Hydroacoustics UPDATE:

Identifying Interference That May Affect ADCP Streamflow Measurements

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Some StreamPro ADCP measurements have been found to be susceptible to electromagnetic interference (EMI), resulting in the measurement of erronouse velocities. Examples of EMI sources include: television, AM, and FM transmissions; power transmission lines; airport radar; and railroad or other mass transit infrastructure. Symptoms of possible EMI include unusual patterns in error velocity and vertical velocities with depth (Figure 1).

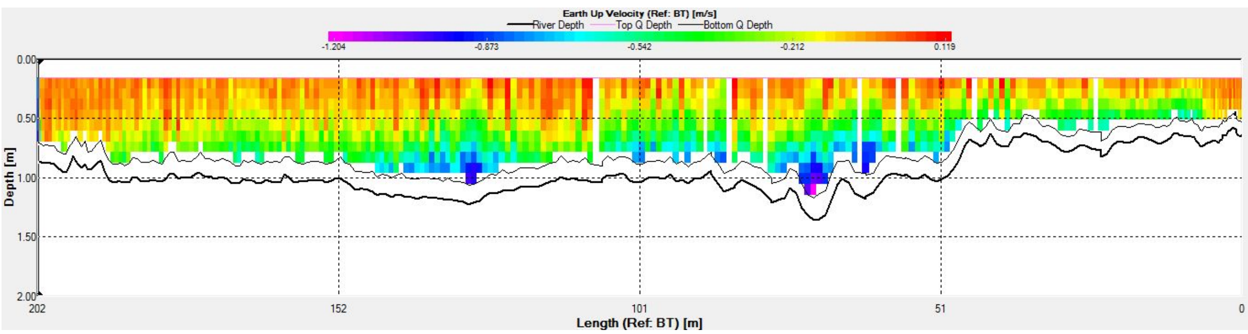


Figure 1. Contour plot of vertical velocity for a StreamPro ADCP experiencing EMI.

Often the measured water velocities magnitudes may also have unusual patterns such as seen in the measurement below (Figure 2) where it can be seen that water velocity appears to increase with depth.

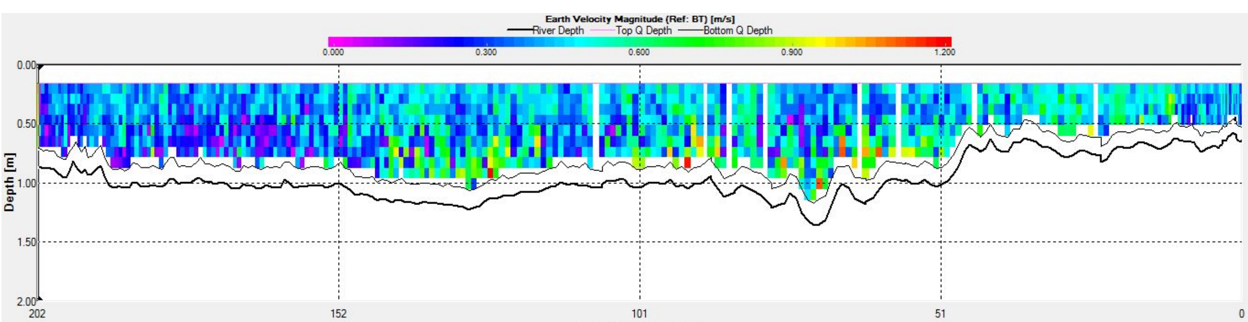


Figure 2. Contour plot of velocity magnitude for a StreamPro ADCP experiencing EMI.

The StreamPro ADCP is thought to be more susceptible to EMI because the transducer is separated from the electronics by a cable. This interference is due to sources specific to a site or measuring section. So, just because a unit experiences interference at one site or one measurement cross section, doesn't mean it would absolutely experience interference at another site or in a different cross section at the same site. Measurements made in streams with low backscatter are more susceptible to this problem as well. Velocities errors caused by EMI tend to be a consistent bias (not related to true water velocity), so errors will be a greater percentage in lower velocities. While this problem is mostly confined to StreamPro ADCPs, it is conceivable that other ADCPs may experience the problem.

