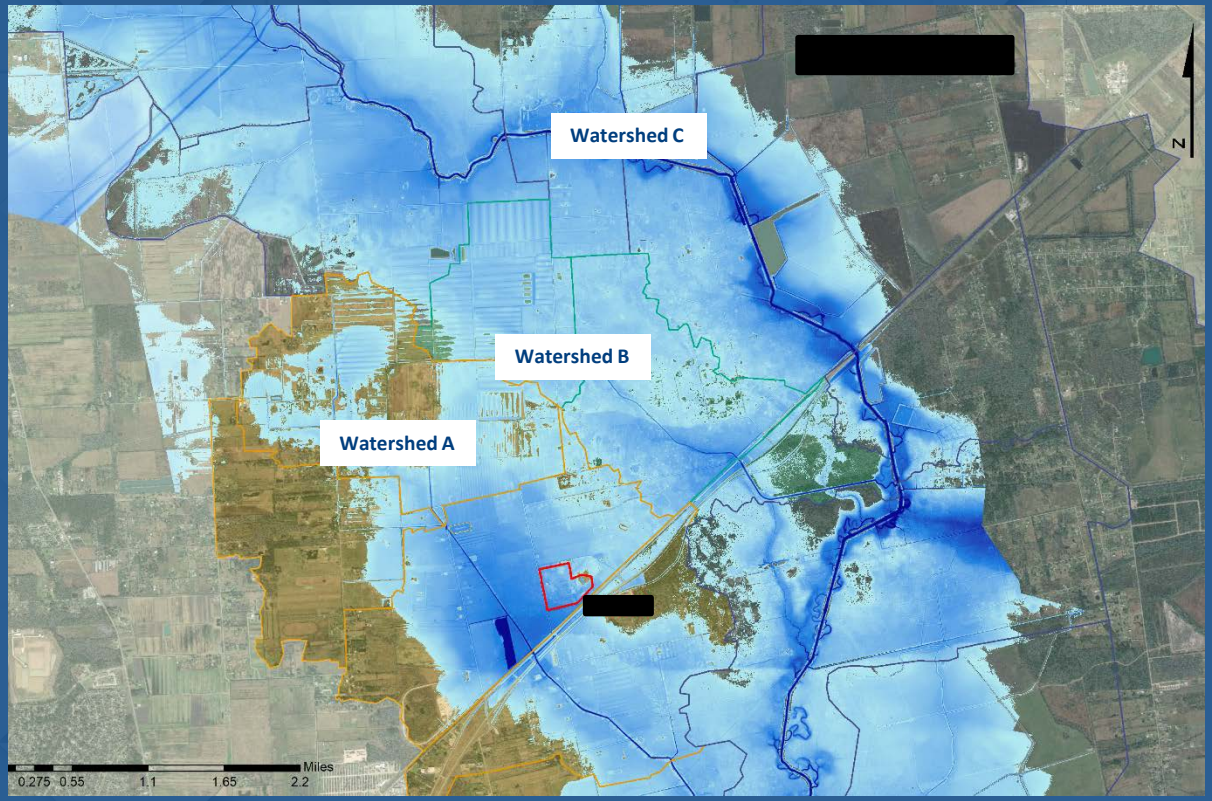

HEC-RAS 2D: The Right Tool for the Job?

Presented by:

Emily Campbell, PE CFM CPESC
Rishab Mahajan, PE CFM

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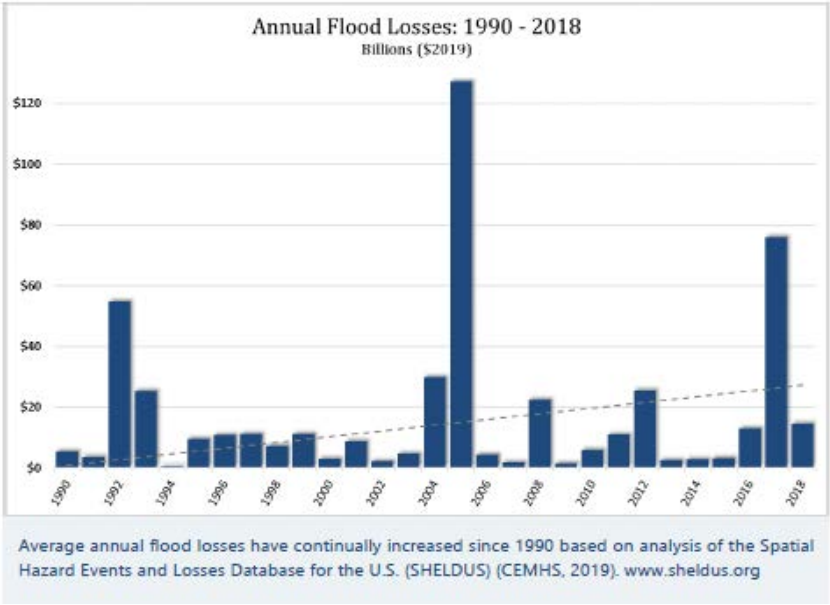
Importance of Floodplain Mapping

