*Response to reviewer comments “Water quality trends following anomalous phosphorus inputs to Grand Bay, Mississippi, USA”, by M. W. Beck, K. Cressman, C. Griffin, and J. Caffrey.*

*We thank the reviewers for providing helpful comments on our manuscript. Our detailed responses to each of the comments are in italics. Reviewer comments are edited for brevity where appropriate.*

Editor comments:

Review 1:

Review 2:

Review 3:

General Comments

Several places in the *ms* was difficult for me (the reader) to follow, primarily because results

would be reported for one parameter,then another, then back to the pt parameter (e.g., paragraphs beginning on lines 216, 249 and 286). Of course, I may have misinterpreted the results reported, but none the less, clarification should be considered.

Specific comments:

Line 27: Example/Suggested Wording (SW)- We examined spatial and temporal patterns...

*Changed.*

Line 29: If incorporate Line 27 SW,then delete ‘and time periods’

*Changed.*

Line 30: Suggest changing Phosphorus to Orthophosphate

*Changed.*

Line 42: Other keywords to consider- phosphate, fertilizer, spills. MS

*The key words were changed to ‘estuary, monitoring, phosphate, phosphogypsum, spills’ to keep within the word limit.*

Lines 45-52: Move paragraph to Line 74, with suggested changes

*Moved and suggested changes incorporated.*

Line 53: Make this the beginning (1st paragraph) of Introduction

*See above comment.*

Line 57: SW- this process, which was stored in large stacks as waste, and is rich...

*Changed.*

Line 62: Considers starting a new paragraph at the beginning of this line.

*New paragraph added.*

Line 63: sw- cm fell in...

*Done.*

Line 69: How much wastewater? If you know, then provide, as did for the April 2005 event

*We do not have this information.*

Line 69: SW- west, and concomitant elevated levels...

*Wording changed to:*

*‘MPC released overflow wastewater into Bayou Casotte to the west, where a fish kill was subsequently observed (MDEQ 2015). Elevated levels of phosphorus were also observed in Bangs Lake to the east.’*

Line 74: Insert the previous mentioned paragraph here (Line 45-52).

Moved.

What was Line 46: SW - Like Grand Bay, most estuaries are nitrogen...

*Added.*

At the end of this newly placed paragraph, SW for last sentence of paragraph -The potential effects.. .less studied, and there are few...nitrogen-limited systems, especially regarding impacts of concentrated fertilizer waste loads.

*Added.*

Line 75: Therefore, will omit ‘…to nitrogen-limited estuaries on ecosystem conditions.’

*Omitted.*

Line 75: Start a new paragraph that begins with SW-The few studies ...

*Added.*

Line 114: Where is Escatawpa River? Its not on the map. How far is it from Grand Bay? 8-16km? How is it connected to Grand Bay?

*The Escatawpa River is north of the reserve and cannot be viewed on the map. We have revised the text as follows:*

*‘The reserve is a retrograding deltaic system and does not have significant freshwater inflows. The Escatawpa River is located approximately five km north of the reserve and inputs into Grand Bay may occur during flood events through small channels. ‘*

Line 123: SW- The current network includes four instrumented sites (Bayou Heron, BH: Bayou ....) that continuously measure physiochemical water quality, and one weather station (Figure 1). Monthly nutrient sampling at the four continuous stations

began in March 2005 and...

*The first part was changed:*

*‘The current network includes five continuous stations: four that measure physiochemical water quality (Bayou Heron, BH; Bayou Cumbest, BC; Bangs Lake, BL; and Point aux Chenes, PC), and one that records meteorological data (Figure 1).’*

*We left the “monthly nutrient sampling” as-is (“at the water quality stations”) because the weather station is also continuous.*

Line 132: SW-At the continuous water quality collection sites, YSI dataloggers measure and store temperature, specific...every 15 minutes. The datalogger sensors were deployed 0.5m above the bottom before August 2005 and 0.25 thereafter.

*Changed to ‘**Water quality parameters logged every 15 minutes by YSI dataloggers were water temperature, specific conductance, salinity, dissolved oxygen, pH, turbidity, and depth. Dataloggers were deployed 0.5 m above the bottom before August 2005 and 0.25 m thereafter. Meteorological data were logged…’*

Line 150: SW- (NH/), nitrite+ nitrate (N02-/N03- ),

*Changed*

Line 150: orthophosphate (P043-)... Now that this is established as what was measured, from hereafter, be consistent using either one of these terms, but mostly use the P0 43-. Change the occurrences that use other terms that are intended to mean the same thing (e.g., phosphorus and phosphate).

*We have edited all occurrences for consistency.*

Line 158: Define "left-censored observations"

*Added (below detection limit) after “left-censored”*

Line 160: SW ~~phosphate~~ P043

Done

Line 164: SW- where orthophosphate was higher...

