Montana Department of
ENVIRONMENTAL QUALITY

MEMO

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To: Michael and Sandra Head, Precision Measurement Engineering, Inc., and Mindy McCarthy, Water Quality Protection Bureau QA Officer

CC: Eric Urban, Water Quality Standards Section Manager

From: Michael Suplee and Rosie Sada, Water Quality Standards Section

Date: May 13, 2013

RE: ***Technical Memorandum*: Best use of MiniDOT Loggers for Dissolved Oxygen Measurement in Streams and Rivers, Part 2**

Introduction

In summer 2011 a miniDOT dissolved oxygen (DO) logger was deployed side-by-side with a YSI 6600 V2-4 sonde equipped with wipers on the sensors (see technical memo from us dated December 5, 2011). The intent of that work was to see if biofilm growth on the MiniDOT sensor (which has no wipers) would cause erroneous DO measurements. It resulted that the MiniDOT gave good readings for about five days before biofilm buildup on the MiniDOT sensor led to erroneously low and high DO values (especially the high values). This memo describes continued testing of the MiniDOT loggers that occurred in 2012.

Methods

In summer and fall 2012 five MiniDOT loggers were deployed side-by-side with YSI 6600 V2-4 sondes equipped with optical DO sensors and wipers. The deployments occurred in the Yellowstone and Little Missouri rivers as part of planned monitoring work. The goal of the paired deployments was to determine if the MiniDOTS, now equipped with algal growth deterrents, would be able to collect quality data for longer periods. Two types of deterrents were tested; a solid copper plate with a hole in it directly over the sensor, and a fine-mesh copper screen covering the entire sensor face (**Figure 1**). All YSIs and MiniDOTs were mounted horizontally and attached to DEQ's portable deployment platform, in water about 1 m deep.

At two of the deployment sites drifting filamentous algae was a significant issue for both types of sondes and for these sites we only present short time periods where we are confident that snagged *Cladophora* was not a problem. The other three sites had very little or no drifting filamentous algae problems and comparisons between the YSIs' results and their companion MiniDOTs were undertaken for the entire record. There were four MiniDOTs with copper screens and one with the solid copper plate.

Figure 1. MiniDOT loggers equipped with the two types of algae growth deterrents tested. On the left is the copper mesh screen, on the right the solid copper plate with an open hole over the sensor.

For each YSI-MiniDOT pair, performance was compared by calculating two DO values important for stream assessment: the daily DO low and the daily delta (daily maximum- daily minimum). For each daily dataset, the difference (expressed as a percent) between the YSI and the MiniDOT DO observations were calculated as follows:

<u>Daily DO Low</u>
% Difference = [YSI MIN (mg DO/L) – MiniDOT MIN (mg DO/L)] ÷ [YSI MIN (mg DO/L]

<u>Daily DO Delta</u>
% Difference = **(**[YSI MAX (mg DO/L) – YSI MIN (mg DO/L)**]** – **[**MiniDOT MAX (mg DO/L) – MiniDOT MIN (mg DO/L)**])** ÷ **[**YSI MAX (mg DO/L) – YSI MIN (mg DO/L)**]**

In all cases the YSI data had passed DEQ' *a posteriori* QC for allowable drift from calibration, instrument interference by snagged drifting algae, etc., and were considered reliable readings. For this reason the YSI observations are in the denominator of the % difference equations (as opposed to using the average of the YSI and MiniDOT observations).

Results

The MiniDOT equipped with the solid copper plate was deployed in the Yellowstone River upstream of Livingston, Montana. Water velocity across both instruments was roughly 2.0-2.5 ft/sec. Results are shown in **Figure 2**. At this site logging continued uninterrupted from deployment to retrieval. Upon retrieval, no major filamentous or diatom-like algal growth was observed on the sensor of the MiniDOT.

