2D Models to Inform and Justify Complex 1D Models

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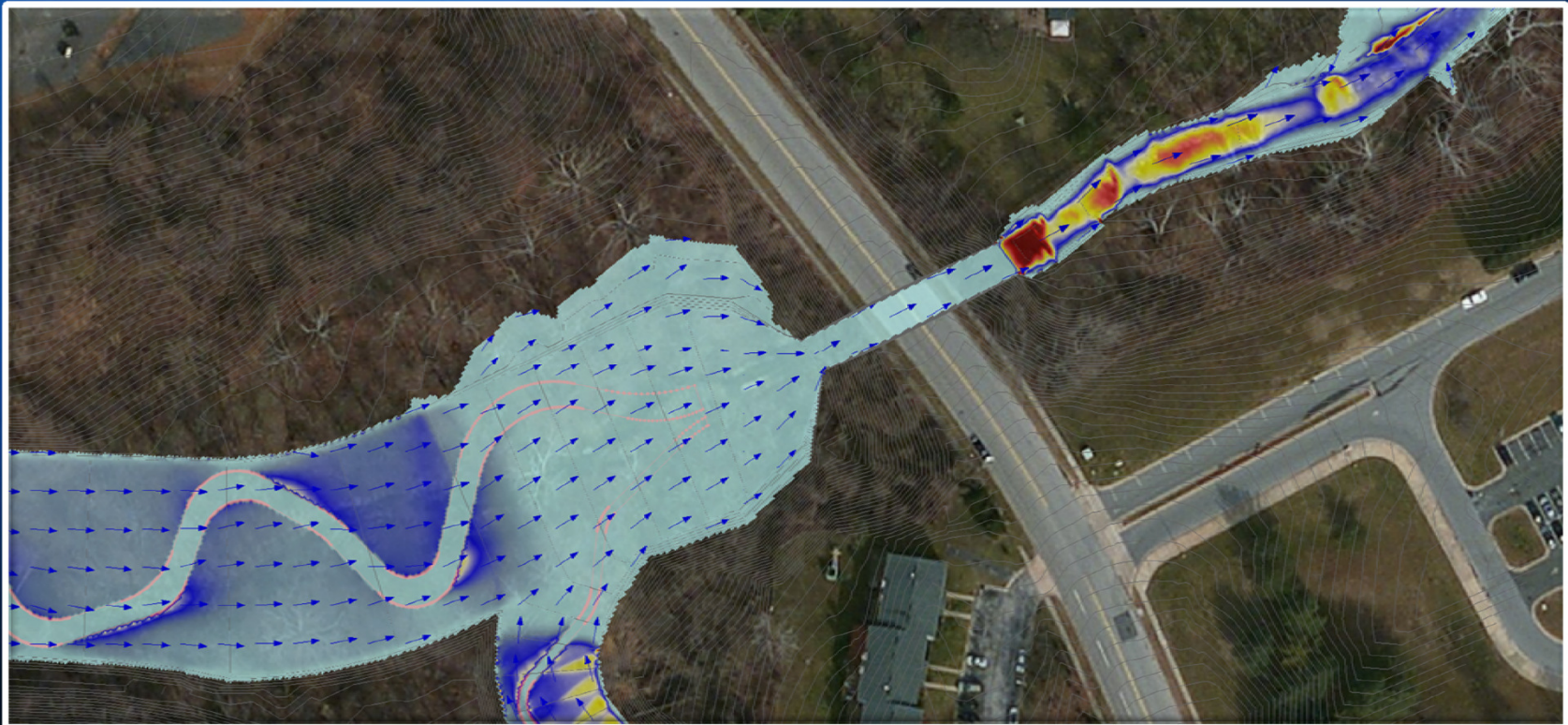
Is one dimension enough?

2D Models

Myths:

- Long computation time
- Significant setup time
- Model instability
- Poor output reporting

Challenges with 1D Models

- Ineffective flow areas
- Expansion/ contraction
- Flow distribution
  - Split flow
  - Lateral flow
  - Rapid overland flow
  - Multiple openings
- Confluences/ junctions
- Cross Section Alignment
- Channel bend losses
- Average velocity/ water surface across XS

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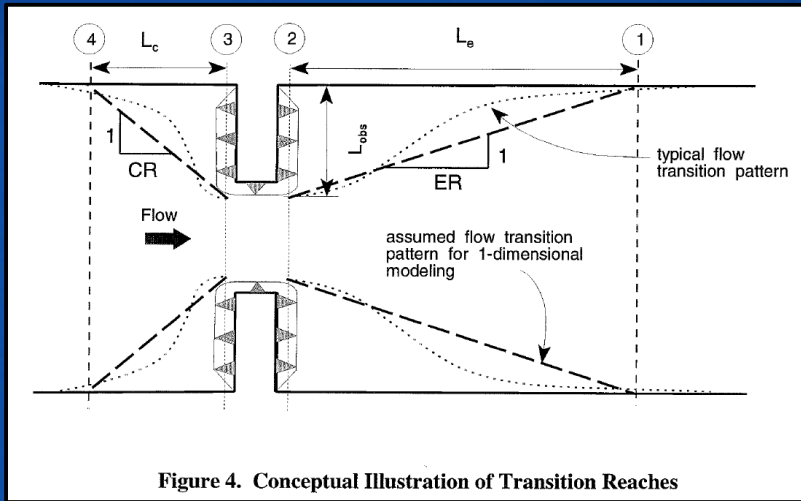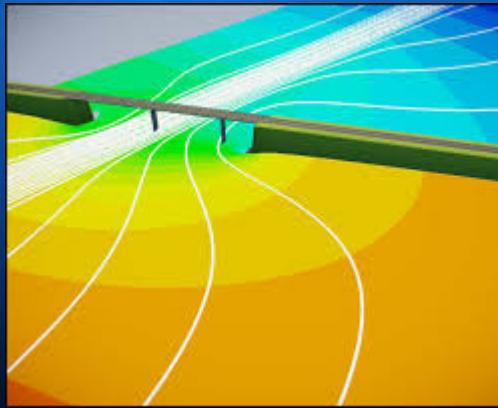
Ineffective Flow Areas – 1D

Figure 4. Conceptual Illustration of Transition Reaches

Bridge Hydraulic Analysis with HEC-RAS, USACE 1996

Expansion Length:

$$L_e = -298 + 257 \left(\frac{F_{c2}}{F_{c1}}\right) + 0.918 (\overline{L}_{obs}) + 0.00479 (Q)$$

Contraction Length:

$$L_c = 263 + 38.8 \left(\frac{F_{c2}}{F_{c1}}\right) + 257 \left(\frac{Q_{ob}}{Q}\right)^2 - 58.7 \left(\frac{n_{ob}}{n_c}\right)^{0.5} + 0.161 (\overline{L}_{obs})$$
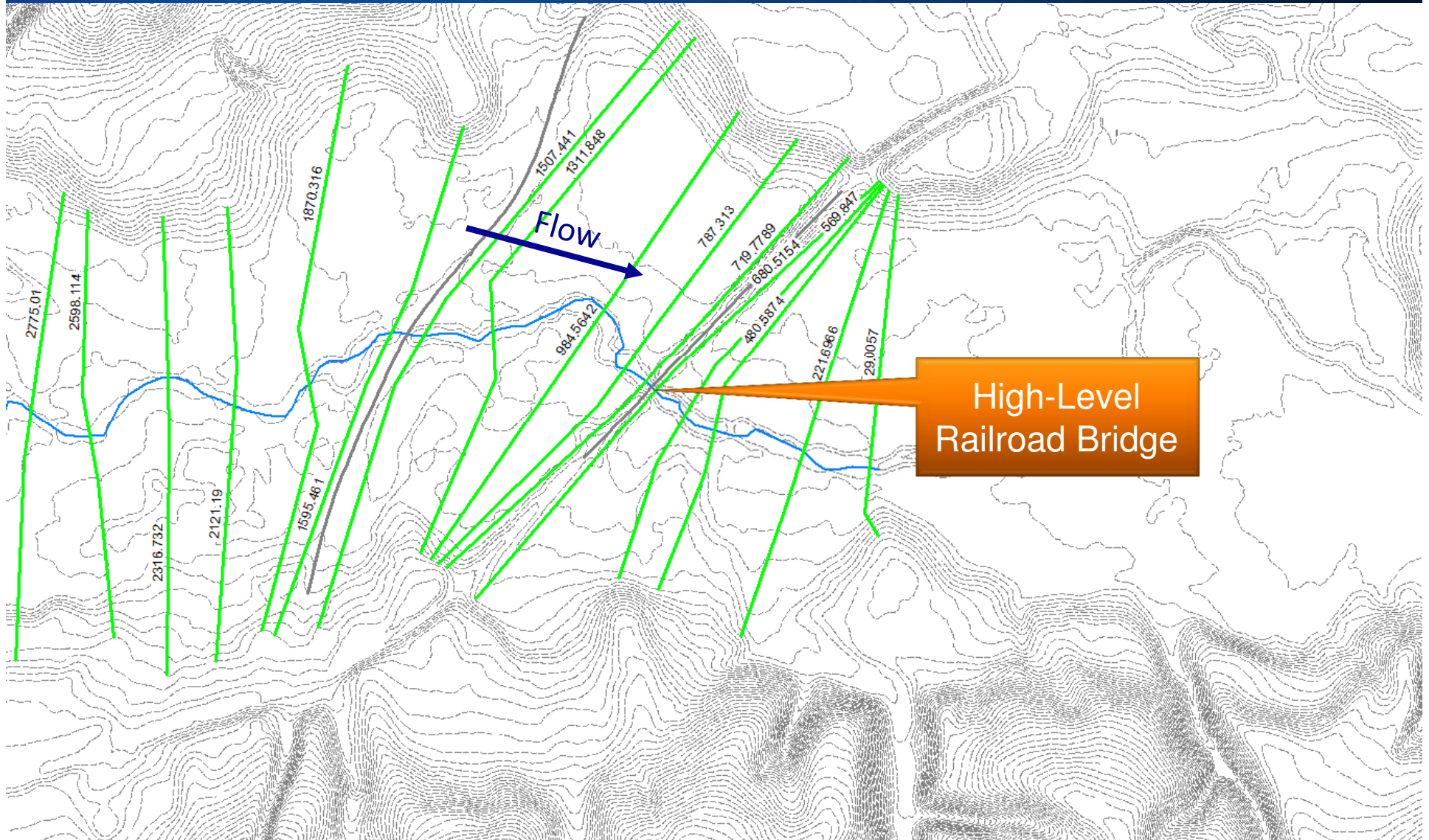
Expansion Ratio:

$$ER = \frac{L_e}{\overline{L}_{obs}} = 0.421 + 0.485 \left(\frac{F_{c2}}{F_{c1}}\right) + 1.80 \times 10^{-5} (Q)$$
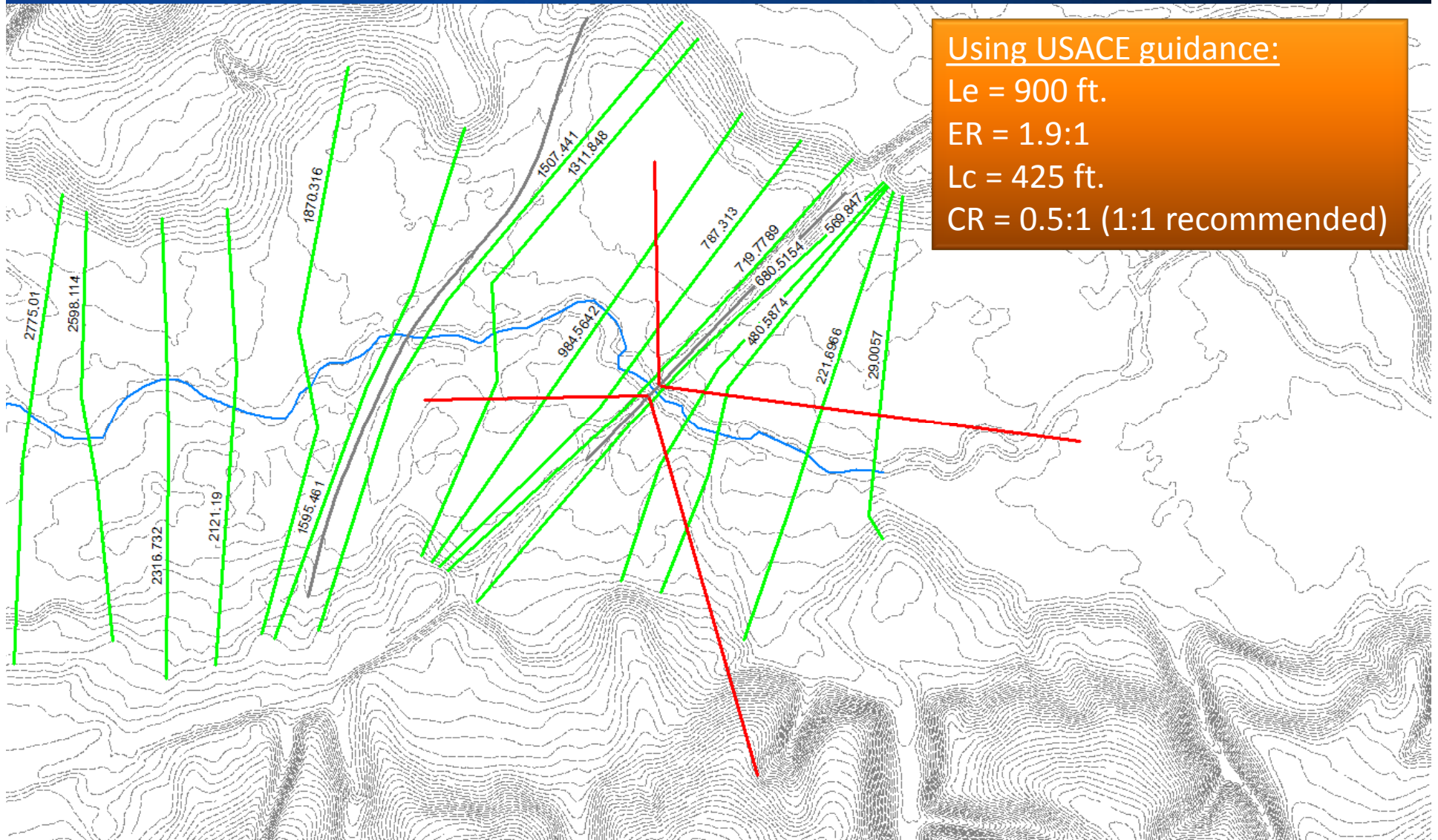
Contraction Ratio:

$$CR = 1.4 - 0.333 \left(\frac{F_{c2}}{F_{c1}}\right) + 1.86 \left(\frac{Q_{ob}}{Q}\right)^2 - 0.19 \left(\frac{n_{ob}}{n_c}\right)^{0.5}$$