- Higher intensity precipitations events have become more frequent
- Average annual losses from flooding have increased over the years
- Accurate floodplain mapping – foundation for any subsequent action to reduce flood risk



Source: ASFPM Report to Nation

When to use 1D, 2D or 1D/2D

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- Pure 2D:
  - Flow expected to spill into floodplain
  - Alluvial fans and estuaries
  - Meanders and loops
  - Cool hydrodynamic animations!
  - Access to good terrain data
- Pure 1D:
  - Mostly uni-directional flow within channel
  - Minimum lateral expansion
  - Run time is a constraint
  - Need to extract a lot of data (velocity, Froude #, shear, normal depth, critical depth etc.)
  - Limited/low quality terrain data
- 1D+2D, when you need both 2D and 1D features

Source: HEC-RAS 2D Modeling User's Manual

……But these are general recommendations

Case Studies

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- Case Study #1: Sometimes 2D is Better
- Case Study #2: Sometimes 1D is Better
- Case Study #3 : Using 2D to Inform 1D
- Case Study #4: A Combined 1D/2D Model

Take-Aways:

- When to choose a 1D model or a 2D model
- Nuances of 1D and 2D and how they can work together

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Case Study #1

Case Study #1: Dam Breach Analysis

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Mule Creek State Prison (MCSP) reservoir

- Located in Amador County, CA
- Used for storage of treated effluent from prison
- Earthen Embankment with storage capacity of 540 acre feet
- Classified a High Hazard by California Division of Safety for Dams (DSOD)
  - Potential for loss of life in case of failure

Case Study #1: Regulatory Requirements

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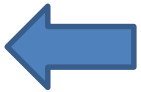
California Code of Regulations
Title 23. Waters
Division 2. Department of Water Resources
Chapter 1. Dams and Reservoirs
Article 6. Inundation Maps



Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures

First Edition

FEMA P-946 / July 2013

California's inundation mapping regulations

- Require inundation mapping for structures greater than 25 feet in height
- Recommends use of 2D model in areas of lateral spreading

Case Study #1: Dam Breach Analysis

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- 2D model allowed breaching at multiple location to determine worst case scenarios
  - 1D model would have required reorientation of cross-sections
- 2D unsteady model is more stable for rapidly changing flows such as dam breach analysis
- 2D model allows rapid creation of inundation maps for multiple breach scenarios

