Lessons From OSW Technical Reviews for Hydroacoustics 2007-2009

by Kevin Oberg

Summary of 2007-2009

NO-NAME-WSC¶

- General Comments¶
  - Hydrographers need to collect an independent water temperature check when conducting FlowTracker measurements. The majority of measurements reviewed did not have an independent water temperature measurement.¶
- ADCP Measurements¶
  - When making StreamPro measurements, OSW strongly recommends that each individual transect have a 3-minute minimum duration. In several instances, transects were less than 3-minutes.¶
  - Invest in tethered boat hydroacoustics when finances enable it. You will increase efficiency during high flows and enable staff to get around to more sites quicker and limit time on bridge (safety). This would particularly help the Eureka office in catching more high-flow measurements in light of personnel limitations during flood operations and the pending retirement of key personnel.¶
  - WinRiver 10.06 is still being used to collected discharge measurements. Strongly encourage all offices utilize WinRiver II when making discharge measurements. The cause of the problems when performing/recording compass calibrations in WinRiver II should be discussed with OSW (Mike Rehmel) and a suitable solution found so that WinRiver 10.06 is no longer necessary.¶
- Flowtracker Comments¶
  - All personnel using hydroacoustic equipment are encouraged to review relevant OSW Technical Memorandums (TM) (2004.04, 2006.02) that document appropriate field and office techniques. In particular, the reason for conducting routine QA procedures (i.e. acoustic Doppler velicometer (ADV) Bucket Tests) could be more clearly understood, which would allow for better interpretation of these tests.¶
  - The DatView software (available at http://hydroacoustics.usgs.gov/) was not widely used in the WSC to review FlowTracker discharge measurements. Although the use of DatView is not required, it is very useful and OSW strongly encourages its use.¶
  - One office was still making 6-depth velocity measurements between 1.5 and 2.5 ft when using FlowTrackers. OSW TM 2004.04 states that .2/.8 depth velocity measurements are required in this depth range and the hydrographer is not allowed to switch to cup meters to avoid this requirement.¶
- Index Velocity Comments¶
  - When establishing/operating index-velocity stations, avoid using vendor supplied methods for computing discharge. Instead, using USGS methods and compute discharge in ADAPS.¶

2009 Hydroacoustics Reviews – Summary¶

In 2009, OSW Technical Reviews were conducted at 17 WSC's. The following is an executive summary of significant review comments on hydroacoustics issues. The number of comments may not only indicate the quality of the WSC hydroacoustics program but almost certainly is affected by other factors (some subjective) like the skill of the reviewer, philosophy of review, number of reviewers, etc.¶

COMMON FINDINGS¶

¶

Issue¤	Category¤	Freq.¤
Integration of Hydroacoustics into QA Plan or related QA plan issues¤	General¤	10¤
Water temperature not being measured/recorded¤	General¤	10¤
Problems with electronic data storage (no plan, inconsistent use, etc)¤	General¤	7¤
Beam checks (bucket tests) not being done or are suspect¤	Flowtrackers¤	6¤
Training needed (generally ADCP) / Attend webinars¤	General¤	6¤
Evaluation of extrapolation is lacking or not in evidence¤	ADCPs¤	5¤
Use DatView software for reviewing Flowtracker Qms¤	Flowtrackers¤	5¤
Firmware/software in use has not been updated to OSW recommended¤	General¤	5¤
Measurements should be reviewed/checked (by trained personnel, etc)¤	General¤	5¤
ADVM beam checks not being done/stored/archived¤	Index Velocity¤	5¤
Problems with Index velocity rating¤	Index Velocity¤	5¤
Moving bed tests not being done or incorrectly done¤	ADCPs¤	4¤
Improper velocity observation depths (0.2, 0.6, 0.8)¤	Flowtrackers¤	4¤
Improper Qm section or locate better measuring section/instrument¤	General¤	4¤
Loop method and/or LC program not used or problems with loop test¤	ADCPs¤	3¤
Problems with compass calibrations / evaluations¤	ADCPs¤	3¤
Proper use of water / bottom modes / configuration¤	ADCPs¤	3¤
Suggest WSC/Office appoint Hydroacoustics Specialist/Coordinator¤	General¤	3¤
ADVM QA parameters not being output/stored/archived¤	Index Velocity¤	3¤
Diagnostic tests not being done¤	ADCPs¤	2¤
Duration of individual transects should be at least 3 minutes¤	ADCPs¤	1¤
High boat speed (rule-of-thumb: boat speed <= water speed)¤	ADCPs¤	1¤
Need to use SMBA – or misuse of SMBA¤	ADCPs¤	1¤
Need better measurement technique¤	General¤	1¤
Stage area rating not validated/documented¤	Index Velocity¤	1¤
Measure edge distances using laser rangefinder or suitable tool¤	ADCPs¤	¤
Sync'ing ADCP/ADVM measurements/Sampling time for Qm's¤	Index Velocity¤	¤

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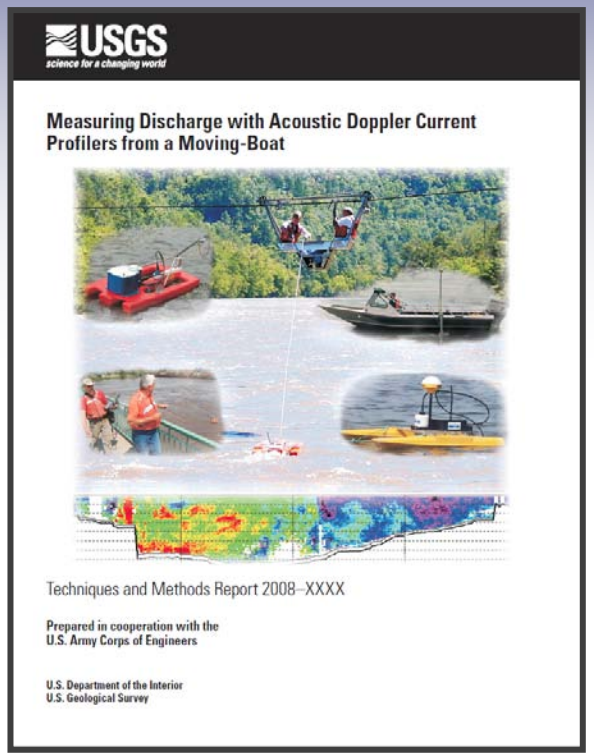
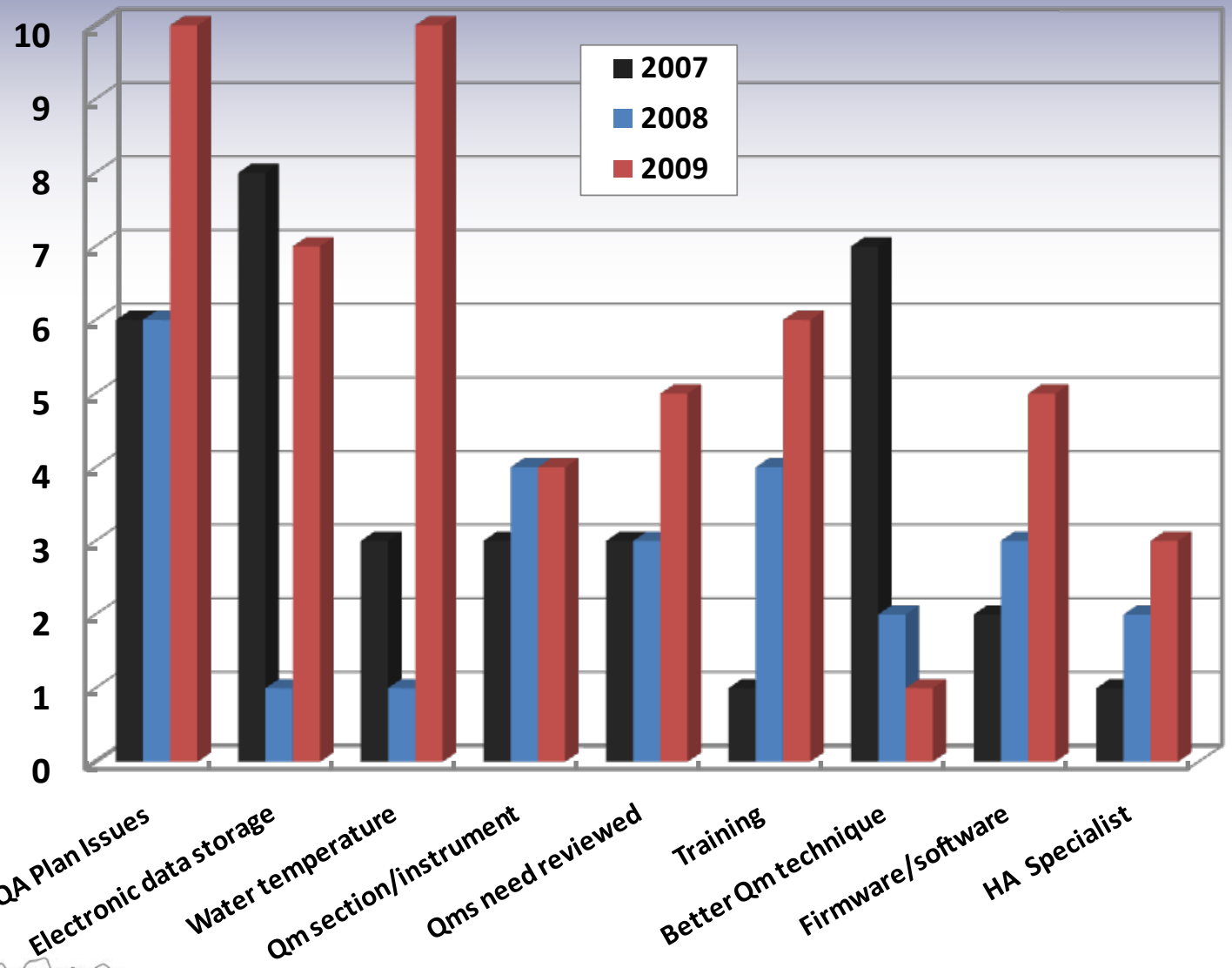
Sources of OSW Guidance

- Techniques and Methods for Moving Boat ADCP Discharge Measurements
- Technical Memos
- Web pages/Mailing list/Forums



General Issues

General Issues



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QA Plan/QA Issues

- WSC has not adequately addressed the use of hydroacoustics in their QA plan, either by having a hydroacoustics component or integrating into their plan
- WSC has not implemented other QA Practices Recommended by OSW
  - Annual instrument checks? (T&M / 2009.05) CA WSC report is a good example. http://hydroacoustics.usgs.gov/publications/CA-ADCP-Check-2007.pdf
  - Beam angle tests (distance tests) (T&M / 2009.05)

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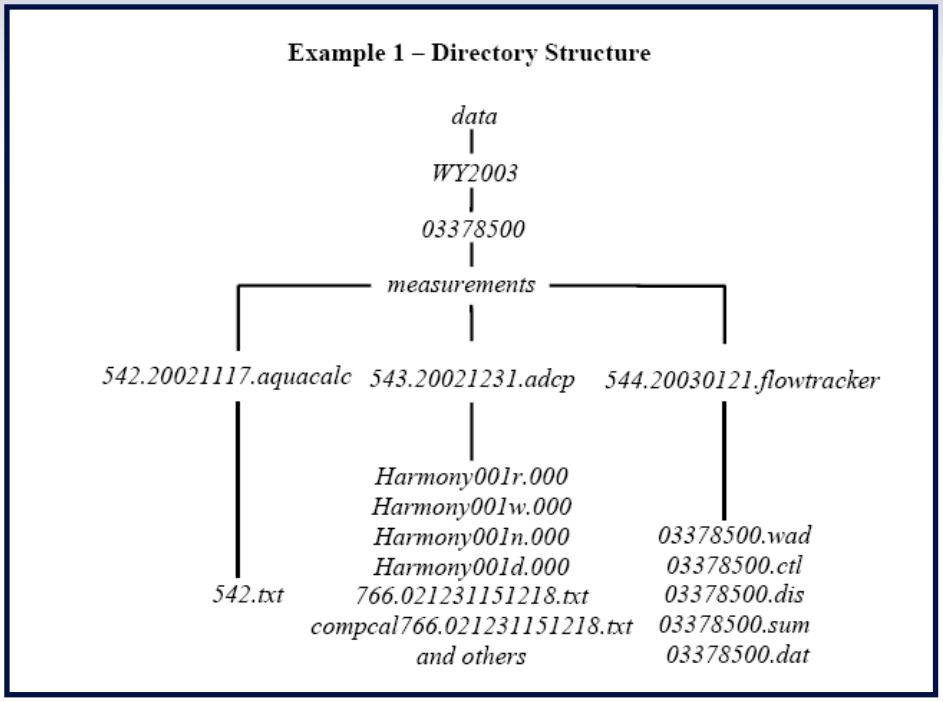
Does WSC have Data Archival Plan? Is it Used Consistently?



- Common problems
  - No policy
  - Inconsistent usage
  - Inconsistent file naming
  - Everyone doesn't have access to archive

OSW Tech Memo 2005.08
Policy and Guidance for Archiving Electronic Discharge Measurement Data

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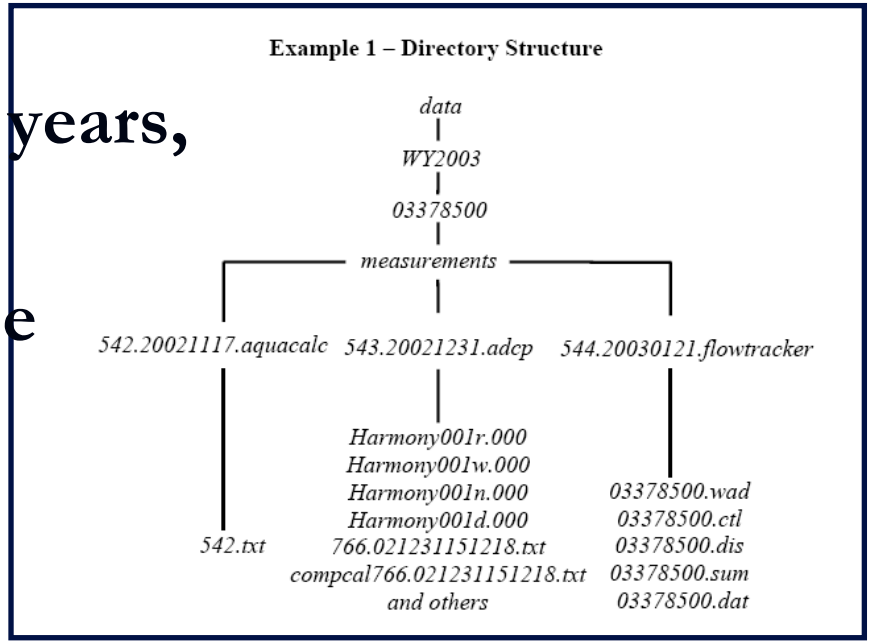
Archiving Electronic Qm's (2005.08)

- Each measurement should have own directory containing all files collected or created as part of the measurement
- Naming convention must include some combination of measurement dates, water years, and/or instrument types
- Recommended that data be archived within 2 days of returning from field