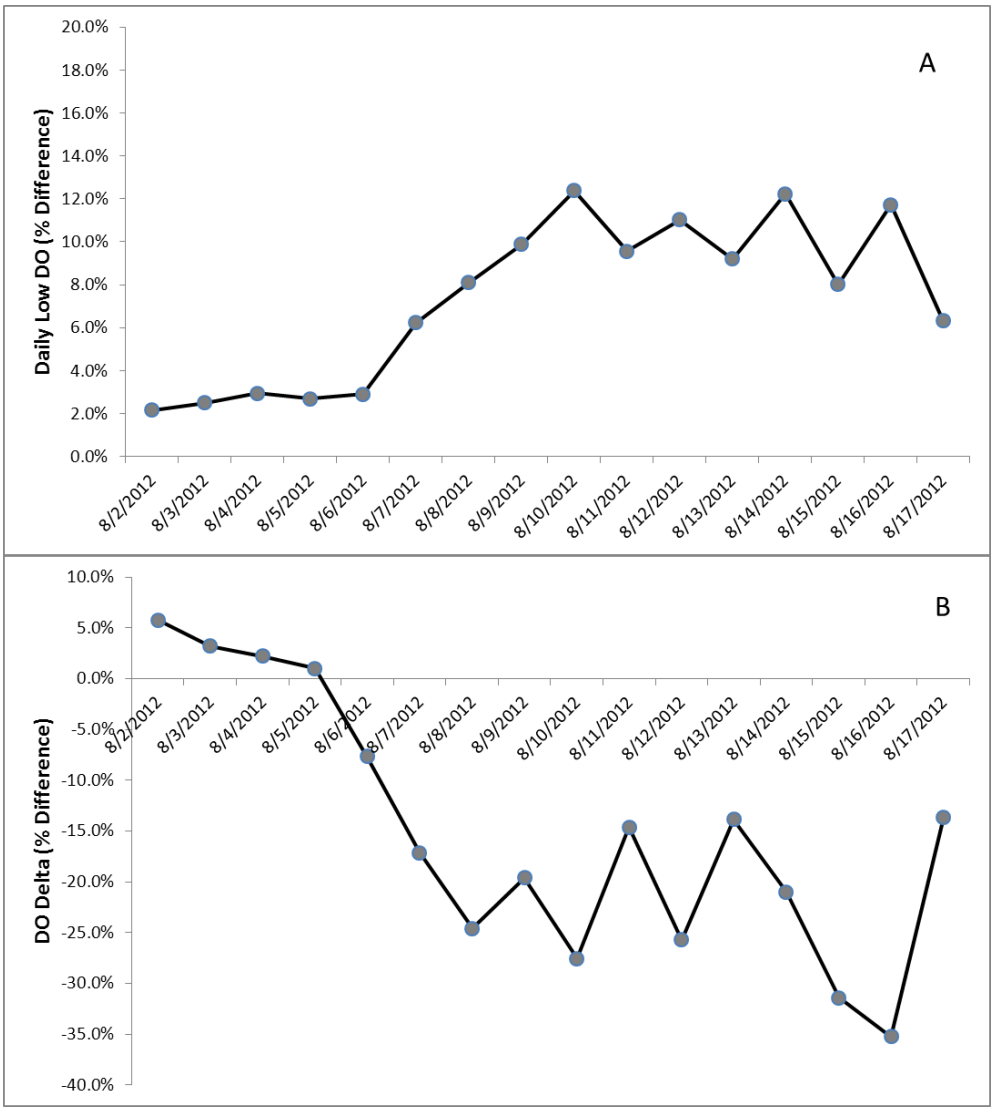

Figure 2. Percent Difference Between YSI and MiniDOT Dissolved Oxygen Recordings for Instruments Deployed in the Yellowstone River Upstream of Livingston, Montana. (A) Percent difference in the recorded daily low DO. (B) Percent difference in the calculated DO delta. The MiniDOT was equipped with a solid copper plate with a hole in the middle over the sensor, the YSI has wipers.

Similar to what was observed in 2011 with the MiniDOT which had no copper plate to deter algal growth, the MiniDOT in **Figure 2** initially provided results very close (<5% difference) to the YSI's, however after about 5 days the MiniDOT readings began to depart substantially.

Figure 3 shows the results for the MiniDOT equipped with copper screen deployed in the Yellowstone River near Custer, Montana. Water velocity across the instruments was about 2.5 ft/sec. In this case there were two cleaning events during which the YSI and MiniDOT were removed and serviced. On the cleaning event of August 20th, the MiniDOT's screen was not removed as the logger looked clean and water was simply swished across the sensor face. But on September 9th the copper screen was removed and the sensor face cleaned with a soft toothbrush. Field notes indicate that on September 9th there was a small amount of fine mud accumulated under the screen. Upon retrieval, no problems were noted for the MiniDOT or the YSI.