Case Study #1: Inundation Results

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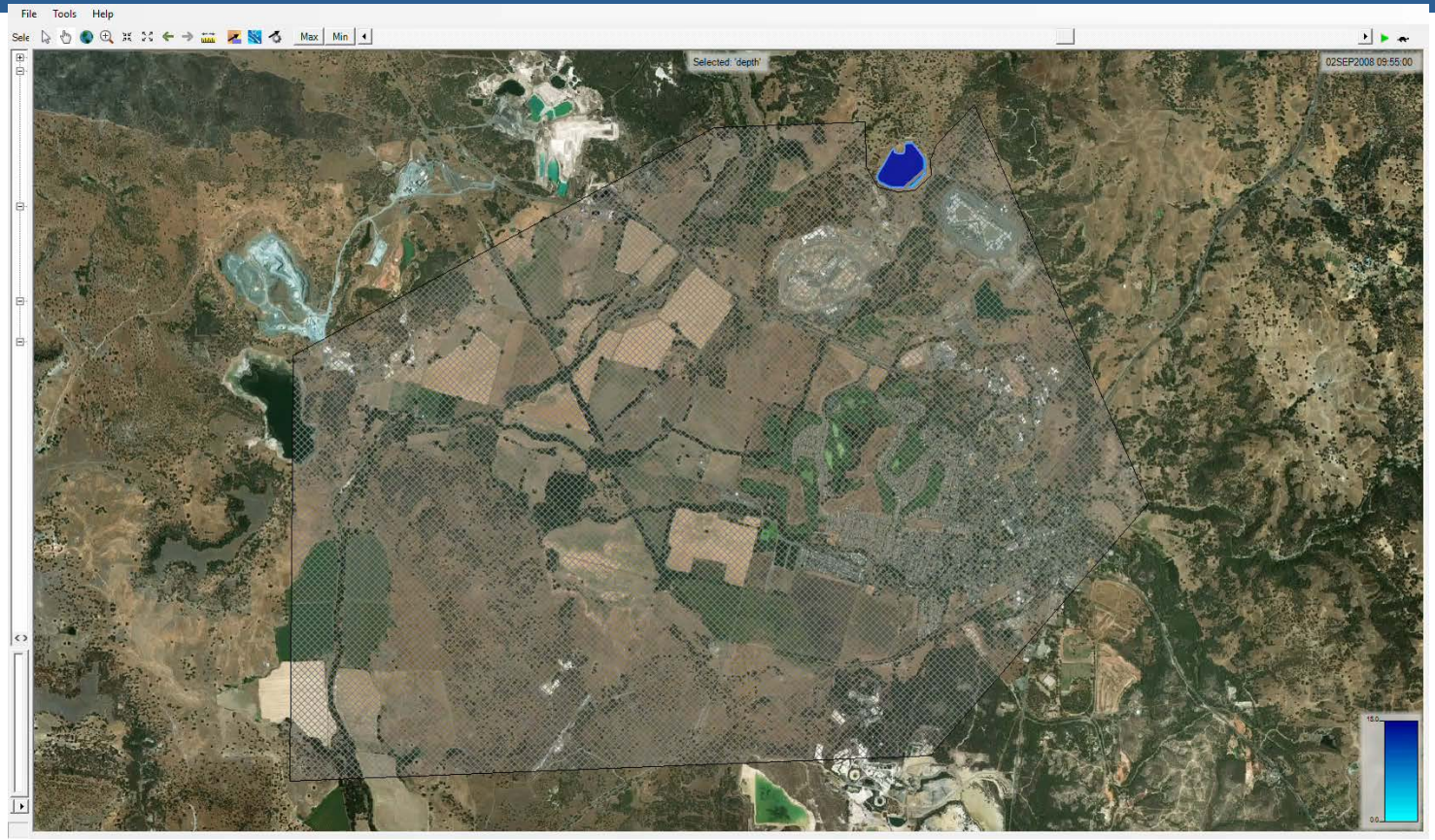
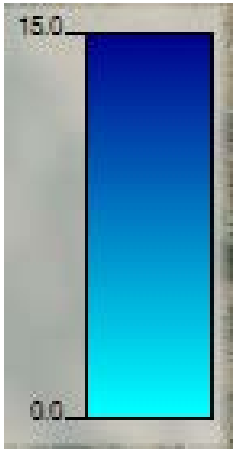


Legend:
Depth (feet)



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Case Study #2

Case Study #2: Sometimes 1D is better

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- Geosyntec modeled a large watershed to determine flood elevations at multiple properties along a river
- 1D and 2D models were developed in parallel
- Ultimately… 1D model was selected
- WHY?

