
Track C: Case Studies:
"Navigating Floodplain & Drainage Challenges for Transportation Projects, City of Mesquite"
TFMA Annual Conference;
March 26th, 2025; 2:40-3:10 (30min)
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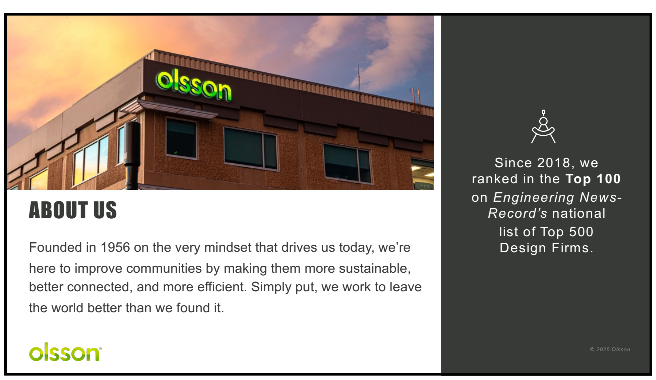
ABOUT US
Founded in 1956 on the very mindset that drives us today, we're here to improve communities by making them more sustainable, better connected, and more efficient. Simply put, we work to leave the world better than we found it.
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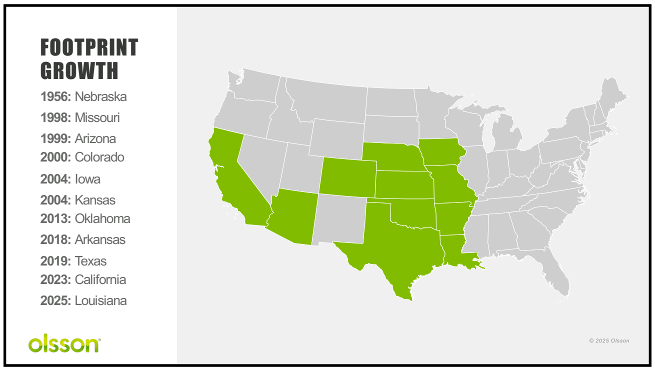
FOOTPRINT GROWTH
1956: Nebraska
1998: Missouri
1999: Arizona
2000: Colorado
2004: Iowa
2004: Kansas
2013: Oklahoma
2018: Arkansas
2019: Texas
2023: California
2025: Louisiana
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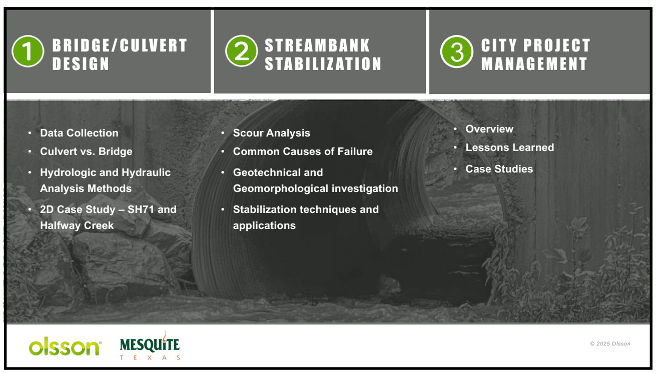
1 BRIDGE/CULVERT DESIGN
2 STREAMBANK STABILIZATION
3 CITY PROJECT MANAGEMENT
• Data Collection
• Culvert vs. Bridge
• Hydrologic and Hydraulic Analysis Methods
• 2D Case Study – SH71 and Halfway Creek
• Scour Analysis
• Common Causes of Failure
• Geotechnical and Geomorphological investigation
• Stabilization techniques and applications
• Overview
• Lessons Learned
• Case Studies
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Bridge & Culvert Design
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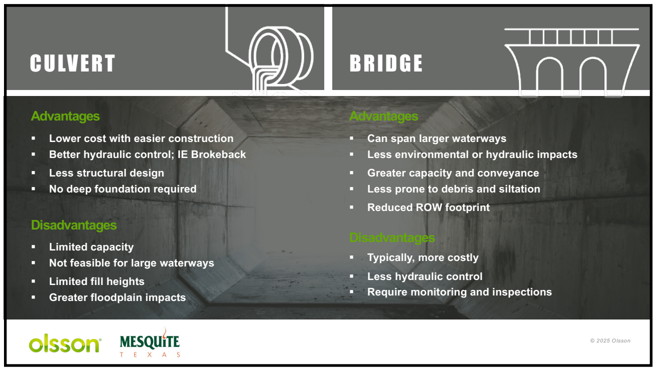

