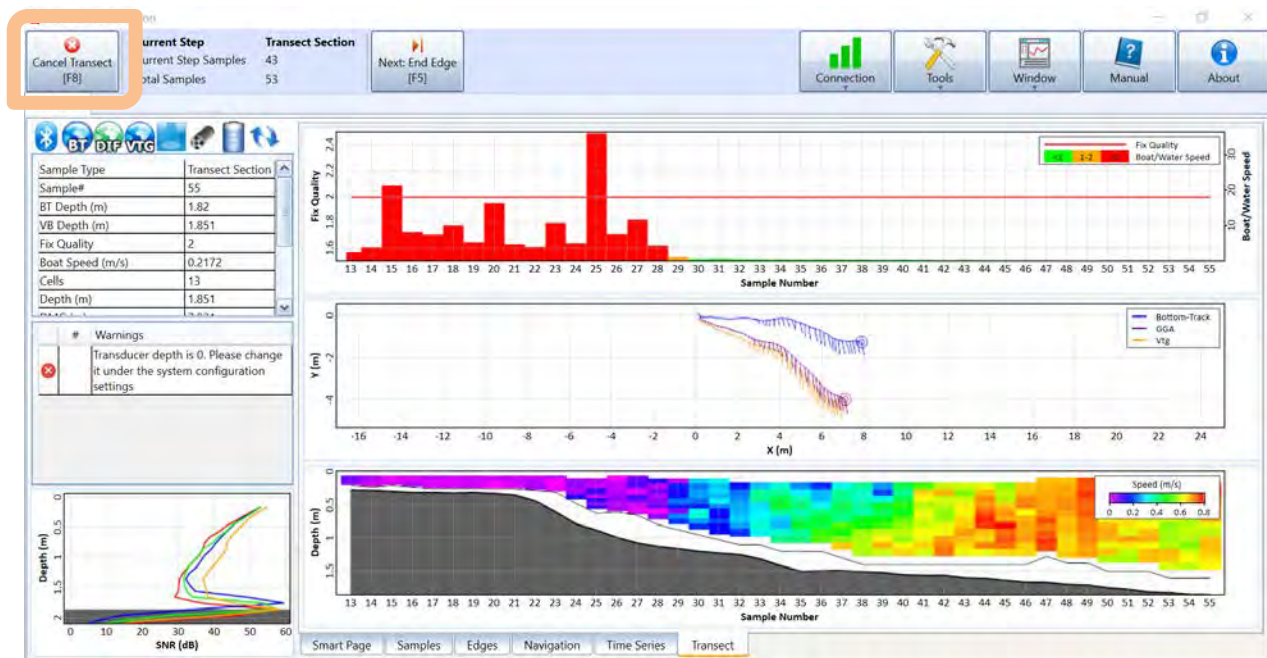


Figure 83. Transect Data Collection

The user can begin moving the vessel across the channel, with the vessel pointing roughly perpendicular to the direction of flow. All attempts should be made to keep the vessel speed and direction constant as it progresses across the river to the end edge. In general, the vessel speed should be less than the speed of the flow.

During the Transect measurement, the user has the option to navigate through any data tabs (described in Section 6.5.8) by clicking the tabs near the bottom of the software. The user can also right-click to manipulate what data variables they would like to view during the transect. It is advisable for the user to also view the QA/QC window which will be updated if various warnings or errors occur. Finally, make sure to monitor the status icons on the top left part of the screen to be alerted of any issues with data quality. At any point during the transect, if an issue is found, the transect can be cancelled by clicking the Cancel Transect button (highlighted in Figure 83).

7.11.6 End Edge

When the vessel reaches the edge of the opposite bank, click the End Edge button highlighted in Figure 84 (or use [F5]).

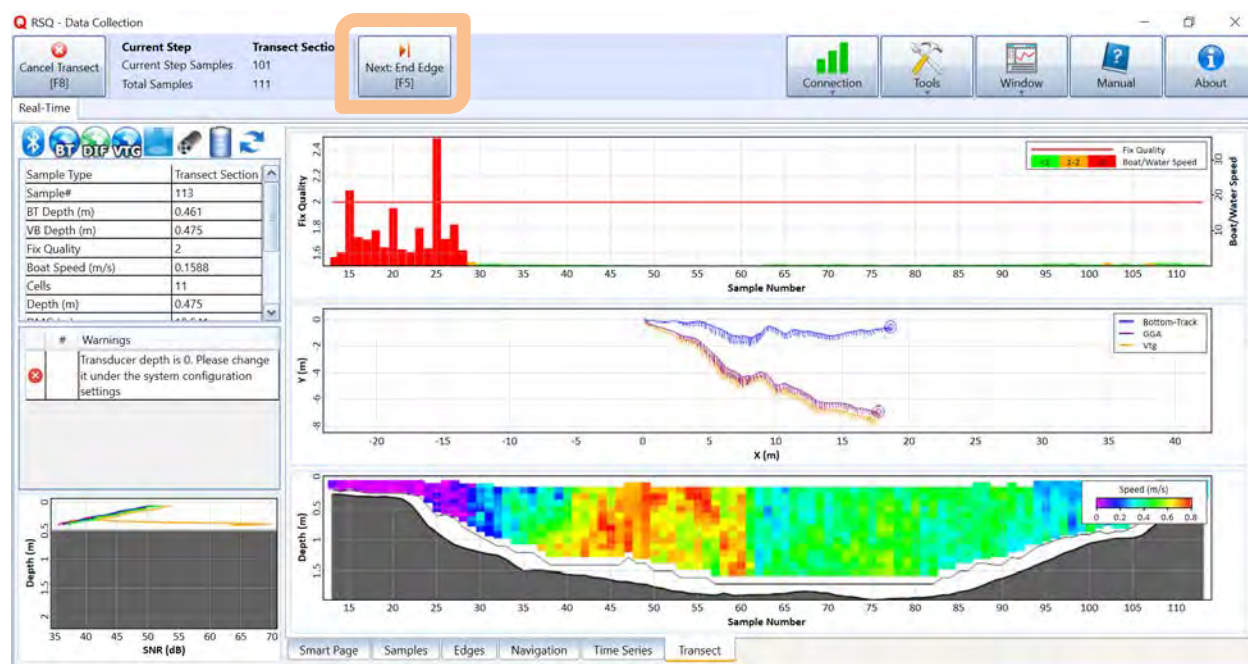


Figure 84. Proceed to End Edge

The same dialog as shown in Figure 80 will appear for the End Edge. The user can change settings if necessary, and proceed by clicking **OK**. The End Edge data collection tab will be activated, as shown in Figure 85. The same rules for the Start Edge apply to the End Edge: the user must keep the vessel as stationary as possible, ideally allowing at least 10 good samples with at least 2 valid vertical cells of data to be measured. When finished, if the Auto-Edge feature is enabled, the RSQ software will move directly to the preview screen for the next Transect. Otherwise, the user must manually complete the transect by clicking the Finish button, highlighted in Figure 85.

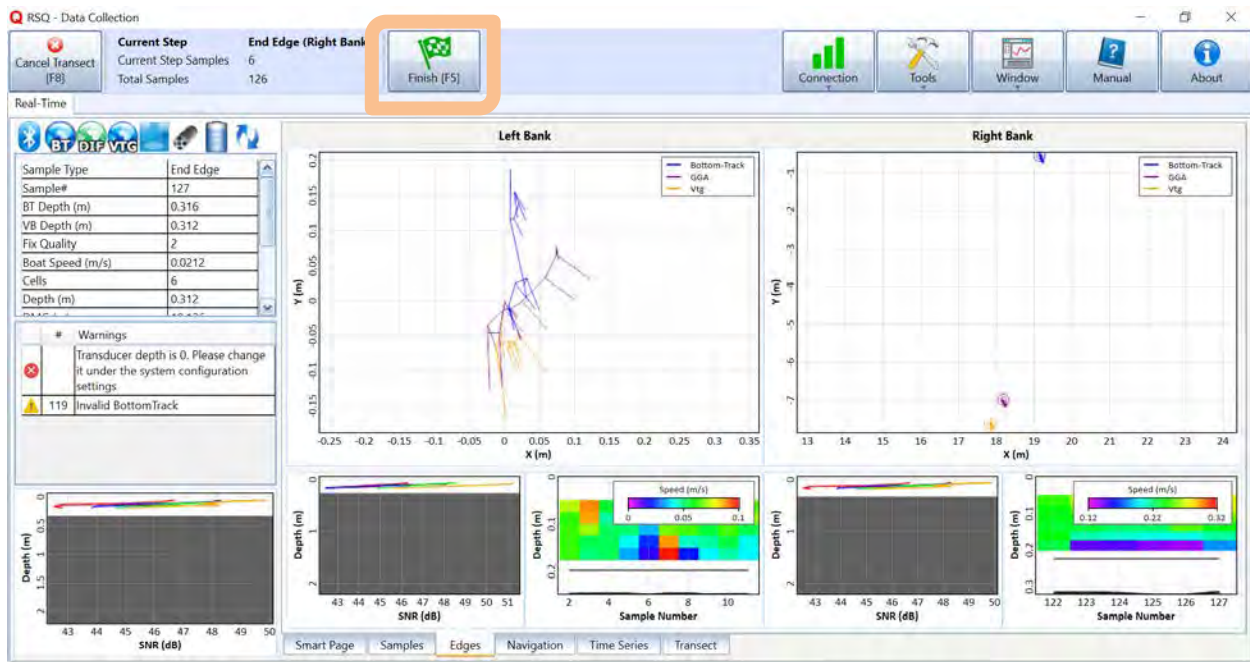


Figure 85. End Edge Sampling

7.11.7 Adding Additional Transects to Measurement

As most discharge measurements require pairs of transects, adding additional transects is assumed after completing an End Edge. The RSQ software will move directly to the preview screen of the next transect, and the process can be repeated (starting from Section 7.11.4) until the desired number of transects is collected. When at least one transect is collected, a new tab called Recorded Data will appear near the top left, shown in Figure 86. Clicking on this tab allows the user to view transects already collected during the current measurement session. Return to the current transect data collection by clicking the Real-Time tab.



Figure 86. Recorded Data Tab

7.12. Discharge Summary Overview

While collecting multiple transects, it is often useful to show the Discharge Summary, described in Section 6.5.9. By using [CTRL+S] or activating the Discharge Summary through the Window button (main toolbar), the user can compare discharge and many other related parameters among already-collected transects. An example of the Discharge Summary is shown in Figure 87.

Name	Start Time (UTC-5)	Duration	Total Q (m³/s)	% Measured	Boat Speed (m/s)	Mean Speed (m/s)	Track Distance (m)	DMG (m)	Max Depth (m)	Mean Depth (m)	Area (m²)
01-Loop_20200130103854	2020-01-30 10:50	00:05:25	0.24	89.18	0.189	0.2512	61.612	0.732	2.179	1.305	0.95551
02-Transect_20200130110147	2020-01-30 11:02	00:02:59	5.5697	75.71	0.1714	0.1175	30.852	30.267	2.159	1.567	47.42055
03-Transect_20200130110511	2020-01-30 11:05	00:03:06	5.5152	75.67	0.1653	0.12	30.906	30.123	2.165	1.525	45.95291
04-Transect_20200130110834	2020-01-30 11:08	00:02:58	5.4968	75.39	0.1743	0.1172	31.192	30.475	2.115	1.539	46.90614
05-Transect_20200130111332	2020-01-30 11:13	00:03:21	5.56	76.22	0.1529	0.1221	30.89	29.702	2.138	1.533	45.53737
Mean			5.5354	75.74	0.166	0.1192	30.96	30.142	2.144	1.541	46.45424
Std Dev			0.0303	0.3	0.0082	0.002	0.135	0.283	0.02	0.016	0.74665
COV			0.0055	0.4	0.0494	0.0169	0.004	0.009	0.009	0.01	0.01607
Totals		00:12:26									

Figure 87. Discharge Summary

Each line in the Discharge Summary represents one transect. During an active measurement session, the user can first click on the Recorded Data tab (see Figure 86), and then any subsequent clicks on an individual line in the Discharge Summary will activate that specific transect for viewing.

The area highlighted in Figure 86 shows parameters that always appear in every Discharge Summary. From left to right, the columns indicate:

- Check box – select this box to use this transect in the statistics at the bottom. Deselecting this for a transect removes it from the statistics calculations.
- Type of Measurement – indicates whether the transect is a Loop [↺], SMBA [📍], or Transect [↗]

- Name – name of transect (as it appears in the Recorded Data tab)
- Arrow – indicates which direction the transect moves (left to right bank [] or right to left bank [])
- Track Reference – indicates whether System [], Bottom Track [], GGA [], or VTG [] is used as a track reference
- Depth Reference – indicates whether the vertical beam [] or bottom track [] is used as a depth reference
- Coordinate System – indicates what coordinate system is chosen (ENU [], XYZ [], or Beam [])
- Start Time – Start time of the transect
- Duration – duration of the transect

The bottom four rows of the Discharge Summary are reserved for certain statistics:

- Mean – the mean (average) of the checked transects for a particular parameter
- Std Dev – the standard deviation of the checked transects for a particular parameter
- COV – the coefficient of variation of the checked transects for a particular parameter
- Totals – the total of the checked transects for a particular parameter (currently only for the Duration)

Any parameter not highlighted in Figure 86 can be selected for display by the user by right-clicking anywhere within the Discharge Summary. Right-clicking activates a menu shown in Figure 88. From the parameter list in the lower portion of this menu, the user can select or deselect what parameter is shown in the Discharge Summary. These options will be remembered the next time a new instance of RSQ is opened. Additional options include:

- **Copy Table to Clipboard** – copies everything displayed in the Discharge Summary to the computer clipboard to be pasted how the user wishes
- **Extract Subsection to New Transect** – this functionality allows the user to create subsections from the current transect. Details on this functionality are described in Section 8.11.
- **Reset to field settings** – this functionality is mainly used in post-processing, and resets any changes to what was originally set during data collection

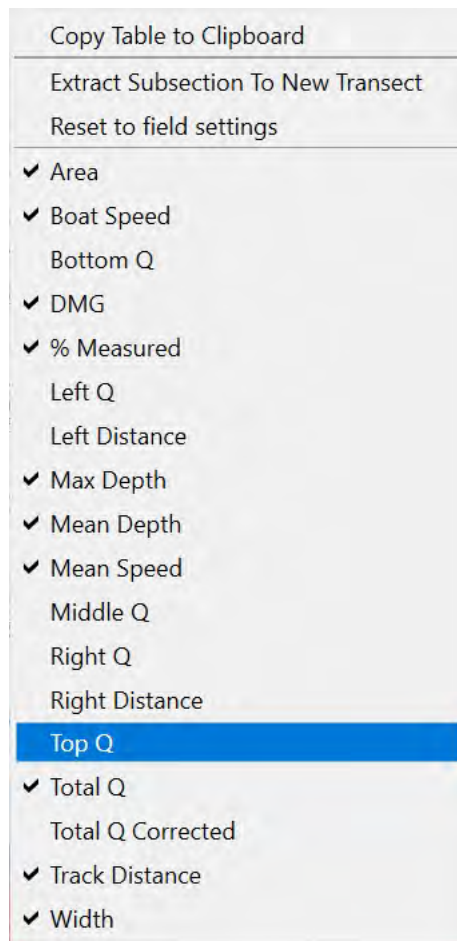


Figure 88. Discharge Summary Options and Parameter Menu

If “Highlight Summary Records” is selected through the Tools > Settings > Moving Boat dialog (described in Appendix B), transects having more than 5% difference in discharge from the mean discharge are highlighted in red. An example of this is shown in Figure 89.

	Name			Start Time (UTC+1)	Duration	Total Q (m ³ /s)	% Measured	Boat Speed (m/s)	Mean Speed (m/s)	Track Distance (m)	DMG (m)	Width (m)	Max Depth (m)	Mean Depth (m)	Area (m ²)
✓	01- Transect_20200626112232			2020-06-26 11:27	00:08:31	-1.0617	51.28	0.0944	-0.0257	78.173	15.693	15.693	5.243	2.637	41.38988
✓	02- Transect_20200626115528			2020-06-26 11:56	00:03:50	2.8554	79.7	0.6323	0.0061	153.649	124.811	128.811	6.257	3.741	466.95933
✓	03- Transect_20200626120019			2020-06-26 12:00	00:06:03	-4.4035	74.82	0.5857	-0.0081	216.712	158.324	162.324	6.287	3.451	546.30839
	Mean					-0.8699	68.6	0.4375	-0.0092	149.511	99.609	102.276	5.929	3.276	351.55253
	Std Dev					2.9665	12.41	0.2433	0.013	56.634	60.895	62.733	0.485	0.467	221.69758
	COV					-3.4101	18.08	0.5562	-1.4125	0.379	0.611	0.613	0.082	0.143	0.63062
	Totals				00:18:24										

Figure 89. Example of Transects Highlighted in Red

7.13. Other Data

A variety of other data can be added to the measurement at any point during the measurement. They can be accessed through the Other Data button, highlighted in Figure 90.

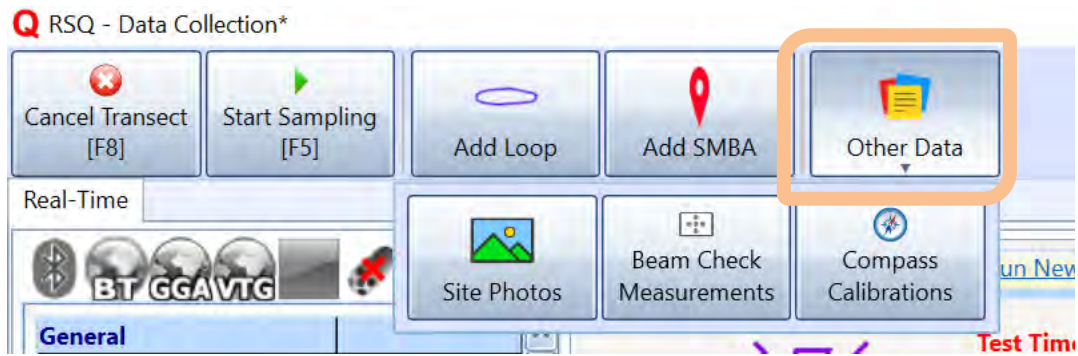


Figure 90. Other Data

7.13.1 Site Photos

Site photos can be added to the measurement for easy reference. Clicking on the Site Photos button opens the Site Photos dialog, shown in Figure 91.

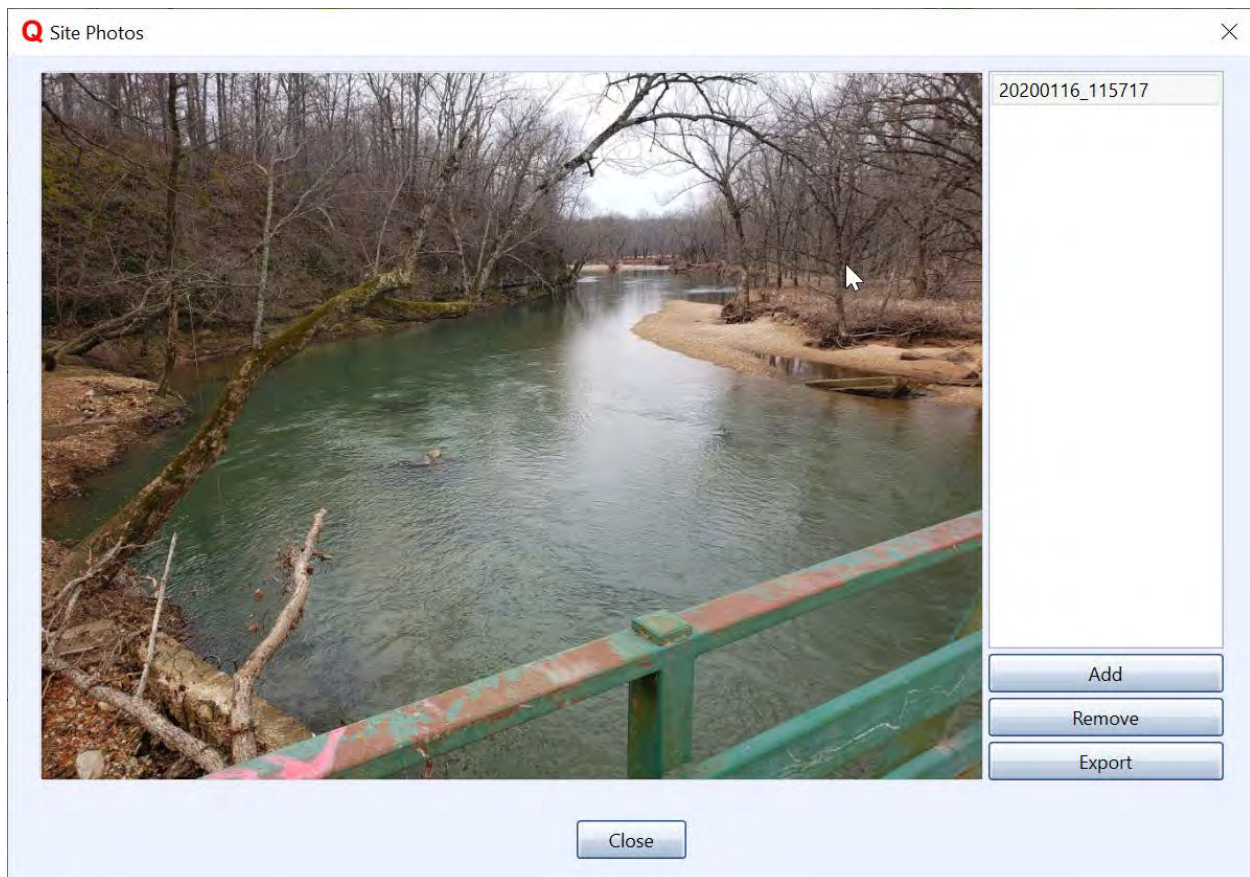


Figure 91. Site Photos Dialog

From here, the user can add or remove photos from the list, which appears on the right. The Export function saves the current photo as a JPG file to the desired folder.

7.13.2 Beam Check Measurements

The procedure for collecting and recording Beam Check Measurements is outlined in Appendix C. Any Beam Check measurements performed during the current measurement session will be saved and viewable through the Beam Check Measurements dialog.

7.13.3 Compass Calibrations

Compass Calibrations can be performed through the Smart Page (described in detail in Section 7.5.4) or through the Hardware Utilities function (see Appendix C). Any compass calibrations performed during the measurement session will be accessible through this dialog, as shown in Figure 92. To add compass calibration files from a different measurement session, click the Import button.

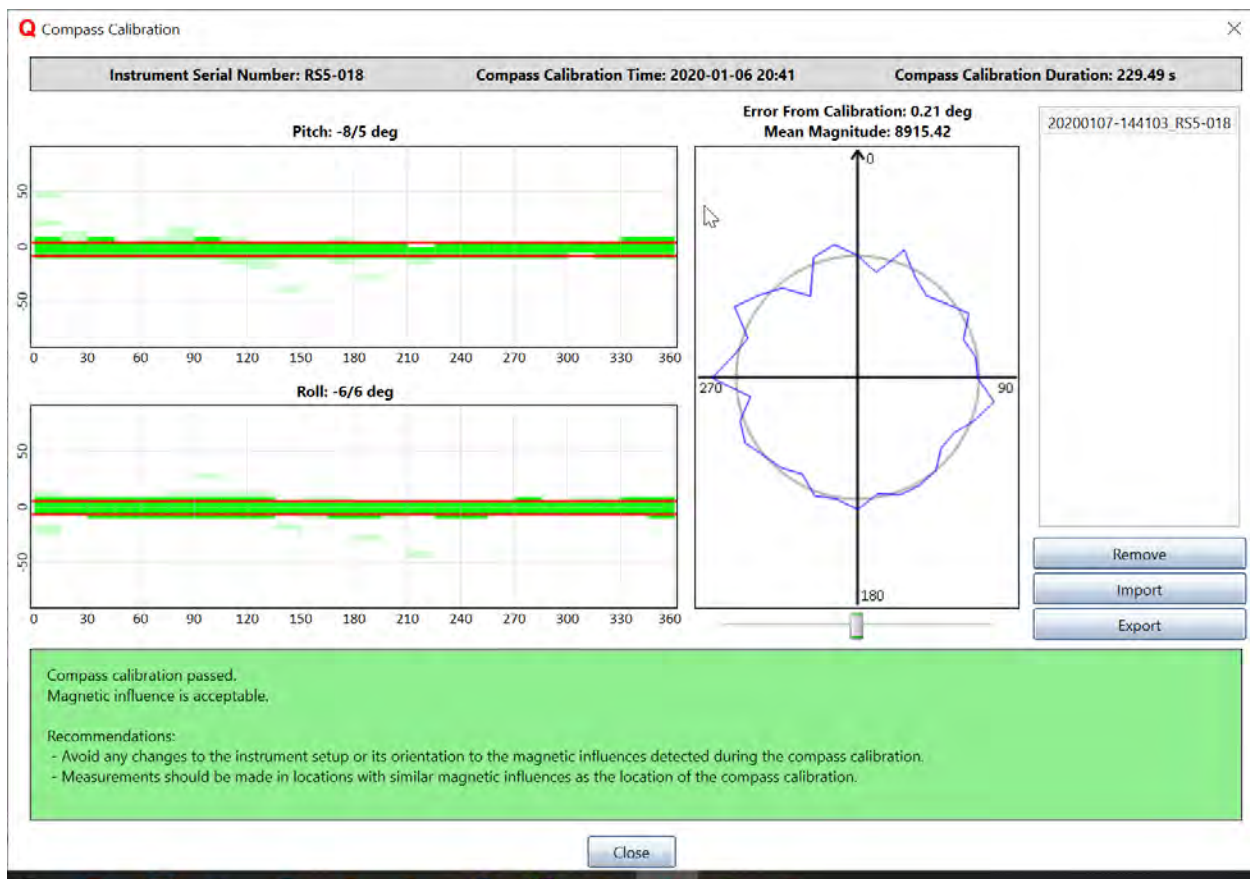


Figure 92. Compass Calibration Files

The export function creates a compass calibration file from the selected compass calibration to save elsewhere on the user's computer.

7.14. Saving and Closing a Measurement

To save and close the current measurement, click the Finish button, shown in Figure 93.

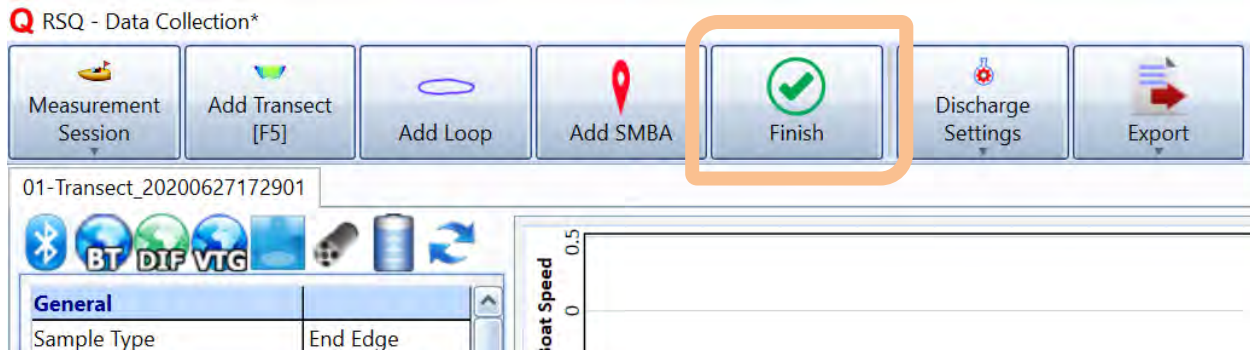


Figure 93. Finish the Measurement

The user will be prompted to save the file through a dialog, at which point the user can modify the destination and automatic naming that is chosen by the software. Once done, click **Save** to record the data file. The .rsqmb file structure is described in detail in Section 8.1.

Section 8. Data Review and Post-Processing – Moving Boat

This portion of the manual will outline how to perform various post-processing operations on data files. Please review the RSQ software layout and data collection procedures covered in Section 6 and Section 7, as the software layout is the same for post-processing, with a few additional features.

Please note that the RSQ software can open one data file at a time. To open multiple files, the user can run another instance of the RSQ software.

8.1. RS5 Data File Format

The RS5 data format consists of one single .rsqmb (RSQ Moving Boat) file for each measurement session. This file contains all associated files and information, including moving bed tests, transects, compass calibrations, beam checks, site photos, and any other data.

8.2. Opening RS5 Data Files

From the main toolbar, select “Open File” (shown in Figure 94), and browse to the location of the desired measurement file. Note that active data collection must be completed to view completed measurements.

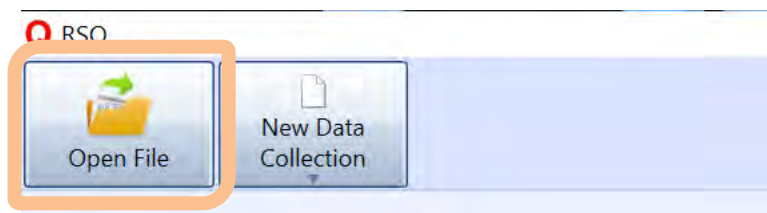


Figure 94. Open File

All transects and moving bed tests will be displayed as clickable tabs under the main toolbar, as indicated in Figure 95.

