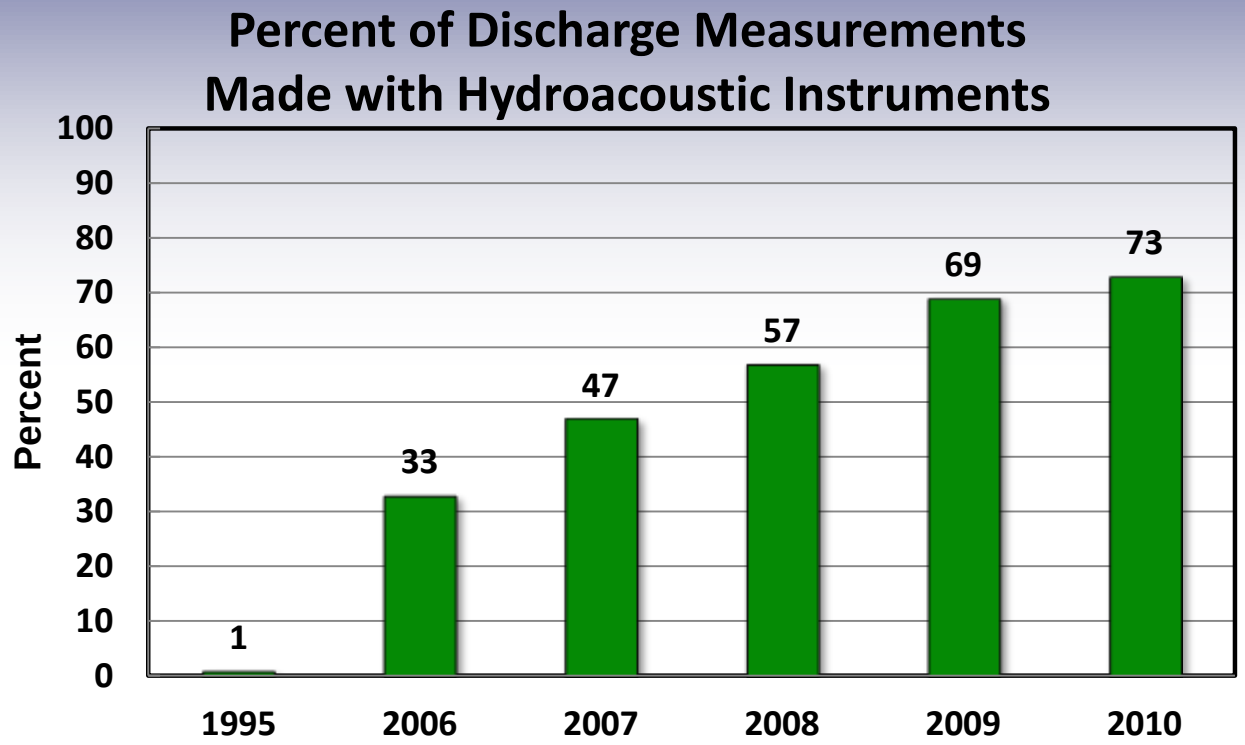
QA of Hydroacoustic Instruments

What's My Responsibility?

Overview of Presentation

- Hydroacoustic Instruments – Discharge measurements and Index Velocity
- Instrument Quality Assurance
  - Acceptance Testing [HIF + WSC]
  - Post Factory-Repair Testing [HIF and(or) WSC]
  - Routine QA [WSC]
- QA for Instruments for which formal testing by OSW is incomplete [WSC]
- ADVM QA
- Question and Answer

Why do we Care about QA?



Approximately 6% of streamflow stations are index velocity stations

- Many procedures exist for mechanical current meters (spin tests, checking pivots/bucket wheels/yokes, current meter exchange, etc.)
- Need have equivalent practices for acoustic instruments

What's My (Your) Responsibility?

- **Objective of this presentation:**
  - **Create awareness of QA activities and their importance**
  - **Provide overview of QA activities led by OSW and others**
  - **Focus on QA activities you can <u>influence</u> or <u>control</u> for hydroacoustic instruments used to make discharge measurements**
  - **Brief overview of ADVM QA**
- **QA is EVERYONE's responsibility! (i.e. not just OSW)**

Hydroacoustics Instruments

- Discharge Measurement Instruments
  - Tested by OSW with formal policy/guidance
  - Incomplete testing with no formal policy/guidance

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Hydroacoustics Instruments

- Acoustic Doppler Velocity Meters
  - Index velocity instruments
  - Instrument and measurement QA are closely linked
  - Details require a separate webinar

Three Kinds of Testing

- **Acceptance Testing** **[HIF + WSC]**
  - Testing conducted to determine if basic requirements instrument operation are met
  - Example: Staff sections are tested to verify that the distance indicated on the staff is accurate to within some spec
- **Post Factory-Repair Testing** **[HIF + WSC]**
  - Testing conducted after a repair. May include all or part of acceptance test procedures
- **Routine QA** **[WSC]**
  - Routine tests done to assure user that instrument is functionally normally

Advantage of HIF Purchase

- Acceptance testing: 100% of Flowtrackers / ADCPs purchased through the HIF are tested
- HIF coordinates recalls/updates, etc.
- HIF maintains database with info on every Flowtracker purchased/repaired/tested
- Lower overhead means lower cost for WSCs

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HIF Acceptance Testing - Flowtrackers

- Power-up check
- Thermistor test
- Beam Check
- Automated tow tank test
- Two cart speeds 18 & 33.5 cm/s

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WSC Acceptance Testing - Flowtrackers

- **Check Flowtracker operation**
  - **Refresh batteries if necessary**
  - **Power up and check menus**
  - **Perform a bucket test**
- ***Best Practice:*** ***Perform a check discharge measurement to verify that the Flowtracker is working.*** **Compare to expected discharge (rating or shifted discharge) provided it is relatively accurate. Doesn't have to be a comparison to AA or ADCP**

HIF Acceptance Testing - ADCPs

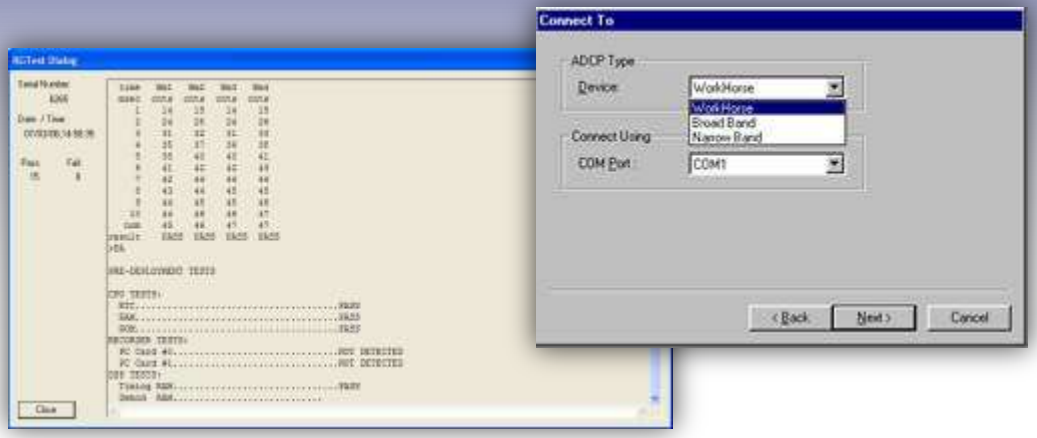
- Tests consist of:
  - Power-up check: comms, heading, pitch/roll, ping
  - Thermistor validation
  - Distance test in flume – StreamPro and M9/S5s only

HIF Acceptance Testing - ADCPs

- New ADCP testing tank being constructed
- Dimensions: 80 x 4 x 4 ft.