*Changed*

Line 165: SW-were also identified as the baseline...

*Done*

Line 168: SW- orthophosphate

*Done*

Line 172: The document reports that the current stations were established in 2005, and implies there are earlier samples being considered that predates the current stations. Doesn't there need to be some description of them?

*Water quality stations were established in 2004 and this was reflected in analyses; nutrients were not added until 2005. To clarify, we revise:*

*‘Nutrient samples (2005-2015) and water quality parameters (2004-2015) were evaluated using descriptive statistics to interpret changes over time in relation to each event…’*

Line 182: SW- orthophosphate

*Done*

line 219: Figure 3 seems to indicate the spike was over 125 NTU, more than the 110 reported on this line

*This was in error; the spike was measured as 129 NTU. Sentence was revised.*

Line 216: It seem the reporting starts jumping around here between parameters and timing related to the rainfall (how long it lasted) and when the breach occurred. The following is some SW to provided order and be consistent with Figure 3 –

Precipitation began on March 27, 2005 and was heaviest during March 31-April 1st, producing a total of 43.2 cm of rainfall. Prior to the storm, salinity at BL was 20-21 psu, then fell during the event and reached its minimum of2.8 cm on April 2nd, one day after the storm ended (Figure 3). Salinity thereafter started trending up, which included some spikes during the first week of recovery. The levee at MPC was breached on April 14th, two weeks post-storm. Salinity ranged from about 7 to 12 psu during, and the days immediately following the breach, as it continued its upward trend mostly unaffected. Turbidity at BL was normally < 10 NTU before the storm, but surged to -100 just prior to the storm, fell to normal concentrations during the rain event, then spiked to 125 NTU immediately following the storm. However, despite some reoccurring spikes, turbidity quickly declined over the next several days, after which it usually remained< 20 NTU. Like salinity, it seemed to be unaffected by the breach (Figure 3).

Unlike salinity and turbidity, pH changed significantly following the breach. The BL water quality station is sufficiently shallow...(rest of paragraph)...returned to pre-spill levels on April 19•11, five days after the spill.

*Paragraph was revised to include the above.*

Line 232: SW – Like pH, orthophosphate was significantly impacted by the breach. At BL on April 25th, 11 days after the breach, PO43- averaged 4.29 mg P/L (Figure 4). It decreased gradually to.. (rest of paragraph).

*Changed, ‘it’ replaced with ‘orthophosphate’.*

Are there any numbers to indicate what P043-concentrations were prior to the breach; before, during, and/or after the rain event. In the current draft, nothing is included (like for other parameters) regarding what effect the rain had, which leaves the reader to wonder if the high P043 concentrations were just part the result of lingering freshwater influence (low salinity). If no data is available, maybe it is enough to more specifically point out somewhere in this paragraph that, since salinity was impacted (lowered) by the storm, but pH was unaffected, AND pH was impacted by the breach, but salinity was not- therefore, it must have been P043-that caused the pH changes related to the breach. [Uh, I wouldn't really use those words, but I hope you know what I mean and the author can create the appropriate inference]

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*Unfortunately, we do not have enough nutrient sampling prior to the breach to fully address this question but we agree with the reviewer’s logic. One sample exists prior to the rainstorm which measured PO4 below detection and an appropriate sentence was added.*

*‘Only one nutrient observation was available prior to the rain event, which measured orthophosphate below detection.’*

*We have also added the following the first paragraph of the discussion:*

*‘These water quality changes are likely a direct cause of the levee breach rather than freshwater inputs from the rain event. Salinity decreased with precipitation, whereas dramatic pH changes did not occur until April 14th when high concentrations of orthophosphate were also observed.’*

Line 237: As per Table 1, the beginning of E1C is July 2006, not April as indicated on previous line

*The reference to E1C was removed as this was incorrect.*

Line 240: Should it be ‘period through June 2006’? Concentrations decreased for 2 months at the beginning of ECl in July, then spiked...

*Yes, this was changed.*

Line 243: SW- As per the seasonal Kendall tests, the reduction in P043 from the beginning to

-

end of.... (Table 3).

*Changed to:*

*For the trend tests, the reductions per year in PO43- during the first event were a decrease of approximately 236% at BL and 80% at BN (Table 3, percent change based on slope per year divided by median).*

Line 244: Can it be assumed the pre-event concentrations were at or below the detection limit at all four stations,then the reduction from the maximum value to that at the end of E1C was nearly 100%. If so, then probably worth stating.

*As noted above, we only have one data point before the breach. Based on several years of data between events that were below detection, we believe the baseline was probably at or below the detection limit, but we can’t back it up with data from the time period. We have added a sentence in the discussion to clarify this point.*

*‘The reduction of orthophosphate concentrations to levels near or below detection limit during the non-impact years suggests background concentrations prior to the first event were at similarly low levels.’*

Line 246: Figure 3 seems to indicate the average sea level is about O.5m, so the surge would be about 1.5m?