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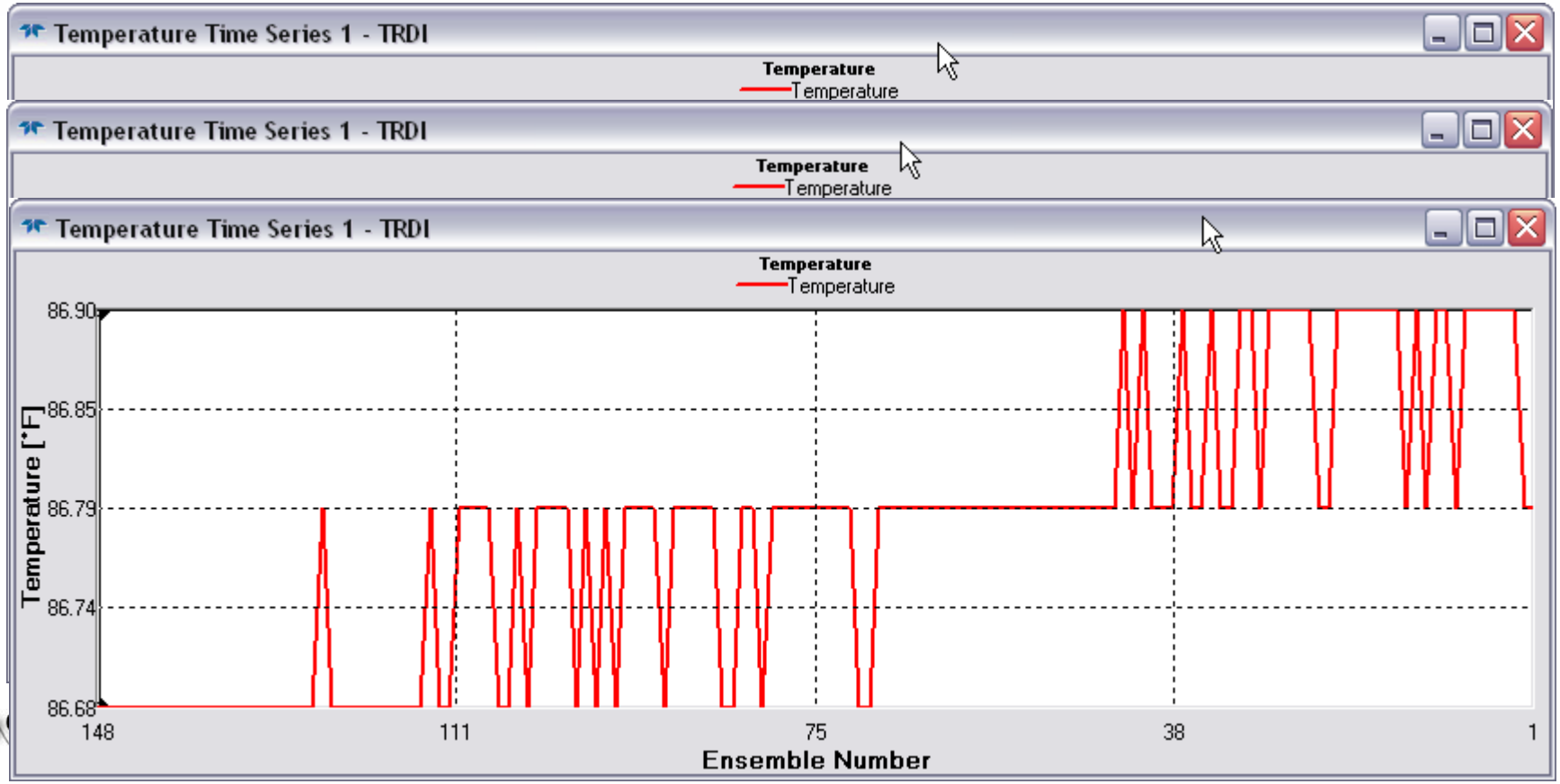
Temperature Sensors & Hydroacoustic Instruments

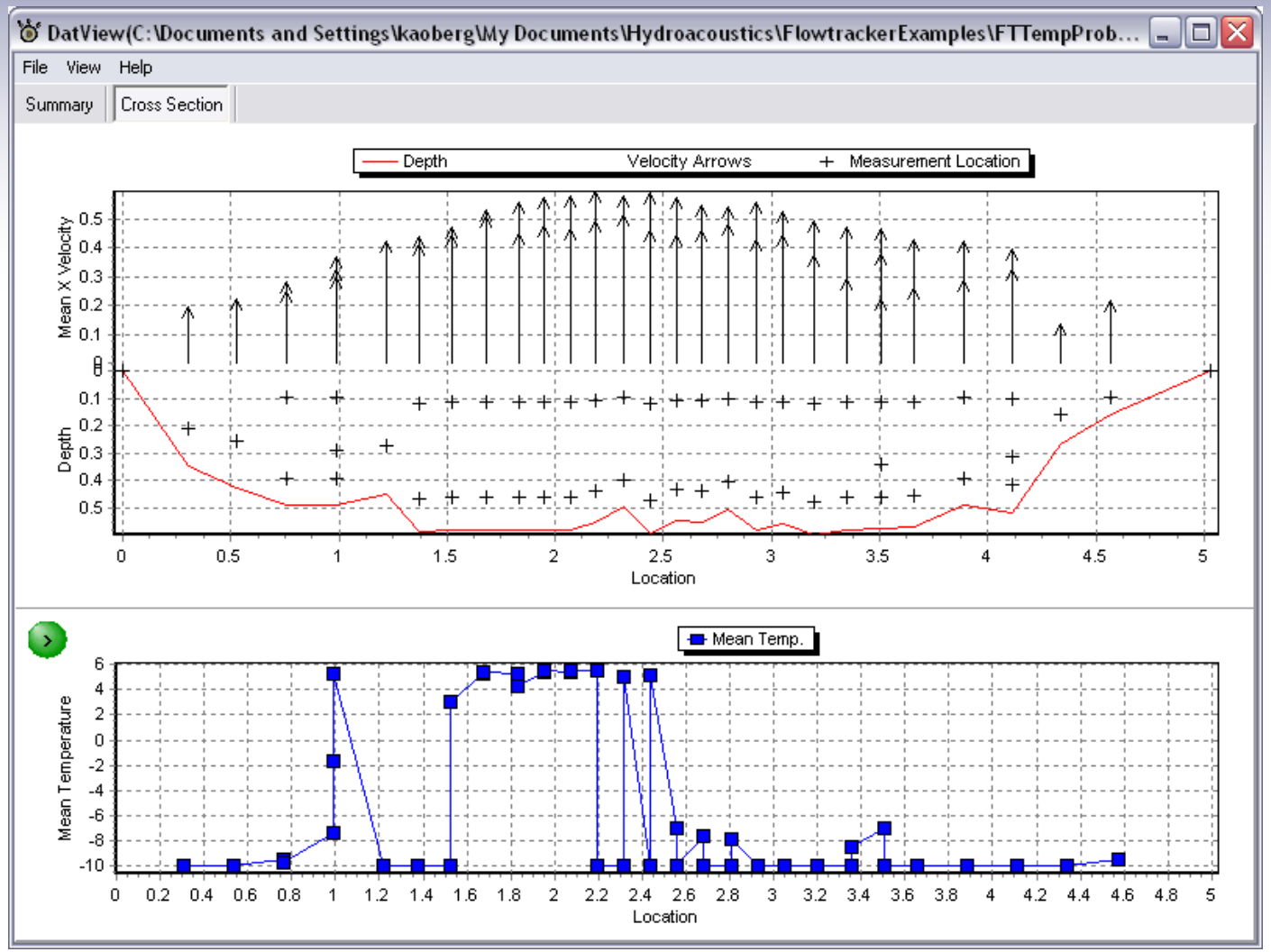
- An accurate water temperature is important for accurate velocities
  - An error of 9° F will cause approximately a 2% error in velocity
- Every measurement made with hydroacoustic equipment needs an independent measure of water temperature for QA (T&M / 2009.05)
- Policy for Flowtrackers not articulated in OSW technical memo (an oversight).

Equilibration Time

- Allow time for instrument (FlowTracker, ADCP) to equilibrate to water temperature. This is especially important if you are moving between temperature extremes. (Hot truck → Cooler stream)



Flowtracker Thermistor Problem



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Measurement Location and Technique

Location Location Location!

- Cannot be emphasized enough!

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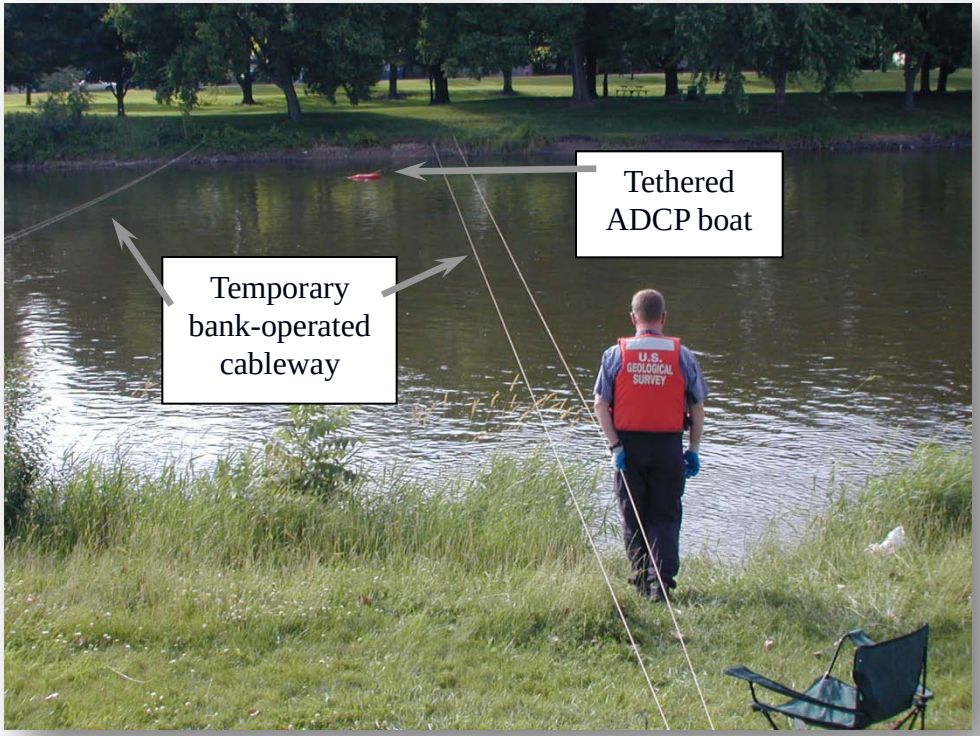
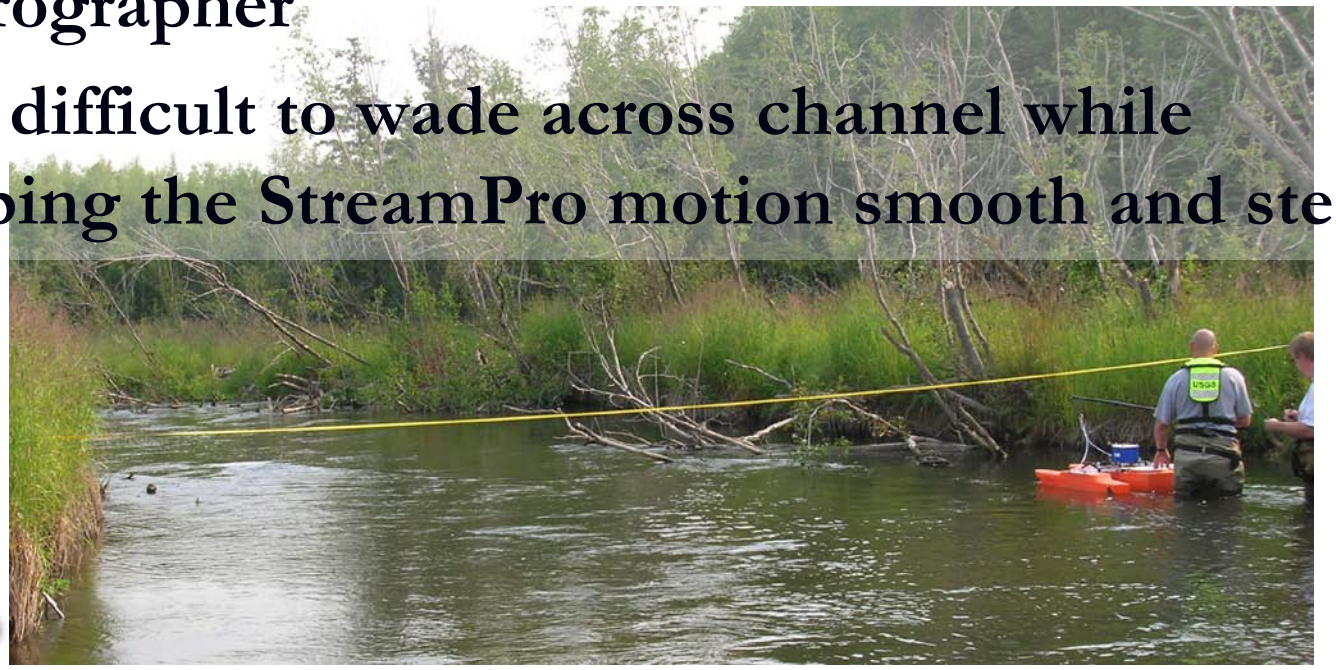
Measurement Location

- Use of bank-operated cableway is encouraged whenever feasible as it results in better Qm's
- Wading with StreamPro / ADCP is discouraged



Guidance for Wading Measurements

- Do NOT Wade with StreamPro's or other shallow water ADCPs!
  - ADCP beams may impinge on the hydrographer or sample the flow disturbance caused by the hydrographer
  - It is difficult to wade across channel while keeping the StreamPro motion smooth and steady



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Recognize Limitations

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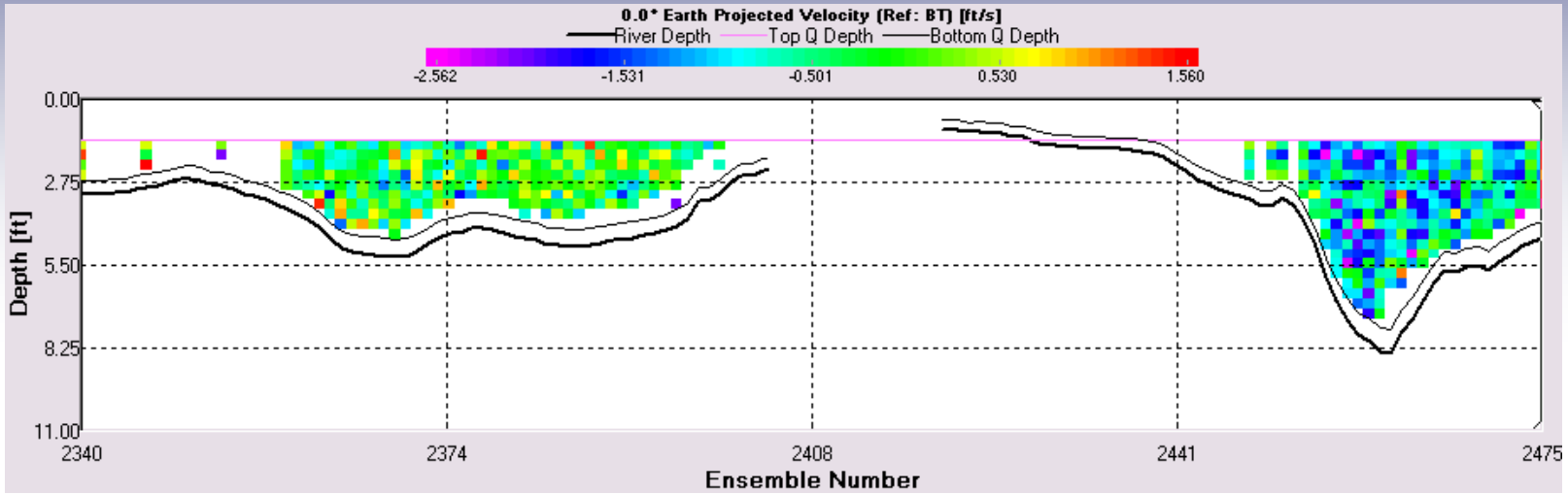
Cannot Use Acoustics Everywhere!



