

Brazos River Flood Study

City Council Presentation

May 18, 2021



US Army Corps of Engineers ${\scriptstyle \odot}$







Introduction

> Why are we here?

- New hydrologic information determined by the US Army Corps of Engineers results in higher stormwater flowrates in the Brazos River, which increases the 100-year floodplain by approximately 3 feet through the City of Waco.
- This new floodplain may impact existing properties, redevelopments, and new developments.

WATER RESOURCE INVESTIGATION BRAZOS RIVER, VICINITY OF WACO, TX

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Audience: City of Waco







Foundational Basis

- Develop numerical models
- Develop data sets

Analysis

- Update technical basis for the NFIP mapping and determine regulatory flood levels
- Assess how the watershed and reservoirs will respond to extreme storm events
- Evaluate reservoir operations during extreme events
- Decisions Policy and Action Recommendations





WHY: INCREASING FREQUENCY AND MAGNITUDE OF PRECIPITATION EVENTS 24 Hour Rainfall for 10 Sq. Mi.

- Regional observed storms
 - USACE extreme storm database
 - 24-hour rainfall for 10 mi²
- Grey band was design standard (100-year) until 2018
- Blue X's points are 2010-2019 storms that exceed 100-year
 - 20+ events exceeded the 100-yr design standard (2010-2019)





STORM ANALYSIS

- ~\$150B damages in Texas, (2015 to present)
- ~160 fatalities in Texas (2015 to 2017)





2007 AND 2015 FLOODING



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2007

o 39,900 cfs

 $_{\odot}$ 13.99 inches of rain in May

2015

- Ended 2014 in significant drought
- 15 18 inches of rainfall on Brazos Basin (Whitney, Aquilla, and Waco)
- 34% 55% flood pool capacity used
- o 30,800 cfs
- Labyrinth weir issues



July 2007 Flood Along Honey Lane





Maco Tribune-Herald



2015 Flooding, Waco, Texas



FLOOD IMPACT DETERMINATIONS







RESERVOIR DATA

 3 Dams provide flood protection for the City of Waco and McLennan County

Whitney Reservoir

- Construction: Initiated May 1947
- Impoundment: December 1951
- Location: RM 442.4 on the Brazos River
- Drainage area: 17,656 square miles
- Runoff: 2.12"
- Regulated release: 25,000 cfs
- Waco Reservoir
 - Construction: Initiated June 1958
 - Impoundment: February 1965
 - $_{\circ}$ $\,$ Location: RM 4.6 on Bosque River $\,$
 - Drainage area: 1,670 square miles
 - Runoff: 7.96"
 - \circ Regulated release: 5,000 30,000 cfs
- Aquilla Reservoir
 - Construction: Initiated August 1976
 - Impoundment: April 1983
 - Location: RM 23.3 on Aquilla Creek
 - Drainage area: 252 square miles
 - Runoff: 10.86"
 - Regulated release: 3,000 cfs









EFFECTS OF DAM REGULATION – HISTORICAL RECORD



- 3 dams are highly effective in providing flood protection for City of Waco
- Highly regulated watershed (82%)
- Must use numerical modeling to determine the threat from flooding





HYDROLOGY - WHY DID THE 100-YR FLOW INCREASE

- Employed numerical modeling techniques
 - State-o-the-art numerical modeling techniques employed
 - $\circ\,$ State-o-the-art applications employed
 - Consistent with other statewide
 Watershed Hydrology Assessments
 - Technology changes, improved capabilities
 - $\circ\,$ Results verified with observational data
- Planned location for Aquilla shifted
 1086 EIS didu't reflect as built location
 - 1986 FIS didn't reflect as-built location
 - Drainage area increased
 - Analysis techniques









- Computed runoff ranges from 99,400 cfs to 148,000 cfs
- Reflects a 2% 61% increase in runoff
- 20% increase central Waco

Location	Drainage Area (sq. mi.)	100-Year Flow (cfs)		
		This Study	FIS Study	
d/s of Aquilla Creek	360	115,000	71,500	
u/s of Bosque River	420	102,000	84,100	
d/s of Bosque River	427	102,000	84,100	
at SH 6 (Waco gage)	464	101,000	84,100	
u/s of Tehuacana Creek	475	99,400	81,400	
d/s of Tehuacana Creek	775	153,000	145,300	
at State Highway 7	1,103	148,000	145,300	



HYDRAULIC SUMMARY AND 1986 FIS STUDY COMPARISON



Increase in 100-year water surface profile Difference ranged from 1'-5' Larger 100-year peak flows

 Aquilla Dam situated at different location in FIS study (RM 20.7) than this study (RM 23.3)

Original study - limited extents Future hydraulic challenges

 Labyrinth weir and debris accumulation impacts Comparison of 1986 FIS 100-year Water Surface Elevations to This Study

