Preliminary Hydrologic Observations of 2011 Riverine Discharge through the Bohemia Spillway in Southeast Louisiana

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Introduction

The Bohemia Spillway area is the 11.8 mile reach on the east bank of the Mississippi River approximately 45 miles downriver of New Orleans extending below the terminus of the Mississippi River (MR&T) levees to Bayou Lamoque (see companion paper for an overview). The spillway is not an engineered water control structure such as the Bonnet Carré Spillway. Rather, it is simply the absence of the artificial river levee that was removed in 1926. It is estimated that 550,000 cubic yards of material were removed from the "front line" levee (OLB, circa 1926). Since 1926, for 85 years, the Bohemia Spillway has had the potential to allow overflow across the natural levee due to high water of the Mississippi River. The landscape has had pre-and post 1926 modifications related to local activities which incidentally affect the potential flow or nature of the flow through the spillway. In spite of these anthropogenic alterations, the Bohemia Spillway seems to represent the best modern example of the overbank flow across a natural levee along the lower Mississippi River. As such, it has significance to understanding a key deltaic process, and a process that may need to be emulated by artificial diversions for coastal restoration in Louisiana. Although, prior hydrologic work was conducted by LPBF in the 2008 flood, the epic river flood of 2011, created an ideal opportunity to directly observe and measure the distribution and nature of the discharge through the Bohemia Spillway.

Methods

The 2011 hydrologic investigation of the Bohemia Spillway used four survey methods.

1. ***Riverside ADCP*** – ADCP surveys were conducted on the Mississippi River above and below the Bohemia Spillway based on the assumption that the reduction in flow would indicate discharge on the east through the Bohemia Spillway. This work was contracted to the University of New Orleans and overseen by Dr. Ioannis Georgiou.

2. ***Bohemia Road Overflow Survey***- Measurements of water depth, velocity and direction were taken along the road which runs the length of the spillway near the crest of the natural levee. This survey was conducted by LPBF staff and overseen by Dr. John Lopez.

3. ***Local Channel Flow Marsh Survey*** – Selected canals on the marsh side of the natural levee were monitored briefly during the flood to gage to tidal effects of the spillway discharge. This work was contracted to the University of New Orleans and overseen by Dr. Ioannis Georgiou.

