Modeling White River, Texas: A Case Study using SToRM

Texas Section ASCE

13 SEP 2013

Background

- Desire to use higher-dimensional models in support of specialized culvert hydraulics.
- Desire to estimate forces on arrays of structures in the flow field.

SToRM

- SToRM is one of recent generation of computer programs that facilitates the use of computational fluid dynamics (CFD) methods by non-experts (in CFD) for practical modeling problems.

Purpose

- See if non-experts can realistically use the tool.
- Reverse engineer a modeling protocol.
- Compare model results to observations.
- Record pitfalls

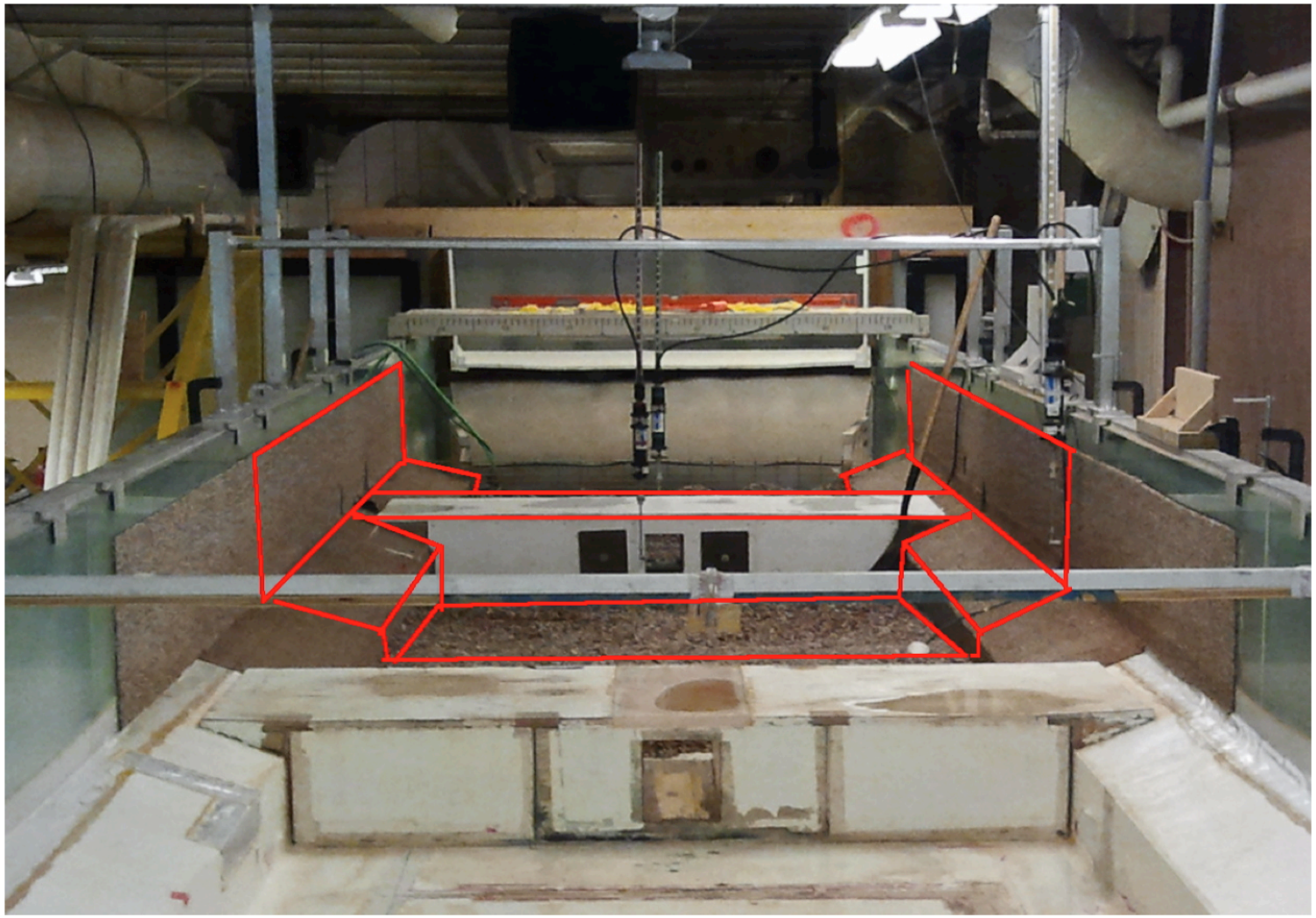
Methods

- Need X,Y,Z topography database
- Needs boundary conditions
  - Specified stage
  - Specified discharge
- Needs a resistance model