CULVERT
BRIDGE
Advantages
Lower cost with easier construction
Better hydraulic control; IE Brokeback
Less structural design
No deep foundation required
Disadvantages
Limited capacity
Not feasible for large waterways
Limited fill heights
Greater floodplain impacts
Advantages
Can span larger waterways
Less environmental or hydraulic impacts
Greater capacity and conveyance
Less prone to debris and siltation
Reduced ROW footprint
Disadvantages
Typically, more costly
Less hydraulic control
Require monitoring and inspections
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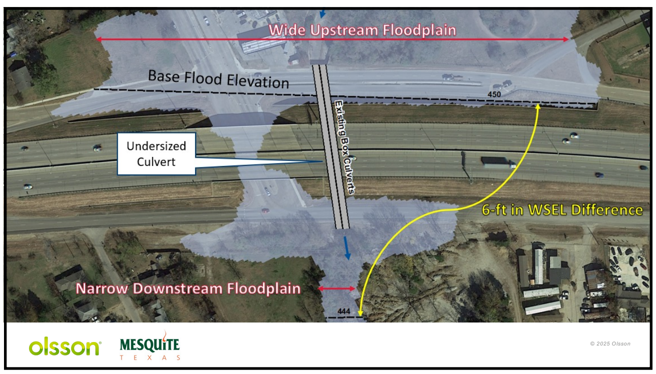

Wide Upstream Floodplain
Base Flood Elevation
450
Existing Box Culvert
Undersized Culvert
6-ft in WSEL Difference
Narrow Downstream Floodplain
444
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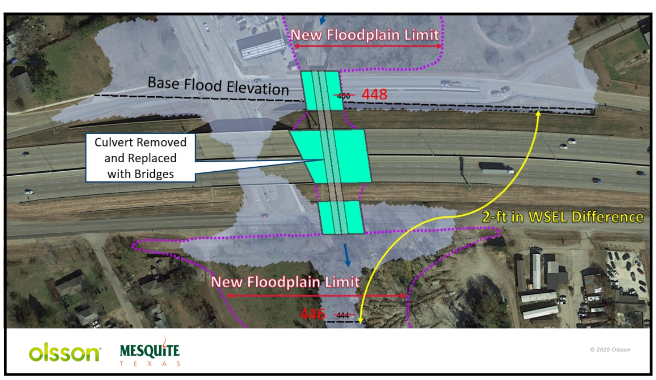

New Floodplain Limit
Base Flood Elevation
448
Culvert Removed and Replaced with Bridges
2-ft in WSEL Difference
New Floodplain Limit
446
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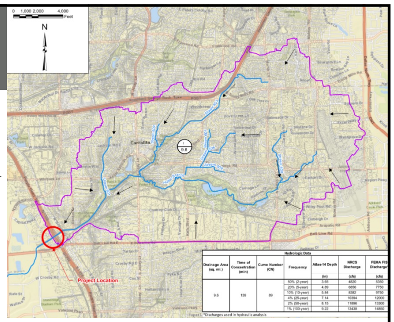
Hydrologic Analysis Methods

- Previous Studies/FEMA FIS Reports
- Rational Method <200ac
- Unit Hydrograph Method (HEC-HMS)
  - Drainage Area between 100-ac and 10 sq. mi.
  - Rainfall Source – NOAA Atlas-14
  - Storage, Losses and Timing
  - Rain - on - Grid
- USGS Gage Analysis (HEC-SSP, Peak FQ)
- Regional Regression Equations
  - DA > 10 sq. mi, not used for urban watershed with reservoirs