*The figure indicates ‘sensor depth’, not ‘sea level’. This was changed in the figure legend for clarity.*

Line 246: SW- rain and approximately 1.5m of storm surge at BL was produced...

*Changed.*

Line 249: SW- affected. A steady increase in turbidity from ~ 23 to over 100 NTU was observed with the storm surge. As the surge receded on August 31st, the observed pH and salinity decreased to a minimum of 6.5 and 5.6 at 18:30, respectively. After the storm passed, pH remained low, varying between 6.5 and 7.0 from August 31st to September 3rd, with occasional increases to 7.8. After September 13th, pH observations stayed above 7.0 and by September 31st, one month after the initial storm surge, pH had nearly attained its pre-storm level (Figure 3). Salinity after reaching its post-surge low began to steadily increase, with daily tidal variations that could exceed 5 psu. Like pH, one month after the initial storm surge, salinity also had nearly fully recovered. Also like pH and salinity, turbidity rapidly decreased after the storm (< 10 NTU), but unlike them, it quickly returned to pre-storm conditions a day after the surge.

*The paragraph was revised.*

Line 350: SW – ~~inorganic~~

*Removed.*

Line 260: sw-At BL during this same time period, average daily pH also was increasing, reaching 9.6 on March 2nd, concomitant with an elevated, albeit declining salinity condition typical of late winter (Figure 2).

Line 261: New Paragraph? SW- In contrast to the other 3 stations, changes in monthly P043 at BC were small and short-lived (Figure 4). However, a more delineated temporal analysis of iSCO diel samples collected at BC in 2012 depicts a stronger c4ange in P043-pattems before and after the storm (Figure 5). Orthophosphate...storm, when concentrations were near detection at low tide, but increased to 0.2.....storm. (~~Figure 5~~)

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Line 267: New Paragraph? SW- Even though the duration of the two events were the same, they were different in the amount ofP043 recovery toward pre-event conditions. The

-

reduction in P043 from the beginning to the end of the second event, based on the

Kendall tests (Table 3), was a decrease.....135% at BN. In addition, the P04 3 concentration at the end of the second event was greater at three sites compared to the first event, despite haYing a lower maximum value at two of them (BN and BL) when E2A began. These differences and slower recovery were related to rainfall, with the post eyent years of2013 and 2014 being very wet years compared to 2006 and 2007 after the first event (Figure 2).

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Line 271: This 1st and 2"d sentences of the paragraph needs clarification. Not sure what stats test was performed to claim BN concentrations were greater for the entire period of this evaluation, and also enabled hierarchical ordering of others. Just looking at Figure 6A is not enough.

Line 274: SW- orthophosphate

Line 275: If omit 1st two sentences of this paragraph (above comment), then include reference to

Figure 6A at end of next sentence...statistical different (Figure 6A).

Line 276: SW- orthophosphate

Line 278: SW- periods for BN, BL, and the first event at PC. Comparisons within time periods showed substantial...

Line 280: SW- .....orthophosphate concentrations (Figure 68). Interestingly, orthophosphate concentrations at BL and BN were.....

Line 287: Reclassify Figure 52 as Figure 7

Line 288: Move the sentences in this paragraph to the end ofthe previous paragraph (Line 285), such that SW- remaining sites during the non-impact periods. The highest **median** P043

-

concentration for BC occurred in ElA. However, none of the time periods were significantly different....(Figure 6A). At PC, there were....E2C time period (Figure

6B).

Line 292: Bring down the results of the other parameters that was started on line 286 to merge with this paragraph, with some rearranging of sentences to improve flow. For example,this new paragraph SW -Within time periods, there were no significant differences between

sites in N02-IN03- (Figure7), but concentrations were significantly greater during ElA than E2A at BLand BC (Figure St-8). For NH/, there was no difference between sites during time periods, except BN and BC were greater than the other two sites during Nil (Figure7). Seasonal Kendall trend tests for NH 4+ during

sampling within time periods indicated reductions within sites, although none of

these changes were significant (Table4). For chlorophyll-a, there were no significant differences between sites for any time period (Figure7). An increasing trend was generally indicated at most sites during advancing time periods (Figure Sl

8), although none were significant. However, the seasonal Kendall tests of samples within time periods showed a significant positive change at all sites during NlA, ranging from 32% to 56% (Table st-5). Increases were also observed during the second event (E2A and E2C), but these were not significant.

Line 300: SW- orthophosphate

Line 301: SW- characterized by extremes in P04 3- concentrations.. . Line 302: Is it similar trends or values in salinity and pH?

Line 325: Define DIN. sw-DIN concentrations (dissolved inorganic nitrogen = N02-/N03- +

NH4+) have been...