Ineffective Flow Areas – Example

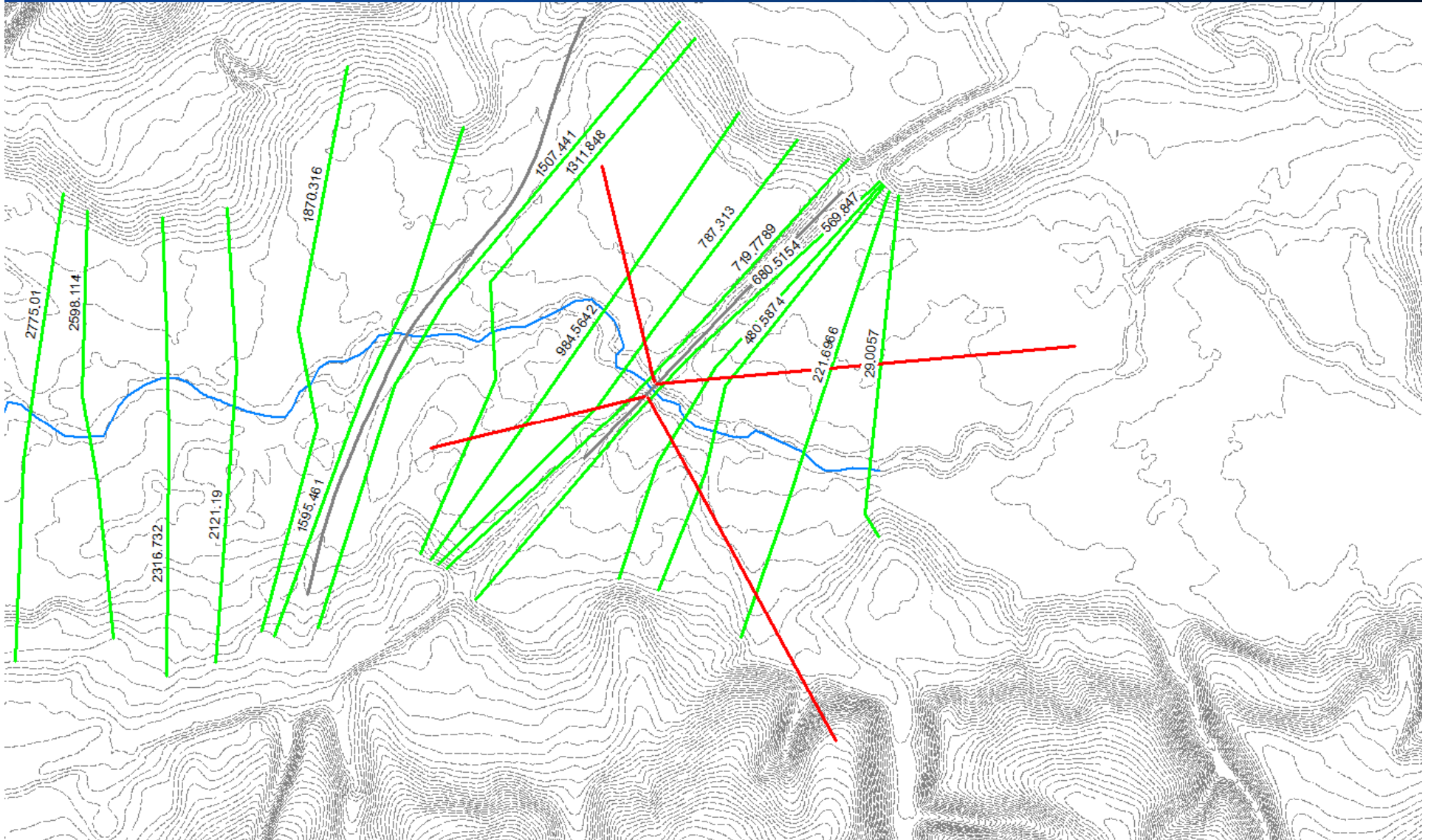# Ineffective Flow Areas – Example
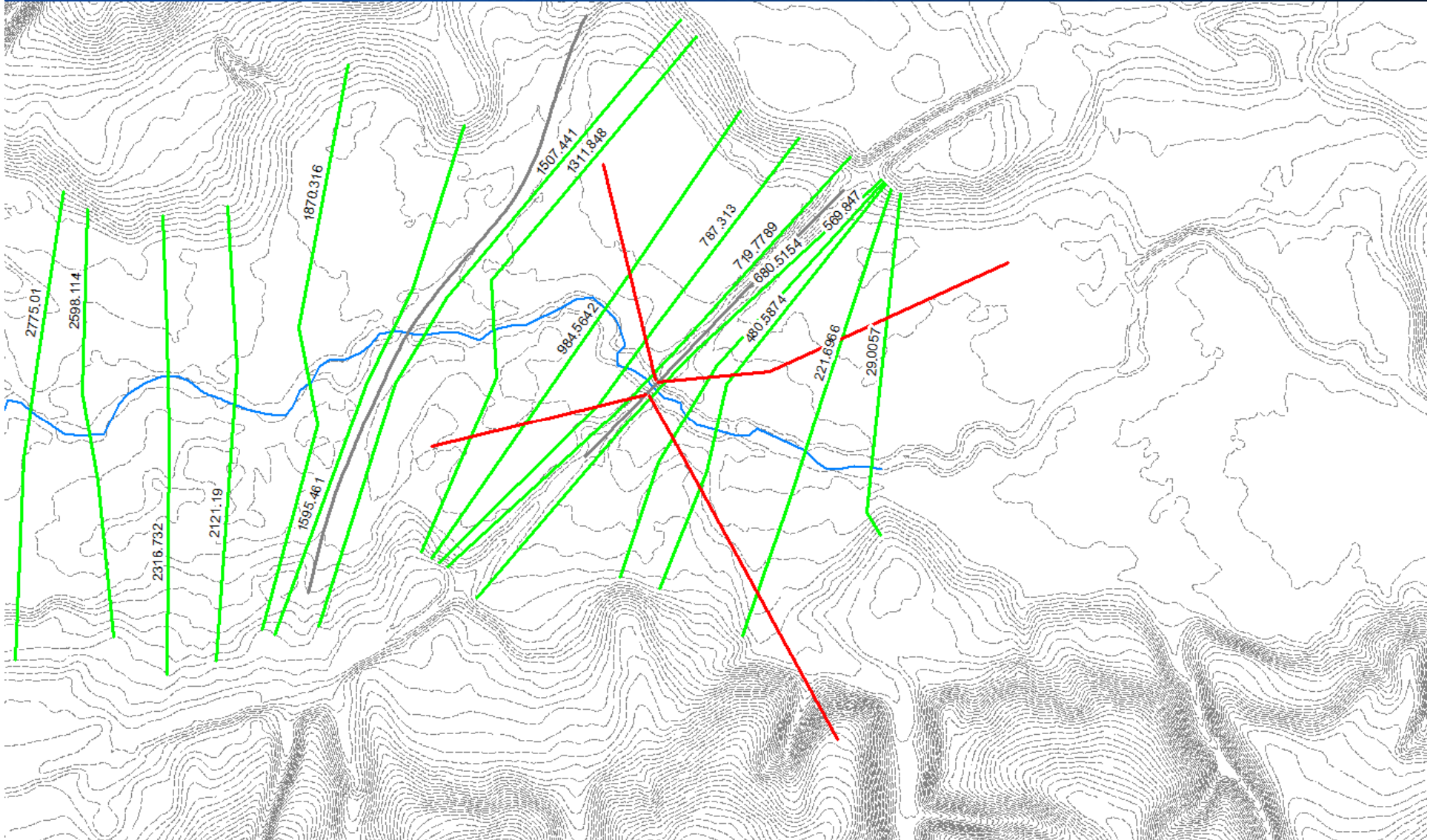