Hydrologic Data						
Drainage Area (sq. mi.)	Time of Concentration (min)	Curve Number (CN)	Frequency	Atlas-14 Depth (in)	NRCS Discharge (cfs)	FEMA FIS Discharge* (cfs)
9.6	139	89	50% (2-year)	3.65	4820	5350
			20% (5-year)	4.89	6856	7750
			10% (10-year)	5.84	8382	9750
			4% (25-year)	7.14	10394	12000
			2% (50-year)	8.15	11896	13300
			1% (100-year)	9.22	13438	14850

*Discharges used in hydraulic analysis

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BRIDGE HYDRAULICS

Off-system Bridges

- Typically, Un-studied A-Zone
- Less stringent hydraulic criteria
  - Free-board and 1' of rise
- May allow Overtopping at overbanks

On-system Bridges

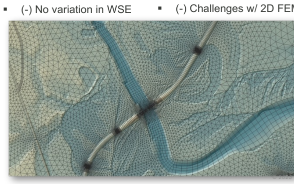
- Urban Conditions
- AE Zone, No-Rise Condition
- Split Flow Conditions wide floodplains
- Multiple Opening Hydraulics - Conveyance

Basic Modeling

- 1D HEC-RAS Model
- (+) Utilize Cross-sections
- (+) Less data required
- (+) Easy and Quick to apply
- (+) Efficient and Familiar
- (-) Non-continuous terrain
- (-) Can't Simulate lateral Q
- (-) No variation in WSE

2D Modeling

- HEC-RAS 2D Model Unsteady
- (+) Continuous Terrain
- (+) Simulates Lateral Spreading
- (+) Momentum exchange
- (-) Requires more Data
- (-) More time and resources
- (-) Requires more experience
- (-) Challenges w/ 2D FEMA FW



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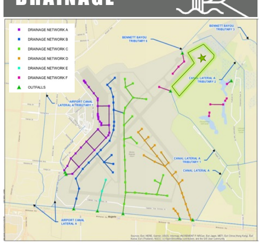
STORM DRAINAGE



Storm-drainage Modeling for Transportation

- Traditional Geopak Drainage 1D Model
  - (+) Easy for production of plans and hydraulic data sheets
  - (+) Ties to Roadway geometry (.GPK) and COGO
  - (+) Utilizes Drainage Cell Library (.CELL)
  - (-) Outdated Software, no-longer used on TxDOT
- Open Roads Drainage Utilities (DU) 3D Model
  - (+) Integrates with new Roadway ORD Model
  - (+) Conflicts can be avoided with utilities and bridges
  - (+) All hydraulic data is saved in cells not separate tables
  - (+) Geopak Reports are replaced by Flex-tables
  - (-) Requires experience designer

(-) Plan production within the model

Storm-drainage Modeling for H&H Studies

- XPSWMM / PCSWMM / Storm CADD / ICM
- (+) Can Combine storm-sewer & surface water
- (+) Provide detailed information of inflow/outflow to and surcharge from storm sewer system
- (+) Surface water modeling can be 1D or 2D
- (-) Expensive

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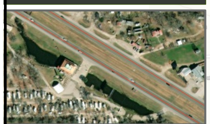
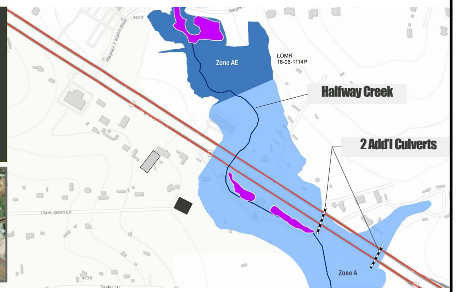
SH 71 at Halfway Creek | *Bastrop, Tx*

2D CASE STUDY





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SH 71 at Halfway Creek | *Bastrop, Tx*

Model Review Findings (Schematic)

