



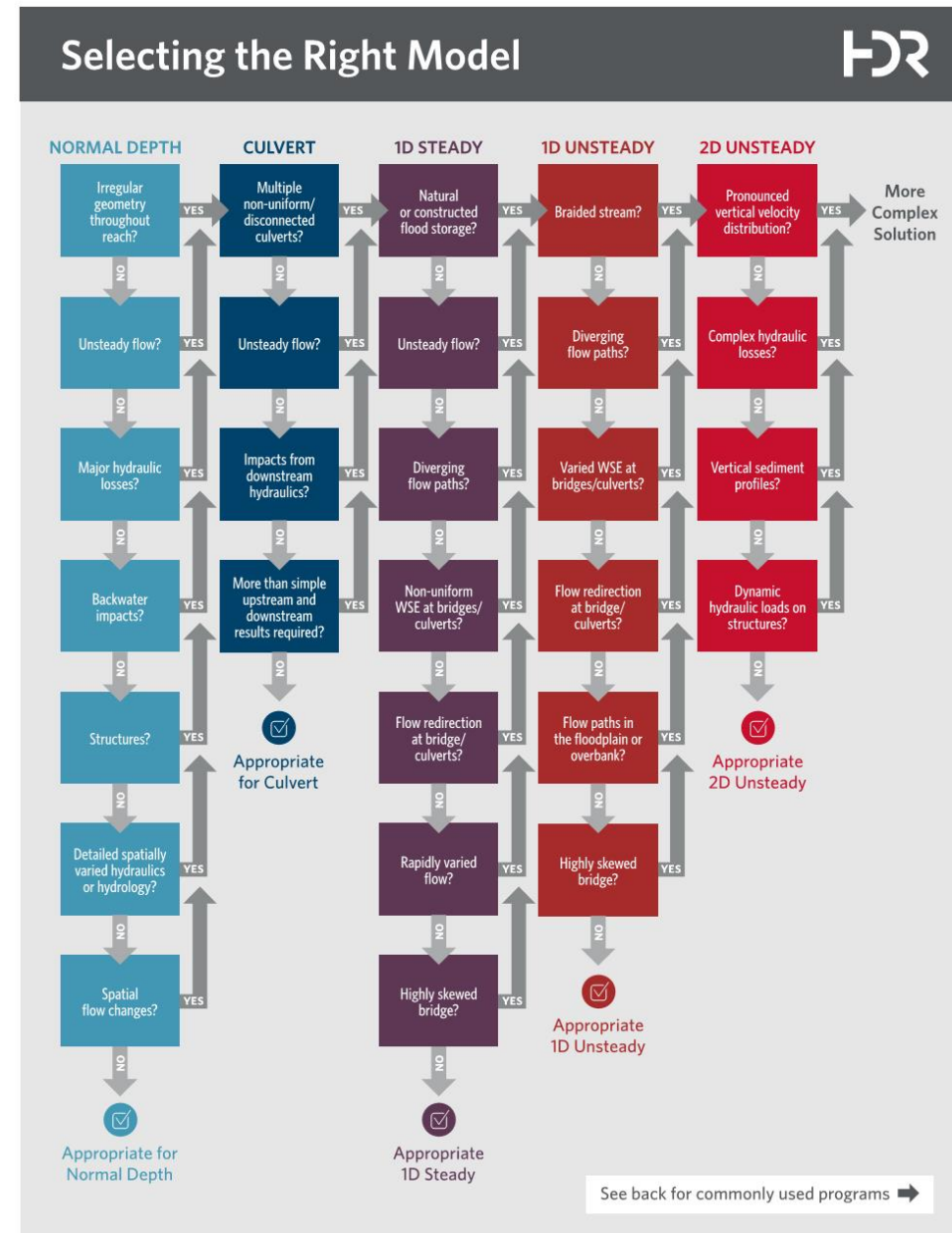
# Selecting the Right Model

Josh Hollon &  
Brinton Swift



# Importance of Model Selection

- Project Management
  - Appropriate use of available budget
  - Schedule management
- Data Needs
  - Input
  - Output
- Risks
  - Hydraulics represent huge risks
  - Lack of detail may not identify risks
  - Simplifications can overestimate risk
  - Wrong analysis can be more costly



# Importance of Model Selection

- Finding the right tool
  - Leverage the tools capabilities
  - Proprietary vs Open Source
  - Future Users
- Available Programs
  - Not an endorsement or recommendation
- Comments/Improvements
  - Email us

## Available Programs



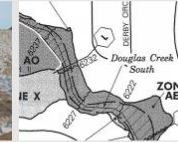
### NORMAL DEPTH

- » FlowMaster
- » Hydraulic Toolbox



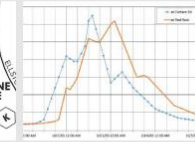
### CULVERT

- » HY-8
- » CulvertMaster
- » UD-Culvert



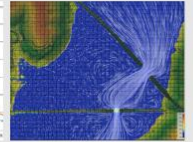
### 1D STEADY

- » HEC-RAS
- » MIKE 11
- » XPSWMM
- » SWMM 5



### 1D UNSTEADY

- » HEC-RAS
- » MIKE 11
- » XPSWMM
- » SWMM 5
- » TUFLOW



### 2D UNSTEADY

- » HEC-RAS
- » SRH-2D
- » Flo2D
- » MIKE 21
- » TUFLOW
- » XPSWMM
- » RiverFlow2D
- » TrimR2D
- » MIKE FLOOD
- » SWMM 5

## Contacts



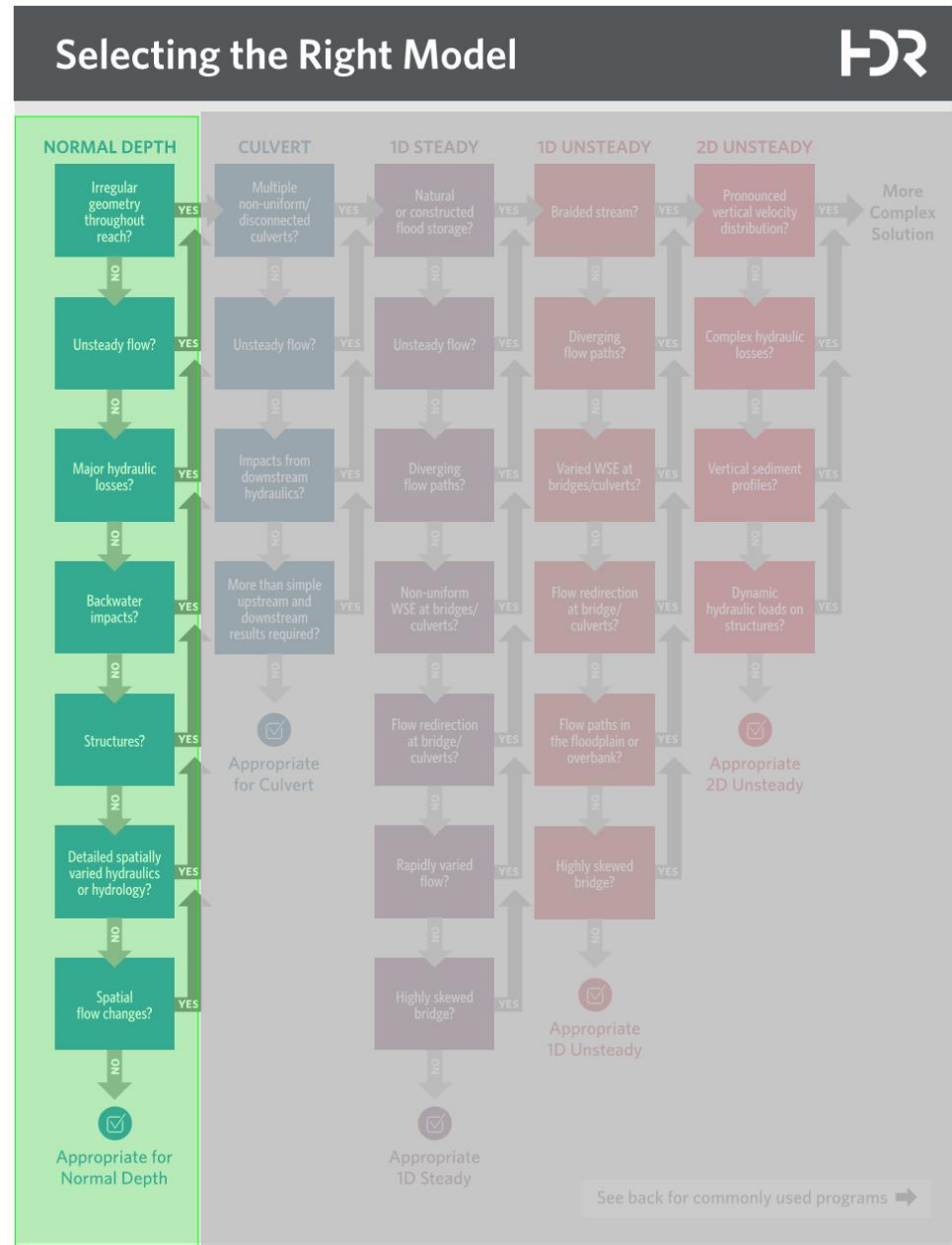
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# Normal Depth