Using USACE guidance:
Le = 900 ft.
ER = 1.9:1
Lc = 425 ft.
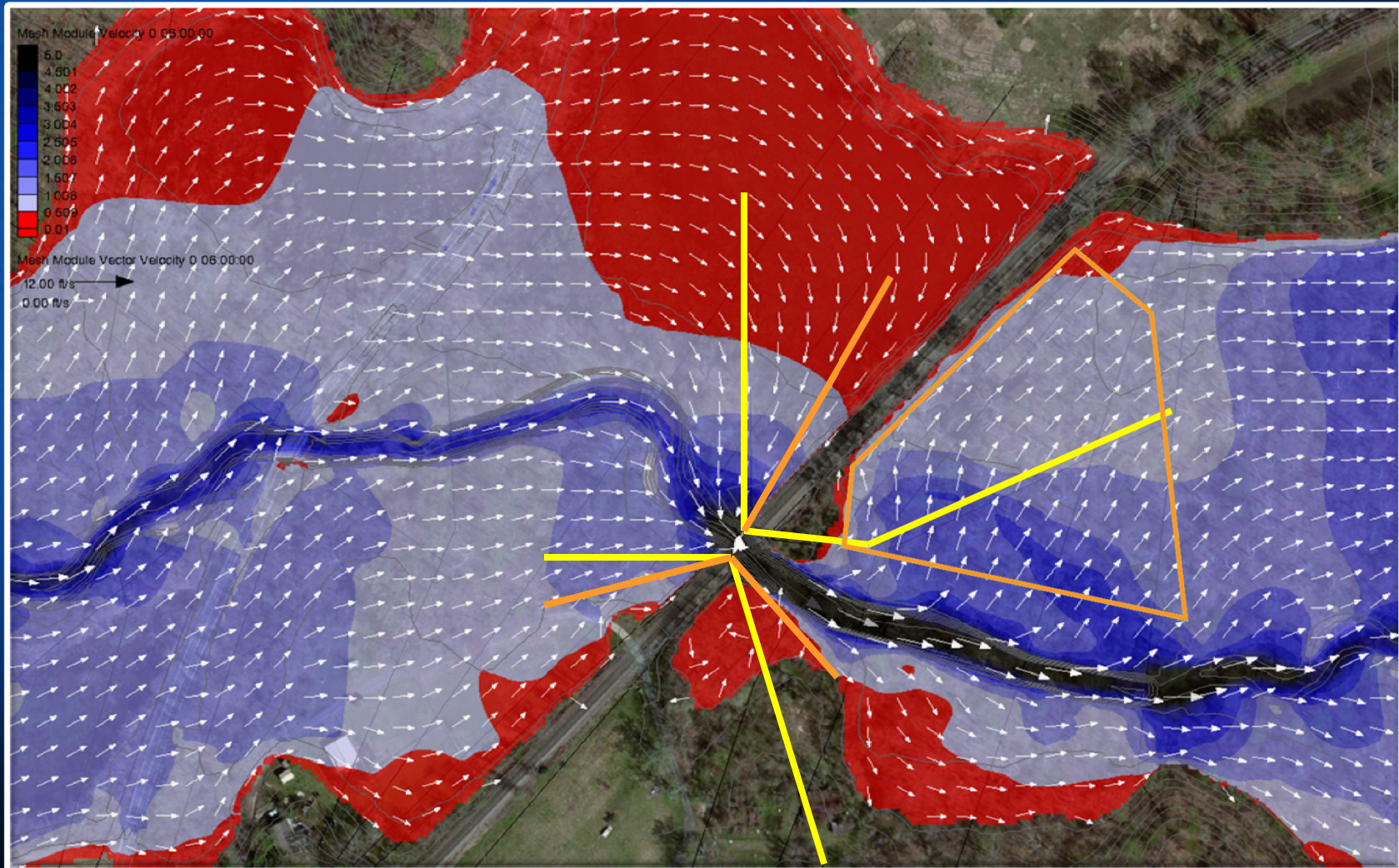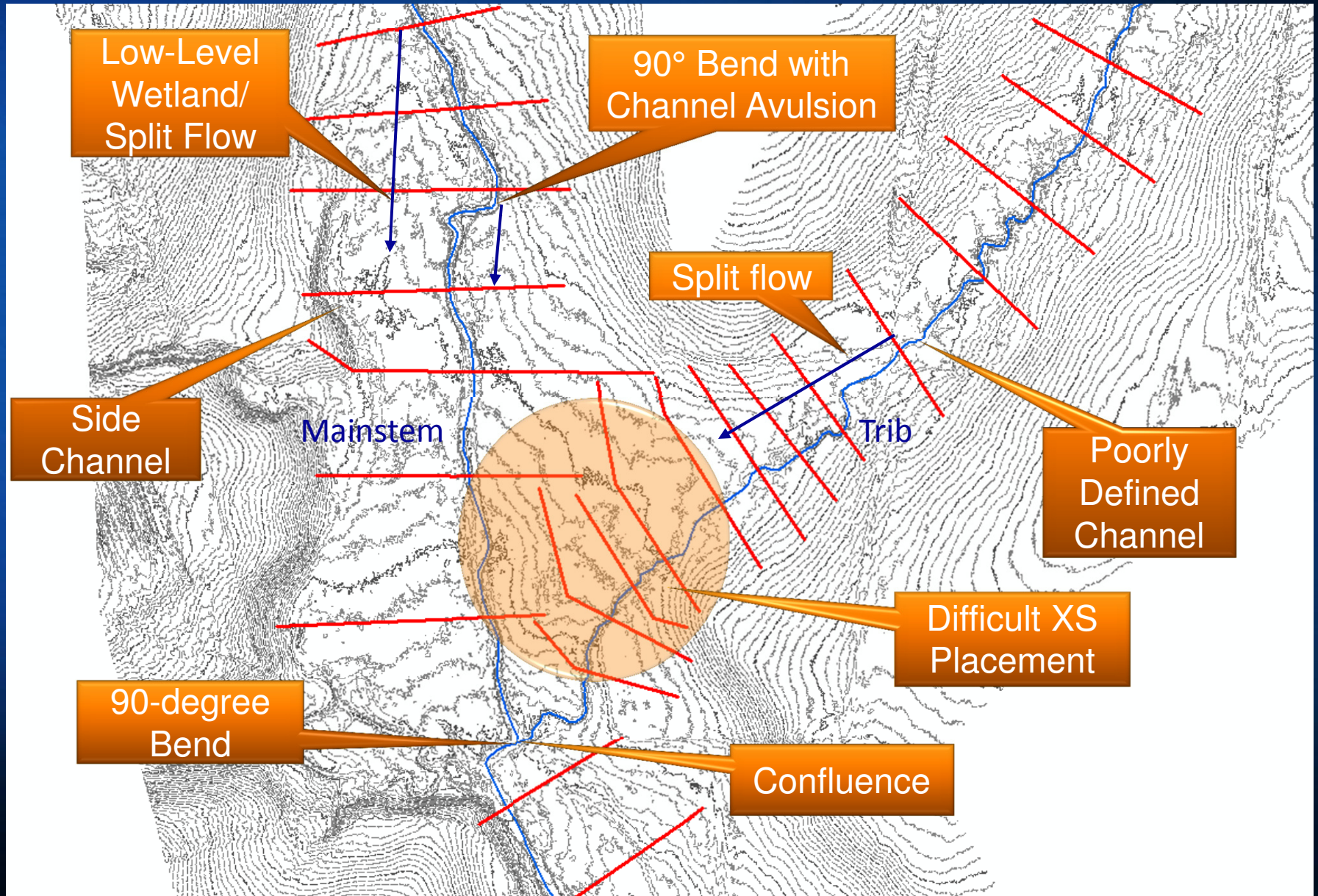CR = 0.5:1 (1:1 recommended)