Use the Right Tool for the Job!

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Measurement Review

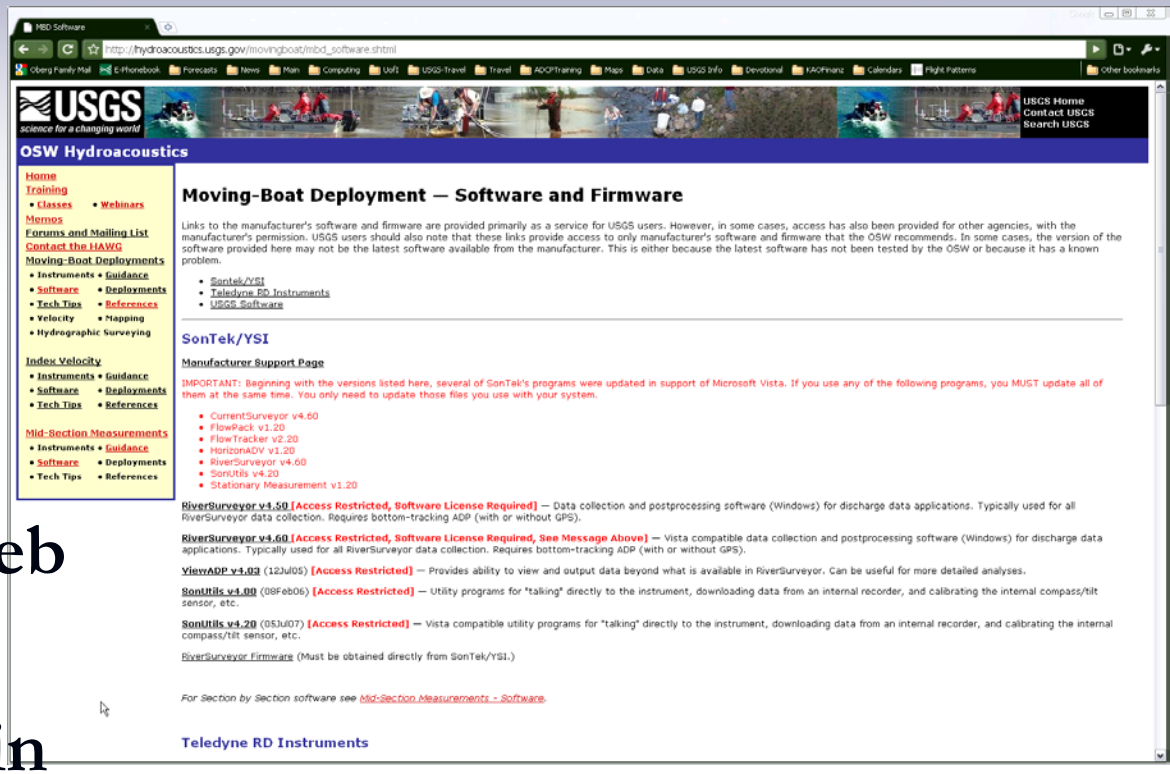
- OSW recommends review of discharge measurements by another trained hydrographer as a good QA practice
- Recommended in training classes and T&M
- Question: Should acoustic Qms be subject to more review than current meter Qms?
- Answer: Need to develop guidelines for this (OSW and WSCs)

Training

- Training is required for using ADCPs for Qm's (2002.02 / T&M) but not point-velocity meters
- Most review comments had to do with keeping current with OSW policies, etc. and encouraging attendance at refresher training classes. Often paired with comments about a Hydroacoustics specialist

Current Software and Firmware

- Users should be using currently recommended software and firmware
- Hydroacoustics Web pages
- More on this later in the presentation



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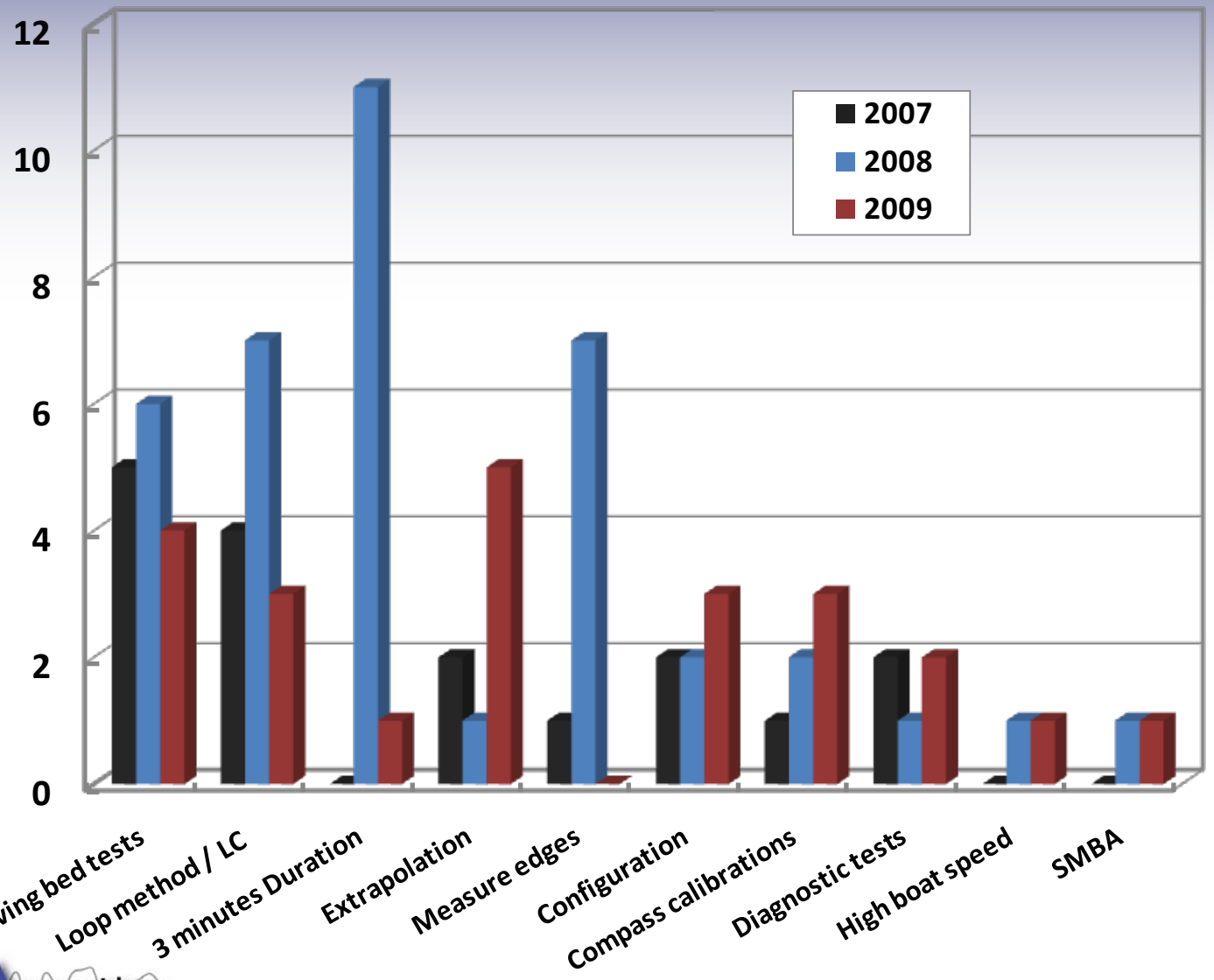
Current Software and Firmware

- Use of WinRiver II 2.04 or greater
  - Have WSC's upgraded to 2.04?
  - Strongly encourage use of USB-to-serial converters
- Use of SxS
  - Not well tested by OSW. If used, WSC's should do comparison measurements to validate (with BT and/or GPS and ADCP)
  - We'd like to know of comparison Qm's with SxS

ADCP Measurement Issues

ADCP Discharge Measurements



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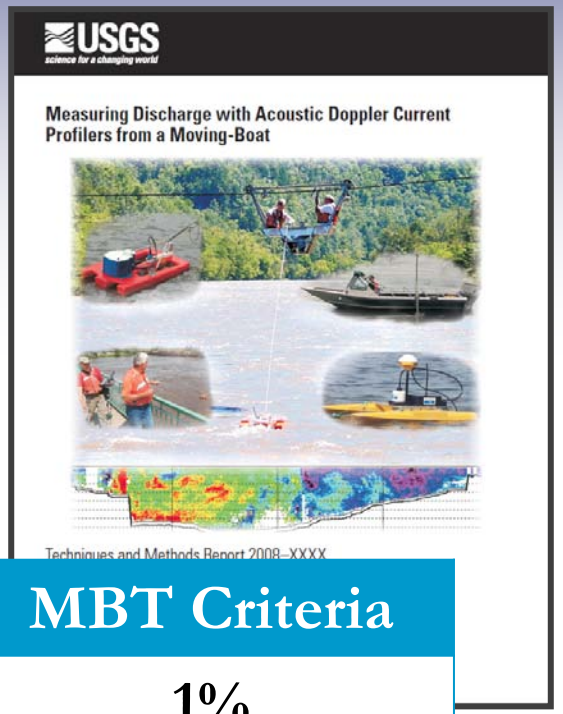
Moving Bed Issues

New Policies in T & M Report

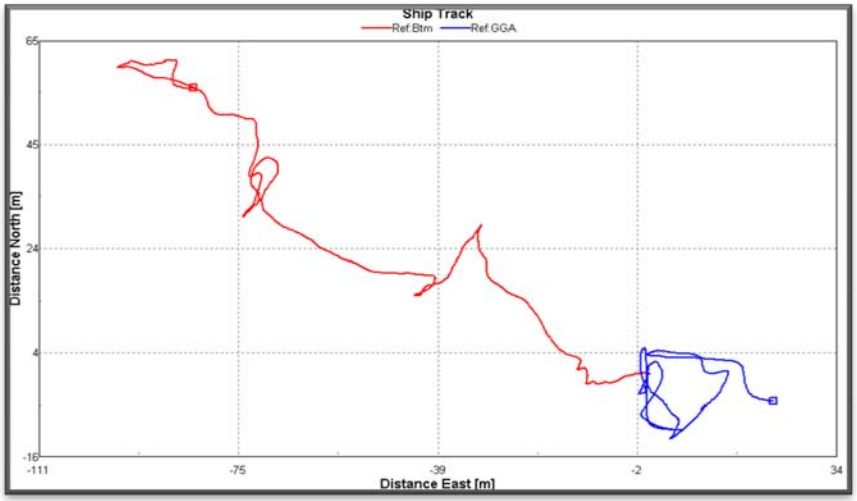
- Every moving-boat Qm must have a moving bed test (MBT)
- Guidance for stationary MBT's (T&M / 2009.05)

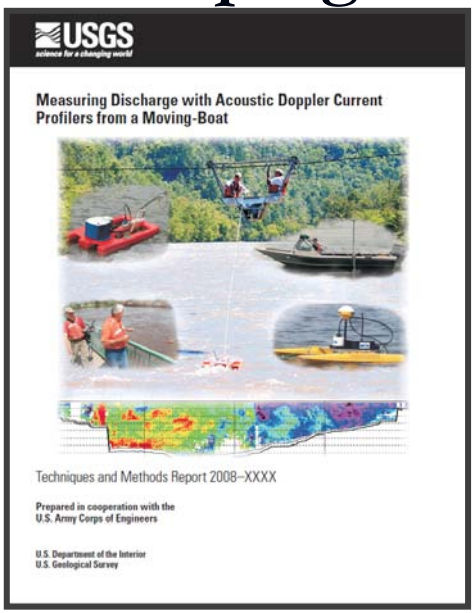


Deployment	Duration of SMBT	MBT Criteria
Tethered boat	5 minutes	1%
Anchored boat	5 minutes	1%
Boat with DGPS	5 minutes	1%
All other	10 minutes	2%

New Policies in T & M Report

- When a moving bed condition is present, preferred method for data collection is:
  - GPS (if available and accurate)
  - Loop MBT and LC program (conditions permit)
  - Multiple stationary MBT's with SMBA program
  - Mid-section method





Loop Moving Bed Tests and Corrections

(SIR / 2003.04 / T&M)

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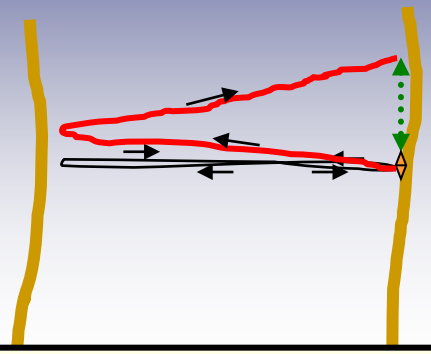
Loop Method Issues