- Irregular Geometry
- Unsteady Flow
- Hydraulic losses
- Backwater Impacts
- Structures
- Spatially varied H&H
- Spatial flow change





- Irrigation channels
- Roadside ditches
- Curb & gutters
- Gutter pans
- Sidewalk chases





Project Explorer

- Untitled1.fm8
  - Trapezoidal Channel - 1

Worksheet : Trapezoidal Channel - 1

Uniform Flow | Gradually Varied Flow | Messages

Solve For: Normal Depth Friction Method: Manning Formula

Roughness Coefficient:	0.035		Flow Area:	48.55	ft <sup>2</sup>
Channel Slope:	0.00500	ft/ft	Wetted Perimeter:	30.22	ft
Normal Depth:	2.45	ft	Hydraulic Radius:	1.61	ft
Left Side Slope:	4.00	ft/ft (H:V)	Top Width:	29.61	ft
Right Side Slope:	4.00	ft/ft (H:V)	Critical Depth:	1.81	ft
Bottom Width:	10.00	ft	Critical Slope:	0.01686	ft/ft
Discharge:	200.00	ft <sup>3</sup> /s	Velocity:	4.12	ft/s
			Velocity Head:	0.26	ft
			Specific Energy:	2.72	ft
			Froude Number:	0.57	
			Flow Type:	Subcritical	

- Simple input
- Simple output

Channel Analysis

Type: Trapezoidal Define...

Side Slope 1 (Z1): 4.0 H:1V

Side Slope 2 (Z2): 4.0 H:1V

Channel Width (B): 10.0 (ft)

Pipe Diameter (D): 0.0 (ft)

Longitudinal Slope: 0.005 (ft/ft)

☐ Override Default

Manning's Roughness: 0.0350

☐ Use Lining

Lining Type: Woven Paper Net

☒ Enter Flow: 200.000 (cfs)

☐ Enter Depth: 2.451 (ft)

Calculate

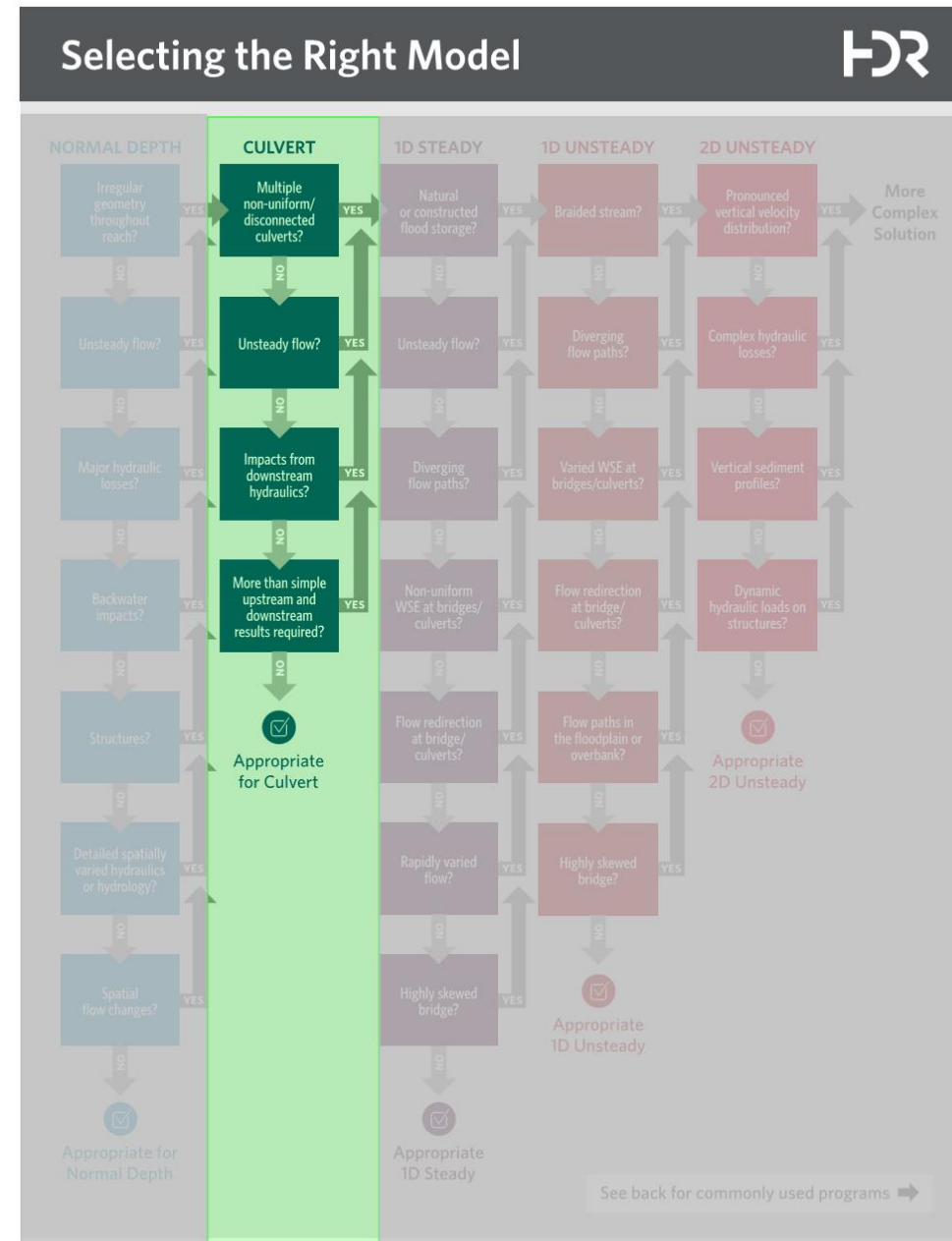
Plot... Compute Curves...

