

OSW Hydroacoustics Webinar

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Status of Testing of Hydroacoustic Instruments – February 2013

TRDI RiverRay, SonTek M9/S5, and the Ott ADC

Kevin Oberg

National Hydroacoustics Coordinator

USGS, Office of Surface Water



Overview

- Background and rationale for testing
- USGS Testing Program with examples
- Status of testing for
 - SonTek M9/S5
 - TRDI RiverRay
 - Ott ADC
- Plans for the future

Background

- The performance of traditional streamgaging instruments (e.g. Price AA) is well documented
- However, for new instruments such as ADCPs and acoustic point velocity meters, relatively few systematic field programs for validating acoustic instruments for streamflow and other hydraulic measurements have been documented.
- Little systematic testing is being done by other agencies, and even less in private industry.

National Field Validations of ADCPs & ADVs

Evaluation of Acoustic Doppler Current Profiler Measurements of River Discharge

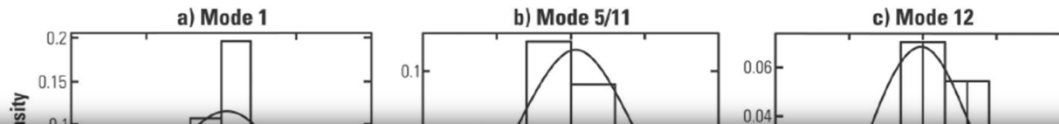
by Scott E. Morlock

USGS Water-Resources Investigations Report 95-4218, 1996

Validation of Streamflow Measurements Made with Acoustic Doppler Current Profilers

by Kevin Oberg and David S. Mueller

2007 -- *J. Hydr. Eng.*, v. 133, No. 12, p. 1421-1432



Contents lists available at [ScienceDirect](http://www.sciencedirect.com)

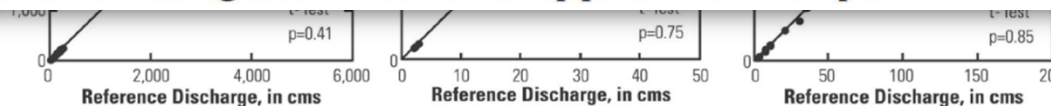
Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol



ELSEVIER

Comparison of bottom-track to global positioning system referenced discharges measured using an acoustic Doppler current profiler



Measurements – Jan 2009 to May 2012

Model	#
Unspecified	27,386
StreamPro	19,744
Rio Grande	19,556
M9	4,144
S5	224
RiverRay	511
Qliner	30
WH Monitor	15
mini-ADP	3
ADP	1
	66,735

USGS Testing Program

- Acceptance Testing **[Lab+Field]**
 - Conducted to determine if basic instrument specs/operation are met
- Routine QA **[Lab+Field]**
 - Routine tests done to insure that instrument performance is acceptable
- Post Factory-Repair Testing **[Lab+Field]**
 - Testing conducted after a repair.
 - Includes all / part of acceptance tests

Flowtracker Testing Example

- Acceptance Testing
 - 100% FTs purchased by the HIF are tested in tow tank
 - Hydrographer ought to make comparison measurement(s) and run routine QA checks when FT is received
- Routine QA
 - Every FT is tested in HIF tow tank on a 3 year cycle
 - Hydrographer routinely reviews beam checks and Qm results
- Post Factory-Repair Testing
 - All FT needing repair must be returned to HIF for tow tank testing after the repair is complete
 - Hydrographer ought to make comparison measurement(s) when FT is received and review routine QA output from FT

USGS Flowtracker Testing

Acceptance Tests

- Power-up check
- Thermistor test
- Beam Check
- Tow tank test @ 2 cart speeds: 18 & 33.5 cm/s

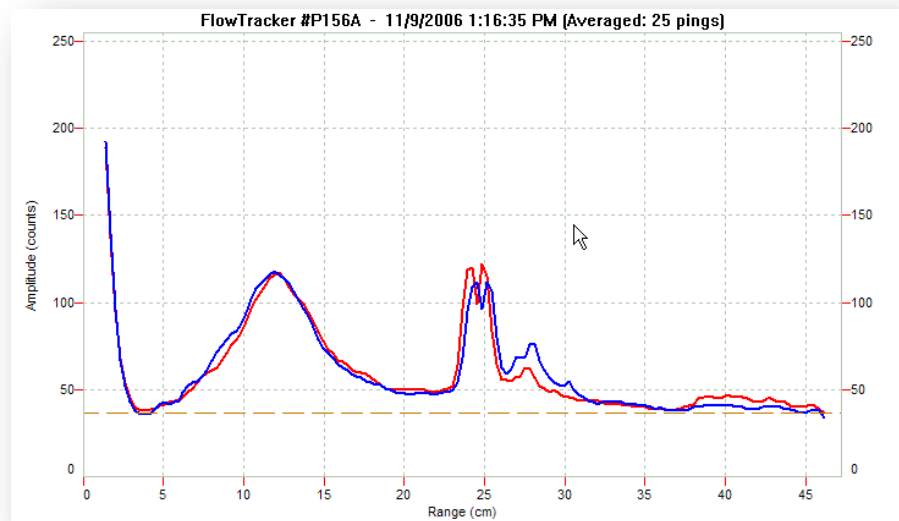


**Routine QA: 100% FTs
Tested every 3 years**

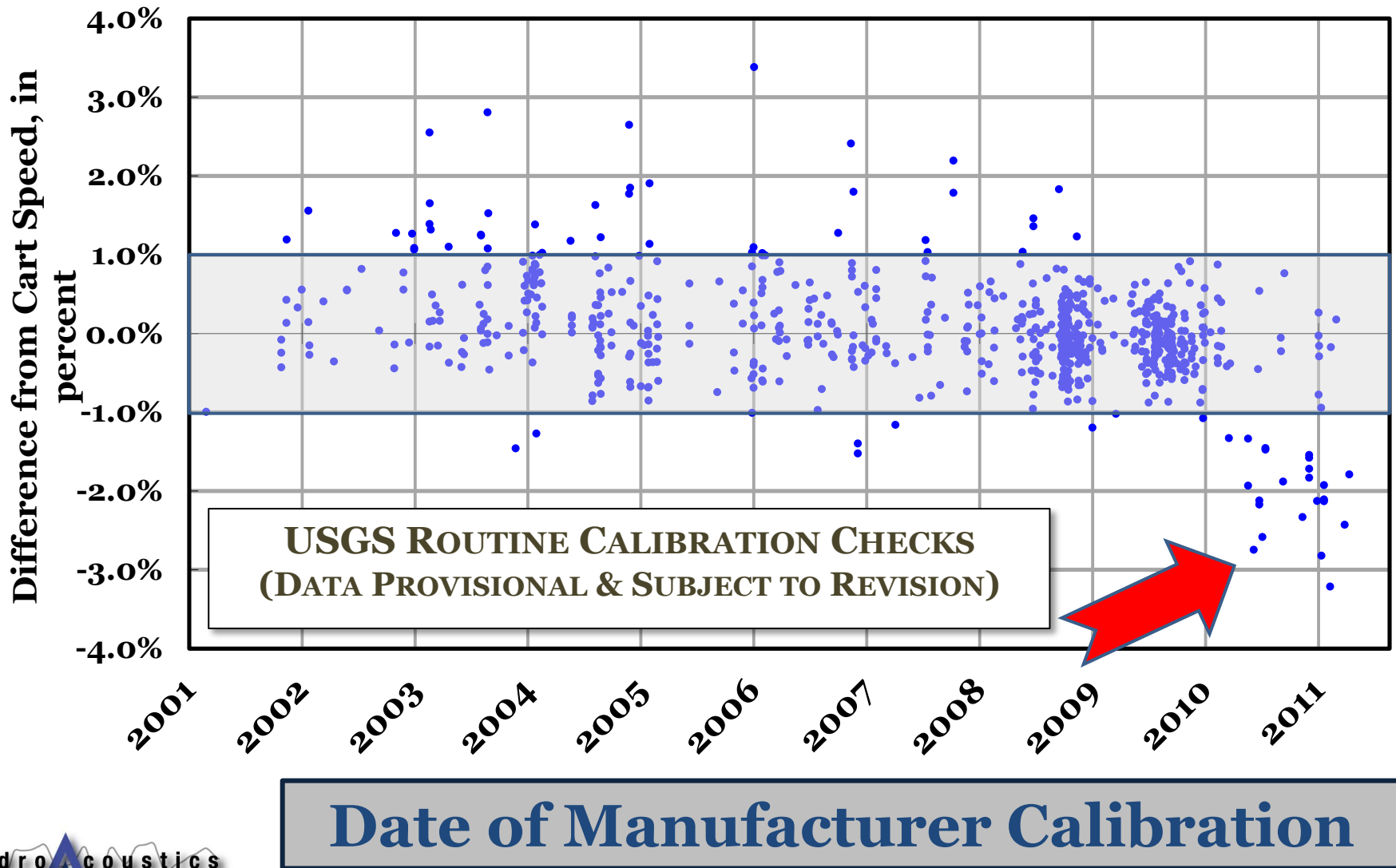
All repaired FTs are tested

Routine QA - Flowtrackers

- Bucket tests
 - After questionable results on auto-beam check
 - After possible damage to instrument (a drop, etc.)
 - Log and compare with previous log tests – should be consistent over time



Value of Independent Testing



ADCP Testing Example

- Acceptance Testing
 - 100% ADCPs purchased by the HIF are tested in tow tank
 - Hydrographer **ought** to make comparison measurement(s) and run routine QA checks when ADCP is received
- Routine QA
 - Periodic tow tank testing is planned (see Future Plans)
 - Annual comparison Qms or ADCP regattas
 - Beam angle tests
- Post Factory-Repair Testing
 - No policy at present for lab testing after repairs
 - Hydrographer **ought** to make comparison measurement(s) and run routine QA checks when ADCP is received