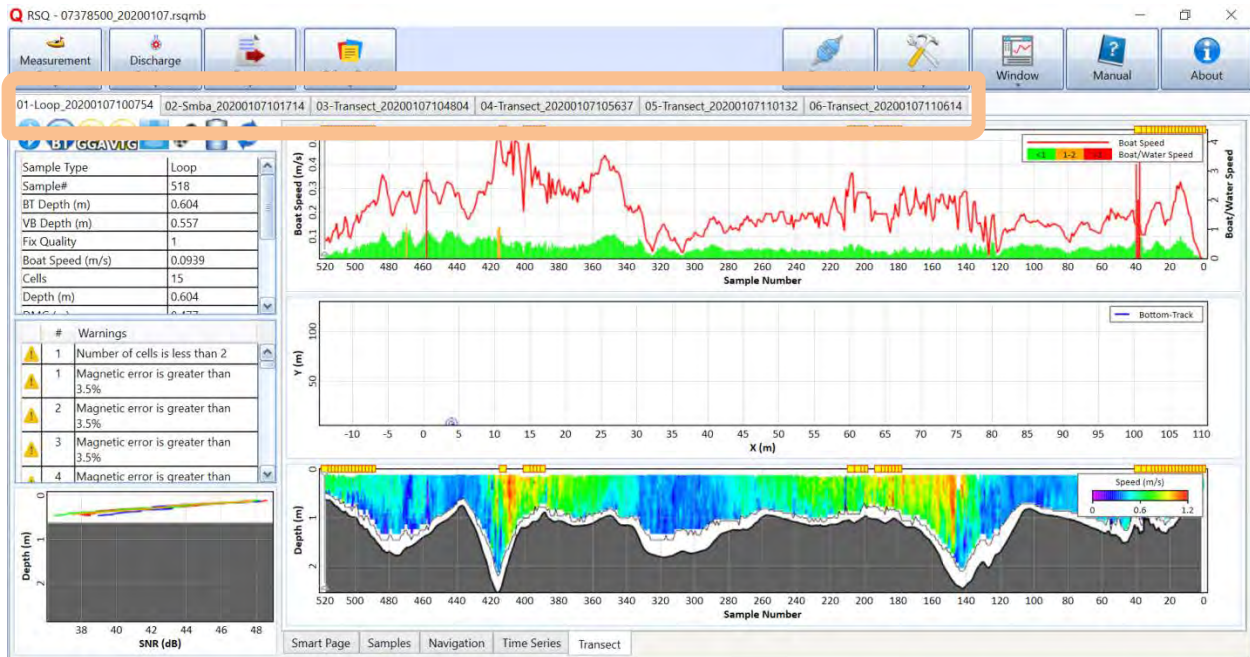


Figure 95. View Data

As with measurement collection, different data tabs along the bottom of the screen allow the user to view different variables. The different data tabs and how to plot different variables is described in Section 6.5.8.

8.3. Opening RiverSurveyor M9/S5 Data Files

The RSQ software is also capable of opening and post-processing files from the RiverSurveyor M9 or S5. To do this, hold down the **SHIFT** key while clicking the Open File button.

8.4. Data Review/Processing View

After opening a data file, the data review and processing layout of the RSQ software, shown in Figure 96, is nearly identical to the data collection view.



Figure 96. Data Review and Processing View

The data file's name will appear on the top of the software screen, and separate tabs can be available for all moving bed and transects (see Appendix B to enable or disable these tabs). The QA/QC Warnings window, Toolbox, and Discharge Summary can be viewed by either clicking the Window button or by using the hot keys outlined in Section 6.7.

8.5. Measurement Session Options

This session describes the various functions under the Measurement Session button, highlighted in Figure 97.

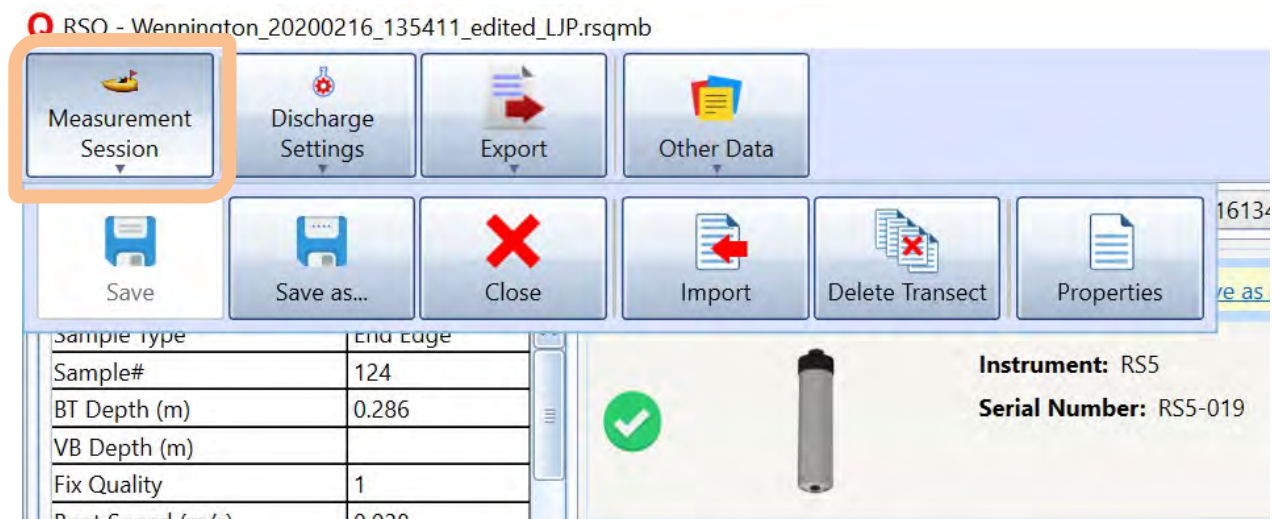


Figure 97. Measurement Session Button

8.5.1 Save

If any changes have been made to the original .rsqmb file, the Save option will be activated, allowing the user to save the file with the current changes. The original .rsqmb file will always be preserved, and clicking the Save button from an original file will prompt the warning shown in **Error! Reference source not found..**

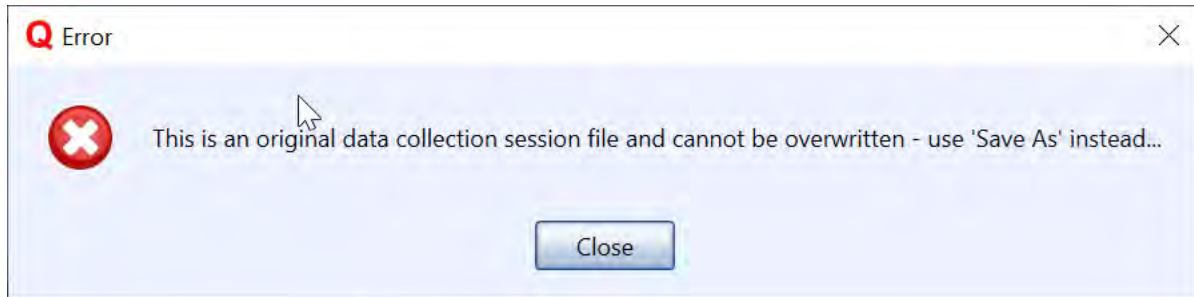


Figure 98. Save Warning

If the user has opened an edited file, the Save option will overwrite that edited file automatically.

8.5.2 Save As...

The Save As button should be used when saving edits during post-processing. The RSQ software will automatically create a file name with “_edited” appended in the file name, but the user has the choice to change it.

8.5.3 Close

The Close button closes the current file that is being viewed.

8.5.4 Import

The Import function allows the user to import transects from another measurement session to the current measurement session. Once the user chooses the measurement file they wish to import from, individual transects from that measurement will be displayed, as shown in **Error! Reference source not found..** Select one transect by clicking on it, or select multiple transects by holding down the **SHIFT** key while clicking.

The imported transects will be added to the right of the last transect in the current measurement session and renamed to follow the numerical order of the transects in the current measurement.

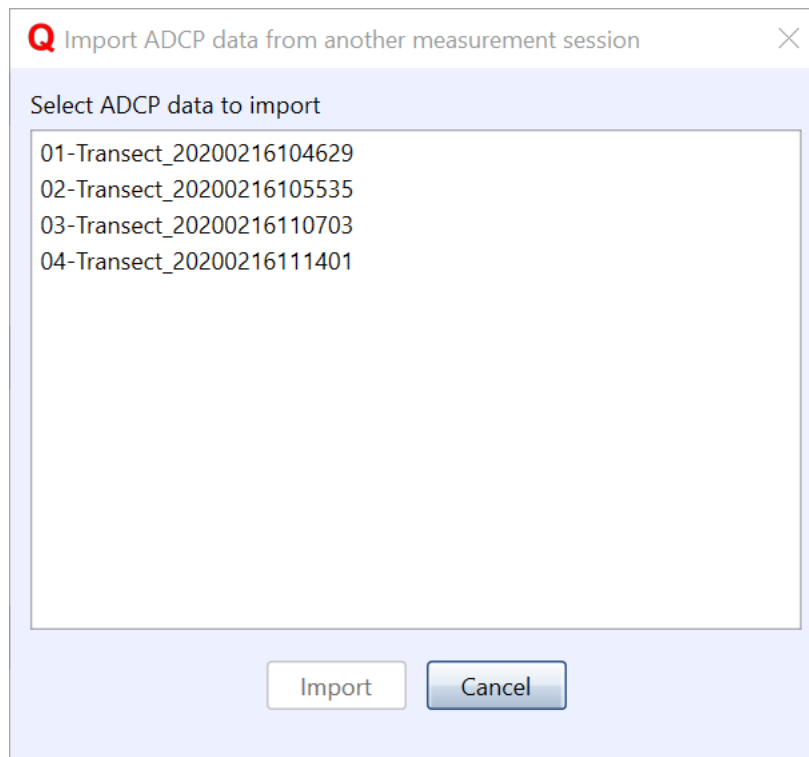


Figure 99. Import Transects

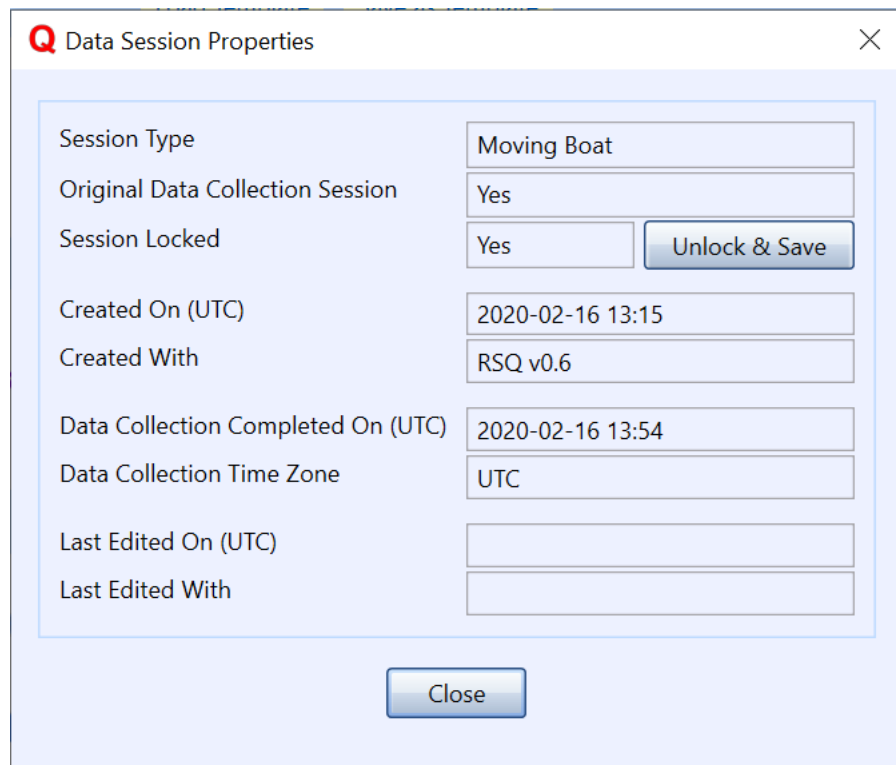
8.5.5 Delete Transect

The Delete Transect function deletes the current transect being viewed from the measurement. A warning will appear before the deletion is performed.

8.5.6 Properties

The Properties button shows information about the current data file (**Error! Reference source not found.**). The following information is displayed:

- Session Type – Moving Boat or Stationary (coming soon)
- Original Data Collection Session – Yes if this is the original data file during data collection
- Session Locked – ability to lock or unlock and save the current file
- Created On (UTC-offset) – time (UTC-offset) when file was created
- Create With – RSQ software version that created the file
- Data Collection Completed On (UTC-offset) – time (UTC-offset) when measurement was finished
- Data Collection Time Zone – UTC-offset
- Last Edited On (UTC-offset) – time when file was last saved
- Last Edited With – RSQ software version that edited the file



Data Session Properties

Session Type	Moving Boat
Original Data Collection Session	Yes
Session Locked	Yes Unlock & Save
Created On (UTC)	2020-02-16 13:15
Created With	RSQ v0.6
Data Collection Completed On (UTC)	2020-02-16 13:54
Data Collection Time Zone	UTC
Last Edited On (UTC)	
Last Edited With	

Close

Figure 100. Data Session Properties

8.6. Discharge Settings

The following features are available from the Discharge Settings button, shown in Figure 101.

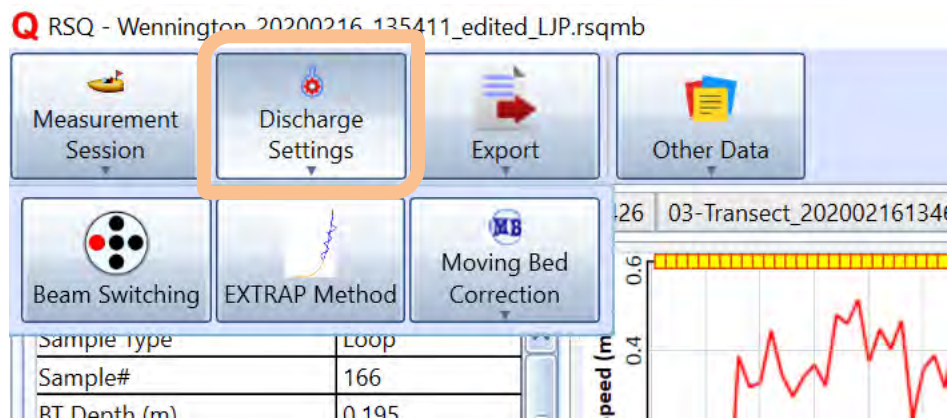


Figure 101. Discharge Settings

8.6.1 Beam Switching

Beam switching is a new feature that allows the user to 'turn off' one beam for velocity calculations. This feature is particularly useful when one beam shows interference that causes bad data. An example of this interference is when one beam is hitting a wall as

the ADP approaches a vertical bank. Because the velocity processing normally requires all 4 beams, if one beam hits a bank before the other beams, it will cut off profiles at a shallower location to avoid data contamination, causing a sloping shoring of data, like the example shown in Figure 102.

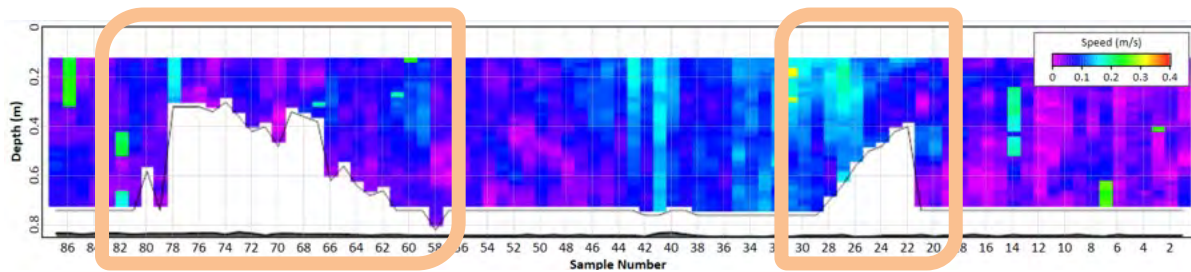


Figure 102. Sloping profile data as one beam hits a vertical wall

Using this data example, the beam switching tool can remove the bad beam from the dataset and use a 3-beam solution to calculate velocities. Opening the beam switching tool will show the dialog in Figure 103.

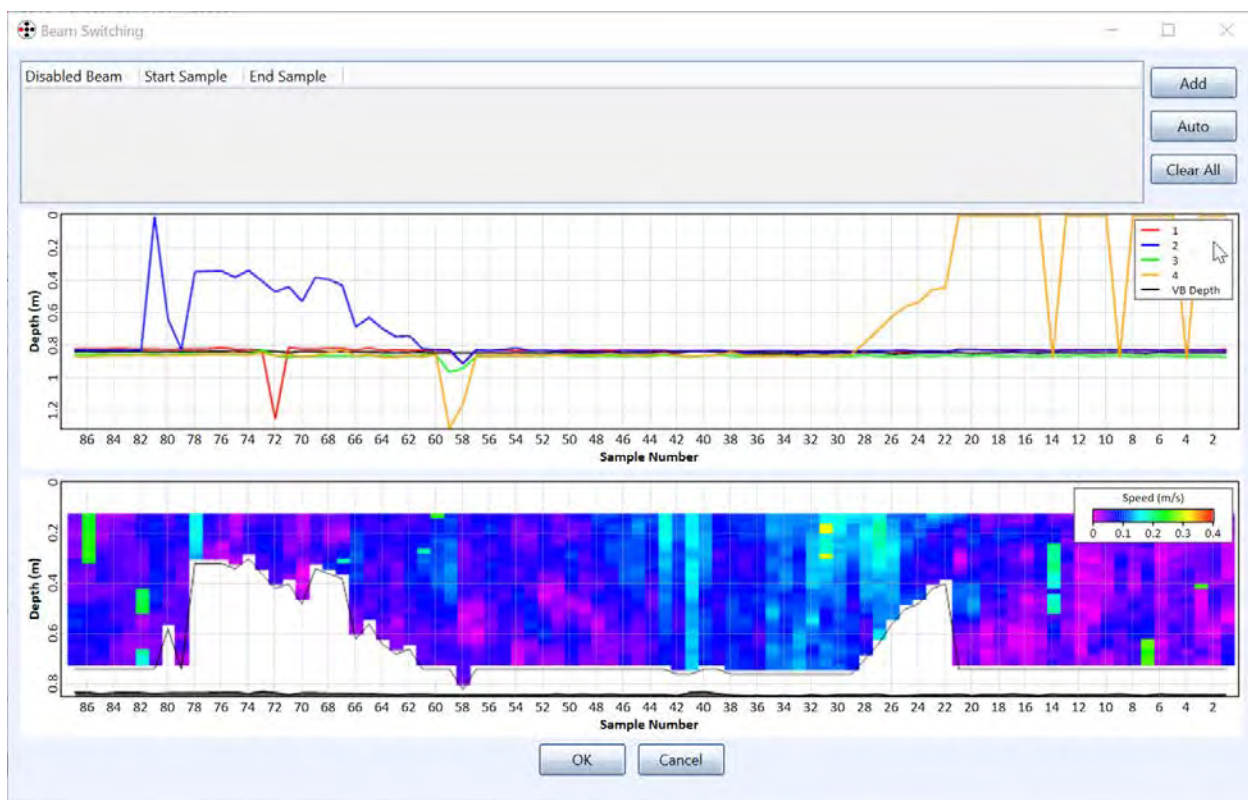


Figure 103. Beam Switching Dialog

From the beam switching dialog, the user can see what beam is hitting an obstacle. In the example in Figure 103, the beam depth plot (middle plot) shows obvious interference from Beam 2 (blue) near the left bank and Beam 4 (yellow) near the right bank. The user can create two different beam switching “sections” to correct these areas.

Clicking the Add button produces the dialog in Figure 104.

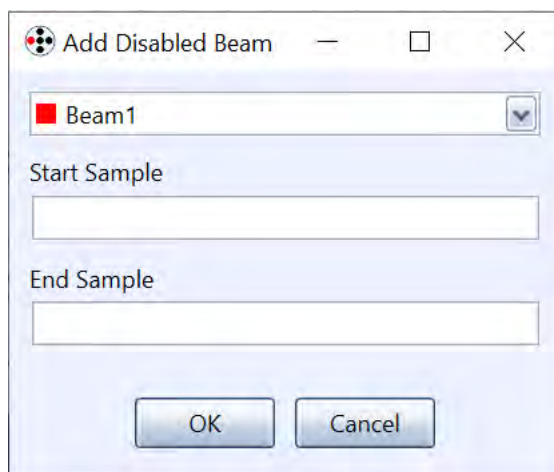


Figure 104. Beam Switching One Section

In the example above, the user would disable Beam 2 between samples 56 and 84, as shown in Figure 105.

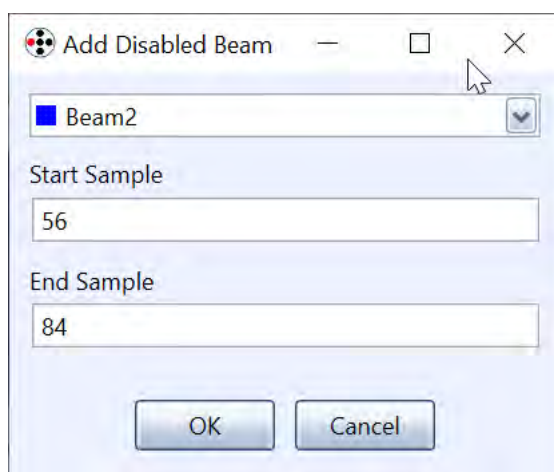


Figure 105. Beam Switching to disable Beam 2

Clicking OK results in the updated profile shown in Figure 106. The section where Beam 2 is disabled is shown with dotted lines in the middle depth plot, and the velocity profile plot (bottom) is updated with the 3-beam solution in the area where originally Beam 2 had interference.

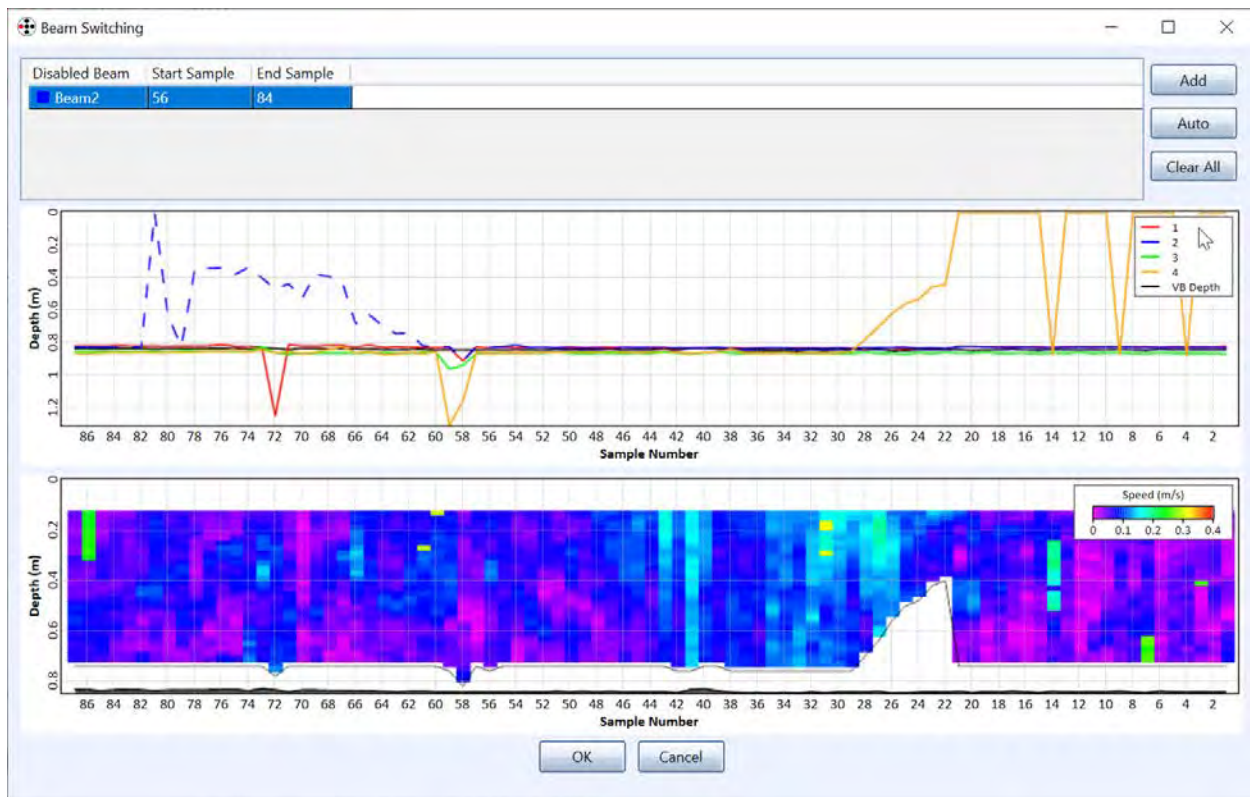


Figure 106. Beam Switching Result of Removing Beam 2

Adding another “section” for Beam 4 between samples 20 and 30 results in the data view shown in Figure 107.

The “Auto” button attempts an algorithm to automatically determine where beams should be disabled, and is still in development.

The “Clear All” button removes all sections for beam switching.

Once the user is satisfied with results, clicking OK will apply the beam switching choices to the transect.

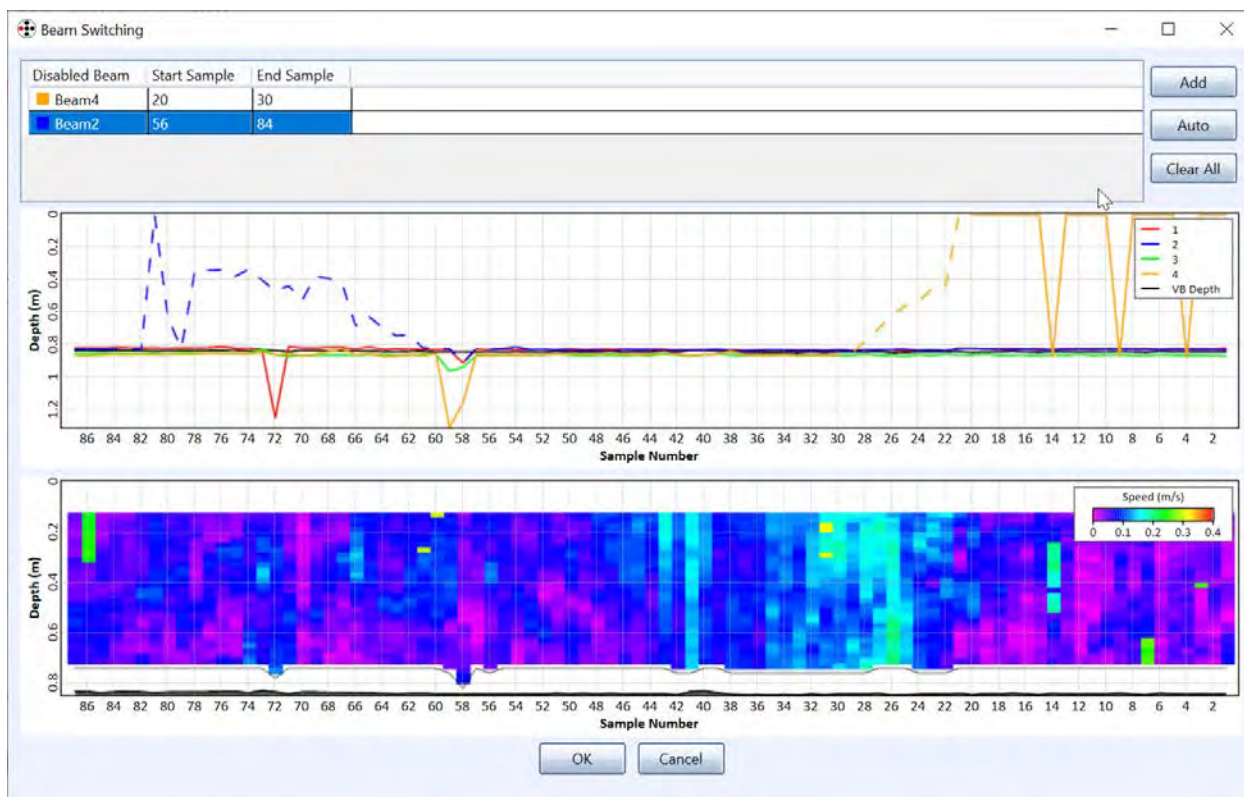


Figure 107. Beam Switching Result from Disabling Beams 2 and 4

8.6.2 Using EXTRAP (USGS)

The USGS created a tool called EXTRAP (<https://hydroacoustics.usgs.gov/movingboat/extrap1.shtml>) to standardize the choice of top and bottom extrapolations based on objective statistics from the measurement data. Due to the usefulness and popularity of the tool, the RSQ software is able to apply this tool directly from its interface. Clicking the EXTRAP Method button loads the EXTRAP interface, as shown in Figure 108.