OK Cancel

Parameter	Value	Unit
Flow	200.0...	cfs
Depth	2.451	ft
Area of Flow	48.549	sq ft
Wetted Perimeter	30.214	ft
Hydraulic Radius	1.607	ft
Average Velocity	4.120	fps
Top Width (T)	29.610	ft
Froude Number	0.567	
Critical Depth	1.811	ft
Critical Velocity	6.404	fps
Critical Slope	0.016...	ft/ft
Critical Top Width	24.488	ft
Max Shear Stress	0.765	lb/ft...
Avg Shear Stress	0.501	lb/ft...

# Culvert

- Multiple, non-uniform openings
- Disconnected culverts
- Unsteady Flow
- Unknown downstream WSEL
- Need more than simple upstream/downstream hydraulic result







- Single Barrel
- Multiple Barrel
- Standard culvert shape
- Simplistic Overtopping



Culvert Calculator - Culvert

Solve For:

Culvert

Discharge:  cfs

Maximum Allowable HW:  ft

Tailwater Elevation:  ft

Section

Shape:

Material:

Size:

Number:

Mannings:

Inlet

Entrance:

Ke:

Inverts

Invert Upstream:  ft

Invert Downstream:  ft

Length:  ft

Slope:  ft/ft

Headwater Elevations

Maximum Allowable:  ft

Computed Headwater:  ft

Inlet Control:  ft

Outlet Control:  ft

Exit Results

Discharge:  cfs

Velocity:  ft/s

Depth:  ft

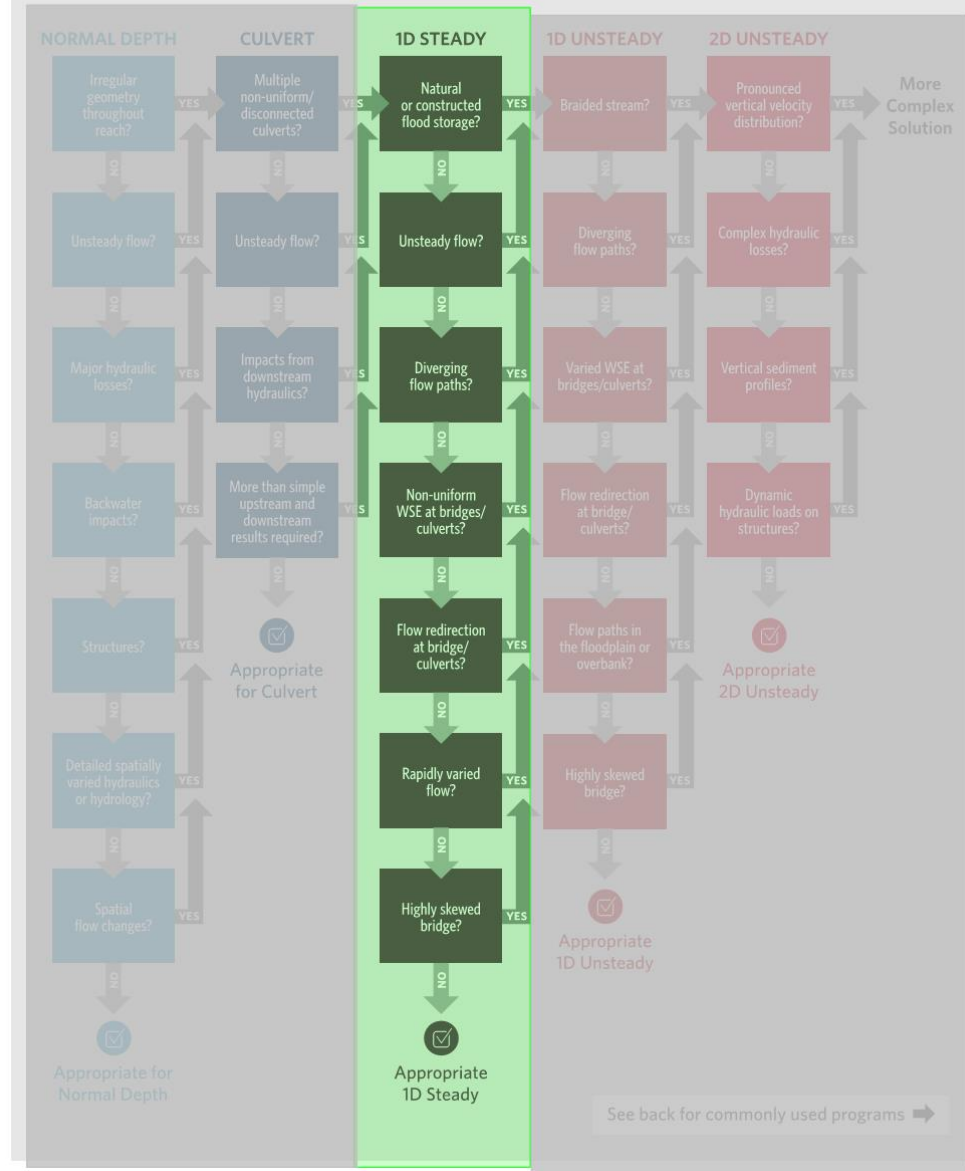
OK Cancel **Output...** Solve Export... Help

- Simple Input
- Simple Output

# 1D Steady State

- Natural or constructed flood storage
- Unsteady flow
- Diverging flow paths
- Varied WSEL at bridges/culverts
- Flow redirection
- Rapidly varied flow
- Need for sediment transport results