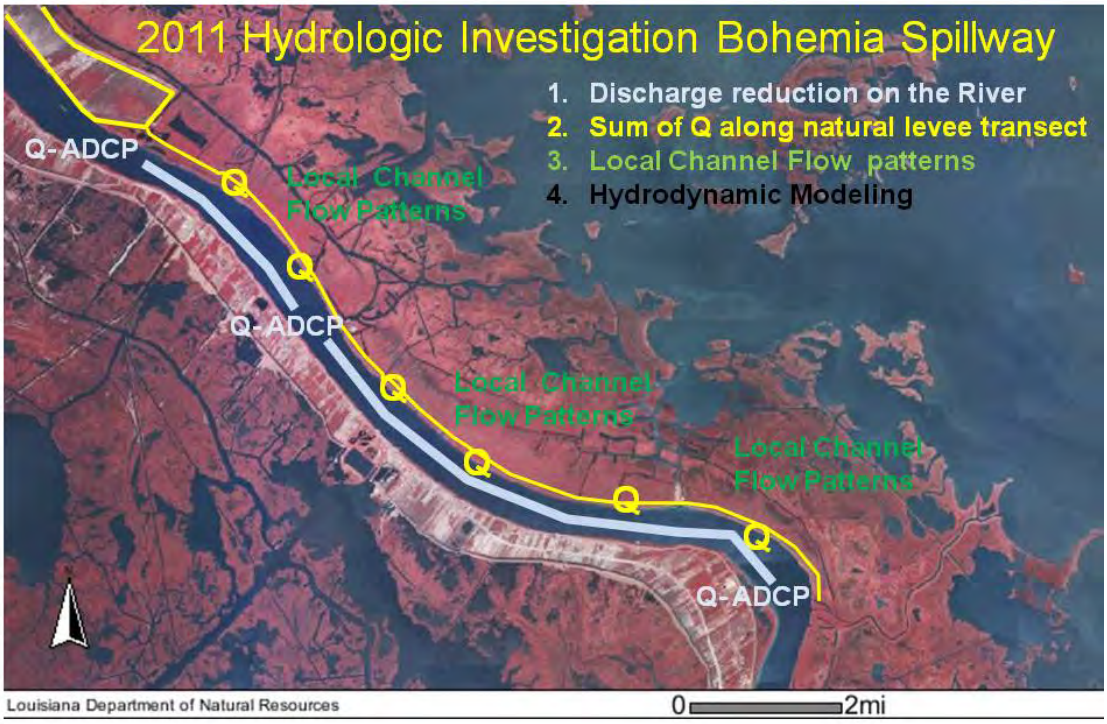

Figure 1: Bohemia Spillway area is east of the Mississippi River downstream of the terminus of the Mississippi River levee (source basemap: SONRIS CIR 2005).

4. ***River Hydrodynamic Modeling*** – Specific modeling of the Bohemia Spillway was incorporated into a regional modeling effort of the Lower Mississippi River to access current hydrologic conditions. This modeling utilized a recent elevation survey of the Bohemia road acquired in Fall 2010. This work was contracted to the University of New Orleans and overseen by Dr. Alex McCorquodale.

The preliminary compilation of data of these three surveys has been completed, and in a September 2011 work meeting we reviewed preliminary results of all four approaches with PI's. The high water survey was conducted from May 17 to June 7 during which the West Pointe a la Hache gage ranged from 7.2 to 7.66 feet (**see Figure 2**). The work by UNO will be documented in two or three reports that should be available by December 2011. All of these survey approaches have various limitations and inherent errors, but together may provide a new level of accuracy for the hydrology of the Bohemia spillway. Field reconnaissance was also conducted pre and post high water (see Figure 2).

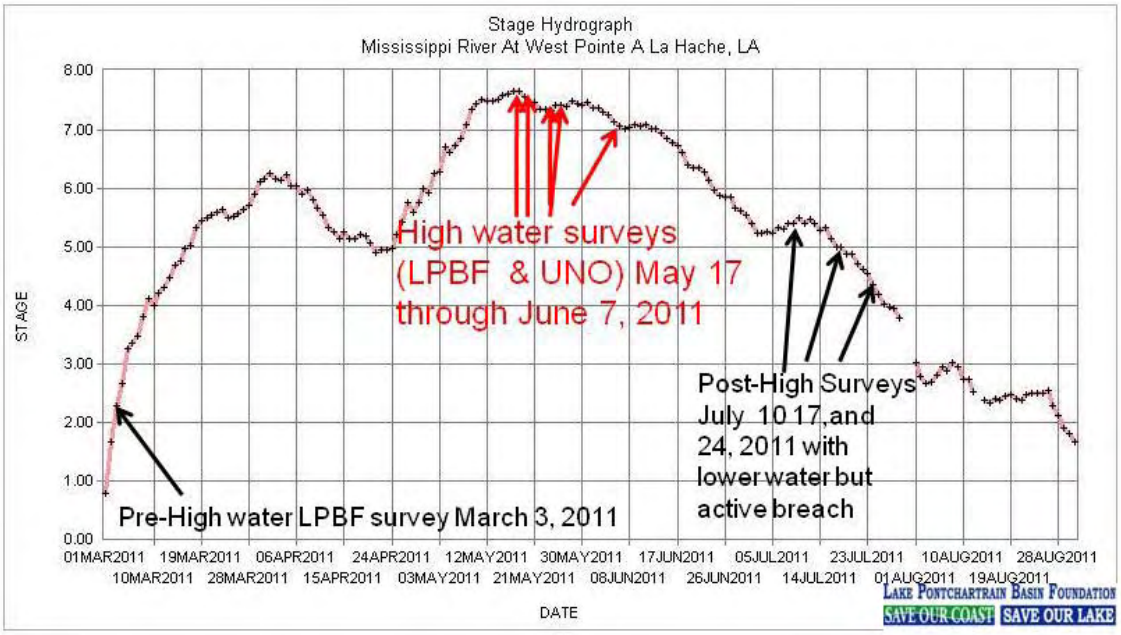

Figure 2: Mississippi River hydrographic (2011) at West Pointe a la Hache, which is just a few miles up-river from the Bohemia Spillway (source- USACE).