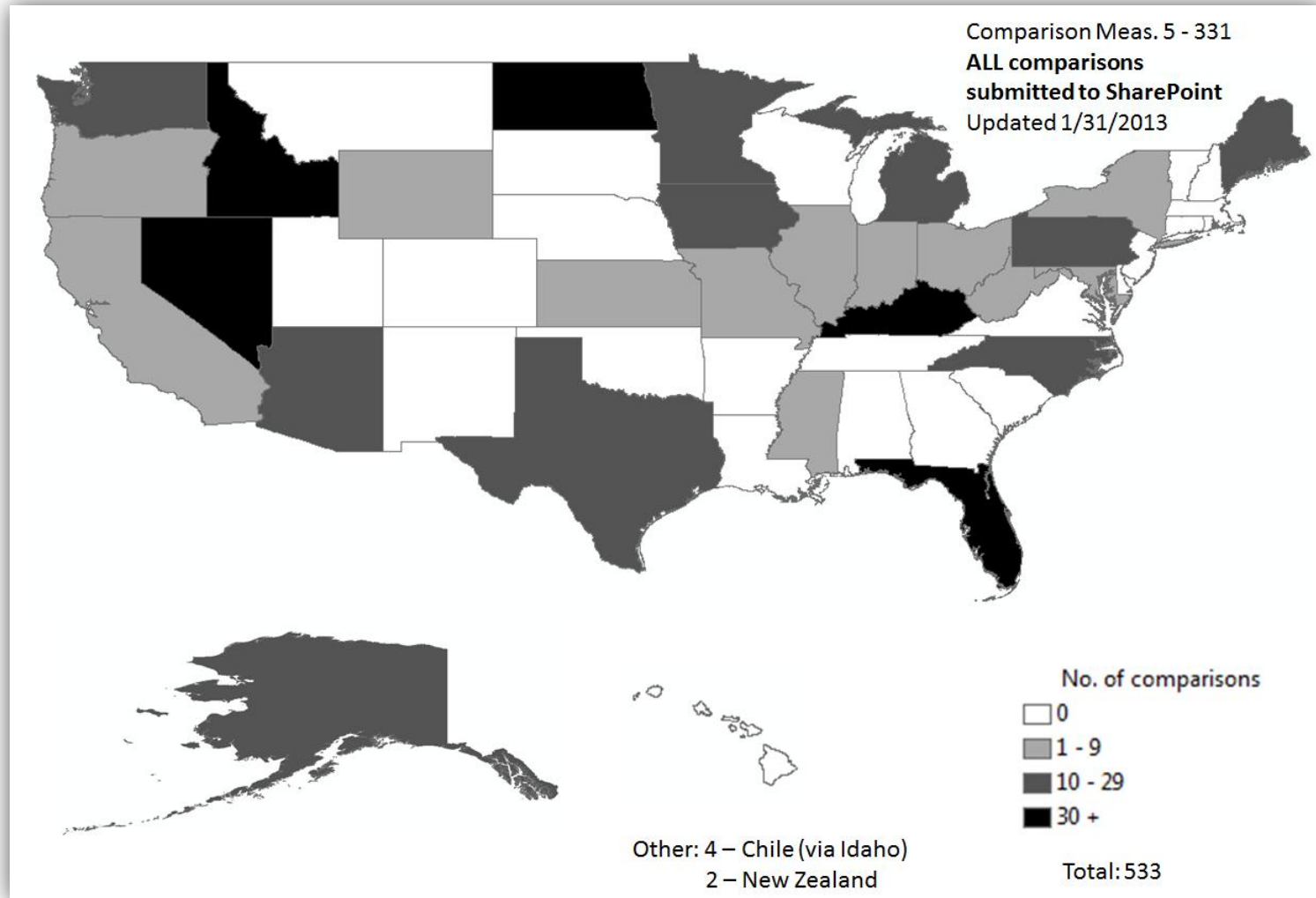


New ADCPS

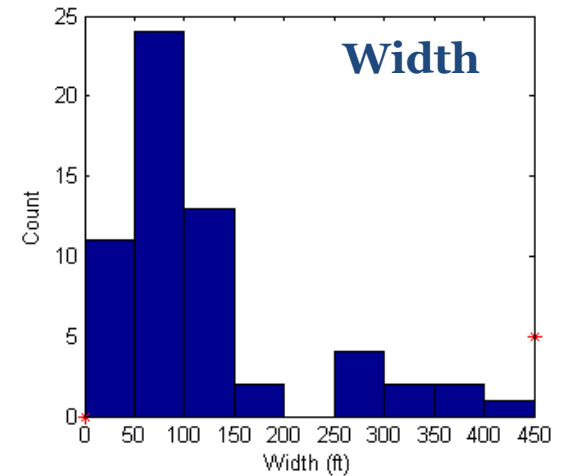
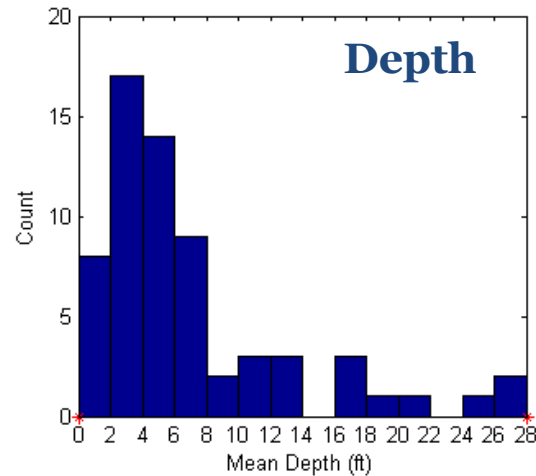
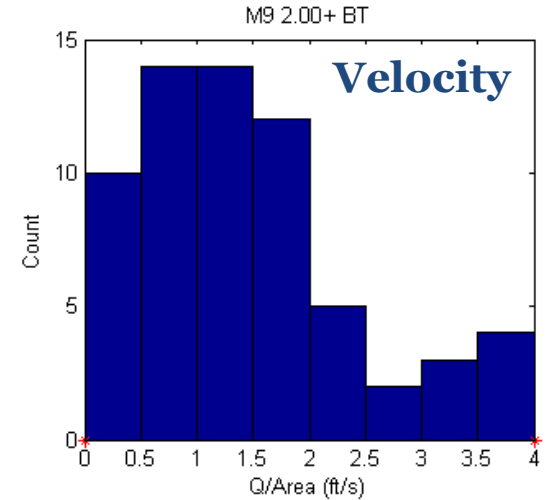
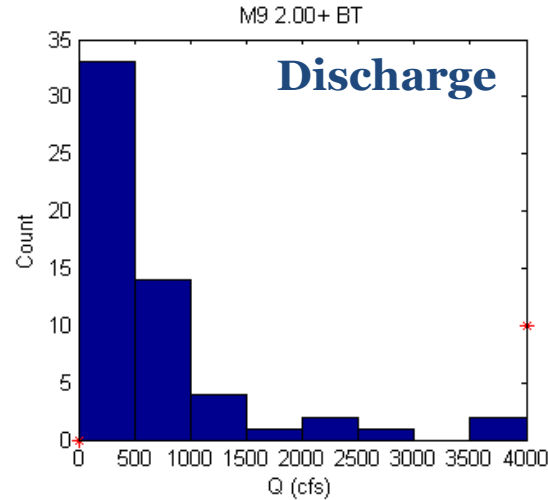
Comparison Requirement

- With the introduction of new instruments such as the M9/S5, OSW has required that WSCs conduct comparison measurements for the range of field conditions for which the instrument will be used.
- Testing should consider such factors as ranges in water velocity, boat velocity, streambed type, flow depth, turbulence, sediment concentrations, and GPS quality.
- Not all offices have submitted comparisons, but many are using new ADCPs/ADVs

