2D Hydraulic and Scour Analysis for Bridge Replacement

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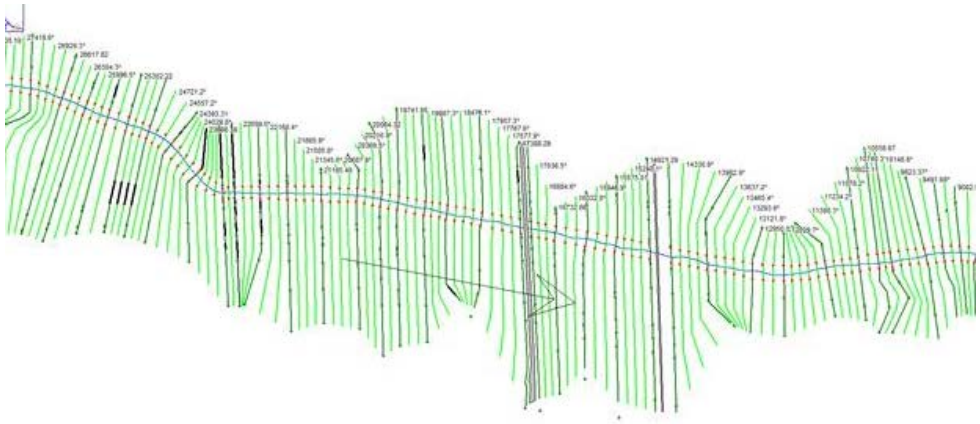
Project Overview

Bridge over Missouri River along Route 47

- Original Bridge
  - Built in 1934-36
  - 2 Lanes of traffic
- New Structure
  - Nine span bridge
  - 2555 feet long
  - 4 Lanes of traffic