- Hydrology – Update sub basins with storage/routing, move to HMS
- Flow Increase Downstream, storage loss upstream of bridge
- Hold current Base Flood Elevation within ROW, no rise 1% WSEL
- Complex - split flow, multiple tributaries, hydrology/timing
- Eliminate road overtopping of SH71 (flooding initiates at 10% AEP)
- Flooding Complaints on both sides of SH71 – Hargis Memo
- Existing Structure straddling creek banks – 5 culverts & weir

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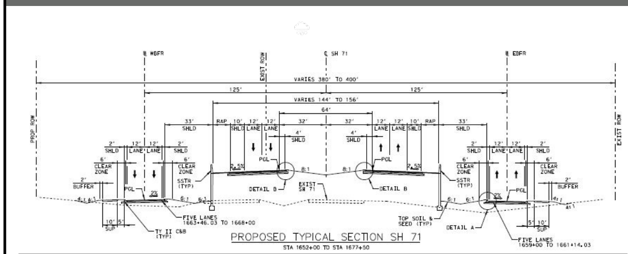
SH 71 at Halfway Creek | *Bastrop, Tx*



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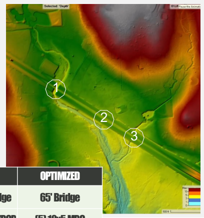
SH 71 at Halfway Creek | *Bastrop, Tx*

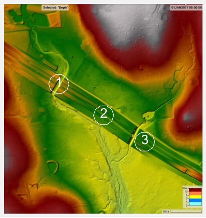
Utilized 2D modeling to:

- Solve a complex flooding issue of a Major Collector while still adding new Frontage and ML.
- Optimized Bridge span lengths, Culvert size
- Minimize roadway embankment and retaining wall height.

2D Existing Results



2D Proposed Results



LOCATION	STRUCTURE	SCHEMATIC	OPTIMIZED
1	Halfway Creek Bridge	35'-70'-35' Bridge	65' Bridge
2	Commercial Culvert 6	Extend exist 36"RCP	(5) 10x5 MBC
3	Unnamed Tributary	(3) 9x5 MBC	70' Bridge

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Scour at Bridges

What is the most common cause of failure of bridges?

Scouring of material from bridge foundations

Scour Definition:

Scour is the result of erosive action of running water, excavating and carrying away materials from the bed and banks of streams

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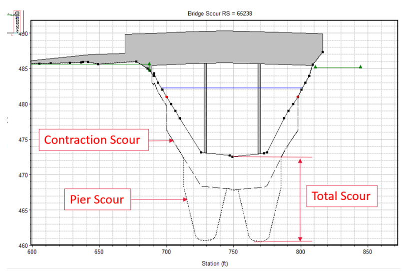
Scour Analysis



- Three components of Total Scour:
  - Long Term aggradation/degradation
  - Contraction Scour
  - Pier/Abutment Scour
- Scour Countermeasures
  - Rock Rip rap
  - Gabion Mattress
  - Concrete Lining

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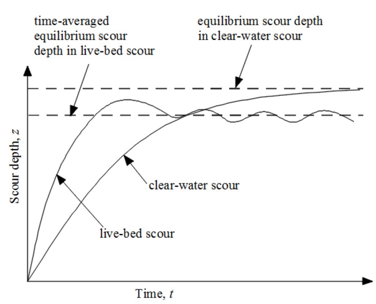
Contraction Scour Conditions



- Live-bed Scour
- Clear-water Scour

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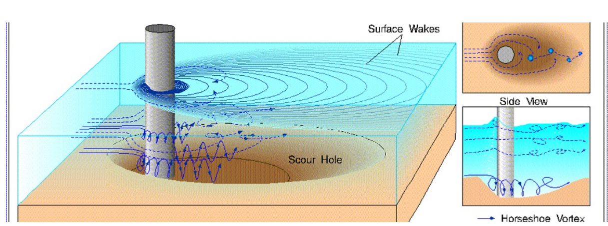
Local Scour - Pier