- Loop method not being used
  - No MBT at all
  - SxS approach being used
  - (SIR / 2003.04 / T&M)
- LC program needs to be used (available at hydroacoustics.usgs.gov) instead of 'hand' computations
- Cannot use loop method with StreamPro ADCPs that do not have a compass



```
                RDI Compass Error Estimating Algorithm

   Press any key to start taking data after the instrument is setup.

Rotate the unit in a plane until all data samples are acquired...
   rotate less than 5º/sec.  Press Q to quit.

 N       NE       E       SE       S       SW       W       NW       N
 ^                ^                ^                ^                ^
Accumulating data ...
Calculating compass performance ...

                        >>> Total error:   0.8º <<<

Press D for details or any other key to continue...
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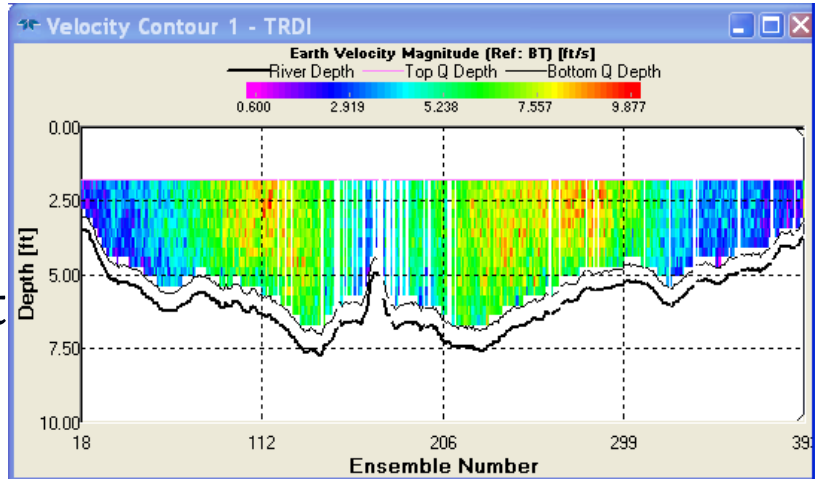

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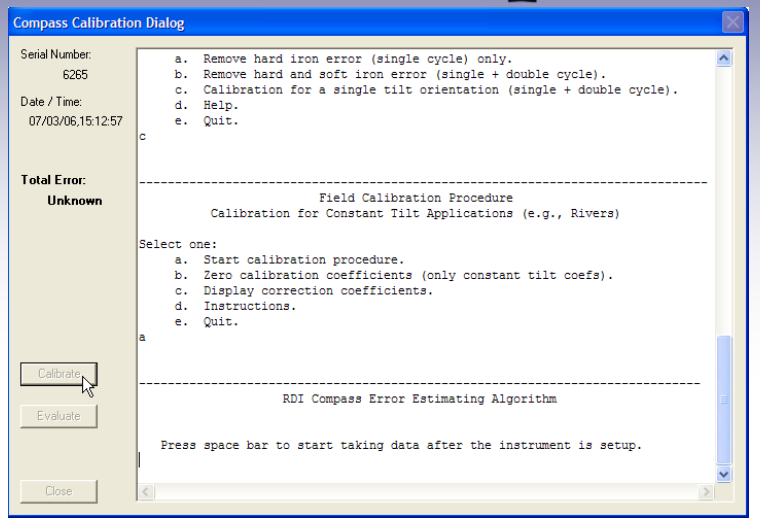
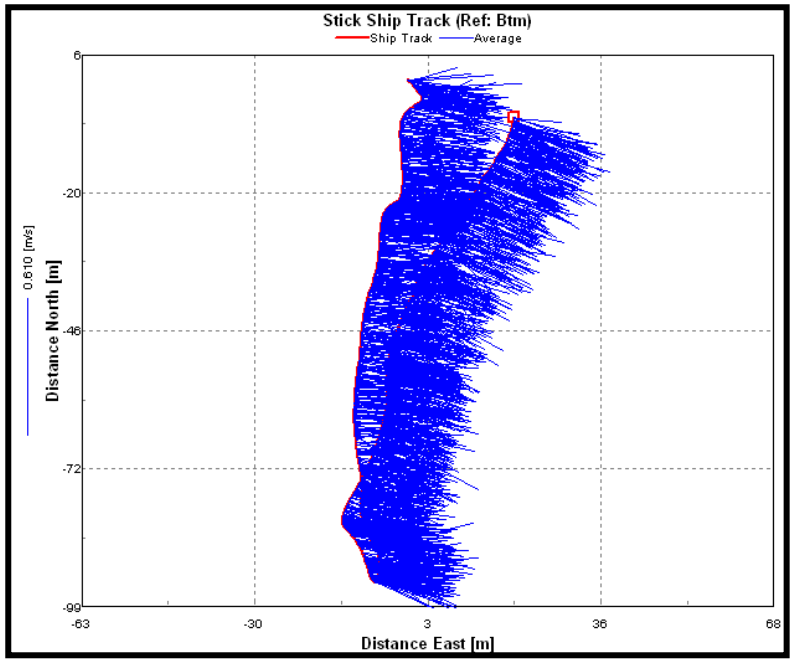
Compass Calibration and Loops

- Compass calibration for Rio Grande has calibration and evaluation steps. Both need to be done. Take 75-80 s.
- In order to make use of the loop method, the ADCP compass must be able to maintain an accurate heading! (ie no large source of magnetism).





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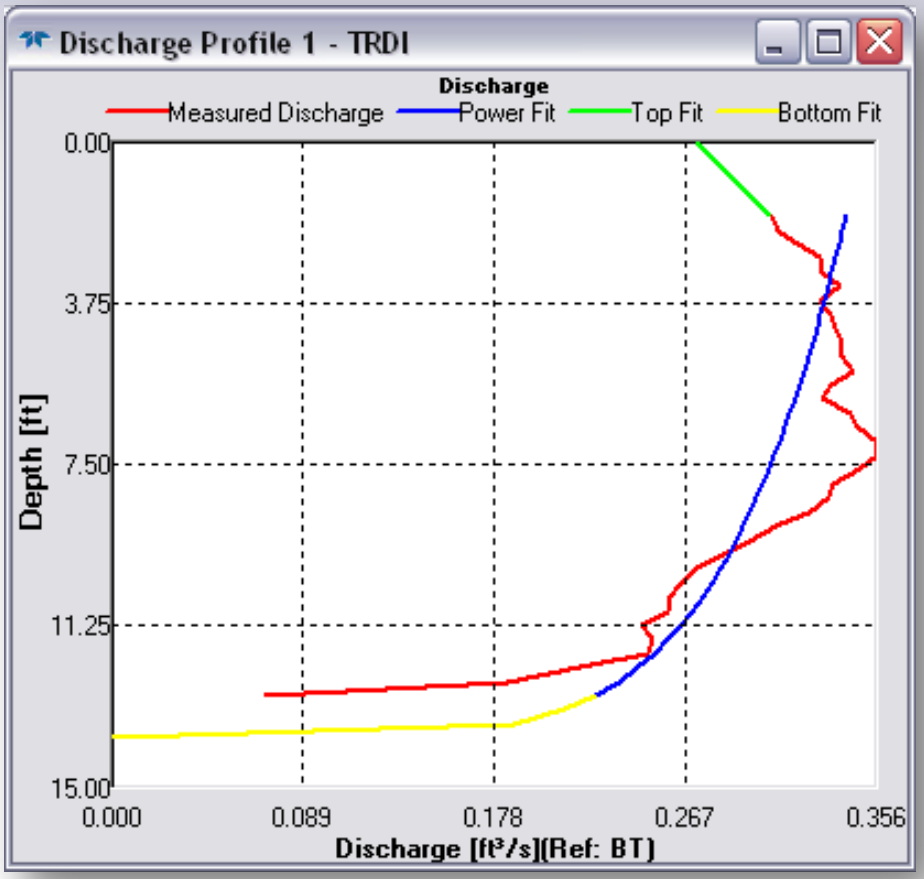
Proper Extrapolation Methods

Evaluate Extrapolation

- What method should be used here?
- Qm's are often not reviewed for appropriate method
- Look for wind shear and other effects in profiles



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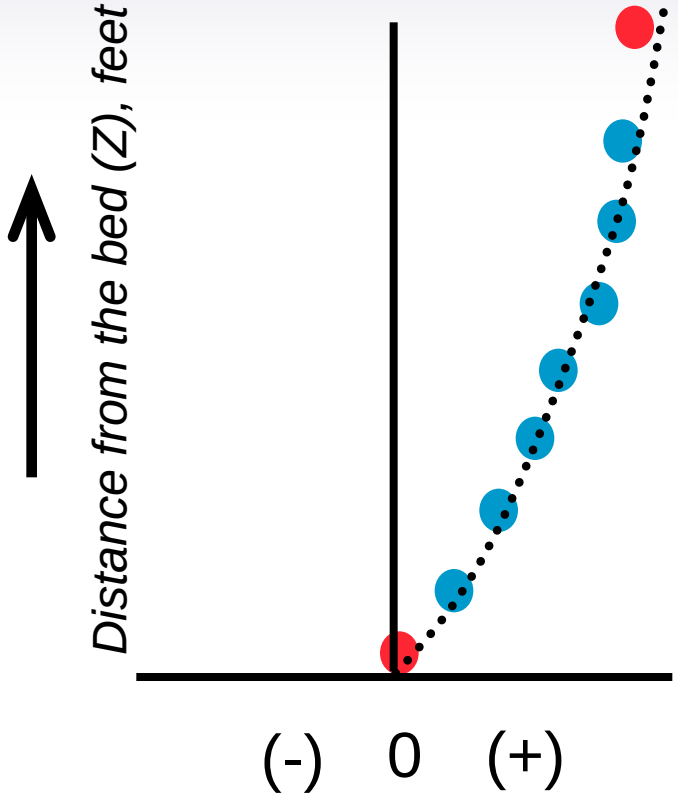
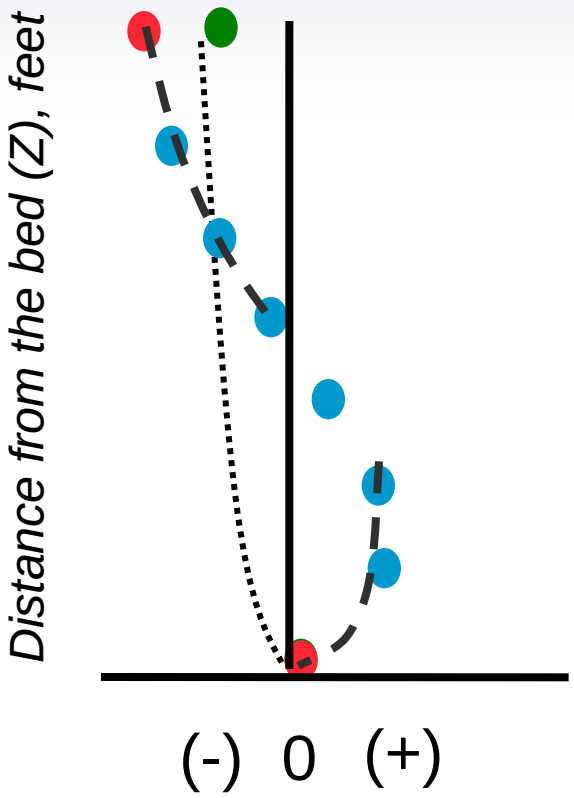
Power Curve Limitations

Unidirectional Flow



Bi-directional Flow



Velocity cross product (f-value), ft^2/s^2

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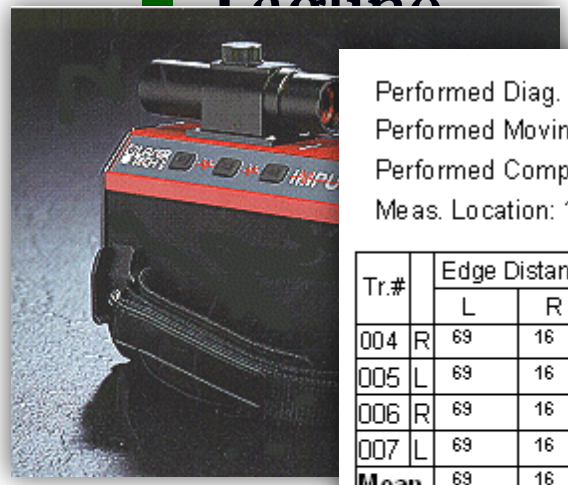
Edge Estimates

- Edge distances must be MEASURED (T&M / 2002.02)
  - Laser rangefinder
  - Tagline



Station Number: 05551540 — Meas. No: 51
Station Name: Fox River at Montgomery, IL — Date: 07/06/2004

Party: KAO/KKJ	Width: 235 ft	Processed by: KAO
Boat/Motor:	Area: 707 ft²	Mean Velocity: 1.90 ft/s
Gage Height: 11.74 ft	G.H.Change: 0.00 ft	Discharge: 1,340 ft³/s

Area Method: Avg. Course	ADCP Depth: 0.270 ft	Index Vel.: 0.00 ft/s	Rating No.: 3
Nav. Method: Bottom Track	Shore Ens.:10	Adj.Mean Vel: 0.00 ft/s	Qm Rating: G