Total Bohemia Spillway Discharge estimate for the peak 2011 flood

Riverside ADCP – 15,000 cfs to 45,000 cfs. The lower estimate is likely to be an underestimate because it is based on an extrapolation of flow from the two upriver ADCP river surveys. The lower river ADCP near Bayou Lamoque was found to have higher discharge than the upper and was discounted. Based on the Bohemia Road Overflow Survey, it is likely the upper portion of Bohemia did have lower flow that the downriver section. Considering uncertainties UNO estimates the maximum flow through eh Bohemia survey may be as high as 45,000 cfs.

Bohemia Road Overflow Survey- This survey involved over 118 measurements along the road. The entire spillway length was subdivided into 18 reaches and discharge was estimated for each reach. In addition, discharge was estimated through several culverts and road washouts (breaches). Since the entire survey was not conducted at the exact peak flood small adjustments were made to estimate the discharge at each reach for the peak of the Flood (May 17). The total discharge of the spillway was estimated by summing the entire road overflow discharge for all reaches, culvert discharges and the estimated discharge through breaches at the maximum stage. The combined discharge for the peak flood is estimated to be 49,000 cfs.

Local Channel Flow Marsh Survey – This survey by itself cannot estimate a total discharge through the Bohemia Spillway. Nevertheless, some relevant observations are that the discharge seen in the canals in the marsh were influenced by astronomical tides. Highest velocity and discharge was observed on falling tides. In spite of the tidal influence flows were not significantly reversed and were dominated by riverine influence.

River Hydrodynamic Modeling – UNO modeling at this time has included the Bohemia Road elevations acquired in 2010, but has only modeled the 2008 flood. The peak flood in 2008 at

West Point a la Hache was 7.46 feet, which is slightly lower than 2011 (7.66 feet). Preliminary modeling indicates the maximum discharge through the Bohemia Spillway in 2008 was 30,000 cfs. Modeling of the 2011 hydrograph is underway, and is expected to generate a slightly higher discharge.

Considering the uncertainty and preliminary nature of this investigation, the most likely peak discharge through the Bohemia Spillway for the 2011 flood is estimated to be 30,000 to 50,000 cfs. An engineering report describing pre-construction designs estimated a cross sectional area of flow of 145,700 sq ft, and an estimated velocity of 2.5 ft per second (implied average flow depth is 2.5 feet). Therefore, it was estimated the spillway could flow 350,000 cfs in 1927 (Orleans Levee Board, 1926). The Orleans Dock Board was reported to have measured discharge around March 1927 as 133,000 cfs through the Bohemia Spillway, and suggested it could flow as much as 250,000 cfs (Times Picayune, 1927). A URS report dated 1984 reported that measured discharge in the Bohemia Spillway for the 1927 flood was 300,000 cfs (URS, 1984). However, the flow through Bohemia was influenced by the artificial crevasse at Caernarvon in 1927, which was estimated to flow at 275,000 cfs (La. State Engineer Report, circa 1929). At the time of the URS report (1984), URS estimated the peak flow through Bohemia Spillway could be as large as 177,000 to 477,000 cfs. According to the URS report, efforts were made to reduce discharge through the Bohemia Spillway. Examination of the West Point a la Hache hydrograph shows that historically river stage exceeded the peak stage in 2011 (7.66 feet), and was as great as 9 feet. Therefore, it is probable that historical peak flow through the Bohemia Spillway was substantially higher than in 2011. The lower stages at West Point a la Hache in recent floods, may be explained by increased flows at sites such as near Ostrica and Fort St. Phillips.