Case Study #2: 2D Model

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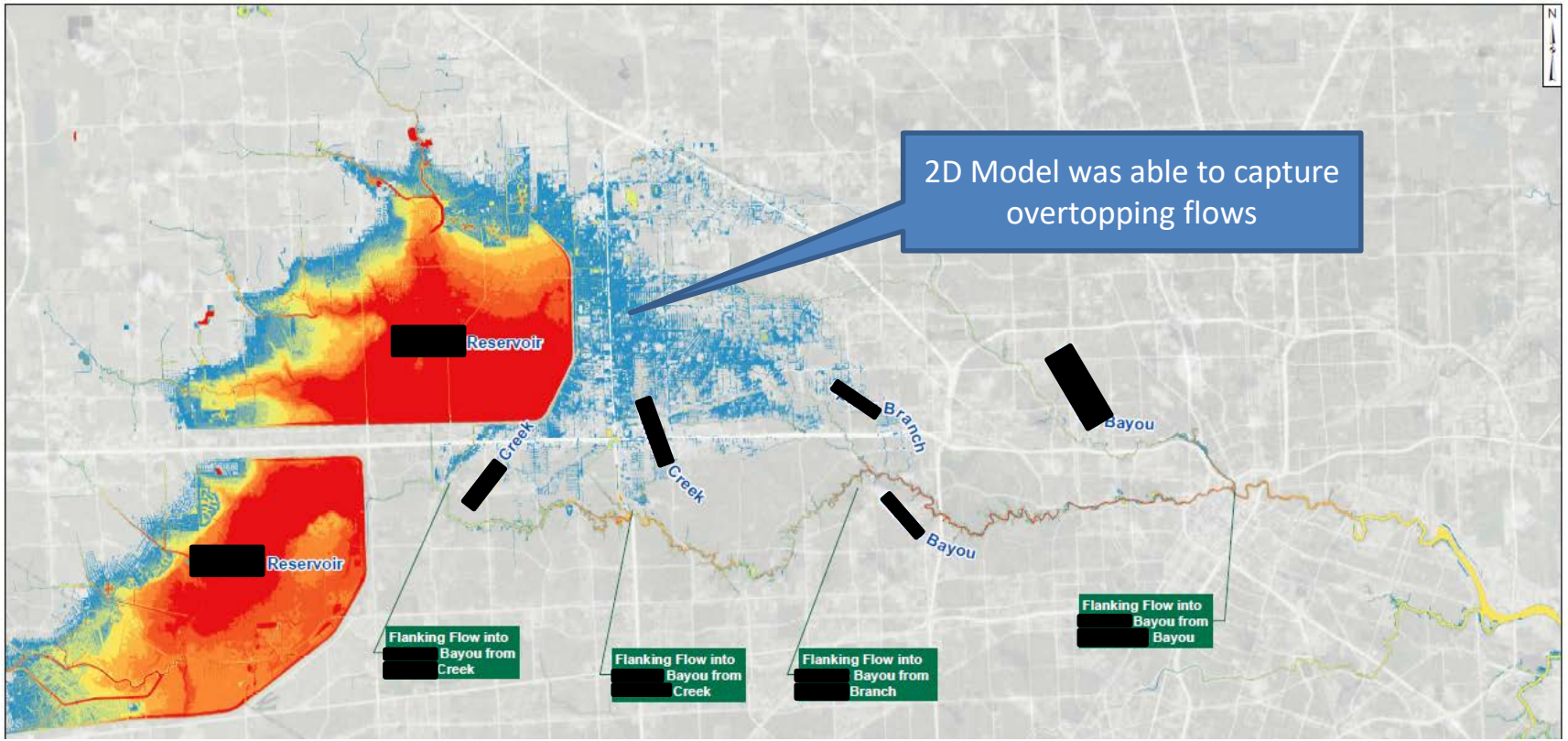

Case Study #2: 2D Model Problems

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- 2D model water levels were not matching calibration data… water level was too low
  - Too much rain was being captured in the 2D model mesh
    - HEC-RAS 2D is a *hydraulics* model not a *hydrology* model
  - Numerous bridges in the primary river of interest were not included in the 2D model
    - 2D can only model bridges as culverts

Case Study #2: 1D Model Strengths

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- HEC-RAS 1D works very well with HEC-HMS
  - Doesn't need to act as a hydrology model
- HEC-RAS 1D can model bridges as bridges
  - Pre-existing regulatory 1D model easily provided bridge data
- Water levels simulated by the 1D model were more accurate

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Case Study #3

Case Study #3: Using 2D to Inform 1D

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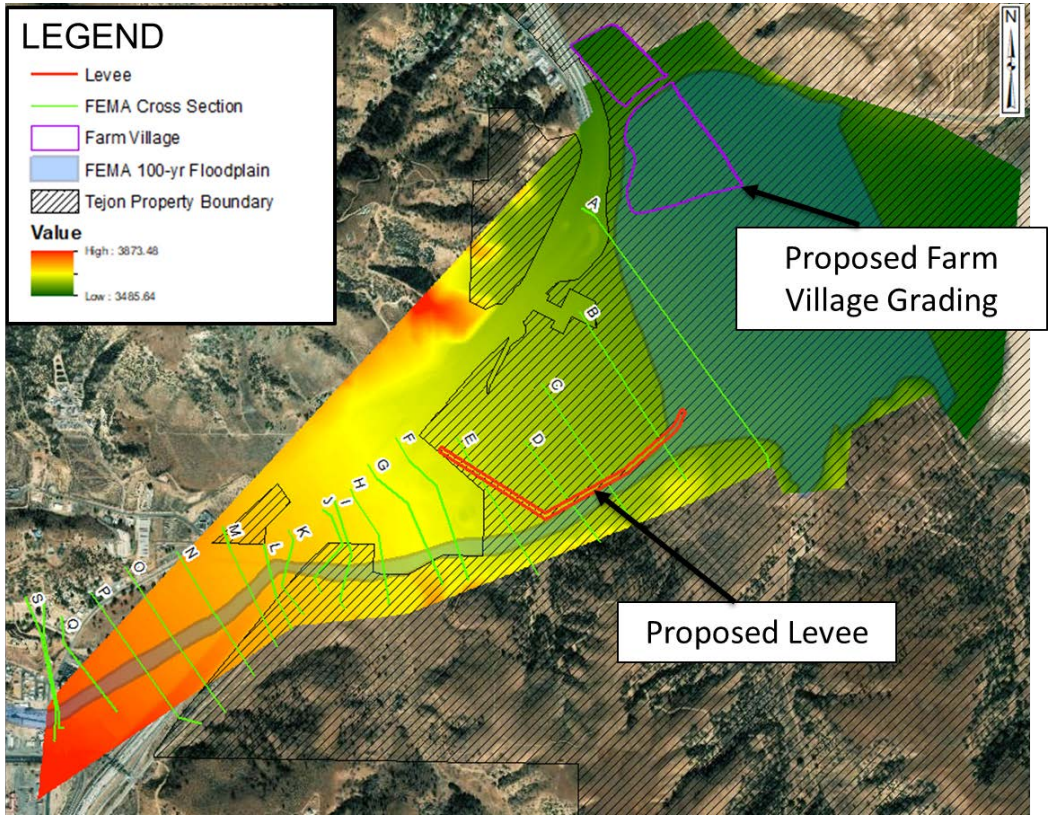