WSC Acceptance Testing - ADCPs

- System checkout
  - Apply power
  - Check comms
  - Run diagnostic tests
  - Note transformation matrix – TRDI ADCPs



- ***Best Practice:*** ***Perform at least 1 check measurement to verify that the ADCP is working.*** Compare to expected discharge (rating or shifted discharge). Comparison doesn't have to be with AA, Flowtracker, or ADCP.

```
>PS3
  1.4789 -1.4747 -0.0082  0.0035
 -0.0222  0.0269 -1.4724  1.4705
  0.2673  0.2643  0.2702  0.2612
  1.0391  1.0453 -1.0403 -1.0451
```

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Post Factory Repair Testing - Flowtrackers

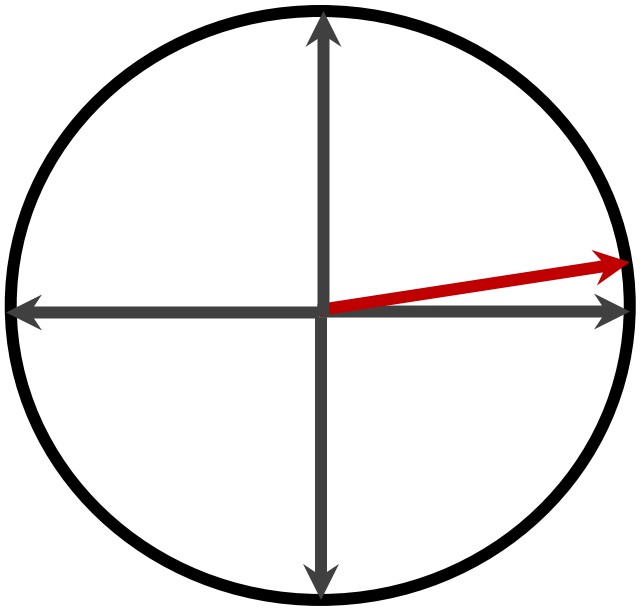
- **Must be** returned to HIF after factory repairs – regardless of who (HIF or WSC) initiated the repair
- ***Best Practice:*** ***Arrange for repairs via HIF***
- When received by HIF they will:
  - Verify to the extent possible that repair was successful
  - Perform routine acceptance tests
- When received at WSC, hydrographer:
  - Should conduct power-up testing and bucket test
  - ***Best Practice:*** ***Make a check QM***

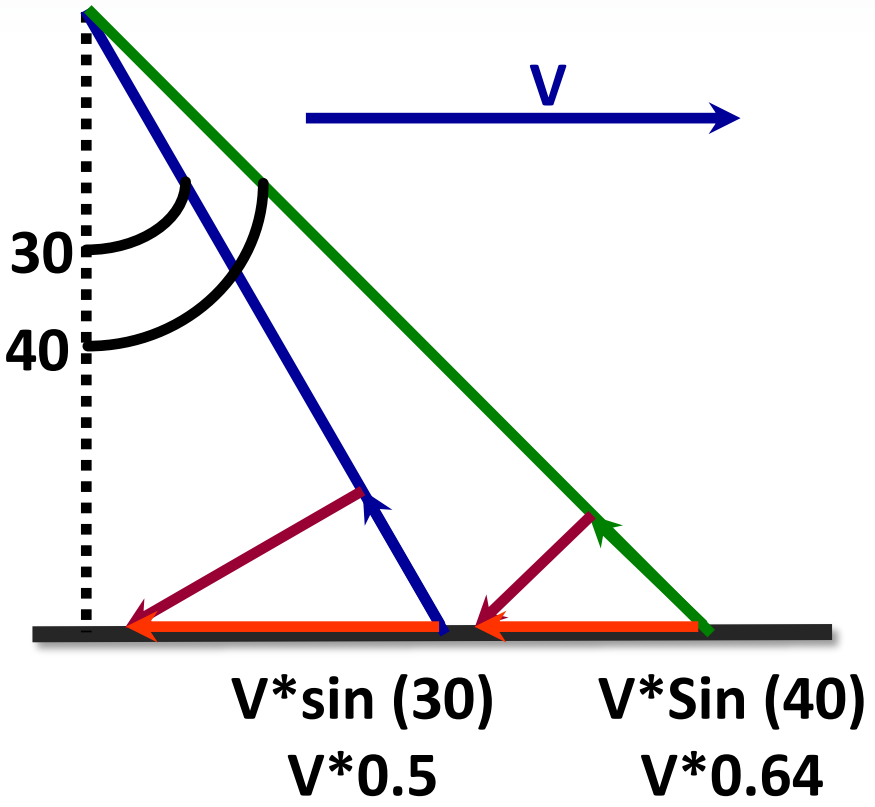
Post Factory Repair Testing - ADCPs

- Not required that ADCP be returned to HIF – though HIF can assist with this
- WSC staff should perform system checkout
  - Apply power
  - Check communications (BBTalk)
  - Run diagnostic tests
  - Check values of transformation matrix and compare to values prior to repair (should be the same)
- <u>Best Practice:</u> ***Make a check QM to verify that ADCP is functioning normally.*** **Not required.**

Routine ADCP QA – Beam Alignment

- Testing all aspects of an ADCP is almost impossible under any circumstances. Beam alignment errors are potentially the largest source of BIAS





Routine ADCP QA – Beam Alignment

- OSW Technical Memo 2009.05 states that beam alignment test should be done for
  - All new instruments not tested by HIF
  - Any ADCP returned from factory repair or evaluation
  - Every instrument once every 3 years
  - After firmware upgrades (?)
- Checking that transformation matrix is unchanged is probably sufficient after a firmware upgrade. Make sure to store a log of matrix.

```
>PS3
  1.4789 -1.4747 -0.0082  0.0035
 -0.0222  0.0269 -1.4724  1.4705
  0.2673  0.2643  0.2702  0.2612
  1.0391  1.0453 -1.0403 -1.0451
```

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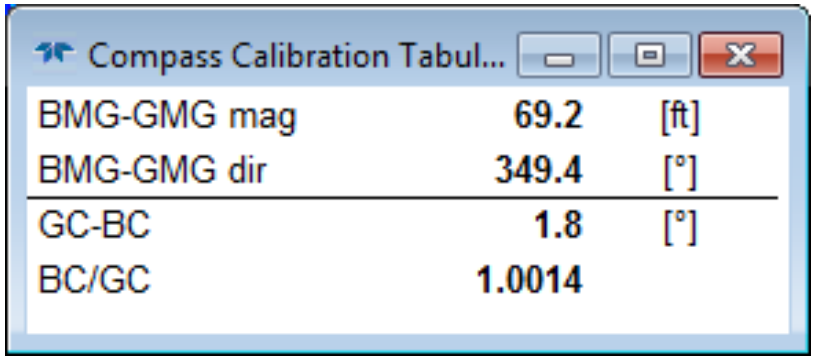
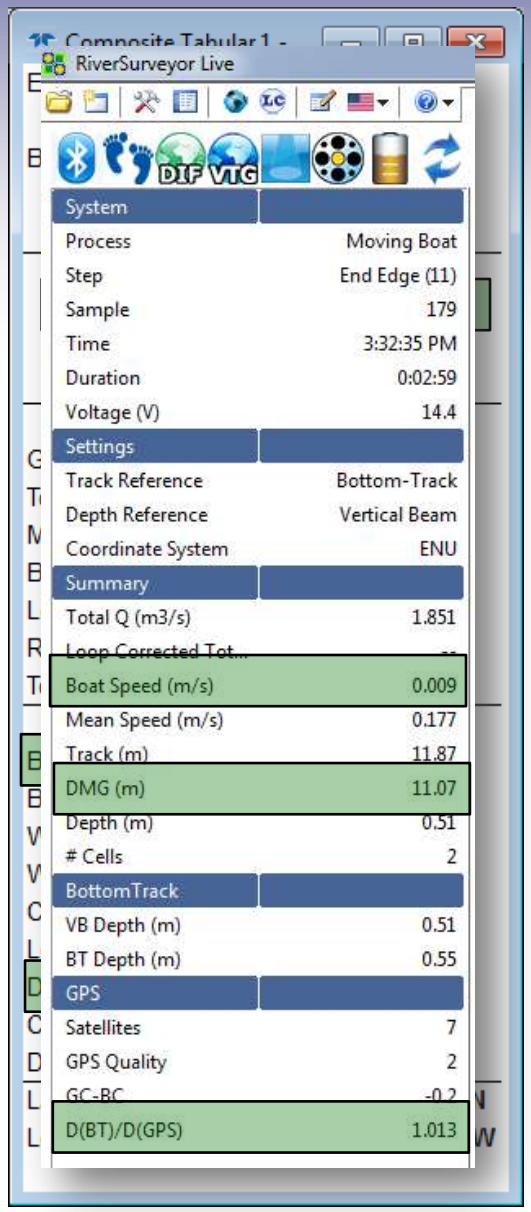
Routine ADCP QA – Beam Alignment

- **Requires:**
  - Manned boat with ADCP/GPS mounts
  - GPS with differential capability (WAAS) (GGA & VTG)
  - Lake or water body shallow enough to reliably bottom track with no rapid changes in bed elevation
  - Ability to navigate at constant heading & speed for long distance
- **Considerations:**
  - Test does not evaluate water tracking, though beam alignment affects both BT and WT
  - Need to maintain bottom tracking
  - Heading is important – NOT course!