Bohemia Spillway Overbank Flow Patterns

As described previously, the Bohemia Road overflow survey was analyzed into 18 different reaches. These analyses along with geomorphic and other cumulative observations in the spillway provide a basis for a hydro-geomorphic classification and description. The length of the spillway was described as generally as one of the following hydro-geomorphic types:

Trenasses-Back levee Canal- Examination of aerial photography reveals that much the marsh side of the natural levee has a rectilinear pattern of small channels. These are typically less than 30 feet wide and less than 6 feet deep. It is likely these canals are trapper canals that pre-date the creation of the Bohemia Spillway in 1926. Due to the uncertainty, these are referred to as trenansses simply because of their small dimensions. A subset of these trenasses actively captures overbank flow, which is then generally discharged into a back canal which nearly runs the length of the spillway.

Natural Levee-Back Levee canal- This classification is entirely in the lower reach of the Bohemia Spillway where the Harris Bayou tributary drainage is present. This is an integrated drainage pattern flowing across and away from the natural levee and to Breton Sound. The drainage is slightly influenced by some linear trenasses, but most flow appears to be captured initially by the natural meandering drainage. This flows into and across the back levee canal. Flow continuing past the back levee does reach the shallow bay of the larger Breton Sound. In the late 1930's Harris Bayou breeched into the river and was dammed in 1940 (LA. State Board of Engineers, circa 1940).

Oil and Gas Canals – Oil and gas canals were dredged with development of the Potash and Quarantine Bay oil and gas field first discovered in 1937/1938. Corps of Engineers' land change maps indicate canal dredging was primarily from 1932 to 1956, but as late as 1974 (Britsch and Dunbar, 1996). These canals have typical widths of south Louisiana oil and gas canals with a typical rectilinear distribution. However, the canals are often shallower than typical oil and gas canals, and some are as shallow as two feet. Some of these canals were dredged relatively close to the river and therefore, at a high bank elevation since they are cut into the natural levee. These canals significantly affect local overflow patterns through the spillway. For example, many of the oil gas canals have prominent erosional gullies near their termination close to the river. Some of these gullies had significant flow during the flood (2,000 to 3,000 cfs). The spoil banks are generally present and where present may deflect or impound flow.

Road Blocking or Deflecting Flow – In a few places it was apparent that the road elevation was significant enough to impede or deflect flow. This was most evident near the upper end of the Bohemia Spillway where two parallel roads are present, which together significantly reduce the discharge.

Artificial River Levee – At three locations in the Spillway the road is more uniformly elevated (7 to 9 feet), and there is also present a partial concrete embankment. It is strongly suspected these are remnants of the original front line river levee constructed prior to 1926. Records indicate that at least 90% of the "front line" river levees were removed in February 1925 (LA. State Board of Engineers, circa 1929) and September 1926, and thus brackets the physical creation of the spillway. A pre-construction engineering report says a short "spur" of the Bohemia levee would be left in place at the upper end of the spillway (OLB, circa 1926). The remaining levees represent approximately 3% of the length of the spillway. It is interesting that during the 2011 flood these remnant levees were not overtopped even though they presumably have not been maintained as levees since pre-1926. Therefore, this implies that if the levees had not been removed in 1926, they would still be effective at preventing flow into the Bohemia Spillway even during the current flood events.

Constructed Hydrologic features. e.g. culverts, conveyance canals - There are basically two types of engineered hydrologic structures in the Bohemia Spillway. Round metal culverts have been placed underneath the Bohemia Road at various times to reduce damage to the road when it is overtopped by river overflow. These culverts vary from approximately 2.5 feet to 6 feet in diameter. Altogether there are eight, round, metal culverts at four locations that have been identified in-place in 2011. The other type of constructed hydrologic feature is a structure composed of 4 concrete box culverts (4 feet by 4 feet) located near the upper end of the Bohemia spillway. These culverts have adjacent conveyance canals running toward the river and to the Back levee canal. We refer to this feature as the Bohemia diversion. It was built in 1979 by Plaquemines Parish, is currently inoperable, and prior to the 2011 flood largely blocked by siltation.