The user is directed to the documentation on EXTRAP User's Guide (https://hydroacoustics.usgs.gov/movingboat/pdfs/extrap_3_x_Users_Guide.pdf) for details on the calculations performed.

After EXTRAP is used to choose the proper top and bottom extrapolations, the user can either apply the extrapolation to the current transect ("Apply to Selected") or apply to the entire measurement ("Apply to All").

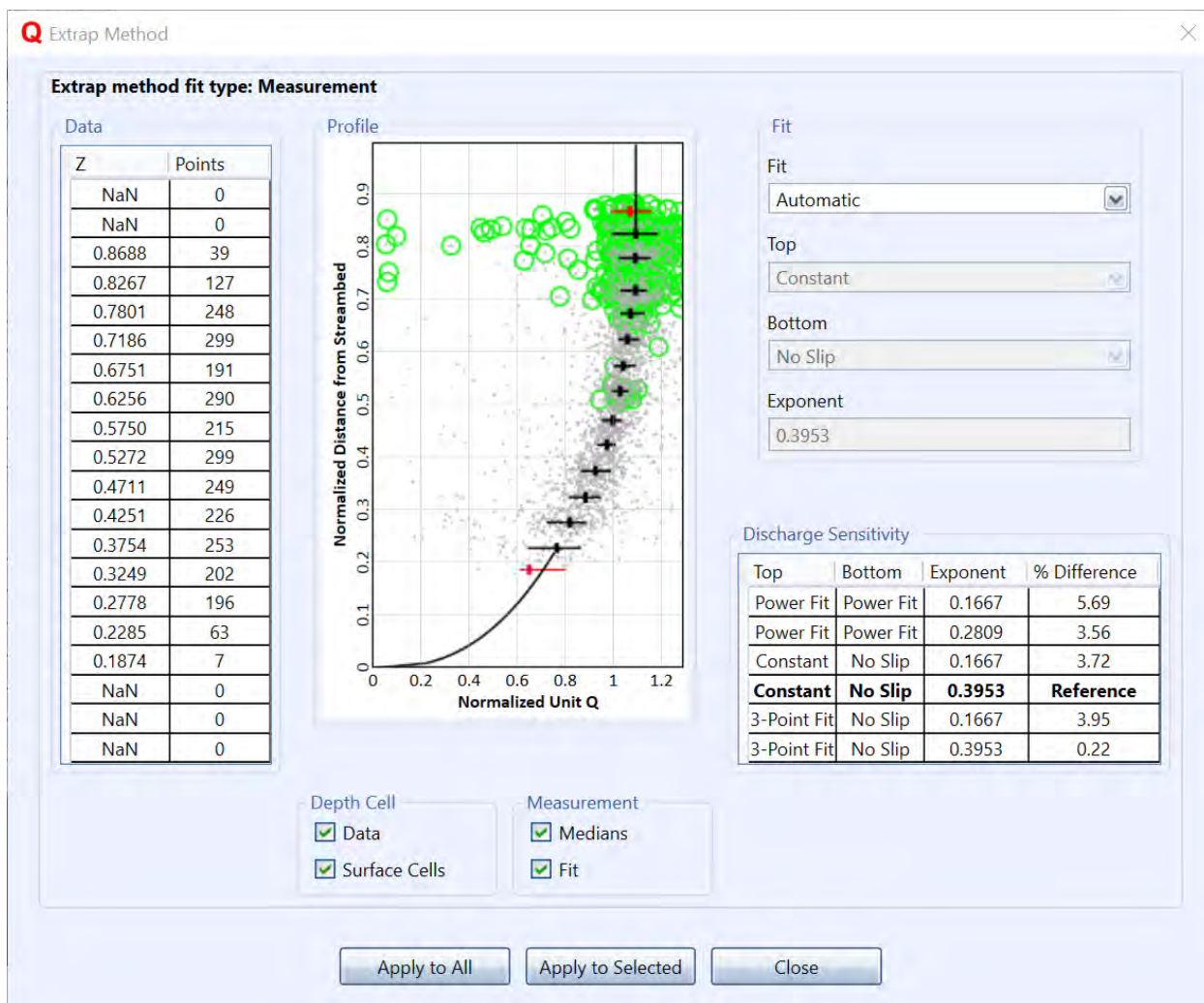


Figure 108. EXTRAP Method

8.6.3 Moving Bed Correction

If moving bed tests were performed during the measurement, they will be available under the Moving Bed Correction button. The user can select either Loop measurements or SMBA measurements.

Choosing the Loop Method will open the dialog shown in Figure 109. If more than one Loop measurement exists, the user can select which file to use in the Loop correction from the Loop Method Files drop-down list at the top. If the Loop measurement indicates a moving bed, the user will be alerted (highlighted in Figure 109), and a correction to discharge values can be made on any transects checked in the bottom box. Hit the Apply button to apply the Loop correction to the transects desired. This option will not appear if the Loop measurement does not indicate a moving bed.

Q Loop Method

Loop Method Files	01-Loop_20200107100754
Distance Made Good (m)	8.477
Loop Time (seconds)	517
Moving Bed Velocity (m/s)	0.0164
Flow Velocity (m/s)	0.5724
Moving Bed Direction (deg)	27.5
Flow Direction (deg)	206.78
Estimated Percent Correction (%)	2.86
Percent Bad Bottom Track (%)	3.47

Difference in flow direction between out and back sections: 1.46 deg.

Loop indicates a moving-bed - select transects to be corrected

- ☒ 03-Transect20200107104804
- ☒ 04-Transect20200107105637
- ☒ 05-Transect20200107110132
- ☒ 06-Transect20200107110614

Apply Close

Figure 109. Loop Method Dialog in Post-Processing

If an SMBA Moving Bed Test exists, it can be accessed by clicking the SMBA Method button, which will bring up the dialog shown in Figure 110. If a correction for the discharge is suggested from the SMBA measurement, the transects to apply the correction can be checked. Hit the Apply button to apply the correction.

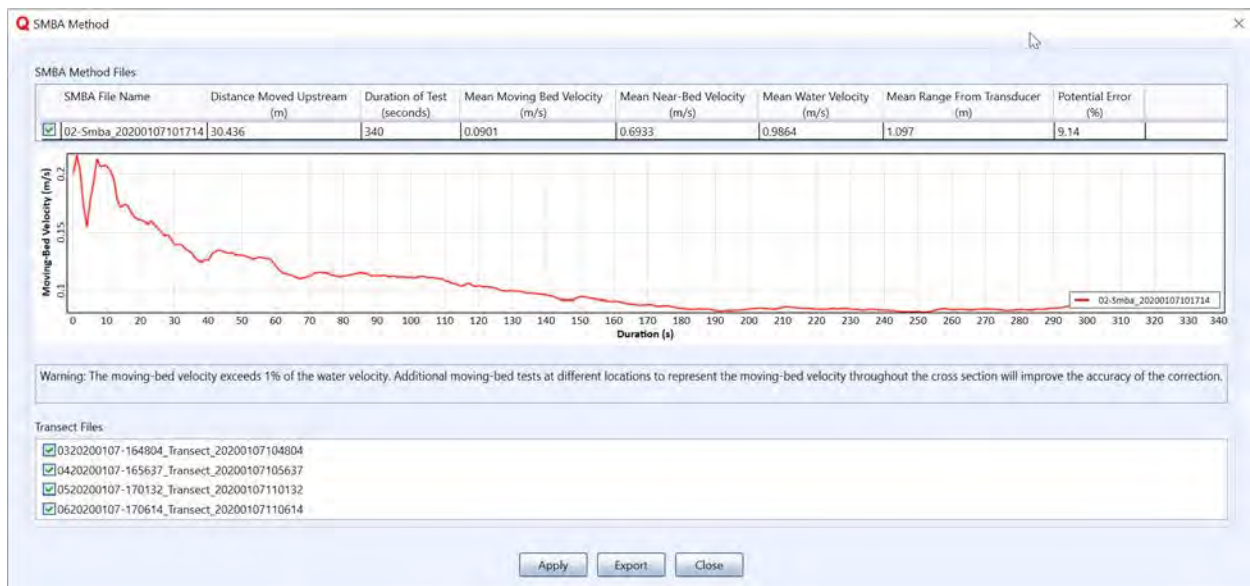


Figure 110. SMBA Method in Post-Processing

8.7. Data Export

RSQ offers a variety of different data export formats, all which can be accessed through the Export button, shown in Figure 111. Each of the options is described in the following sections.

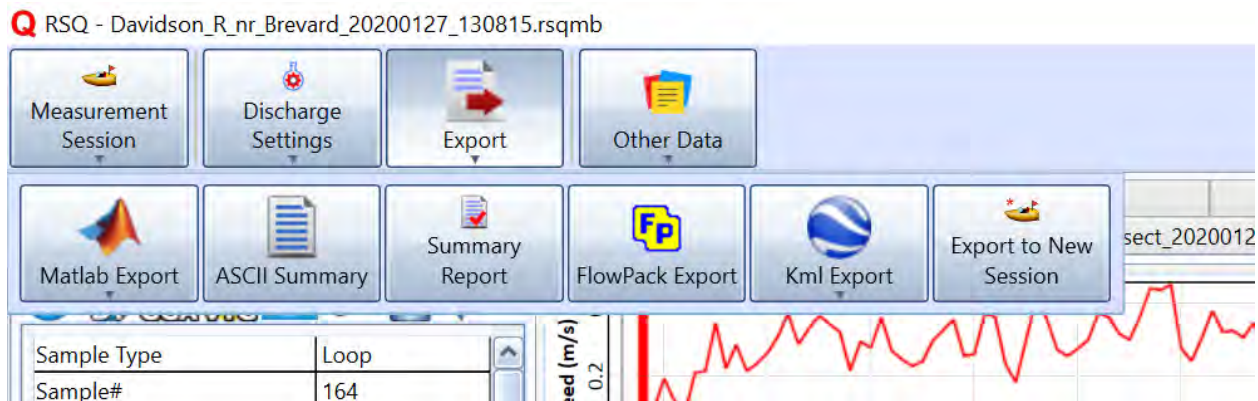


Figure 111. Export Options

8.7.1 Matlab Export (for QRev)

The Matlab Export tool exports the .rsqmb to .mat files for post-processing in Matlab and formatted for QRev. QRev is a USGS developed software available here: <https://hydroacoustics.usgs.gov/movingboat/QRev.shtml>. The file structure mimics that of the Matlab export for the RiverSurveyor M9/S5 to make the import to QRev simpler.

Clicking the Matlab Export button allows the user to choose to export the current transect or all transects. If All is selected, RSQ will create a new folder in the same

location as the .rsqmb file containing the Matlab exported files, like the example shown in Figure 112.

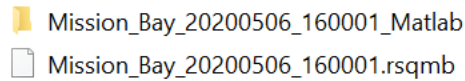


Figure 112. Original .rsqmb file (bottom) and new folder created by Matlab Export (top)

Within the Matlab folder, the files will have the structure shown in Figure 113.

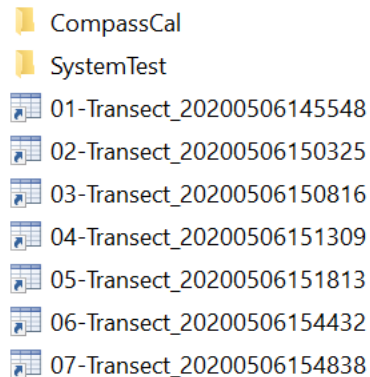


Figure 113. Matlab Export Folder Containing Files

System Test and Compass Calibration files are stored in a separate folder, and individual transects and moving bed measurements are separated into individual .mat files. The structure of the .mat files is outlined in Appendix E.

Please note that if a compass calibration was not performed during a measurement, there will be no compass calibration folder exported. This can occur if multiple measurements are performed at the same site, but only one compass calibration was performed prior to all the measurements. In this case, the user can manually add a compass calibration to a measurement by using the Other Data function (see Section 7.13.3).

8.7.2 ASCII Summary

The ASCII Summary exports the measurement summary to an ASCII file with a .dis extension. This file can be opened by any ASCII reader (like Notepad, for example). The user can choose the name of the file and the location to save it. General configuration information from the Smart Page will be included, along with the following summary parameters for each transect:

- File Name
- Start Edge (left or right)
- Start Time
- Duration

- Track
- DMG
- Width
- Area
- Boat Speed
- Mean Speed
- Left Q
- Right Q
- Top Q
- Middle Q
- Bottom Q
- Total Q
- Moving Bed Corrected Q
- % Measured

8.7.3 Summary Report

Exporting the Summary Report generates the detailed report shown in Figure 114, which will automatically open. The report contains summaries of various values, and can contain plots of the depth, pitch/roll, boat speed/direction, track, and speed contour plots for each transect. To configure what charts are included in the Summary Report, please see Appendix B.

Pressing the Print button on the bottom allows the user to either print the report or save it as a .pdf file.

Q Discharge Measurement Summary Report

Discharge Measurement Summary

Date Measured: 2020-01-27

Site Information				Measurement Information			
Site Name		Davidson R nr Brevard		Operator		AFO	
Station Number		03441000		Vessel			
Location				Measurement Number		1052	

System Information		System Setup		Units	
Instrument Type	RS2	Transducer Depth (m)	0.052	Distance	m
Instrument Sub-Type	RS5	Screening Distance (m)	0	Velocity	m/s
Serial Number	RS5-0	Salinity (PSS-78)	0	Area	m ²
	09	Magnetic Declination (deg)	-6.6	Discharge	m ³ /s
Firmware Version	0.90			Temperature	°C

Discharge Calculation Settings				Discharge Results	
Track Reference	Bottom-Track	Left Method	Slope	Width (m)	18.862
Depth Reference	Vertical Beam	Right Method	Slope	Area (m ²)	13.893
Coordinate System	ENU	Top Fit Type	Power Fit		74
Moving Bed	None	Bottom Fit Type	Power Fit	Mean Speed (m/s)	0.5135
Correction				Total Q (m ³ /s)	7.1334
				Max Depth (m)	1.184
				Max Speed (m/s)	0.9525

Measurement Results																	
Tr #		Start Time (UTC-8)	Duration	Track Distance (m)	DMG (m)	Width (m)	Area (m ²)	Boat Speed (m/s)	Mean Speed (m/s)	Left Q (m ³ /s)	Right Q (m ³ /s)	Top Q (m ³ /s)	Bottom Q (m ³ /s)	Middle Q (m ³ /s)	Total Q (m ³ /s)	Total Q Corrected (m ³ /s)	% Measured
04	R	12:39:20	00:02:19	18.001	16.831	18.66	13.70312	0.1286	0.5354	0.0364	0.0252	1.2984	1.369	4.6077	7.3367		62.8
05	L	12:44:56	00:02:18	19.575	17.871	19.395	13.97727	0.1408	0.5038	0.0338	0.0006	1.2167	1.138	4.6531	7.0422		66.07
06	R	12:49:12	00:02:28	18.875	17.432	18.956	14.0459	0.1267	0.51	0.034	0.0017	1.3034	1.262	4.5625	7.1636		63.69
07	L	12:52:01	00:02:18	18.583	17.484	19.008	14.0571	0.1337	0.5011	0.0346	0.0039	1.229	1.1441	4.6321	7.0437		65.76
08	R	12:54:37	00:02:34	18.918	17.609	19.133	13.87553	0.1221	0.5224	0.0347	0.0028	1.2566	1.3092	4.6459	7.2492		64.09
09	L	12:57:20	00:02:05	18.328	17.259	18.783	13.92769	0.1455	0.5128	0.0326	0.0126	1.2786	1.1702	4.6486	7.1426		65.08
10	R	13:01:48	00:02:33	17.915	17.001	18.525	13.77972	0.1163	0.5067	0.0405	0.0119	1.2108	1.2092	4.5104	6.9827		64.59
11	L	13:04:36	00:02:09	17.647	16.91	18.434	13.78357	0.1357	0.5156	0.0429	0.0119	1.2136	1.1691	4.6692	7.1066		65.7
Mean				18.48	17.3	18.862	13.89374	0.1312	0.5135	0.0362	0.0088	1.2509	1.2213	4.6162	7.1334	0	64.72

Figure 114. Summary Report

8.7.4 FlowPack Export

Choosing the FlowPack Export will create a .CSV (comma-separated-value) file that can be imported to the SonTek FlowPack software

(<https://www.sontek.com/software/detail.php?FlowPack-Software-7>) for creating Index Velocity Ratings. The structure of the file is shown in the example file in Figure 115.

Year	Month	Day	Hour	Minute	Seconds	Duration (s)	Discharge (m3/s)
2020	1	27	20	39	20	139	7.3367
2020	1	27	20	44	56	138	7.0422
2020	1	27	20	49	12	148	7.1636
2020	1	27	20	52	1	138	7.0437
2020	1	27	20	54	37	154	7.2492
2020	1	27	20	57	20	125	7.1426
2020	1	27	21	1	48	153	6.9827
2020	1	27	21	4	36	129	7.1066

Figure 115. Example of FlowPack Export .CSV File Format

8.7.5 KML

The KML export creates a .KML file containing the vessel tracks and automatically open Google Earth if it is installed on the laptop. The user has the option to export only the current transect or all transects in the measurement. Note that files will be geo-located only if the RS5-Max (with GNSS/GPS option) is used. Bottom-track track lines will be plotted starting at the same position as GNSS/GPS tracks. An example of the exported tracks is shown in Figure 116. The individual transects and different track options can be activated or deactivated using the left navigation pane in Google Earth.

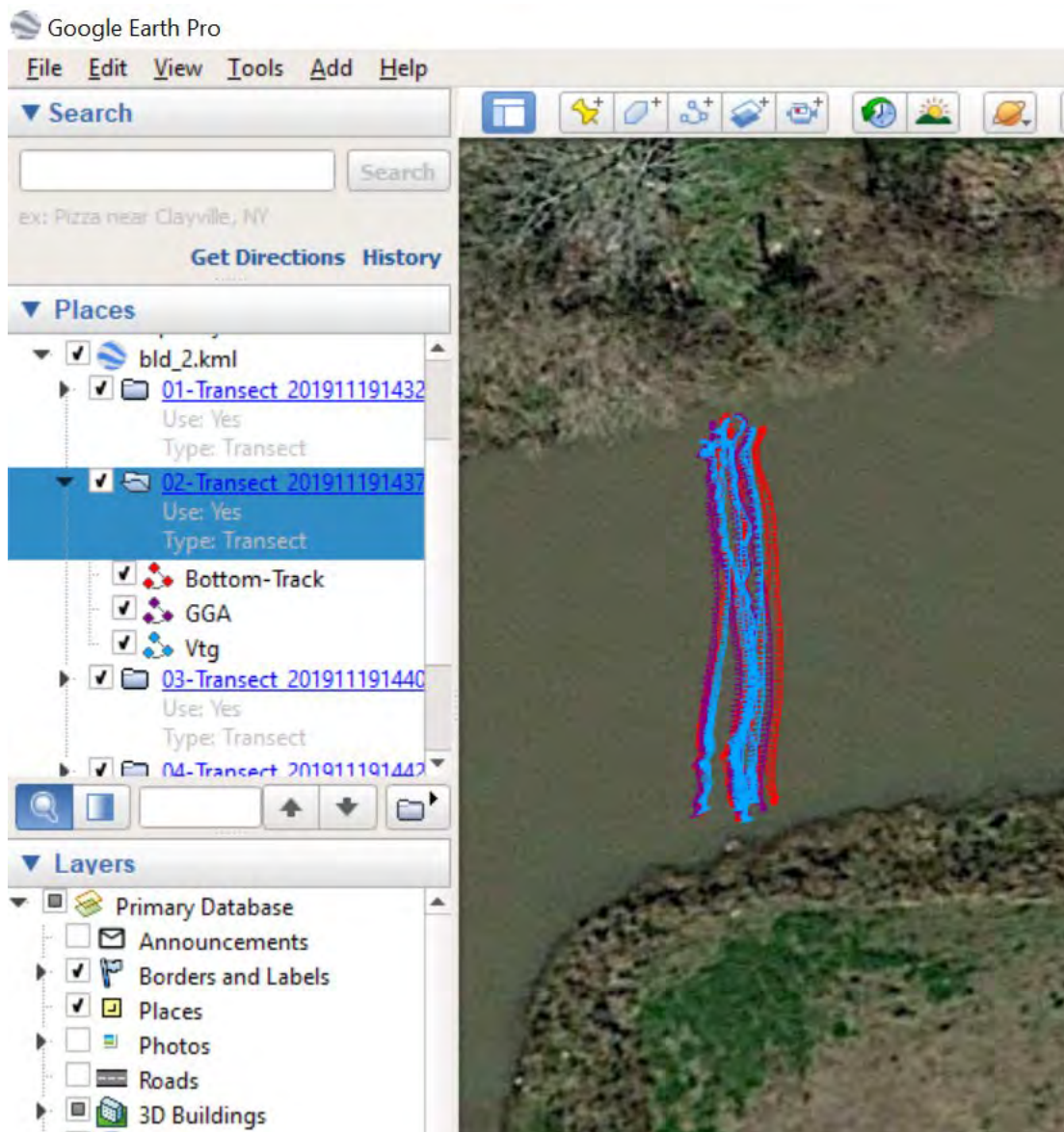


Figure 116. Sample KML Export Showing All Transects of a Measurement

8.7.6 Export to New Session

The Export to New Session function allows the user to create a new measurement file from existing transects in the current measurement. An example of the dialog is shown in Figure 117. The user can select one transect by clicking on it, or multiple transects by holding down the **SHIFT** key and clicking. Clicking the **Export** button will prompt the user to choose a name for the new .rsqmb file that will be created with the desired transects.

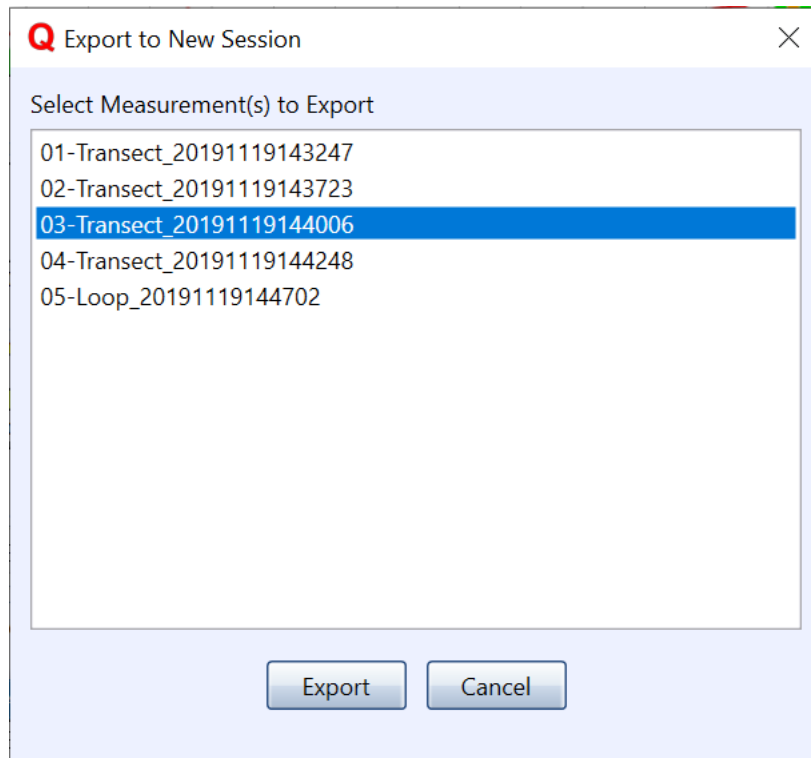


Figure 117. Export to New Session Dialog

8.8. Other Data

Other data from the measurement (site photos, beam check files, and compass calibration files) can be viewed from the Other Data button. The functionality and descriptions of the data can be found in Section 7.13.

8.9. Toolbox

The post-processing Toolbox allows the user to enter or modify settings from the Smart Page conveniently. The Toolbox can be activated by either selecting it from the Window button (main toolbar) or using **[CTRL+T]**. This will activate the Toolbox window shown in Figure 118

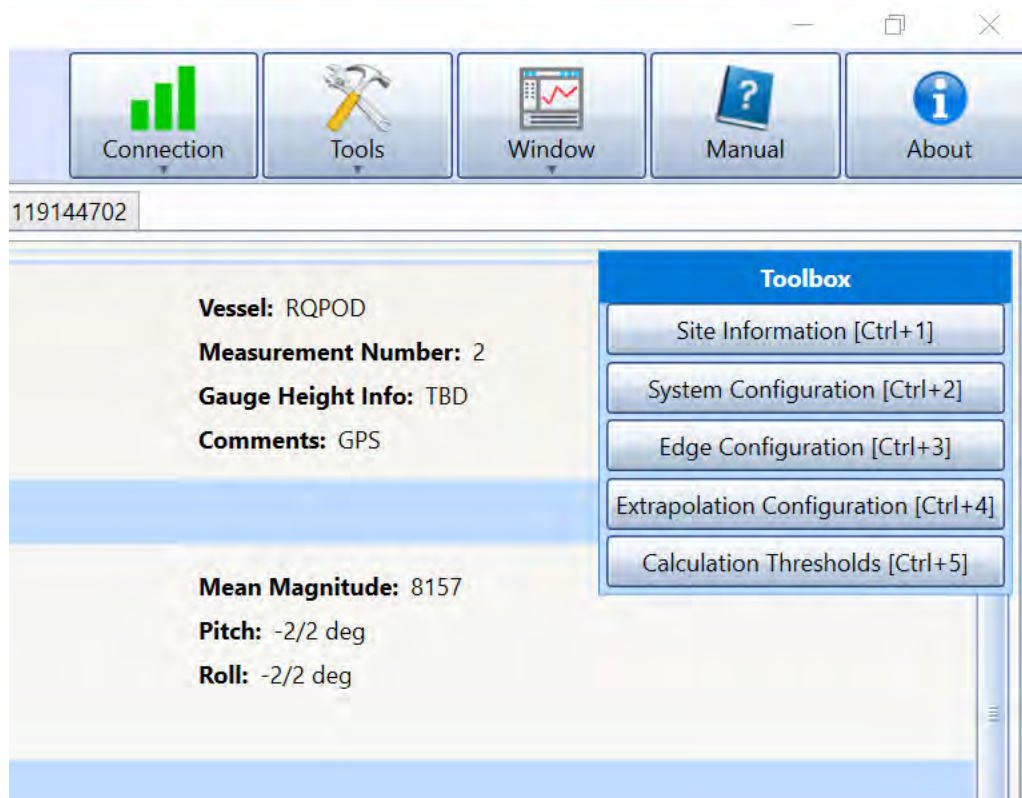


Figure 118. Post-Processing Toolbox

Individual categories can either be selected by clicking them or using the hot keys. They include:

- Editing Site Information **[CTRL+1]**
- Editing System Configuration **[CTRL+2]**
- Editing Edge Configuration **[CTRL+3]**
- Editing Extrapolation Configuration **[CTRL+4]**
- Editing Calculation Thresholds **[CTRL+5]**

All settings in the Toolbox can be changed by using the Smart Page in post-processing as well. Changes made to these settings will be reflected in all data and calculations as they are applied in the software. Each setting and category is described in detail in Section 7.5.

8.10. Reset to Field Settings

To reset the measurement to field settings, first, show the Discharge Summary (**CTRL+S**). **Right-clicking** anywhere in the Discharge Summary panel will show the “Reset to field settings” function (see Figure 119).

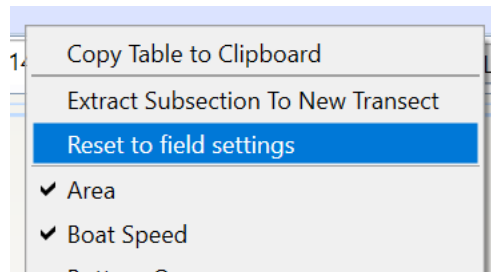


Figure 119. Reset to Field Settings

8.11. Extract Subsection to New Transect

Some users may wish to take a subsection of a transect and save that as a new transect. The benefit of this is that all calculations, including final discharge, will be recalculated for that subsection only. To do this, **right-click** on the line of the transect the user wishes to subsection in the Discharge Summary panel (**CTRL+S**) and select “Extract Subsection to New Transect” (Figure 120).

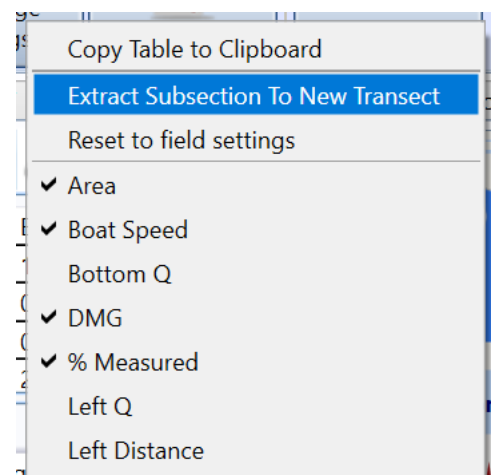


Figure 120. Extract Subsection to New Transect

The Extract to Subsection dialog will appear, shown in Figure 121.