Beam Alignment Procedure

- Mount ADCP (note beam orientation)
- Conduct internal ADCP diagnostic tests
- Begin pinging – but not recording
- Configure software to view Distance Made Good (DMG) and ratio of BT and GPS DMG (known as BC/GC)
- Record GPS (GGA/VTG) and ADCP data
- When boat at desired speed, begin recording
- Maintain constant compass heading /speed





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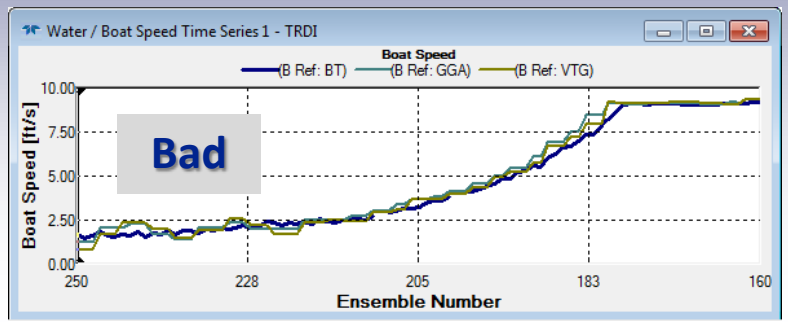
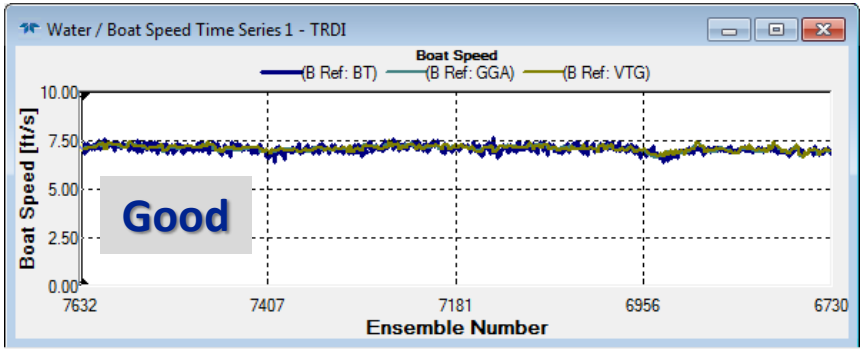
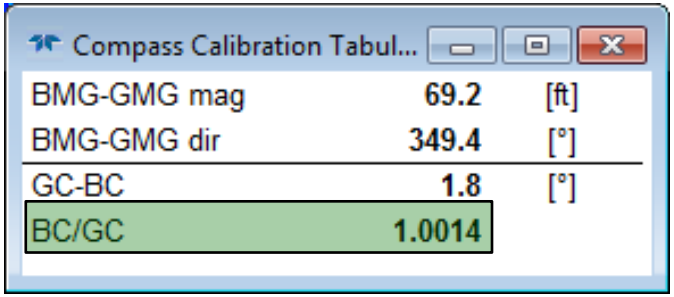
Beam Alignment Procedure

- Traverse a long (1,200–2,500 ft) course. Longer is better
- At the end of the course but <u>before reducing speed or changing heading</u>, stop recording
- Record BC/GC value
- Do a reciprocal traverse (a transect of the same length at a heading ~180 degrees from the previous course)







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Beam Alignment Procedure

- Record BC/GC value
- Average BC/GC values for reciprocal courses
- Rotate ADCP 45 degrees and repeat 4 times
- For most ADCPs: 0.995 < BC/GC < 1.003
- If BC/GC is outside this range, arrange for return to factory for factory beam alignment test
- Alternative: *Pay for factory to perform test and report results*

Beam Alignment Procedure

9/7/2005	U.S. DEPARTMENT OF THE INTERIOR *U.S. Geological Survey* **Acoustic Profiler Beam Alignment Test Form**	Processed by Ck'd by	

Location			
Date	, 20_____	Party	

Mfgr:	Model	Freq.	Serial	Firmware	Software

ADCP Depth	Filename Prefix	Diagnostic Test File	Test Errors?
			Y or N

Boat/Motors Used	ADCP Water Temp	Measured Water Temp.
	°C at	°C at

GPS Used	Moving Bed Test File	Moving bed
		Y or N

Site Conditions		Describe measurement location	
Max Water Depth			
Max Water Speed			
Max Boat Speed		Weather	
Water Mode			
Bottom Mode		Salinity	
Streambed material		ppt at	ppt at
Other Commands			

Beam Orientation	Heading	Filename or number	Field BT/GT	Final BT/GT	Notes
USGS Standard			0.995 to 1.003		
Comments					
			Sheet No.	of	sheets

USGS Standard

Comments

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Beam Alignment Procedure

- Document and store results in accordance with QA plan / Electronic data archive. Preferably use an Instrument History Log

USGS ADCP Instrument History Log

Model:		Serial Number:		Office Location	
Frequency:		Purchase Date:			

Task codes: BAT = Beam-angle test (distance course); CQM = comparison discharge measurement; DT = Diagnostic test; FU = Firmware upgrade; RTM = Returned to manufacturer for repair; RFM = Received from manufacturer

Date	Person	Task	Comments and Description of Work Performed

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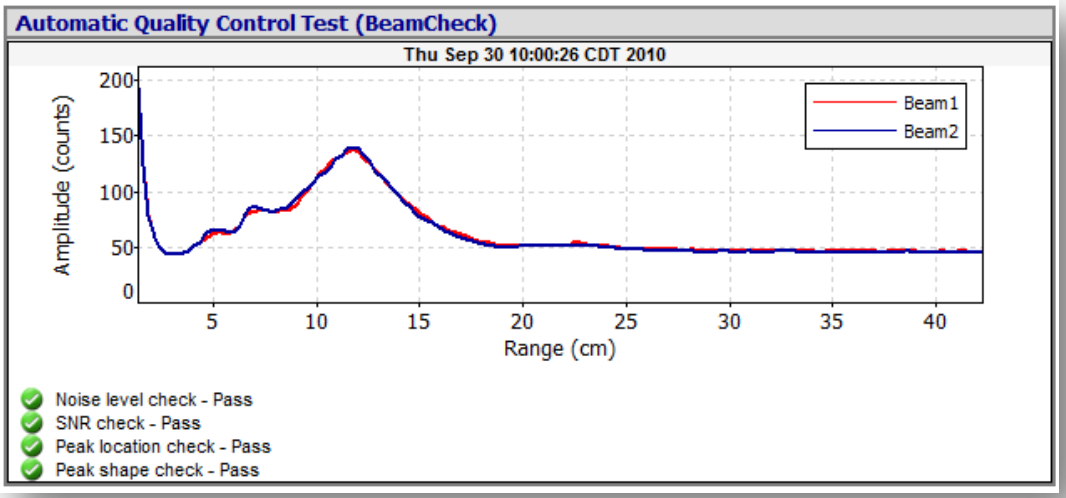
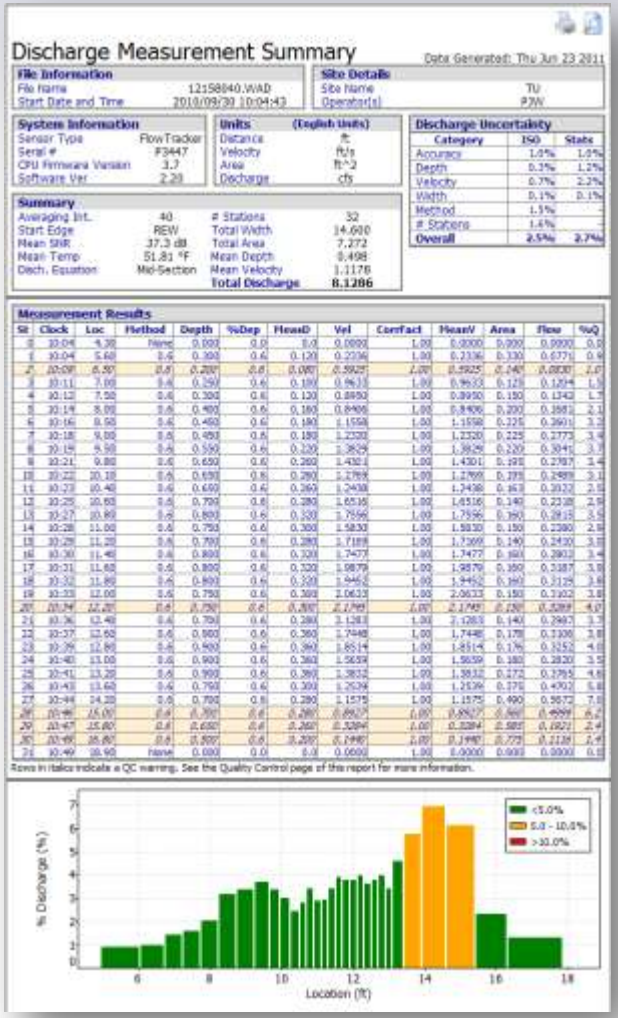
Routine ADCP QA – Beam Alignment