The overall flow through Bohemia Spillway is roughly a three-way spilt through three of the hydro-geomorphic types, i.e. Natural Levee/Bayou Drainage and Back Levee Canal, Trenassse and Back Levee Canal, and Oil and Gas Canals. Analyses suggest that the flow is slightly suppressed by the Oil and Gas canals, and by the presence of the Road Blocking or Deflecting Flow reaches. Overall the effect of flow reduction due to anthropogenic features is probably less than 15%.

Conclusions

Specific Bohemia Spillway discharge estimates are preliminary, but the total discharge for the peak flood condition of river stage in 2011 is estimated to be 30,000 to 50,000 cfs. Prior estimates of historical discharges are being investigated, but suggest that the discharge through the Bohemia Spillway has been reduced over time. More detailed forensic and historical investigation may substantiate this important aspect of the spillway history. Flow patterns can be readily characterized through the various reaches of the spillway, and the majority of the discharge is through hydro-geomorphic types that are similar to what might be expected from overbank flow across a river's natural levee, i.e. flow through small trenasses or bayous. Oil and gas canals (and spoil banks) short circuit flow and also locally impound river water. Nevertheless, the Bohemia Spillway provides great insight into the physical and biologic processes that have been occurring for over 85 years due to the river's reconnection to the adjacent wetland landscape.

