2-Dimensional vs 1-Dimensional Hydraulic Modeling at Iowa Bridge Improvements

September 25, 2025

PRESENTED BY

Eric Dean, PE, CFM

benesch

Agenda

- What is Hydraulic Modeling
- Why do we do Hydraulic Modeling
- Hydraulic Modeling Software
- 1-D v 2-D Hydraulic Comparison
- Case Study
- Lessons Learned

benesch

Hydraulic Modeling What and Why

benesch

What is Hydraulic Modeling

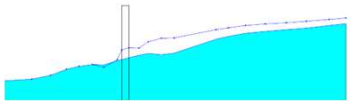
- Use of mathematical equations and computer simulations to predict how water behaves in natural and engineered systems, such as rivers, and water and sewer networks.
- Conservation of momentum and conservation of mass

benesch

Why do we do Hydraulic Modeling

Determine Backwater

- The difference between the modeled water surface elevations for topography being evaluated and the base topographic condition.
- For the Q100, 1.5' for low damage and 1.0' for high damage.



benesch

Why do we do Hydraulic Modeling

Determine Freeboard

- The vertical clearance measured between the channel or operational low beam, and the stage for the given discharge with the proposed bridge in place.
- 3.0' above Q50

benesch

Why do we do Hydraulic Modeling

Determine Scour

- Numerous factors
- Q500 Check, Q200 Design

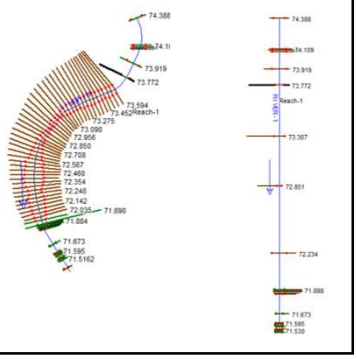
benesch

Hydraulic Modeling Software

benesch

What is 1-D Hydraulic Modeling (HEC-RAS)

- Appears to be 2-D
- Calculations are done in 1-D aka a straight line
- Use cross sections



benesch

What is 2-D Hydraulic Modeling (SMS)

- Appears to be 3-D
- Calculations are done in 2-D
- Uses a mesh

benesch

When to use 1-D Hydraulic Modeling

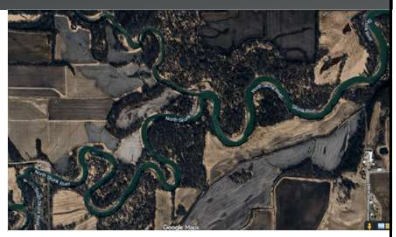
- When a bridge is located within a detailed Flood Insurance Study (FIS) area, or the upstream flood plain has a high damage potential (such as a residence or business located in then upstream flood plain)

benesch

When to use 2-D Hydraulic Modeling

- For complex hydraulic locations, a 1-D hydraulic analysis may not adequately capture the effects of flooding and backwater.

  These locations may include overflow bridges, flood plains with flank or lateral levees and roadways that are significantly skewed to the flood plain.



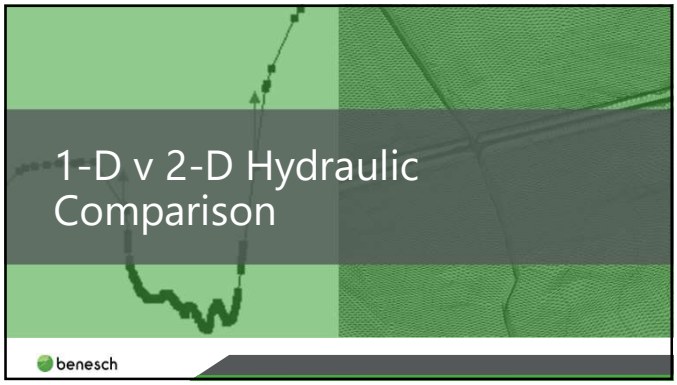
benesch

2-D Pros and Cons

2-D Pros	2-D Cons
More accurate*	Takes more time
More intrinsic output	Specialty software
Cutting edge	Software Familiarity