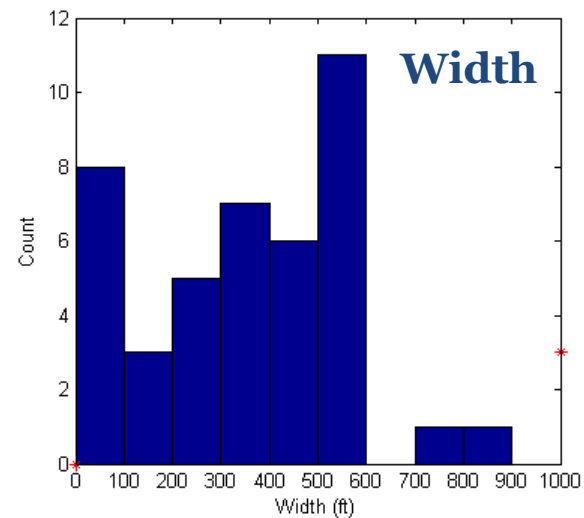
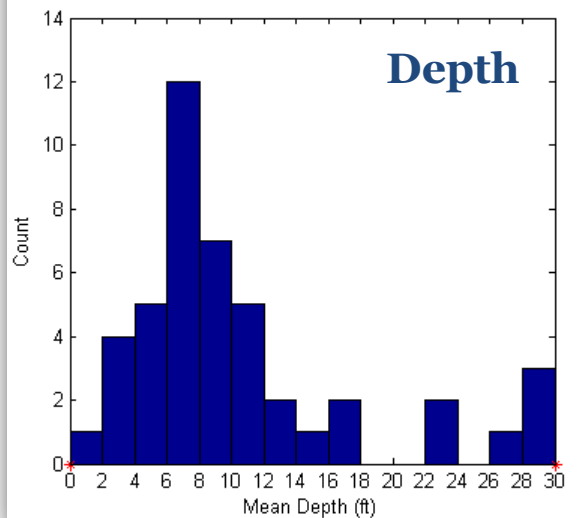
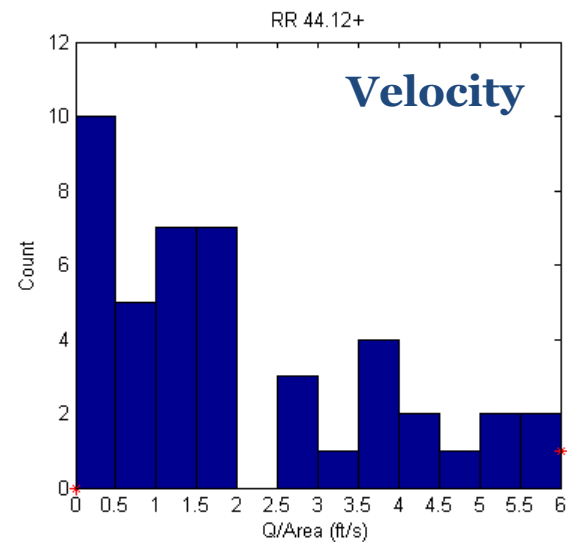
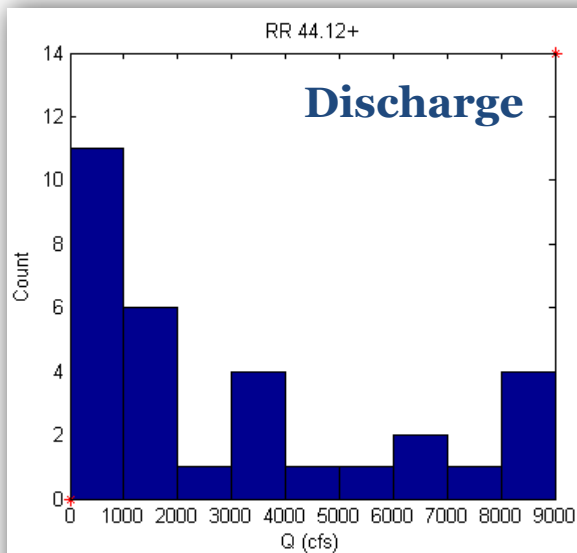
Comparison Measurement Submissions



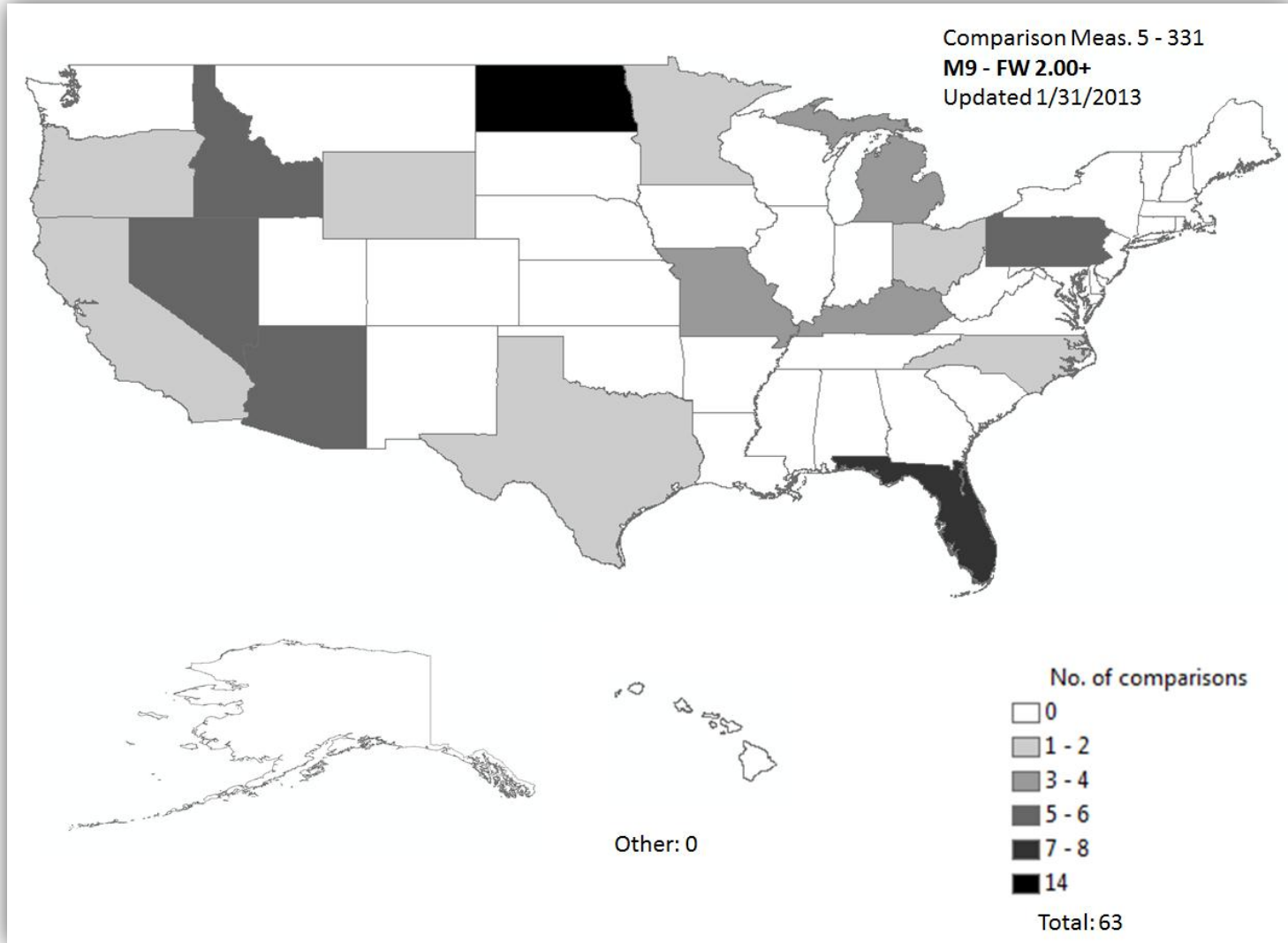
SonTek M9 Qm Characteristics



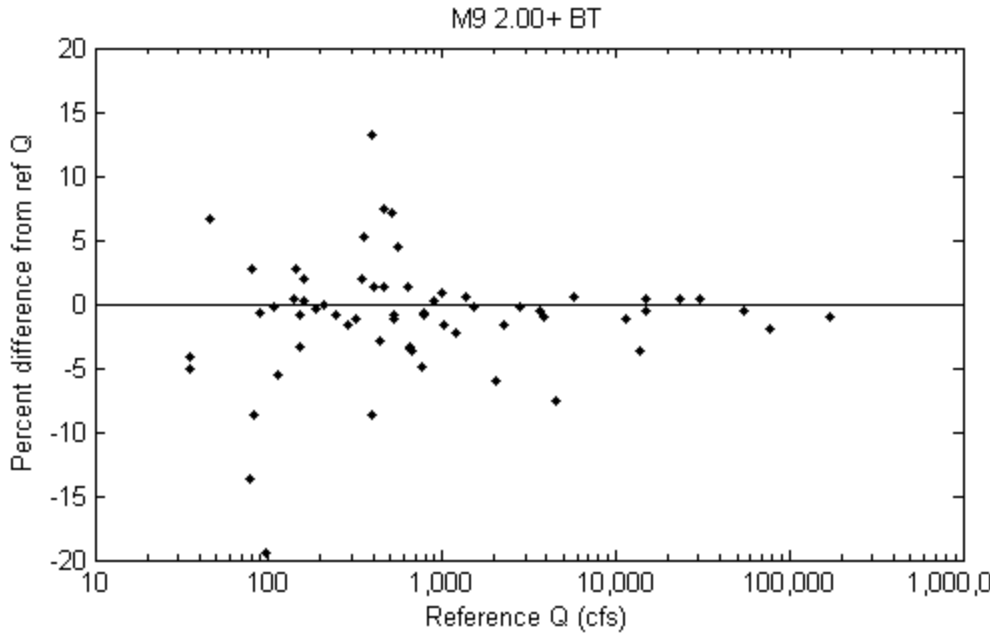
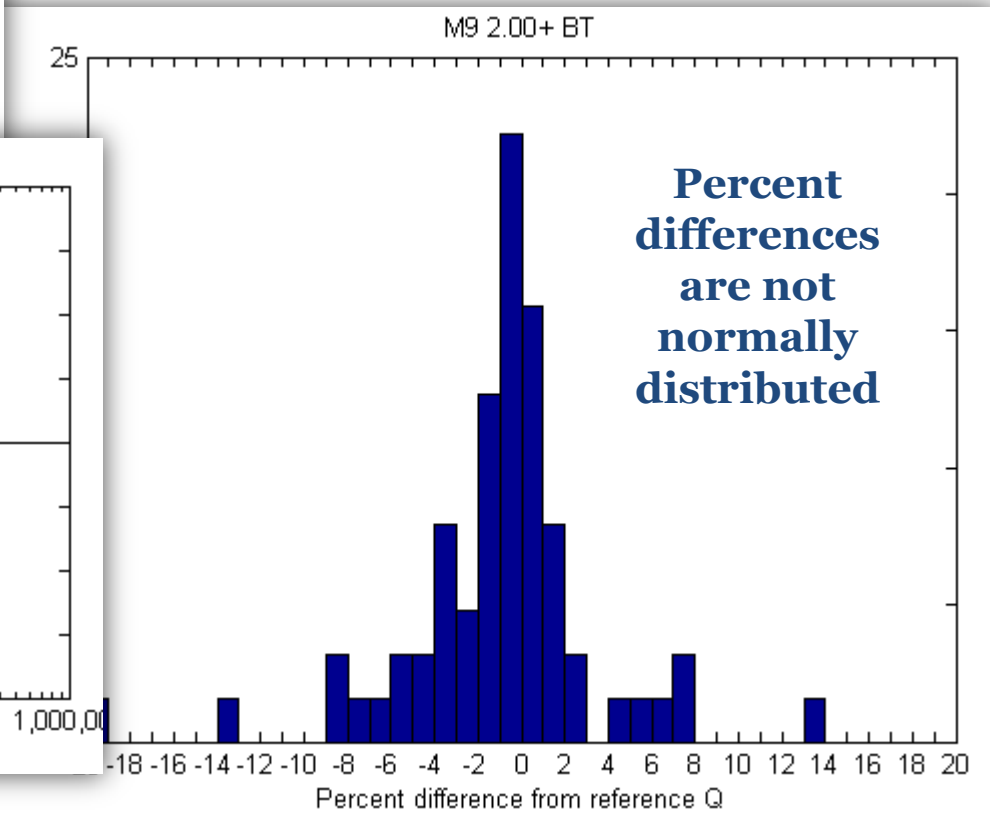
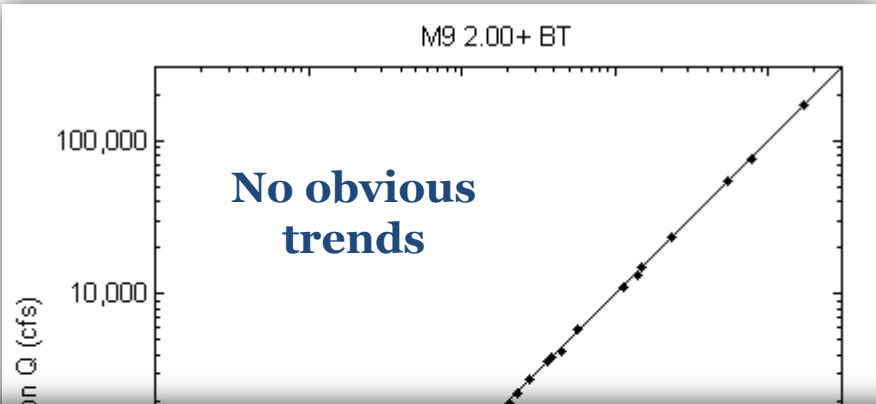
TRDI RiverRay Testing Results