- Instrument-specific Considerations
  - M9/S5s: Similar performance to Rio Grande? Can ask HIF to perform distance test for a fee
  - StreamPros: Cannot be tested without compass & GPS. HIF/Mfgr can conduct beam alignment test.
  - RiverRay ???
  - Policy/experience with new instruments will evolve. Makes comparison QMs are all the more important.

Routine QA - Flowtrackers

- Review auto-beam checks for every QM
- Document any changes/anomalies
- Run bucket test if QC Check fails





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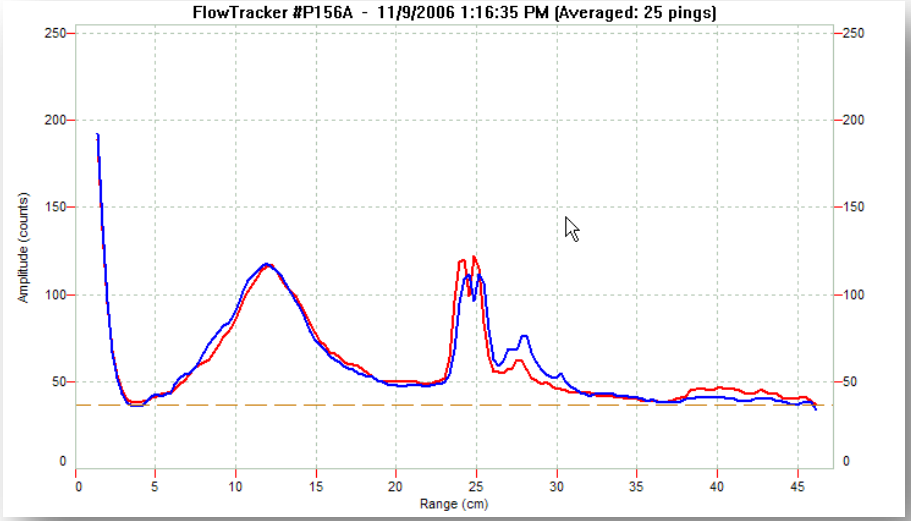
Routine QA - Flowtrackers

- **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**



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Routine QA - Flowtrackers

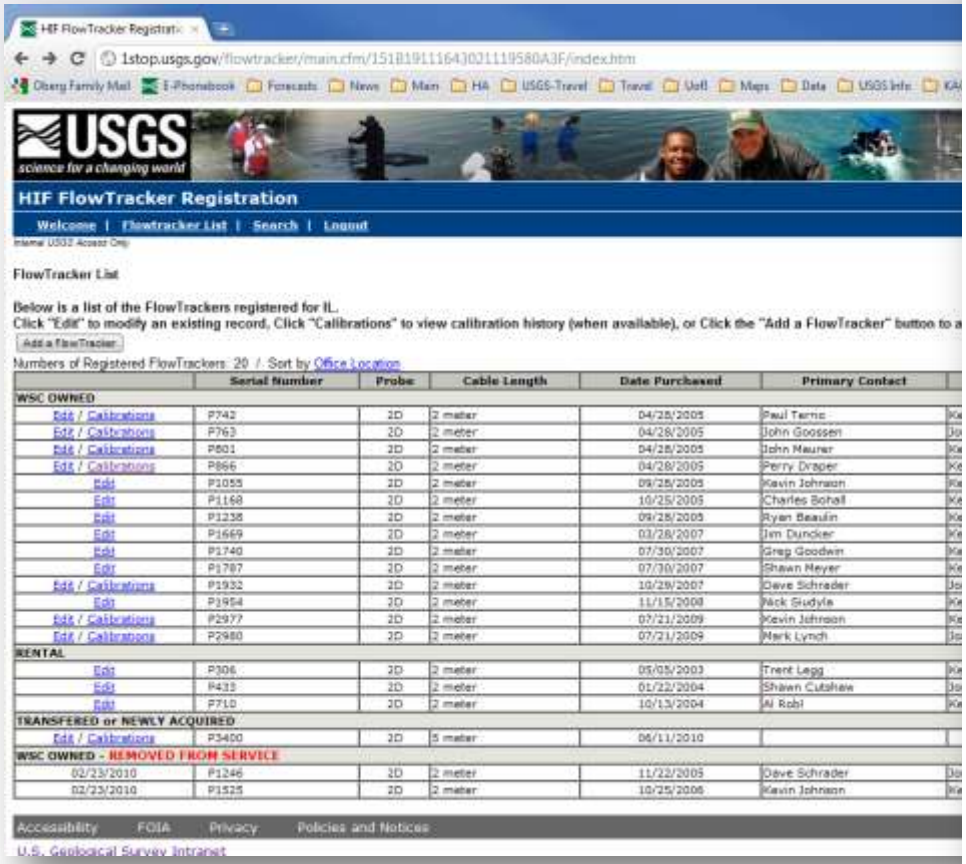
- Flowtracker Calibration Program
  - Every ADV recalled every 3 years (OSW Memo 2010.12)
  - Tests performed include: thermistor check, bucket test, and tow tank test at 2 speeds
  - Flowtracker re-calibrated if necessary
  - A WSC may request that a Flowtracker be tested at any time

Routine QA - Flowtrackers

- OSW Flowtracker Calibration Program - Hydrographer Responsbilities:
  - Register all WSC Flowtrackers in HIF database
  - (http://1stop.usgs.gov/flowtracker/)
  - Respond in a timely manner to recall or let HIF know
  - Review results (ask questions as necessary)

Routine QA - Flowtrackers

- **Sample Flowtracker QA Test Results**



P866 (20110128) Summary.xlsx

Summary Results

FlowTracker Serial Number => P866
CPU (Firmware) Version = > 3.7
Date Checked => 2011-01-28

OVER ALL PERFORMANCE OF METER => PASS

Velocity Check Summary Data

18 cm/s (0.59 ft/s) % Error =>	-0.17%	PASS
18 cm/s (0.59 ft/s) ± Error Band =>	1.36%	PASS
18 cm/s (0.59 ft/s) SonTek ± Error Band =>	2.39%	
33.53 cm/s (1.12 ft/s) % Error =>	-0.36%	PASS
33.53 cm/s (1.12 ft/s) ± Error Band =>	1.74%	PASS
33.53 cm/s (1.12 ft/s) SonTek ± Error Band =>	1.75%	
Beam Check =>		PASS
Temperature Probe Check =>		PASS

##########

NOTES: Overall performance of the meter being tested is set to PASS if all values in Velocity, Beam Check, and Temperature Probe Check tests are set to PASS or FAIR. Set to FAIL if any of Velocity, Beam Check, or Temperature Probe Check tests are set to FAIL.

Velocity Summary Check PASS/FAIL criteria (all meter data averaged to 1 second data).

^ Meter velocity % error set to PASS if the meter determined velocity % error is within SonTek Error Band for the set velocity.

^ Meter velocity % error set to FAIL if the meter determined velocity % error is outside SonTek Error Band for the set velocity.

^ Meter Error Band (2 standard deviations) set to PASS if value is less than or equal to SonTek Error Band.

^ Meter Error Band set to FAIR if value is greater than SonTek Error Band but less than 1.25 * SonTek Error Band.

^ Meter Error Band set to FAIL if value is greater than 1.25 * SonTek Error Band.