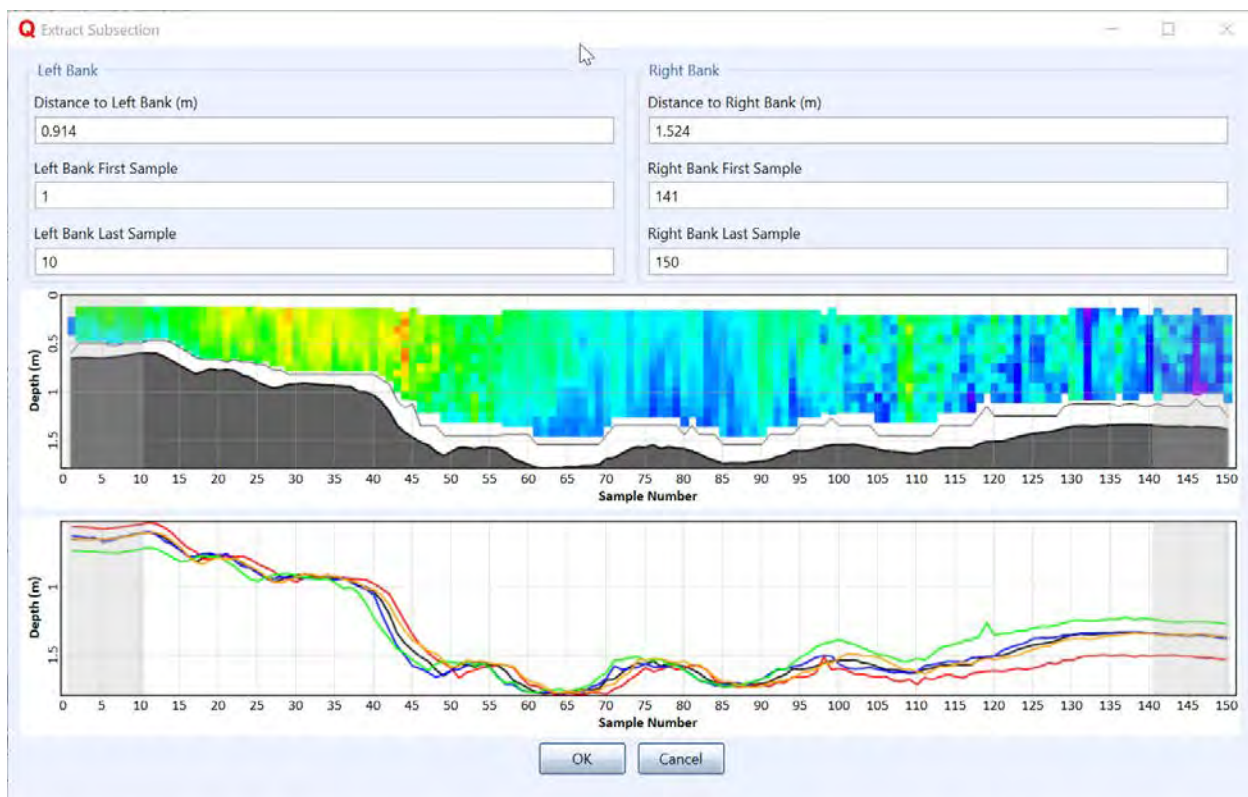


Figure 121. Extract Subsection Dialog

The dialog requires the user to define new left and right bank edges, which are shown visually with grey areas. The edge definition is required in order to perform proper discharge calculations on the subsectioned data. The example shown in Figure 122 depicts a subsectioned region that will have:

- Left edge between samples 40 and 50
- Transect between samples 51 and 94
- Right edge between samples 95 and 105

Clicking OK will create a new transect that will appear at the end of the transect list in the current measurement session with new parameters calculated, including final discharge.

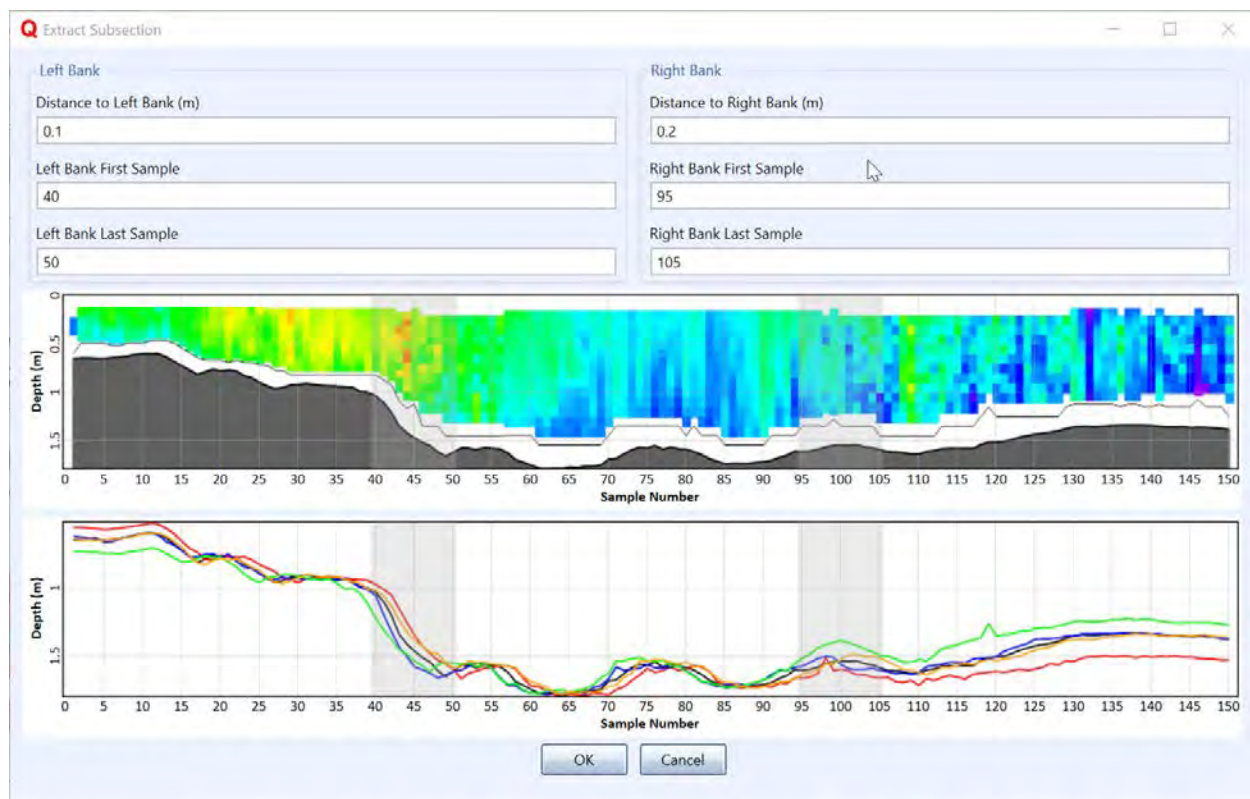


Figure 122. Extract Subsection Example

8.12. Data Processing Suggestions and Tips

This section outlines steps suggested by experienced field Hydrologists for processing data files. The following contains suggestions only, and each measurement will require steps specific to that site, setup, and data collection. Please use these steps as a guide only.

1. Review the System Settings. Be sure that the settings are consistent among transects and if not, they differ for a known reason.
2. If necessary, change the Track and Depth reference to best represent the highest quality field measurement.
3. Select the Navigation or Transect tab to evaluate the collected data across the channel.
4. Use the Sidebar tabular data or Samples tab to evaluate specific settings (i.e. Duration of the measurement, GPS Quality).
5. Visually review each measurement by clicking on each tab or by using CTRL+Tab
6. Evaluate Bottom Track vs. GPS (if applicable) to observe any compass, GPS or moving bed issues.
7. Make sure the magnetic declination is set appropriately for the site (the default setting is zero).
8. Make sure that the GC-BC (angle of average GPS course since start of transect minus ADP bottom-track course; value near 0 is desired) is less than 2 degrees

- and the D(BT)/D(GPS) (Ratio of Bottom Track track distance to GPS track distance) is approximately 1.
9. If using GPS, make sure the number of GPS satellites is good and the GPS quality is valid.
 10. On the Transect tab, evaluate different plots by right-clicking on the vertical axes.
 11. Plot the depth measured by the Vertical Beam as well as Bottom Track depth. Make sure the VB and BT depth scales are the same. Check for any major discrepancies.
 12. Evaluate Boat Speed and Water speed plotted on the same graph. Ideally, the Boat speed should not exceed the water speed where possible.
 13. Make sure that Heading/Pitch/Roll and Temperature are relatively constant.
 14. Verify that the SNR data and beams are valid with special focus on the edges and shallow water.
 15. Verify water velocity in ENU: U (up) and D (Error Velocity) should be close to zero.
 16. Make sure that discharge curve and profile extrapolation is applicable (using Processing Toolbox – Profile Extrapolation).
 17. Verify that the SNRs are valid for the contour (graph at the bottom).
 18. Verify that the velocity cell cutoff on the contour plot is valid, also look at the screening distance and make sure that is graphically correct.
 19. In the Discharge Measurement Summary make sure that:
 - References and Coordinates should be the same
 - Starting edges should alternate
 - Date/times should be consecutive
 - Duration of measurements should be similar
 - Use the Statistics to identify any outliers
 - Channel width and discharge areas should be similar
 - Uncheck or delete problematic records

Section 9. RSQ for PC – Stationary

9.1. Overview – RSQ Stationary Software for PC

This section describes the RSQ software for RS5 data collection, viewing, and post-processing for Stationary measurements. Many aspects of the software will be a repeat for Moving Boat measurements (see Section 6), but they are all documented here for completeness. Please see Section 6.1 for details on the software requirements. The software includes everything needed to make real-time Stationary discharge measurements as well as post-process the data. Additionally, RSQ is capable of post-processing RiverSurveyor M9/S5 Stationary data files.

9.2. Software Layout during Data Collection

Whether in data collection or viewing/post-processing mode, the RSQ software is divided into multiple areas. When first starting RSQ, the user will have the option to either open a data file for viewing/post-processing, or to start a new measurement (shown in Figure 123). This section

will give an overview of software functions for data collection, and data viewing/post-processing. Stationary measurements is covered in Section 11.

To start a Stationary measurement, click the “Stationary” button.

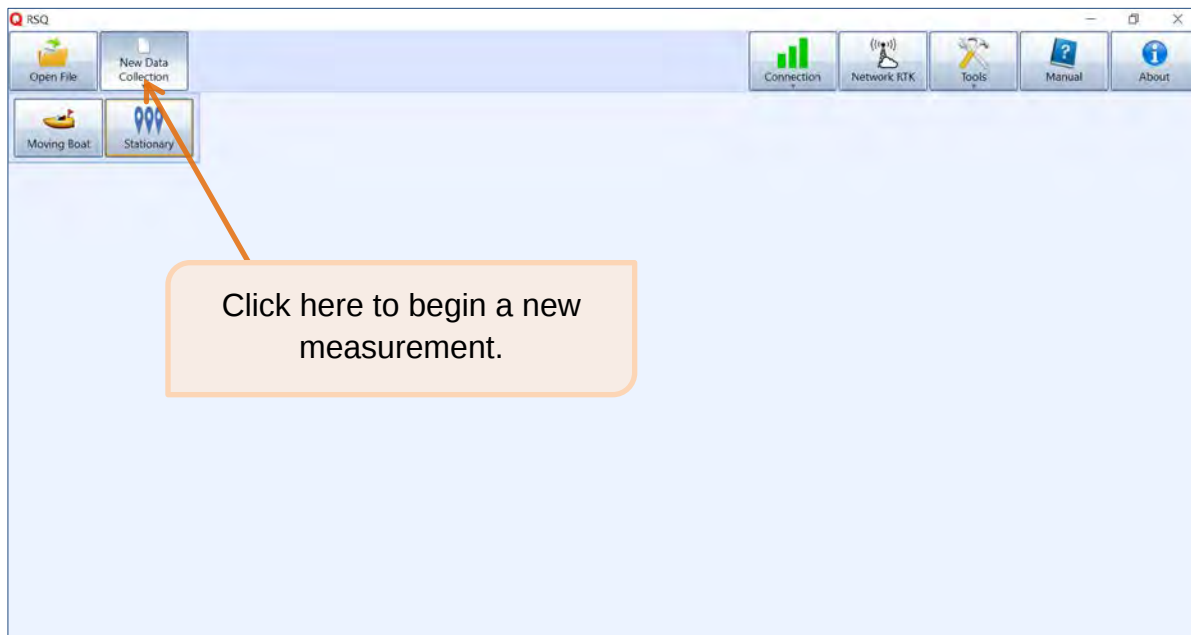


Figure 123. RSQ Main Landing Page

During data collection, the RSQ software interface is shown in Figure 124. Users familiar with the RiverSurveyor M9/S5 systems will notice that the layout of RSQ is very similar to RiverSurveyor Live.

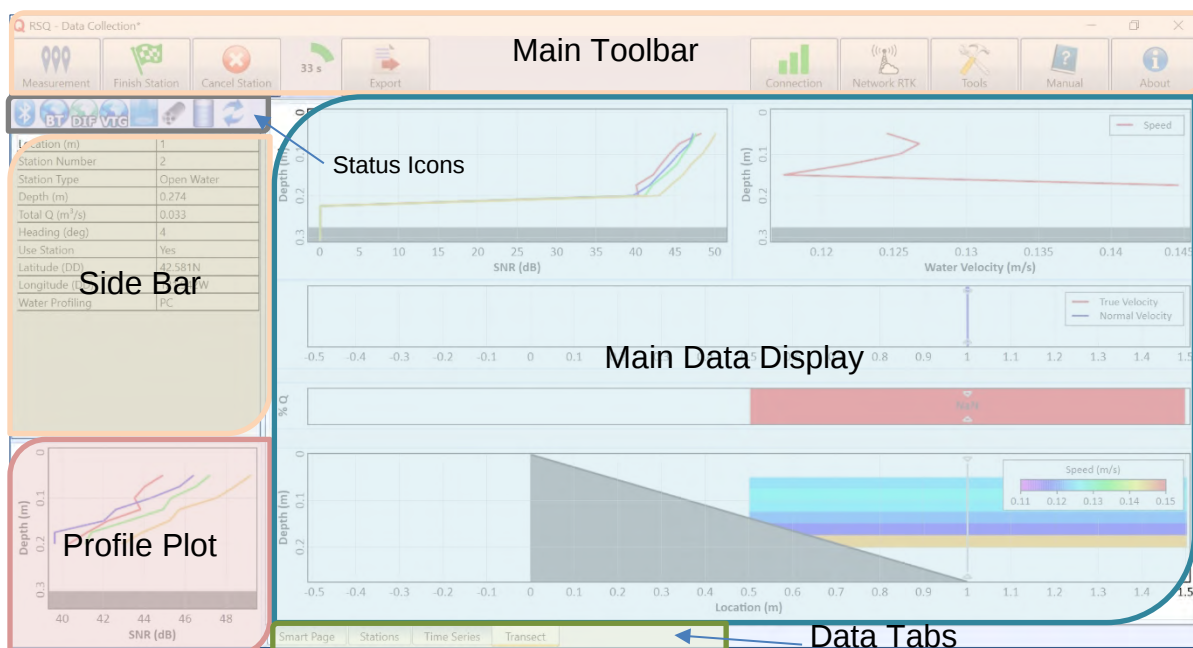


Figure 124. RSQ Interface During Active Stationary Data Collection

9.2.1 Main Toolbar

Once a new measurement is started, the main toolbar will change slightly to accommodate various options during the measurement. The main toolbar contains the main functions required during a measurement. When a measurement is first started, the main toolbar will have the buttons shown in Figure 22.



Figure 125. Main Toolbar When Starting a New Stationary Measurement

Choices on the left include:

- Measurement – option to discard measurement
- Add Start Edge – start Stationary measurement by adding a Start Edge
- Export – export measurement (various options)
- Other Data – add Site Photos, Beam checks, and view compass calibrations

More general functions exist on the right. They include:

- Connection – use this to connect to the system and view connection status (details and instructions in Section 7.1)
- Network RTK (see Section **Error! Reference source not found.**)
- Tools – various software tools including Beam Check and firmware upgrades (details and instructions in Section 6.8)
- Manual – open the RS5 User Manual (this document)
- About – view RSQ software version

When the first measurement is complete, the user will see an expanded main toolbar, shown in Figure 23.



Figure 126. Main Toolbar After Measurement is Complete

9.2.2 Status Icons

Various status icons will update from sample to sample to give the user a quick visual indication of the various components of the system. From left to right, the icons represent:

- Bluetooth connection status
- Bottom track status
- GGA status

- VTG status
- Depth status
- System Status
- Battery Status
- Data Collection Status

Hovering over each icon will show a description of the status. Please see Section 6.5.3 for status icon details.

9.2.3 Sidebar

The sidebar can be found on the left upper portion of the software during a measurement, and is highlighted in Figure 21. The side bar is a sample-by-sample table displaying various real-time parameters. The variables displayed in the side bar can be configured by **right-clicking** on the side bar and selecting/deselecting various parameters of choice (Figure 127).

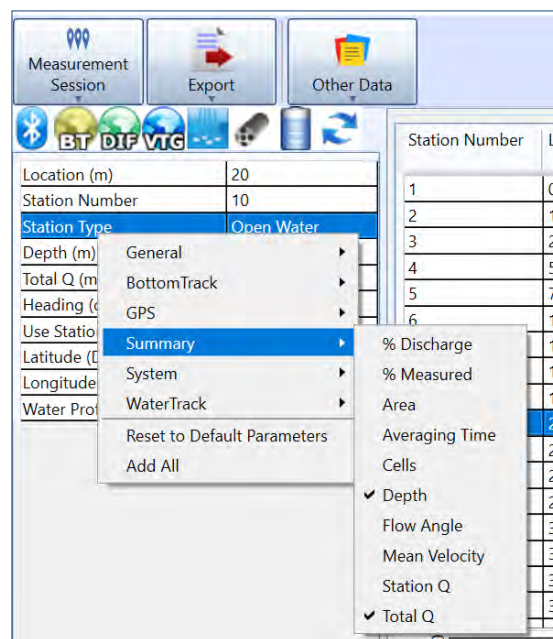


Figure 127. RSQ Side Bar Configuration

9.2.4 Profile Plot

The default display shows the SNR profile for each beam for that sample. The parameter plotted and can be changed by **right-clicking** on the plot.

9.2.5 Main Data Display

The main data display is the large area of the software where the main data parameters in various forms are plotted. **Right-clicking** on plots provides options for configuring the plots.

9.2.6 Data Tabs

Data tabs offer different views of various data during the measurement. They include:

- Smart Page – view Smart Page for current setup parameters and settings
- Stations – Data for individual stations
- Time Series – view various time series
- Transect – comprehensive view of measurement profiles, station discharge, and contour plots

Section 10. Collecting a Measurement – Stationary

The Stationary discharge method uses an alternative approach to the standard moving boat method of measuring water currents and discharge using an ADP. When in Stationary mode, the ADP operates from a fixed mounted position, stationary vessel, or platform. This measurement procedure is similar to that used for the SonTek FlowTracker2 and is in adherence to ISO velocity area measurement techniques. Measurements are made at stationary positions, usually along a tagline, to obtain a more precise representation of the mean velocity profile and therefore determine discharge. Stationary-Measurement can be used in a wide range of applications such as:

- Discharge Measurements
- Current Profiling across transects
- Under Ice Measurements

10.1. Stationary Discharge Measurement Principles

The procedure for making a discharge measurement follows the well-established methodology as outlined by Campbell (2015). This method is also referred to as the “Mid-Section method” of computing discharge and is the same method adopted by the SonTek FlowTracker.

The mid-section method involves making a series of velocity and depth measurements at a specific number of locations (more commonly known as stations, panels or verticals) across a river cross-section. At each station, the depth and mean velocity profile are measured. The depth is computed using either the 4-velocity beams, the vertical beam, or manually measured (using a rod or other device) and entered into the software. The mean velocity profile for each station is computed from data from all valid cells above the riverbed. The width of a single station is determined to be the sum of

half the distance to the previous station and half the distance to the following station. This method assumes that the velocity profile at each station represents the mean velocity for the entire rectangular station area.

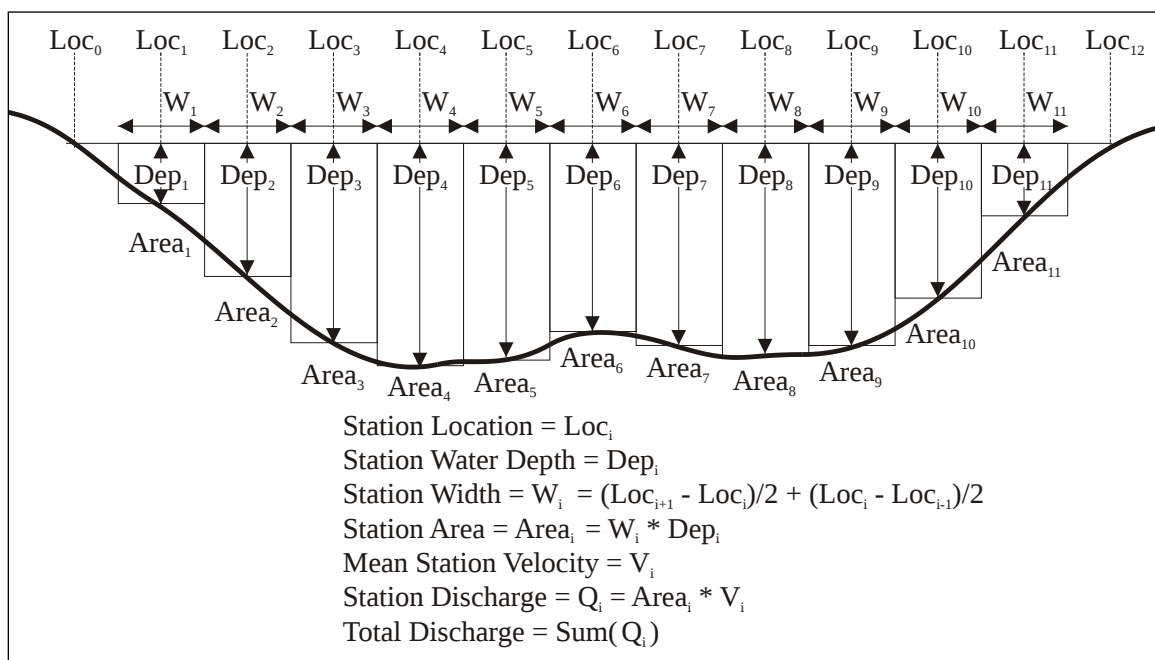


Figure 128. Mid-section Method for Discharge Measurement

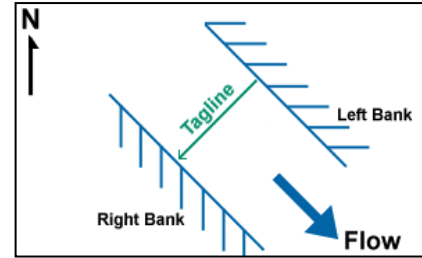
Each station is measured for a significant time to remove any environmental and temporal variation in the water velocities. Typically within the USGS, the recommended duration of measurement for a single station is 40 seconds. However, in particularly turbulent waters, extremely low-velocities, or in areas or rapidly changing water-level, a longer period may be required. This recommended sample time might vary from country to country and even within different organizations.

The general steps for the measurement process are as follows:

10.1.1 Setting up the Location

- A measurement section is selected based on the criteria outlined in Section 10.2 below.

- A graduated tag line is strung across the river, in the case where GPS is not used. In an ideal measurement site, the flow should be perpendicular to the tag line at all points with no flow reversals or obstructions. For ice measurements, a series of holes (one for each station) is drilled in the ice.
- The spacing of the stations along the tagline is selected so as to provide about 20-30 stations. Each of these stations should also be positioned so that no station is expected to yield more than 10% of the total discharge. Ideally, no station should have more than 5% of the total discharge. This generally means that the stations are not equally spaced but are instead spaced closely together in deeper and high velocity areas and further apart in shallower and slower flowing areas.
- The magnetic-north heading (azimuth) of the tagline is measured. This is the compass orientation of the tagline in the direction of the right river bank. Setting the tagline azimuth is important because it allows the RS5 to rotate freely around the sample location and still measure the correct mean-station velocity by using its internal compass to resolve the true direction of velocity and then calculate the normal velocity to the tagline. In the example above, the tag line is oriented to the southwest (225°). The azimuth should be measured with the internal compass in the RS5 (preferred) or a hand-held compass.



10.1.2 Make the Measurement

- The operator starts at one edge (the start bank), recording the starting-edge location, water depth and gauge heights.
- The operator then proceeds to the first station and enters the station location, transducer depth, and gauge heights (not required). If ice is present, the values for the ice thickness, depth of water and slush thickness should also be entered.
- The RS5 is positioned with the transducers submerged and the system as vertical as possible. Ideally the system will be mounted to a platform, vessel, or mounting structure.
- Data collection begins and the RS5 measures the 3D current velocities and bottom depth throughout the water column.
- Only the component of water velocity perpendicular to the transect line (or azimuth) is used to ensure proper discharge calculations, regardless of the flow direction. This normal component of the velocity is known as the “Normal Velocity”. The true flow direction or “True Velocity” is still measured, recorded and will be displayed on screen or as a comparison with the Normal Velocity.
- At the end of the averaging time for the measurement, the discharge is calculated using the formula shown in Figure 128.
- Repeat the steps above at each station along the transect until the last station is completed.

10.2. Selecting a Measurement Location

The key issues to consider when selecting the location of your measurement cross-section are:

- Select an area of relatively uniform and steady flow. Try to avoid areas with standing eddies or strong turbulence. Note that a measurement may still be made in these areas however it may take longer to establish a mean profile (i.e. the averaging interval may need to be increased).
- The cross-section should have gradual changes in depth.
- Flow along the riverbanks should be low or close to zero.

10.3. RS5 Mounting and Instrument Orientation

Mounting: The mount to which the RS5 will be attached should meet the following criteria as closely as possible. Please remember that while the transducer depth should be as shallow as possible, the transducers must be completely submerged at **all** times during data collection. The key to good Stationary measurement data collection is that the transducers remain in a position that is relatively constant in location to the riverbank.

- Rigid and level when the transducer is in the water to minimize vibration.
- For some applications it is advantageous that the mount be easily retractable when the vessel is moving from one station to the next.
- As with a moving vessel measurement; on small to mid-sized boats (10' – 25') - the mount can extend over the bow; on larger boats, it is preferable to mount the ADP on either the port or starboard side near mid-ship.
- Transducer depth should be adjustable.
- Constructed of non-ferrous material (ideally aluminum).
- Make sure the RS5 is at least a few meters away from the engine or any other ferromagnetic objects mounted to the boat to ensure proper operation of the compass (if used in ENU orientation).
- The vessel maintains as much as possible a constant and steady position and orientation to the riverbank. Note: Bottom-tracking velocity reference is preferred if there is significant motion of the vessel during data collection.

Instrument Orientation: This is important when making measurements with using the XYZ orientation (i.e. similar to the FlowTracker reference) and/or when using the internal compass (ENU) to determine the tagline azimuth. In the first case, the x-velocity measured by the system is used to compute discharge for that particular station. This will require that the systems x-axis is pointed facing downstream as shown in Figure 129 below. In this orientation, the +X arrow indicator on the RS5 housing will be pointing directly downstream. In addition, the RS5 should not be allowed to rotate during data collection (similar to using a FlowTracker).

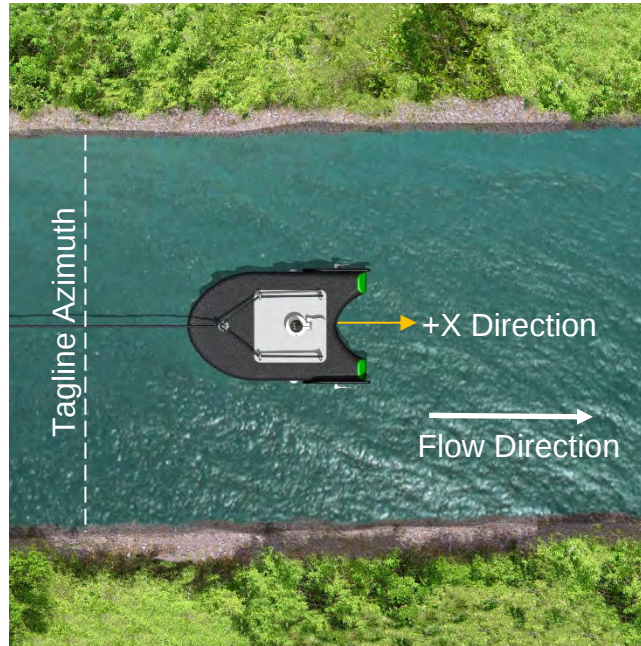


Figure 129. RS5 Orientation in the Stream

In most cases, the ENU orientation will be preferred during data collection. The primary reason is that when using the ENU orientation the system will always measure the true velocity and the normal velocity regardless of its angle to the tagline. This ability is helpful in many river conditions especially when you are deploying the system from a small boat with a line. In this case, the boat can freely rotate into the current as it changes in the cross-section and using the internal compass it will accurately compute the true velocity and normal velocity. The same system orientation shown in the figure above must be used when measuring the tagline azimuth using the internal compass of the M9/S5. This procedure (Get Tagline Azimuth) is described in Section 10.7.5.1.

