Summary of Observed Channel Dimensions in Mardi Gras Pass in the Bohemia Spillway, Southeast Louisiana: September 2019 Update

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Introduction

This report supplements previous reports that present the results of surveys completed by The Lake Pontchartrain Basin Foundation (LPBF) since Mardi Gras Pass (MGP) breached to the Mississippi River at mile marker 43.7 in March of 2012. All prior survey reports as well as a comprehensive study of the development of MGP are available for download at http://saveourlake.org/lpbf-programs/coastal/technical-reports/. Mardi Gras Pass is located in the Bohemia Spillway, an 11.8-mile un-leveed reach on the east bank of the Mississippi River, approximately 45 miles downriver from New Orleans (Figure 1). On September 5, 2019, LPBF conducted a bathymetric survey to measure bottom elevation and water depths within MGP and surrounding water bodies. On August 27, 2019, a bank survey was conducted by LPBF to map the spatial extent of the pass. Bank and bathymetric survey statistics were computed for the entire extent of MGP and for each of the individual five reaches. These surveys were conducted to document changes occurring from July 2018 to September 2019, which is typical high water season on the Mississippi River and in the Bohemia Spillway.

Figure 1: Location of Mardi Gras Pass in Plaquemines Parish, LA.
Data Collection and Processing

All data points were collected using a Trimble Geo Explorer 6000 GeoXR GPS receiver attached to a Zephyr Model 2 GNSS external antenna. Using an internet connection to access LSU’s C4G real-time network (RTN) the unit was capable of Real Time Kinematic (RTK) data collection. RTK data collection means that when surveying, real time corrections are acquired from nearby base stations and post processing collected data is not necessary. This survey grade GPS system provides latitude, longitude, and elevation (XYZ) of land locations to a high degree of precision. When coupled with the boat-mounted fathometer (SonarMite Echo Sounder), depth measurements are simultaneously recorded with the GPS data for each point. From these measurements, bottom surface elevation can be calculated as the elevation of the water surface minus depth (depth-applied elevation). Quality assurance was conducted using ASCII file generator and any data points collected over the set horizontal (2 inches), vertical (3 inches) precision or PDOP over 6.0 were flagged. The GPS points were downloaded into Microsoft Excel, and points exceeded the above criteria were deleted, for both surveys.

On August 27, 2019, the GPS unit and external antenna were used to complete a bank survey of Mardi Gras Pass. Each point collected contained a latitude, longitude, and elevation. A total of 116 GPS points was collected at approximately 100-foot intervals along the bank (Figure 2). A small number of bends were either inaccessible or tree coverage blocked the GPS signal. There are scour holes in Reach 4A, & 4B, the original Bohemia Spillway Diversion Culverts and therefore, a greater concentration of points was purposely captured at these locations to determine if the scour continues. The remaining GPS points, after quality assurance, were then imported into ArcMap and a polygon feature was computer generated based on the bank survey points (Figure 2). This polygon feature represents the surface extent of MGP for the September 2019 survey.
Figure 2: Bank survey points of Mardi Gras Pass collected on August 27, 2019, along with the polygon representing the extent of the pass.

On September 5, 2019 a bathymetric survey was conducted with the fathometer mounted on a 19-foot Cape Horn boat and run in “Continuous Topo” mode while traveling different paths up and down the pass. “Continuous Topo” mode allows the unit to obtain data points every five feet. A total of 8,779 data points was collected during the bathymetric survey of Mardi Gras Pass, the Mississippi River, and into the Back Levee Canal (Figure 3). The GPS-fathometer combination measured and recorded latitude, longitude, elevation of the fathometer (approximately 1 foot below the water surface), and depth (measured by the fathometer) for each point along the survey paths. Parameters were set in the data collector to account for the 1-foot fathometer drag and the height of the pole mounted GPS receiver to return elevation readings at the water surface. Water depth measurements were subtracted from the water surface elevations to calculate the bottom surface elevation. A visualization of bottom surface elevation of the channel and adjacent water bodies is interpolated from the bathymetric and bank survey points (Figures 4 and 5).
Figure 3: Bathymetric survey points of Mardi Gras Pass and the Mississippi River collected on September 5, 2019.
Figure 4: Mardi Gras Pass and Mississippi River interpolated bottom surface elevation based on bathymetric surveys collected on September 5, 2019. Interpolated bottom surface was generated using the Spatial Analyst Toolbox in ArcGIS 10.7.
Figure 5: Mardi Gras Pass interpolated bottom elevation based on bathymetric surveys collected on September 5, 2019. Mississippi River and Back Levee Canal bathymetry points were excluded from this interpolation. Interpolated bottom surface was generated using the Spatial Analyst Toolbox in ArcGIS 10.7.