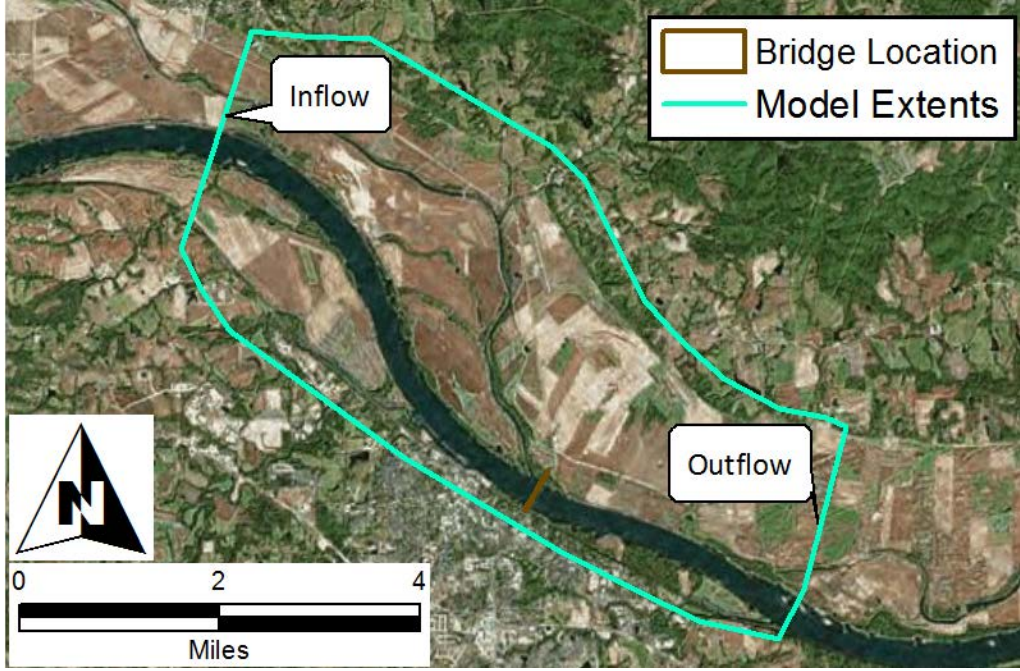
Potential reasons to consider 2D Model

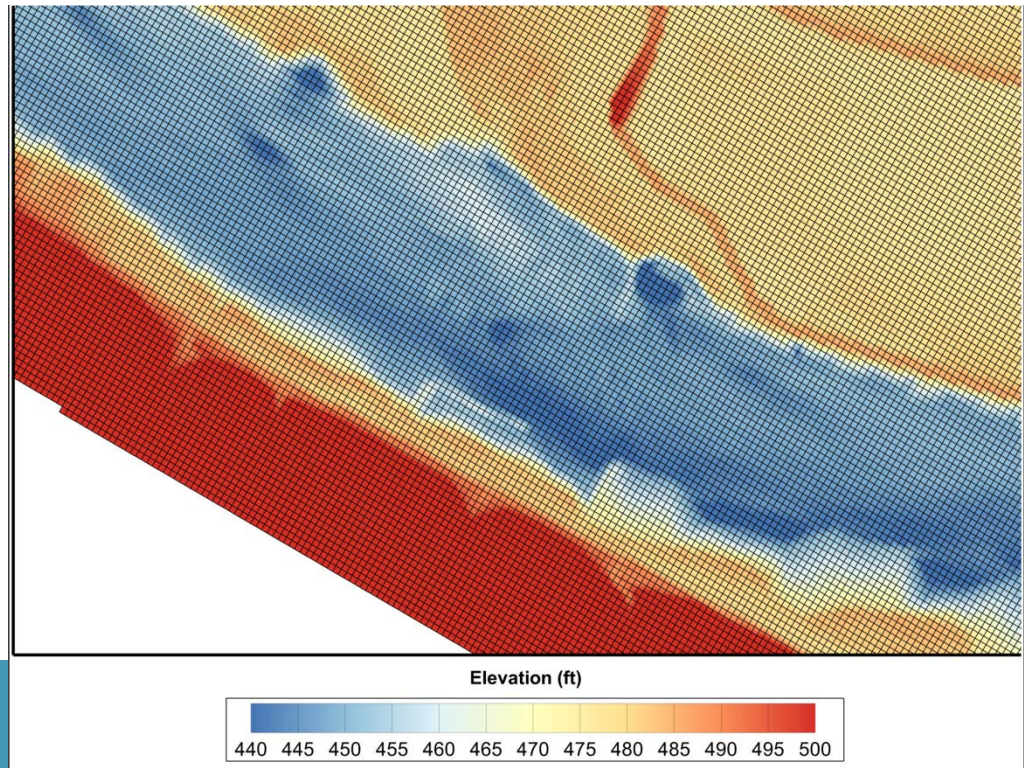
- HEC-18 states consider a 2D model “for bridges with complex flow characteristics…”
  - Embankments skewed to the flood flows
  - Multiple floodplain openings
  - Wide flood plains
  - Highly contracted flows
  - etc
- Not necessary for all bridges