**Especially when there is complex flow patterns, multiple openings, severe bridge skews, or irregular channels*

benesch



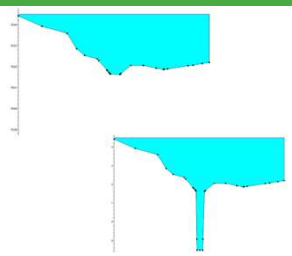
1-D v 2-D Hydraulic Comparison

benesch

1-D vs 2-D Modeling Approach

Model Development for Both Approaches

- Survey that is supplemented with LiDAR
- Create sections for use in modeling
- Carve out channel where using LiDAR
- Determine Manning numbers
- Determine Flows

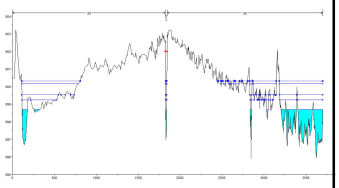


benesch

1-D vs 2-D Modeling Approach

Model Development 1-D

- Apply ineffective areas, expansion, and contraction coefficients
- Determine if sections were done at correct spot
- Interpolate or add sections if needed
- Add manning number and banks to sections
- Add in Roadway elevations in geometry editor

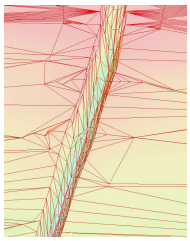


benesch

1-D vs 2-D Modeling Approach

Model Development 2-D

- Create full scatter by combining Survey, Carve Out, and LiDAR
- Create a Mesh
- Assign Manning number to areas
- Adjust scatter to account for profile change and piers
- Add in “arc” for structure information
  - Length, elevation bridge type

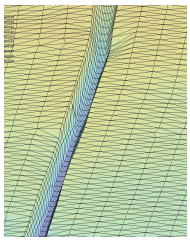


benesch

1-D vs 2-D Modeling Approach

Model Development 2-D

- Create full scatter by combining Survey, Carve Out, and LiDAR
- Create a Mesh
- Assign Manning number to areas
- Adjust scatter to account for profile change and piers
- Add in “arc” for structure information
  - Length, elevation bridge type

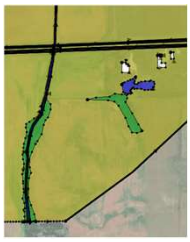


benesch

1-D vs 2-D Modeling Approach

Model Development 2-D

- Create full scatter by combining Survey, Carve Out, and LiDAR
- Create a Mesh
- Assign Manning number to areas
- Adjust scatter to account for profile change and piers
- Add in “arc” for structure information
  - Length, elevation bridge type

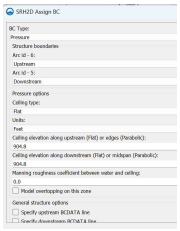


benesch

1-D vs 2-D Modeling Approach

Model Development 2-D

- Create full scatter by combining Survey, Carve Out, and LiDAR
- Create a Mesh
- Assign Manning number to areas
- Adjust scatter to account for profile change and piers
- Add in “arc” for structure information
  - Length, elevation bridge type

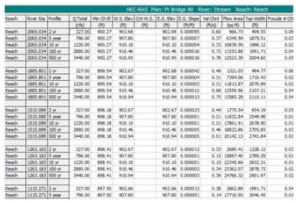


benesch

1-D vs 2-D Modeling Approach

Model Results 1-D

- Can only get information at sections
  - Cross Section Summary Table
  - Water Surface Profile
  - Cross Section View
  - Bridge Output Summary Table
- Use GIS plus terrain to get a plan view map