10.4. Starting the System

To start the system, please refer to Section 5 on how to power on the RS5 and all of its components before attempting to connect to the system.

10.5. Connecting to the System

Please refer to Section 7.3 for details on how to connect to the RS5 system using RSQ.

10.6. Starting a Stationary Measurement

Once the RS5 is connected in the RSQ software, click the **New Data Collection** button (Figure 44). Click the **Stationary** button. The Stationary option will be coming soon.



Figure 130. New Data Collection

10.7. Smart Page (Pre-measurement Setup Checklist)

The RSQ Smart Page is the landing page where a measurement starts. It guides the user through the proper steps for pre-measurement tests and setup that should occur prior to each discharge measurement to ensure both the functionality of the RS5 hardware for proper data collection as well as proper configuration of setup parameters. Each section is described in detail in the following sections.

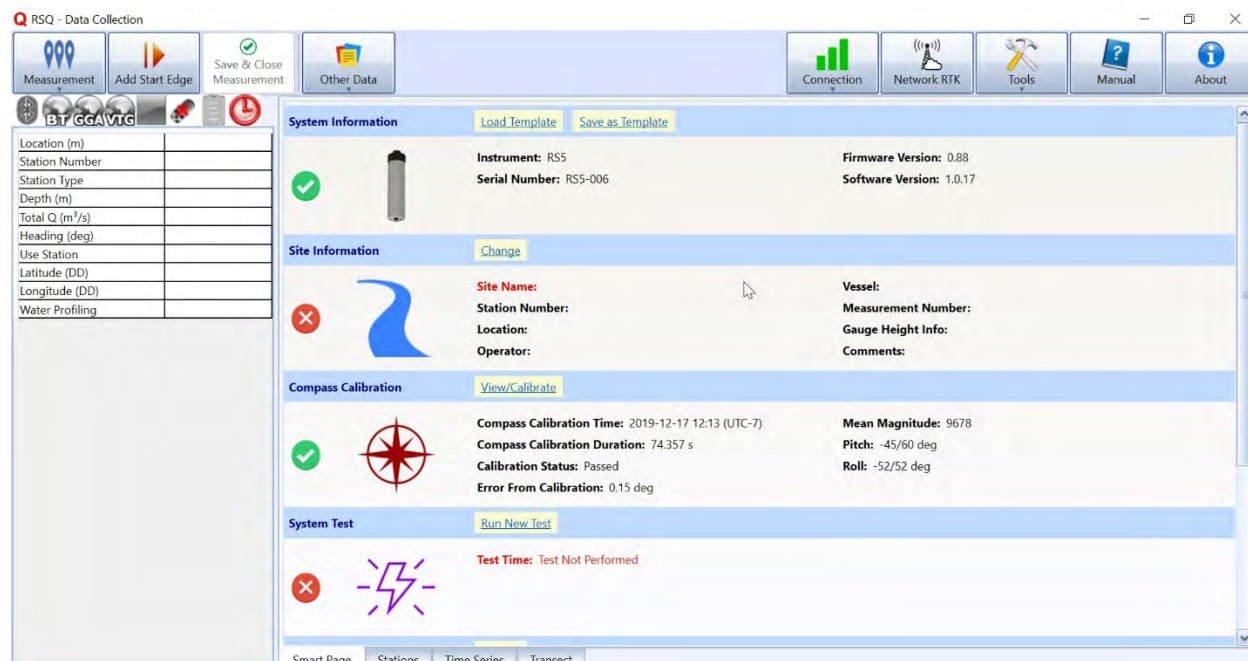


Figure 131. Smart Page

In general, sections with a red X must be addressed before starting a new measurement. Sections with a green check mark indicate those items are ready for a

measurement to begin. Aside from the System Test and Compass Calibration, entries in the Smart Page can be changed in Post-processing (see Section 8).

10.7.1 System Information

The System Information section (Figure 46) lists the information for the RS5 instrument currently connected, including the type of instrument (RS5), Serial Number, Firmware Version, and the current RSQ software version used.



Figure 132. Smart Page: System Information

The System Information section is also where the user can load an existing template by clicking the Load Template link (highlighted in Figure 132). Once selected (Figure 133), the user can use the drop-down menu at the top of the dialog to select an existing template. The selected template will appear in the dialog to guide the user. Click **Select** to choose the active template.



Figure 133. Load Template Dialog

From the System Information section, the user also has the option to save their existing Smart Page settings to a template by clicking the **Save as Template** link.

10.7.2 Site Information

The Site Information section (Figure 51) contains user-input information about the site and the operator for the measurement.

Site information includes:

- Site name
- Station number
- Location
- Operator
- Vessel
- Measurement number
- Gauge Height Information
- Comments

To change the Site Information entries, click the Change link, highlighted in Figure 134.

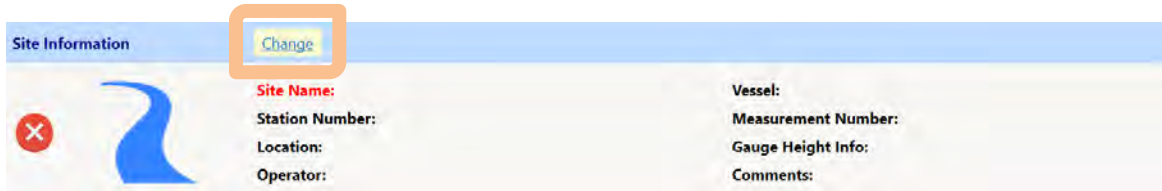


Figure 134. Site Information

10.7.3 Compass Calibration

The compass calibration procedure for a Stationary measurement is the same as for a Moving Boat measurement. Please see Section 7.5.4 for details on the RS5 compass calibration procedure.

10.7.4 System Test

The system test for a Stationary measurement should be performed before each measurement, and is the same as the Moving Boat system test. Please see Section 7.5.2 for details on the System Test.

10.7.5 System Configuration

System configuration settings (shown in Figure 135) are specific to each measurement, location, and hardware setup. Information is entered by clicking the Change link highlighted in Figure 56.

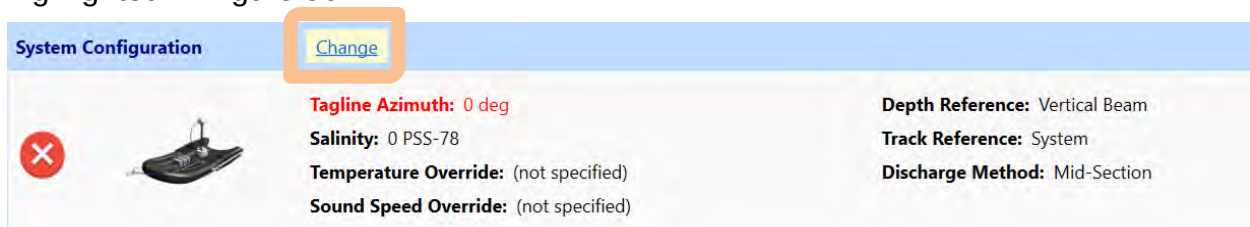


Figure 135. System Configuration

A dialog will pop up allowing the user to enter various configuration parameters (see Figure 136). These items must be entered with care, as they directly affect the final discharge calculations.

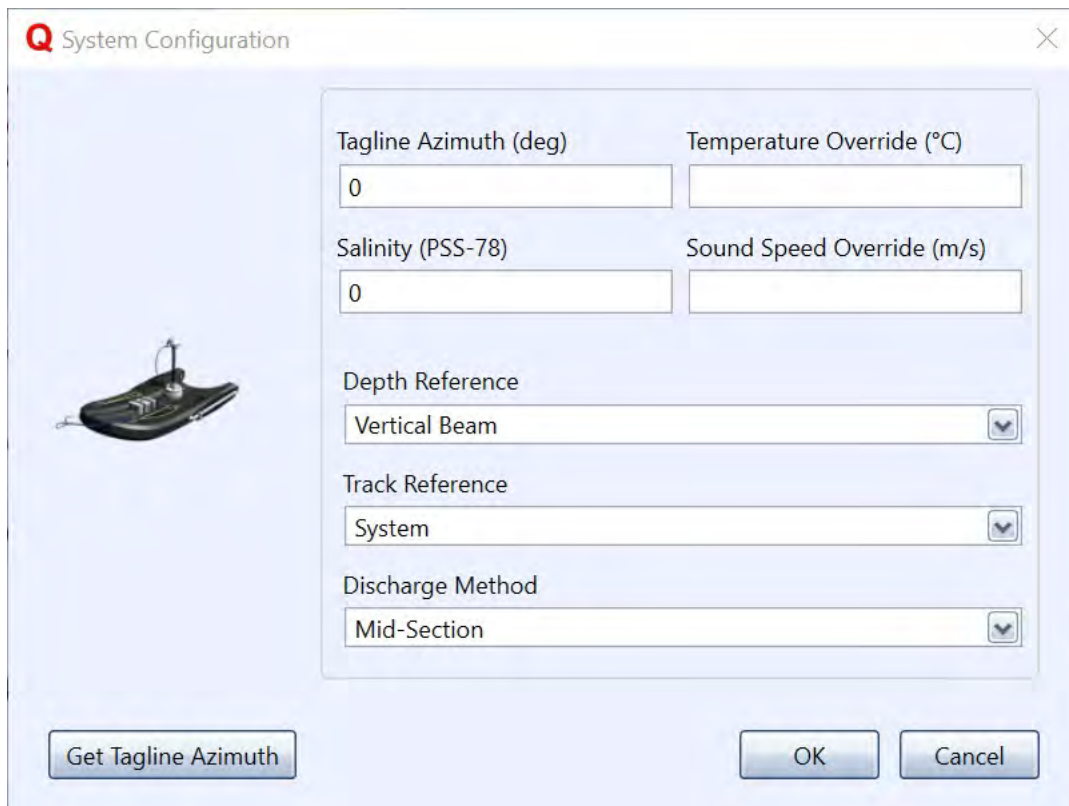


Figure 136. System Configuration Dialog

If the System Configuration section has not been completed, a red X will remain visible in that section. The Tagline Azimuth field is highlighted in red if not completed – if the proper value is not entered or obtained, the “normal velocity” for each station will be incorrect. This value can be modified in post-processing if it is entered incorrectly. Each setting in the System Configuration is described in detail in the following sections.

10.7.5.1 Tagline Azimuth

As described in Section 10.1, the Tagline Azimuth represents the angle heading of a real or imaginary tagline representing the transect, and all velocities will be calculated normal to that tagline azimuth. If a tagline azimuth is known (based on the heading of a bridge), or measured with a magnetic compass, it can be entered in the Tagline Azimuth field. The tagline azimuth (in degrees) is defined to point FROM the left bank TO the right bank, and magnetic north defines 0 degrees heading for the azimuth.

The preferred method of obtaining the tagline azimuth is by using the RS5 internal compass. To do this, click the **Get Tagline Azimuth** button in the System Configuration dialog (bottom left). You will see the dialog shown in Figure 137.

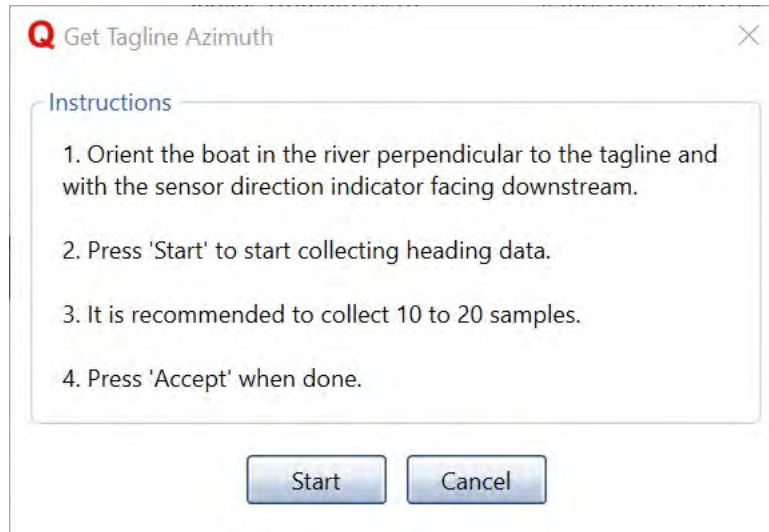


Figure 137. Get Tagline Azimuth Dialog

Before pressing start, move the RS5 to the location where the tagline azimuth will be recorded. Usually this location is near the center of the channel where the highest velocities flow, and will give the best estimate of the main river flow direction. Once the RS5 is in that location, press the **Start** button. The RS5 will begin recording compass heading data, with various results shown in Figure 138. It is recommended that 10-20 seconds worth of samples be recorded before pressing **Accept**.

Once the Accept button is pressed, the final average tagline azimuth value (+90 degrees from the magnetic compass heading) is automatically populated in the Tagline Azimuth value in the System Configuration section.

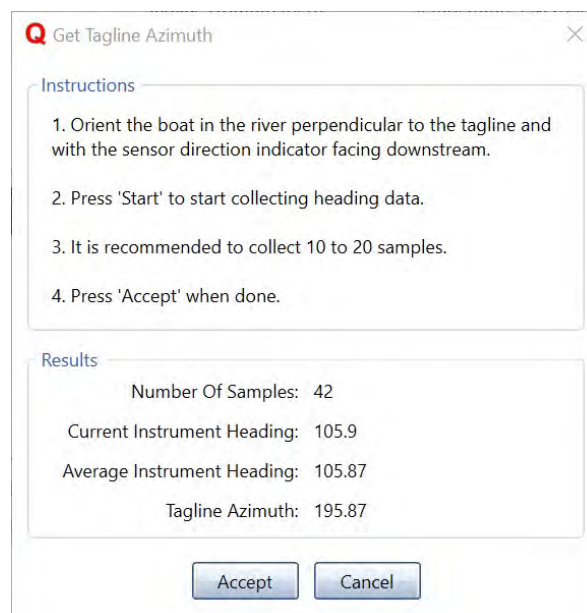


Figure 138. Get Tagline Azimuth during Sampling

10.7.5.2 Salinity

Salinity (PSS-78) generally refers to the concentration of the minerals dissolved in water.

Typical values include:

- 0-0.5 (freshwater)
- 0.5-30 (brackish)
- 30-50 (saline water, typical for large inland seas and oceans, with average ocean salinity at 35)
- >50 (brine – not advised for ADP measurement)

Salinity affects the speed of sound in water; high salinity values increase the speed of sound. Manual entry of an accurate salinity value enables correction of the speed of sound in water which is required for the velocity calculation. Because speed of sound corrections using the PSS-78 convention are only valid up to 42, a maximum salinity of 42 is allowed in the RSQ software. It is not recommended to collect ADP measurements in brine water that has a higher salinity. Corrections are recommended in any aquatic environment not considered freshwater. Reference values can be obtained from published sources or determined in situ with an appropriate meter.

10.7.5.3 Temperature Override

Temperature affects the speed of sound in water in a similar way as salinity: an increase in temperature increase the speed of sound. The RS5 is equipped with a temperature sensor built into the transducer housing. The system is designed to automatically calculate the velocity with the measured temperature. In the case where the user wishes to use an external temperature measurement, the temperature can be entered in the Temperature Override variable, which will be used over the measured temperature.

10.7.5.4 Sound Speed Override

As with the Temperature Override feature, the sound speed measured by an external measurement can be entered here to override the automatic calculation using the measured temperature by the RS5.

10.7.5.5 Depth Reference

Two options exist for determining water depth. Both options are available for post-processing and the user can choose the default reference.

- **Vertical Beam:** Applies data from the vertical transducer to determine water depth for the cross-sectional area. This choice is often preferred as it applies to the depth directly below the instrument.
- **Bottom-Track:** This option averages depth values measured by the four angled beams to determine water depth.

10.7.5.6 Track Reference

The ADP measures water velocity using multiple acoustic pulses transmitted and received throughout the water column (see RS5 Technical Manual for more details, coming soon). When the ADP is in motion, the apparent velocity measured by the ADP is a combination of boat velocity and water velocity. In order to determine true water velocity the boat speed must be determined and then subtracted from the apparent velocity. The RS5 Stationary application offers two methods, known as tracking references, to determine boat velocity.

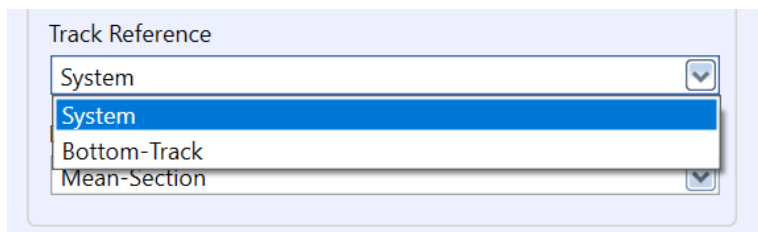


Figure 139. Track Reference Options

An appropriate track reference should be selected when setting up a measurement, but can be changed during post-processing, if necessary.

a. System (Default)

The ADP references velocity data only to itself. The more stationary that the ADP beams remain, the better the stationary measurement will be. It is not recommended for discharge measurements from a moving vessel.

b. Bottom Tracking

Boat velocity is calculated using signals received from multiple acoustic pulses reflected from the channel bed and banks. If the channel bed is stationary (i.e. no bedload flux), then the apparent velocity will consist entirely of boat and water motion, so water velocity can be determined by removing bottom-tracked boat motion. If the channel bed is in motion (i.e. active bedload flux) the apparent velocity will involve a combination of boat, water, and channel-bed velocities. If a moving bed exists at a site, it is recommended that 'System' is used for the track reference.

10.7.5.7 Discharge Method

The Discharge Method has two choices:

- Mean-Section
- Mid-Section

Both methods are similar in theory but differ slightly in their calculations. Please consult your agency guidelines for which method should be used.

10.8. Quality Configuration

Quality Configurations can be entered by clicking **Change** in Quality Configurations section of the Smart Page (Figure 140).

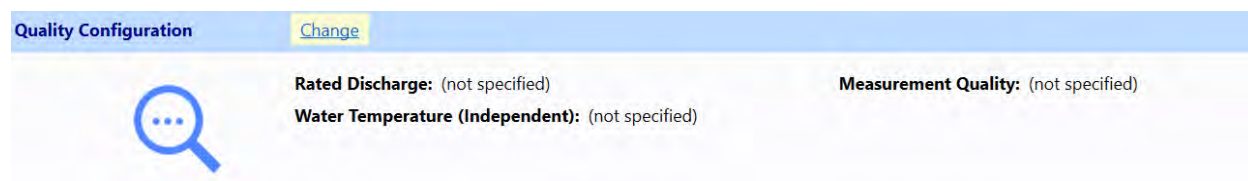


Figure 140. Quality Configuration

When the rated discharge is entered, any calculations based on percent rated (or total) discharge will use the rated discharge value. The Water Temperature and Measurement Quality fields are optional for those who want to record these additional observations.

10.9. Templates from Smart Page

As with Moving Boat measurements, Stationary measurements can also use Templates. Please see Section 7.9 for details.

10.10. Data Collection

After completing the Pre-measurement tests and initial site specific entries to configure the System from the Smart Page, the measurement is ready to begin. On the main tool bar click the Add Start Edge button as shown in Figure 141. The software provides a step-by-step procedure for the Stationary measurement, outlined below. Each step is explained in detail in the following sections.

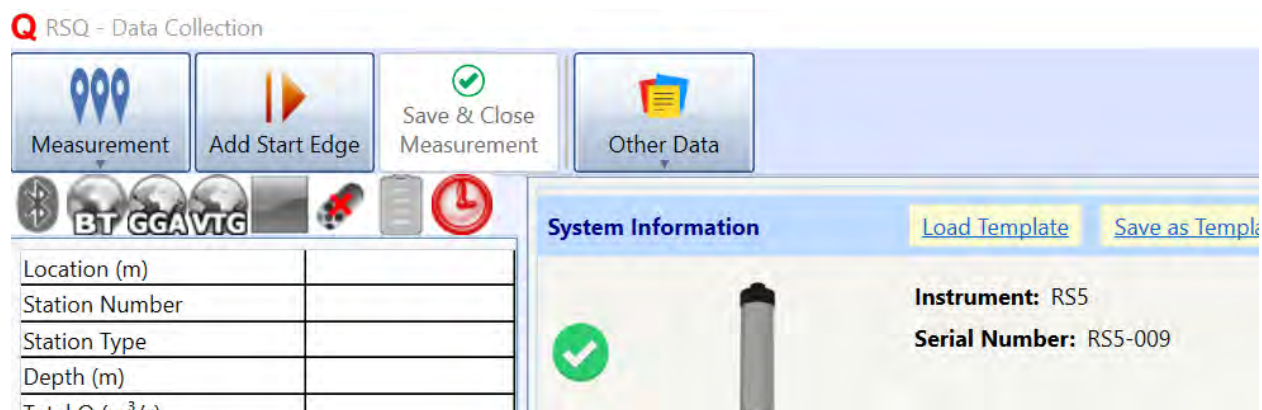


Figure 141. Add Start Edge from Smart Page to Start a Measurement

10.10.1 Start a Measurement – Add Start Edge

From the Smart Page, click the Add Start Edge button to begin the measurement. The Add Station #1 dialog will appear, as shown in Figure 142. During the first station, the RS5 does not take any samples.

Add Station #1	
Station Type	Left Bank
Location from initial point (m)	0
Transducer depth below water surface (m)	0
User Input Water Depth (m)	0
Screening Distance (m)	0
Coordinate System	ENU
Averaging Time	40
Velocity Correction Factor	1.000
Gauge Height (m)	0
Auxiliary Gauge Height (m)	0
Gauge Height Observation Time (UTC-7)	2021-04-15 14:49

Extrapolation OK Cancel

Figure 142. Add Start Edge Dialog

The configurable choices and details are documented below:

- Station Type** – Left Bank or Right Bank (looking downstream)
- Location from initial point** – the location on the tagline, if used
- Transducer depth below water surface** – the depth of the center of the vertical beam of the RS5 below the water surface
- User Input Water Depth** – input the water depth if measured independently. If a value is entered here, the water depth will use this value as default (as opposed to the depth measured by the RS5)
- Screening Distance** – enter any desired screening distance (defined from the water surface)
- Coordinate System** – ENU or XYZ
- Averaging Time** – the averaging time over which the station will be averaged (in seconds, or samples)
- Velocity Correction Factor** – factor applied to the measured average velocity of at the station
- Gauge Height** – input independent gauge height measurement, if it exists

- j. **Auxiliary Gauge Height** – input an additional gauge height measurement, if it exists
- k. **Gauge Height Observation Time** – input the time at which the gauge height is measured.

Once the Start Edge information is entered, pressing OK will automatically bring up the dialog for the next station.

10.10.2 Add Stations

Once the Add Station dialog appears, the RS5 will begin sampling. The Add Station for the next station will appear automatically, as shown in Figure 143.

Add Station #2	
Station Type	Open Water
Location from initial point (m)	0
Transducer depth below water surface (m)	0
User Input Water Depth (m)	0
Screening Distance (m)	0
Coordinate System	ENU
Averaging Time	40
Velocity Correction Factor	1.000
Gauge Height (m)	0
Auxiliary Gauge Height (m)	0
Gauge Height Observation Time (UTC-7)	2021-04-15 14:58

1 - Transducer Depth

Extrapolation OK Cancel Add End Edge

Figure 143. Add Station Dialog

Similar inputs exist for a Station and the Add Start Edge. The user will notice that the Station Type drop-down menu will have more choices, which are defined below.

- Open Water – this is the typical station type for normal station measurements
- Ice – the Ice station settings will enable additional settings, as shown in Figure 144. These include parameters for the depth to the bottom of the ice and/or slush, and are defined by the diagram shown at the left of the dialog.
- Island Edge – An island edge can be entered when the user is physically incapable or does not want to measure over a specific location. If one island edge is entered, RSQ will automatically expect another island edge to be entered following the first one. The RS5 will not sample and discharge will not be

calculated between the two island edges, but the software will keep track of the location along the tagline and the overall transect width.

Parameter	Value
Station Type	Ice
Location from initial point (m)	0
Ice Thickness (m)	0
Water Surface To Bottom Of Ice (m)	0
Water Surface To Bottom Of Slush Ice (m)	☒ 0
Transducer depth below ice (m)	0
Transducer depth below water surface (m)	0
User Input Water Depth (m)	0
Screening Distance (m)	0
Coordinate System	ENU
Averaging Time	40
Velocity Correction Factor	1.000
Gauge Height (m)	0
Auxiliary Gauge Height (m)	0
Gauge Height Observation Time (UTC-7)	2021-04-15 14:58

Figure 144. Ice Station Setup Choices

Once the station setup parameters are entered, the user can press OK to begin measuring. Before beginning the measurement samples, the RS5 will perform an assessment to set up the SmartPulse acoustic settings properly. The user will see the message shown in Figure 145.

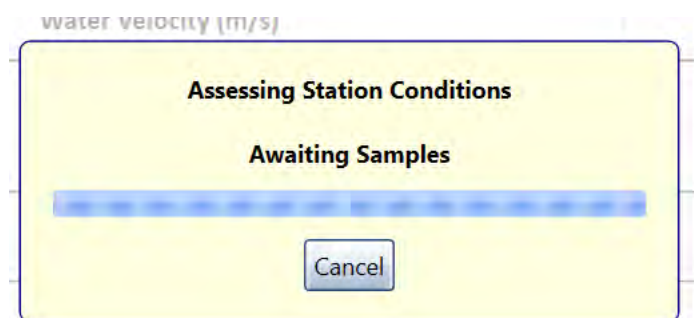


Figure 145. Station Assessment

The assessment will need only a few samples and should take a few seconds to finish automatically. If the assessment fails, the user will see various messages like the one shown in Figure 146.

If the assessment fails, the error message shown in will appear. The user should try moving to a new location for the station, or manually entering a depth in the Station setup dialog.

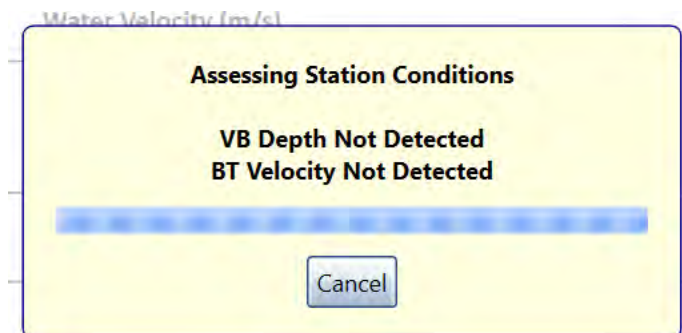


Figure 146. Station Assessment Messages

If the assessment succeeds, the RS5 will automatically begin measuring at that station.

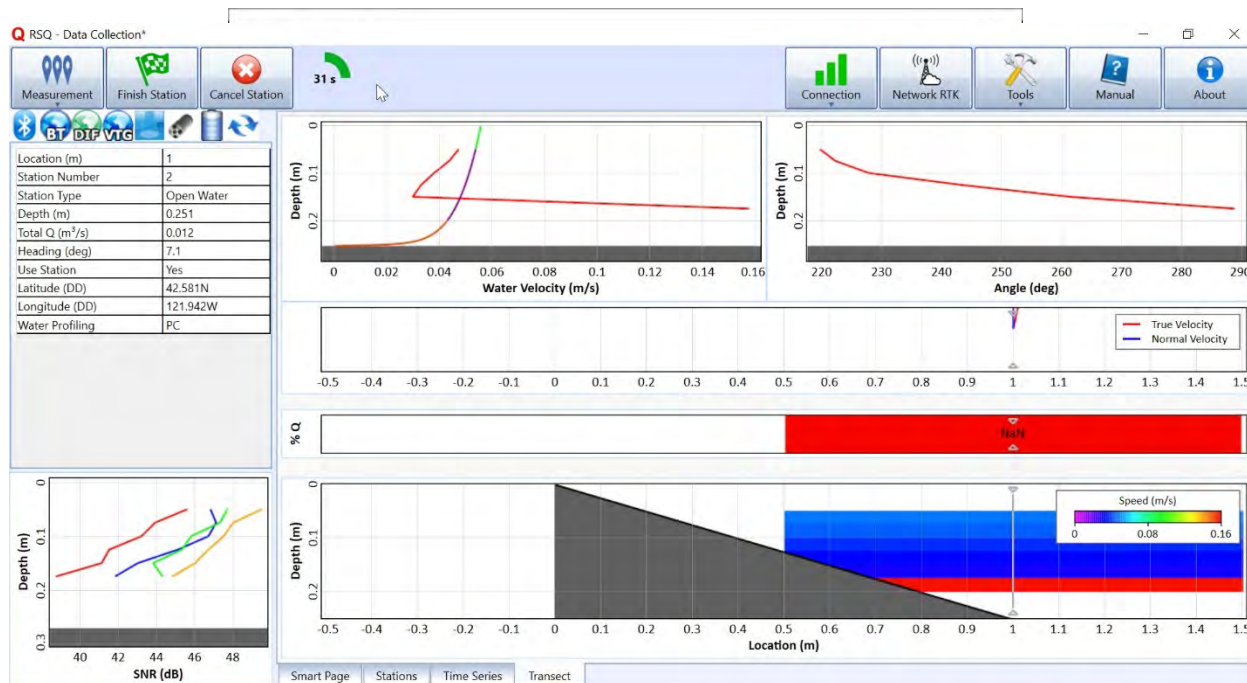


Figure 148. Station Measurement Screen

The user will see the screen shown in Figure 148. Each individual one-second sample is updated on the Transect tab. The counter for the measurement time is located at the top left on the toolbar. Note that the Stations and Time Series tabs display station-average values, and are updated as more stations are measured and completed.