MagVar Method: None (0.0°)	Bottom Est: Power (0.1667)	Rated Area: 0.000 ft²	Diff.: -4.40%
Depth Sounder: Not Used	Top Est: Power (0.1667)	Control1: 4-Clear	
		Control2: Unspecified	
		Control3: Unspecified	

Performed Diag. Test: NO
Performed Moving Bed Test: NO
Performed Compass Test: NO
Meas. Location: 1500 ft DS of gage

Project Name: foxmon_ds1200001r.mmt
Software: 1.01

Tr.#		Edge Distance L	Edge Distance R	#Ens.	Discharge Top	Discharge Middle	Discharge Bottom	Discharge Left	Discharge Right	Discharge Total	Width	Area	Time Start	Time End	Mean Vel. Boat	Mean Vel. Water	% Bad Ens.	% Bad Bins
004	R	69	16	552	473	561	157	106	23.9	1320	234	701	12:49	12:56	0.41	1.88	2	1
005	L	69	16	393	473	576	150	136	22.6	1358	237	719	12:56	13:01	0.54	1.89	1	1
006	R	69	16	398	467	546	158	133	22.2	1327	235	699	13:01	13:06	0.53	1.90	1	0
007	L	69	16	331	468	575	150	137	25.6	1355	233	707	13:06	13:10	0.62	1.92	2	0
Mean		69	16	418	470	564	154	128	23.6	1340	235	707	**Total**	00:21	0.52	1.90	2	1
SDev		0	0	94	0.088	0.391	0.116	0.421	0.043	0.547	0.53	0.83			0.03	0.00		
R/M%		0	0	52.9	1.2	5.2	5.1	24.3	14.4	2.8	1.8	2.8			40.13	1.73		

Remarks: Measurement made 120 ft US of Mill Street Bridge using bank-operated cableway.
Measurement made as a part of a series of ADCP test measurements
Concurrent Price AA current meter Qm's made this day

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Proper Configuration

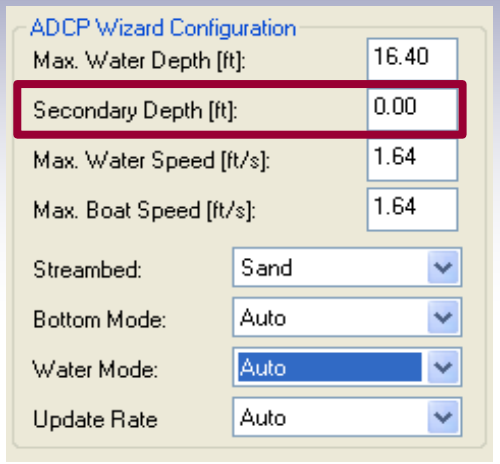
Example: Indiscriminate Use of Water Mode 12

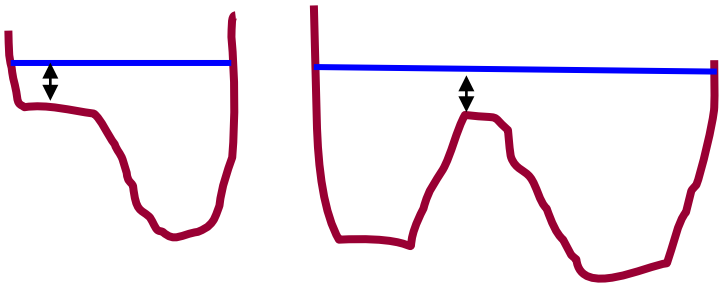
- Mode 5/11 (often need to try both)
  - Low instrument noise
  - Small bins
  - Limited application
- Mode 12
  - High-ping rate
  - Small bins
  - Potential errors in dynamic conditions
- Mode 1
  - Robust mode
  - Highest instrument noise
  - Limited bin sizes

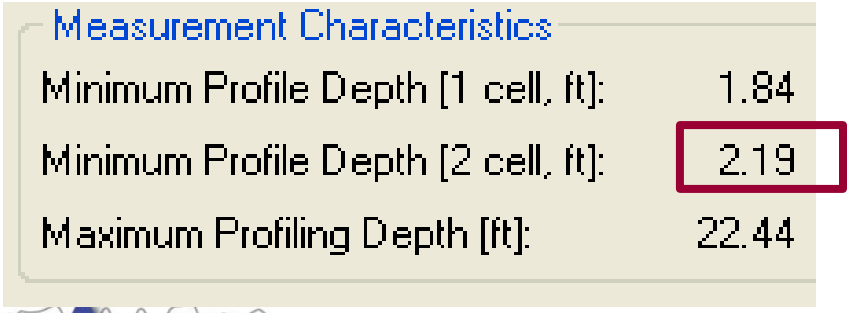
Too fast, too deep, too turbulent

Dynamic Conditions

Wizard Configuration Secondary Depth



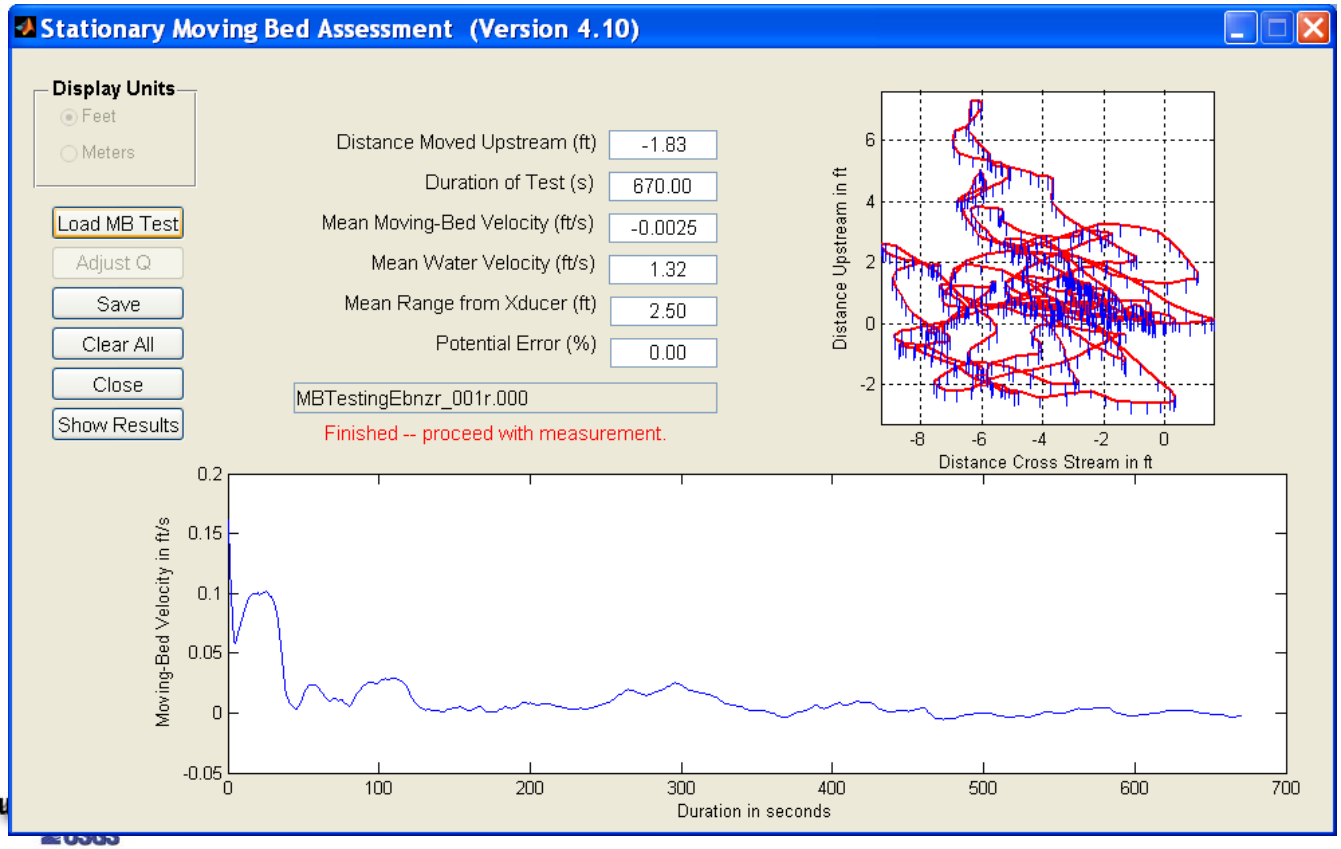




- If not zero, will attempt to configure depth cell size to get at least 3 good cells in this depth
- **Only** use when you **MUST** profile in this depth
- Recommend first leaving at zero, then verify the minimum profile depth (2 cells) in the summary page is acceptable
- Entering an unnecessary secondary may result in smaller depth cells and increase measurement noise

StreamPro Issues

- Make sure that stationary moving bed tests are being done