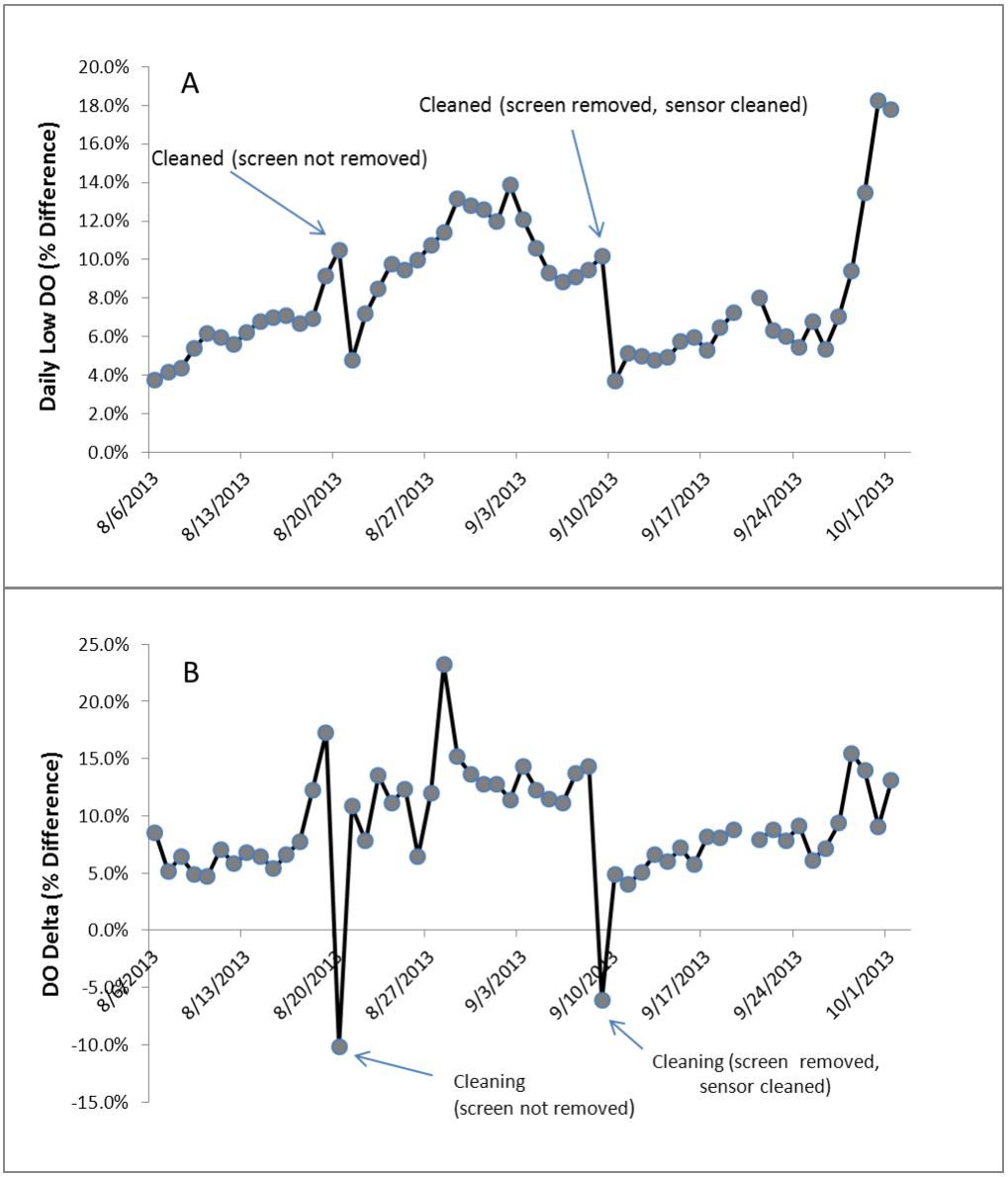

Figure 3. Percent Difference Between YSI and MiniDOT Dissolved Oxygen Recordings for Instruments Deployed in the Yellowstone River near Custer, Montana. (A) Percent difference in the recorded daily low DO. (B) Percent difference in the calculated DO delta. The MiniDOT was equipped with copper screen over the sensor, the YSI has wipers.