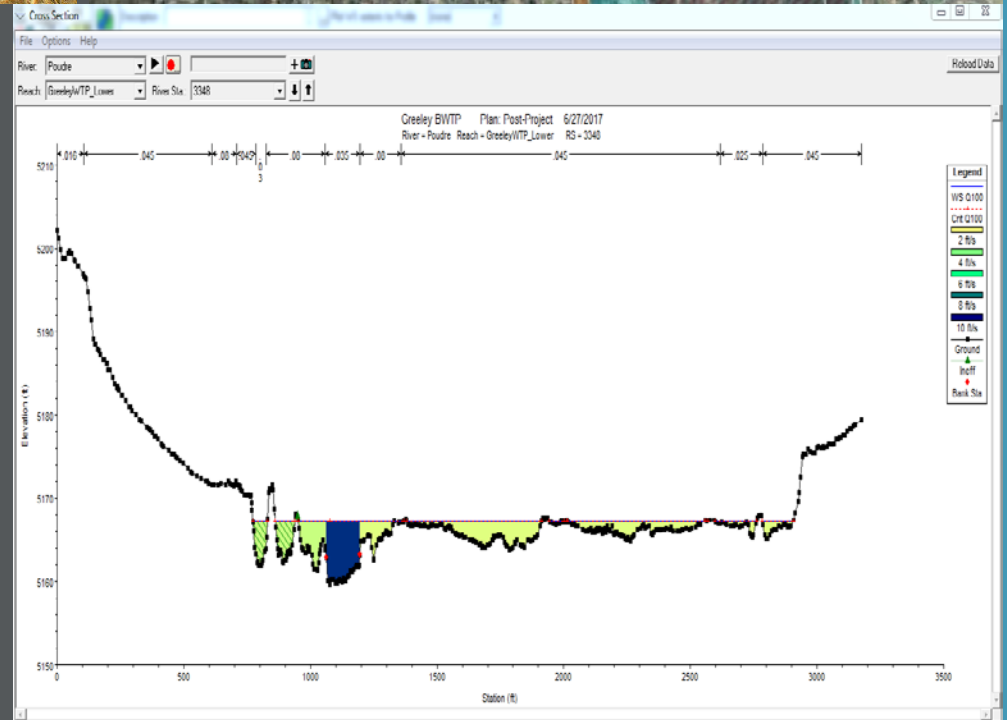
## Selecting the Right Model

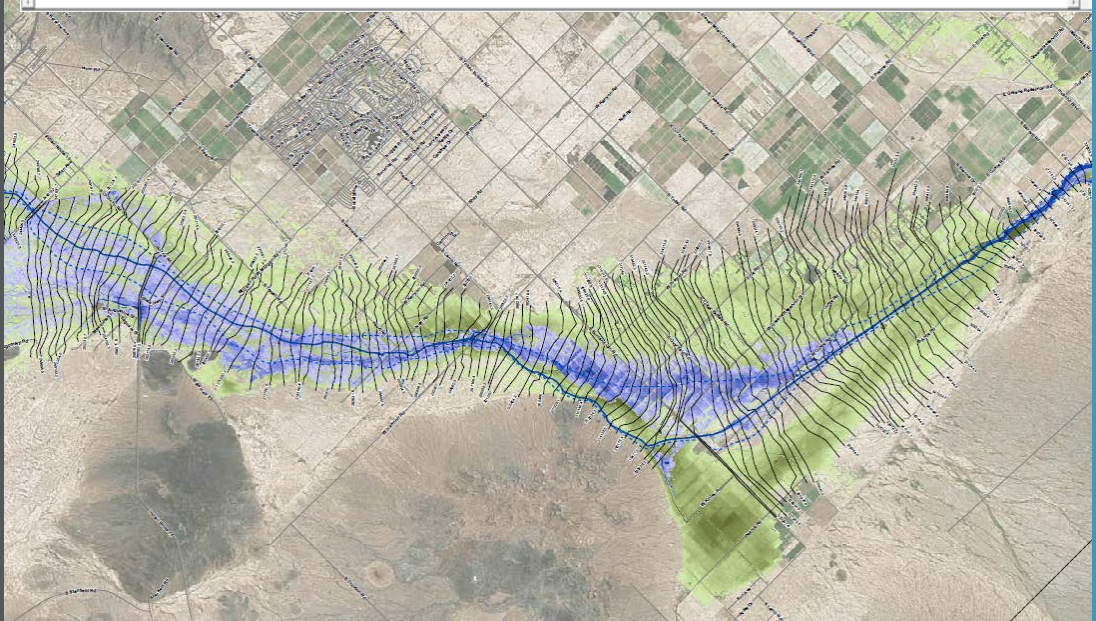
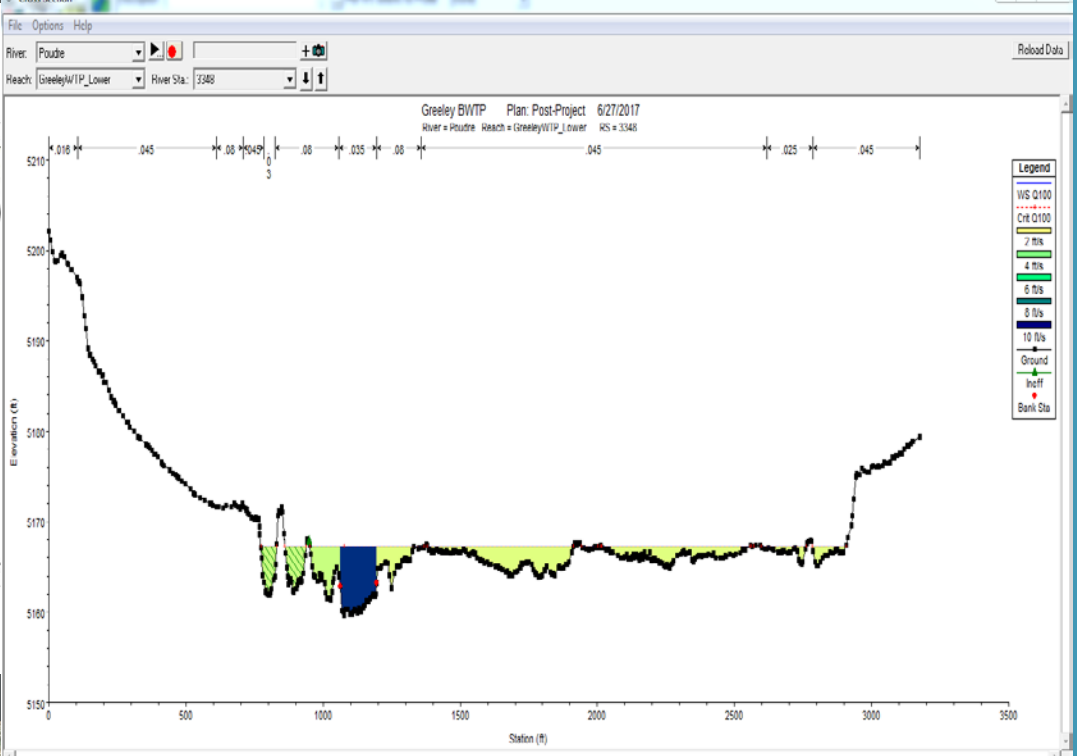
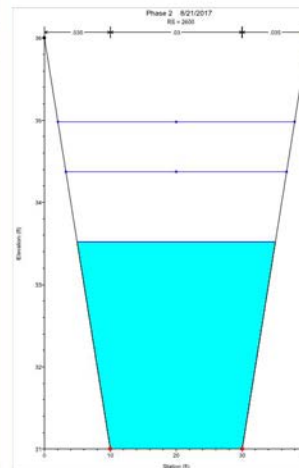
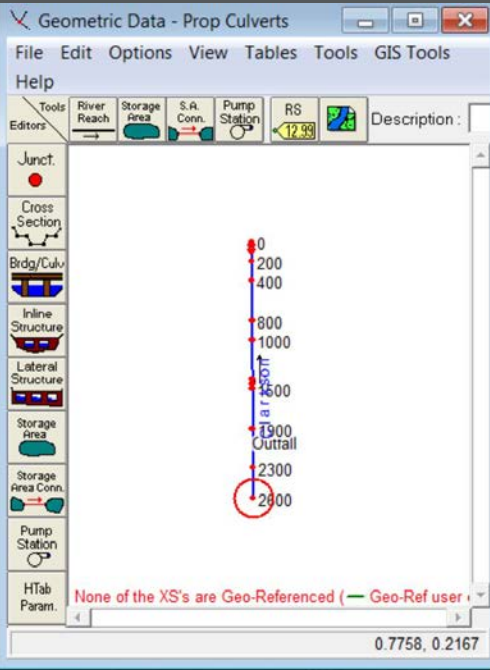






- Channels with varying vegetation/roughness
- Multiple channel reaches
- Bridges
- Culverts
- Parallel Floodplains