Beam Check set to PASS if the following criteria are met;
Beam peak position is within 0.3 cm of each other; and
Peak SNR* of beams are within 4 dB of each other.
(* SNR = 0.43 * [peak level (counts) - noise (counts)].)

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FlowTracker QA Test Results

- 23 meters (~9%) failed at least 1 of the QA tests
  - Temperature probe failures: 4 (~2%)
  - Velocity failures: 11 (~4%)
  - Remainder: beam check

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Periodic Instrument Check

- ***Best Practice:*** ***Conduct periodic instrument checks.*** **Not required. Conduct at regular interval, e.g. annually?**
- **Individual ADCP comparison QMs**
  - **Compare discharge measured with your ADCP with discharge measured with a current meter, some other accepted instrument, or stable S-Q rating**
  - **Don't always use the same measurement location**
  - **What happens when the comparison is outside an acceptable range (for example 5%)?**
    - **Repeat measurements – also at different sites**
    - **Record results in Instrument History Log**

Periodic Instrument Check

- ADCP Regattas
  - Compare discharges measured by many/all WSC ADCPs
  - Select site where multiple sections can be used
  - Ideally have one instrument measuring continuously
  - Steady – or near steady-flow conditions
  - Synchronize times for ADCPs/Laptops before starting
  - Maintain 5 channel depth separation for similar acoustic frequencies
  - Good opportunity for review of important policies, new info regarding ADCPs, etc.

Example Regatta Summary

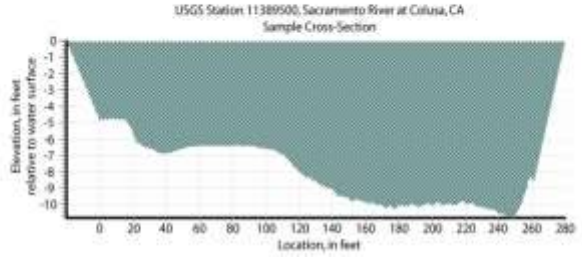
http://hydroacoustics.usgs.gov/publications/CA-ADCP-Check-2007.pdf

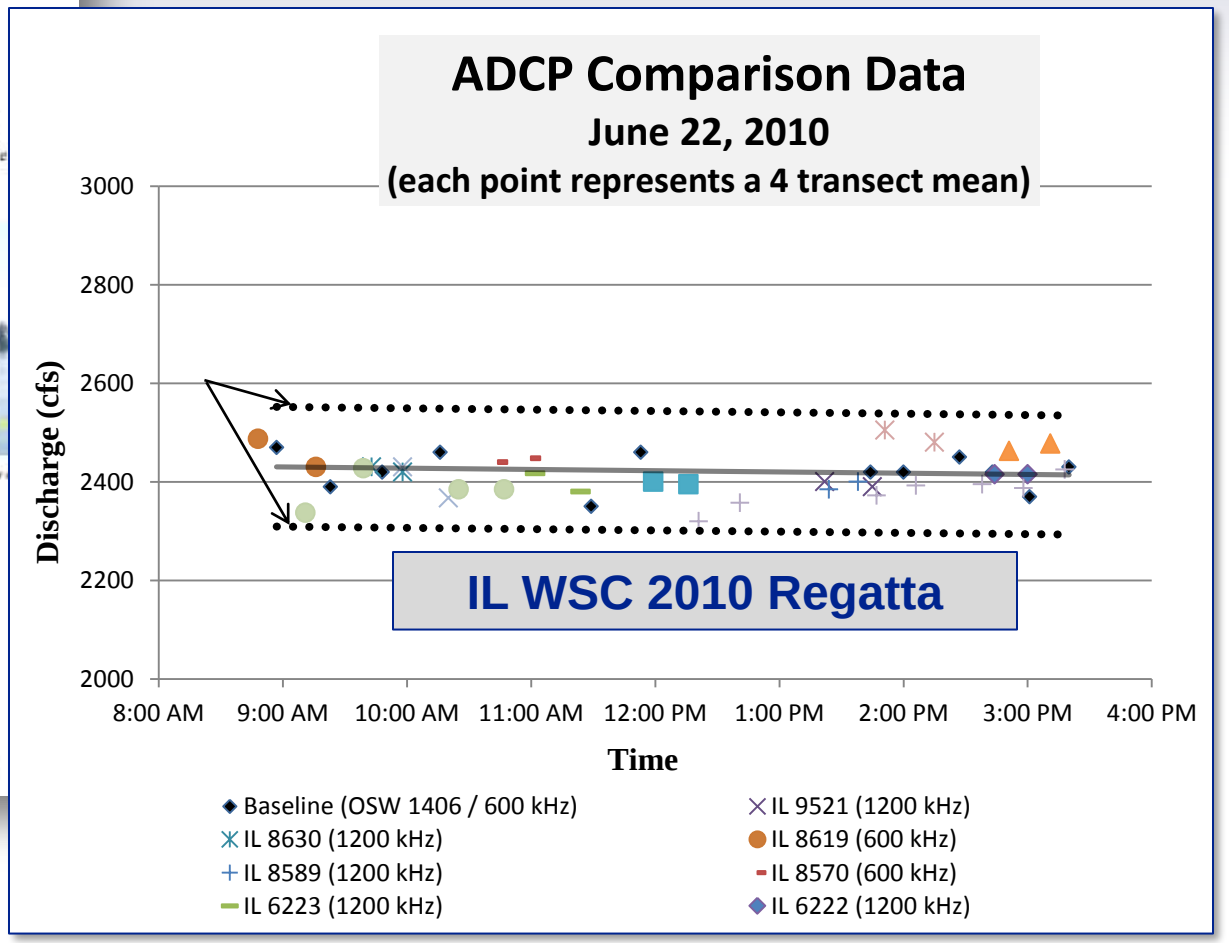
Summary of 2007 California District ADCP Check Measurements
Sacramento River at Colusa, CA
May 30, 2007

Introduction

To ensure that the best possible discharge measurements are collected and that all acoustic discharge measurement equipment is properly functioning, the USGS Office of Surface Water recommends that all acoustic Doppler current profilers (ADCP) used for measuring discharge be checked at least one time per year at a stable gage. In 2007 12 units were tested; 4 from USGS hydrodynamics group, 3 from the California Department of Water Resources, and 1 each from the USGS Sacramento, Redding and Ukiah field offices, U.C. Davis, and the Yurok Tribe Environmental Program.

The 2007 ADCP check was conducted at USGS gaging station 11389500, the Sacramento River at Colusa, CA (Figure 1). This station was selected by the USGS Sacramento Field Office staff because it has a strong rating and has been very consistent over time. General information regarding this station can be obtained from the Station Information Page available through NWIS Web[1]. The testing location is a wide and shallow site, the channel width is on the order of 300 feet, and the depth ranges from 5 feet to a maximum of approximately 11 feet (Figure 2). Channel characteristics at this location lend particular importance to boat operation to minimize pitch and roll variations and maintain proper transducer depth. Problems in either of these areas can produce biased measurements.