Several features in **Figure 3** are apparent. Compared to the MiniDOT fitted with the solid copper plate (**Figure 1**) and the 2011 MiniDOT which had no algal deterrent, the screen-equipped MiniDOT was able to collect quality data considerably longer before notable departure from the YSI occurred. Percent differences in the daily DO low and DO delta remained well below 10% for 12 full days from deployment and about 17 days after a thorough cleaning. Note that the incomplete cleaning on 8/20 led to percent differences from the YSI (generally 9-15%) over the following days that were still considerably better than what was observed in the solid-plate MiniDOT (**Figure 1**), at least for DO delta. Another interesting feature is that the cleaning events had some type of short-term effect on the MiniDOT sensors because the sign of the difference

shifted markedly on the day of cleaning (or the following day), but then rebounded to more typical differences after that.

Figure 4 shows that results from instruments deployed in the Yellowstone River at Billings, MT. The MiniDOT was equipped with a copper screen and water velocity across the instruments here was about 2 ft/sec. The data are for a 7 day period following the August 20th cleaning event and field notes indicate the MiniDOT looked clear of growth; the screen was not removed on the August 20th cleaning. **Figure 4A** shows that the MiniDOT daily low DO differed from the YSI more than was the case near Custer, MT (**Figure 3A**), at least following deployment or after a thorough cleaning. The DO delta differences are fairly consistent with results from the site near Custer, MT during the periods after deployment or after cleaning (**Figure 3B, 4B**).