A station can be finished before the designed time is finished by clicking the **Finish Station** button in the toolbar, shown in Figure 149. The user can also cancel the station by clicking the **Cancel Station** button, and no data for the station will be saved.

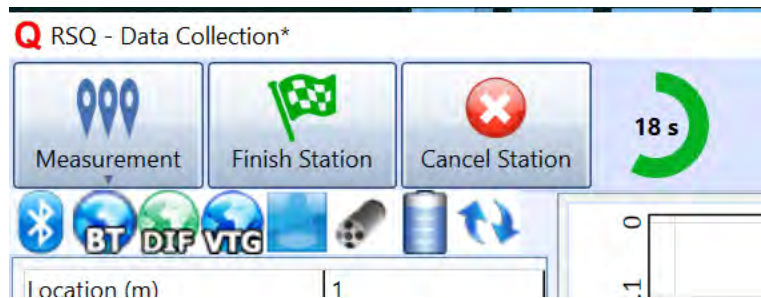


Figure 149. Finish or Cancel Station

Once the station timer is finished, or the Finish Station button is pressed, the results will be displayed, as shown in Figure 150.

Station Result	
Mean Velocity (m/s)	0.1238
Station Depth (m)	0.374
Station Q (m ³ /s)	0.0463
Total Q (m ³ /s)	0.0463
Percent Discharge (%)	100
Location (m)	1
Station Width (m)	1

Figure 150. Station Result

If results are acceptable, press Accept. Otherwise, the user can repeat the station measurement by clicking the **Repeat** button. If the **Repeat** button is pressed, the station dialog for the last station will appear to restart the process. If **Accept** is pressed, the dialog for the next station will automatically appear.

In this way, continue measuring additional stations until all stations are completed. Stations do not need to be measured in physical order along the tagline; they can be inserted in between already-measured stations as long as the station location is entered correctly. The data in the Stations and Time Series tabs will be updated as additional stations are added.

10.10.3 Add End Edge

The End Edge is the final edge setup to close the measurement, once all stations have been measured. To enter an End Edge, press the End Edge button on the bottom right

of the Station dialog, shown in Figure 148. The End Edge dialog, shown in Figure 151, looks very similar to the Start Edge dialog. The Station Type will automatically default to the correct bank based on the Start Edge selection.

Station Type	Right Bank
Location from initial point (m)	5
Transducer depth below water surface (m)	0
User Input Water Depth (m)	0
Screening Distance (m)	0
Coordinate System	ENU
Averaging Time	40
Velocity Correction Factor	1.000
Gauge Height (m)	0
Auxiliary Gauge Height (m)	0
Gauge Height Observation Time (UTC-7)	2021-04-15 16:07

Extrapolation OK Cancel

Figure 151. End Edge Dialog

10.11. Other Data

A variety of other data can be added to the measurement at any point during the measurement. They can be accessed through the Other Data button from the main toolbar, and are the same for a Stationary and Moving Boat measurement. To see details on the other data, please see Section 8.8.

10.12. Saving and Closing a Measurement

To save and close the current measurement, click the [Save & Close Measurement](#) button, shown in **Error! Reference source not found.**

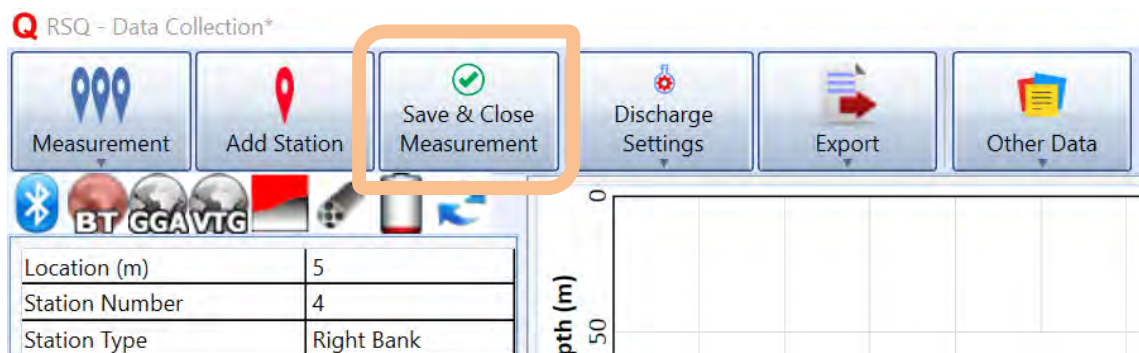


Figure 152. Finish the Measurement

The user will be prompted to save the file through a dialog, at which point the user can modify the destination and automatic naming that is chosen by the software. Once done, click **Save** to record the data file. The .rsqst file structure is described in detail in Section 11.1.

Section 11. Data Review and Post-Processing – Stationary

This portion of the manual will outline how to perform various post-processing operations on data files. Please review the RSQ software layout and data collection procedures covered in Section 6 and Section 7, as the software layout is the same for post-processing, with a few additional features.

Please note that the RSQ software can open one data file at a time. To open multiple files, the user can run another instance of the RSQ software.

11.1. RS5 Stationary Data File Format

The RS5 data format consists of one single .rsqst (RSQ Stationary) file for each measurement session. This file contains all associated stations, files, and information, including stations, compass calibrations, beam checks, site photos, and any other data.

11.2. Opening RS5 Stationary Data Files

Opening a Stationary .rsqst file is no different from opening a Moving Boat .rsqmb file. From the main toolbar, select “Open File” (shown in Figure 153), and browse to the location of the desired measurement file. Note that active data collection must be completed to view completed measurements.

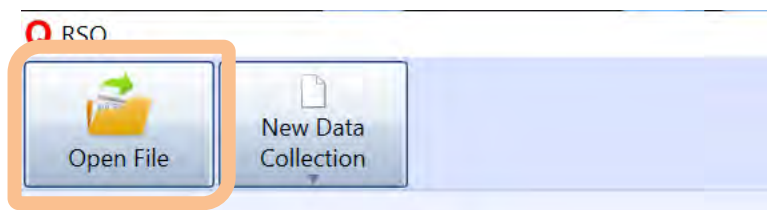


Figure 153. Open File

11.3. Opening RiverSurveyor M9/S5 Data Files

The RSQ software is also capable of opening and post-processing files from the RiverSurveyor M9 or S5. To do this, hold down the **SHIFT** key while clicking the Open File button.

11.4. Data Review/Processing View

The data review and processing layout of the RSQ software, shown in Figure 154, is nearly identical to the data collection view. The default screen will be on the Stations tab. Clicking on each station will update the data table at the left side of the software. Double-clicking on a station will open the Edit Station dialog, shown in Figure 155. The user can modify the settings available in the dialog, with the choice to apply to all stations by checking the box(es) on the right.

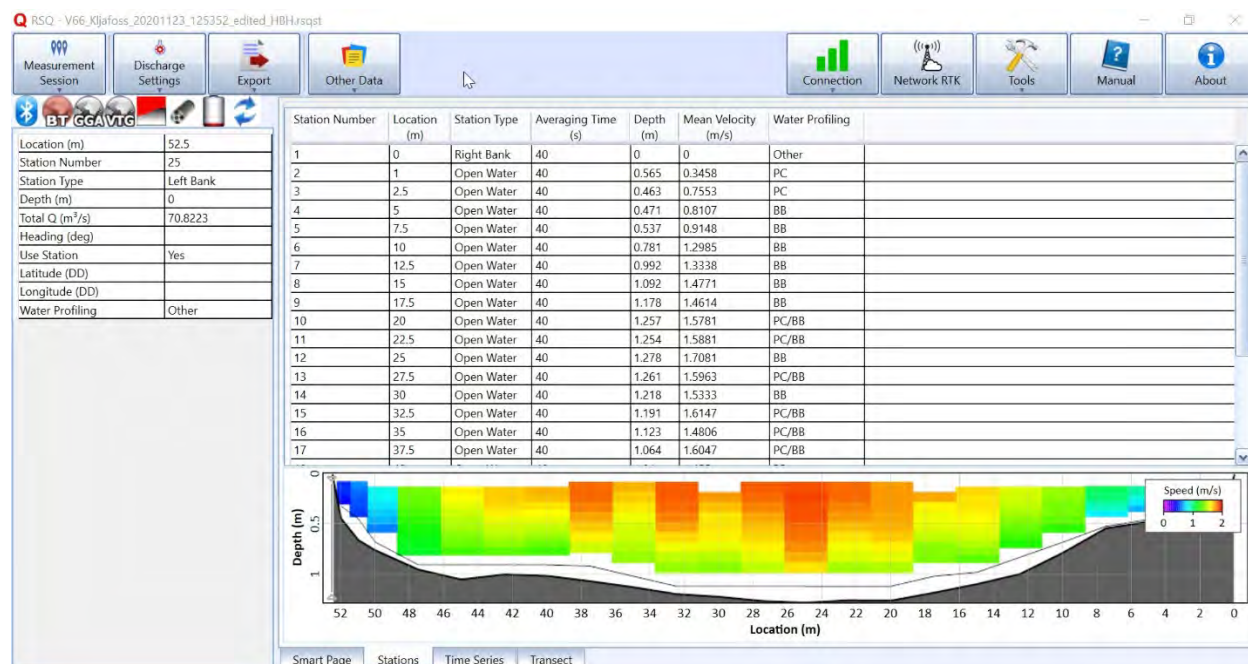


Figure 154. Data Review and Processing View

Station Type	Open Water	
Location from initial point (m)	30	
Transducer depth below water surface (m)	0.02	☐ Apply To All
User Input Water Depth (m)	0	☐ Apply To All
Screening Distance (m)	0	☐ Apply To All
Coordinate System	ENU	☐ Apply To All
Averaging Time	40	
Velocity Correction Factor	1.000	
Gauge Height (m)	0	
Auxiliary Gauge Height (m)	0	
Gauge Height Observation Time (UTC-7)	2020-11-23 04:31	

1 - Transducer Depth

Extrapolation OK Cancel

Figure 155. Edit Station Dialog

The user also has the ability to modify the Extrapolation selections by clicking the Extrapolations button on the lower left. The Extrapolations dialog will appear, as shown in Figure 156. The various extrapolation choices are described in Section 7.7. Note that these are not the same as using the USGS Extrap tool, which is described in Section 8.6.2.

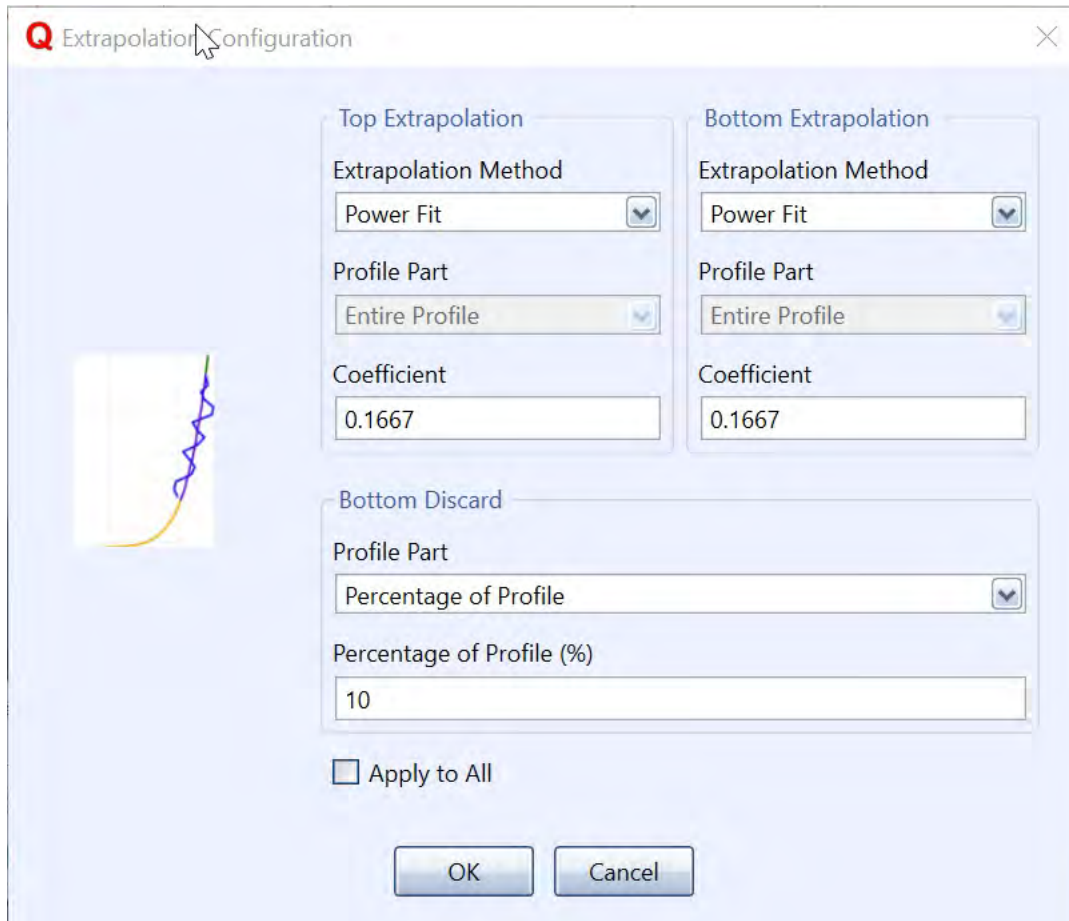


Figure 156. Extrapolations Dialog

11.5. Measurement Session Options

This session describes the various functions under the Measurement Session button, highlighted in Figure 157. The options available during a Stationary measurement are a subset of what is available during a Moving Boat measurement. Details for each option can be found in Section 8.5.

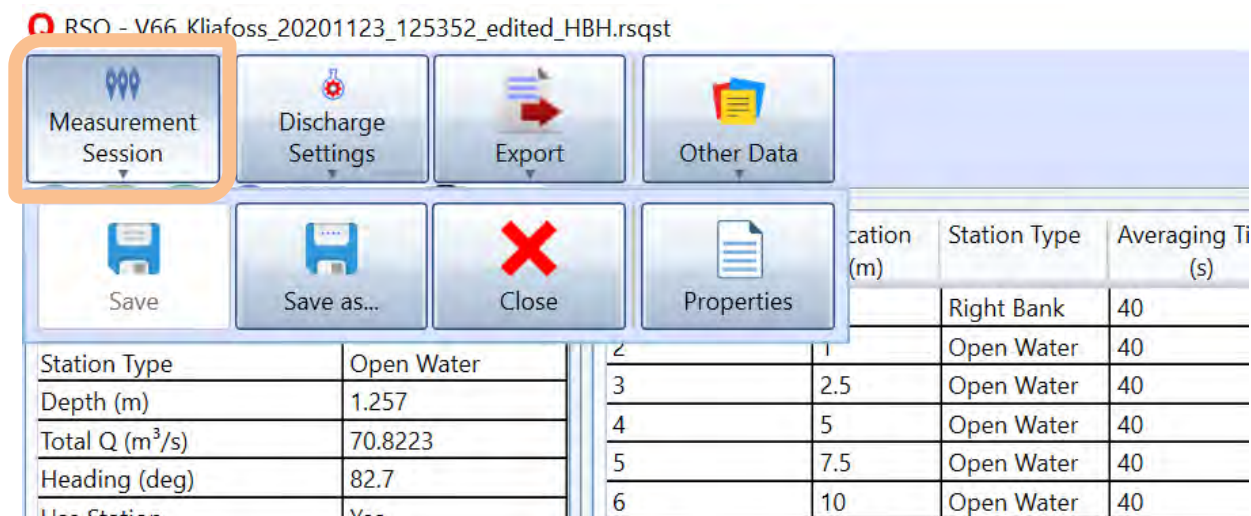


Figure 157. Measurement Session Button

11.6. Discharge Settings

Under the Discharge Settings button, Stationary measurements offer the ability to use the USGS Extrap tool to perform extrapolations. Details on Extrap and how to use it can be found in Section 8.6.2.

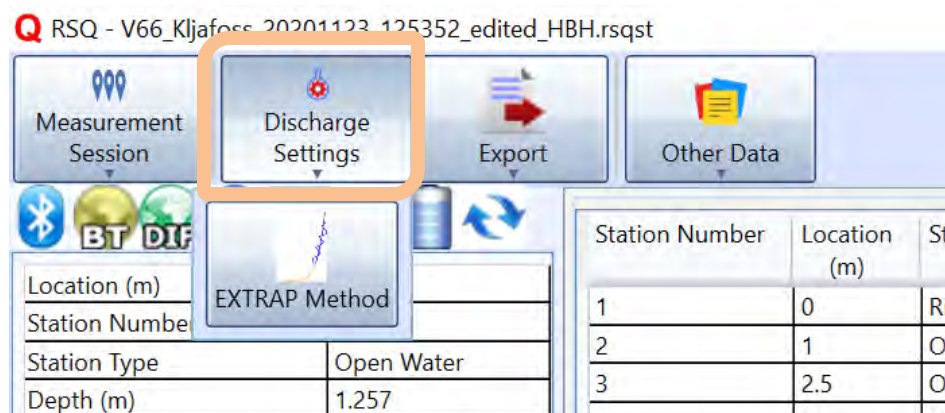


Figure 158. Discharge Settings

11.7. Data Export

RSQ offers a variety of different data export formats, all which can be accessed through the Export button, shown in Figure 159. Each of the options is described in the following sections.

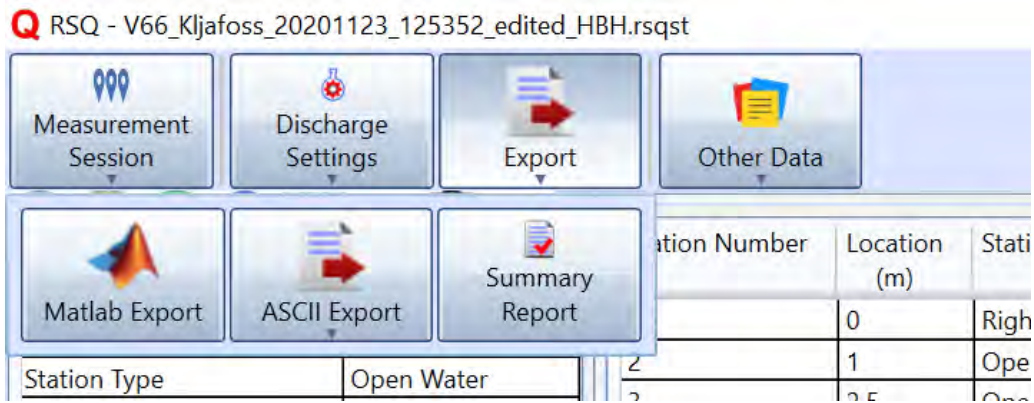


Figure 159. Stationary Export Options

11.7.1 Matlab Export

The Matlab Export tool exports the .rsqst to .mat files for processing in Matlab. Clicking the Matlab Export button will create a .mat file in the same folder as the original .rsqst data file. Please see Appendix F for details on the Matlab export file format.

11.7.2 ASCII Export

The ASCII Export provides various ASCII export files. The user has the option to export the Discharge Summary (.dis file), or All ASCII Files (.dis, .sum, and additional cell velocity, SNR, and beam velocity files). This file can be opened by any ASCII reader (like Notepad, for example). The user can choose the name of the file and the location to save it.

11.7.2.1 DIS file

The .dis file is exported to the following format:

Discharge Measurement Summary Report
Date Measured:

Site Information
Site Name;
Station Number;
Location;

Measurement Information
Operator;
Vessel;
Measurement Number;

System Information

Instrument;
Serial Number;
Firmware Version;
Software Version;

System Configuration

Tagline Azimuth;
Salinity;
Temperature Override;
Sound Speed Override;
Discharge Method;
Track Reference;
Depth Reference;

Quality Configuration

Rated Discharge;
Measurement Quality;
Water Temperature (Independent);

Discharge Results

Area;
Mean Speed;
Width;
Total Q;
Max Depth;
Max Speed;
Flow Angle;
Rated Discharge;
% difference Q;
Water Temperature (Independent);
Mean Water Temperature;
Mean Weighted Gauge Height;

Discharge Uncertainty

Category;ISO;
Depth;0.12;
Velocity;-;
Width;0.12;
Cells;0.25;
Stations;1.88;
Instrument;0.25;

Overall;-;

Units
Angle;
Area;
Depth;
Distance;
Discharge;
Frequency;
Pressure;
Profile Range;
Salinity;
SNR;
Sound Speed;
Temperature;
Time;
Voltage;
Water Velocity;

Stations

#	Time	Location from initial point	Station Type			
	Temperature	Depth	Flow Angle	Mean Velocity	Area	
	Discharge %	Discharge				

System Test

Test Time;
Battery;Passed
Temperature Sensor;
Compass;

Compass Calibration

Compass Calibration Time;
Compass Calibration Duration;
Calibration Status;
Error From Calibration;
Mean Magnitude;
Pitch;
Roll;

11.7.3 Summary Report

Exporting the Summary Report generates the detailed report shown in Figure 114, which will automatically open. The report contains summaries of various values, and

can contain plots of the depth, pitch/roll, boat speed/direction, track, and speed contour plots for each transect. To configure what charts are included in the Summary Report, please see Appendix B.

Pressing the Print button on the bottom allows the user to print the report or save it to a file. Pressing the Save PDF button saves the report directly to a .pdf file format.

Discharge Measurement Summary Report

Date Measured: 2020-11-23

Site Information		Measurement Information	
Site Name	Kljafoss	Operator	HBH/NFR
Station Number	V66	Vessel	DEMO RS5
Location	Cableway	Measurement Number	

System Information		System Configuration		Quality Configuration	
Instrument	RS5	Tagline Azimuth	5 deg	Rated Discharge	
Serial Number	RS5-008	Salinity	0 PSS-78	Measurement Quality	(not specified)
Firmware Version	1.06	Temperature Override		Water Temperature (Independent)	
Software Version		Sound Speed Override			
		Discharge Method	Mid-Section		
		Track Reference	System		
		Depth Reference	Vertical Beam		

Discharge Results		Discharge Uncertainty		
Area	50.67761	Category	ISO	Statistical
Mean Speed	1.3975	Depth	0.12 %	1.46 %
Width	52.5	Velocity		1.39 %
Total Q	70.8223	Width	0.12 %	0.12 %
Max Depth	1.278	# Cells	0.25 %	0 %
Max Speed	1.8854	# Stations	1.88 %	0 %
Flow Angle	-1.66	Instrument	0.25 %	0.25 %
Rated Discharge		Overall		2.04 %
% difference Q				
Water Temperature (Independent)				

Print Save PDF Close

Figure 160. Stationary Summary Report

11.8. Other Data

Other data from the measurement (site photos, beam check files, and compass calibration files) can be viewed from the Other Data button. The functionality and descriptions of the data can be found in Section 7.13.

Section 12. References

- 1) Campbell, Paul. "Standard Operating Procedures for under ice discharge measurements using ADCPs." *Water Survey of Canada*, 2015. Version 2.
- 2) Chen, Cheng-Lung. "Unified Theory on Power Laws for Flow Resistance." *Journal of Hydraulic Engineering*, vol. 117, no. 3, 1991, pp. 371–389., doi:10.1061/(asce)0733-9429(1991)117:3(371).
- 3) Mueller, David S. "Extrap: Software to Assist the Selection of Extrapolation Methods for Moving-Boat ADCP Streamflow Measurements." *Computers & Geosciences*, vol. 54, 2013, pp. 211–218., doi:10.1016/j.cageo.2013.02.001.
- 4) Mueller, David S., and Chad R. Wagner. "Development of a Simple Loop Method for Correcting Acoustic Doppler Current Profiler Discharge Measurements Biased by Sediment Transport." *World Environmental and Water Resource Congress 2006*, 2006, doi:10.1061/40856(200)161.
- 5) Mueller, David S., Mike S. Rehmel, and Chad R. Wagner. "Cause and Solution for False Upstream Boat Velocities Measured with a StreamPro Acoustic Doppler Current Profiler." *Proceedings of Hydraulic Measurements and Experimental Methods 2007, American Society of Civil Engineers Conference, 2007*.
- 6) Simpson, Michael R., and Richard N. Oltmann. "Acoustic Doppler Discharge-Measurement System." *USGS Publications Warehouse RSS*, USGS, 1 Jan. 1990, pubs.er.usgs.gov/publication/70015885.

Appendix A. Site Selection Requirements

The **Site Selection Requirements** for performing discharge measurements using a SonTek-RS5 instrument are based on a number of measurement site and hydraulic requirements. The measurement site and hydraulic requirements are similar to what a Hydrologists or Hydrographer will use in the selection of monitoring site for either natural or artificial control. The site and hydraulic requirements that need to be taken in into account with every discharge measurement are summarized under the following points.

- a) Uniform flow conditions throughout the measurement section,
- b) Straight length of channel with uniform cross-section and slope (10 times section width).
- c) Flow in the channel should be confined to a single well-defined channel with stable banks.
- d) Avoid a site with wide shallow sections or secondary side channels.
- e) Bends upstream of site should be avoided as this will result in angular flow towards tagline,
- f) Steep slopes upstream should be avoided as this could result in high approach velocities at the measurement site causing turbulent flow conditions.
- g) Avoid measurement sections with deep pools as the reduction in velocity normally diverge from uniform flow conditions,
- h) Avoid prominent obstructions in a pool or excessive plant growth that can affect the flow pattern.
- i) Turbulent flow conditions should be avoided if possible.
- j) Negative and or back flow should be avoided at all times.
- k) Flow conditions must be within the instrument and equipment specifications

Appendix B. Settings

B-1. General Tab

The General Tab contains settings pertaining to general software functionality. The options are shown and described below:

The screenshot shows the 'Settings' dialog box with the 'General' tab selected. The dialog has three tabs: 'General', 'Moving Boat', and 'Units'. The 'General' tab contains the following settings:

Setting	Value
Language/Lenguaje/Langage/Sprache	English
UI Scale	100%
Charting Scale	100%
Data storage location	C:/Users/xfan/Test Data/RS5 Test Data/RS-Q/RSQ
Data collection processes	☒ Moving Boat ☒ Stationary
File naming	SiteName_Date_Time
Folder naming	Site Name
Allow simulated connections	☒
Show diagnostic parameters	☐
Check for crash reports	☒

At the bottom of the dialog are three buttons: 'OK', 'Cancel', and 'Reset to Default'.

- **Language**

Automatic languages include: English, French, German, Greek, Italian, Japanese, Korean, Polish, Portuguese, Portuguese (Brazilian), Romanian, Russian, Spanish, Spanish (Latin America)

- **UI Scale**

The UI Scale sets the user interface scale for text, buttons, and software features. The default value is 100%.

- **Charting Scale**

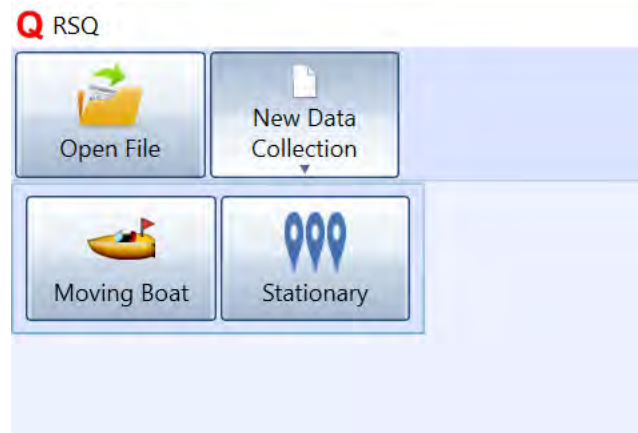
The Charting Scale sets the axis/legend labels for all charts separately.

- **Data Storage Location**

This sets the location where the RSQ files will be saved after a measurement is collected.