- Encourage use of Stationary Moving Bed Analyzer (SMBA) software for determining if moving bed condition exists and to correct the discharge



Other ADCP Qm Issues

- ADCP Qm's not locked (2003.04)
- Diagnostic tests need to be run prior to each Qm or minimum of 1/day (T&M / 2009.05)
- ADCP depth not being measured. Can be significant bias (2-3%) in small streams and should be carefully measured from water surface to center of transducers.
- Compliance with number of transects policy
  - 4 or 8 transect means
  - Do not want odd-numbers of transects
  - (2002.02)

FlowTracker

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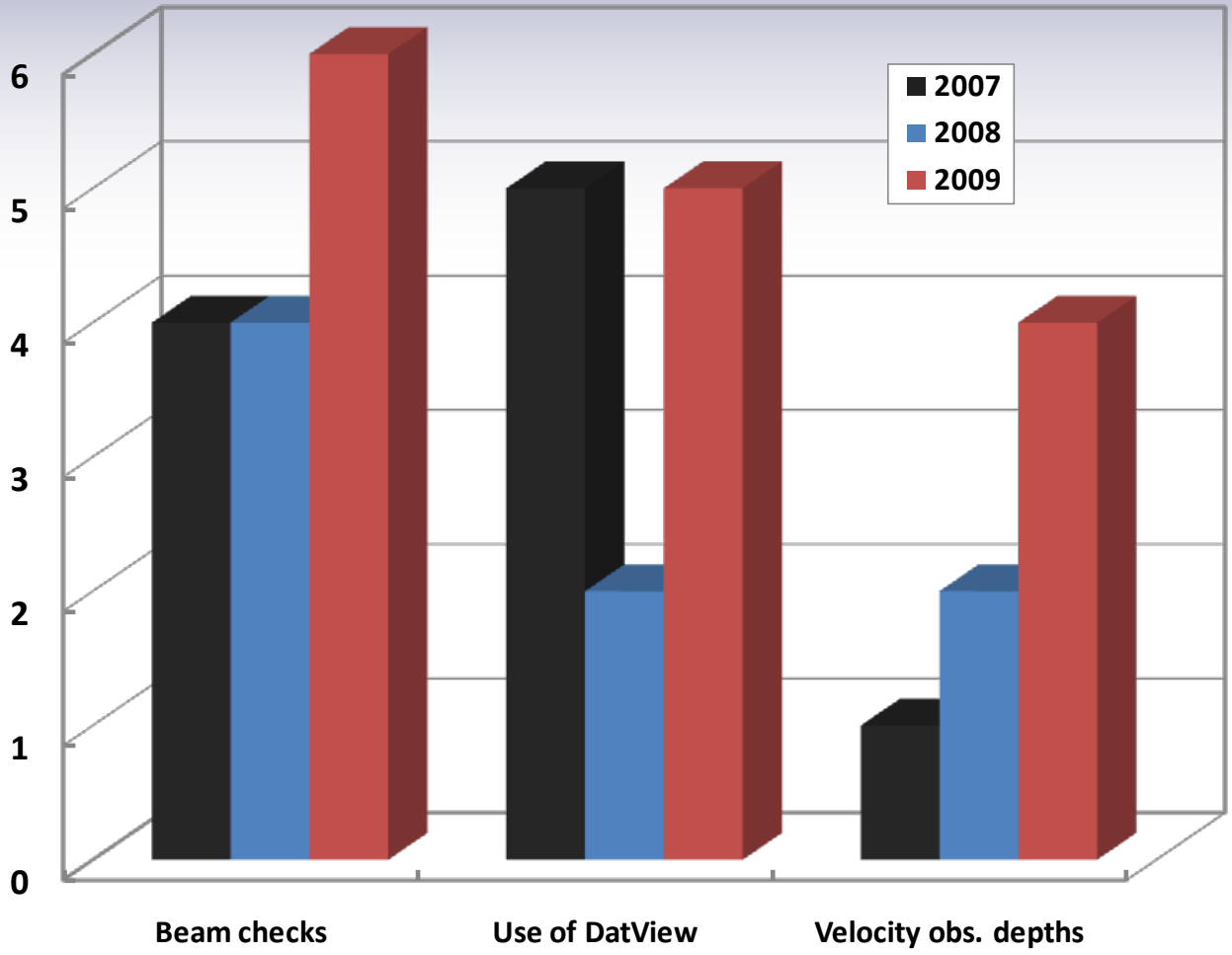
USGS

Flowtracker Issues



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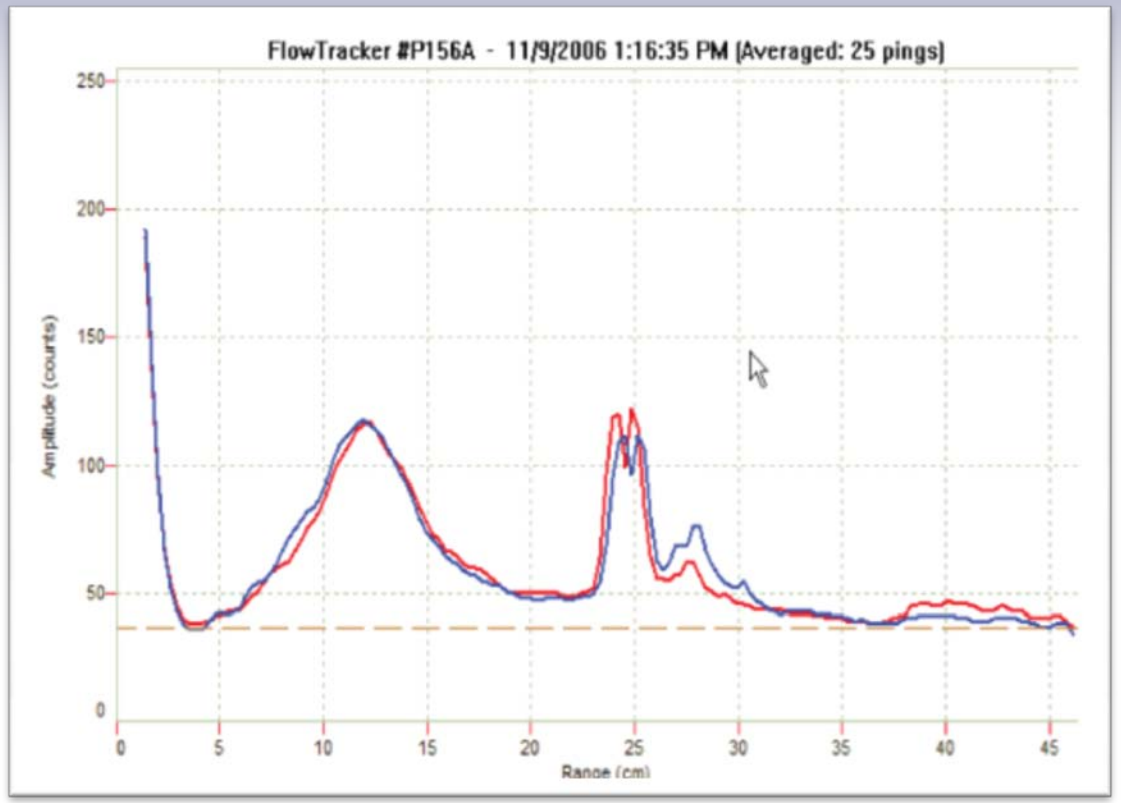
ADVChecks not Run Prior to Field Trip



OSW Technical Memo (2007.01)

SonTek/YSI FlowTracker firmware version 3.10 and software version 2.11 upgrades and additional policy on the use of FlowTrackers for discharge measurements

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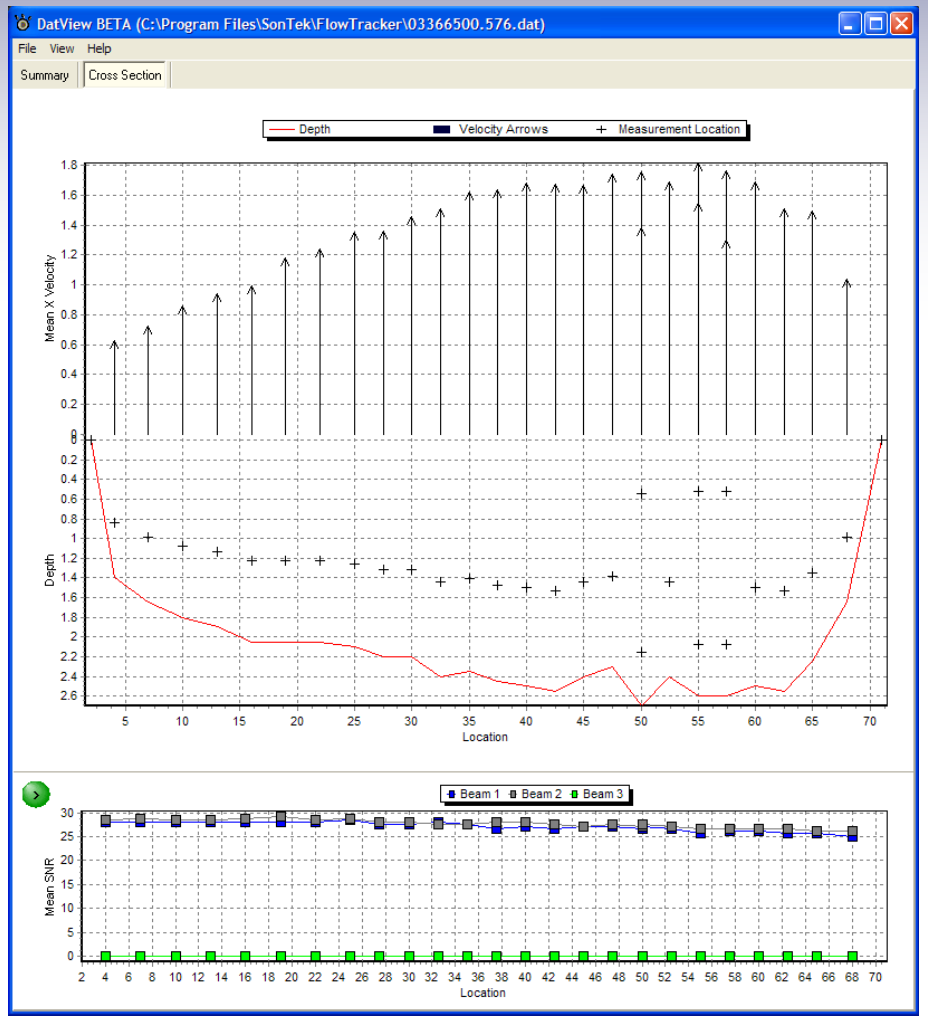
Flowtracker Issues

- Compliance with OSW Technical Memo 2007.01
  - Velocity sampling (1-, 2-, and 3-point methods)
  - Is current firmware/software being used?



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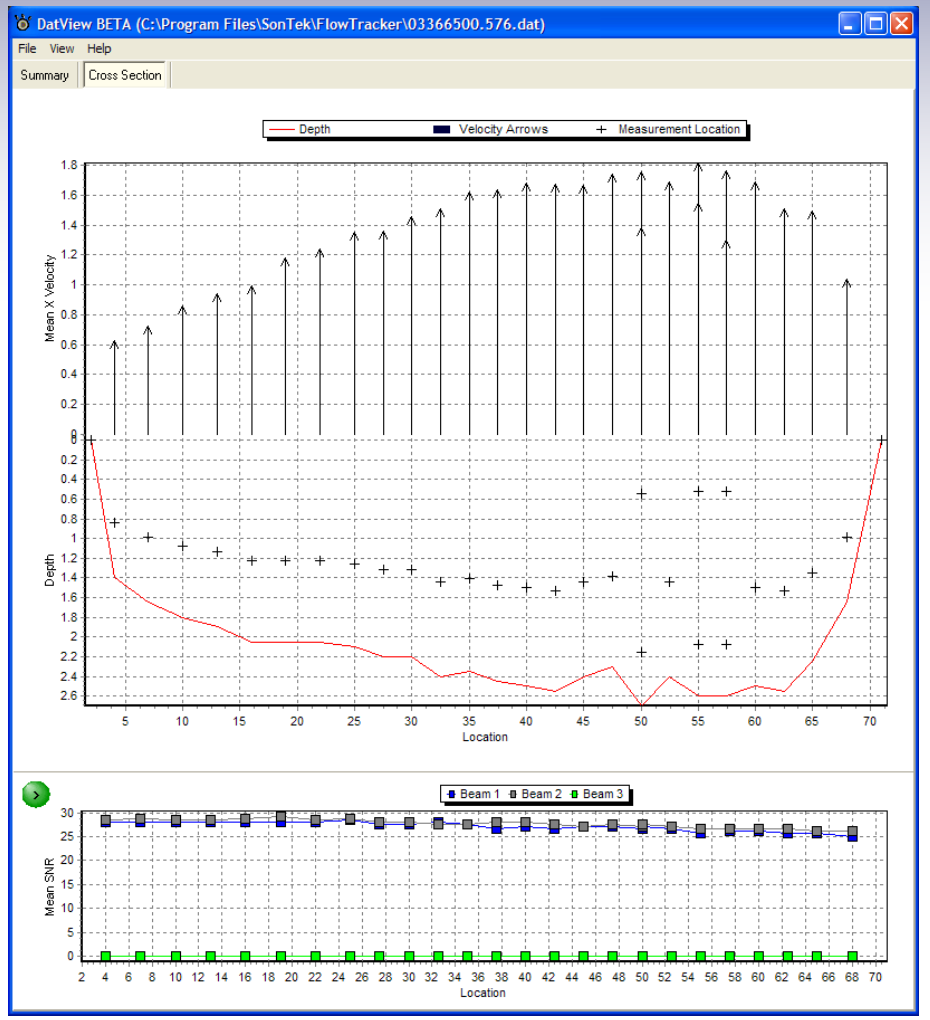
Flowtracker Issues

- Use of DatView
  - For questionable measurements or where SonTek software highlights a possible issue.
  - Issues highlighted by SonTek software should be explained or discussed on the measurement note.



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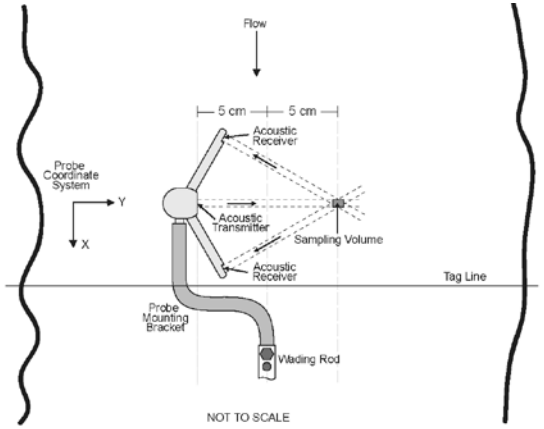
FlowTracker Measurement Errors

Most FlowTracker measurement problems are the result of:

- *Poor site selection*
- *Boundary issues* (avoid placing sample volume with 2" of any boundary)
- Poor instrument orientation
- Low signal-to-noise ratio



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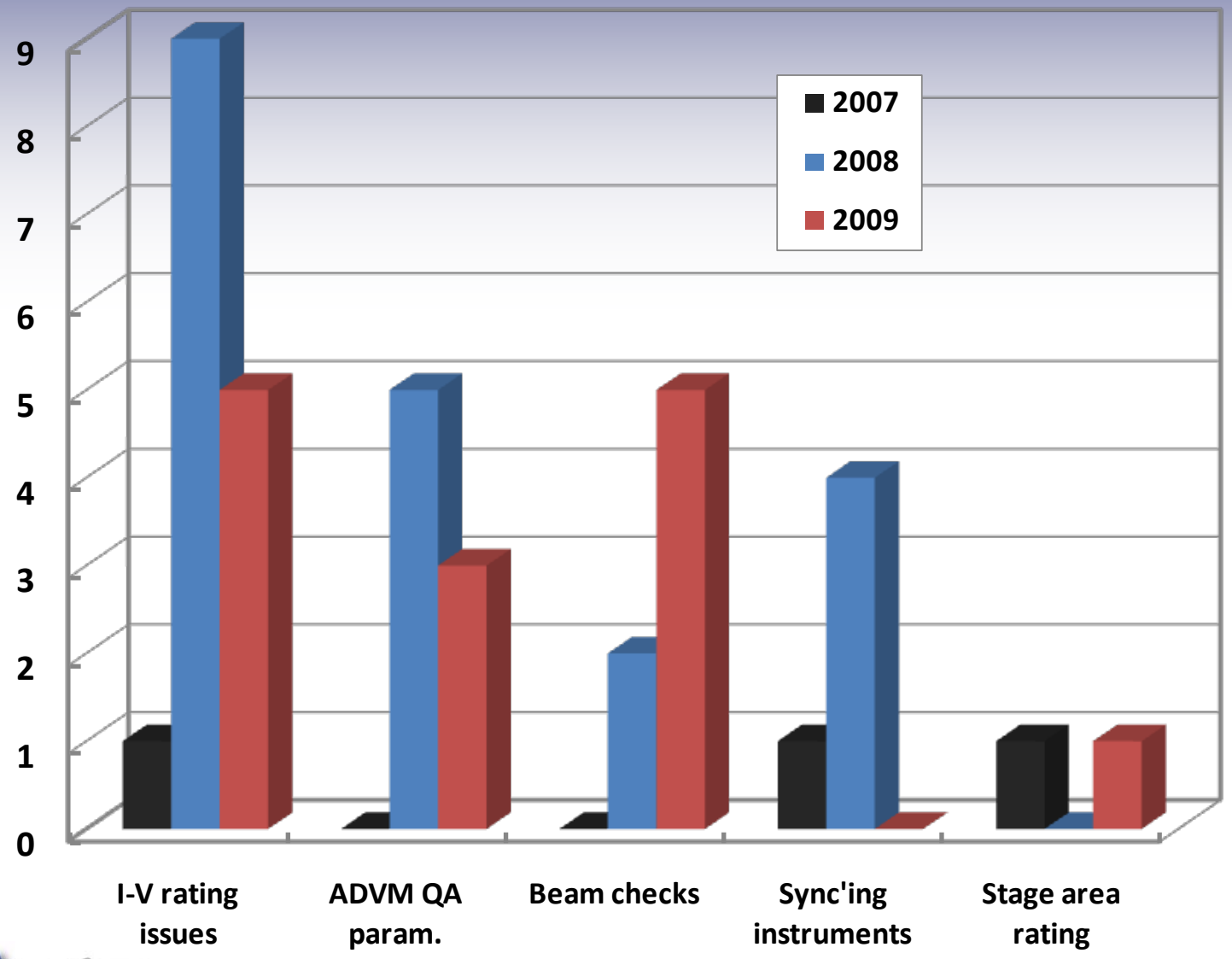
Index Velocity Issues

Index Velocity Issues



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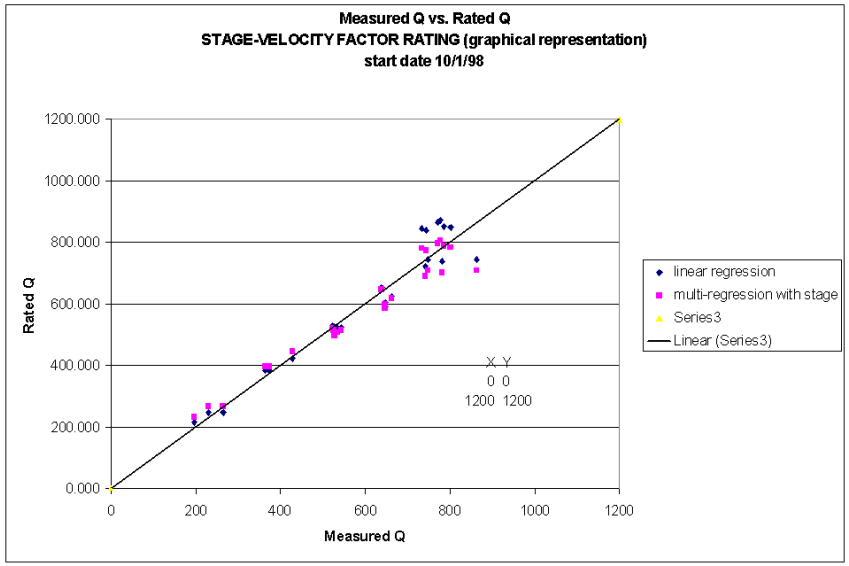
Index Velocity Ratings

- Sometimes, the rating "analysis" is no more than adding a trend line to the data.
- Documentation is required that clearly identifies the logic used, analysis results, and the final rating selected (with hydrologic reasoning). Reviewers should not have to second guess a hydrographer's choice for a rating.