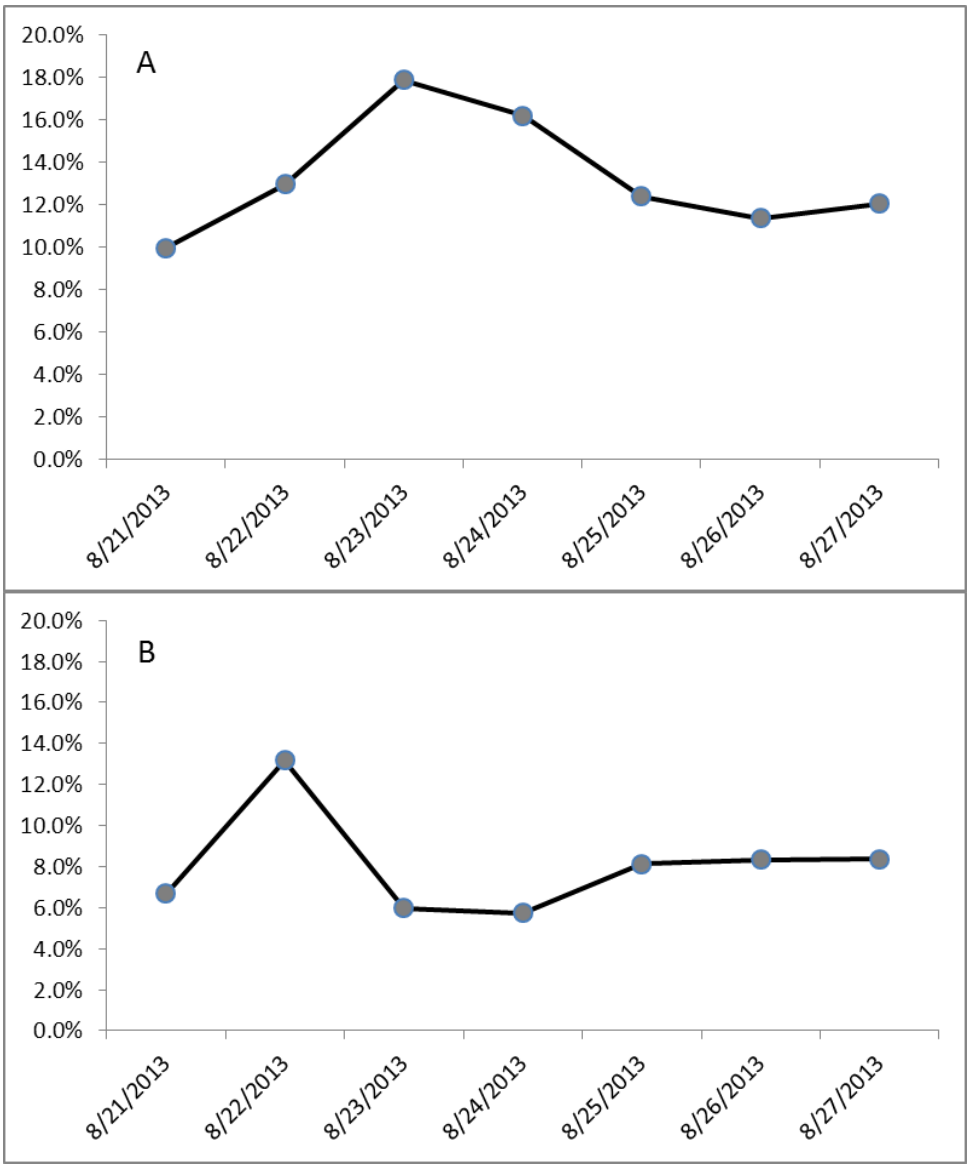

Figure 4. Percent Difference Between YSI and MiniDOT Dissolved Oxygen Recordings for Instruments Deployed in the Yellowstone River at Billings, Montana. (A) Percent difference in the recorded daily low DO. (B) Percent difference in the calculated DO delta. The MiniDOT was equipped with copper screen over the sensor, the YSI has wipers.

Figure 5 shows results from the site on the Yellowstone River upstream of Huntley dam. The MiniDOT was equipped with a copper screen. Here water velocity was slower, roughly 1.0-1.3 ft/sec (about half of the previously described Yellowstone River sites). Both instruments were deployed at this site on August 17th (one day prior to the data shown).