M9 Submissions – Firmware ≥ 2.00



M9 Test Results – FW 2.0+ BT



M9 Test Results

No. of Qms		M9 Firmware			
		0.8x	1.0x	1.50	2.00+
Ref.	BT	46	27	29	63
	GGA	21	13	14	41
	VTG	21	13	15	41

Number of M9 measurements

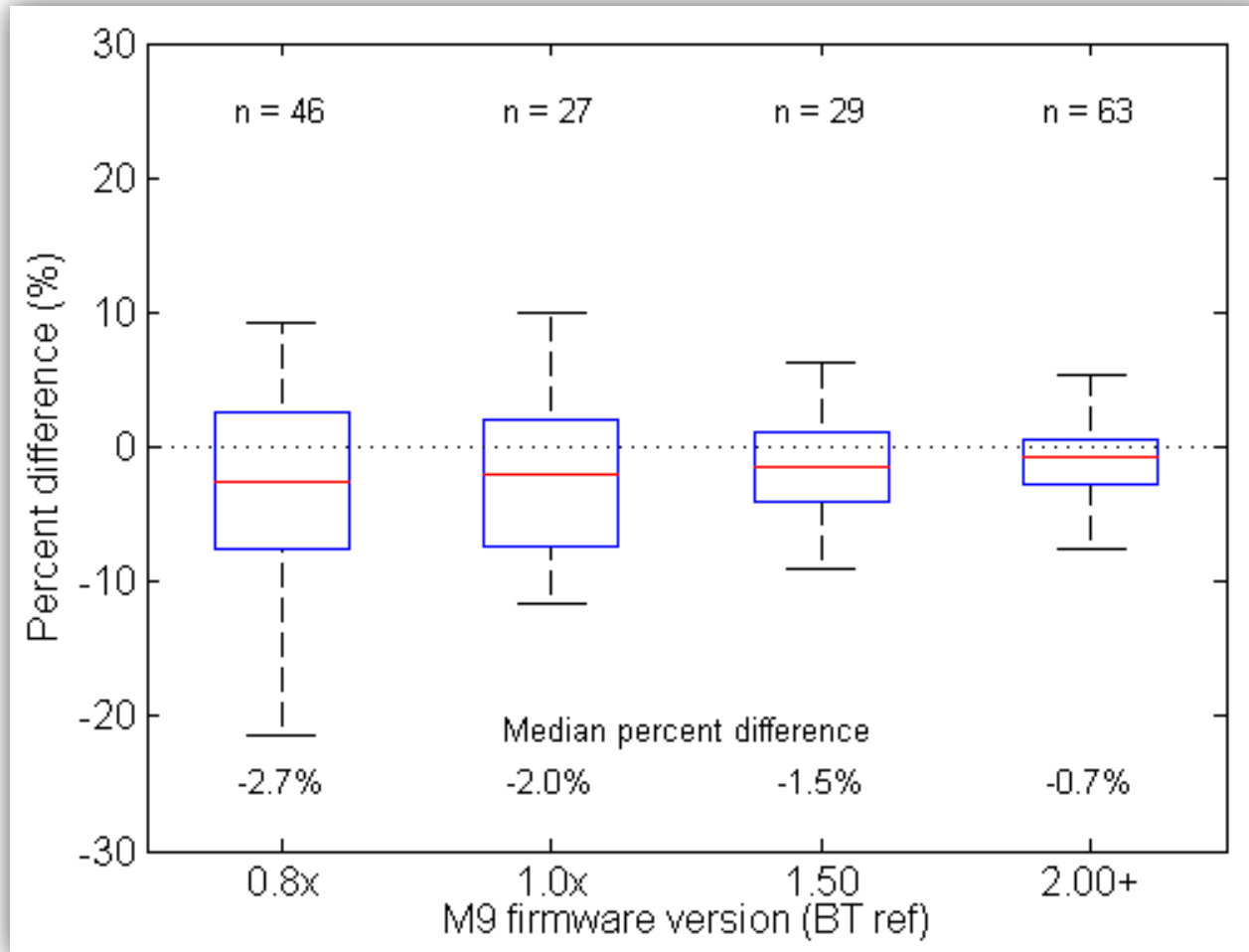
p values		M9 Firmware			
		0.8x	1.0x	1.50	2.00+
Ref.	BT	0.02	0.10	0.02	0.03
	GGA	0.01	0.04	0.12	0.21
	VTG	0.01	0.01	0.02	0.16

M9 discharge not equal to Ref. discharge (in red)

Median % diff.		M9 Firmware			
		0.8x	1.0x	1.50	2.00+
Ref.	BT	-2.7	-2.0	-1.5	-0.7
	GGA	-4.1	-6.2	-2.1	-1.1
	VTG	-3.0	-6.1	-3.6	-0.9