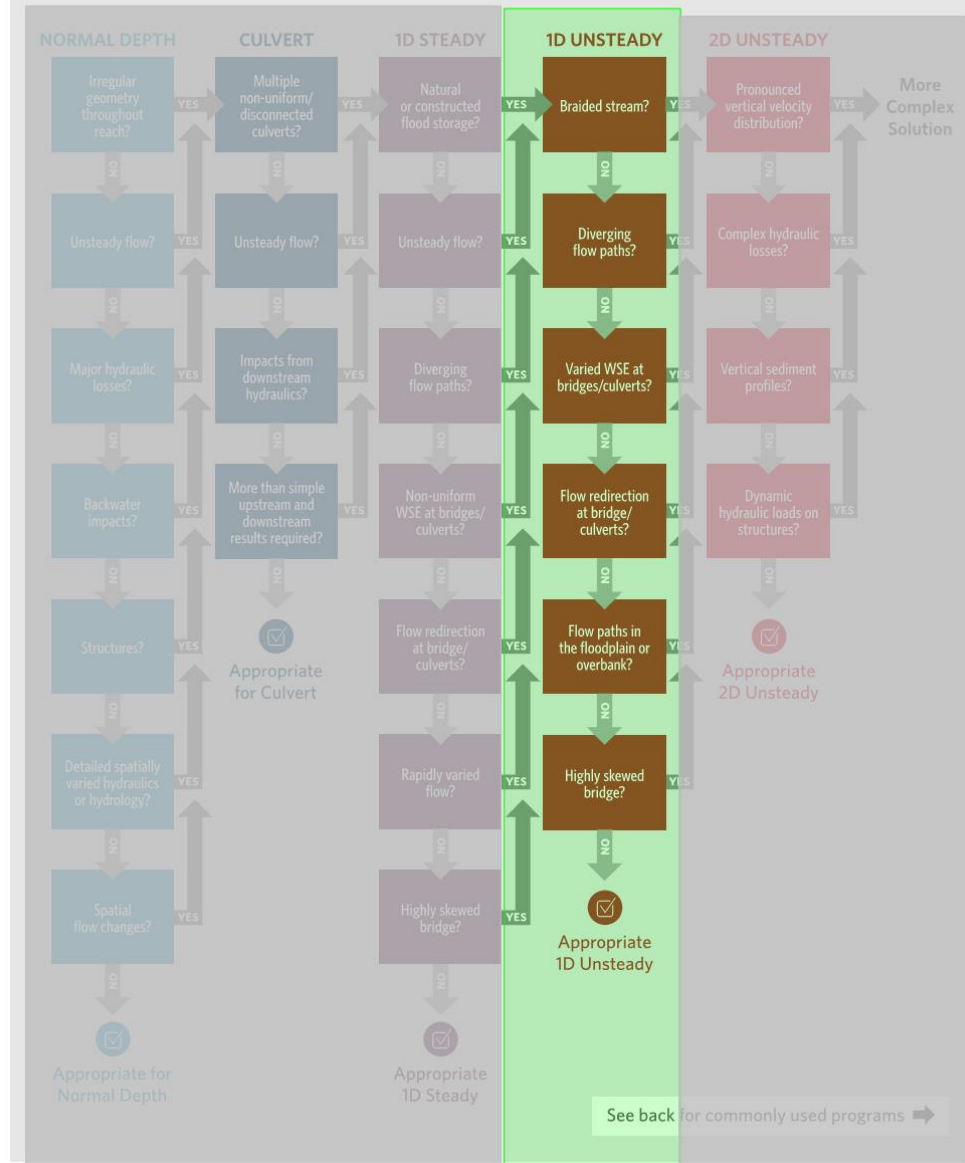
- Wide range of applications
  - Bridge analysis
  - Scour analysis
  - Channel design
  - FEMA Permitting
  - Simple prismatic channels
  - Complex channel section geometry



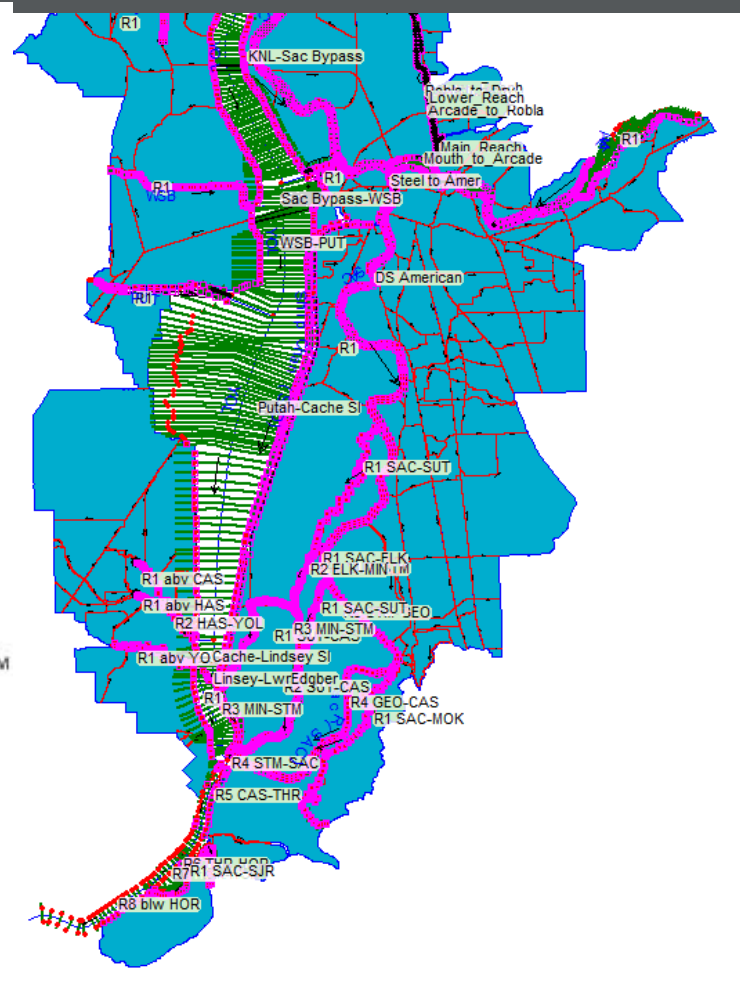
# 1D Unsteady State

- Braided Streams
- Diverging flow paths
- Varied WSE at bridges/culverts
- Highly skewed bridges

## Selecting the Right Model

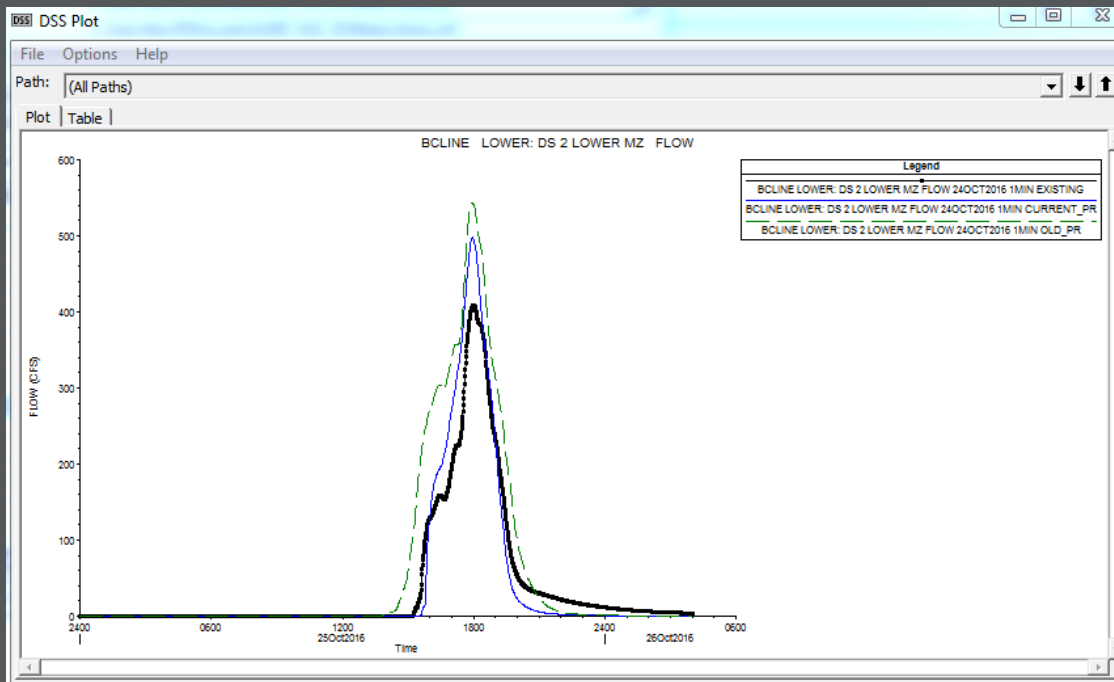






- **Flood routing (Volume!)**
  - Floodplain storage
  - Looped hydrograph
  - Split flow timing
- **Storm durations**
- **Sediment transport**
- **Tides or Reservoir operations**







