REPORT FOR
BRAZOS RIVER EROSION STUDY

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1. BACKGROUND

Due to the accelerated bank erosion along the Brazos River following significant flooding in 2015, 2016 and Hurricane Harvey in 2017, the City of Richmond, Texas contracted with Huitt-Zollars, Inc. to conduct a geomorphologic study of the bank erosion along the Brazos River. About eight (8) miles of the river flow through the City. This reach includes two (2) US Highway 90A bridges and the Union Pacific Railroad bridge.

For this study, Huitt-Zollars performed geomorphologic analyses to project the meander migration of the river during the next thirty (30) years using two (2) methods - The Time Sequence and Extrapolation Method (TSEM) and the Observation Method for Meander Migration (OMMM) developed by Dr. Jean-Luis Briaud, PhD, PE at Texas A&M University. The exhibits showing the results of the TSEM analysis are included in Attachment A. Results of the OMMM analysis are included in Attachment B.

Following Hurricane Harvey in August/September 2017, the Brazos River, as measured by the United States Geologic Service (USGS) Gauge #08114000 (Richmond Gauge) in Richmond, Texas located just downstream of the US 90A eastbound bridge, experienced its highest ever-recorded flow (122,000 cfs) and water surface elevation. The gauge is set at 27.94’ above NVGD29, therefore a gauge reading of 55.19’ which equals 83.13’ above mean sea level. This resulted in significant accelerated erosion of the river’s banks, up to 30-40 feet of bank loss in some locations.

2. HISTORICAL FLOWS IN THE BRAZOS RIVER

The graph below shows the plot of over 24,000 daily mean flows (January 1, 1953 through December 31, 2018) in the Brazos River as measured and recorded at the Richmond Gauge by the United States Geologic Survey (USGS). The daily mean flow in the river has exceeded 100,000 cubic feet per second (cfs) only eleven (11) times. Six (6) of these flows occurred in May-June 2016 and in August-September 2017. The other five (5) events occurred over sixty (60) years ago in May 1957. Hurricane Harvey produced the two (2) highest ever-recorded daily mean flows on August 31 and September 1, 2017 with both flows exceeding 122,000 cubic feet per second (cfs).


![Daily Mean Flows (CFS)](image-url)

In summary: Over the past sixty-five (65) years, the floods in May-June 2016 and in August-September 2017 produced five (5) of the top eleven (11) highest daily mean flows ever-recorded on the Brazos River in Fort Bend County.

3. **GEOMORPHOLOGY OF THE BRAZOS RIVER**

A river’s meander belt is defined as the area within which river shifts its channel across its floodplain (meanders) from time to time. The meander belt for the Brazos River is indicated below by the area in yellow. It is defined by a band of alluvial soils (deposits of sand, silt, clay, and gravel) varying in width to around six (6) miles. Within this area are the remnants of old (ancient) oxbows indicating the past locations of the river. The meander belt is bordered on both side by higher elevations and the Beaumont Formation consisting primarily of clay. It is within this belt the Brazos River has moved since its beginning, creating oxbows, Oyster Creek and other creeks, bayous and gullies.

Typically, a river’s meander belt ranges in width from 15 to 20 times the river’s width. Interestingly, the width of the Brazos River is around 400 feet. With a meander belt of over 6 miles in width, this results in the Brazos River’s meander belt being over 70 times its width. This is three to four times wider that a typical meander belt. This seems to indicate that the Brazos River, through history, meanders 3 to 4 times farther than most rivers.

Fortunately, the majority of the City of Richmond is located on the Beaumont Formation which is at a higher elevation and contains approximately 10-15 feet more clay material atop the sand layer which is fairly prevalent throughout Fort Bend County. This additional layer of clay is located near the ordinary
high water mark of the river and is less erodible than the silty-sand layer that exists throughout most of the alluvial flood plain. Together, the higher elevation and this layer of clay slow the migration of the river into the Beaumont Formation area.

4. MEANDER MIGRATION BY TIME SEQUENCE AND EXTRAPOLATION METHOD

Huitt-Zollars, Inc. used available past aerial images of the river to perform a fluvial geomorphological assessment using the Time Sequence and Extrapolation Method to project the anticipated meandering of the river over the next thirty (30) years. This method analyzes the historical meander migration of the river based on developing migration rates from historic aerial photographs, by considering the ratio of the radius of the meander divided by the river’s width, by extrapolating meander migration direction and by projecting the extent of meander migration based on these parameters over the next thirty (30) year period.

Seven (7) areas of interest (AOI) were investigated along the river in Richmond. The location of these seven (7) AOIs are shown on the exhibit below.