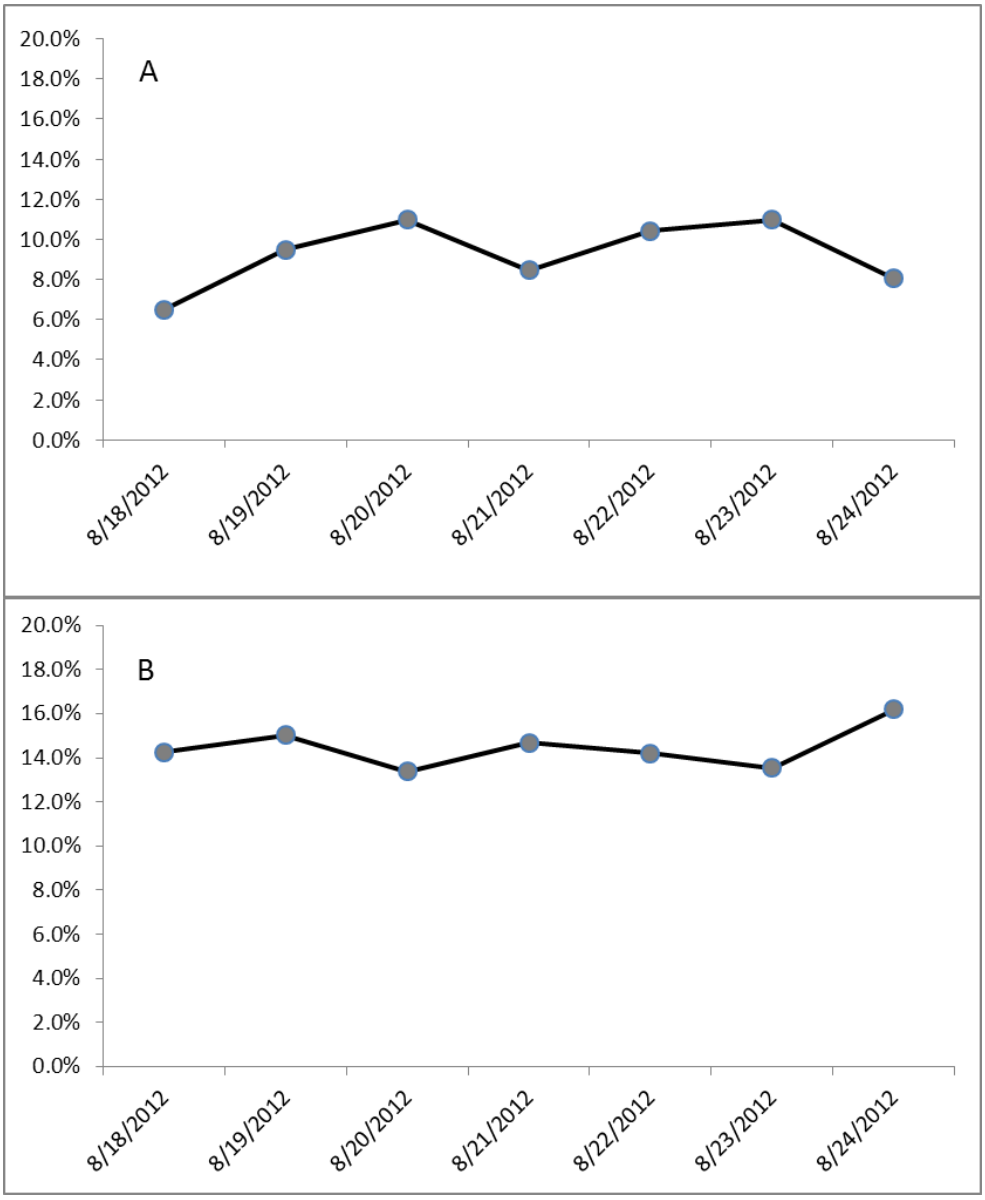

Figure 5. Percent Difference Between YSI and MiniDOT Dissolved Oxygen Recordings for Instruments Deployed in the Yellowstone River just upstream of Huntley Dam near Huntley, Montana. (A) Percent difference in the recorded daily low DO. (B) Percent difference in the calculated DO delta. The MiniDOT was equipped with copper screen over the sensor, the YSI has wipers.

At the Huntley dam site in **Figure 5** the percent difference in the daily DO low was usually <10%. However, the difference in DO delta was around 14%, i.e., somewhat high right from initial deployment. The relatively high percent difference in DO delta between instruments at the Huntley dam site is driven by the fact that

the daily high DO values recorded by each instrument were very different, with the MiniDOT's being up to 1.74 mg DO/L *lower* than the YSI's.

The next comparisons are from paired instruments on the Little Missouri River (**Figure 6**). This MiniDOT was equipped with a copper screen. The Little Missouri River deployment was very different from the Yellowstone River sites in that velocity of the stream was much lower than any of the Yellowstone River sites and the stream carried much more suspended silts and clays.