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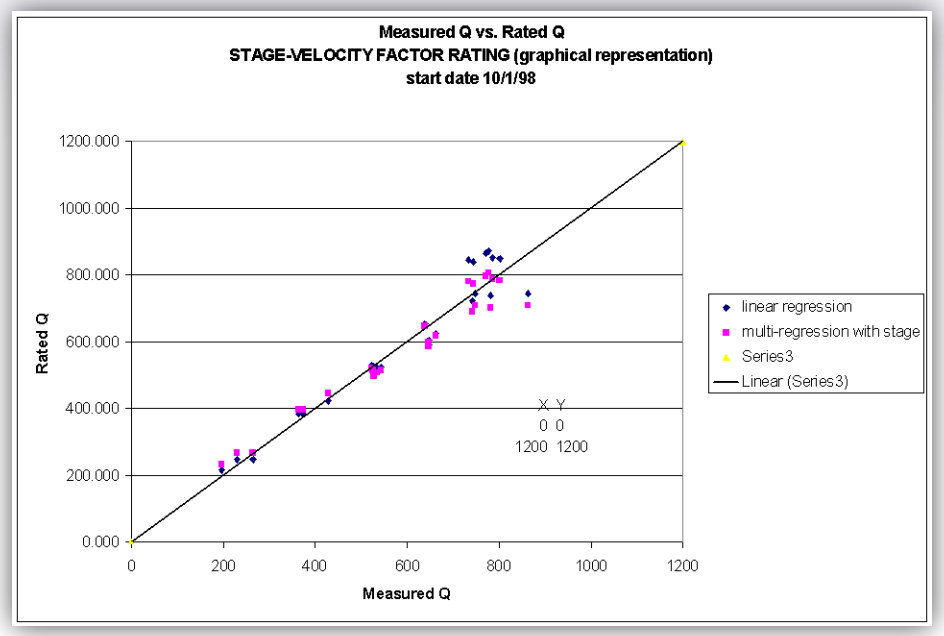
Index Velocity Ratings

- Lots of "house-keeping" issues
  - Documentation
  - Consistency
  - Carryover of info from year to year
- Ratings not being maintained/updated
- Inconsistent use of 'rated' section (stage-area)



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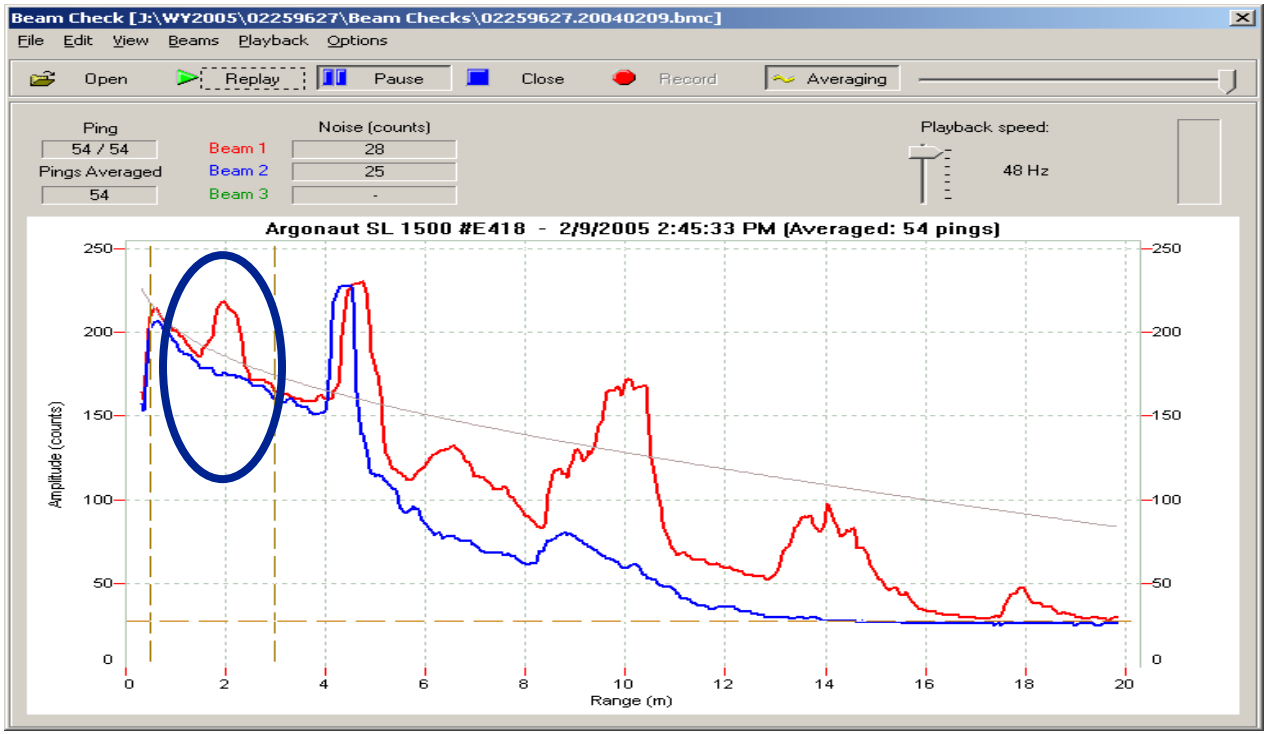
Beam Checks

- Are they being done?
  - Stored in recorder? Site visits? Not overwritten?
  - Archived according to WSC plan?
- Are they being analyzed?



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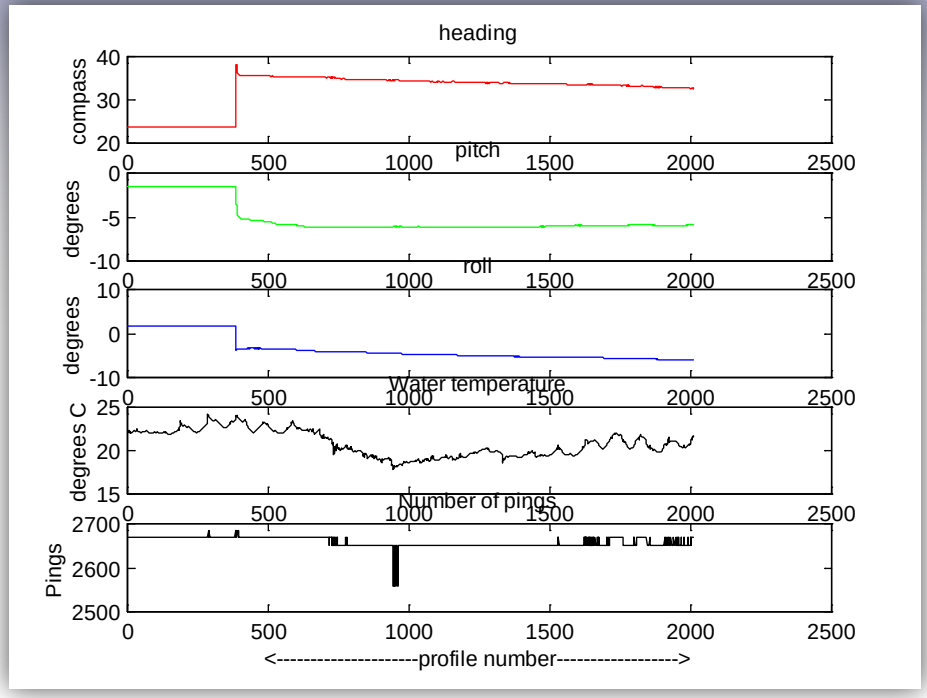
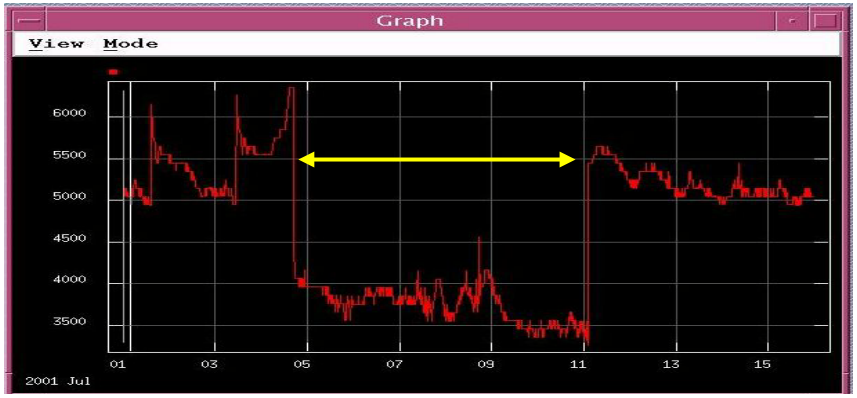
Recording And Analyzing QA Data

- QA data are often not retrieved, reviewed, and archived (internal data, beam checks, etc.)
- QA data should be stored in the velocity data archive for the site
- Data are often not analyzed. Can be used to detect changes or issues with the site / instrument





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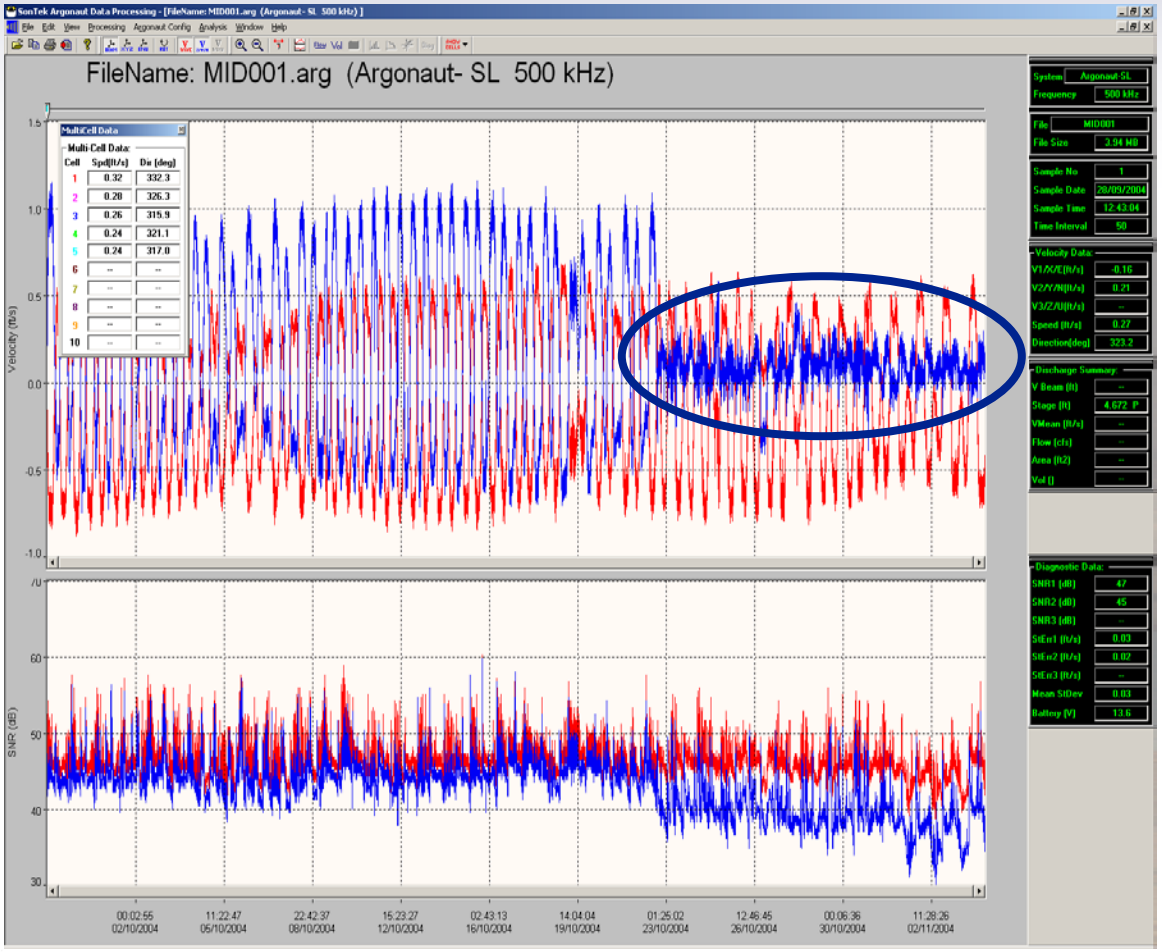
Recording And Analyzing QA Data

- From an Index-Velocity 'expert': "*Many times the instrument orientation (beams are measuring different flow regimes) and configurations are improper, i.e. cell begin is too close and/or cell end is too far and averaging intervals are usually too short.*"

Are Velocity Components Reviewed?

- Problem identified as Beam 2 issue



Beam components

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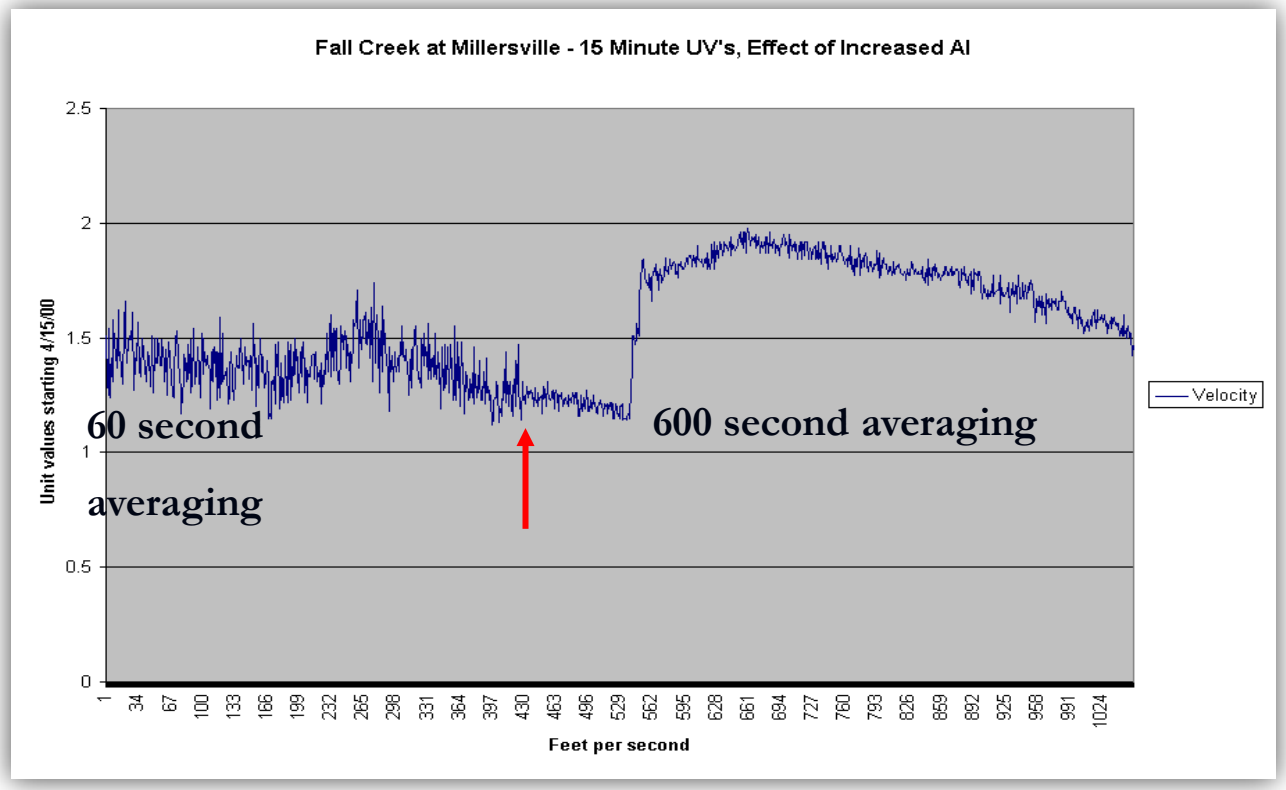
Index Velocity Issues

- Not making use of multi-cell data
- Is ADVM setup info in station description?
- Are the following parameters being transmitted?
  - Vel X, SNR, Cell end, Vel Y, temperature
- ADVM / Qm times not synchronized

Index Velocity Issues

- Record index velocity at 1-minute intervals during Qm's
- Is averaging interval appropriate for site?



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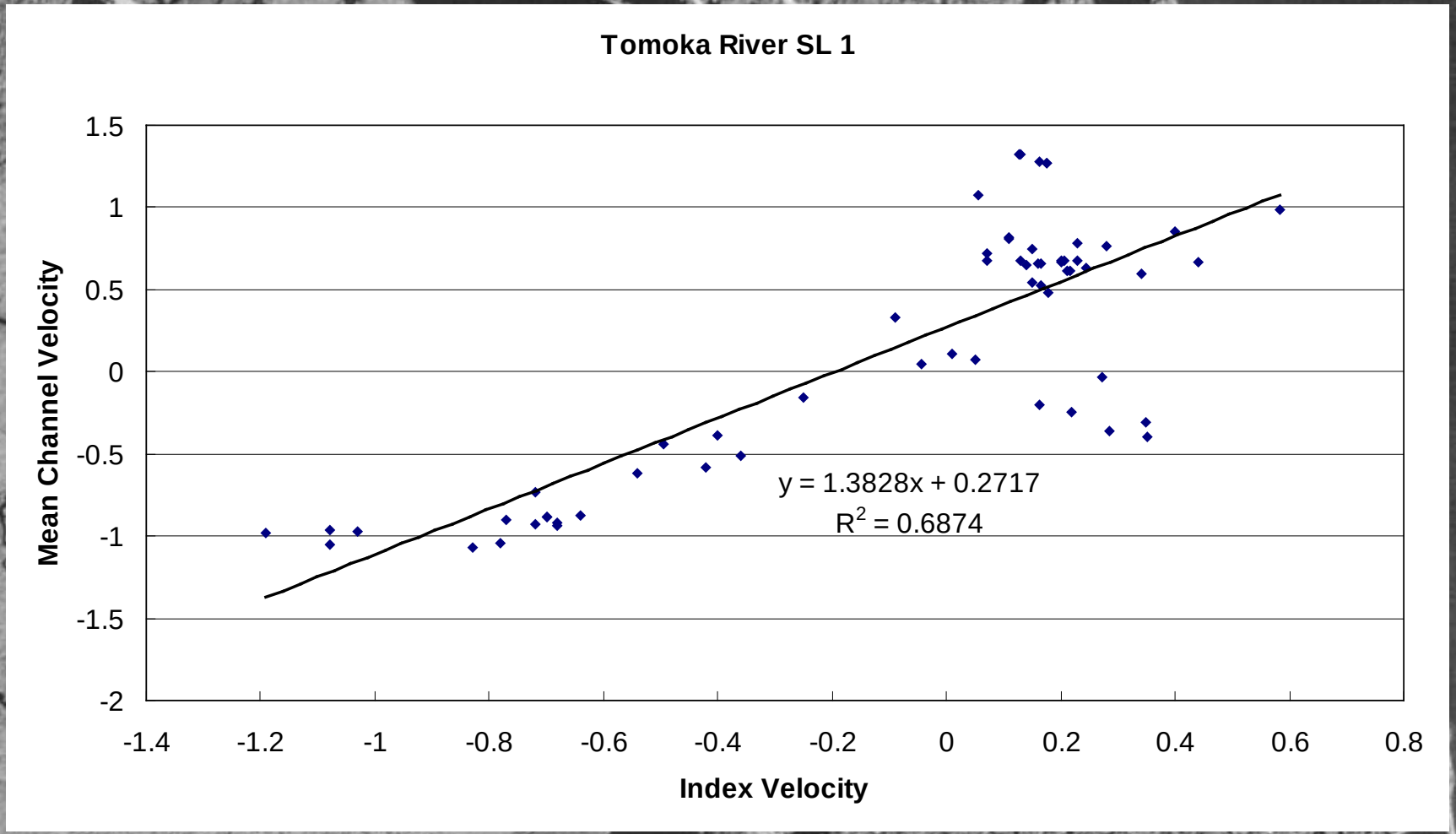
Location of Index Sites



Emerging Issues

WinRiver II Versions

- Last OSW recommended version is 2.04, but latest TRDI release is 2.07
- No changes between 2.04 and 2.07 that affect Q for moving boat measurements
- Most significant change is improve stability in SxS
- Users can stay with 2.04 unless they have a need to use the SxS feature (mid-section method), StreamPro firmware 31.07 or newer (new extended range and/or compass), or RiverRay