For the Time Sequence and Extrapolation Method, Huitt-Zollars developed best fit circles which were superimposed on the banks of the river for each aerial photograph. In the case where the radius of a circle increases in subsequent aerials, the meander bend is expanding. The comparison of subsequent circle centroids indicates whether the meander is extending, moving or rotating downstream. The methodology estimates if and how meander bends are migrating by calculating the magnitude and direction of centroid movement between two aerial photographs. These circles with their varying radii and centroid locations give a visual indication of the movement of the meander.

The forecasted meander migration direction for the Year 2048 is shown to be in the same direction as the migration shows in the aerial photographs used for this analysis. Attachment A contains the results of this investigation which was concluded prior to Hurricane Harvey in August/September 2017.
5. TEXAS A&M UNIVERSITY OBSERVATION METHOD FOR MEANDER MIGRATION (TAMU-OMM)

The TAMU Observation Method for Meander Migration (TAMU-OMM) results in a site specific meander migration prediction based on the past observed movement of the meander, the past flow hydrograph, the erodibility of the soil at the meander site, and an assumed future hydrograph. A point is selected on the river’s outer bank as well as a direction along which the migration is to be predicted. Results from previous soil samples taken along the river in both the Beaumont Formation and the Alluvial floodplain, tested in the Erosion Function Apparatus (EFA) at Texas A&M University, were used in our analyses. TAMU-OMM uses the EFA test results along with the past observations to develop a site specific prediction model. This model is used with the assumed future hydrographs to calculate the future meander for the selected point and direction of the meander. A deterministic prediction can be made by using one prediction of the future hydrograph. In addition, predictions of many equally possible hydrographs in a probabilistic manner can be made to perform a probabilistic migration analysis.

The TAMU-OMM was performed by Huitt-Zollars, Inc. to develop projected migration distances at the seven (7) locations along the river. Results of this analysis is contained in Attachment B.

6. SUMMARY

Huitt-Zollars, Inc. conducted a geomorphologic analysis of seven (7) areas of interest along the Brazos River in Richmond to project the extent of meander migration over the next thirty (30) years. The two (2) methods used for this analysis were the Time Sequence and Extrapolation Method (See Attachment A) and the Texas A&M University Observation Method for Meander Migration (See Attachment B).

The results of both methods compared favorably for all seven (7) areas of interest.

Area of Interest 1 projects some movement of the meander to the northeast and downstream of the intake for the City’s Surface Water Plant. Consideration should be given to closely monitoring AOI 1 due to its proximity of the intake. Although this meander is somewhat downstream of the intake, its interaction with the intake and localized erosion of the banks near the intake should be monitored.

Area of Interest 2 projects some movement of the meander to the northwest into undeveloped property.

Area of Interest 3 projects meander migration to the north which will continue impacting residences in this area. This AOI has significant consequences should it occur.

Area of Interest 4 also projects the movement of the river meander to the southeast continuing towards residences. This AOI has significant consequences should it occur.

Area of Interest 5 is directly downstream of AOI 4 and on the opposite side of the river. Meander migration is projected to the west into undeveloped terrain.

Area of Interest 6 projects the river to continue is meander migration to the east – southeast impacting the subdivision. This AOI has significant consequences should it occur.

Area of Interest 7 projects the river’s meander to move downstream and impact the west abutments of the UPRR and TxDOT’s US 90A bridges as well as properties and structures along the west bank of the river. This AOI has the most significant consequences associated with this projected meander migration.
ATTACHMENT A

Projected Meander Migration based on Time Sequence and Extrapolation Method
Legend

Time-Sequence Map 2013.dwg Polyline
<all other values>

Layer

RIVER ALIGNMENT 1951
RIVER ALIGNMENT 1970
RIVER ALIGNMENT 1979
RIVER ALIGNMENT 1989
RIVER ALIGNMENT 2016
RIVER ALIGNMENT 2048
1951 CIRCLE
1970 CIRCLE
1979 CIRCLE
1989 CIRCLE
2016 CIRCLE
2048 CIRCLE
LEVEE
ATTACHMENT B

Projected Meander Migration based on Texas A&M University Observation Method for Meander Migration (TAMU-OMM)
Legend

Probabilistic Linework 2013.dwg Polyline
<all other values>

Layer

RIVER ALIGNMENT 1951
RIVER ALIGNMENT 2016
2048 RIVER MEAN PROJECTION
DIRECTION LINES
LEVEE

Exhibit 5B
Drawn by: JG
Date: 01/07/2019

Scale: 1" = 200'

BRAZOS RIVER - RICHMOND
AREA OF INTEREST 5

BRAZOS RIVER