Ineffective Flow Areas – Example

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Ineffective Flow Areas – Example

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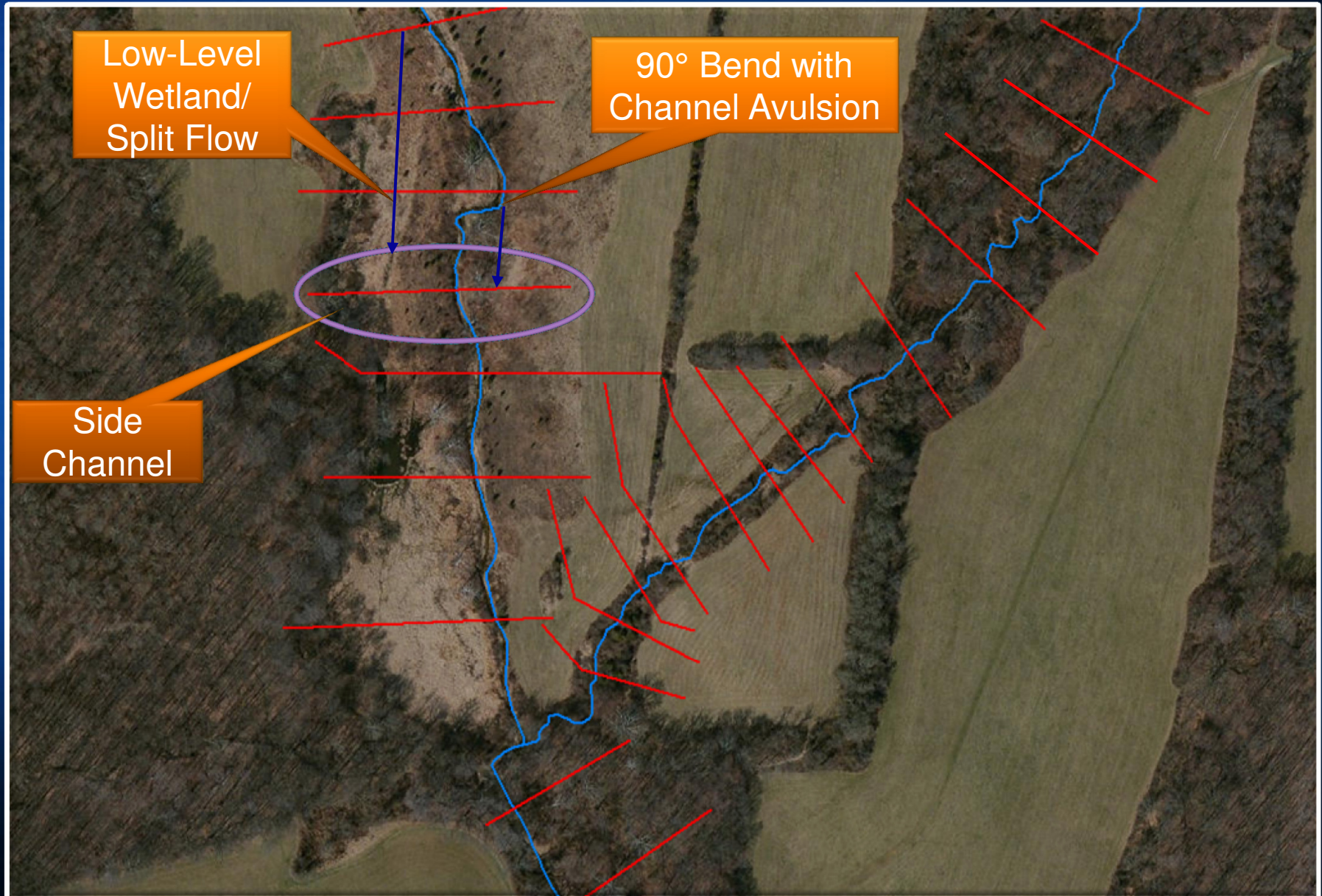- Channel bend losses
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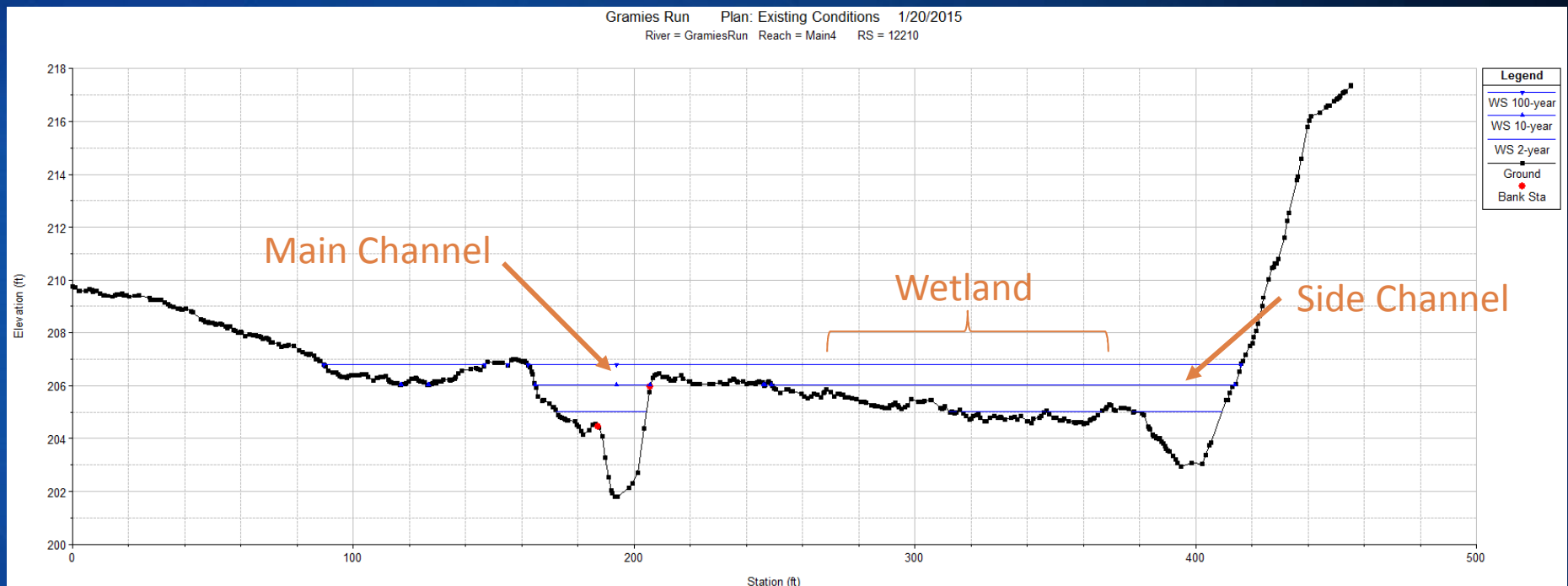
Stream Restoration Example