Using the spatial analyst toolbox a raster was created showing where bottom elevation had either increased in value (erosion) or decreased in value (deposition) and a map was created showing the change in bottom surface elevation from the previous July 2018 survey compared to the September 2019 survey (Figure 6 and Figure 7). Some fallen trees are known to be located on the bottom and in Mardi Gras Pass due to erosion of the shoreline, the movement of these fallen trees and newly fallen trees could possibly account for large amounts of erosion or deposition. This is due to the Sonarmite Fathometer signal pinging off the fallen tree and misrepresenting the bottom elevation. The largest amounts of both deposition and erosion are located in Reach 3. This was due to the deepest part of the channel in this area shifting approximately 165 feet toward the northwest. About 50-58 feet of erosion took place to create a new scour hole and the old scour hold was filled it with about 20-33 feet of deposition.
Figure 6: Mardi Gras Pass bottom elevation difference map that shows change in bottom elevation from the July 2018 interpolation compared to the September 2019 interpolation. All interpolations created using bathymetry data from respective surveys and the ArcMap 10.7 Spatial Analyst Toolbox.
Figure 7: Mardi Gras Pass and adjacent Mississippi River bottom elevation difference map that shows change in bottom elevation from the July 2018 interpolation compared to the September 2019 interpolation. All interpolations created using bathymetry data from respective surveys and the ArcMap 10.7 Spatial Analysis Toolbox.

To interpret the survey data, a series of basic geo-processing steps were completed in ArcGIS to obtain summary statistics describing the width, depth, and bottom elevation of MGP. To measure width, 47 transects crossing the channel were clipped based on the MGP boundary (Figure 8). These transects were used to compute the average width in each reach as well as the overall average width of MGP. In order to accurately calculate cross-sectional area, multiple transect locations from the July 2018 report had to be moved, 2 transects had to be deleted due to changes along the banks of MGP and also due to the straightening process of the pass itself.
Figure 8: Transects used to summarize the width of Mardi Gras Pass at various locations and the length (feet) of each transect (bank-to-bank distance).

**Polygon Analysis Method Using Depth Interpolation**

To assess the depth of MGP, individual polygons were clipped from the extent polygon representing the boundaries of the pass. The resultant polygon layer divided the entire pass into 46 polygons (Figure 9). Next, the zonal statistics tool was used to calculate the average depth inside of each polygon from the depth interpolation that was created from the raw bathymetry data.
Figure 9: Polygons used to summarize the average depths (feet) of the Mardi Gras Pass in Reaches 1 through 4A. Average depth statistics computed using raw bathymetry points

A more illustrative assessment of the depths through Mardi Gras Pass can be obtained by analyzing the thalweg depth (Figure 10). For the purposes of this analysis, the thalweg depth was calculated as the average of the five deepest measurements for each polygon defining the deepest points along the entire length of the channel.
Figure 10: Polygons used to summarize the average thalweg depths (feet) of the Mardi Gras Pass in Reaches 1 through 4A. Average thalweg depth statistics computed using raw bathymetry points; thalweg depth was determined by averaging the five deepest values for each polygon.

**Transect Analysis Method Using Interpolated Bathymetry**

The Transect Analysis Method Using Interpolated Bathymetry is used to obtain the most accurate cross-sectional area measurements of Mardi Gras Pass by creating an interpolation from the bathymetry data by using the 3D Analyst toolbox in ArcMap. The Interpolation produces a continuous bottom elevation and depth surface for Mardi Gras Pass filling in gaps where bathymetry data could not be collected due to the area being too shallow or inaccessible. With a complete dataset, we are able to analyze depths and bottom elevation along the entire transect producing a more accurate data set and cross-sectional area.
For the Transect Analysis Method, depth, bottom elevation, and thalweg depth are being analyzed only along the width transects (Figure 8). Using the Zonal Statistics tool in the Spatial Analyst Toolbox in ArcGIS 10.7 average, minimum, and maximum values were acquired for both depth and bottom elevation from the interpolated surface raster for both data sets along each transect. The completed tool outputs a table that contains the average, minimum, and maximum values for each transect, reach, and the entire Mardi Gras Pass. Values were only used if they were directly on the width transect. This method results in the best possible representation of the channel and cross-sectional area.