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New Profilers

SonTek/YSI RiverSurveyor

TRDI RiverRay

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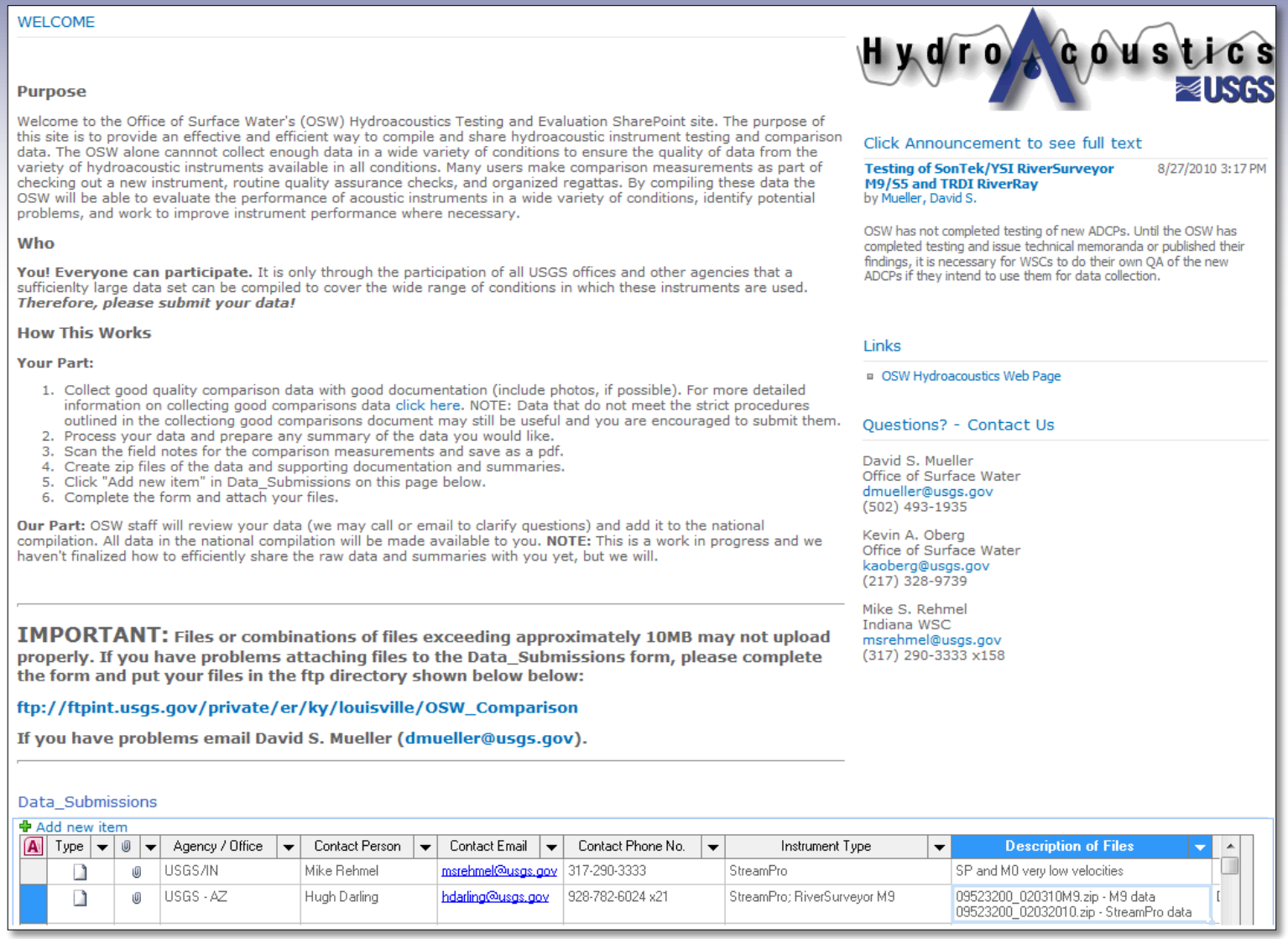
New Instruments: RiverSurveyor and RiverRay

- OSW doesn't have sufficient data to find all potential issues
- Make comparison QMs for the range of conditions
  - Water velocities
  - Streambed type
  - Flow depths
  - Turbulence
  - Sediment concentration
- Use the instrument if there are no significant differences from the comparison measurements. Consistent biases are of particular concern
- Document and submit comparisons to OSW Sharepoint site https://xcollaboration.usgs.gov/wg/OSWHA/Testing

Sharepoint Testing Pages



WELCOME

Hydro Acoustics USGS

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 alone cannnot collect enough 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 sufficienlty 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 comparisons data click here. NOTE: Data that do not meet the strict procedures outlined in the collectiong good comparisons document may still be useful and you are encouraged to submit them.
2. Process your data and prepare any summary of the data you would like.
3. Scan the field notes for the comparison measurements and save as a pdf.
4. Create zip files of the data and supporting documentation and summaries.
5. Click "Add new item" in 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://ftpint.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

Questions? - Contact Us

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Indiana WSC
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(317) 290-3333 x158

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 M0 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

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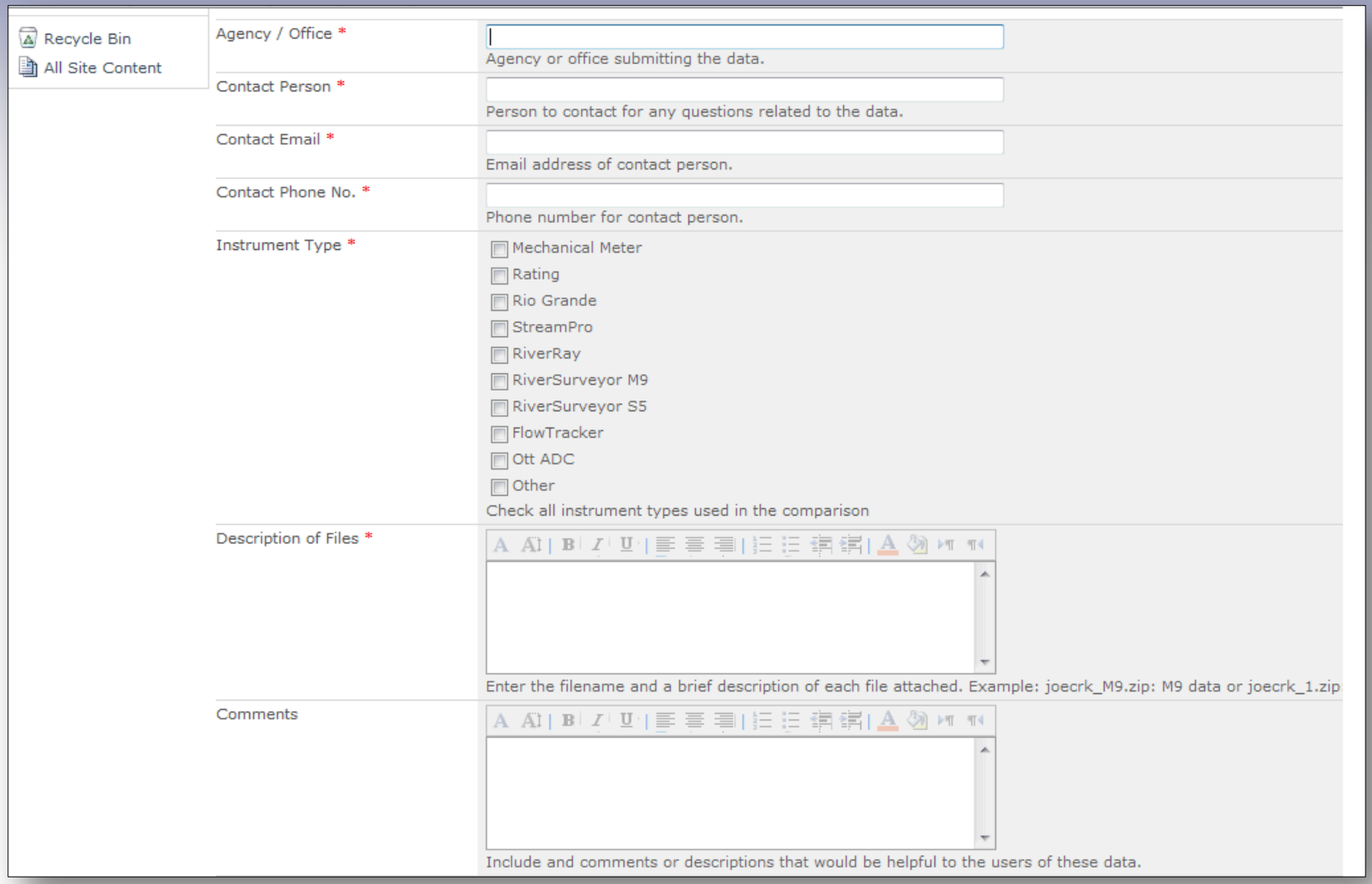
https://xcollaboration.usgs.gov/wg/OSWHA/Testing

Sharepoint Testing Pages



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https://xcollaboration.usgs.gov/wg/OSWHA/Testing