Hydraulic Model Setup

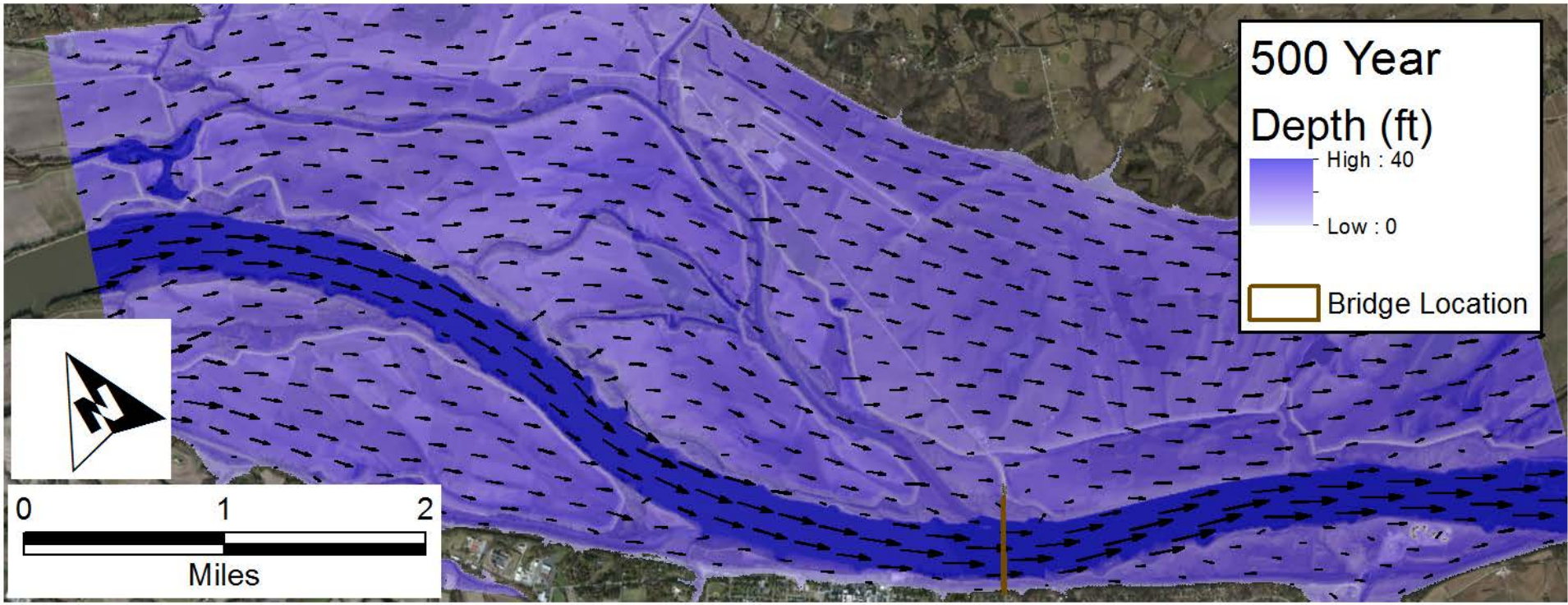
- TUFLOW Classic Model
- Includes entire floodplain
- Inflow Upstream/WSE downstream
- Elevations: Lidar, single/multi beam bathy
- 40ft square grid cells
- Piers represented as partially blocked cells
- Bridge deck not included (won't submerge)





Contraction Scour

- Can 1D model accurately represent how much water contracts under the bridge and how much goes over the roadway?



Local Scour Approach

- CSU Equation for channel piers
- FDOT Methodology for overbank piers
  - "…FDOT Methodology should be considered as an alternative, particularly for wide piers in shallow flows with fine bed material." – HEC18 5th Edition