**September 2019 Transect Analysis Results Using Interpolated Bathymetry**

The water depths located along the transects ranged from 0.0 feet (Reach 1, 4A and 4B) to 64.5 feet (Reach 3). Reach 2 had the greatest average water depth at 32.6 feet, and Reach 4A had the lowest average water depth at 21.4 feet. The average water depth for the entire pass was 24.5 feet. The average bottom elevation for the entire pass was -23.4 feet Reach 2 had the largest average bottom elevation at -31.2 feet, while Reach 4A had the smallest average bottom elevation at -20.3 feet (Table 1).

**Table 1: Summary statistics by reach for transects used to assess the width, depth, and bottom elevation of Mardi Gras Pass based on the interpolated surface raster of the September 2019 survey.**

<table>
<thead>
<tr>
<th>Reach</th>
<th>Number of Width Transects</th>
<th>Avg. Width (ft)</th>
<th>Min. Width (ft)</th>
<th>Max. Width (ft)</th>
<th>Avg. Depth (ft) (a)</th>
<th>Min. Depth (ft) (a)</th>
<th>Max. Depth (ft) (a)</th>
<th>Avg. Bottom Elevation (ft) (b)</th>
<th>Avg. Thalweg Depth (ft) (c)</th>
<th>Average Cross-Sectional Area (ft²) (d)</th>
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<tr>
<td>1-4</td>
<td>47</td>
<td>245</td>
<td>171</td>
<td>386</td>
<td>24.5</td>
<td>0.0</td>
<td>64.5</td>
<td>-23.4</td>
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<td>236</td>
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<td>38.5</td>
<td>-21.5</td>
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<td>4,352</td>
</tr>
</tbody>
</table>

Table footnotes
(a) The average, minimum, and maximum depth values refer to summary statistics based on values for the set of transects in each reach. These depth values utilize the interpolated surface along each width transect. Therefore, the minimum and maximum of each reach refers the minimum and maximum average depth for the set of transects within the reach and not the minimum or maximum value of the individual points within a transect or reach.

(b) Bottom Elevation is calculated by subtracting fathometer depth measurements from the elevation of the water surface. Average Bottom Elevation values are the average from an interpolated surface of the bathymetric points.

(c) For the purposes of this analysis, the Average Thalweg Depth for each polygon is defined as the average of the maximum depths for all the transects within a reach, and the entire Mardi Gras Pass.

(d) For the purpose of this analysis, the Summation Method is use to calculate cross-sectional for all 47 transects at 5 foot intervals, cross-sectional area for the transects is averaged per reach and for the entire pass. The interpolated surface fills in gaps between collected data and can potentially underestimate cross-sectional area.
Cross-sectional Area Comparison

The Summation Method was used to calculate cross-sectional area for each transect at 5 foot intervals and was compared to cross-sectional area values from the September 2019 survey (Figure 11). Bottom elevation values were used to calculate cross-sectional area rather than depth values due to the constant fluctuation of the depth of Mardi Gras Pass from Mississippi River and tidal influences. Bottom elevation is only changed by erosional or depositional processes rather than water level giving a more accurate representation in the changes in cross-sectional area from the July 2018 survey to the September 2019 survey. For the September 2019 survey, Reach 3 contained the largest cross-sectional area measurement of 13,708 square feet located at transect 12. Reach 4B contained the smallest cross-sectional area measurement of 3,254 square feet located at transect 35. Reach 3 as a whole had the largest average cross-sectional area of 9,018 square feet. Reach 4B had the smallest average cross-sectional area of 4,351 square feet. The entire MGP had an average cross-sectional area of 5,745 square feet (Table 1).

![Change in Mardi Gras Pass Cross Sectional Area](image1)

![Cross-sectional area comparison of July 2018 vs. September 2019](image2)

Figure 11: Cross-sectional area comparison of July 2018 vs. September 2019. The transect numbers on the histogram correspond to the transect locations on the map.
Percent change was calculated for all transects and reaches of MGP. Mardi Gras Pass as a whole had an increase in cross-sectional area from the July 2018 survey by 39.6%. The greatest change in cross-sectional area occurred in Reach 3 at transect 11 with a 88.5% increase. The smallest change in cross-sectional area occurred in Reach 4B at transect 26 with a 0.14% decrease. All reaches experienced an increase in cross-sectional area and had the following increase percentages: Reach 1; 51.9% Reach 2; 50.7%, Reach 3; 46.9%, Reach 4A; 25.1%, Reach 4B; 36.7%.