Flow Data - CVHS Hydrology 1997 85%

ns Help

Conditions | Initial Conditions | Apply Data

Boundary Condition Types

Hydrograph	Flow Hydrograph	Stage/Flow Hydr.	Rating Curve
nal Depth	Lateral Inflow Hydr.	Uniform Lateral Inflow	Groundwater Interflow
ite Openings	Elev Controlled Gates	Navigation Dams	IB Stage/Flow

Rules  

Add Boundary Condition Location

RS ... Add Storage Area ... Add SA Connection ... Add Pump Station ...

Select Location in table then select Boundary Condition Type

	R1	22.357	Flow Hydrograph	▲
e_Creek	Main_Reach	0.378	Flow Hydrograph	
river	Bear US	12.710	Flow Hydrograph	
lough	Best Slough	1.46	Flow Hydrograph	
_Sink	Subreach1	38.385	Lateral Inflow Hydr.	
_Sink	Subreach3	21.962	Lateral Inflow Hydr.	
	R1	9.073	Flow Hydrograph	
	Subreach2	15.680	Flow Hydrograph	
	Subreach2	15.630 IS	Elev Controlled Gates	
.C	Subreach1	1.464	Flow Hydrograph	
reek	Dry CreekLower	8.134	Flow Hydrograph	
_NEMDC	Lower_Reach	0.169	Flow Hydrograph	
14	ELK	R1 SAC-SUT	9.416	Flow Hydrograph
	Feather	1	147.396	Flow Hydrograph
	Feather_Trib_A	1	2.014	Flow Hydrograph
16	Georgiana (GEO)	R1 SAC-MOK	0.037	Stage Hydrograph
17	KNI	Subreach1	7.13	Flow Hydrograph
18	Lindsey Sl (LIN)	R1 abv YOL	6.180	Flow Hydrograph
19	Lwr Egbert (EGB)	R1	4.761	Flow Hydrograph
20	Natomas Cross	Main_Branch	5.163	Flow Hydrograph
21	NEMDC	Upper_Reach	6.366 IS	Elev Controlled Gates
22	PUT	R1	9.922	Flow Hydrograph
23	Robla_Creek	Lower_Reach	0.142	Flow Hydrograph
24	SAB_18020109	R1	2.990	Flow Hydrograph
25	SAC	NCC to NEMDC	62.787 IS	Elev Controlled Gates

Time

## • More complex analysis

- Hydrographs
- Computational stability
- Model run times

## • More output data

- Animated WSE
- Durations of flow
- Volumes of flow

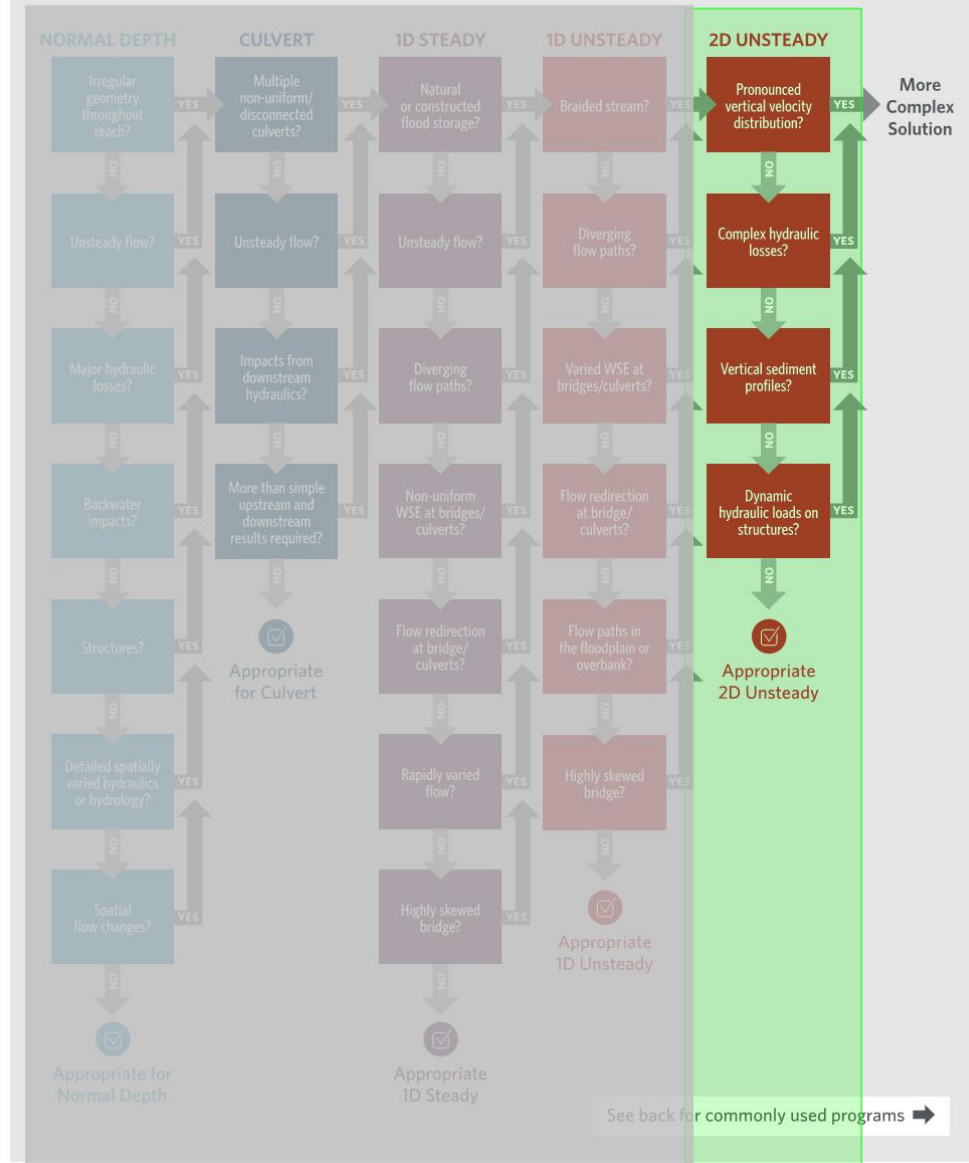
## • More experience needed

Task	Time
Writing Geometry	23.03 sec
Writing Event Conditions	0.16 sec
Preprocessing Geometry(64)	1 min 3.30 sec
Unsteady Flow Computations(64)	1 hours 19 min 27 sec
Writing to DSS(64)	3 min 30.91 sec
Post-Processing(64)	16 min 55.88 sec
Computing Maps	0.31 sec
Complete Process	1 hours 41 min 21 sec