	1986 FI	S	This Stud	у	
Location	Q (cfs)	WSE (ft)	Q (cfs)	WSE (ft)	WSE Diff. (ft)
Brazos River					
D/S of Lake Brazos Dam	81,400	384.6	102,000	386.3	1.7
IH 35	81,400	387.7	102,000	390.2	2.5
Franklin Avenue	81,400	388.4	102,000	391.5	3.1
Washington Avenue	81,400	388.5	102,000	391.8	3.3
Waco Drive/US 84	81,400	389.4	102,000	392.5	3.1
Herring Avenue	81,400	390.3	102,000	393.9	3.6
MLK Boulevard	84,100	391.9	102,000	396.1	4.2







COMPARISON OF DAM INFLOWS TO UNREGULATED AREA RUNOFF



- For a large storm impacting both regulated and unregulated areas
 - Unregulated areas peak 1st
 - Dams crest more slowly
 - For extreme events that impact both regulated and unregulated watersheds:
 - The Waco area will experience 2 peak discharges
 - Peak from unregulated area
 - Peak releases from 3 dams 3+ days later





TRANSPOSED STORMS – RESULTS

- New Braunfels storm btw 100-yr to 500-yr. mitigated by dam operations
- Dawson storm peak discharge resultant from surcharge operations at 3 dams & unregulated area
- Brenham storm peak discharge resultant from surcharge operations at 3 dams

Peak Flows at Brazos River at Waco Gage				
Storm		Flow (cfs)		
Albany 1978		190,100		
New Braunfels 1998		114,100	\triangleright	
Canyon 2002		233,600		
Larto Lake 2008		164,700		
Dawson 2015	(3-day warning)	190,400	\triangleright	
Dawson d/s 2015	(1-day warning)	225,000	>	
Brenham 2016	(3-day warning)	181,900	\triangleright	
Dawson d/s 2015 500-yr loss rates		245,000		





DELIVERABLES

- Numerical models
- Digital GIS based outputs
- Basis for preparedness planning
- Presentations
- Reports
 - \circ Volume 1 NFIP mapping analysis and data
 - \circ Volume 2 Dam operational/storm shift data and analysis







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- U. S. Army Corps of Engineers Kansas City District
- United States Geological Survey
- University of Texas at Arlington
- Walker Partners



Project History

- Updates to the existing FEMA Base Flood Elevations (BFE's) have not been performed since 1987.
- FEMA's most recent Flood Insurance Study (FIS) did NOT:
 - Update hydrology and hydraulic modeling of the Brazos River.
 - Account for growth and development along the Brazos.
- The Corps of Engineers' 2019 Hydrologic Study is now available and is the best available data; however, the Corps did not update the Flood Insurance Rate Maps (FIRMs).









Eflective: September 26, 2008 Federal Emergency Management Agency FLOOD INSURANCE ETUDY NUMBER #SOCYODA:



Study Extents

- Study extents are approximately 5-miles upstream of the confluence of the Brazos and Bosque Rivers and approximately 1-mile downstream of US 77.
- Remapping efforts within the City of Waco, City of Bellmead, and the City of Lacy Lakeview are to occur.
- Updated floodplains and Base Flood Elevations within the extents of the study.





Project Updates

- Updates include the Lake Brazos Labyrinth Dam, constructed in 2008, Baylor Football Stadium, Track and Field Stadium, and Baseball Facility.
- Other updates include new topographic information based on field surveys and updated LIDAR mapping of the Brazos.
- Updated discharge data associated with Atlas-14 Rainfall developed by National Oceanic and Atmospheric Administration (NOAA) was incorporated.









Flow Discharge Increases through Waco

Based on the 2019 Corps of Engineers' Study, the flows in the Brazos increased through Waco.

Project Discharges (CFS)					
Location	1987 FEMA Flows	2019 USACE Flows			
Lake Shore Dr.	84,100	104,000			
N. MLK Jr. Blvd	84,100	104,000			
E. Waco Drive.	81,400	102,000			
Washington Ave.	81,400	102,000			
I-35	81,400	102,000			
US-77	81,400	101,000			
Lake Brazos Dam	81,400	101,000			





Example Results

Water surface elevations are expected to increase up to 3.2 ft. from that of the Flood Insurance Rate Maps.

This is a result of the increased stormwater flowrates.





Summary of Results





What Happens Next?

- So now that we have new 100-year stormwater flowrates <u>and</u> the resulting new 100-year floodplain, what happens next?
 - 1. FEMA will review and approve the new 100-year floodplain maps (which the City uses to regulate and manage development in, and near, the floodplain).
 - The Consulting Team, in collaboration with City staff, is preparing updates to the <u>Stormwater Policy</u> and <u>Drainage Design Criteria</u> with recommendations for updates to the <u>Flood Protection Ordinance</u>.