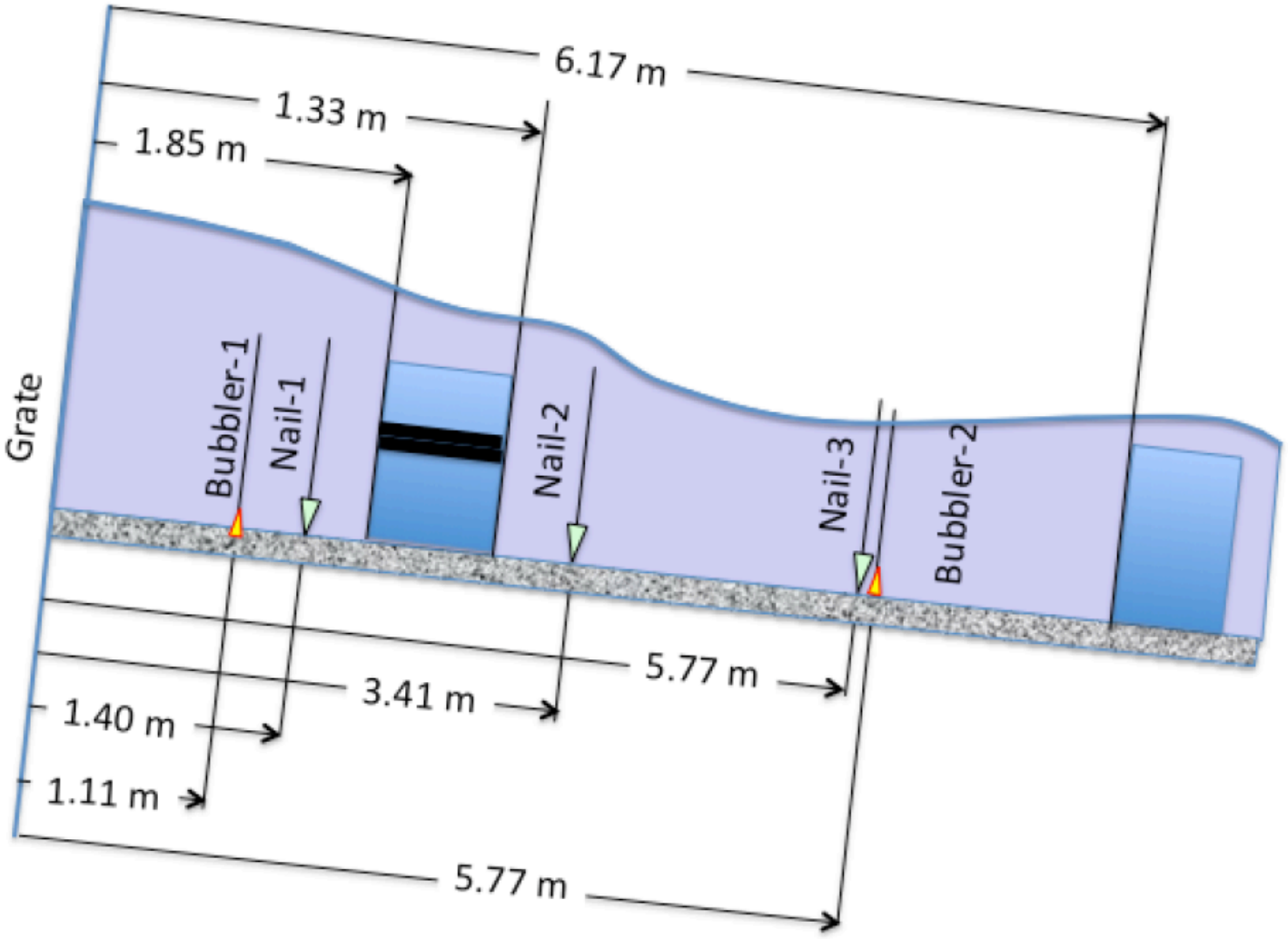
Methods

- Need a grid system (grid generator is part of the program)
  - Inside/outside of boundaries tricky
- Need to select a time-step