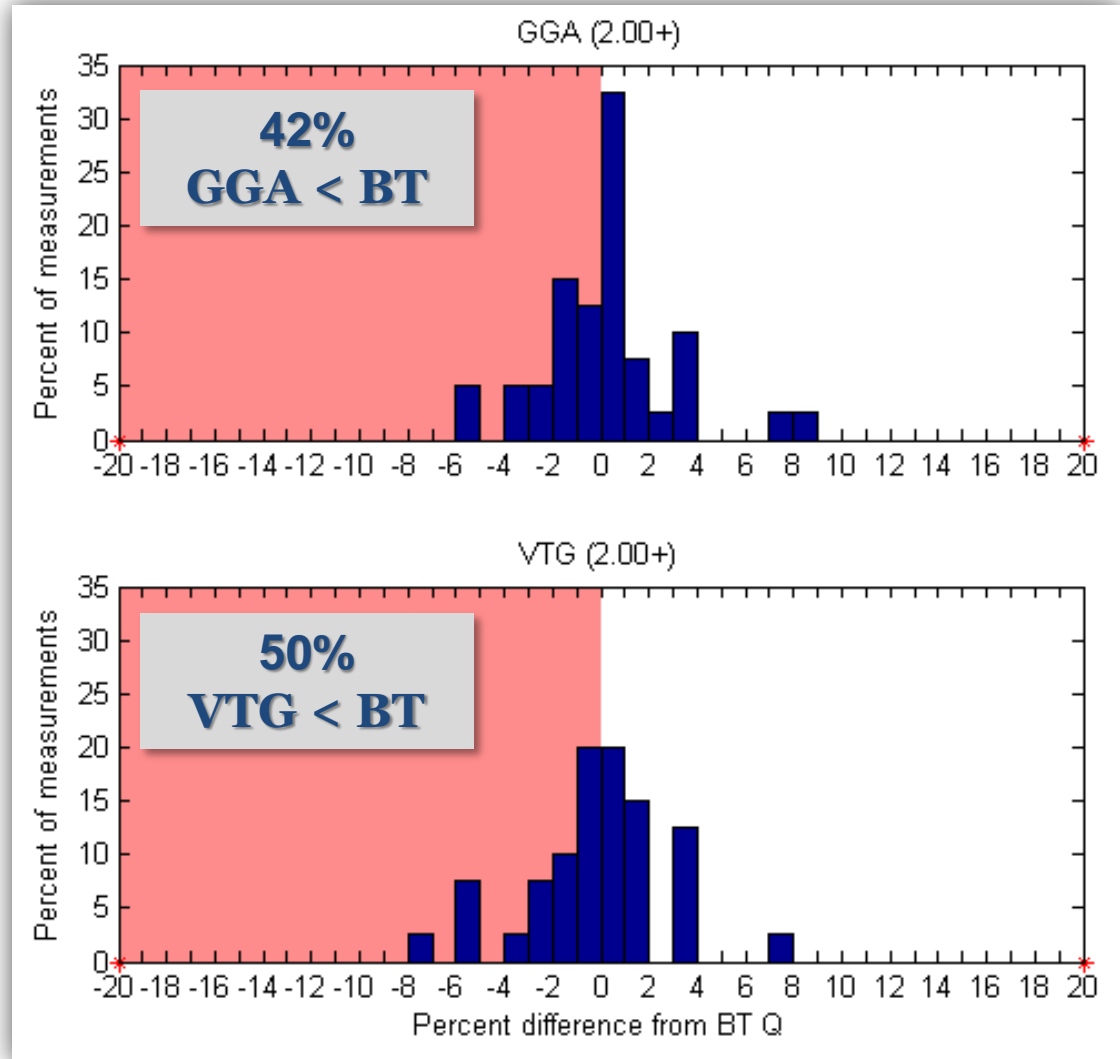
General improvement in accuracy

Changes in M9 Accuracy Over Time



Issues to be Aware Of

- Validity of compass calibrations is an ongoing concern
- 42% of the M9 Qms had a GGA Q < BT Q
- 50% of the M9 Qms had a VTG Q < BT Q



Issues to be Aware Of

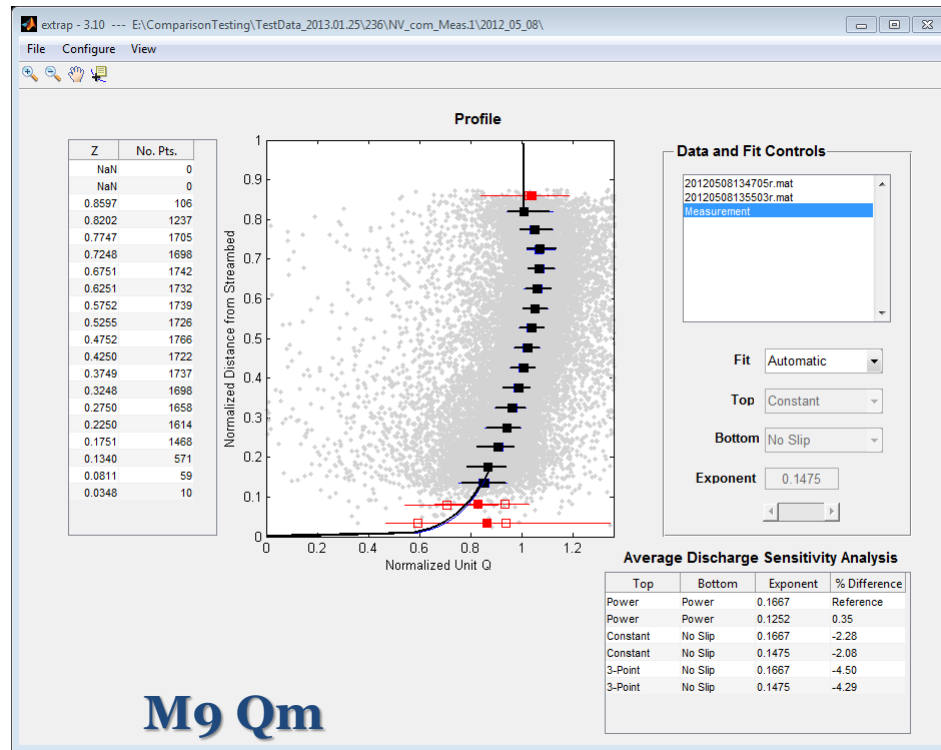
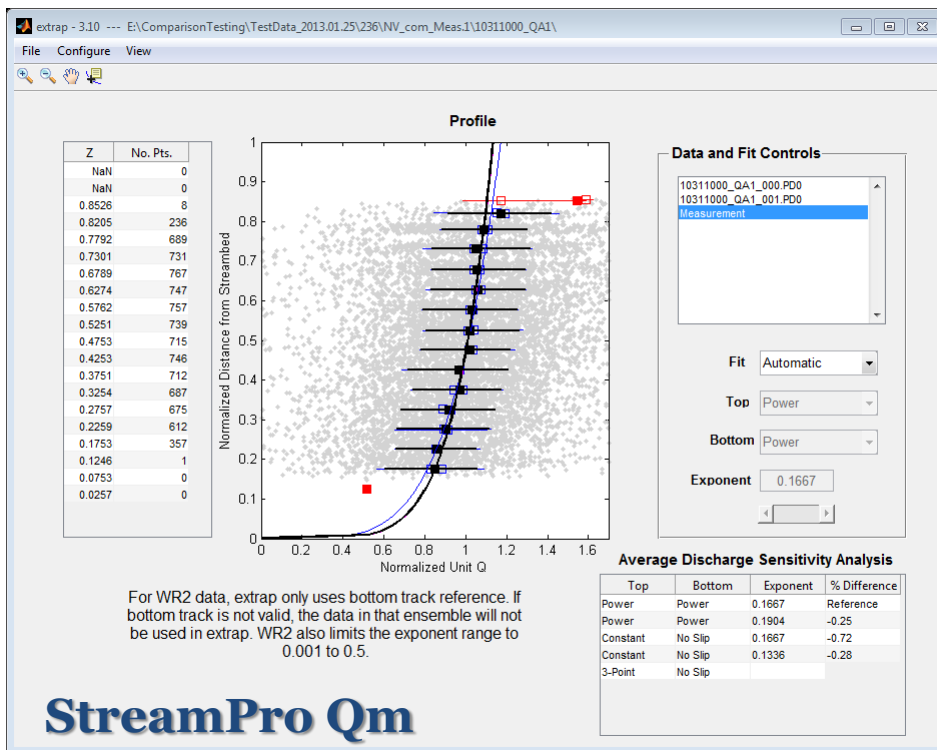
- Be sure to follow best practices for compass calibrations for SonTek M9s / S5s.

<https://simon.er.usgs.gov/smf/index.php?topic=516.0>

- When in doubt, make sure that you make stationary moving bed tests (SMBTs)

Issues to be Aware Of

- Potential for flow disturbance when using 3 Mhz – especially HD ‘mode’