In order to address this problem, TRDI began installing additional shielding in all StreamPro ADCPs, beginning in February 2015. The internal shield is intended to minimize the effects of EMI. For StreamPros manufactured prior to that date, TRDI developed a kit that provides the transducer with external shielding. In USGS testing, the additional shielding reduced the StreamPros susceptibility to EMI, but did not eliminate it.

USGS moving-boat ADCP measurement processing software QRev added an EMI quality assurance check for Teledyne RD Instrument manufactured ADCPs in QRev version 3.31. The criteria used in that initial implementation resulted in many false positive warnings of potential EMI issues. The criteria were adjusted in version 3.40 and now provide reliable warnings. These new criteria are also in version 3.43. Thus, a QRev message regarding the potential for EMI in version 3.43 should not be ignored. When there is a potential for EMI the data should be carefully evaluated in WinRiver II for unrealistic patterns in the vertical velocity, intensity, and correlations (note: these cannot be evaluated in QRev). If unrealistic patterns are observed, the velocity data are likely biased by an unknown amount and the measured discharge may not be accurate. This document provides information on how potential EMI can be identified in Teledyne RD Instrument ADCPs.

Potential EMI

Potential EMI can be identified by examination of the results of the PT3 test and by increases in error velocity, vertical velocity, or correlation with depth. The following steps should be followed:

1. Review PT3 results. The PT test results are found in the diagnostic test results stored for each measurement. The table in figure 3 below shows correlations for increasing lags. For StreamPro ADCPs, the beam correlations can range from 0 to 100. In ideal conditions, beam correlations should drop to 15% or less of the lag 0 value by lag 3 and should remain low. However, most field conditions are not ideal. QRev software currently evaluates the PT3 test as follows: greater than 50% correlation in any beam for any lag in lags 3-7 and correlations greater than 25% correlation at lag 7 in any beam. If two are more of these conditions are true QRev will issue an EMII warning. Figure 4 shows an example PT3 test result that indicates strong EMI. The correlations shown are all greater than 80 for lag 3 and tend to stay high.

2. If the PT3 correlation results indicate a potential interference source, compare the “RSSI (counts)” values (last row on the PT3 test output in figure 3) to the beam intensity values during the measurement transects. The “RSSI (counts)” indicates the noise floor for the location where the PT3 test was completed. For instruments such as RiverPro and RioPro that have multiple test results use the RSSI form the “H-Gain W-BW” results. If the location where the PT3 test was conducted is different from the measurement location, it is possible that the noise floor might be different for the measurement section. If the beam intensities (in counts) during the measurement remain greater than 20 counts above the maximum RSSI (in counts) the interference is not likely to affect the measured velocities.

   For example, in the PT3 test in figure 4, beam 4 has an RSSI of 91 counts. Examination of the signal intensity for each beam (figure 5) shows that beam 4 intensities drop below 90 counts at times, so it is likely that the EMI might be affecting the velocity data. As previously mentioned, data affected by EMI may include unusual patterns in error velocity and vertical velocities with depth. The contour plot of vertical velocity in figure 6 is an example of significantly biased data where the vertical velocity measured by the ADCP ranges from positive near the surface and become increasingly negative with depth. Correlation can also be an indicator of EMI issues. Correlations typically vary a small amount between depth-cells. However, if correlations increase with depth (figure 7), this can indicate the EMI signal is being correlated instead of, or in addition to, the signal placed in the water by the ADCP.