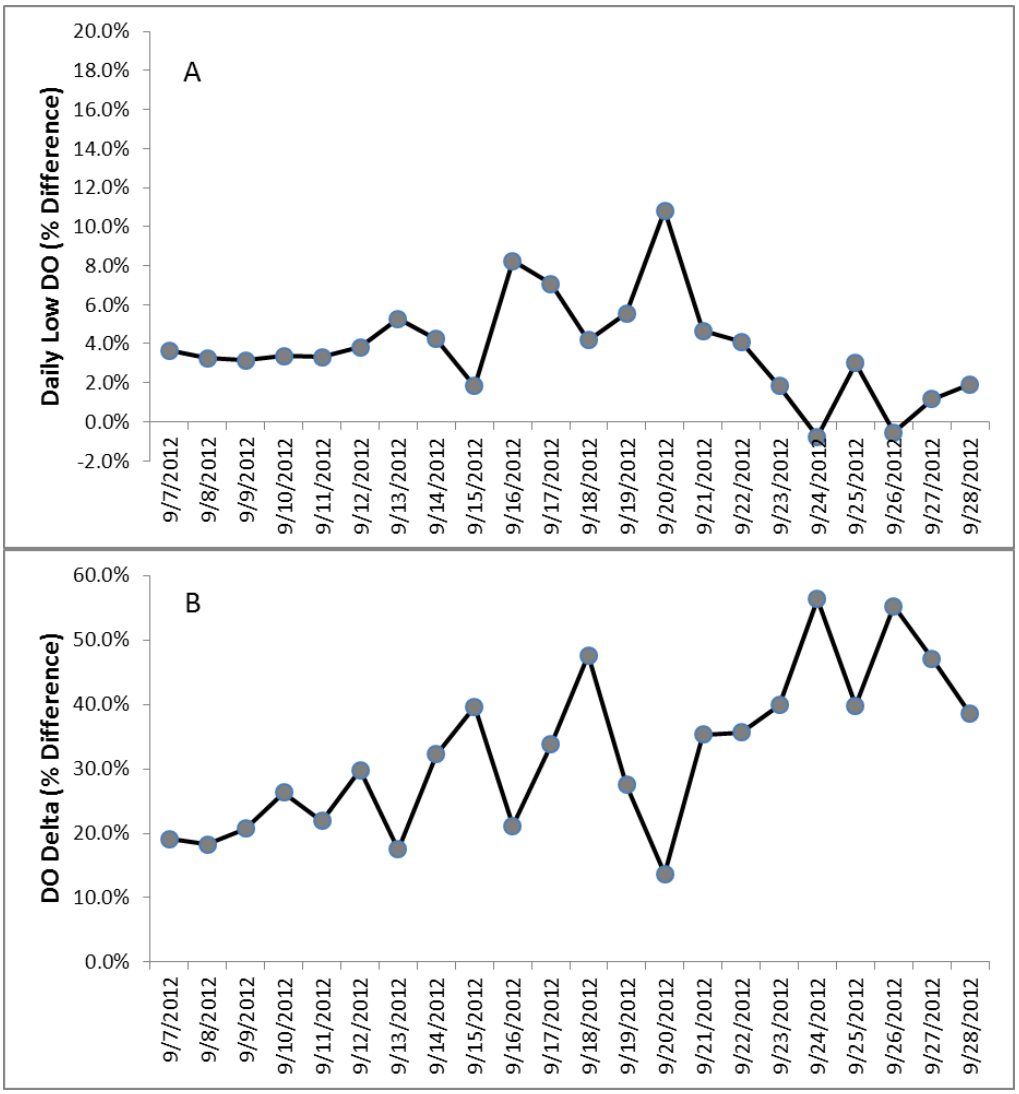

Figure 6. Percent Difference Between YSI and MiniDOT Dissolved Oxygen Recordings for Instruments Deployed In the Little Missouri River near Alzada, Montana. (A) Percent difference in the recorded daily low DO. (B) Percent difference in the calculated DO delta. The MiniDOT was equipped with copper screen over the sensor, the YSI has wipers.

At the Little Missouri River site, the daily lows were very consistent between the two instruments for about nine days, after which they became more erratic although still within reasonable agreement (almost always <10% difference) during the twenty-two day paired deployment. In contrast, the two instruments showed poor agreement in DO delta right from the initial deployment on September 6th, and this situation only

worsened over time. This stems from the fact the daily high DO recorded by the MiniDOT was (just like in **Figure 5**) much lower, often around 1 mg DO/L lower, than the YSI. This site showed the highest disparity (18-56% difference) between the DO deltas provided by each instrument.

Discussion

The results in **Figure 2** (MiniDOT with copper plate with hole in it) are in line with what was observed in 2011 (see 12/5/2011 Technical Memo) for a MiniDOT equipped with no algae deterrent. For the first 5 days or so the results are very close to the YSI's, however after that the differences begin to ramp up and much of the difference is due to the MiniDOT providing much higher daily DO highs than what was recorded by the YSI. The plate provided little or no growth deterrence; in fact during the same summer another plate-equipped MiniDOT (not part of this study) grew filamentous algae right through the hole in the center.

The screen-equipped MiniDOTs showed different patterns which appears to be driven by water velocity across the instruments. Where water velocity was highest (ca. 2.5 ft/sec; **Figure 3**) the MiniDOT gave readings generally in good agreement with the YSI (1) directly following initial deployment and (2) following a thorough cleaning which included removal of the copper screen and cleaning of the sensor face. Under such circumstances the MiniDOT could collect good-quality data for about 12-18 days.

With progressively lower water velocities, however, screen-equipped MiniDOT observations increasingly differed from the YSIs (**Figures 4**, **5**, and **6**), most notably for DO delta. This was driven mainly because the daily DO highs recorded by the screen-equipped MiniDOTs were often much lower than what the YSI recorded. This is in sharp contrast to the plate-equipped MiniDOT which exhibited <u>higher</u> daily DO highs than the companion YSI (**Figure 2**).

It is not clear why the daily DO highs become muted in the screen-equipped MiniDOTs as water velocity across the instruments decreases. But the data are consistent enough across these paired deployments to indicate that this is a fairly repeatable pattern. Daily DO minima were less influenced by water velocity.

Conclusions and Recommendations

1. The solid copper plate with a hole in the middle provides no added benefit in terms of deterring algal growth and extending MiniDOT data collection.

2. For MiniDOTs equipped with a fine copper screen, if sufficiently high flow (roughly 2.5 ft/sec) is maintained across the instrument during deployment reasonably good data collection can be achieved for about two weeks. However:

3. When velocity across the screen-equipped MiniDOT is insufficient, erroneous DO delta results will occur.

We recommend the MiniDOTs be equipped with a coarser copper mesh that will allow better water flow across the sensor, especially in lower-velocity situations. Hopefully the mesh will still provide sufficient algal deterrence. The updated mesh should be tested in various flow situations to understand the length of time over which it can collect good data. In the absence of such knowledge, a MiniDOT cleaning event should be scheduled every week (i.e., every 5-7 days).