Research Flume



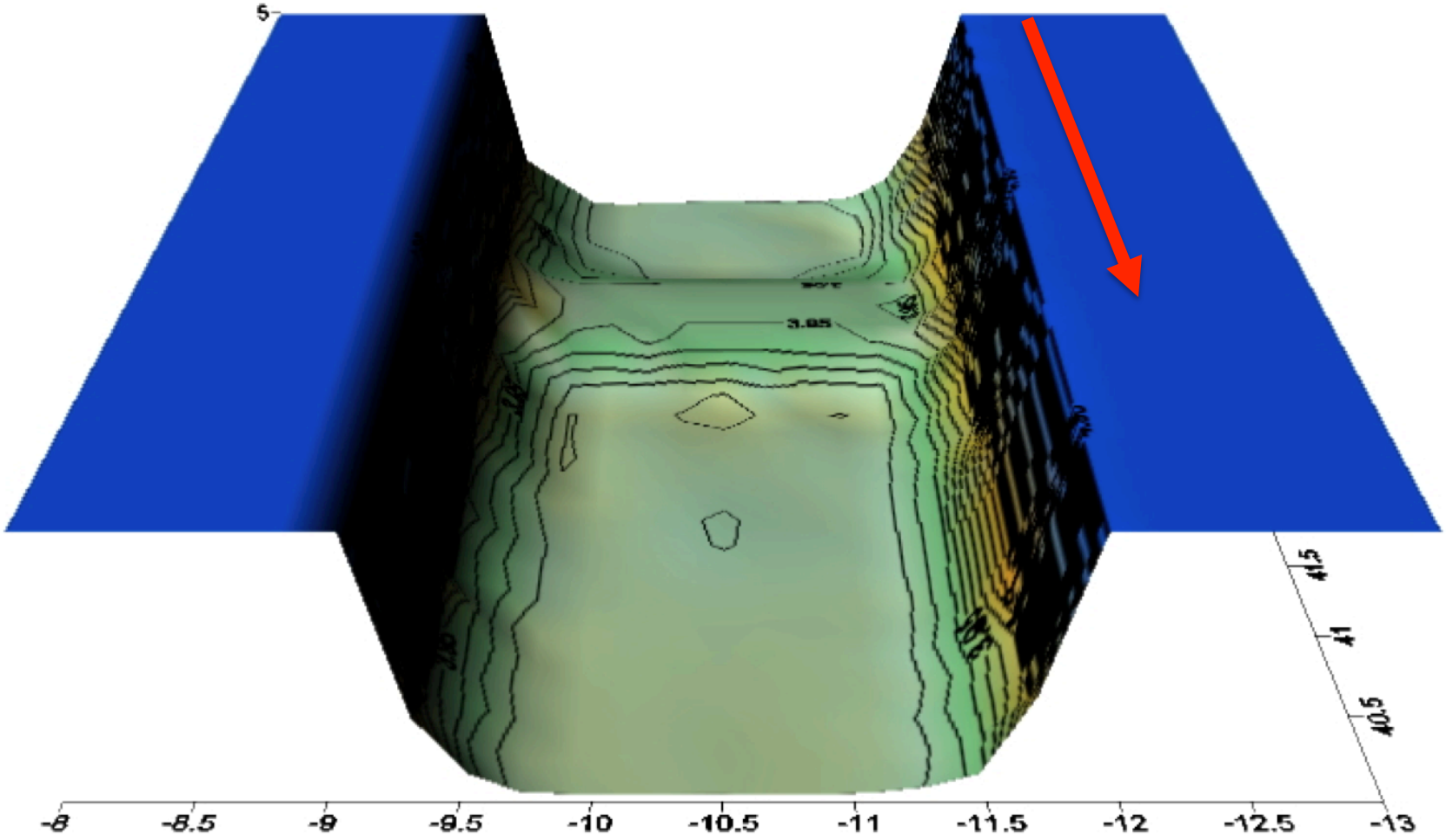
Research Flume



Research Flume

- Used total station to produce topographic model.
  - 26 fixed targets (establishes a reference plane).
  - 200 random targets to generate the topography.
  - Gridding with analyst oversight to produce the topographic database