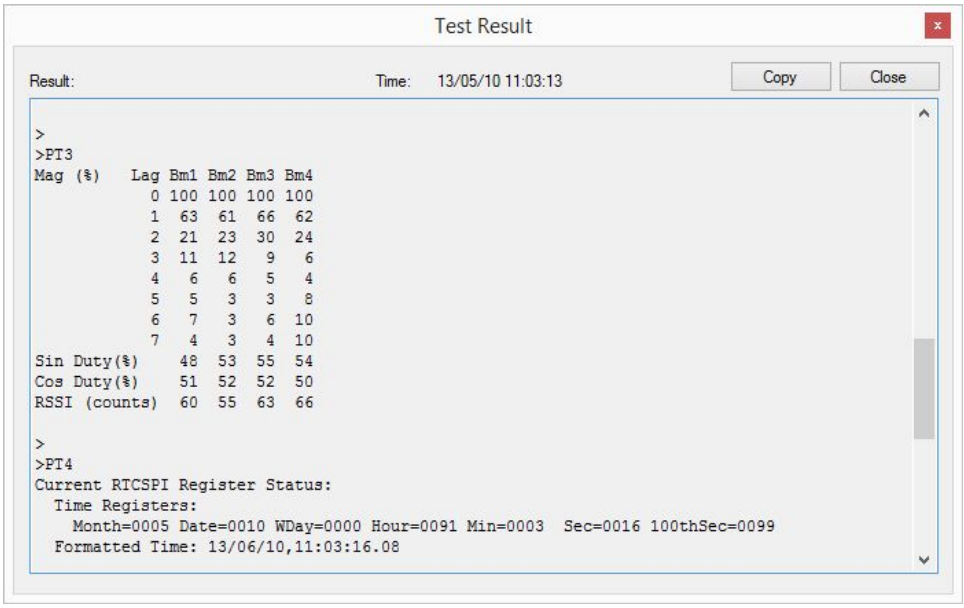


Figure 3. Example of a StreamPro PT3 Test Results with no apparent EMI.