Stream Restoration Example...
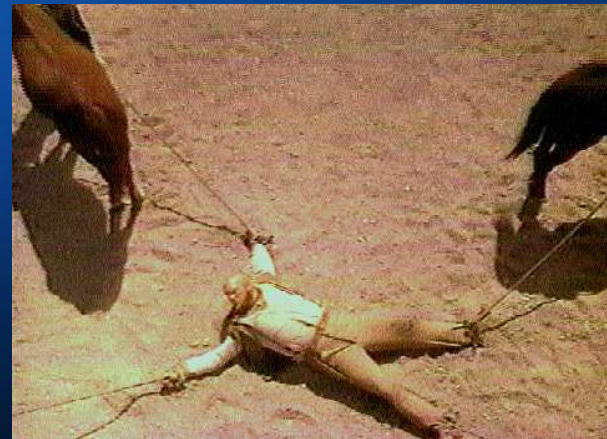
Stream Restoration Example...

Low-Level Wetland/ Split Flow

90° Bend with Channel Avulsion

Side Channel

Stream Restoration Example...

Gramies Run   Plan: Existing Conditions   1/20/2015
River = GramiesRun   Reach = Main4   RS = 12210

Main Channel

Wetland

Side Channel

Legend
WS 100-year
WS 10-year
WS 2-year
Ground
Bank Sta

Decision Time...
- Levee(s)?
- Split flow?
- Lateral structure?
- Ineffective flow?
- Realign XS?

Stream Restoration Example...

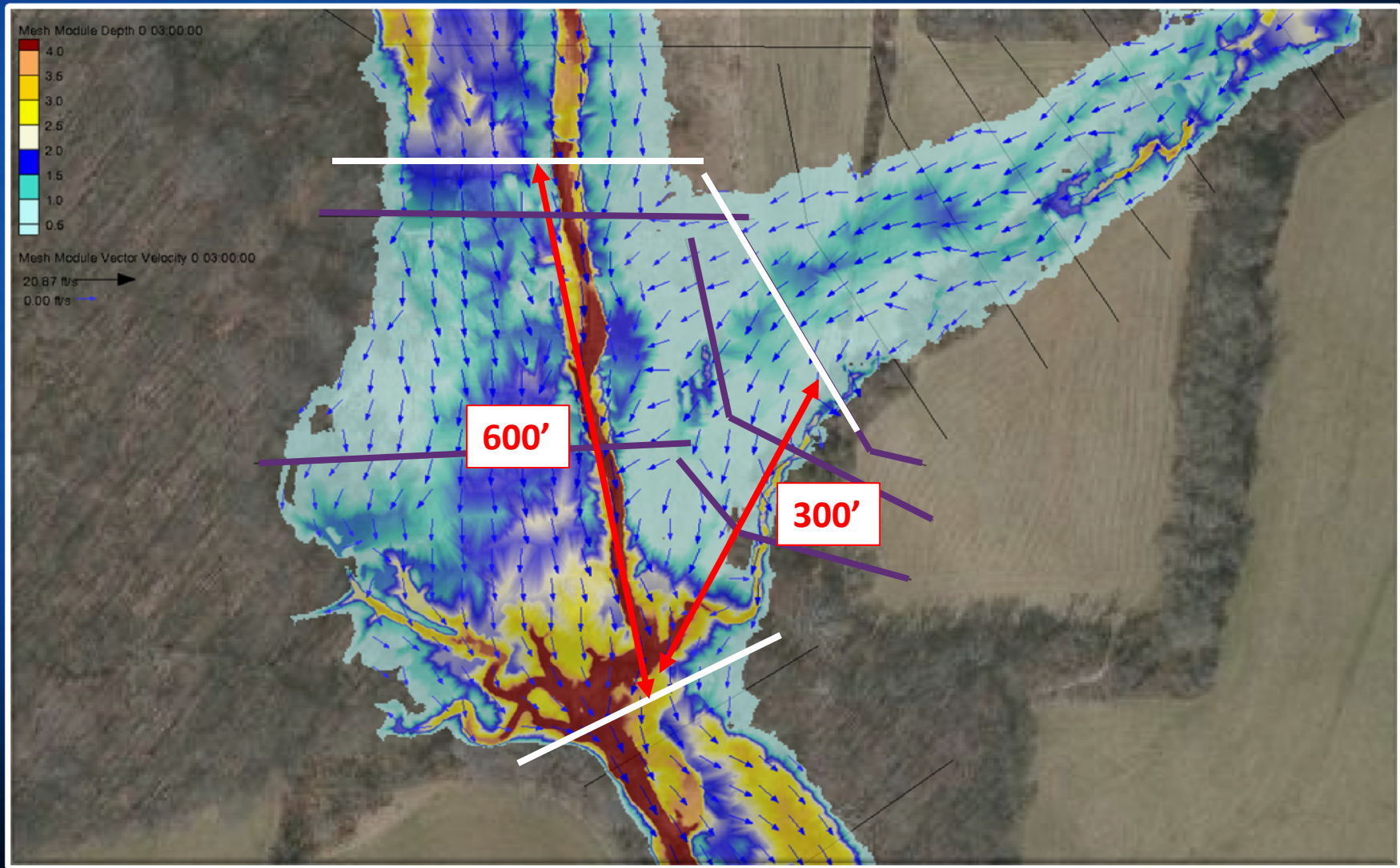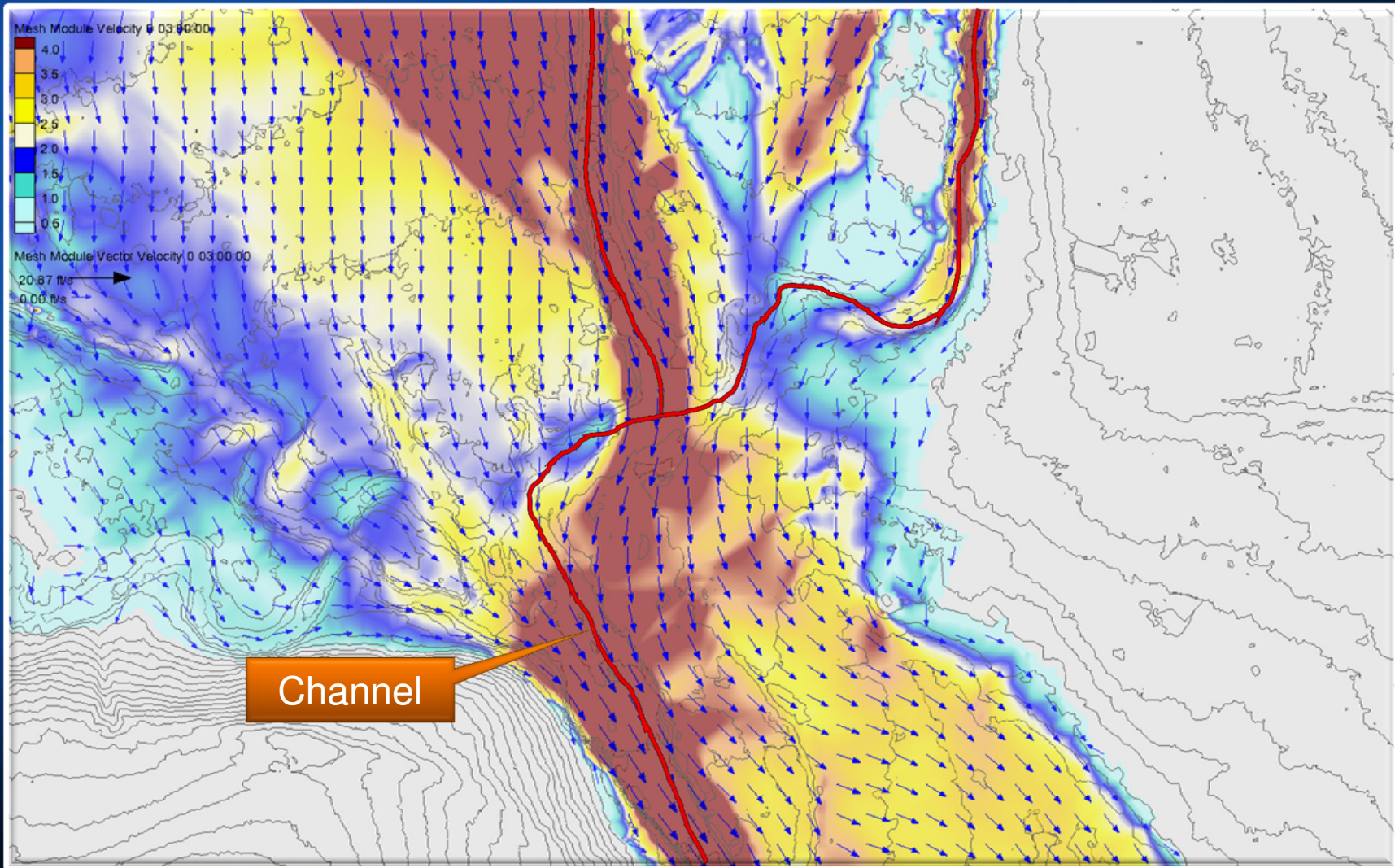## 2D Results at 1D Cross Section:

Stream Restoration Example…

Split flow

Poorly Defined Channel

Difficult XS Placement

90-degree Bend

Confluence
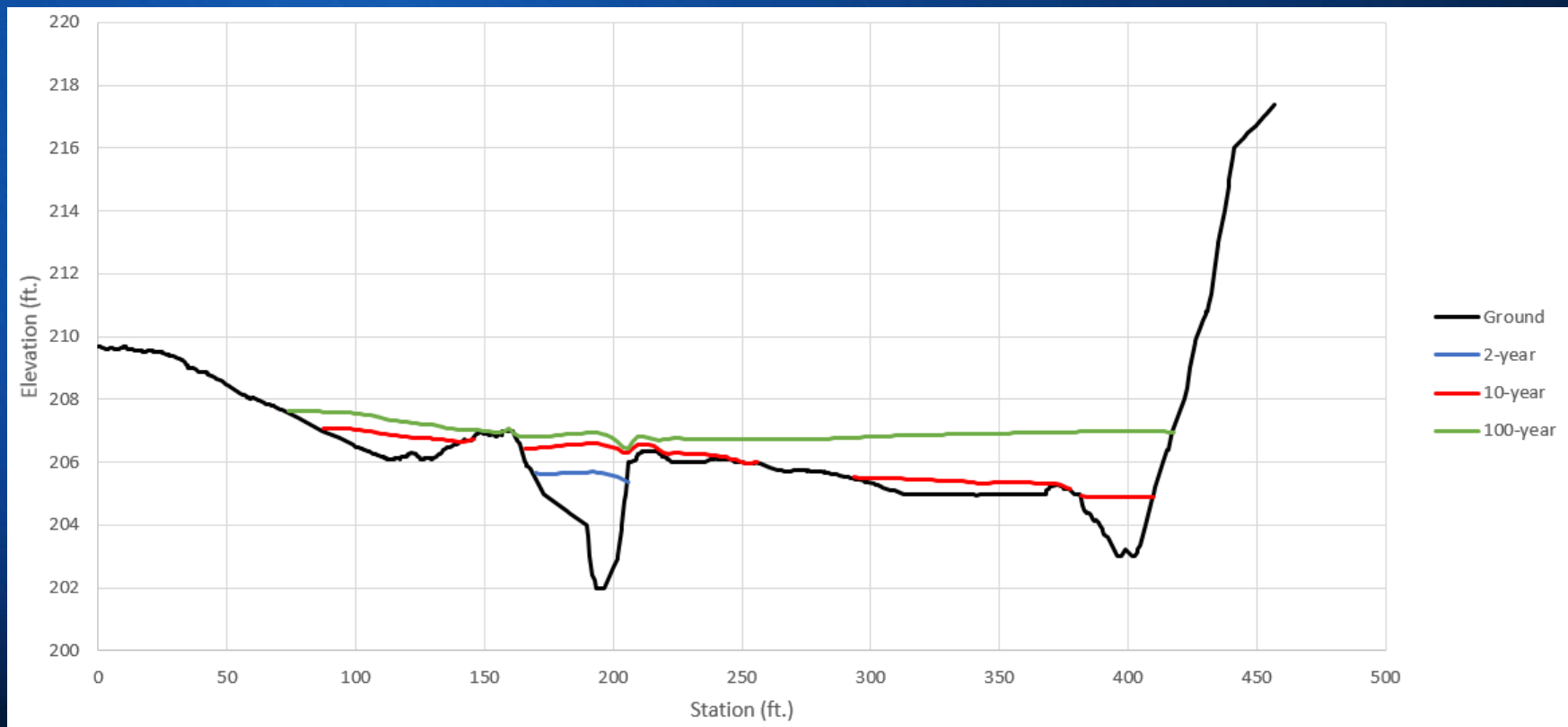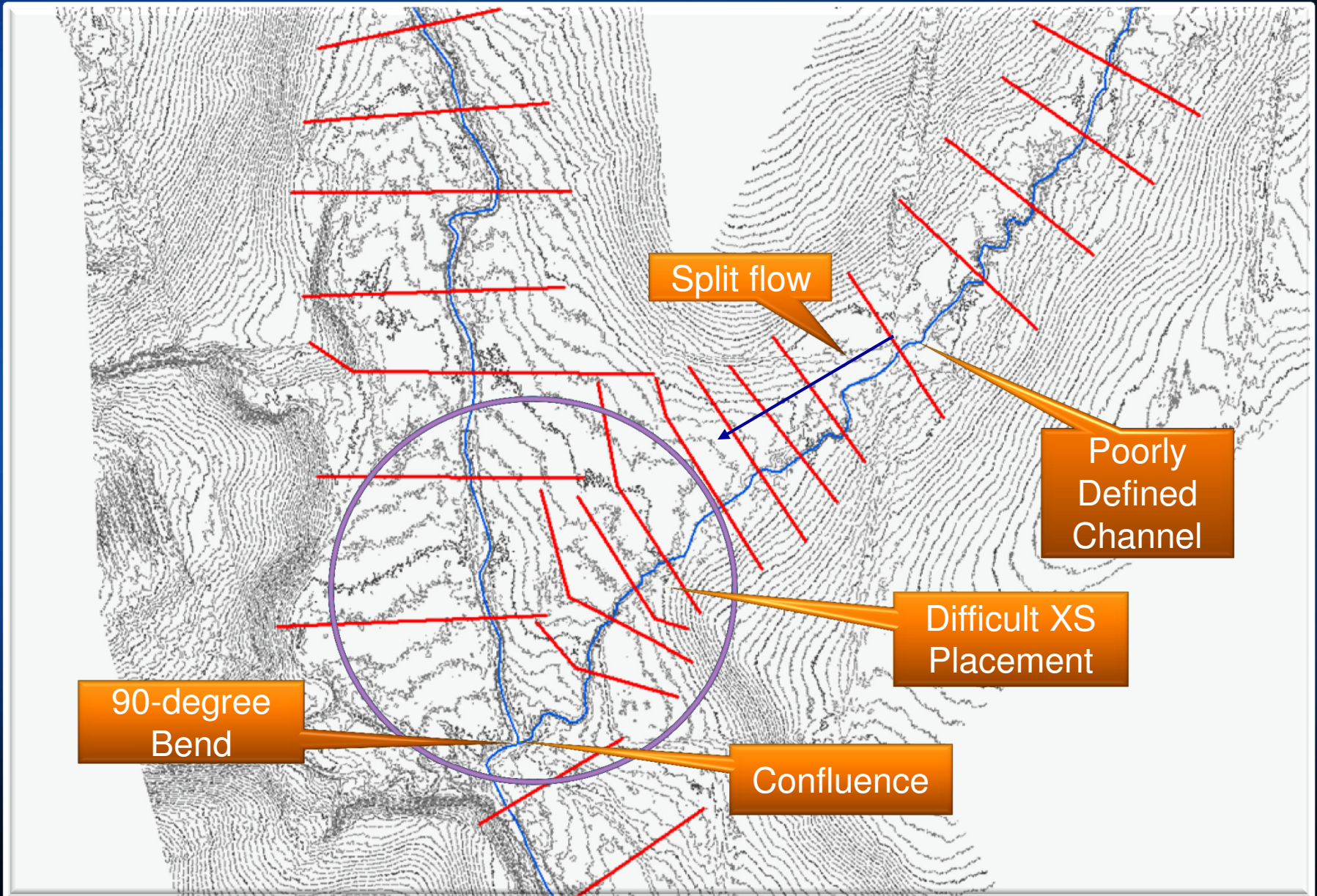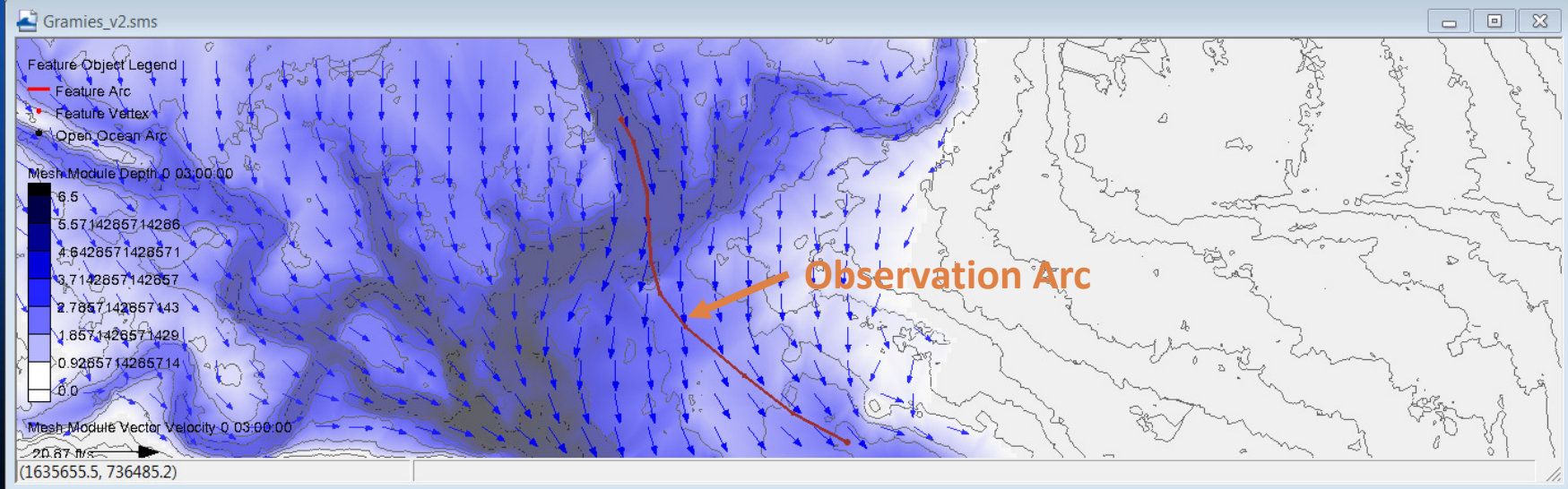
Stream Restoration Example…