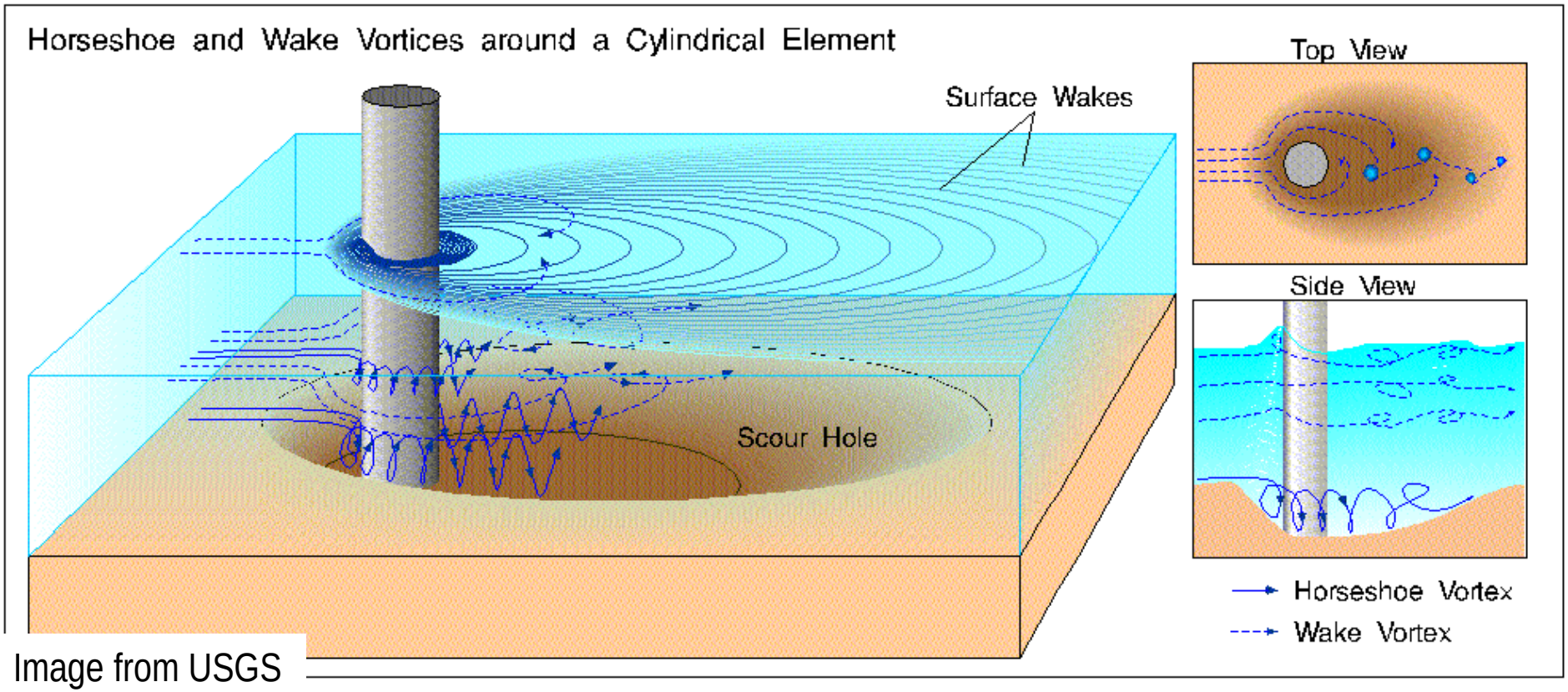


Image from USGS

Impact of Angle of Attack CSU Equation

$$\frac{y_s}{y_1} = 2.0\ K_1\ K_2\ K_3 \left(\frac{a}{y_1}\right)^{0.65} Fr_1^{0.43}$$

Table 7.2. Correction Factor, K_2, for Angle of Attack, θ, of the Flow.			
Angle	L/a=4	L/a=8	L/a=12
0	1.0	1.0	1.0
15	1.5	2.0	2.5
30	2.0	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5.0
Angle = skew angle of flow L = length of pier			

- Scour depth proportional to K_2
- At least double the scour if angle of attack > 30 degrees

Impact of Angle of Attack Florida DOT Methodology

$$a_{proj} = a\cos\theta + L\sin\theta$$

$$a^* = K_{sf} a_{proj}$$

where:

a = Effective pier width, ft (m)

θ = Angle of attack in degrees

L = Pier length, ft (m)

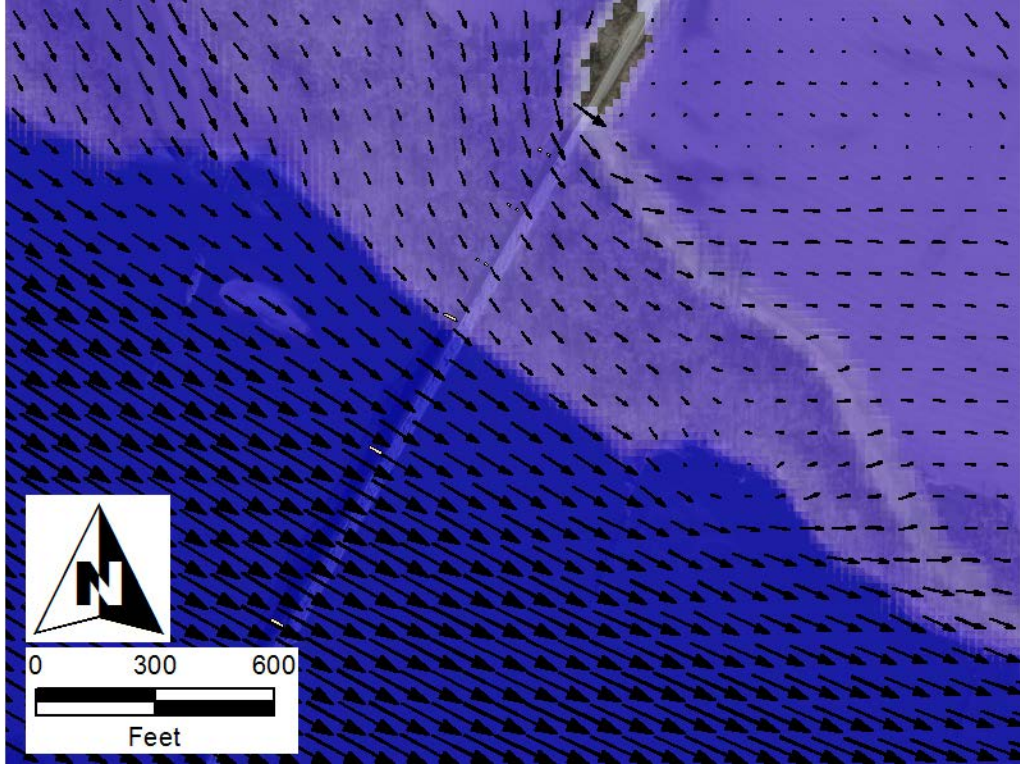
K_{sf} = Shape factor (1.0 unless square nosed)