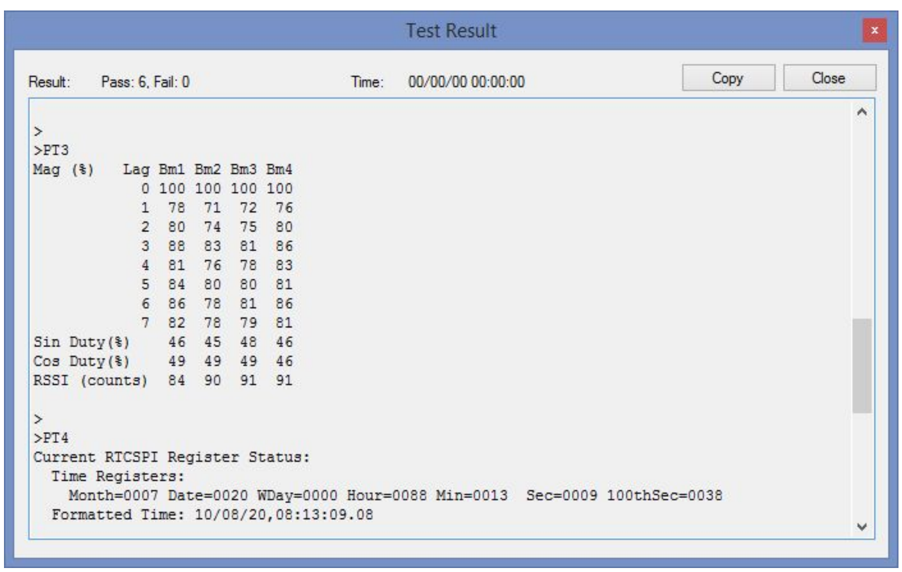


Figure 4. Example of PT3 Test Results with evidence of significant EMI

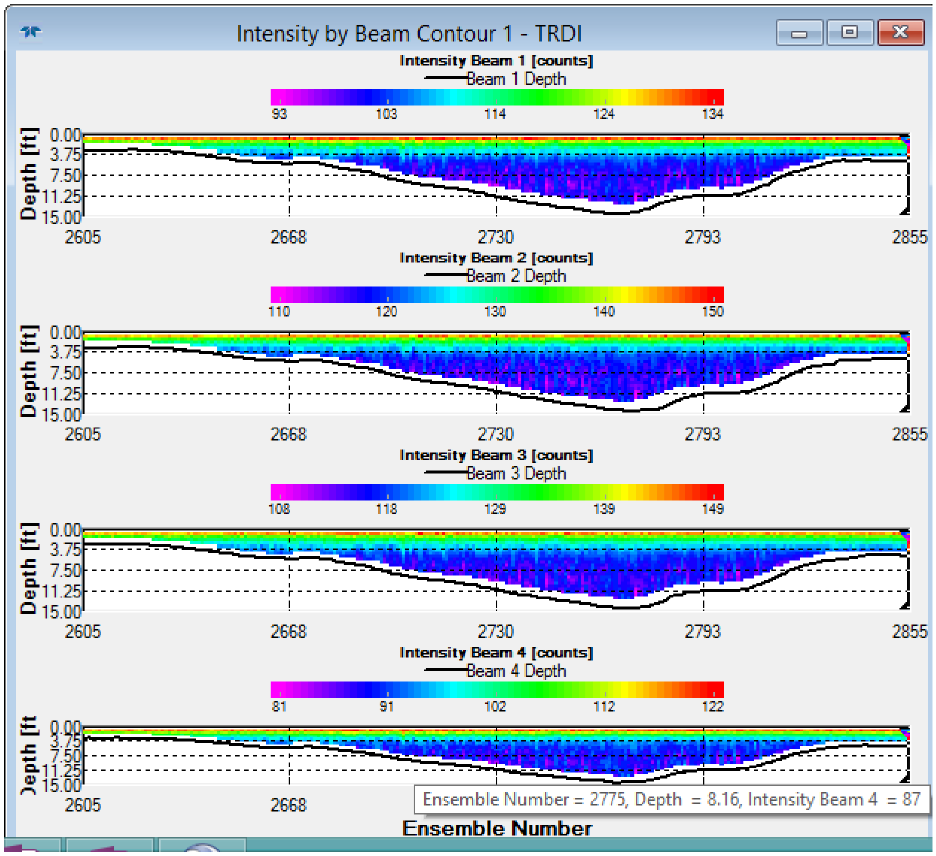


Figure 5. Contour plots of beam intensity (RSSI) for an ADCP measurement.

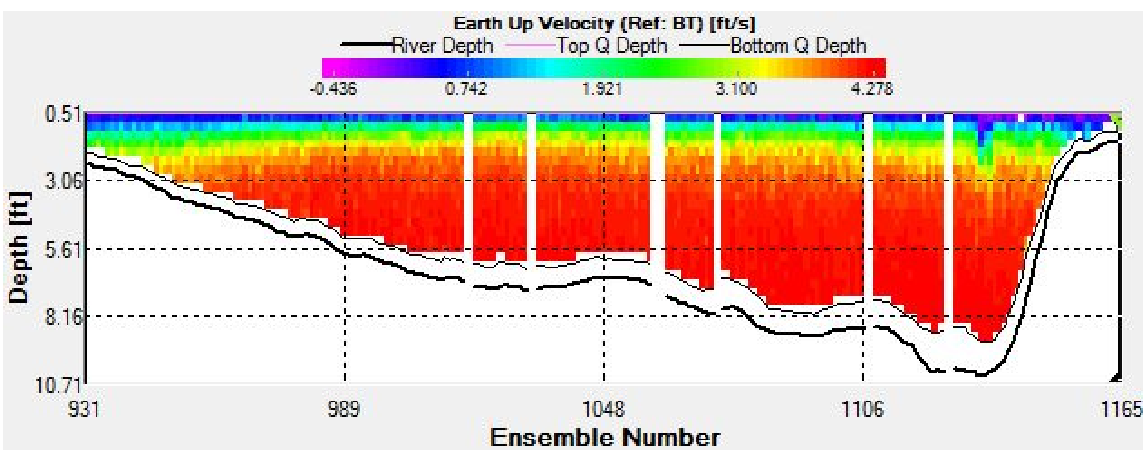


Figure 6. Example of a contour plot with vertical (Up) velocities which become increasingly more negative with depth.