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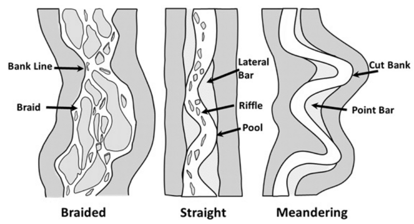
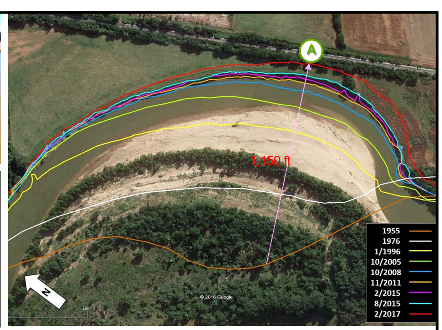
Instability and Stream Planform

Stream planform is:

- the shape of a stream when viewed from above
- useful in understanding stream morphology and potential stream response to change



Brazos River near Highbank, TX



Brazos River near Highbank, TX

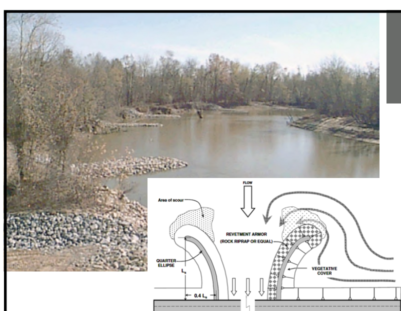
BRAZOS RIVER
Highbank, TX

Bank Retreat ~1,200 ft in 60 years

BEFORE (2017)

AFTER (2018)

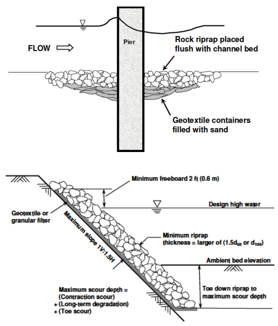
HYDRAULIC COUNTERMEASURES:
RIVER TRAINING STRUCTURES



TRANSVERSE STRUCTURES
Impermeable spurs (jetties, groins, wing dams)
Permeable spurs (fences, netting)
Transverse dikes
Bendway weirs/Stream barbs[1]
Hardpoints
Drop structures (check dams, grade control)
Embankment Spurs
LONGITUDINAL STRUCTURES
Longitudinal dikes (crib/rock toe/embankments)
Retards
Bulkheads
Guide banks
AREAL STRUCTURES/TREATMENTS
Jacks/tetrahedron jetty fields
Vanes
Channelization
Flow relief (overflow, relief bridge)
Sediment detention basin

HYDRAULIC COUNTERMEASURES:
Armoring

REVETMENTS AND BED ARMOR
Rigid
Soil cement
Roller compacted concrete
Concrete pavement
Rigid grout filled mattress/concrete fabric mat
Fully grouted riprap
Flexible/articulating
Riprap
Self launching riprap (windrow)
Riprap fill-trench
Gabions/gabion mattress[2]
Wire enclosed riprap mattress (rail bank/sausage)
Articulated blocks (interlocking and/or cable tied)
Concrete/grout mattress (fabric-formed)
Partially grouted riprap
LOCAL SCOUR ARMORING
Riprap (fill/apron)
Fully grouted riprap
Concrete armor units (Toskanes, tetrapods, etc.)[3]
Grout filled bags/sand cement bags
Gabions/gabion mattress[2]
Articulated blocks (interlocking and/or cable tied)
Sheet pile/cofferdam
Partially grouted riprap



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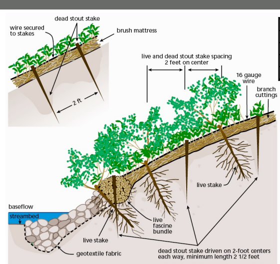
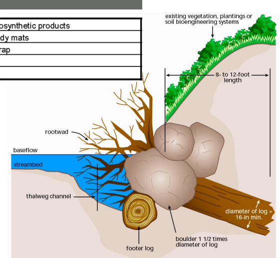
BIOTECHNICAL COUNTERMEASURES