- **Data Collection Processes**

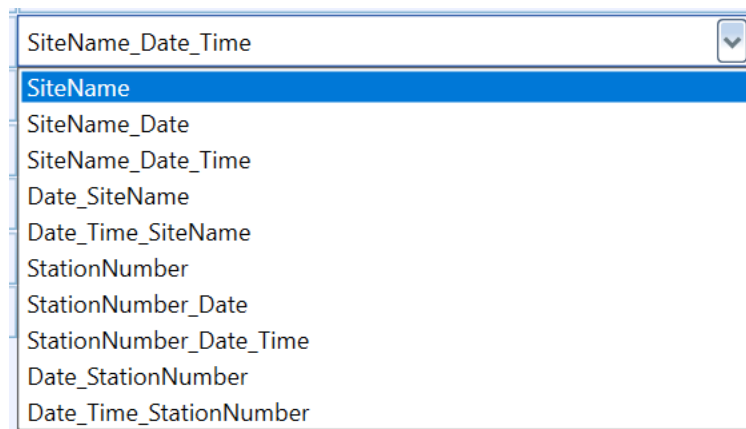
This gives the user the ability to toggle either Moving Boat, Stationary, or both methods to be viewed when the New Data Collection button is clicked, shown below:



If users know they always use one or the other option, they can disable the unused option.

- **File Naming**

This option sets the default file naming convention used by RSQ. The options are shown below:



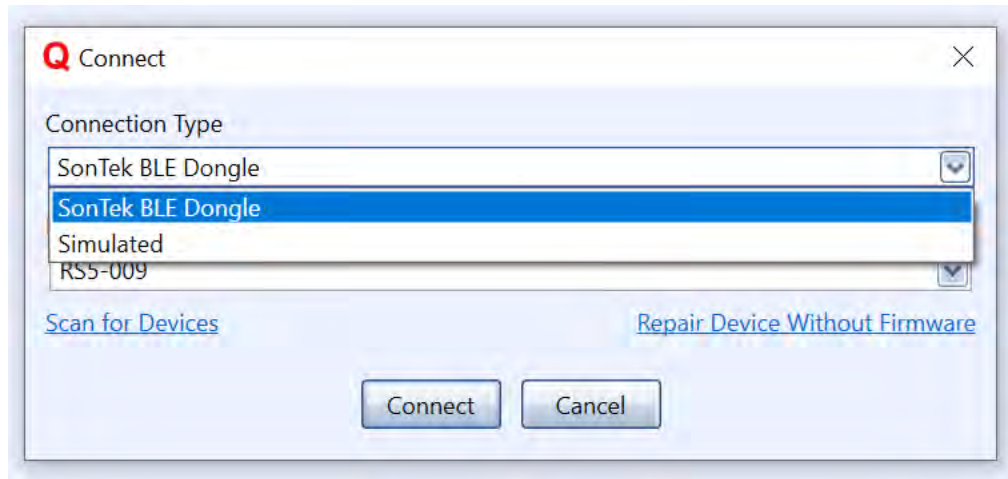
- **Folder Naming**

This sets the folder naming convention when folders are created by the software. The options are:

- a) Site Name
- b) Station Number
- c) Year-Month

- **Allow Simulated Connections**

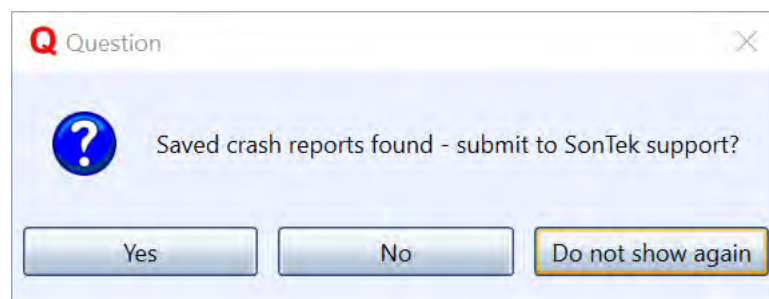
The simulated connection option allows the user to simulate a connection to an RS5 system. It can be used for training purposes or to familiarize a user with the connection and data collection interface and steps prior to obtaining an instrument. The simulation plays back an existing data file as if the user were performing a real measurement. If the “Allow simulated connections” option is checked, when the user clicks the Connect button (or uses **CTRL+N**), they will see the following choices:



To connect to a real system, the user should select “SonTek BLE Dongle.” For the simulated connection, they can select “Simulated” and the software will run through the same steps as it would with a real connection.

- **Check for Crash Reports**

When this option is selected, the user will see the following pop-up will appear when the RSQ software starts up:



The user can send the generated crash report via email to SonTek. Clicking on “Do not show again” essentially toggles this option in the software settings.

B-2. Moving Boat Tab

The Moving Boat tab shows settings specific to moving boat measurements. Options are shown and described below:

Setting	Value
Highlight summary records	☒
Synchronize charts' X axes	☒
Show measurement tabs when Summary is visible	☒
Automatic MATLAB Export	☐
Side-bar parameter ordering	Manual
Visible Time Series charts	3
Summary Report chart type	Time Series & Transect
Extrap method fit type	Measurement

- **Highlight Summary Records**

Checking the “Highlight summary records” will highlight transects in red in the Discharge Summary that exceed 5% difference in discharge compared to the mean. Please see Section 7.12 for an example.

- **Synchronize Charts' X-axes**

When enabled, this option synchronizes the X-axes of different charts if the user zooms in or out on one of them. This most often applies to charts having an X-axis of Sample Number or Track Distance. Disabling this option allows each chart to zoom individually.

- **Show measurement tabs when Summary is visible**

This option allows users to optimize space in the software. When enabled, if the Discharge Summary is shown, transect tabs along the top of the software will disappear, allowing more space to view data.

- **Automatic MATLAB Export**

When this option is enabled, when a file is opened, the MATLAB export function will automatically create the exported files in a separate folder to facilitate processing in QRev.

- **Side-bar Parameter Ordering**

This setting allows the user to manually order the parameters displayed in the side-bar (top left). Alternatively, and user can select automatic ordering (alphabetical).

- **Visible Time Series charts**

This option allows the user to select the number of time series charts displayed in the Time Series tab.

- **Summary Report chart type**

The user can select here what charts to include in the Summary Report (described in Section 8.7.3). Options include None, Time Series, Transect, or Time Series & Transect.

- **Extrap method fit type**

This setting allows the user to choose what data the EXTRAP method (via Discharge Settings) will use for its calculations and results. Options include a single Transect, or the entire Measurement. The default is Measurement.

B-3. Units Tab

This is where the user can adjust units displayed in the software. This is also where the number of decimals displayed can be configured as well. Use the 'Metric' or 'US/Imperial' buttons on the bottom right to set all applicable units to either choice if desired. The choices selected here will be saved for subsequent software sessions.

Measurement Value	Unit Options
Amplitude	Counts
Angle	Degrees, Radians
Area	Square feet, Square meters
Counts	Counts
Depth	Centimeters, Fathoms, Feet, Inches, Kilometers, Meters, Miles, Millimeters, Yards
Discharge	Acre feet per day, Acre feet per hour, Cubic feet per second, Cubic meters per second, Liters per second, Megaliters per day, Million UK gallons per day, Million US gallons per day, UK gallons per minute, US gallons per minute

Distance	Centimeters, Fathoms, Feet, Inches, Kilometers, Meters, Miles, Millimeters, Yards
Fraction Decimal	Decimal
Fraction Percent	Percent
Frequency	Gigahertz, Hertz, Kilohertz, Megahertz
GPS Position	Decimal Degrees, Degrees Minutes Seconds, DegreesMinutes
Pressure	Bar, Decibars, Feet of water, Meters of water, Pascal, Pound Force per Square Inch
Profile Range	Centimeters, Fathoms, Feet, Inches, Kilometers, Meters, Miles, Millimeters, Yards
Salinity	Practical Salinity Scale
SNR	Decibels
Sound Speed	Centimeters per second, Feet per second, Furlongs per fortnight, Inches per second, Kilometers per hour, Knots, Meters per second, Miles per hour, Millimeters per second, Yards per second
Temperature	Celcius, Fahrenheit, Kelvin
Time	Data Collection Time Zone, Local PC Time Zone, UTC
Time Span	Minutes, Seconds
Voltage	Millivolts, Volts
Water Velocity	Centimeters per second, Feet per second, Furlongs per fortnight, Inches per second, Kilometers per hour, Knots, Meters per second, Miles per hour, Millimeters per second, Yards per second

Appendix C. Hardware Utilities

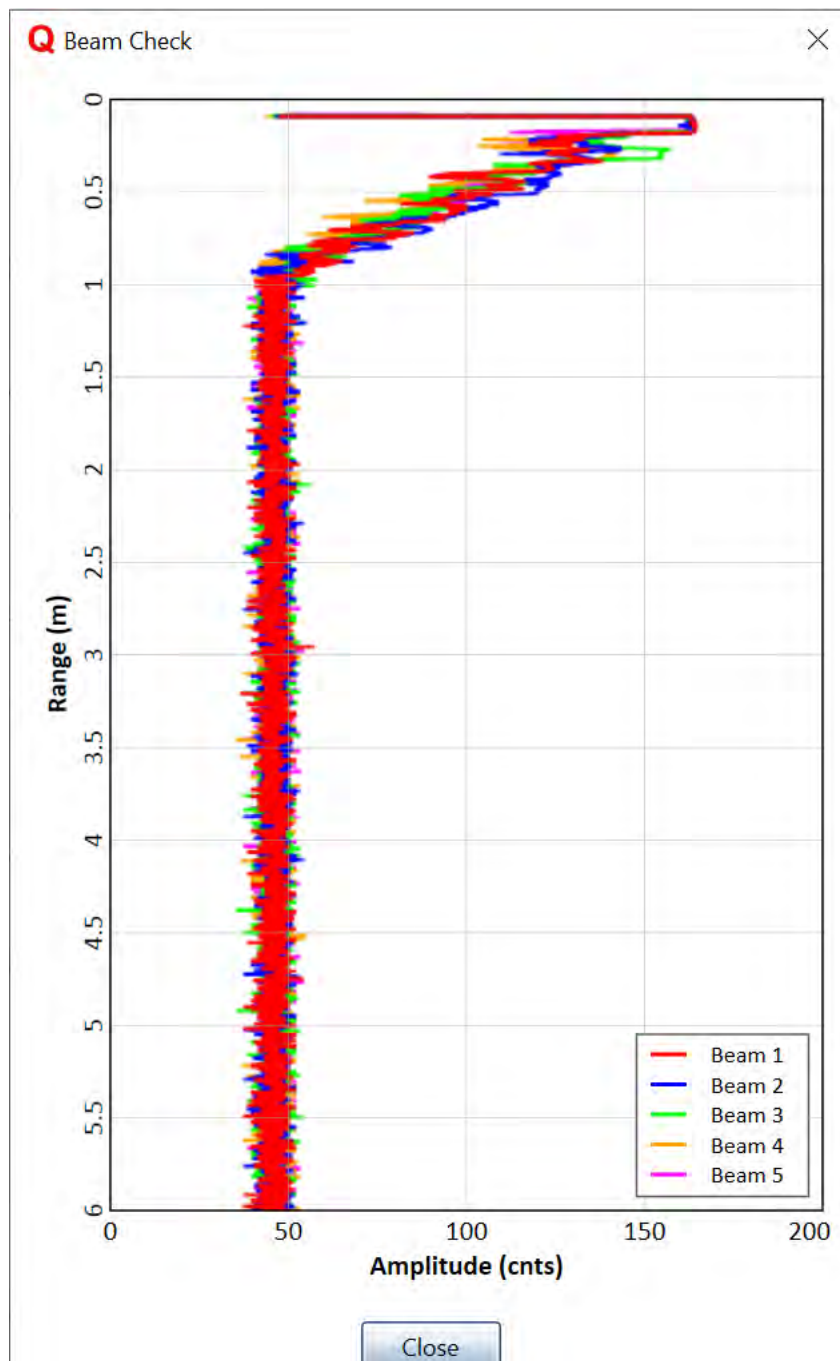
The Hardware Utilities tools requires an active connection to an RS5 system. If the user is not connected to a system, the connection dialog will appear before moving forward to the Hardware Utilities dialog, shown below:



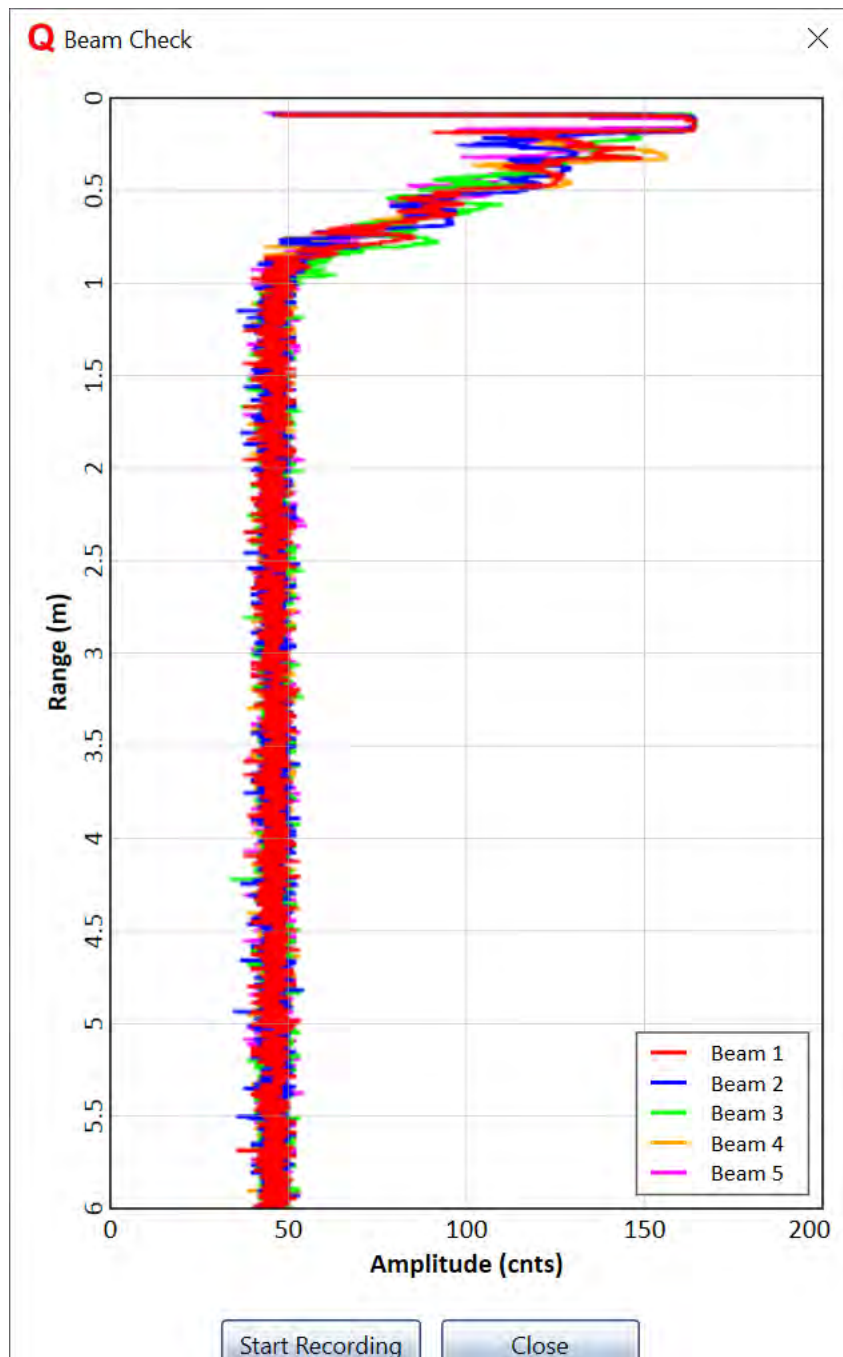
C-1. Beam Check

The Beam Check is a standard diagnostic tools accompanying all SonTek systems. It is generally used to observe site conditions and diagnose any site or instrument issues. It is good practice to collect a Beam Check file when arriving at a new site to understand the response of the ADP transducers and to ensure that the acoustic signals are getting the quality and range that are expected.

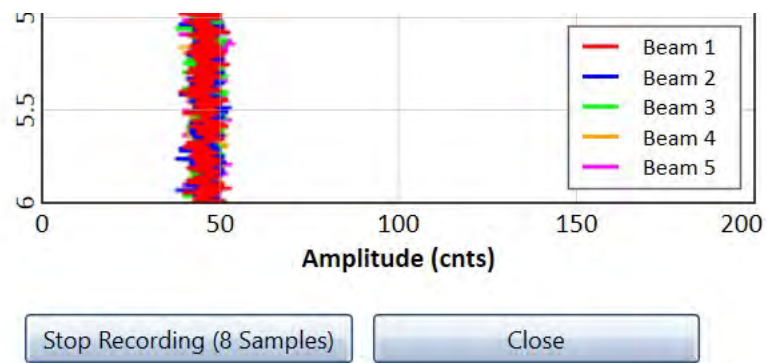
The Beam Check displays the reflected Amplitude (counts) of each beam versus range from the system. If a measurement has not been started, clicking the Beam Check button will simply display the Beam Check data, as shown below.



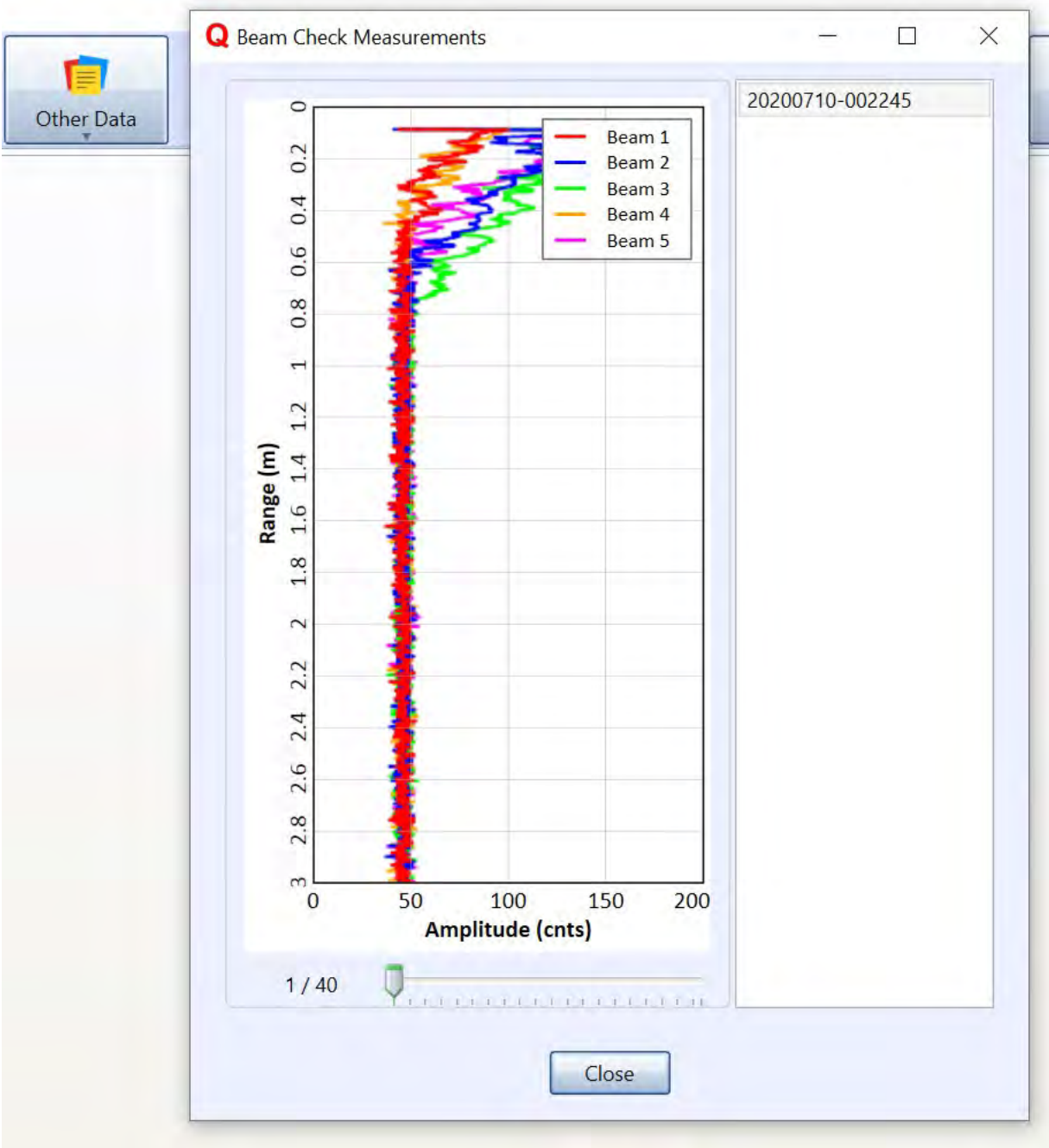
If a measurement has already begun, the Beam Check dialog will include an option to record the file, as shown below.



When the Start Recording button is pushed, there will be a sample counter as well as a Stop button on the bottom of the dialog, as shown here:



The recorded Beam Check files will be saved automatically with the measurement (.rsqmb) file, and can be viewed by clicking on the Other Data button:



C-2. Compass Calibration

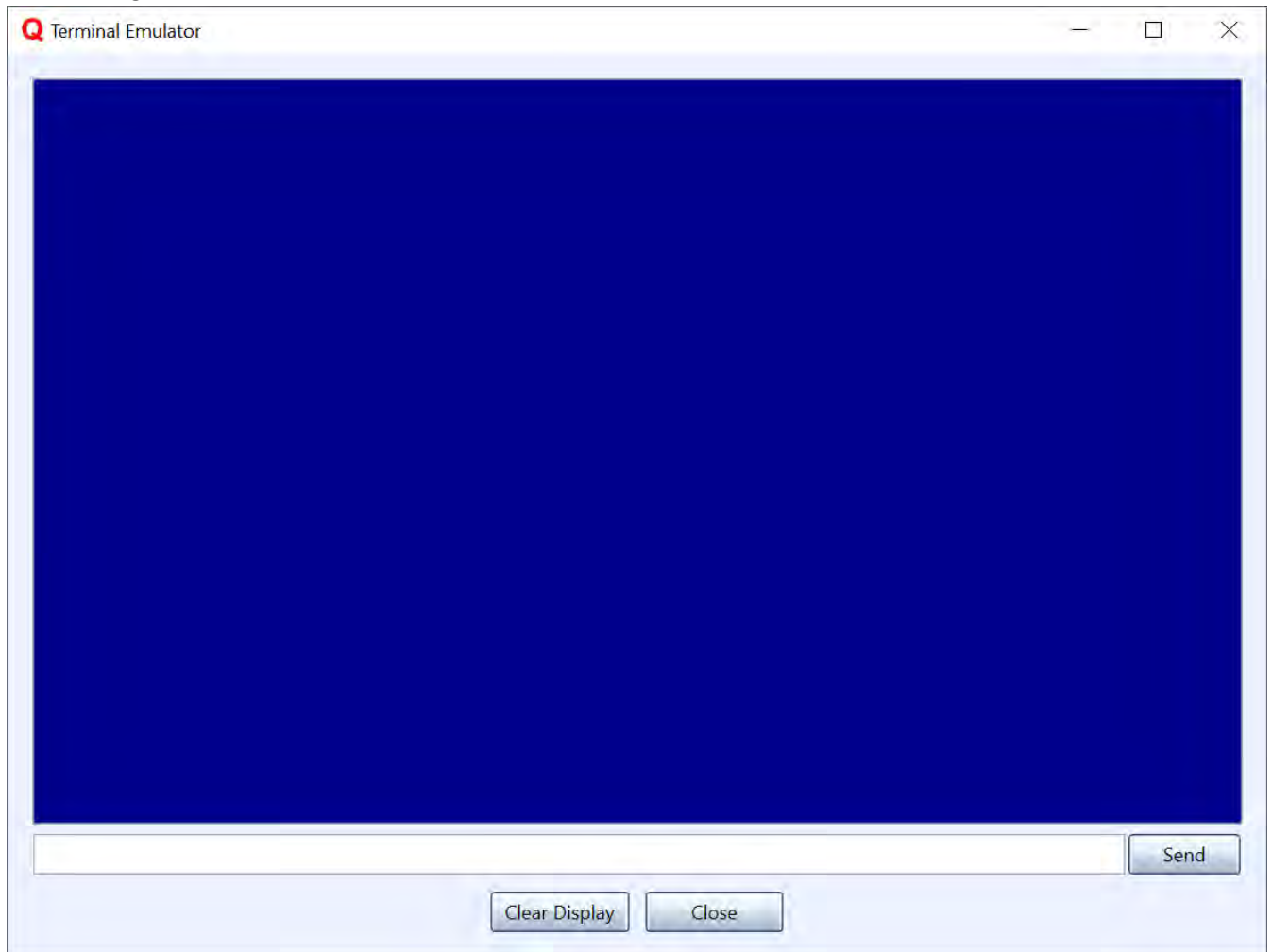
A compass calibration can be performed through this dialog, as well as through the Smart Page. Please refer to Section 7.5.4 for details on how to perform a compass calibration with the RS5.

C-3. System Test

The System Test can be performed through this dialog, as well as through the Smart Page. Please refer to Section 7.5.2 for details on the System Test.

C-4. Terminal Emulator

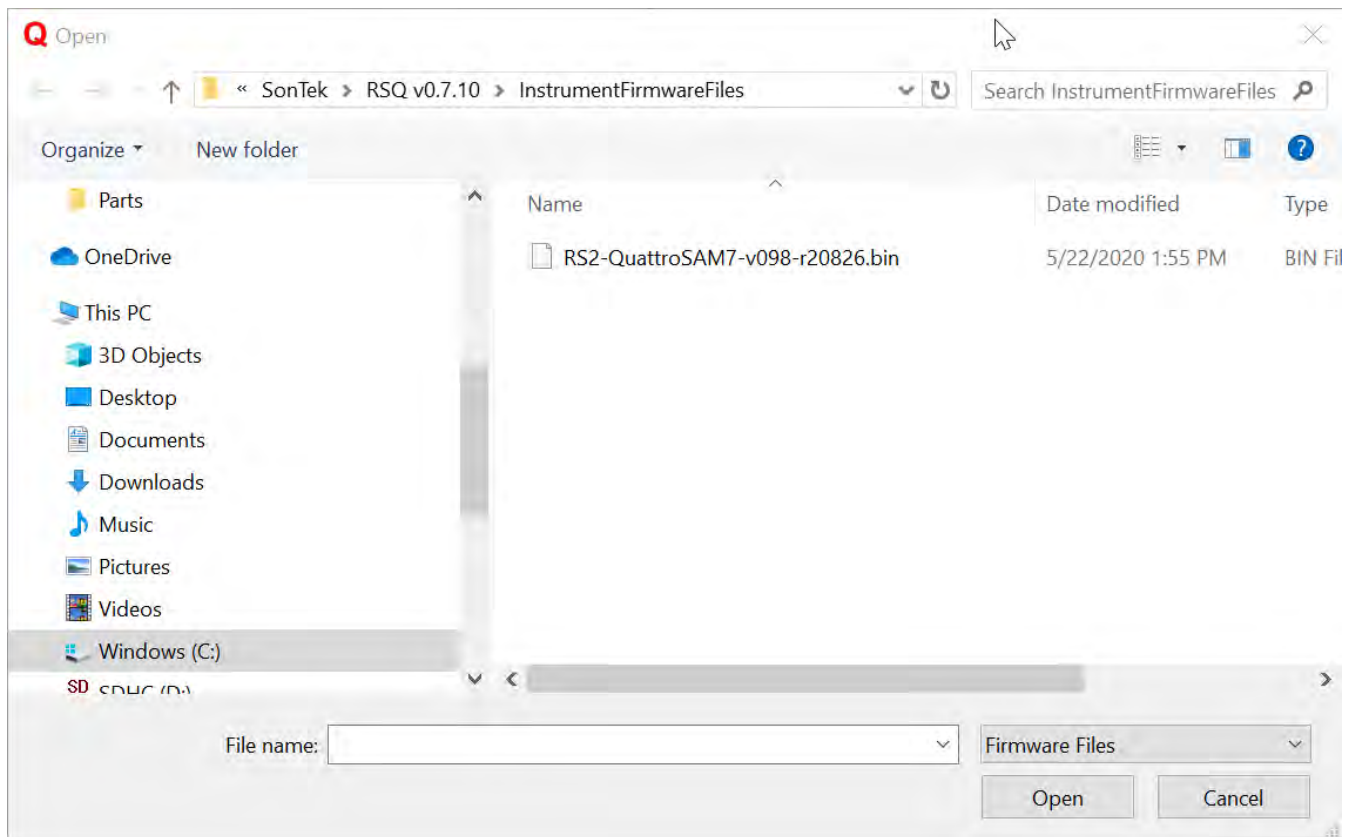
The RSQ software provides a terminal emulator interface for advanced users who have been in contact with SonTek Technical Support and have received special instructions for issuing terminal commands. The terminal emulator interface is shown below:



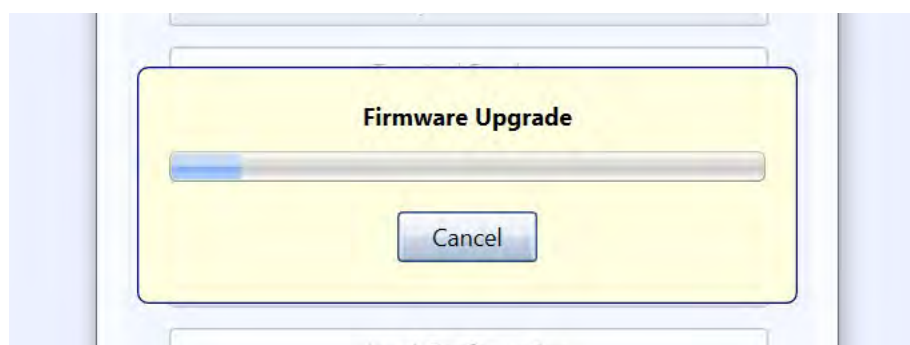
C-5. Firmware Upgrade

The Firmware Upgrade button allows the user to load new firmware onto the RS5. Please ensure that before performing a firmware upgrade, there is sufficient battery life in the RS5. A low battery could cause communications drops and jeopardize the firmware upgrade process.