Ott ADC

- Make comparison QMs for the range of conditions
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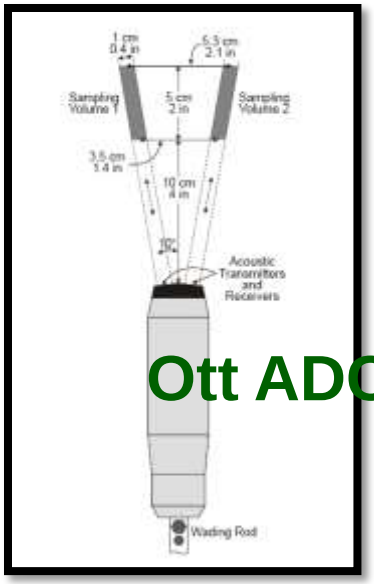
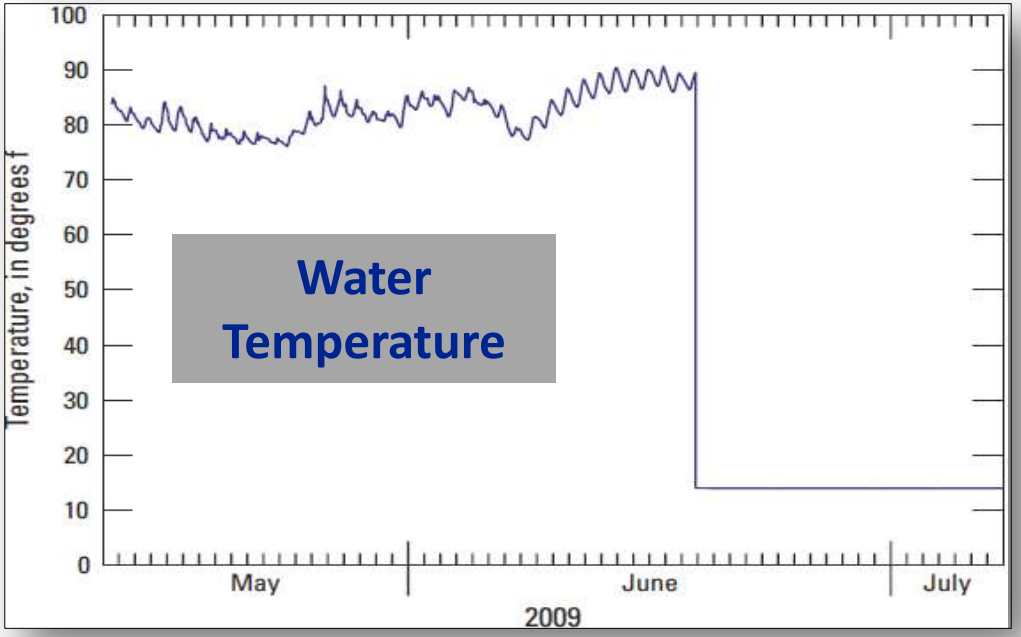


ADVM QA

- Independent water temperature checks every site visit (at depth of & near to ADVM transducers)
- Monitor time series data for changes (SNR, temperature, velocities, pitch/roll, standard error, cell end, water depth, etc.)



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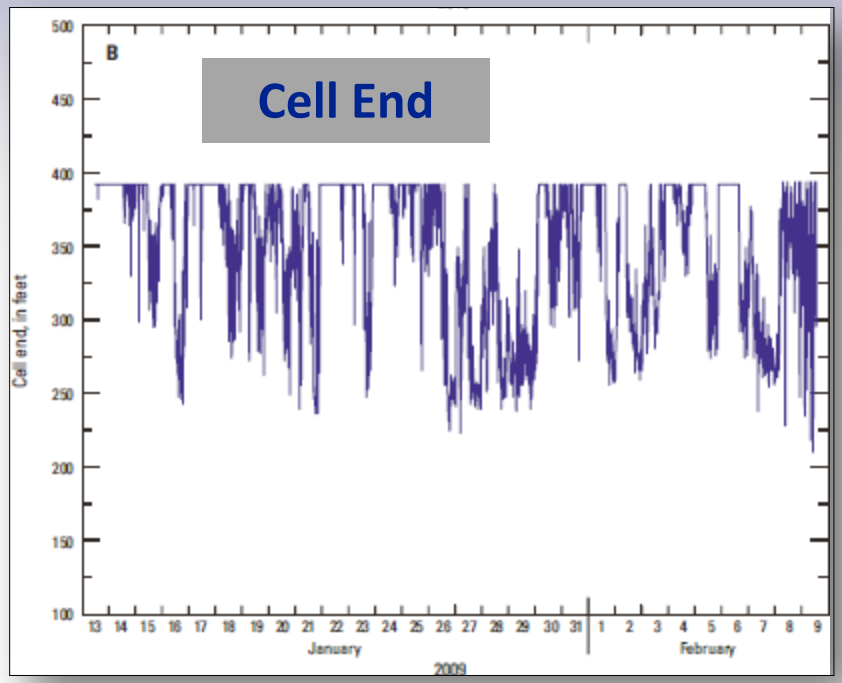
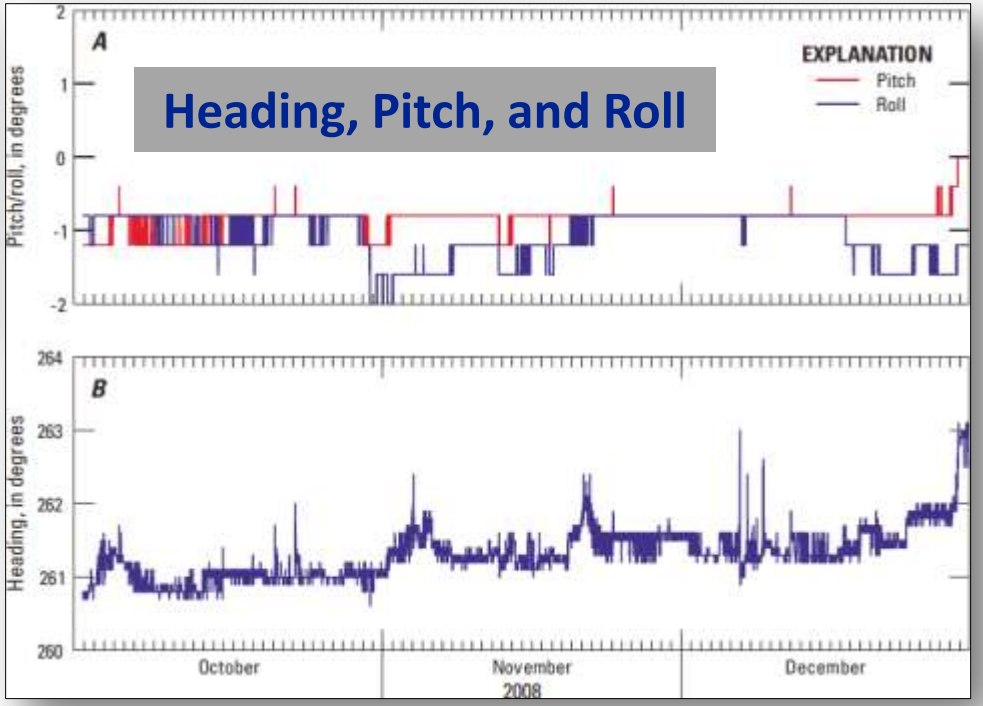
ADVM QA