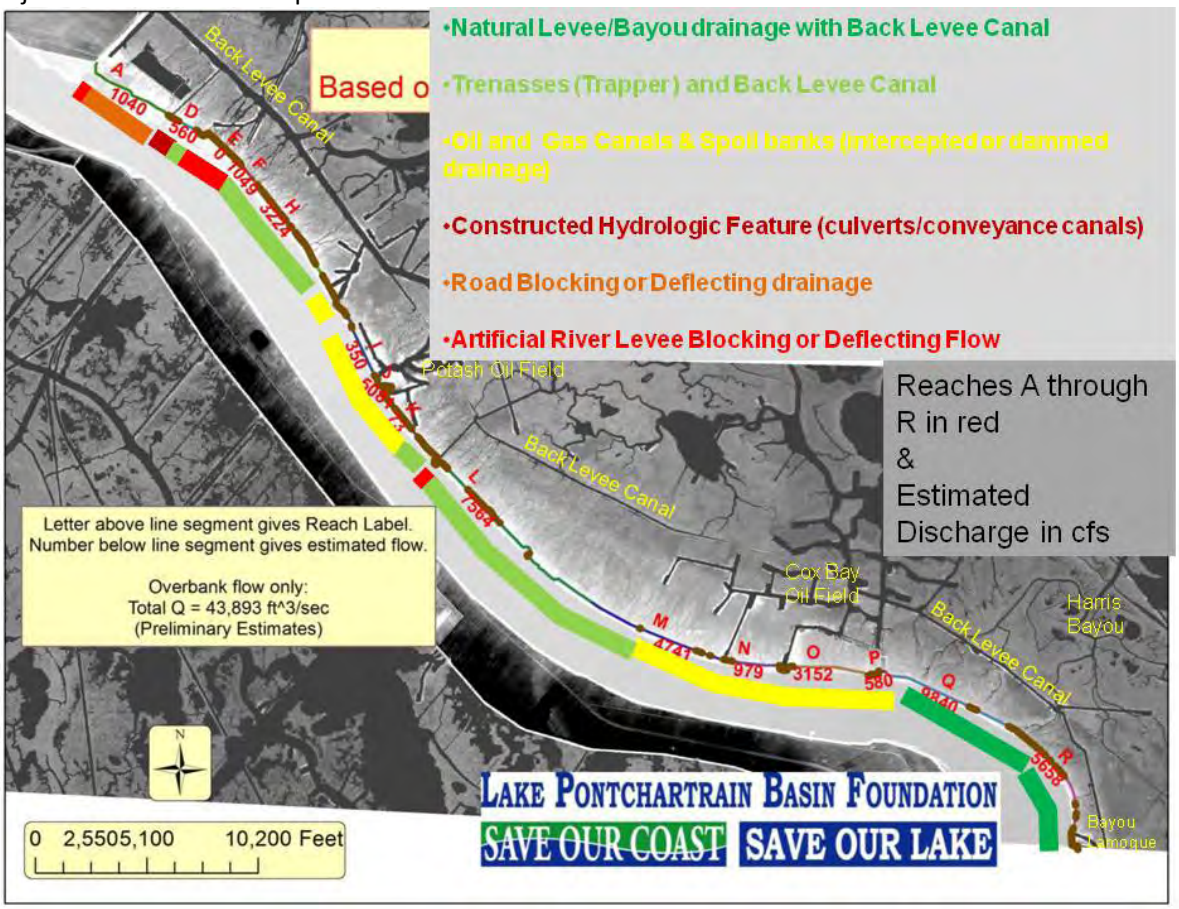

Figure 3: Classification of the hydro-geomorphic areas identified for the various reaches through the Bohemia Spillway,

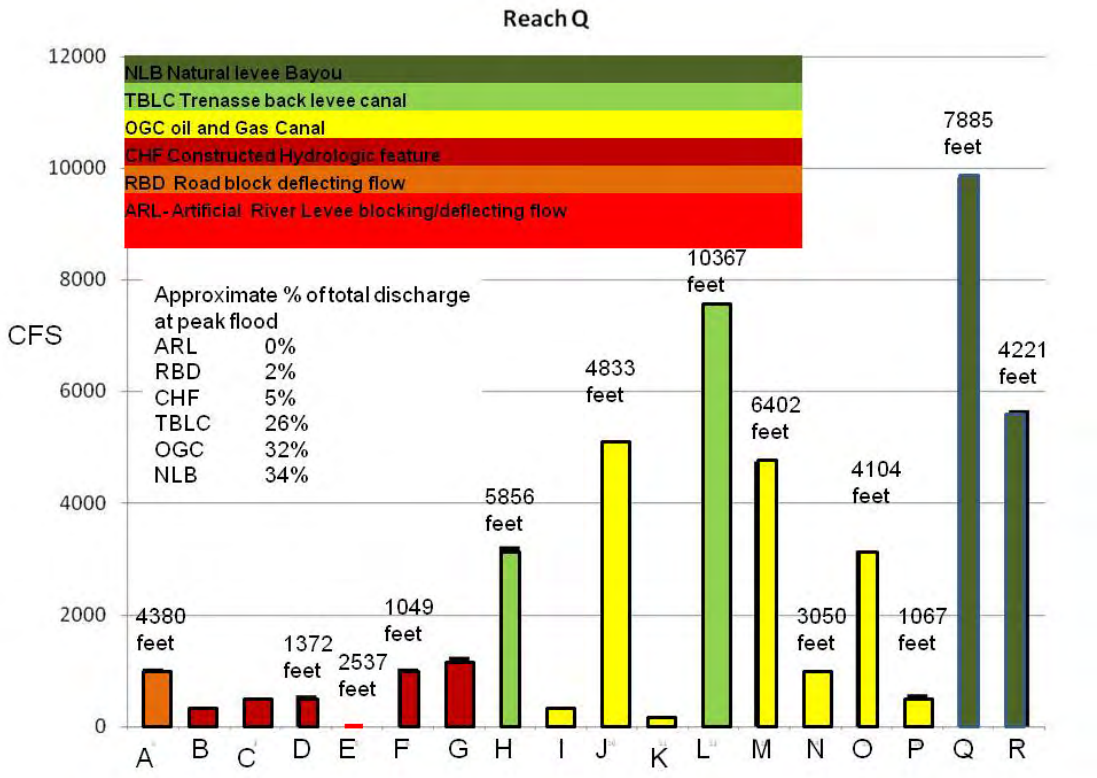

Figure 4: Preliminary Discharge estimate for the various reaches through the Bohemia Spillway and the hydro-geomorphic classification. The majority of discharge occurs in three types: Natural levee/bayou, Trenasse/Back canal, and Oil and gas canal.

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