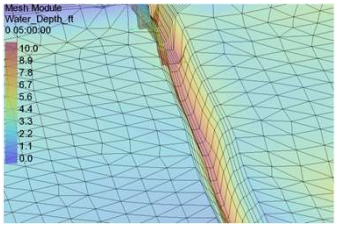


benesch

1-D vs 2-D Modeling Approach

Model Results 2-D

- Opportunities are endless
  - 3d representation of water surface, depth, velocity
  - Compare different models natural vs proposed
  - Need “monitor” or “observation” lines for data at a specific station or profile

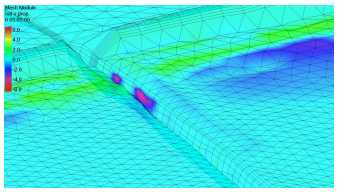


benesch

1-D vs 2-D Modeling Approach

Model Results 2-D

- Opportunities are endless
  - 3d representation of water surface, depth, velocity
  - Compare different models natural vs proposed
  - Need “monitor” or “observation” lines for data at a specific station or profile

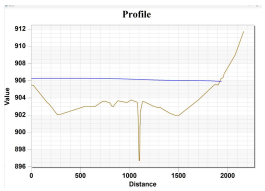


benesch

1-D vs 2-D Modeling Approach

Model Results 2-D

- Opportunities are endless
  - 3d representation of water surface, depth, velocity
  - Compare different models natural vs proposed
  - Need “monitor” or “observation” lines for data at a specific station or profile



benesch

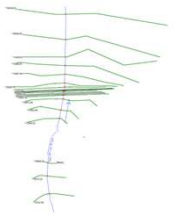
CASE STUDY

Case Study

benesch

FIRM Panel

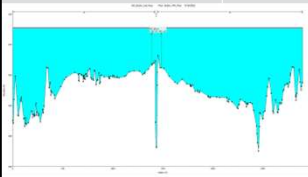
1-D	2-D

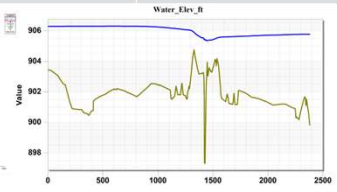


benesch

HWL Comparison

	1-D	2-D
Proposed	905.1	905.9/905.3





benesch

Computation Time

1-D	2-D
2 Seconds 	5 Minutes 

benesch

Level of Effort

Set Up

Effort	Hours
Survey that is supplemented with LiDAR	16 hours
Create sections for use in modeling	8 hours
Carve out channel where using LiDAR	4 hours
Determine Manning numbers	8 hours
Determine Flows	8 hours
TOTAL	44 hours

benesch

Level of Effort

1-D

Effort	Hours
Apply ineffective areas, expansion, and contraction coefficients	4 hours
Determine if sections were done at correct spot	1 hour
Add manning number and banks to sections	2 hours
Interpolate sections if needed	1 hour
Add in Roadway elevations in geometry editor	4 hours
TOTAL	12 hours

benesch

Level of Effort

2-D

Effort	Hours
Create full scatter by combining Survey, Carve Out, and LiDAR	8 hours
Create a Mesh	4 hours
Assign Manning number to areas	2 hours
Adjust scatter to account for structures	2 hours
Add in "arc" for structure information	1 hour
TOTAL	17 hours

benesch

Learning/Troubleshooting/Iterations

1-D

Lots of written guides that are easy to follow

2-D

Better off with Youtube: RiverGeeks, NHI, or Aquaveo

benesch

Level of Effort Comparison

	1-D	2-D
Both Approaches	44	44
Software Specific First Model	12	17
Second Model	4	12
Total Time	**60**	**73**
Learning/Troubleshooting	*12*	*40*
Iterations	*$*	*$$*

benesch

Lessons Learned

- Preliminary in 1-D? Difficult to change in 2-D
- Understand compatibility between ORD and HEC-RAS
- Getting Carve Out into 2-D
- Garbage in, Garbage out
- Have scatter reviewed before moving on
- Order of operation when doing scatter for different models
- Save often, crashing issues

benesch

Questions?

benesch