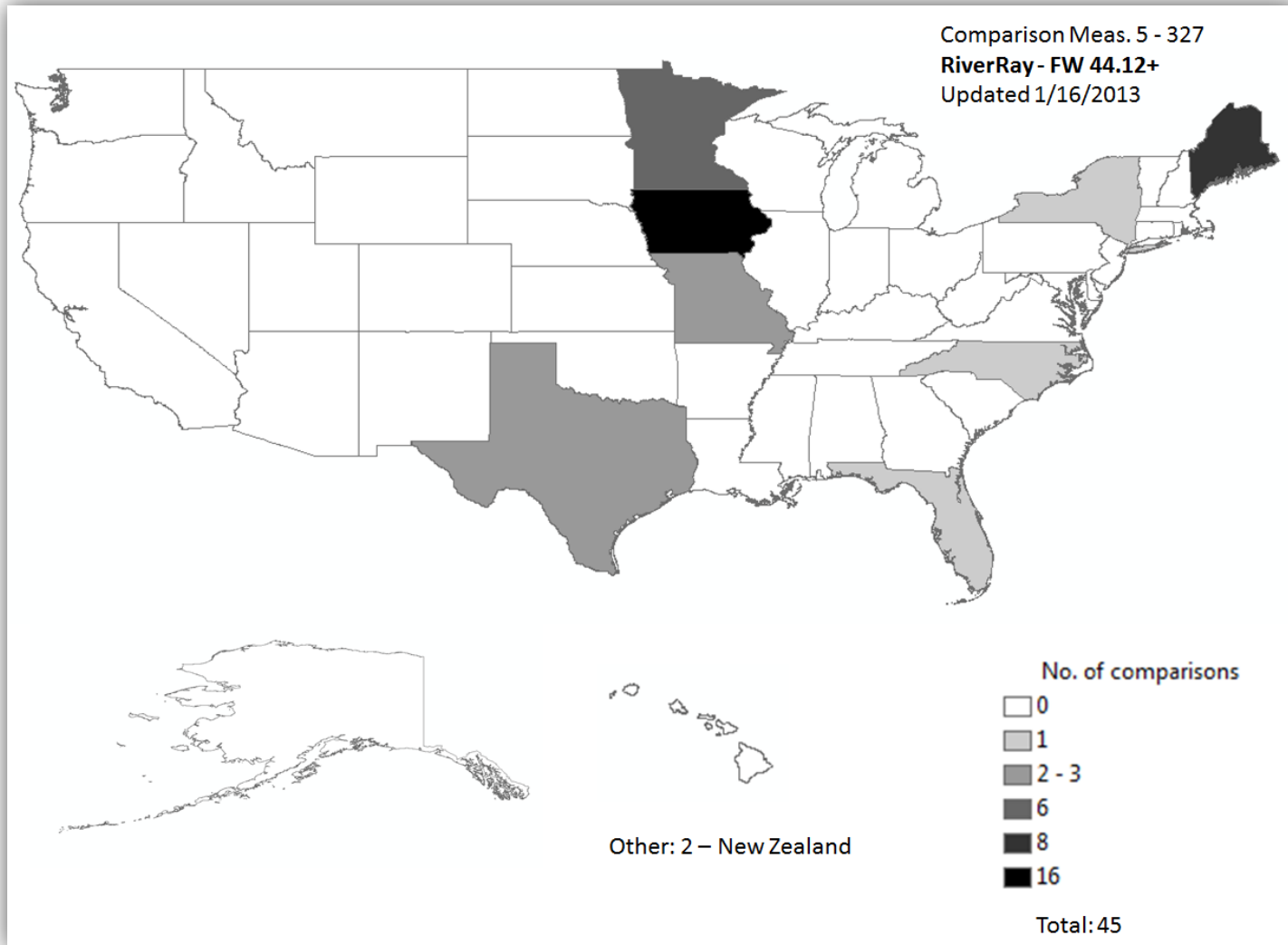


Testing Priorities/Plans in 2013

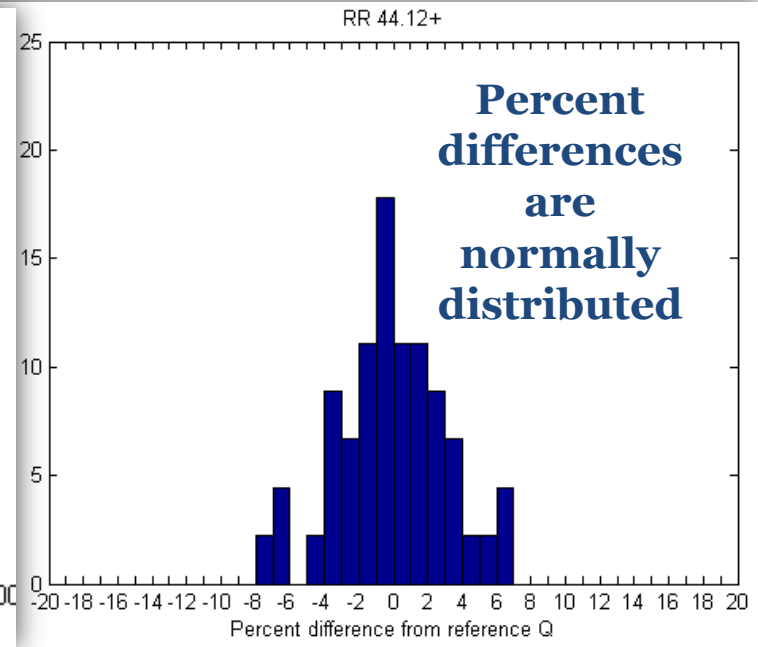
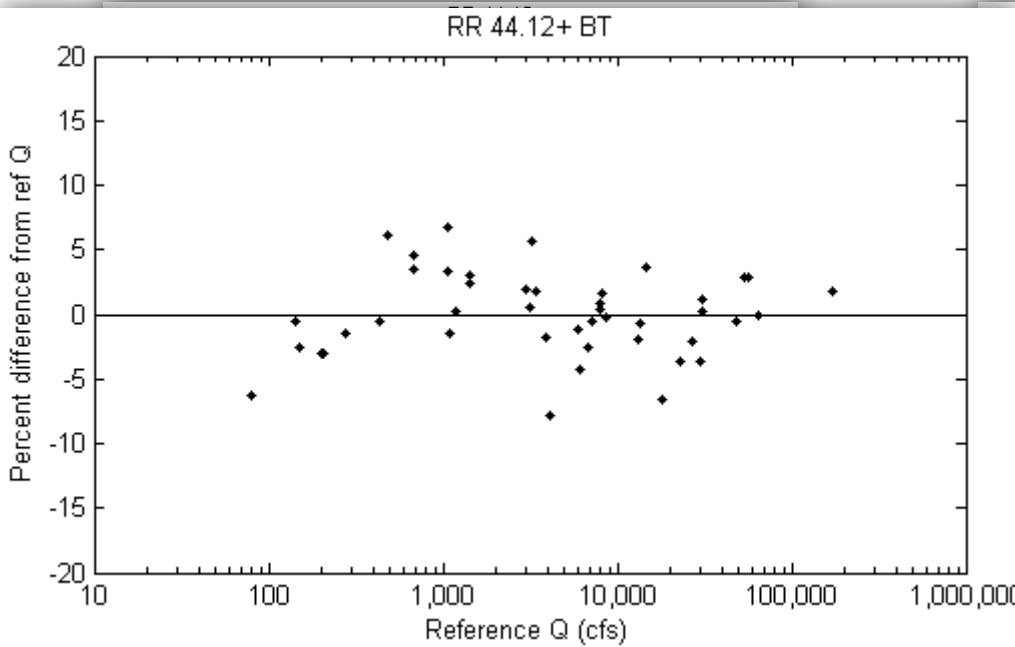
- **Publish OSW Tech Memo (and possibly a journal article) summarizing results**
- Work with SonTek to improve compass cal
- Evaluate software update to compass cal procedure in RSLive software (Feb-Mar??)
- Resolve issues with 3 Mhz flow disturbance

	SonTek M9/S5
Discharge	> 1,500 cfs
Mean Velocity	> 2.0 ft/s
Mean Depth	> 8 ft
Width	> 150 ft

RiverRay Submissions – Firmware ≥ 44.12



RiverRay Test Results



Statistically, there is no difference between RR Qs and Reference Qs

	RiverRay (ref: BT)	
	44.12+	Low BS
No. (n)	45	5
p value	0.935	0.063
Mean % difference	0.0	-18.0
Median % difference	-0.3	-17.1

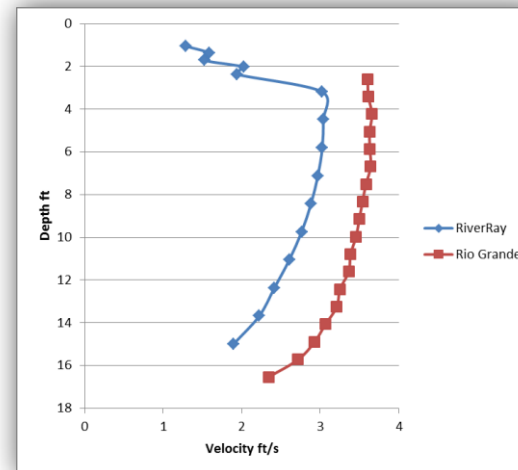
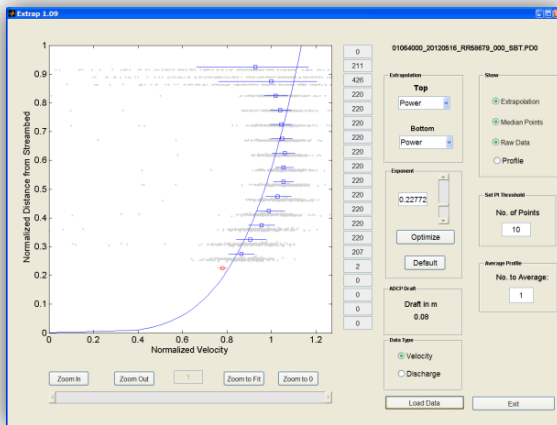
Testing Priorities/Plans in 2013

- **Publish OSW Tech Memo (and possibly a journal article) summarizing results**
- Evaluate performance of new compass
- Any enhancements / firmware upgrades
- Coordinate with other agencies

	TRDI RiverRay
Discharge	> 2,000 cfs
Mean Velocity	> 2 ft/s
Mean Depth	> 10 ft
Width	> 600 ft ??

Issues to be Aware Of

- Some reports of issues in low backscatter environments even after TRDI degaussing and firmware modifications. Not substantiated yet



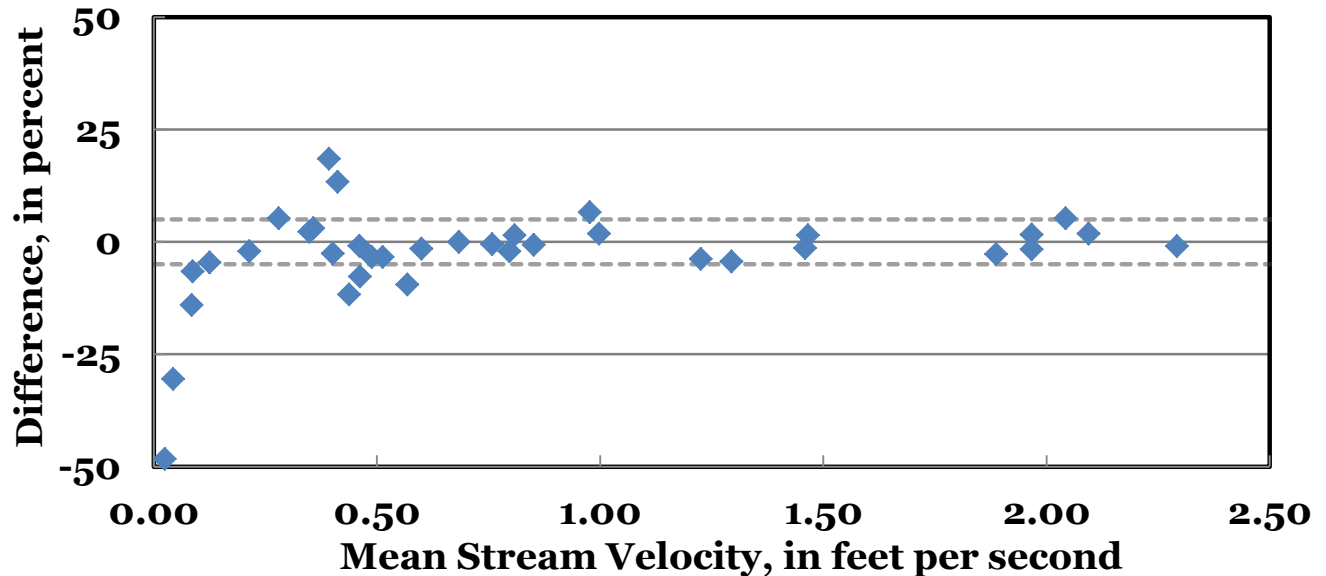
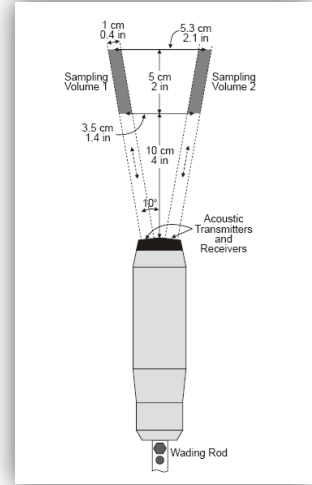
- Follow best practice guidance for RiverRays with Honeywell compass.
<https://simon.er.usgs.gov/smf/index.php?topic=514.0>