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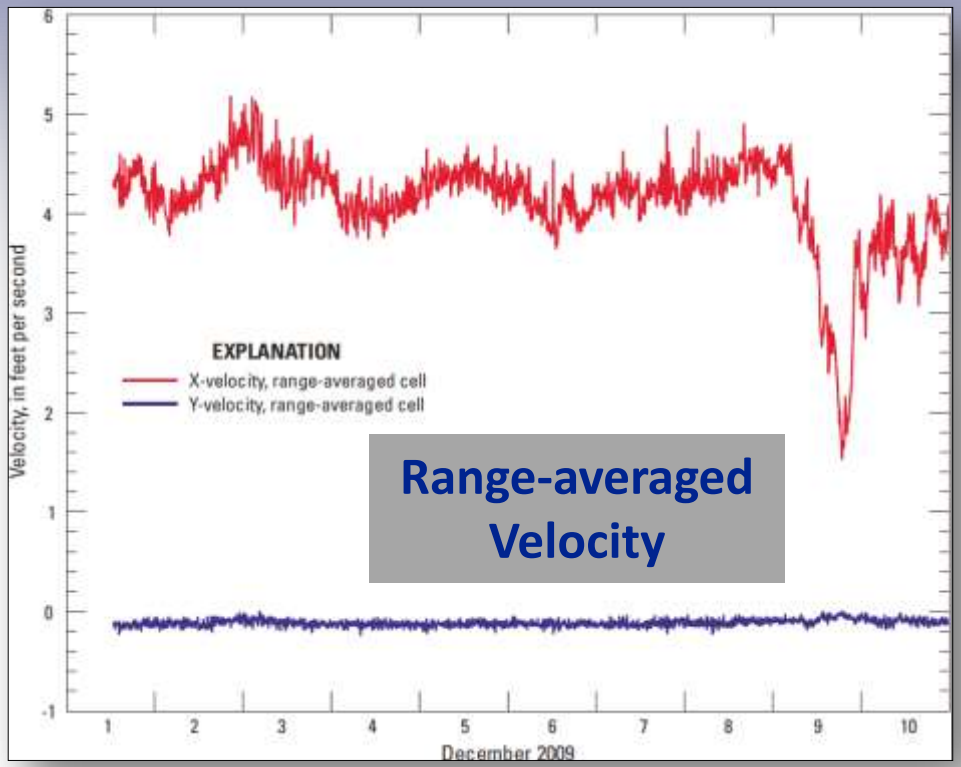
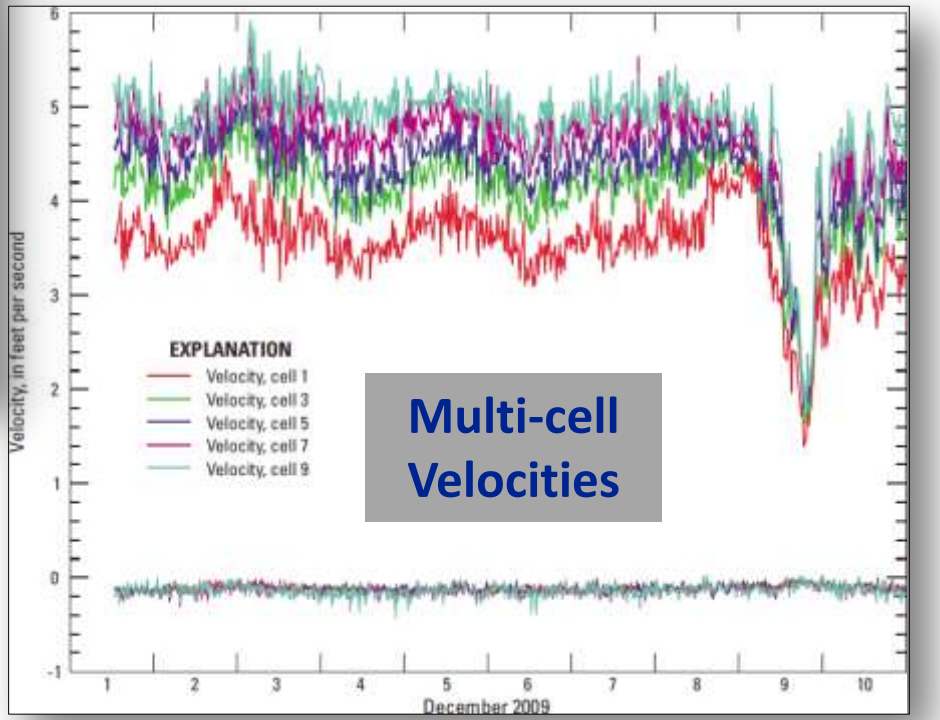
ADVM QA



Range-averaged Velocity



Multi-cell Velocities

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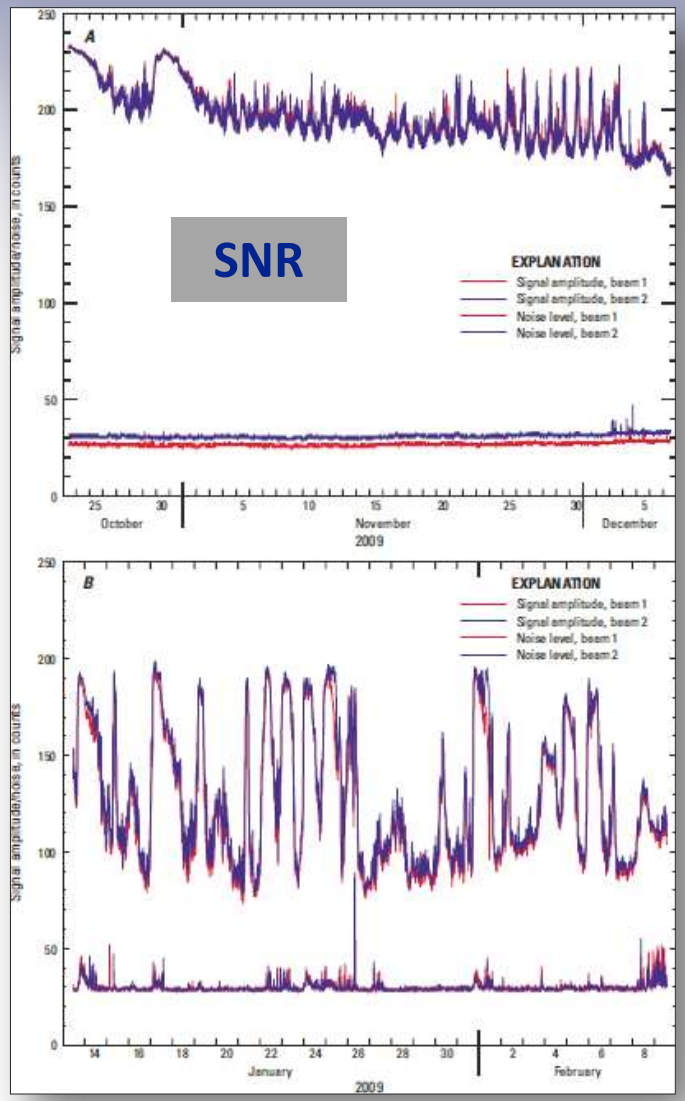
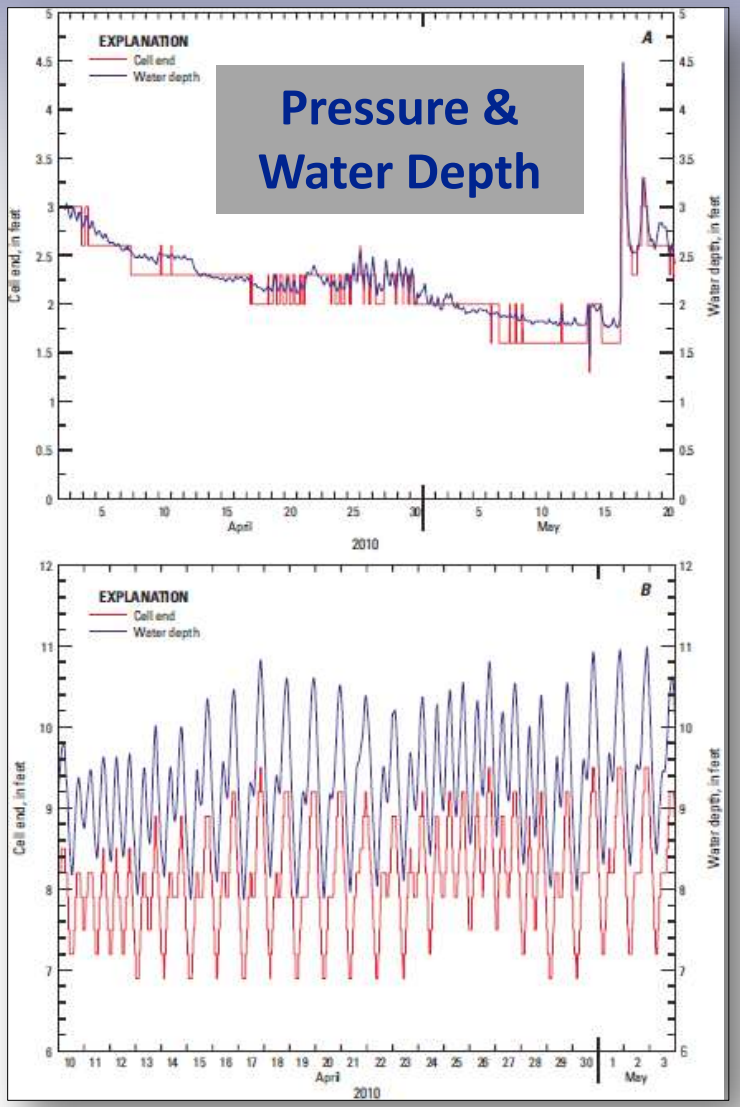
ADVM QA





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