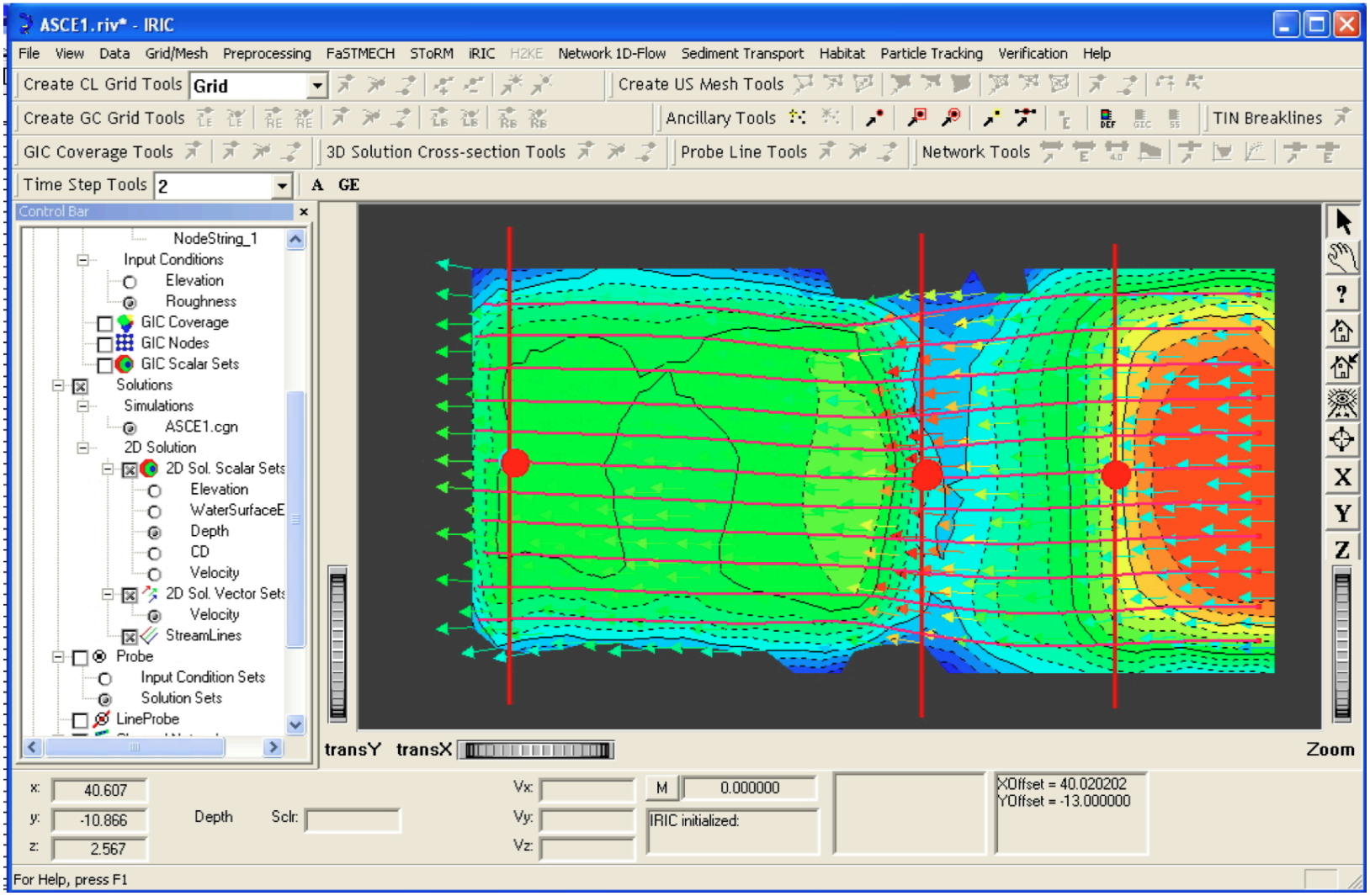
Research Flume



Research Flume

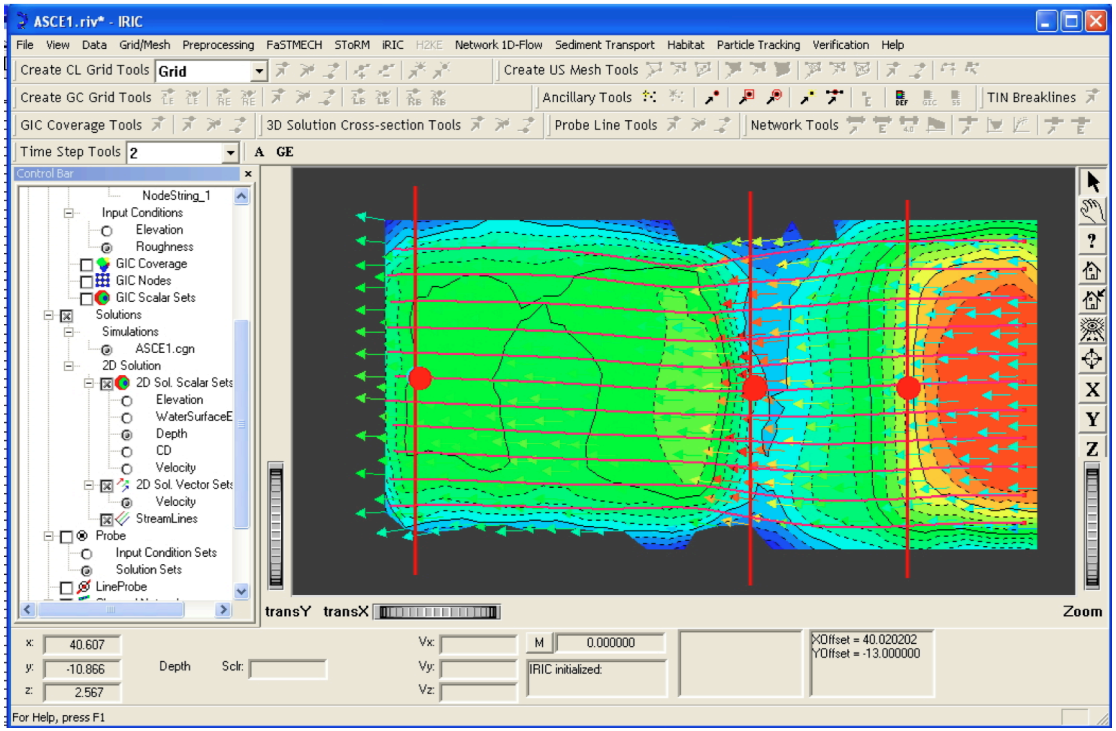
- Manning's resistance model
- Boundary conditions from an experimental run
- Initial condition - set to downstream flow depth
- Time step selection – trial and error