Vegetated geosynthetic products
Fascines/woody mats
Vegetated riprap
Root wads
Live staking



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BIG DRY CREEK
Centennial, CO

- Grouted stacked boulder wall
- Longitudinal peaked stone toe protection
- Riffled grade controls
- Vegetated soil lifts


BEFORE

AFTER

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CITY PROJECT MANAGEMENT: OVERVIEW

TRANSPORTATION PROJECTS INVOLVING FLOODPLAIN CAN INCLUDE THE FOLLOWING CHALLENGES:

- Thoroughfares crossing major creeks can include multiple jurisdictional boundaries
- Floodplain impacts to project drainage system
- Project impacts to floodplain
- Bridge structure scour and channel erosion protection
- Environmental, agency coordination, permitting
- Utility Coordination
- Impacts to adjacent property
- More frequent and larger flood events in recent years

CITY PROJECT MANAGEMENT: LESSONS LEARNED

- **TWO- PHASE DESIGN OPTION-**
  Preliminary Design (30%+/-): initial H&H, horizontal and vertical alignment, ROW/permitting requirements, Final Design scope, stakeholder meeting
  Final Design- complete design, ROW, permitting, utility relocations
- **ROW ACQUISITION, UTILITY COORDINATION, PERMITTING-**
  Initiate in 30%-60% Design to keep off critical path
- **CONSTRUCTIBILITY REVIEWS-**
  Field review of existing conditions and design
- **CHANNEL ALIGNMENT/STABILZATION-**
  Evaluate need for protection of slopes, abutments, and bridge structure due to channel alignment, erosion, etc.
- **COMMON FLOODPLAIN PROJECT ELEMENTS-**
  Electric Transmission Lines, parks and trails, property access, continuously changing channel conditions due to scour and erosion

CITY PROJECT MANAGEMENT: LESSONS LEARNED

UTILITY IDENTIFICATION AND COORDINATION
Electric transmission lines- check for clearance, impacts to construction activity


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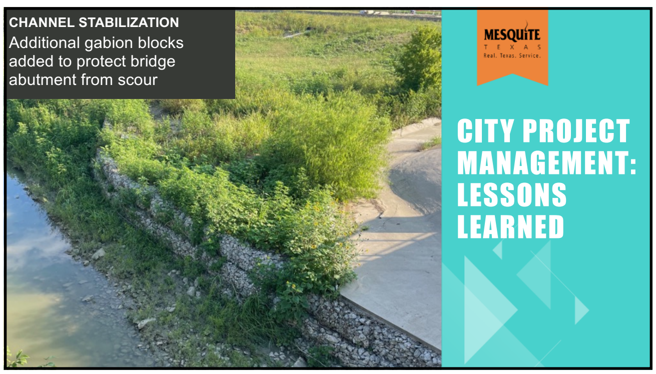
CITY PROJECT MANAGEMENT: LESSONS LEARNED
CHANGING CONDITIONS DUE TO SCOUR AND EROSION
Channel erosion in park at creek bend approaching bridge structure


CHANNEL STABILIZATION
Additional gabion blocks added to protect bridge abutment from scour
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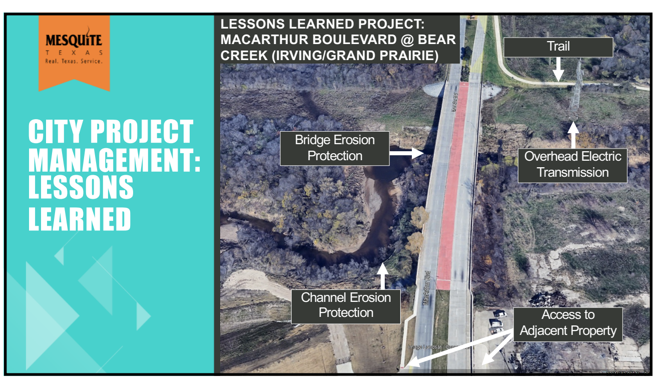
CITY PROJECT MANAGEMENT: LESSONS LEARNED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CITY PROJECT MANAGEMENT: LESSONS LEARNED
LESSONS LEARNED PROJECT: MACARTHUR BOULEVARD @ BEAR CREEK (IRVING/GRAND PRAIRIE)
Trail
Bridge Erosion Protection
Overhead Electric Transmission
Channel Erosion Protection
Access to Adjacent Property