- Regulatory models are in 1D (this is changing!), but some floodplains are complex and hard to identify how water will flow through the area
- Geosyntec used a 2D model to develop a 1D regulatory model in an alluvial floodplain

Case Study #3: Why 2D?

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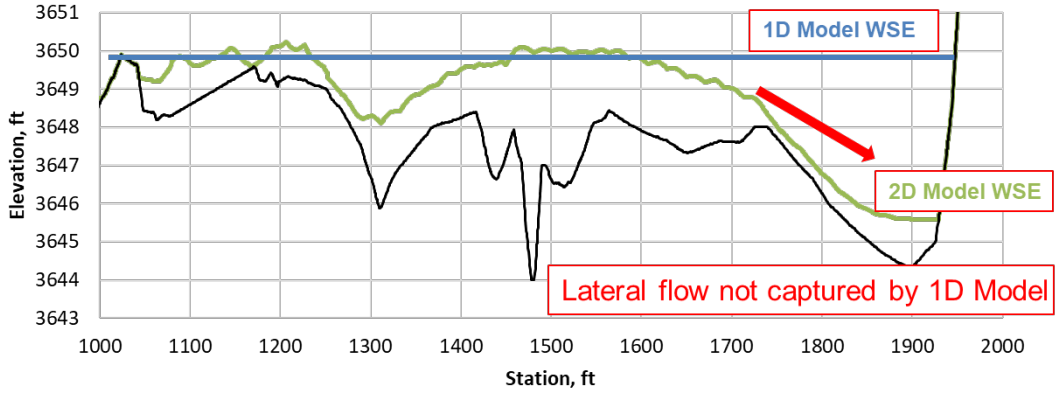
- Hard to predict flow direction
- Lateral Flow is not captured in1D models
- Split flow is not captured in 1D models.



Case Study #3: Transforming 2D to 1D

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- RAS Mapper allows the modeler to observe water surface elevation contours
- 1D models calculate a single water surface elevation for a cross section
- 1D cross sections were dog-legged to approximately match water surface contours developed by the 2D model