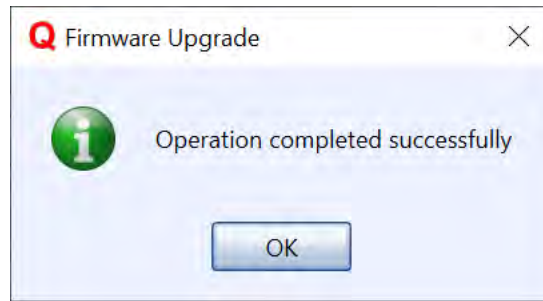
When the Firmware Upgrade button is pressed, the following dialog will appear:



The RSQ software will point to a default firmware folder, and search for a firmware file (with extension .bin). If the user is provided with a different firmware file (as a beta tester, or for any other reason), the user can navigate to the location where that file is located. Pressing the Open button will initiate the firmware upgrade process. A status bar will appear:



When successful, the following message will appear:



C-6. Instrument Options

This function contains various settings the user can enable, if desired. They include:

Enable GNSS

Configure GNSS Antenna

These settings allow the user to enable the GNSS/GPS function on their RS5 and to configure an external GNSS/GPS antenna to connect to the RS5.

Please see Appendix D for detailed instructions on how to Enable External GNSS and configuring it.

C-7. Load Configuration

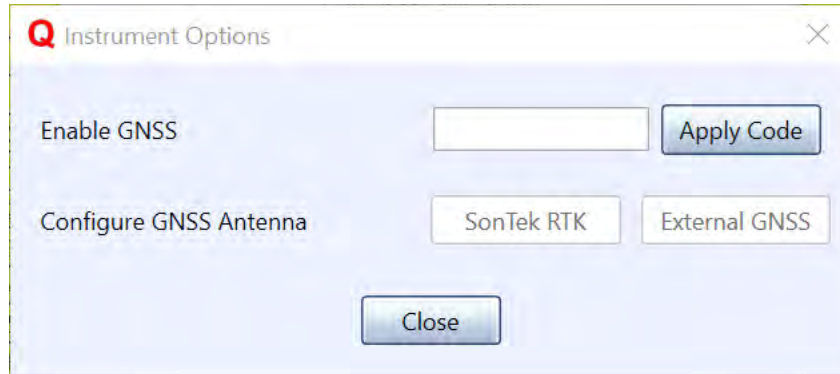
This function allows the user to load a configuration (.ini) file. Please see SonTek Technical Support for more details on the configuration file, if needed.

C-8. Save Configuration

This button saves the current configuration to a configuration (.ini) file. This may be requested by SonTek Technical Support during troubleshooting.

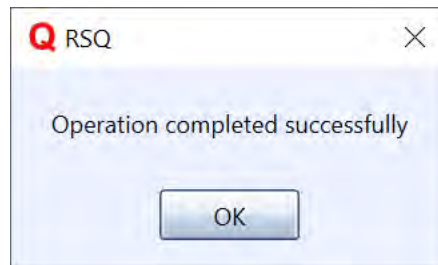
Appendix D. How to Enable External GNSS

The GNSS/GPS unlock and configuration operations can be found through Tools > Hardware Utilities > Instrument Options. Please note that the RS5 system must be connected to see these options. The Instrument Options dialog is shown below:

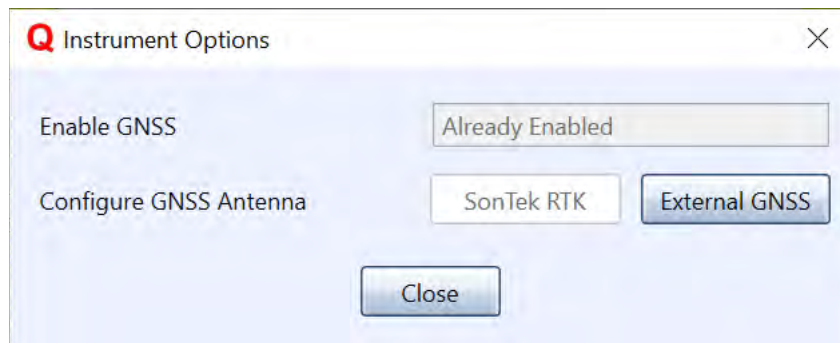


If the user has upgraded their RS5-STD system to RS5-Max, they will need to first use the unlock code provided by SonTek to enable the GNSS/GPS capabilities of the Max system. Please note that the following steps do not need to be performed if the user has purchased a Max system directly from SonTek, as these steps will already have been configured.

The instrument unlock code is an 8-digit alpha-numeric code specific to each RS5 system. Enter the code into the space in the "Enable GNSS" line and press Apply Code. If the code is entered properly, the following message will appear:



The user will also see that the GNSS feature has been enabled:



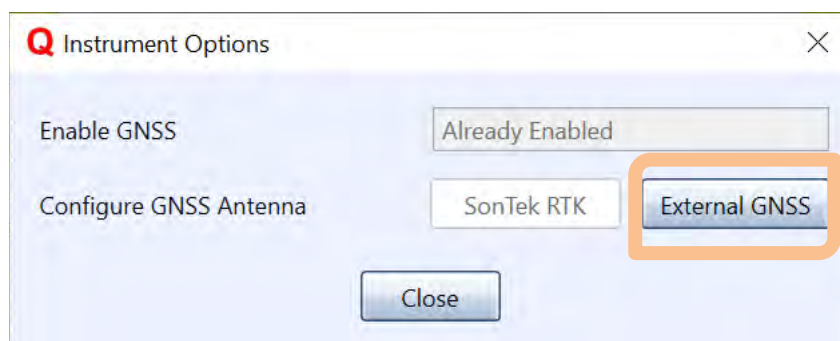
If the user is configuring an external GNSS/GPS antenna to use for the first time, the antenna must be configured for serial communications at a **baud rate of 38400.**

The data output rate for the strings required should be configured according to the following table:

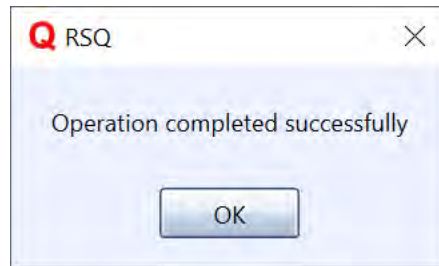
Message	Required Output Rate	Description
GGA	5Hz	UTC time, position, quality and DGPS diagnostics
VTG	5Hz	ground speed and direction
RMC	1Hz	UTC date and magnetic declination
ZDA	1Hz	UTC date
GSV	1Hz	detailed satellite (in view) information
GSA	1Hz	list of satellites used in fix

When configuration is finished, the external antenna must be connected via serial cable to the RS5 system through the GPS connector port. Power both the RS5 and antenna on, and go outside to a location where a reliable GNSS/GPS signal can be achieved.

Then, click the “External GNSS” button highlighted below:



If successful, the following message will appear:



If the process fails, please check all connections and ensure that the antenna is on and receiving proper GNSS location data. The antenna is now configured to work with the RS5. This process does not need to be repeated each time the antenna is connected to the RS5, and is only required the first time.

Appendix E. Matlab Export File Structure – Moving

IMPORTANT NOTES:

- The term “sample” refers to a single vertical profile, taken over a period of 1 s.
- For the four parameters containing *Velocity* data (BottomTrack.BT_Vel, Summary.Mean_Vel, Summary.Boat_Vel, and WaterTrack.Velocity), the data are in the same coordinate system that was selected in the software when the .mat file was exported.

For example:

- BT_Vel when exported in ENU coordinates will be:
 1. East Velocity (i.e. velocity to the East)
 2. North Velocity
 3. Up Velocity
 4. Difference Velocity (aka Error Velocity; the difference between measuring the vertical component of the velocity from the two pairs of opposing beams)
- BT_Vel when exported in *XYZ coordinates* will be:
 1. X Velocity
 2. Y Velocity
 3. Up Velocity
 4. Difference Velocity
- BT_Vel when exported in *Beam coordinates* will be:
 1. Beam 1
 2. Beam 2
 3. Beam 3
 4. Beam 4
- GPS Altitude (from the GGA string) is based on a proprietary, non-published geoid, and referenced to the bottom-center of the antenna.

The basic order of the root structures is as follows. For the Size Column:

- NS is the number of samples;
- NC is the maximum number of cells;
- If the structure contains another structure inside it, or the parameter is a scalar, the size is NA.

Structure Name	Description
BottomTrack	Bottom Track Velocity, Depth and Frequency variables (includes Vertical Beam)
General	General parameters pertaining to various settings
GPS	GPS data and quality information.
Processing	Processing settings
RawGPSData	The raw GPS data from either the internal GPS or an external serially connected GPS system. This data is stored in its raw format with the same frequency that was output from the GPS
Setup	System settings, edge information and profile extrapolation
SiteInfo	Site information

Summary	Calculated discharge variables and the data used to compute them
System	Core system related parameters: Compass, Temperature, Time, SNR, Voltage and Profiling settings
Transformation_Matrices	System frequencies and transformation matrices
WaterTrack	Water velocity and profiling variables in coordinates selected for output

BottomTrack Structure

Parameter Name	Description	Size
All_Beams_Beam_Depth	Depth for each beam (including vertical beam) for each sample, including the Transducer Depth. The order of beams is 1-2-3-4-VB.	NS x 5
VB_Depth	Vertical Beam depth for each sample, including the Transducer Depth	NS x 1
BT_Depth	Mean Bottom Track depth for each sample, including the Transducer Depth and compensation for tilt. This is the mean of the depth measured by each active transducer and projected in vertically below of the ADP	NS x 1
BT_Vel	Bottom Track Velocity for each direction (or beam, if exported in Beam coordinates) for each sample	NS x 4
BT_Beam_Depth	Bottom Track depth for each beam for each sample, including the Transducer Depth and compensation for tilt	NS x 4
BT_Frequency	Frequency of Bottom Track data for each sample (correlate with Frequency parameter from Transformation_Matrices structure)	NS x 1
Units	Units for above parameters	NA

General Structure

Parameter Name	Description	Size
Disabled_Beam	Indicates whether a beam is disabled using the Beam Switching feature. If beam is used, '-1' will be displayed. Otherwise, the beam number less 1(0,1,2, or 3) will be displayed for those samples with that beam disabled (beams 1,2,3, or 4, accordingly).	NS x 1
Sample_Number	Sample number	NS x 1
Sample_Time	Sample time	NS x 1
Sample_Type	Sample type (Start Edge, Transect Section, End Edge)	NS x 1
Total_Duration	Total cumulative duration	NS x 1
Use_BT	This corresponds to the setting in the Samples tab called "Use BT" which allows the user to disable that sample due to bad bottom track. If the sample is used, the value is 1, otherwise it is 0.	NS x 1
Units	Units used	

GPS Structure

Parameter Name	Description	Size
Altitude	Altitude	NS x 1
DBT_DGPS	Ratio of bottom track distance to GGA track distance	NS x 1
GC_BC	Angle of average GPS course since start of transect minus ADP bottom-track course (if valid)	NS x 1
Gps_Age	Age of GPS data record	NS x 1
Gps_Geoid	Geoid separation	NS x 1
GPS_Quality	GPS quality (4=RTK, 5=float, 2=Diff, 1=no correction, 0=no GPS)	NS x 1
HDOP	Horizontal dilution of precision	NS x 1
Latitude	Latitude	NS x 1
Longitude	Longitude	NS x 1
Satellites	Number of satellites	NS x 1
Utc	Time in UTC	NS x 1
Utm	UTM Easting and Northing value	NS x 2
Units	Units used	NA

Processing Structure

Parameter Name	Description	Size
Screening	User-applied minimum SNR filtering settings, in dB	NA
Corrections	User-applied heading correction, in degrees	NA

RawGPSData Structure (This structure contains 5 columns per sample because the instrument samples the GPS port at 5 Hz)

Parameter Name	Description	Size
GgaAltitude	\$GPGGA altitude above sea level for each high frequency GPS sample (m)	NS x 5
GgaLatitude	\$GPGGA latitude for each high frequency GPS sample	NS x 5
GgaLongitude	\$GPGGA longitude for each high frequency GPS sample	NS x 5
GgaQuality	\$GPGGA fix quality for each high frequency GPS sample (4 = RTK, 2 = Differential, 1 = Standard, 0 = Invalid)	NS x 5
GgaTimeStamp	\$GPGGA time stamp for each high frequency GPS sample	NS x 5
GgaUTC	\$GPGGA UTC for each high frequency GPS sample (HHMMSS.S)	NS x 5
Raw_GPS_Strings	Contains the full raw GPS string for each sample	NS x 1
VtgMode	\$GPVTG active mode for each high frequency GPS sample	NS x 5
VtgSogMPS	\$GPVTG speed over ground for each high frequency GPS sample (m/s)	NS x 5
VtgTimeStamp	\$GPVTG time stamp for each high frequency GPS sample	NS x 5
VtgTmgMag	\$GPVTG magnetic course made good for each high frequency GPS sample (degrees)	NS x 5

VtgTmgTrue	\$GPVTG true course made good for each high frequency GPS sample (degrees)	NS x 50
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Setup Structure

Parameter Name	Description	Size
sensorDepth	Transducer depth (m)	NA
screeningDistance	Vertical screening distance (m)	NA
userSalinity	User input salinity (pss)	NA
magneticDeclination	Magnetic Declination (degrees)	NA
offsetX	GPS Antenna Offset (X)	NA
offsetY	GPS Antenna Offset (Y)	NA
coordinateSystem	Coordinate system (0 = Beam; 1 = XYZ; 2 = ENU)	NA
trackReference	Track reference (0 = System; 1 = Bottom Track; 2 = GPS GGA; 3 = GPS VTG)	NA
depthReference	Depth reference (0 = Vertical beam; 1 = Bottom Track)	NA
startEdge	Start edge (0 = Left bank; 1 = Right bank)	NA
Edges_0_DistanceToBank	Left Edge: Distance to the bank	NA
Edges_0_EstimatedQ	Left Edge: Estimated discharge	NA
Edges_0_Method	Left Edge: Method (0 = User input discharge; 1 = Vertical bank; 2 = Sloped bank)	NA
Edges_1_DistanceToBank	Right Edge: Distance to the bank	NA
Edges_1_EstimatedQ	Right Edge: Estimated discharge	NA
Edges_1_Method	Right Edge: Method (0 = User input discharge; 1 = Vertical bank; 2 = Sloped bank)	NA
extrapolation_Top_nFitType	Profile Extrapolation - Top: Fit equation type (0 = Constant fit; 1 = Power fit)	NA
extrapolation_Top_nEntireProfil	Profile Extrapolation - Top: Fit (0 = Use entire profile; 1 = User selected number of cells)	NA
extrapolation_Top_dExponent	Profile Extrapolation - Top: Power fit exponent	NA
extrapolation_Top_nCells	Profile Extrapolation - Top: Number of cells used in extrapolation	NA
Extrapolation_Top_nPercentage	Empty – not used	NA
extrapolation_Bottom_nFitType	Profile Extrapolation - Bottom: Fit equation type (0 = Constant fit; 1 = Power fit)	NA
extrapolation_Bottom_nEntirePro	Profile Extrapolation - Bottom: Fit (0 = Use entire pro-file; 1 = User selected number of cells)	NA
extrapolation_Bottom_dExponent	Profile Extrapolation - Bottom: Power fit exponent	NA
extrapolation_Bottom_nCells	Profile Extrapolation - Bottom: Number of cells used in extrapolation	NA
Extrapolation_Bottom_nPercentage	Percentage of profile to apply the bottom extrapolation	NA
extrapolation_nDiscardType	Method for discarding cells at the bottom of the profile (0 = user selected number of cells; 1 = percentage of profile)	NA
extrapolation_nDiscardCells	Number of cells discarded	NA
extrapolation_dDiscardPercent	Percentage of profile discarded	NA
headingCorrection	Empty – not used	NA
hdtHeadingCorrection	Empty – not used	NA
headingSource	Empty – not used	NA

Units	Units used	NA
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SiteInfo Structure

Parameter Name	Description	Size
Site_Name	Entry in Site Name	NA
Station_Number	Entry in Station Number	NA
Location	Entry in Location	NA
Party	Entry in Party	NA
Boat_Motor	Entry in Boat Motor	NA
Meas_Number	Entry in Measurement Number	NA
GaugeHeightInformation	Entry in GaugeHeightInformation	NA
Comments	Entry in Comments	NA

Summary Structure

Parameter Name	Description	Size
Boat_Vel	Boat velocity used for discharge calculation for each sample	NS x 4
Bottom_Q	Discharge for the bottom section for each sample	NS x 1
Cells	Number of cells used for discharge calculation for each sample	NS x 1
Depth	Depth used for discharge calculation for each sample	NS x 1
Left_Q	Discharge for the left edge for each sample	NS x 1
Mean_Speed	Mean water velocity for each sample, inclusive of the top and bottom extrapolation	NS x 1
Mean_Vel	Mean water velocity for each sample, inclusive of the top and bottom extrapolation, for the horizontal velocity components.	NS x 2
Middle_Q	Discharge for the middle (measured) section for each sample	NS x 1
Left_Q Right_Q	Discharge for the right edge for each sample	NS x 1
Top_Q	Discharge for the top section for each sample	NS x 1
Total_Q	Total discharge for each sample	NS x 1
Track	Track location for each sample in X and Y coordinates	NS x 2
Area	Area	NA
Units	Units used	NA

System Structure

Parameter Name	Description	Size
Battery_Voltage	Battery voltage for each sample	NS x 1
Cell_Size	Size of depth cells for each sample	NS x 1
Cell_Start	Start of the first cell for each sample	NS x 1
Heading	Compass heading for each sample	NS x 1
MagneticError	Magnetic error for each sample	NS x 1
Pitch	Pitch for each sample	NS x 1
Roll	Roll for each sample	NS x 1
SNR	Signal to noise ratio for each cell of each beam per sample	NC x 4 x NS
Temperature	Temperature for each sample	NS x 1
SerialNumber	Instrument serial number	NA
GPS_Compass_Heading	Empty – not used	NS x 1

Time	Time for each sample	NS x 1
Units	Units used	NA

Transformation Matrices Structure

Parameter Name	Description	Size
Frequency	Frequencies available for the system	3 x 1
Matrix	Transformation matrices for each frequency	4 x 4 x 3

WaterTrack Structure

Parameter Name	Description	Size
Correlation	Each correlation score for each cell of each sample. Only applicable for samples collected with SmartPulse ^{HD}	NC x 4 x NS
Vel_Expected_StdDev	Each calculated standard deviation of water velocity for each cell of each sample	NC x 4 x NS
Vel_StdDev	Each standard deviation of water velocity for each cell of each sample	NC x 4 x NS
Velocity	Each water velocity component for each cell of each sample	NC x 4 x NS
WT_Frequency	Frequency used for WaterTrack data for each sample (correlate with Frequency parameter from Transformation_Matrices structure)	NS x 1
Units	Units used	NA

Appendix F. Matlab Export File Structure – Stationary

IMPORTANT NOTES:

- The term “sample” refers to a single vertical profile, taken over a period of 1 s.
- For the four parameters containing *Velocity* data (BottomTrack.BT_Vel, Summary.Mean_Vel, Summary.Boat_Vel, and WaterTrack.Velocity), the data are in the same coordinate system that was selected in the software when the .mat file was exported.

For example:

- BT_Vel when exported in ENU coordinates will be:
 1. East Velocity (i.e. velocity to the East)
 2. North Velocity
 3. Up Velocity
 4. Difference Velocity (aka Error Velocity; the difference between measuring the vertical component of the velocity from the two pairs of opposing beams)
- BT_Vel when exported in *XYZ coordinates* will be:
 1. X Velocity
 2. Y Velocity
 3. Up Velocity
 4. Difference Velocity
- BT_Vel when exported in *Beam coordinates* will be:
 1. Beam 1
 2. Beam 2
 3. Beam 3
 4. Beam 4

The basic order of the root structures is as follows. For the Size Column:

- NS is the number of stations;
- NC is the maximum number of cells;
- If the structure contains another structure inside it, or the parameter is a scalar, the size is NA.

Structure Name	Description
BottomTrack	Bottom Track Velocity, Depth and Frequency variables (includes Vertical Beam)
General	General parameters pertaining to various settings
GPS	GPS data and quality information.
Processing	Processing settings
Setup	System settings, edge information and profile extrapolation
SiteInfo	Site information
Summary	Calculated discharge variables and the data used to compute them
System	Core system related parameters: Compass, Temperature, Time, SNR, Voltage and Profiling settings
Transformation_Matrices	System frequencies and transformation matrices

WaterTrack	Water velocity and profiling variables in coordinates selected for output
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BottomTrack Structure

Parameter Name	Description	Size
All_Beams_Beam_Depth	Average depth for each beam (including vertical beam) for each station, including the Transducer Depth. The order of beams is 1-2-3-4-VB.	NS x 5
VB_Depth	Vertical Beam depth for each station, including the Transducer Depth	NS x 1
BT_Depth	Mean Bottom Track depth for each station, including the Transducer Depth and compensation for tilt. This is the mean of the depth measured by each active transducer and projected in vertically below of the ADP	NS x 1
BT_Vel	Bottom Track Velocity for each direction (or beam, if exported in Beam coordinates) for each station	NS x 4
BT_Beam_Depth	Bottom Track depth for each beam for each station, including the Transducer Depth and compensation for tilt	NS x 4
BT_Frequency	Frequency of Bottom Track data for each station (correlate with Frequency parameter from Transformation_Matrices structure)	NS x 1
Units	Units for above parameters	NA

General Structure

Parameter Name	Description	Size
Coordinate_System	ENU or XYZ	NS x 1
Sample_Time	Sample time at beginning of station	NS x 1
Stationary_Station_Number	Station number	NS x 1
Stationary_Station_Type	Station type (Right/Left bank, Open Water, Ice, Island Edge)	NS x 1
Use_Station	1 = Use, 0 = not used	NS x 1
Velocity_Correction_Factor	Velocity correction factor	NS x 1
Units	Units used	NA

GPS Structure

Parameter Name	Description	Size
Altitude	Altitude	NS x 1
Gps_Age	Age of GPS data record	NS x 1
Gps_Geoid	Geoid separation	NS x 1
GPS_Quality	GPS quality (4=RTK, 5=float, 2=Diff, 1=no correction, 0=no GPS)	NS x 1
HDOP	Horizontal dilution of precision	NS x 1
Latitude	Latitude	NS x 1

Longitude	Longitude	NS x 1
Satellites	Number of satellites	NS x 1
Utc	Time in UTC	NS x 1
Utm	UTM Easting and Northing value	NS x 2
Units	Units used	NA

Processing Structure

Parameter Name	Description	Size
Screening	User-applied minimum SNR filtering settings, in dB	NA
Corrections	User-applied heading correction, in degrees	NA

Setup Structure

Parameter Name	Description	Size
sensorDepth	Transducer depth (m)	NA
screeningDistance	Vertical screening distance (m)	NA
userSalinity	User input salinity (pss)	NA
magneticDeclination	Magnetic Declination (degrees)	NA
offsetX	GPS Antenna Offset (X)	NA
offsetY	GPS Antenna Offset (Y)	NA
coordinateSystem	Coordinate system (0 = Beam; 1 = XYZ; 2 = ENU)	NA
trackReference	Track reference (0 = System; 1 = Bottom Track; 2 = GPS GGA; 3 = GPS VTG)	NA
depthReference	Depth reference (0 = Vertical beam; 1 = Bottom Track)	NA
startEdge	Start edge (0 = Left bank; 1 = Right bank)	NA
Edges_0_DistanceToBank	Left Edge: Distance to the bank	NA
Edges_0_EstimatedQ	Left Edge: Estimated discharge	NA
Edges_0_Method	Left Edge: Method (0 = User input discharge; 1 = Vertical bank; 2 = Sloped bank)	NA
Edges_1_DistanceToBank	Right Edge: Distance to the bank	NA
Edges_1_EstimatedQ	Right Edge: Estimated discharge	NA
Edges_1_Method	Right Edge: Method (0 = User input discharge; 1 = Vertical bank; 2 = Sloped bank)	NA
extrapolation_Top_nFitType	Profile Extrapolation - Top: Fit equation type (0 = Constant fit; 1 = Power fit)	NA
extrapolation_Top_nEntireProfil	Profile Extrapolation - Top: Fit (0 = Use entire profile; 1 = User selected number of cells)	NA
extrapolation_Top_dExponent	Profile Extrapolation - Top: Power fit exponent	NA
extrapolation_Top_nCells	Profile Extrapolation - Top: Number of cells used in extrapolation	NA
Extrapolation_Top_nPercentage	Empty – not used	NA
extrapolation_Bottom_nFitType	Profile Extrapolation - Bottom: Fit equation type (0 = Constant fit; 1 = Power fit)	NA
extrapolation_Bottom_nEntirePro	Profile Extrapolation - Bottom: Fit (0 = Use entire pro-file; 1 = User selected number of cells)	NA

extrapolation_Bottom_dExponent	Profile Extrapolation - Bottom: Power fit exponent	NA
extrapolation_Bottom_nCells	Profile Extrapolation - Bottom: Number of cells used in extrapolation	NA
Extrapolation_Bottom_nPercentage	Percentage of profile to apply the bottom extrapolation	NA
extrapolation_nDiscardType	Method for discarding cells at the bottom of the profile (0 = user selected number of cells; 1 = percentage of profile)	NA
extrapolation_nDiscardCells	Number of cells discarded	NA
extrapolation_dDiscardPercent	Percentage of profile discarded	NA
headingCorrection	Empty – not used	NA
hdtHeadingCorrection	Empty – not used	NA
headingSource	Empty – not used	NA
Units	Units used	NA

SiteInfo Structure

Parameter Name	Description	Size
Site_Name	Entry in Site Name	NA
Station_Number	Entry in Station Number	NA
Location	Entry in Location	NA
Party	Entry in Party	NA
Boat_Motor	Entry in Boat Motor	NA
Meas_Number	Entry in Measurement Number	NA
GaugeHeightInformation	Entry in GaugeHeightInformation	NA
Comments	Entry in Comments	NA

Summary Structure

Parameter Name	Description	Size
Cells	Number of cells used for each station	NS x 1
Station_Area	Area of each station	NS x 1
Station_Averaging_Time	Station averaging time	NS x 1
Station_Mean_Flow_Angle	Station mean flow angle	NS x 1
Station_Mean_Velocity	Station mean velocity	NS x 1
Station_Percent_Discharge	Station percent discharge (based on rated discharge value entered by user)	NS x 1
Station_Q	Station discharge	NS x 2
Stationary_Depth	Station depth used to calculate area	NS x 1
Total_Q	Total discharge for measurement (will be repeated NS times)	NS x 1
Units	Units used	NA

System Structure

Parameter Name	Description	Size
Battery_Voltage	Battery voltage for each sample	NS x 1
Heading	Compass heading for each sample	NS x 1
MagneticError	Magnetic error for each sample	NS x 1

Pitch	Pitch for each sample	NS x 1
Roll	Roll for each sample	NS x 1
SNR	Signal to noise ratio for each cell of each beam per sample	NC x 4 x NS
Temperature	Temperature for each sample	NS x 1
SerialNumber	Instrument serial number	NA
GPS_Compass_Heading	Empty – not used	NS x 1
Time	Time for each sample	NS x 1
Units	Units used	NA

Transformation Matrices Structure

Parameter Name	Description	Size
Frequency	Frequencies available for the system	3 x 1
Matrix	Transformation matrices for each frequency	4 x 4 x 3

WaterTrack Structure

Parameter Name	Description	Size
Correlation	Each correlation score for each cell of each sample. Only applicable for samples collected with SmartPulse ^{HD}	NC x 4 x NS
Vel_StdDev	Each standard deviation of water velocity for each cell of each sample	NC x 4 x NS
Velocity	Each water velocity component for each cell of each sample	NC x 4 x NS
Water_Profiling	Type of acoustic profiling pulse used (PC, BB, PC/BB)	NS x 1
Units	Units used	NA