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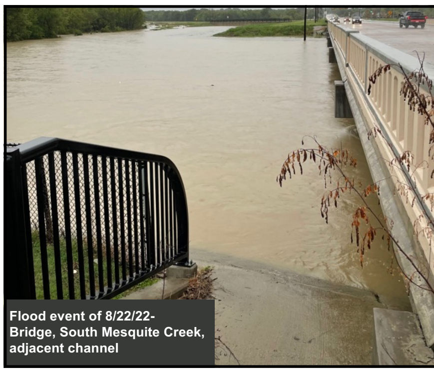
CITY PROJECT MANAGEMENT: LESSONS LEARNED

LESSONS LEARNED PROJECT:
MACARTHUR BOULEVARD @ BEAR CREEK

- **Dallas County Bond Program Project**
- **Multi-jurisdictional: Cities of Irving and Grand Prairie**
- **Oncor Transmission Lines adjusted for clearance (project cost), de-energized for bridge beam installation**
- ROW acquisition from property at bridge on east side involving claim of damages, reconstructed driveway access
- **Individual 404 Permit, Wetlands Mitigation**
- **Meandering stream movement from initial survey resulted in bridge alignment revision and addition channel erosion protection**
- Channel slope protection at bridge
- Trail constructed after project
- New development and driveway access on west side after project



Flood event of 8/22/22- Bridge, South Mesquite Creek, adjacent channel

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MESQUITE PROJECT: PIONEER ROAD

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MESQUITE PROJECT: PIONEER ROAD

(BELT LINE ROAD TO E. CARTWRIGHT ROAD) COMPLETED 2015

- **Two-Phase Design**, **constructed by Dallas County** as part of Major Capital Improvements Program (MCIP)
- **Stakeholder Meeting** (Charrette)- Preliminary Design determined four-lane divided thoroughfare was not practical to construct with narrow existing ROW in residential area, Public Meeting prior to construction
- Four-lane undivided concrete thoroughfare including bridge, large culverts, and parallel drainage channel
- **Minimal environmental impact**, CLOMR/LOMR, **Nationwide 404 Permit**
- New thoroughfare higher than some existing residential lots and adjacent City Lake Park created **challenges with access, drainage, fences, screening, retaining walls**
- Construction **accommodated wood electric transmission poles without relocation**
- **Flood event of 8/22/22-** 14 inches of rain upstream and 12 inches locally, main channels and bridge structure functioned properly, one intersection closed due to high water

Existing Westbound Bridge and Proposed Eastbound Bridge.

MESQUITE PROJECT: F. P. LUCAS BOULEVARD

MESQUITE PROJECT: F. P. LUCAS BOULEVARD

MCKENZIE ROAD TO E. CARTWRIGHT ROAD UNDER CONSTRUCTION

- **Two-Phase Design, constructed by City** as part of Dallas County MCIP
- **Stakeholder Meeting** (Charrette)- changed typical section and construction phasing, switched project delivery from County led to City led
- Westbound bridge previously constructed
- Previous slope protection project in South Mesquite Creek
- Four-lane divided concrete thoroughfare including eastbound bridge and large culverts
- **Minimal environmental impact**, CLOMR/LOMR, **Nationwide 404 Permit**
- Significant fencing coordination with adjacent property owner
- Fiber subcontractor bored through City sanitary sewer outfall line during relocations
- **No conflict with crossing electrical transmission lines but will have to be de-energized for bridge construction, other overhead line relocations required**
- **Project includes pedestrian trail and trail connection**

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