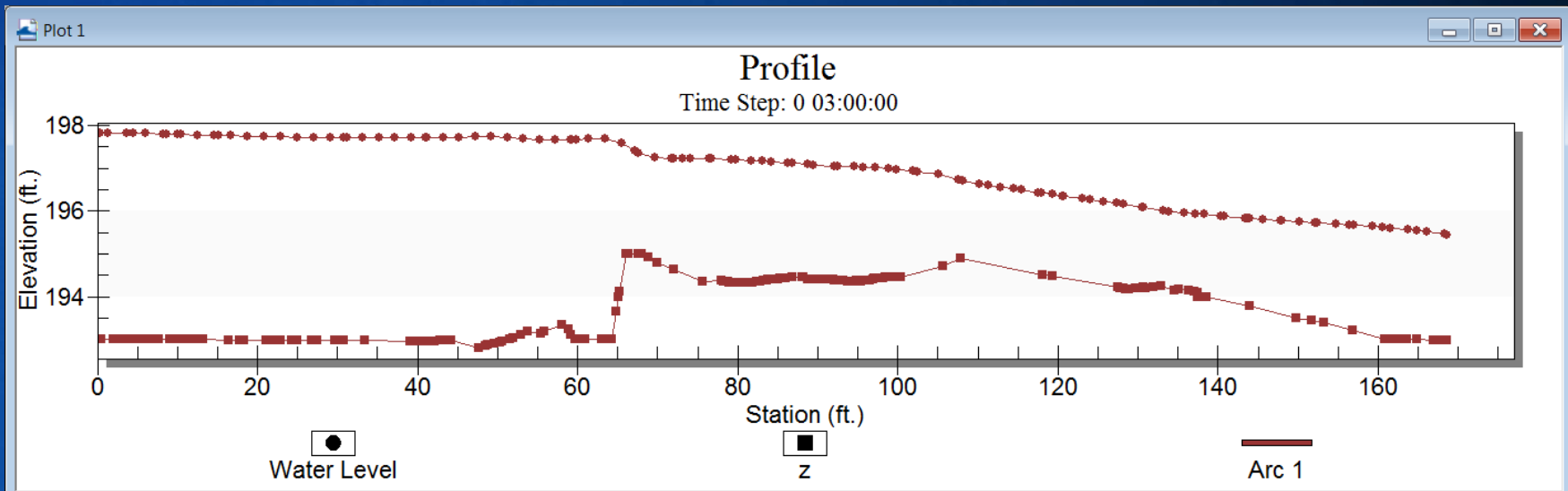# Stream Restoration Example...
Velocity

Stream Restoration Example...
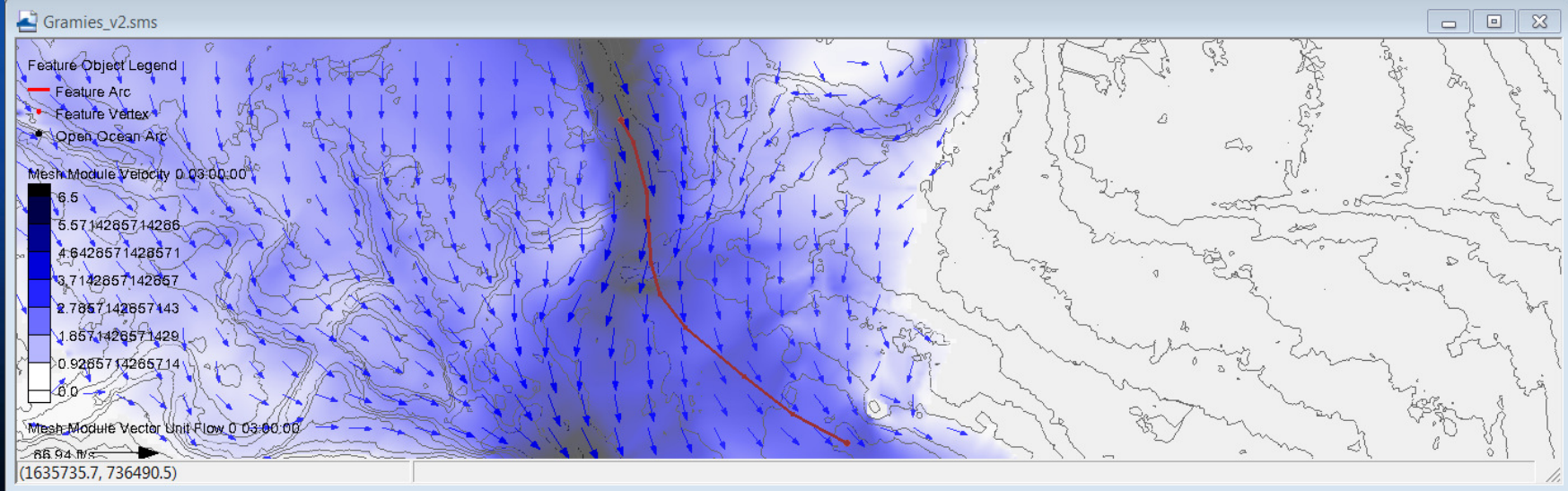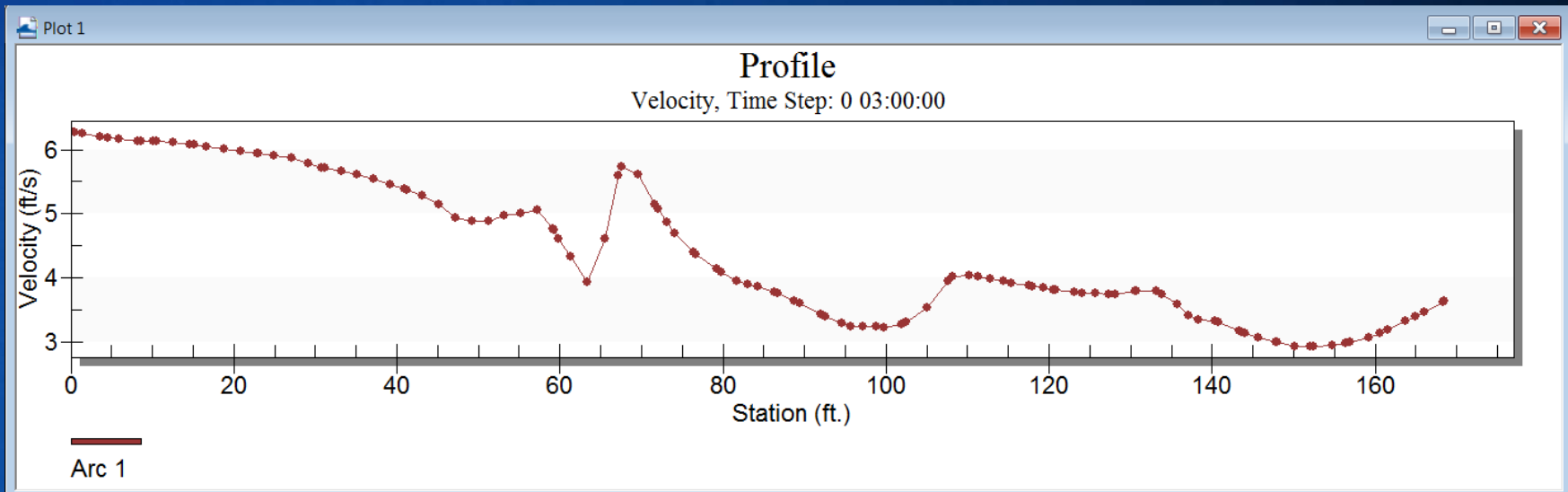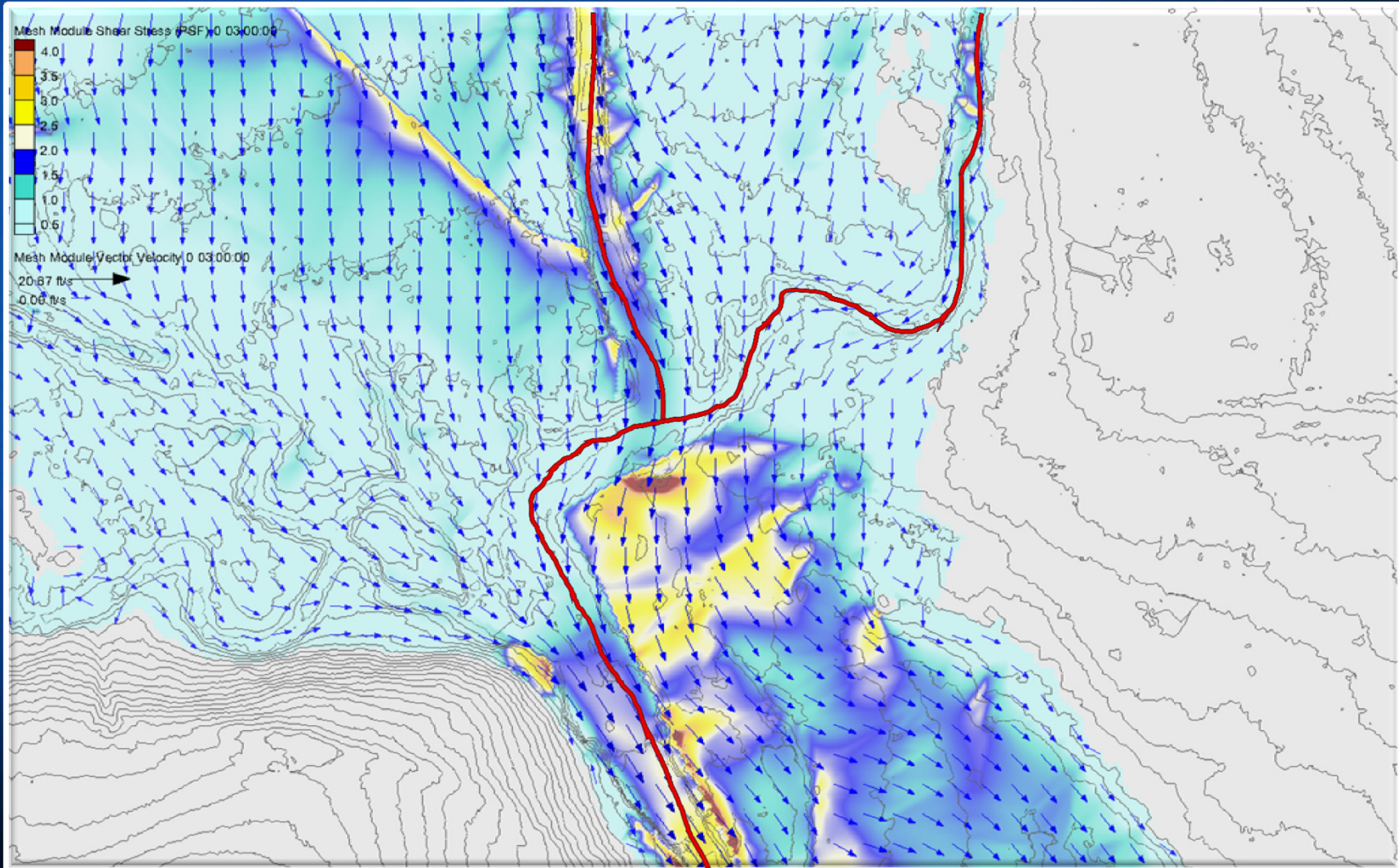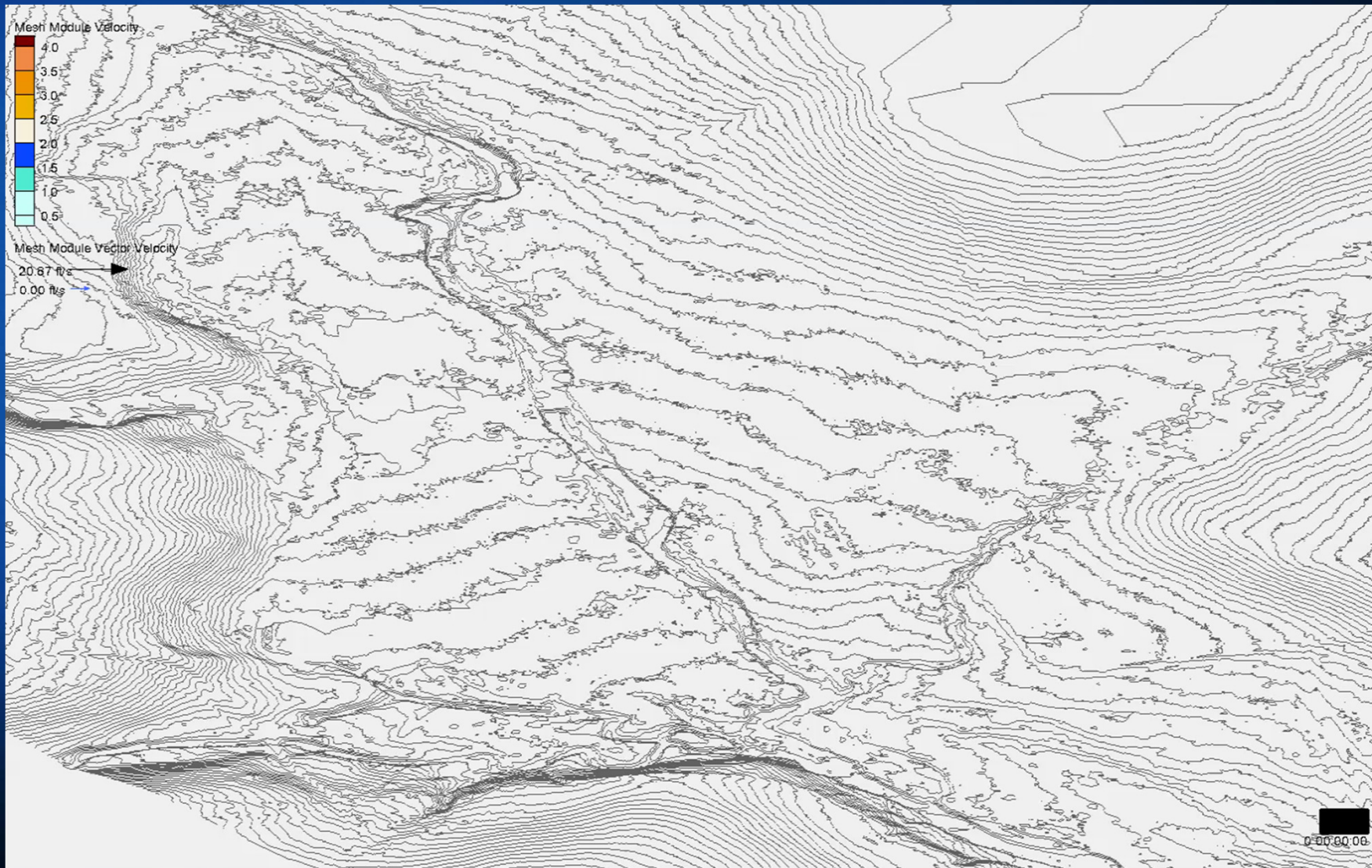
Stream Restoration Example…

Stream Restoration Example...
Shear Stress

Stream Restoration Example…

Questions?

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