Ott ADCs

ADC Testing Status

- Lab and Field Comparisons: 2008-2009
 - 36 field comparison Qms were made
 - Various tow tank tests
 - Bias found in very low velocities
 - Various usability issues



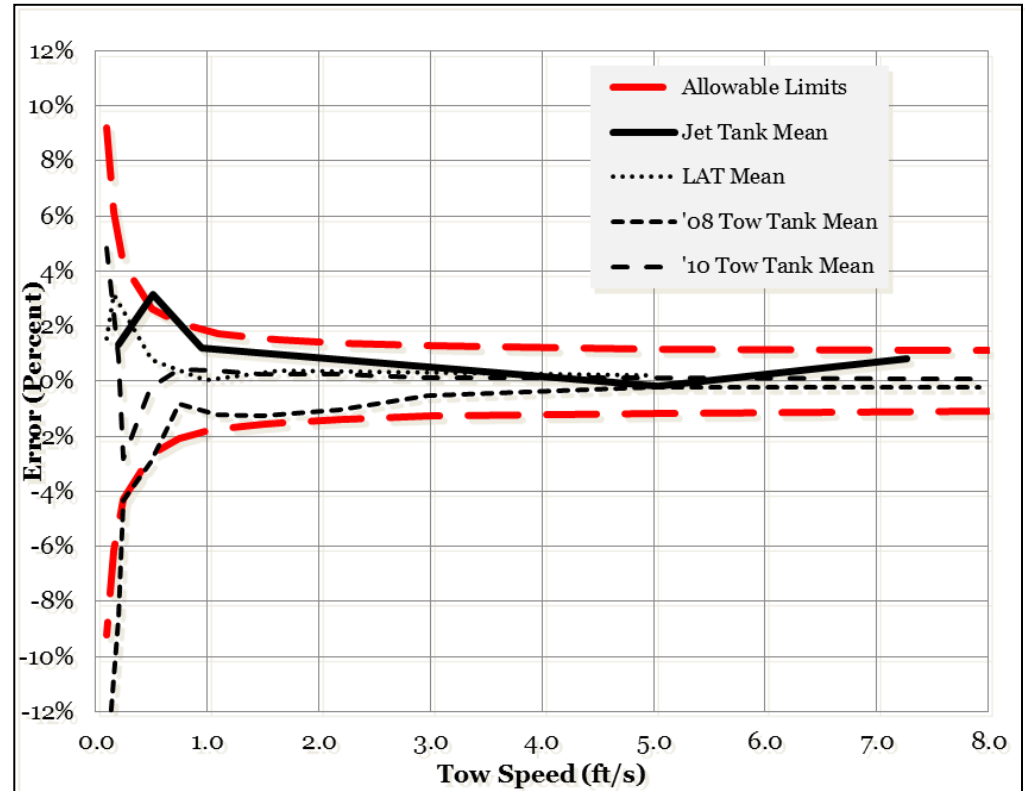
ADC Testing Status

- Ott modified firmware and software to address above and other issues
- Lab and Field Comparisons: 2010-present
 - 10-12 comparison Qms
 - Lab comparisons are still on-going
 - Completed boundary checks



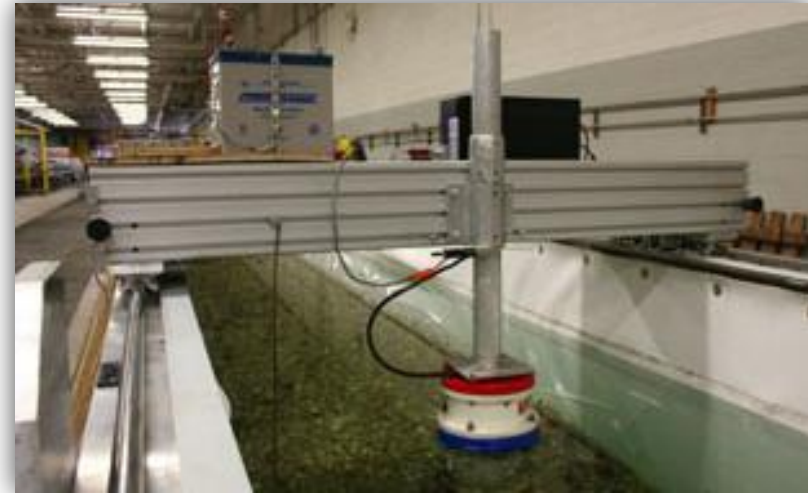
Some Issues with Lab Testing

- Recent HIF testing in new large acoustic towing tank and jet tank indicate possible problems with ADCs
- However, these apparent problems may have to do with tank differences or other factors
- Don't match results from 2008/2010



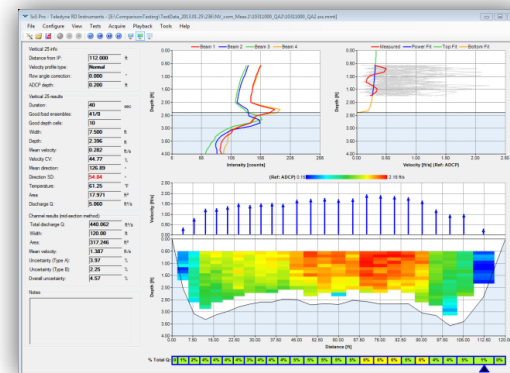
Future Testing Activities (FY 2013)

- Implement an ADCP Lab Testing Program
 - Similar to Flowtracker program
 - Distance tests in tow tank
 - StreamPros implemented first (Sept 2013)
- Implement program for other ADCPs in next fiscal year(s)



Future Plans (FY 2013)

- More formal testing of mid-section software for ADCPs
 - We are aware of some nuances (or possible issues) in the current software that need investigated
 - However, it seems the results obtained are generally OK
- Comparison measurements for flow under ice – especially if software changes are forthcoming
 - Provided long list of changes required to vendors, but no response as yet



Future Testing Activities (FY 2013)

- Field and lab testing of Ott ADCs
- Conduct testing of Hemisphere A101 GPS (and possibly other models) because A100 is no longer being sold
- Test SX Blue GPS (for use with StreamPros). We have seen anomalous results with SX Blue (GGA performs better than VTG in locations with multipath)



Future Plans (FY 2013)

- Update on guidance/requirements for Routine QA/QC testing - in revisions to Moving Boat ADCP T&M- Sept 2013) **(Current Draft)**

Instrument Condition	Quality Assurance Test		
	Beam Alignment Test ^a	Transformation Matrix Check	Comparison Measurement
New	Required		Required
Transducer repair or replacement	Required		Required
Non-transducer hardware repair or upgrade		Required	Required
Required, recommended or allowed firmware change		Required	
Unapproved or testing firmware change		Required	Required

- Comparison measurement should be made with each ADCP at least once during a three year period
- Maintain an instrument history log
- Store comparison measurements and QA info permanently

Conclusions/Recommendations

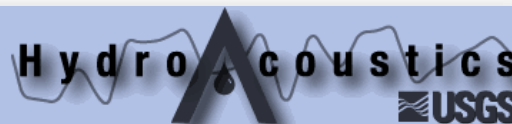
- Preliminary indications: No differences between RiverRay & Reference discharge measurements
- For SonTek M9s: No substantive differences between M9s & Reference discharge measurements, with the following caveats:
 - Need to investigate why BT results seem different than GPS results
 - When using GPS and (or) Loop MBT, the compass calibration is valid (not necessarily easy)
 - Proper MBTs are done
 - 3 Mhz HD used in high percentage of cross section (being investigated)

Conclusions/Recommendations

- When compass calibration is suspect, **always use stationary MBT**. Use multiple SMBTs where possible.
- Hydrographer is responsible to make sure equipment is working properly. When a new or repaired HA instrument is received, conduct 1 or more comparison measurements and other tests to make sure that the instrument is working correctly.

Share Comparison Measurements

WELCOME



Purpose

Welcome to the Office of Surface Water's (OSW) Hydroacoustics Testing and Evaluation SharePoint site. The purpose of this site is to provide an effective and efficient way to compile and share hydroacoustic instrument testing and comparison data. The OSW also collects and uploads data in a wide variety of conditions to ensure the quality of data from the variety of hydroacoustic instruments available in all conditions. Many users make comparison measurements as part of checking out a new instrument, routine quality assurance checks, and organized regattas. By compiling these data the OSW will be able to evaluate the performance of acoustic instruments in a wide variety of conditions, identify potential problems, and work to improve instrument performance where necessary.

Who

You! Everyone can participate. It is only through the participation of all USGS offices and other agencies that a sufficiently large data set can be compiled to cover the wide range of conditions in which these instruments are used. **Therefore, please submit your data!**

How This Works

Your Part:

1. Collect good quality comparison data with good documentation (include photos, if possible) for more detailed information on collecting good comparison data, click here. **NOTE:** Data that do not meet the strict guidelines outlined in the "Collecting Good Comparison Data" document may still be useful, and you are encouraged to submit them.
2. Process your data and prepare any summary or the data you would like.
3. Scan the field notes for the comparison measurements and save as a pdf.
4. Create zip file of the data and supporting documentation and summaries.
5. Click "Add new item to the Data Submissions" on this page below.
6. Complete the form and attach your files.