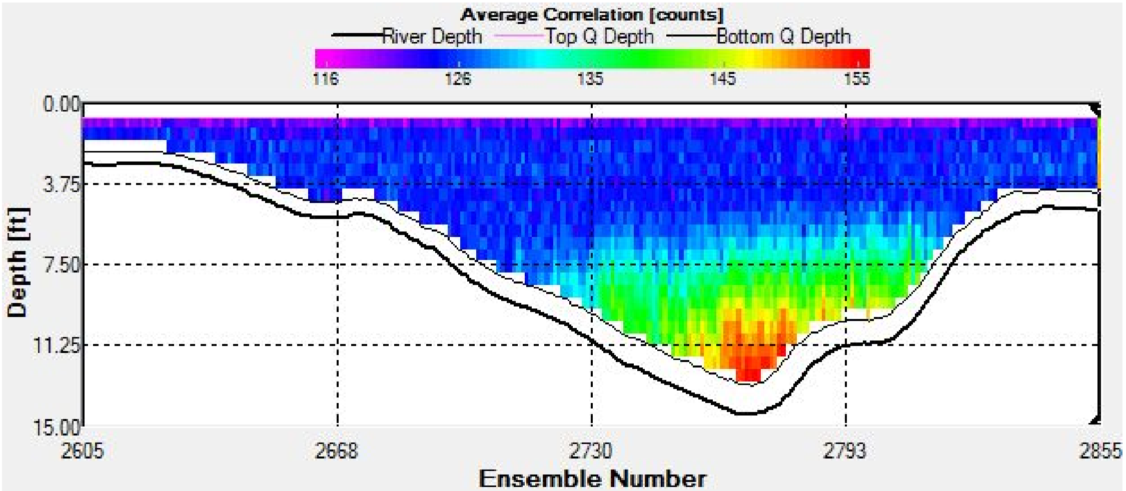
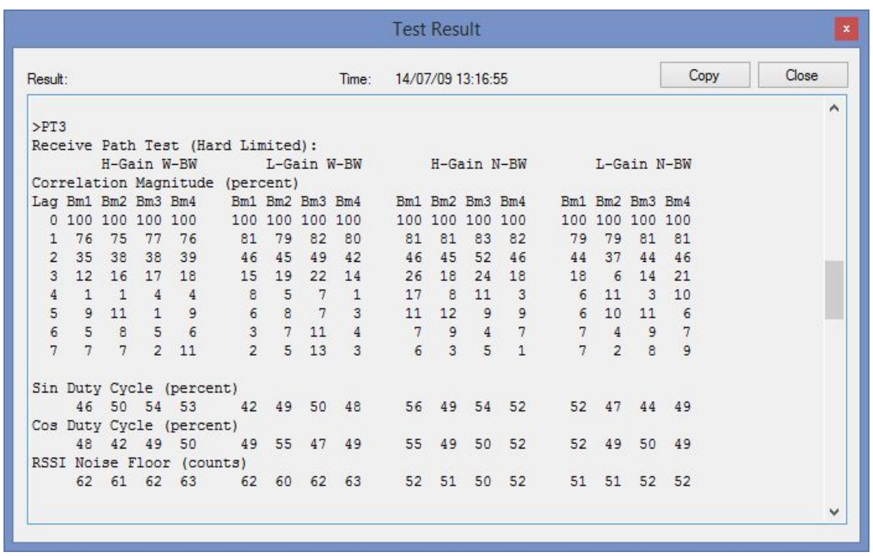


Figure 7. Example of a correlation contour plot with correlation values that increase with depth.

3. If EMI is present in discharge measurement data, the hydrographer should move to a different measuring section. Most likely the new section will have to be a considerable distance away. If diagnostic tests at the new location still indicate that EMI is present, another instrument should be used to measure streamflow.