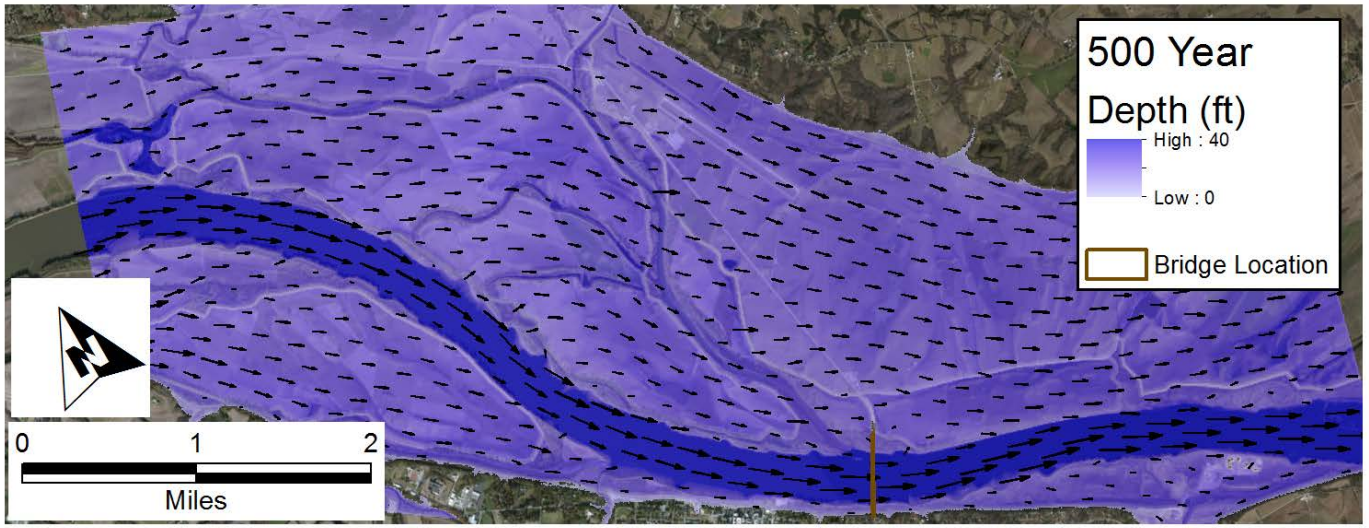
Scour depth is proportional to a*

If length > 4 width and 30 degree angle of attack, scour increases by a factor of 2.86

Hydraulic Model Results

- Flow split between channel and floodplain
- Channel piers – Flows aligned with piers
- Overbank piers – Flows skewed to piers





Summary

- 2D hydraulic models for scour analysis
  - Provide more accurate flows for contraction scour
  - Provide angle of attack
- 2D models not always necessary
- HEC-18 gives descriptions of when a 2D model may be more appropriate