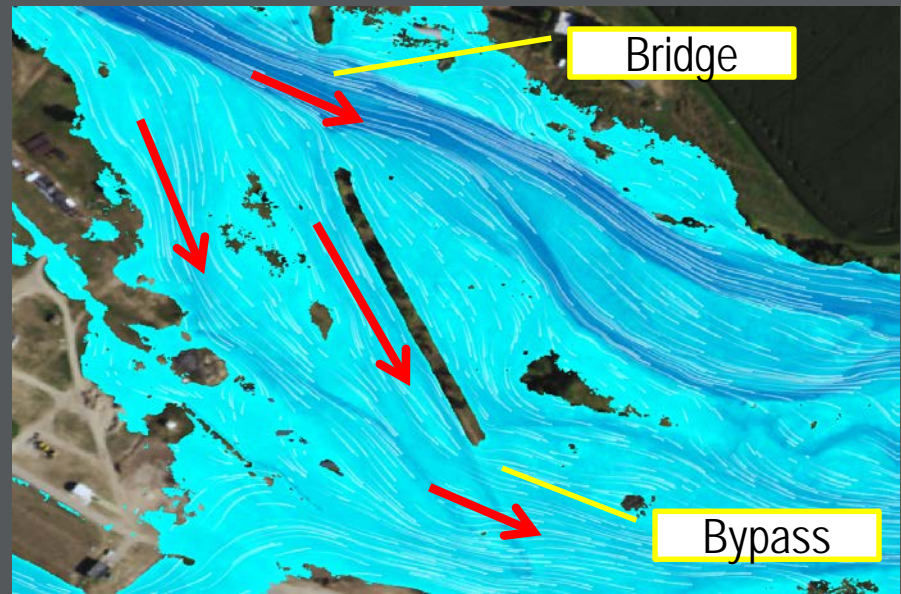
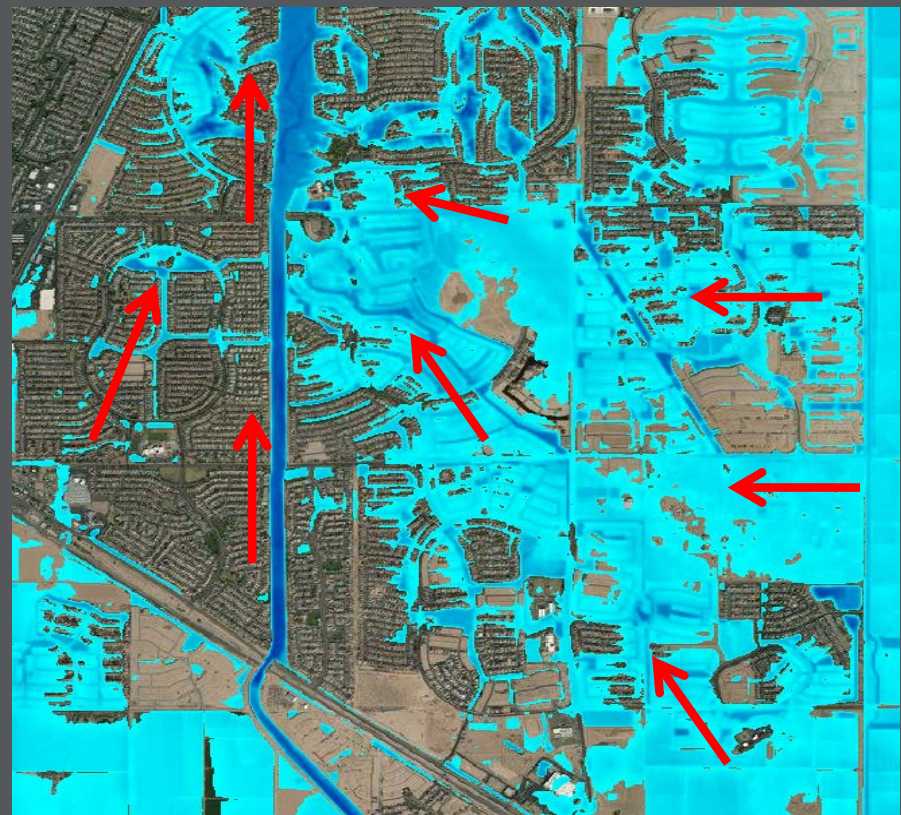
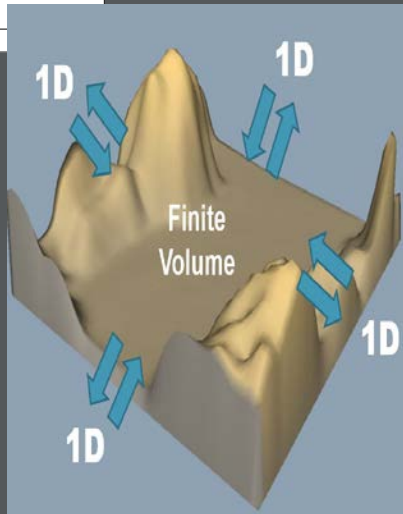
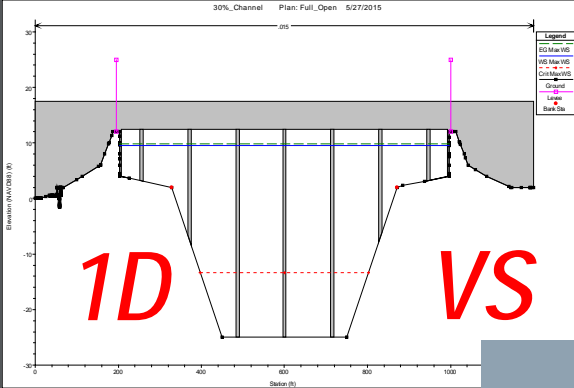
## 2D

- Vertical velocity distribution
- Complex hydraulic losses
- Vertical sediment profiles
- Need dynamic hydraulic loads on structures