Case Study #3: Creating 1D XS from 2D

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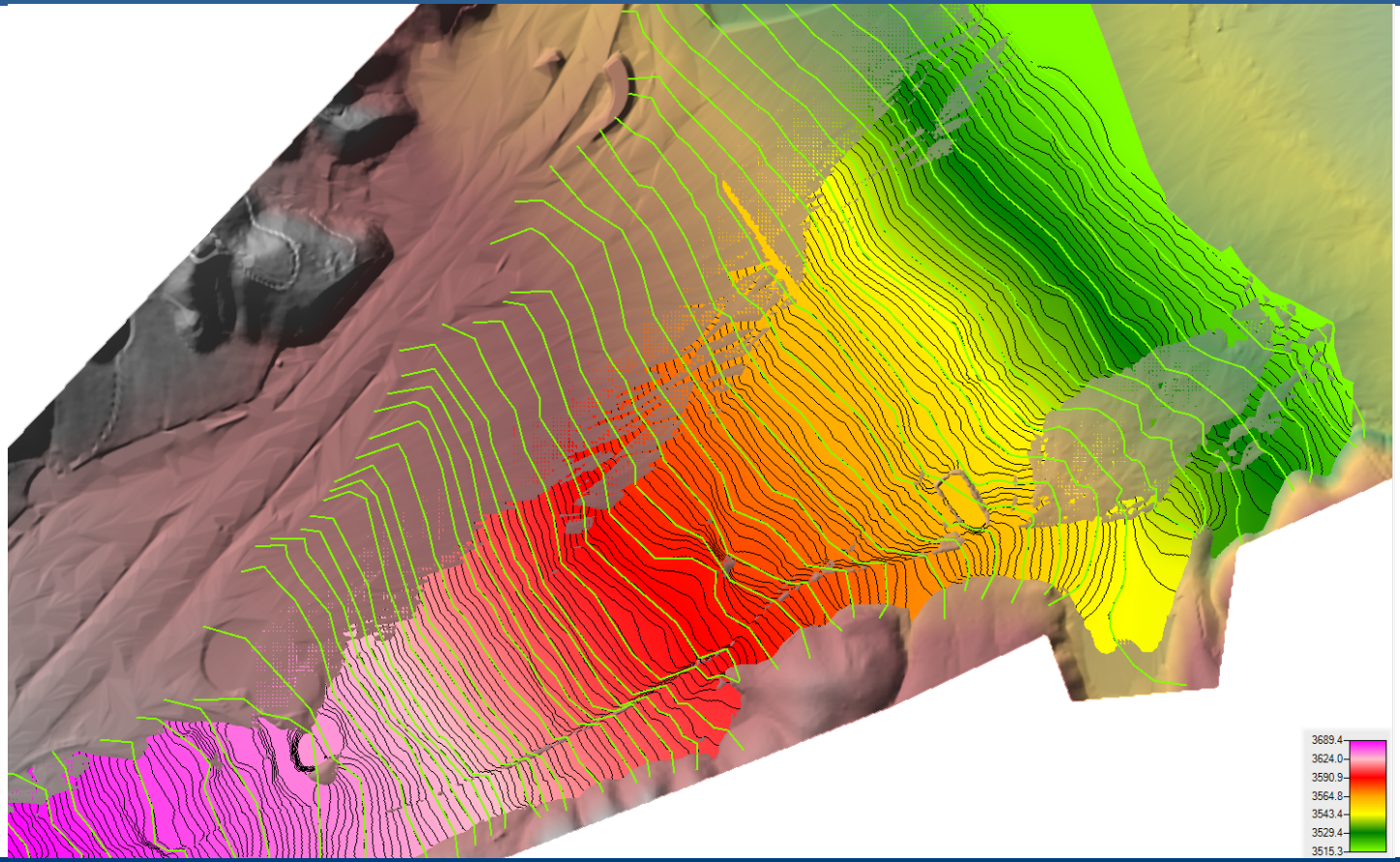

Case Study #3: 2D vs 1D Results

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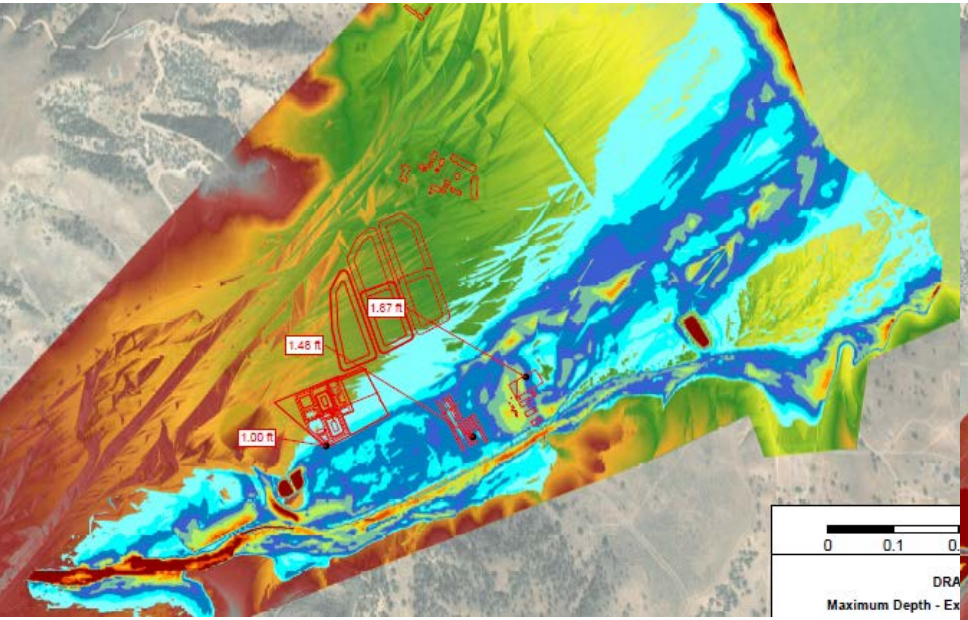
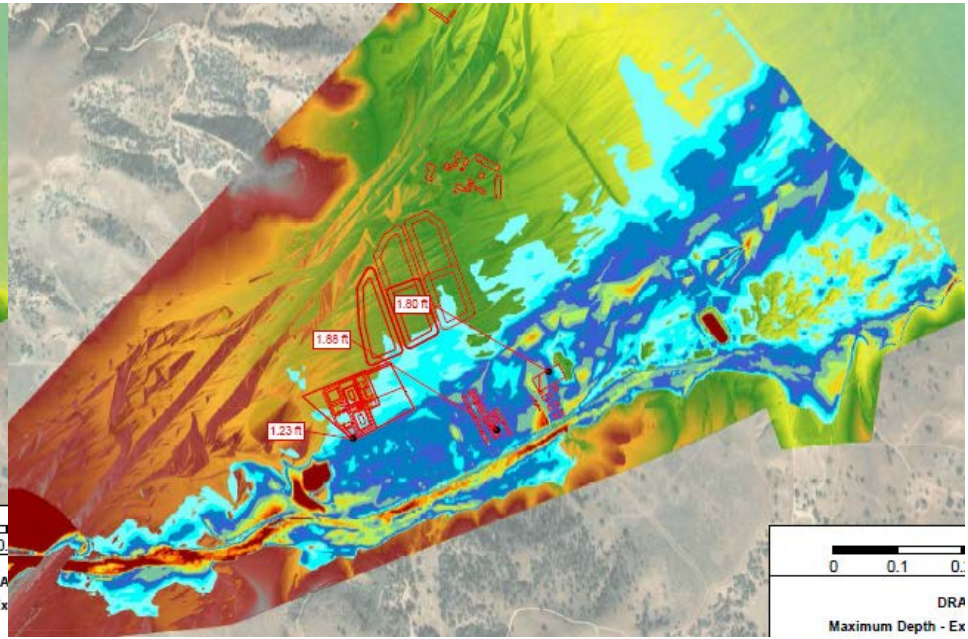
2D Model:



1D Model:



Case Study #3: Response from FEMA….

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- We will use this as a best practice case example – the right way, particularly with the extremely complex site condition (i.e. alluvial flood fan)

- FEMA paraphrase: ‘We see 2-D modeling with 1-D thinking, which is not informative. This is 1-D modeling with 2-D thinking’

Case Study #4

Case Study #4: A Combined 1D/2D Model

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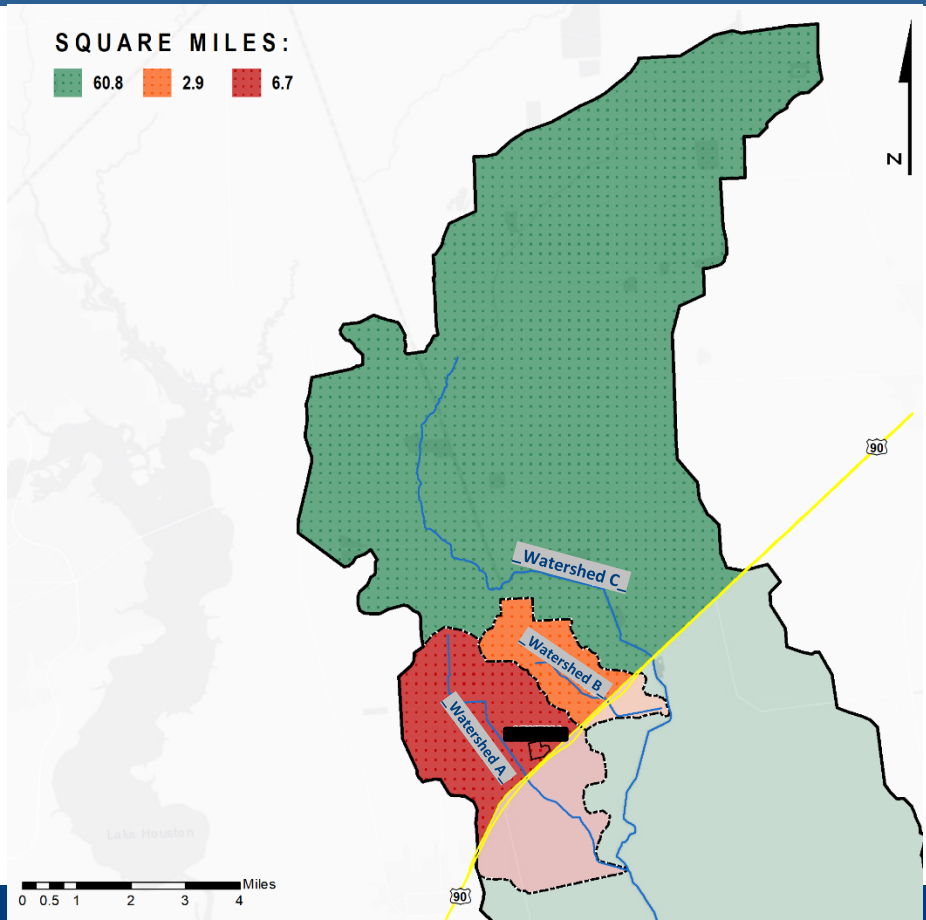
- 3 parallel rivers are bisected by a railroad
- Originally modelled as 3 separate 1D models
- During an extreme storm event, the railroad constricted flow
- Water behind the railroad bridge overtopped the watershed boundary
- Flow from the largest watershed flooded the smaller watersheds