Line 333: What ratios and where were they reported in this *ms* that were comparable? Also, no results were provided for DIN, just NOf/NOf and NH/ separately.

Line 334: SW- These studies are similar to the results of Grand Bay, such that elevated nitrogen (NH/ and N02-/NOf) also was observed with eleYated P043-

concentrations (Figures 6-8).

Line 337: DIN results not reported in this *ms.*

Note: In the discussion, prior to Line 365: Include more development of spill consequences on ecosystem and biota. In the *Introduction,* reference is made to Viskup (lines 65-67) and the damages of $2 million. Perhaps pull that sentence from the *Introduction* and save it for the *Discussion* where it can be further developed (types of damages and correlation to events), along with potential thresholds. Compared to Rekik 2012? Same for the MDEQ 2015 report on fish kills. *Do* these reports/results have management implications which can be provided in the following section?

Line 578 Table 2: Tables and Figures should stand alone, so include (P04 3-), since P043- is used in

table

Line 578: sw -ammonium and nitrate/nitrite (N02-/NOf), ...

Figure Legends:

Lines 588 and 589: Use ortho, since that is what is used on the actual graph label and even later in this figure description (Line 592}. Therefore, SW- pH, and orthophosphate for Bangs Lake, within Grand Bay National Estuarine Research Reserve. All...excluding orthophosphate, which was sampled monthly.

Line 592: SW- categories (Table 1) in relation to...

Line 598: Earlier reported the rains began March 27th on Line 216

Line 601: SW- orthophosphate...since that is what is used on the actual graph label

Line 602: SW - Distance of stations from spill increases from top to bottom panels.

Line 606: Since Poii-s used as a graph label,SW- orthophosphate (P043 )•..

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Line 607: SW- spill event on August 28, 2012 at Bayou Cumbest station, approximately 7 km

from the spill site. Elevated P043

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is observed...

Line 610: SW- time period. Boxes depict median and middle quartiles of the values, and whiskers depict the 5 and 95 percentiles. Outliers are represented as points. Black boxes indicate??? and green boxes???. Boxplots within each...

Lines 615 and 621: Switch Figures 51(becomes Figure 8) and 52 (Figure 7).

Line 615: Then would be- FIGURE 7. Boxplot summaries of nitrogen and chlorophyll-a data for sites grouped by time periods. Boxes depict median and middle quartiles of the values, and whiskers depict the 5 and 95 percentiles. Outliers are represented as points. Color shading of boxes represent ??? . Boxplots within each...

Line 621: Then would be- FIGURE 8. Boxplot summaries of nitrogen and chlorophyll-a data

for time periods grouped by site. Boxes depict median and middle quartiles of the values, and whiskers depict the 5 and 95 percentiles. Outliers are represented as points. Color shading ofboxes represent???. Boxplots within each...

Figure Legends:

Figure 2.

• Date ranges (width) of green bars do not seem to be correct, compared to supporting text. For example, during 1st event's precipitation, the bar depicts a low rainfall period.

• For Orthophosphate, indicate this a log scale, and on they-axis, show the values that correspond to the guideline between .01and 0.1, between 0.1and 1.0, and especially for the guideline above 1.0.

• On bottom x-axis, show more than every 5 years; preferably every year, with additional hash marks for months. It currently is hard to follow the changes reported in the text related to time periods.

Figure 3.

• Same issue with the green bar...please check if accurately depicts date range of events.

• Add units for Salinity

Figure 4.

• Same issue with the green bar...please check if accurately depicts date range of events.

• For these graphs, indicate they are on a log scale, and on they-axis,show the values that correspond to the guideline between .01and 0.1, between 0.1and 1.0, and especially for the guideline above 1.0 for BN and BL.

• As above, on bottom x-axis, show more than every 5 years; preferably every year, with additional hash marks for months.

Figure 5.

• Add units for Salinity.

• On X-axis indicate this is a time line,provide labels:

2012 Dates

(Time: EST)

Figure 6.

• For these graphs, indicate they are on a log scale,and on the y-axis, show the values that correspond to the guideline between .01and 0.1, between 0.1and 1.0,and above 1.0 where applicable.

• Change "time frames" to "time periods," since that is what is used in text.

• 6B's lettering to denote significance is opposite of all other graphs. Reverse it, so that "a" represents the greatest values, "b" the next, and so forth.

• As mentioned above in Figure Legends, what is the meaning of the black and green boxes?

Figure 7 (Was S2)

• Indicate the graphs that are on a log scale. For those graphs, on they-axis show the values that correspond to the guideline between those that are numbered.

• What is the meaning of the black and various shades of green boxes?

Figure 8 (Was Sl)

• Indicate the graphs that are on a log scale. For those graphs,on they-axis show the values that correspond to the guideline between those that are numbered.

• What is the meaning of the black and various shades of green boxes?