- If you upgrade to 2.07 you will have configuration issues with StreamPros using firmware prior to 31.07 (configures for 30 bins, when 20 max in old firmware)

StreamPro Firmware

- Many changes, will soon have the 6th version in 14 months

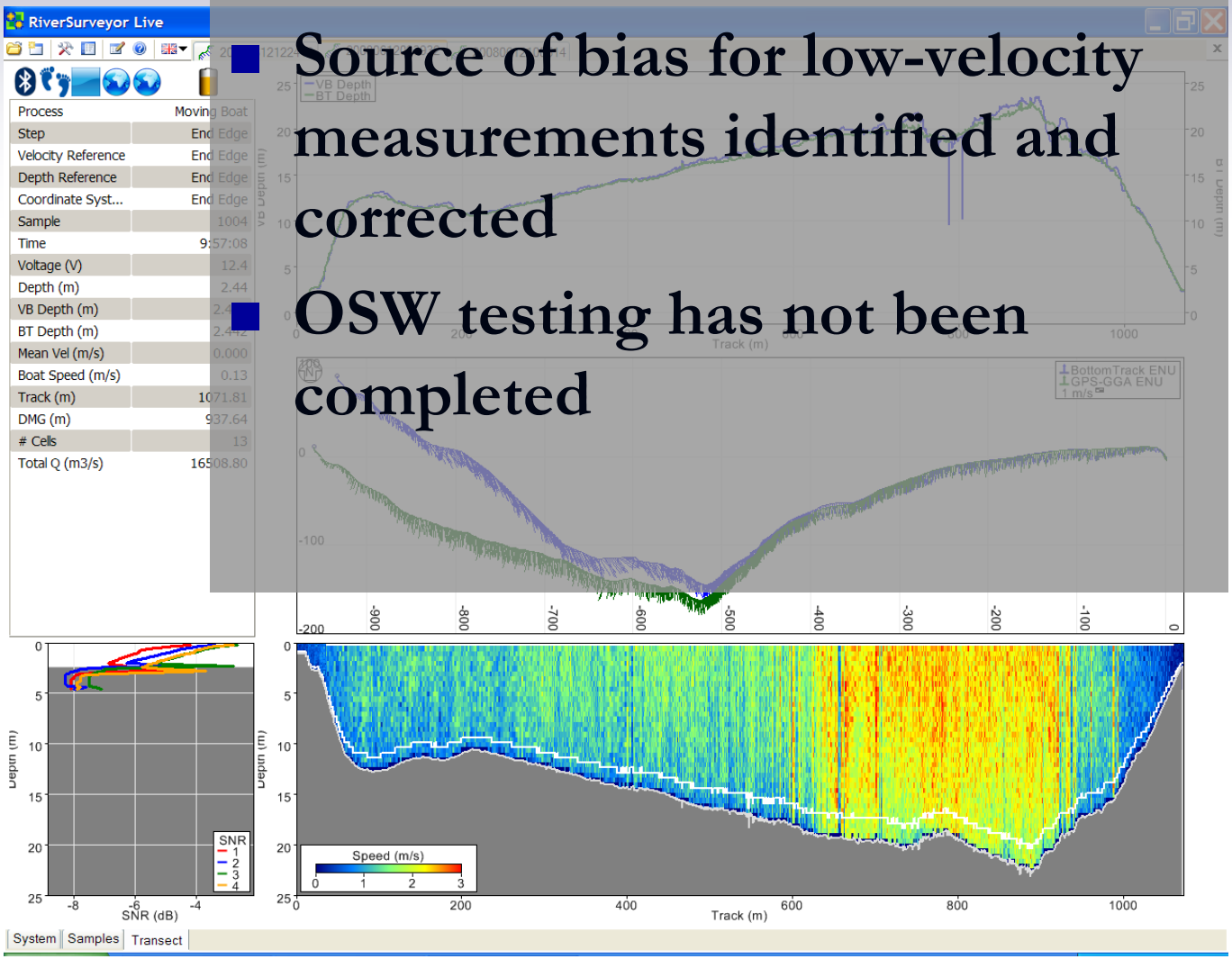
StreamPro Firmware	Comments
31.05 and earlier	Depth measurements biased low
31.06	Fixed depth bias, improved BT
31.07	Added support for compass, increased range, Btchanges
31.08	BT change, fixed time stamp issue. Found initialization issue with WRII 2.07
31.09	Fixed initialization issue with WRII 2.07. TRDI had issues with some StreamPros becoming unresponsive during upgrade. Pulled by TRDI
31.10	Out soon. Fixes minor depth and BT issues and 31.09 upgrade issue

Software and Firmware

- OSW is considering only mandating a change in software/firmware when a known issue is fixed that significantly affects total discharge. Otherwise, keeping an updated page that contains the available software and firmware for instruments along with any known issues.
- With the increased instrument types and software, OSW can not do complete and through testing of the software or firmware in all conditions. No matter how much testing we attempt do complete some issues are not discovered until the software/instrument are much more widely used.
- OSW will continue testing as thoroughly as possible

SonTek ADCPs

- Only a few delivered to USGS
- Source of bias for low-velocity measurements identified and corrected
- OSW testing has not been completed



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New TRDI Profiler – RiverRay

- Flat face Phased array - 600 kHz
- Sold with tethered boat, Bluetooth
- Evaluations in progress

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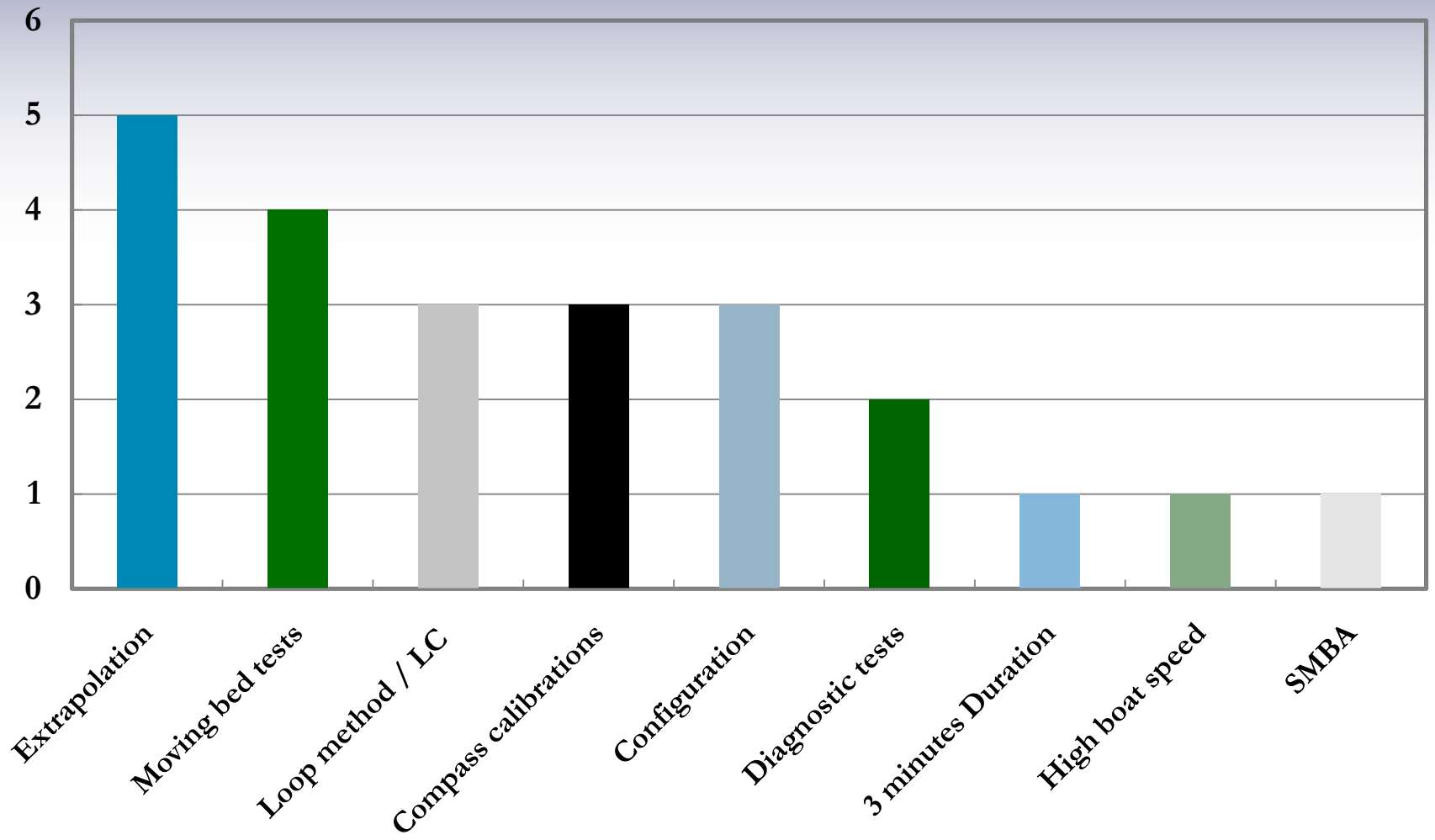
Reminder

- **Question:** ***"Can we collect data with the SonTek M9 (or some other instrument)"?***
  - **If an instrument has not been tested fully by OSW and no formal technical guidance (i.e. memo) has been published, WSC's are responsible for their own QA. Please consult with OSW first.**
  - **It is <u>always</u> a good idea to do a check measurement(s) with any newly-purchased instrument (Flowtracker, Rio Grande, etc.)**

Questions?

2009 ADCP Issues



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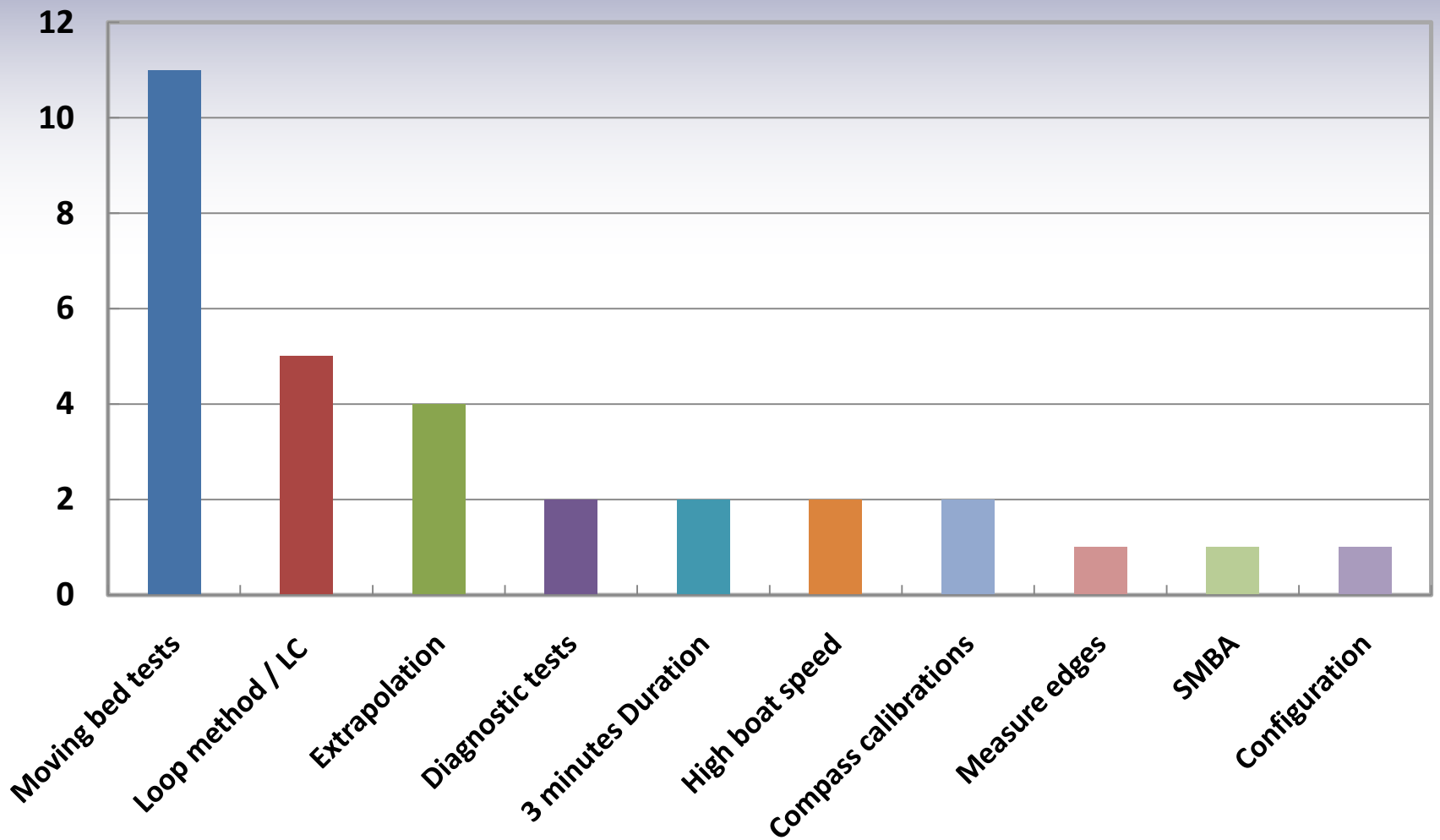
2008 ADCP Issues



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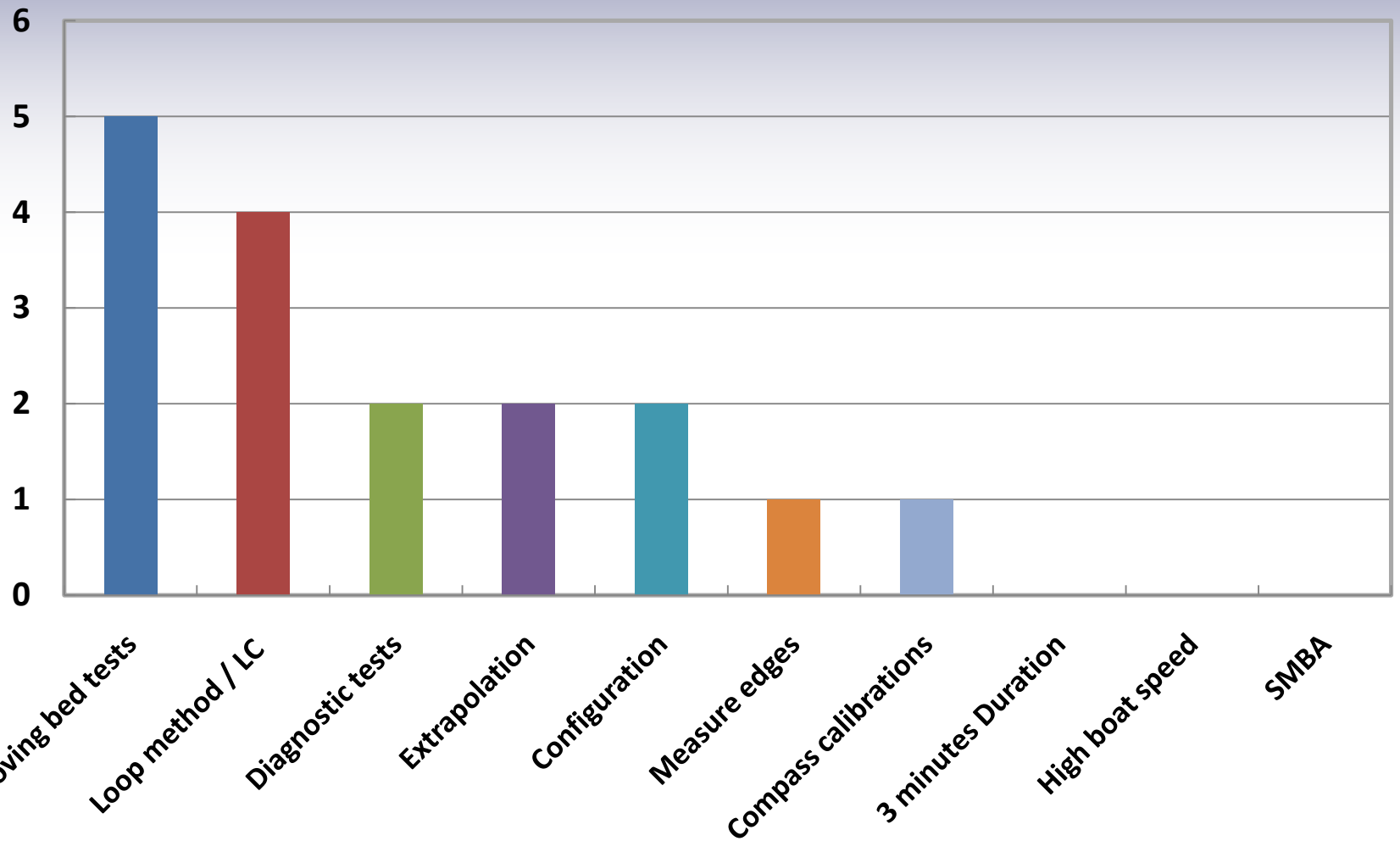
2007 ADCP Issues



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