Case Study #4: A Combined 1D/2D Model

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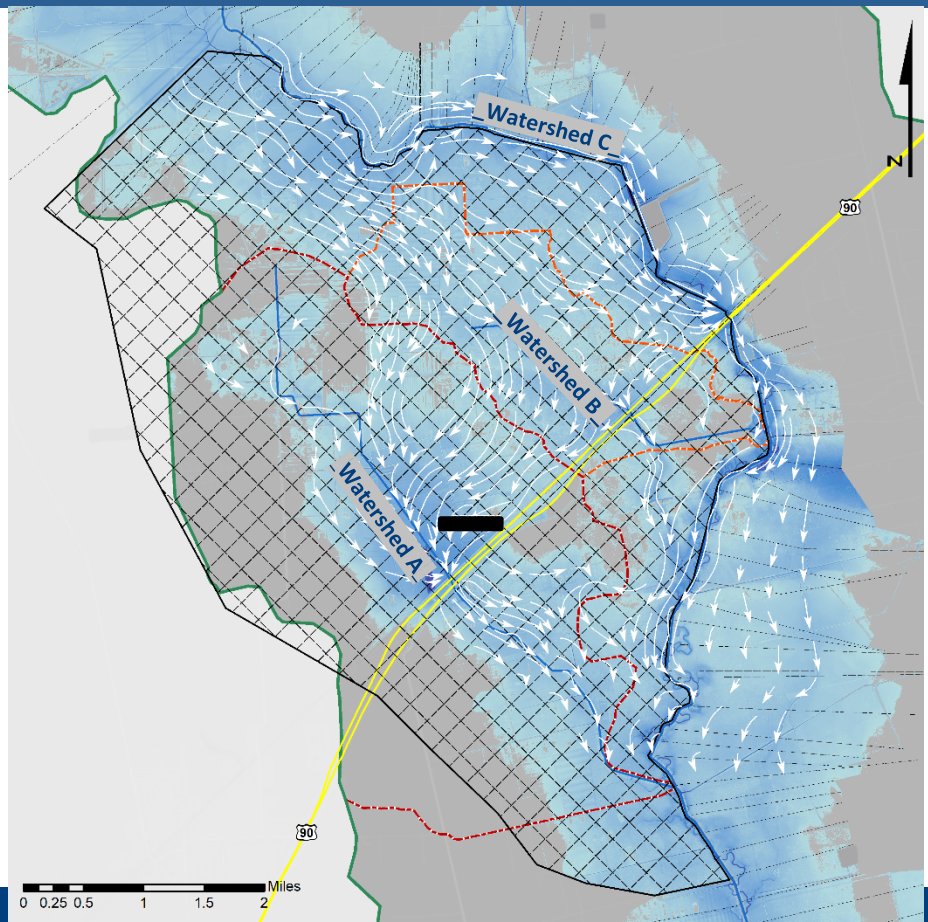
- To simulate overtopping flows through the watersheds, a combined 1D/2D model was developed
- A 1D/2D interface was placed on the right bank of River C upstream and downstream of the railroad



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Lessons Learned

Lessons Learned

Geosyntec consultants

- Dam breach analysis – 2D is a no brainer!
- Adding inflows to 2D mesh can be tricky especially in case of a large drainage area
- Multiple bridges in the study area may require use of 1D
- Regulatory requirements may dictate the use of 1D-can be informed 2D model
- 1D/2D can be combined to have the best of both models

Questions?

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Lessons Learned

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- 1D RAS unsteady models are unstable… 1D/2D are a nightmare
- 1D/2D interface is a source of instability
  - Zero height weir: not in the manual, but critical for our model to run
  - Limited by number of station/elevation points
  - Two models calculating WSEL/flows in/out for same area
- Cell size and orientation really matter
  - Near 1D/2D interface
  - Near constricted areas (between bridges)
- Adding flows to 2D model domain can be tricky
- Manning's n has a powerful effect