## Selecting the Right Model

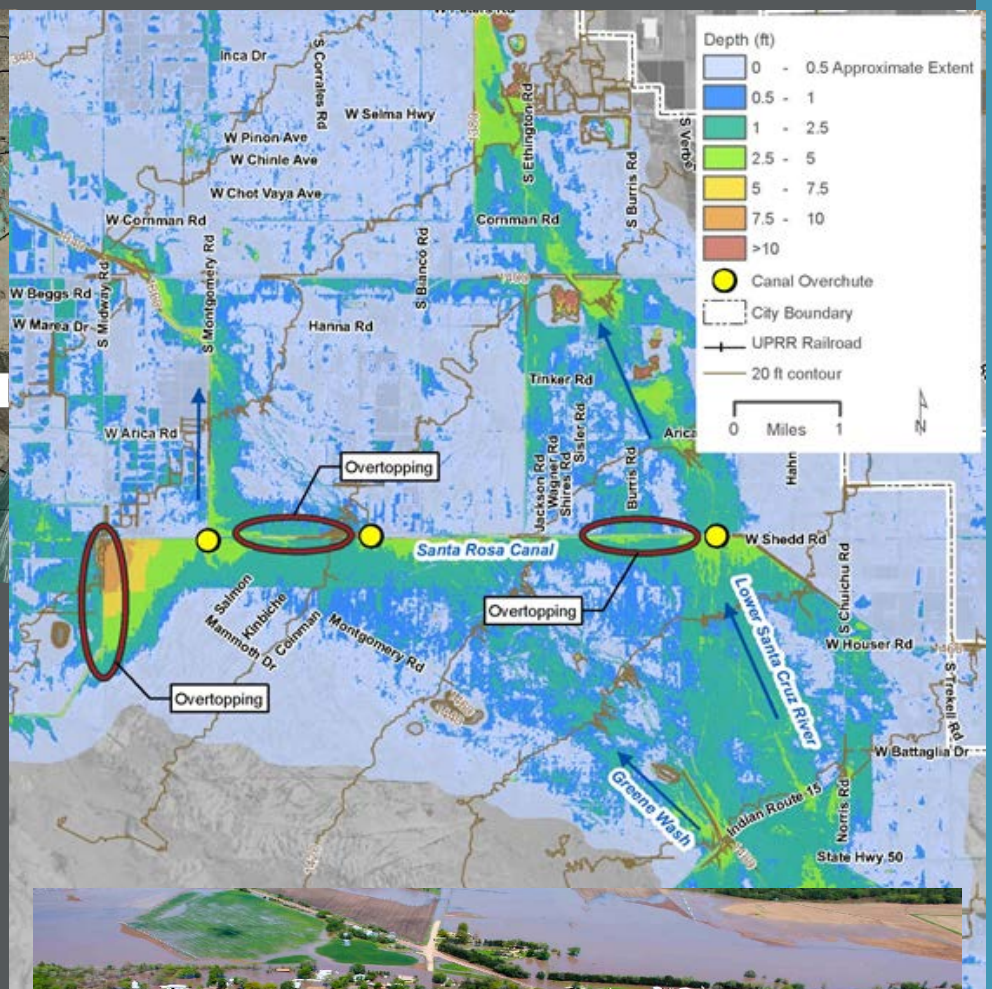
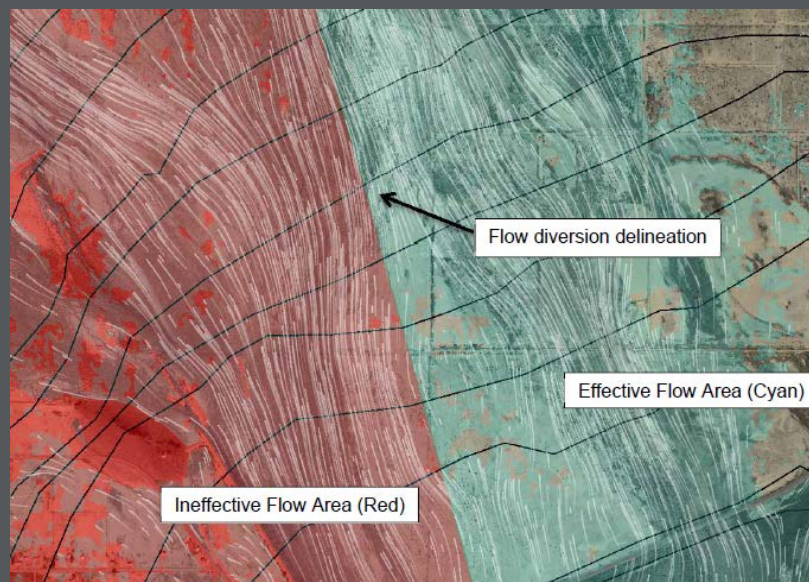






- Split flow paths
  - Bridges
  - Braided systems
  - Complex floodplains
- Non-uniform WSE
- Highly skewed bridges
- Floodplain storage



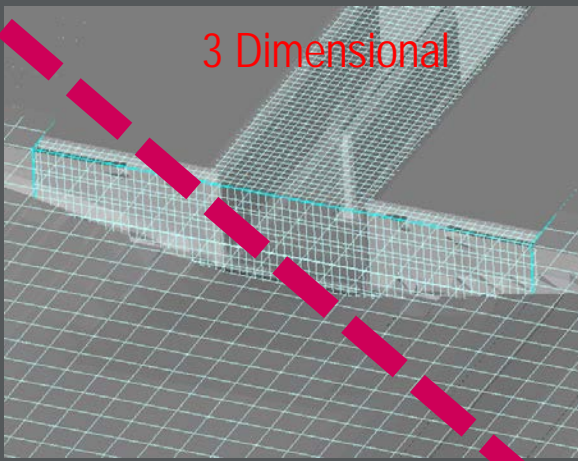


- More spatial detail
  - More terrain data
- Great for visualizations
  - Easy to understand
- Informative for 1D models
- Requires experience





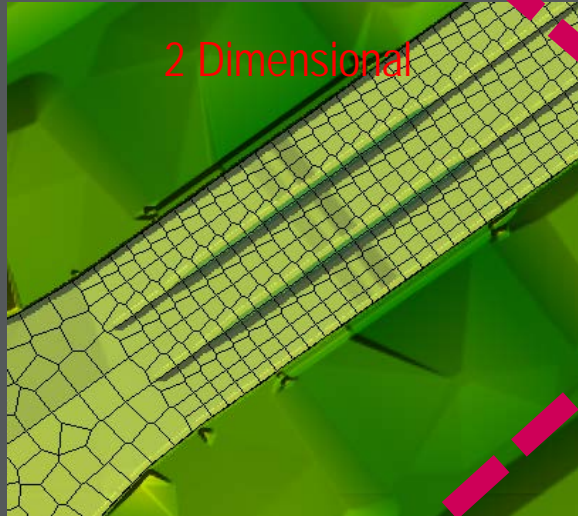
3 Dimensional



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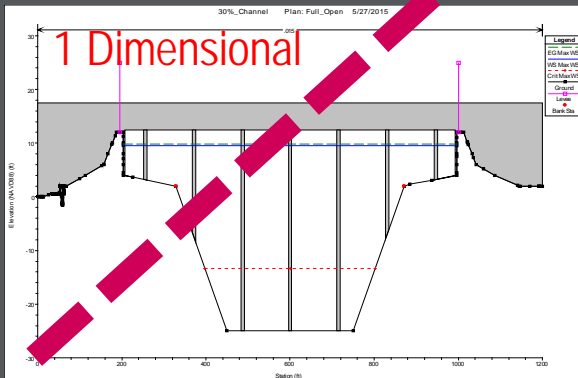
2 Dimensional



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1 Dimensional



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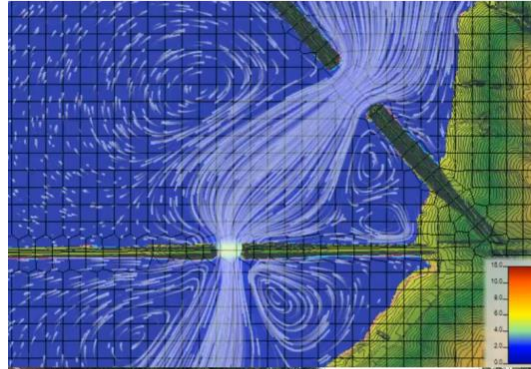
A 3D visualization of a 3D grid. A red dashed line runs diagonally across the grid. A cyan wireframe box is positioned on the grid, representing a 3D volume. The text "3 Dimensional" is written in red at the top.

A black and white photograph of Albert Einstein standing in profile, facing right, in front of a chalkboard. The chalkboard is covered with mathematical equations, including  $i = \gamma^i a_i$ ,  $\gamma^i \partial_i + a_i \gamma^i$ ,  $\nabla_k = 0$ ,  $T_{\alpha\beta} x^\alpha x^\beta$ , and  $a^\alpha \partial_\alpha x^\beta$ . A large, thick red 'X' is drawn diagonally across the right side of the image, from the top right towards the bottom left.

2 Dimensional

# Questions

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- Brinton Swift, 303.318.6312  
[Brinton.Swift@HDRInc.com](mailto:Brinton.Swift@HDRInc.com)



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