PT3 Test Results for RiverRay, RiverPro, RioPro and Rio Grande ADCPs

The PT3 test results appear somewhat different for RiverRay RiverPro, RioPro, and Rio Grande ADCPs. Figure 8 shows the results of a typical PT 3 test for a RiverRay ADCP. Note that the correlations also range from 0 to 100.



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Test Result
Result:                    Time:   14/07/09 13:16:55          Copy   Close

>PT3
Receive Path Test (Hard Limited):
        H-Gain W-BW        L-Gain W-BW        H-Gain N-BW        L-Gain N-BW
Correlation Magnitude (percent)
Lag Bm1 Bm2 Bm3 Bm4    Bm1 Bm2 Bm3 Bm4    Bm1 Bm2 Bm3 Bm4    Bm1 Bm2 Bm3 Bm4
  0 100 100 100 100    100 100 100 100    100 100 100 100    100 100 100 100
  1  76  75  77  76     81  79  82  80     81  81  83  82     79  79  81  81
  2  35  38  38  39     46  45  49  42     46  45  52  46     44  37  44  46
  3  12  16  17  18     15  19  22  14     26  18  24  18     18   6  14  21
  4   1   1   4   4      8   5   7   1     17   8  11   3      6  11   3  10
  5   9  11   1   9      6   8   7   3     11  12   9   9      6  10  11   6
  6   5   8   5   6      3   7  11   4      7   9   4   7      7   4   9   7
  7   7   7   2  11      2   5  13   3      6   3   5   1      7   2   8   9

Sin Duty Cycle (percent)
     46  50  54  53     42  49  50  48     56  49  54  52     52  47  44  49
Cos Duty Cycle (percent)
     48  42  49  50     49  55  47  49     55  49  50  52     52  49  50  49
RSSI Noise Floor (counts)
     62  61  62  63     62  60  62  63     52  51  50  52     51  51  52  52
```

Figure 8. Example of typical PT3 Test Results for a RiverRay ADCP.

For Rio Grande ADCPs, the correlations range from 0 to 255. To check for EMI, it is necessary to multiply the lag 0 value (255) for a beam by the specified criteria (0.15 for ideal conditions and 0.5 or 0.25 for

QRev criteria) and see if the correlations have decreased to approximately that level by lag 3 through lag 7. In the PT3 test results for a Rio Grande in figure 9, the correlations have decreased to 38 (assumed ideal conditions) or less by lag 3. Fifteen percent of 255 (lag 0 correlation) equals 38. Thus, these test results do not show evidence of EMI.

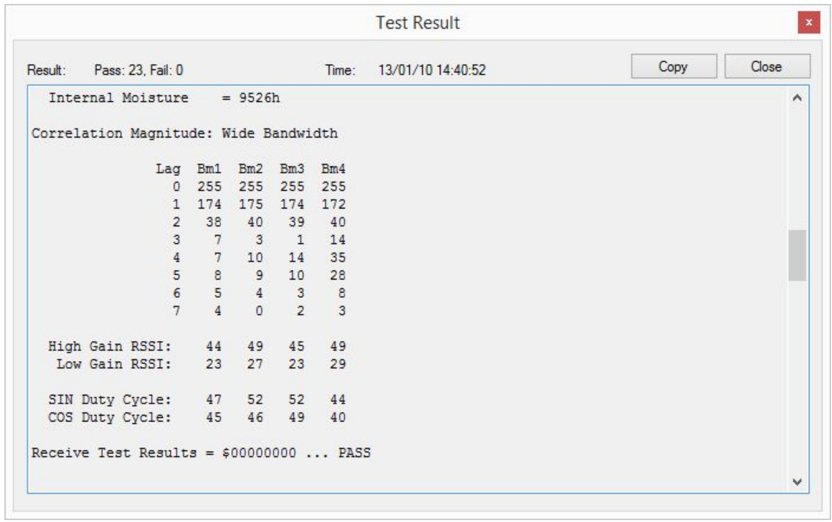

Figure 9. Example of typical PT3 Test Results for a Rio Grande ADCP.