**Bottom Elevation Cross-sections and Profiles**

Using the bottom elevation interpolation of Mardi Grass Pass and the Mississippi River several graphs were created to show accurate to scale size comparisons, bottom profiles, and bottom profile changes. To show size comparison (Figure 12) the smallest and largest cross-sectional areas of Mardi Gras Pass were graphed on top of the Mississippi River cross-section adjacent to Mardi Gras Pass. Bottom elevations along Transect 35 (smallest) and Transect 12 (largest) were extracted from the interpolation and graphed, bottom elevation was also used for the Mississippi River cross-section just north of Mardi Gras Pass. Transect 35 (smallest) cross-sectional area is 2.2% of the Mississippi River and Transect 12 (largest) cross-sectional area is 9.4% of the Mississippi River.

![Comparative Cross-Sections of Mardi Gras Pass and Mississippi River](image)

Figure 12: Comparative cross-sections of Mardi Gras Pass and the adjacent Mississippi River. Mississippi River cross-section was calculated directly south of Mardi Gras Pass. Black line represents smallest cross-sectional area found in Mardi Gras Pass and the red line represents the largest. All three cross-sectional profiles are to scale.
To look at the bottom elevation profile of Mardi Gras Pass and the Mississippi River for the September 2019 survey (Figure 13) centerline points were created at the center of the width transect lines (Figure 8) for Mardi Gras Pass, the points were then continued across the Mississippi River in a straight line at a set distance of 200 feet. Bottom elevation values were extracted to those points and distances were calculated for each point from the mouth of Mardi Gras Pass where it meets the Back Levee Canal to each centerline point. The bottom elevations and distances were used to create the bottom elevation profile and it is to scale.

Figure 13: Bottom elevation profile down the centerline of Mardi Gras Pass starting where it meets the Back Levee Canal at its most eastern point, through the entire length of Mardi Gras Pass, into the Mississippi River, and across to the Westbank. Profile of both Mardi Gras Pass and Mississippi River are to scale.

The July 2018 profile from the previous report was overlaid with the September 2019 profile in order to compare the surveys and look for deposition or erosion along the bottom of Mardi Gras Pass (Figure 14). Comparing the July 2018 and September 2019 bottom elevation profiles both large and small changes can be seen throughout the majority of Mardi Gras Pass, meaning both erosional and depositional events took place over the approximate 13-month period. In reach 1
the start of Mardi Gras Pass was located about 210 feet farther inland than the previous survey, meaning the overall length of the pass decreased in size. In reach 3, the known scour hole completely filled-in making the scour hole in reach 2 the deepest point along the centerline. In reach 4B about 600 feet of uniform erosion occurred, similar to what was seen from November 2019 to July 2018. This means that roughly 5 feet of erosion occurred across the entire stretch making both profiles look similar in trend and appearance but with a uniform 5 foot offset.

Figure 14: Comparative bottom elevation profiles of Mardi Gras Pass for both the July 2018 survey and September 2019 survey. Both profiles are down the same centerline of Mardi Gras Pass and to scale.

**Conclusion**

The time period from July 2018 to September 2019 was an extreme period of high water on the Mississippi River. The Mississippi River gauge in Pointe a la Hache recorded a low value of 1.29 in August 2018 and a maximum value of 8.00 in July 2019, and an average stage of 5.47 feet for that time period. From the July 2018 to the September 2019 survey, Mardi Gras Pass
experienced an increase in average width (from 208 feet to 245 feet), increase in average depth (from 21.0 to 24.5 feet), increase in max depth (from 62.1 to 64.5 feet), increase in average bottom elevation (from -20.1 feet to -23.4 feet), increase in average thalweg depth (from 32.8 feet to 37.4 feet), and increase in average cross-sectional area (from 4,172 square feet to 5,745 square feet). These increases are due to the erosional effects of increased discharge and velocity values experienced in Mardi Gras Pass from the high volumes of water entering from the Mississippi River. Although the majority of change in Mardi Gras Pass is caused by erosion, we do see some sites of localized deposition with either eroded MGP sediments or sediments from the Mississippi River. The largest cross-sectional areas now range from 2.2% to 9.2% that of the adjacent Mississippi River. The biggest changes that occurred over the past flood season are the significant changes seen in the movement and size of the scour hole Reach 3 with the scour hole. The new scour hole reaches depths of up to 67 feet and is located 165 feet northwest of the old scour hole that has been filled in with up to 33 feet of sediment. The movement of the scour hole and large amount of erosion on the western bank of Mardi Gras Pass around transects 11, 12, and 13 along with the large amounts of deposition observed on the eastern bank of Mardi Gras Pass are potentially signs the pass is going through a process of channel straightening. LPBF will continue to monitor Mardi Gras Pass through the low water season and into the next flood season.

References