Research Flume



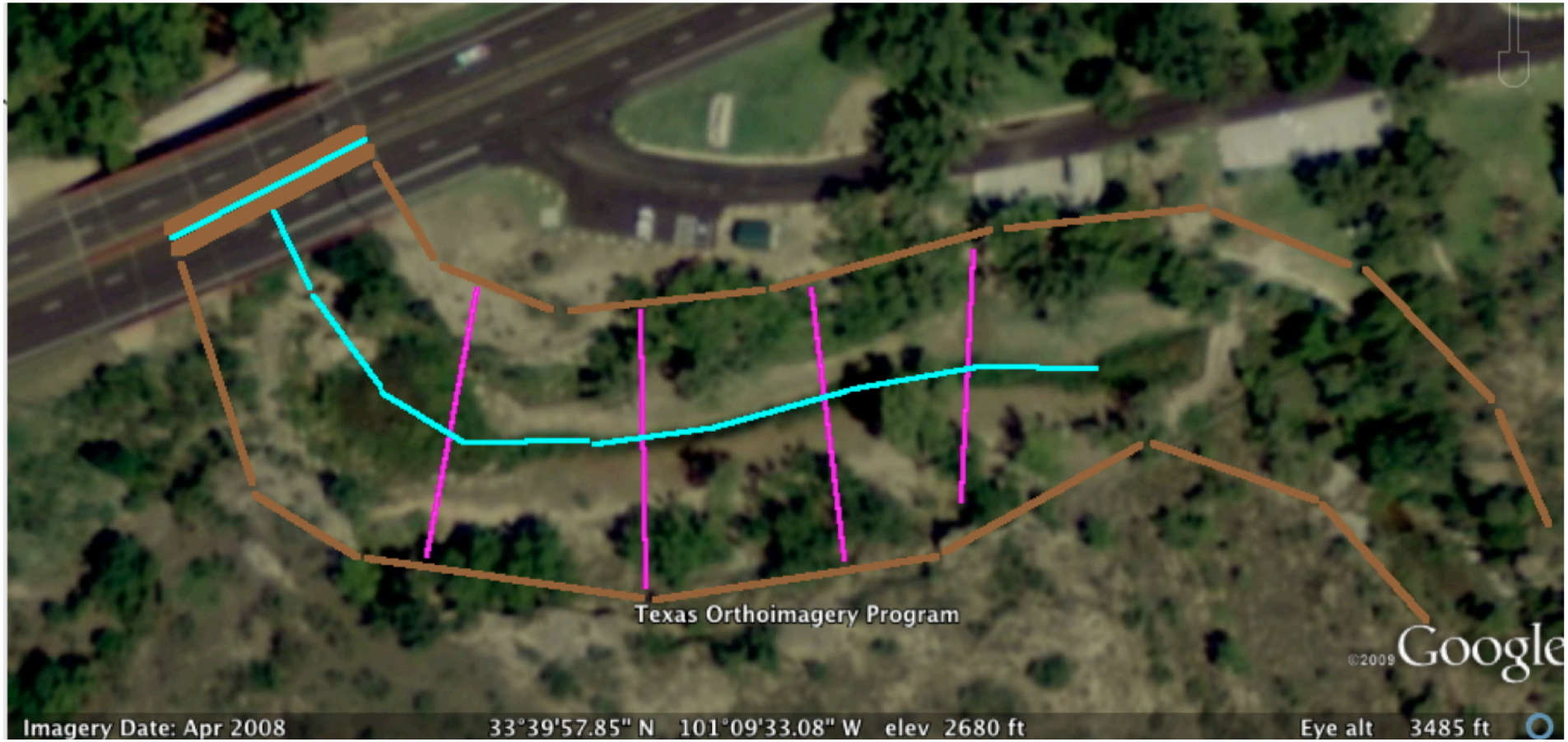
Research Flume

Research Flume



Probe Location	$V_{x\ meas.}$	$V_{y\ meas.}$	$V_{x\ mod.}$	$V_{y\ mod.}$
Upstream of Step (Rightmost Line)	0.83 m/s	0.03 m/s	0.87 m/s	0.03 m/s
Downstream of Step (Middle Line)	1.61 m/s	0.06 m/s	1.67 m/s	0.02 m/s
Further Downstream (Leftmost Line)	0.72 m/s	0.01 m/s	0.94 m/s	0.01 m/s