Our Part: OSW staff will review your data (we may call or email to clarify questions) and add it to the national compilation. All data in the national compilation will be made available to you. **NOTE:** This is a work in progress and we haven't finalized how to efficiently share the raw data and summaries with you yet, but we will.

IMPORTANT: Files or combinations of files exceeding approximately 10MB may not upload properly. If you have problems attaching files to the Data_Submissions form, please complete the form and put your files in the ftp directory shown below below:

ftp://ft pint.usgs.gov/private/er/ky/louisville/OSW_Comparison

If you have problems email David S. Mueller (dmueller@usgs.gov).

Click Announcement to see full text

Testing of SonTek/YSI RiverSurveyor M9/S5 and TRDI RiverRay 8/27/2010 3:17 PM
by Mueller, David S.

OSW has not completed testing of new ADCPs. Until the OSW has completed testing and issue technical memoranda or published their findings, it is necessary for WSCs to do their own QA of the new ADCPs if they intend to use them for data collection.

Links

- OSW Hydroacoustics Web Page

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• **On ADCP**
• **Mid-section open water**
• **Mid-section ice**
• **ADCPs for a range of conditions with limited data (previous slides)**

Data_Submissions

+ Add new item

Type	Agency / Office	Contact Person	Contact Email	Contact Phone No.	Instrument Type	Description of Files
	USGS/IN	Mike Rehmel	msrehmel@usgs.gov	317-290-3333	StreamPro	SP and MD very low velocities
	USGS - AZ	Hugh Darling	hdarling@usgs.gov	928-782-6024 x21	StreamPro; RiverSurveyor M9	09523200_020310M9.zip - M9 data 09523200_02032010.zip - StreamPro data

ADCP Comparisons Needed

	SonTek M9/S5	TRDI RiverRay
Discharge	> 1,500 cfs	> 2,000 cfs
Mean Velocity	> 2.0 ft/s	> 2 ft/s
Mean Depth	> 8 ft	> 10 ft
Width	> 150 ft	> 600 ft ??

A scenic landscape featuring a calm lake in the foreground, a dense forest of evergreen trees in the middle ground, and a range of mountains with patches of snow in the background under a clear blue sky. The word "Questions?" is overlaid in large, bold, yellow text across the center of the image.

Questions?

SonTek M9 Qms

**Jan 2009-
April 2012**

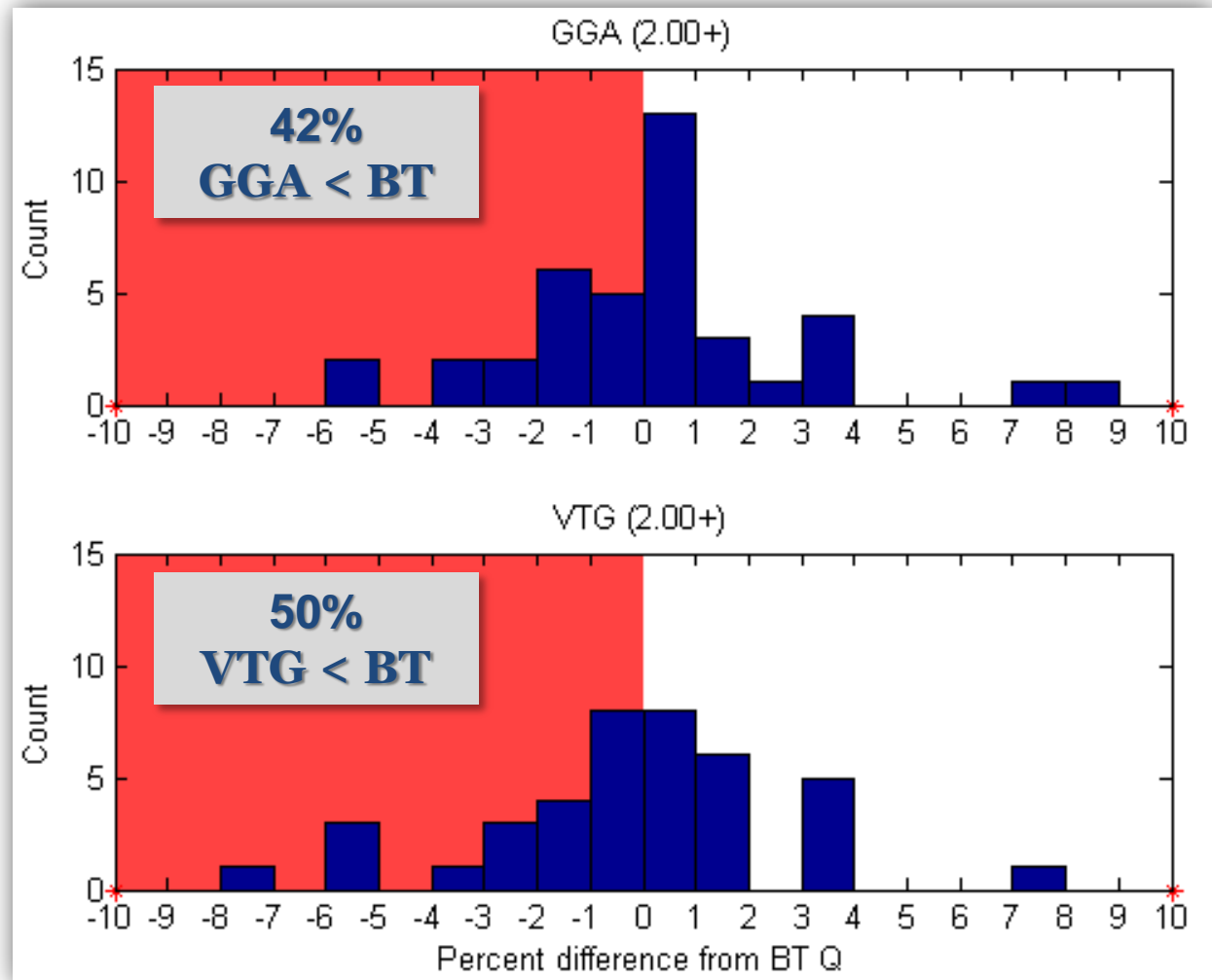
WSC	SonTek M9/S5 Qms	WSC	SonTek M9/S5 Qms
		New	
Alabama	7	Hampshire	109
Arizona	559	New Mexico	43
Arkansas	1	New York	121
California	316	North Carolina	86
Florida	1531	North Dakota	1
Georgia	70	Ohio	112
Idaho	177	Oregon	39
Kansas	1	Pennsylvania	39
Kentucky	174	South Carolina	4
Louisiana	78	Tennessee	123
Minnesota	47	Texas	44
Mississippi	47	Virginia	44
Missouri	303	Washington	2
Montana	2	West Virginia	183
Nevada	115	Wisconsin	57

TRDI RiverRay Qms Jan 2009- April 2012

WSC	TRDI RiverRay Qms	WSC	TRDI RiverRay Qms
California	4	Mississippi	25
Florida	58	New York	141
Iowa	55	Oklahoma	9
Maine (MA)	67	Texas	57
Michigan	47	Washington	23
Minnesota	25		

Issues to be Aware Of

- Validity of compass calibrations is an ongoing concern
- 42% of the M9 Qms had a GGA Q < BT Q
- 50% of the M9 Qms had a VTG Q < BT Q

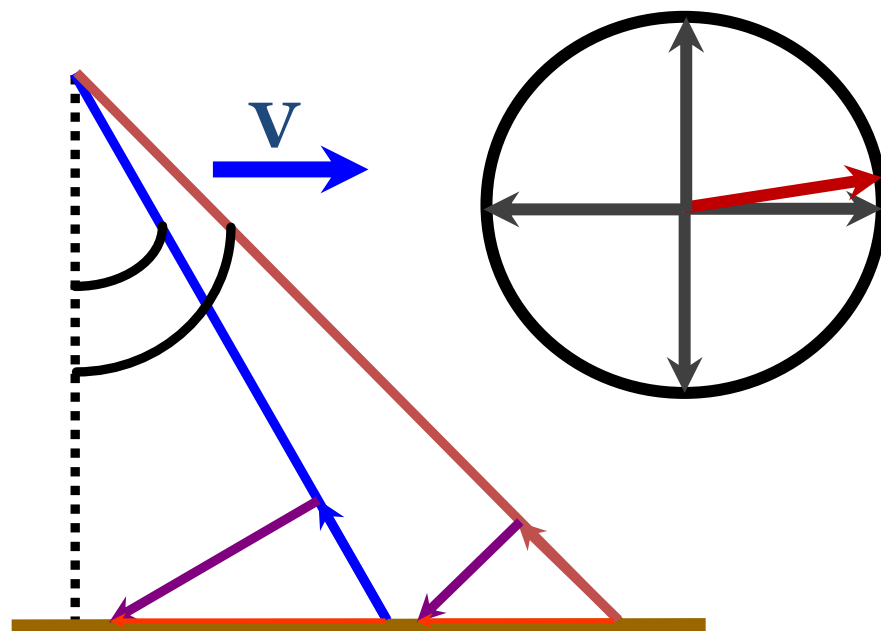


Routine QA Examples – Regattas



- 19 - TRDI Rio Grandes
- 3 - TRDI StreamPros
- 1 - TRDI RiverRay
- 1 - Sontek/YSI RS-M9

- Beam angle tests check for errors in both horizontal and vertical beam alignment



Measurement Characteristics for M9 and RiverRay Comparison Measurements