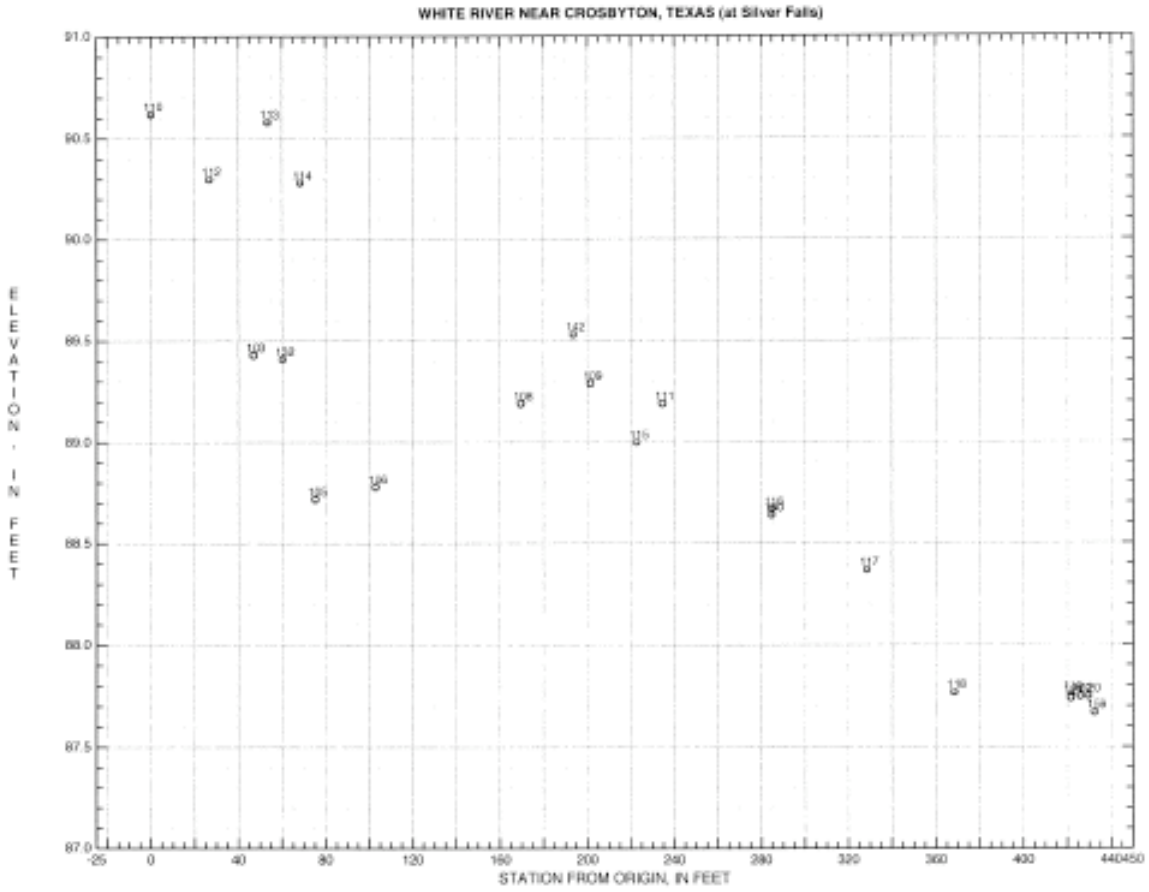
White River


Texas Orthoimagery Program
©2009 Google
Imagery Date: Apr 2008
33°39'57.85" N 101°09'33.08" W elev 2680 ft
Eye alt 3485 ft

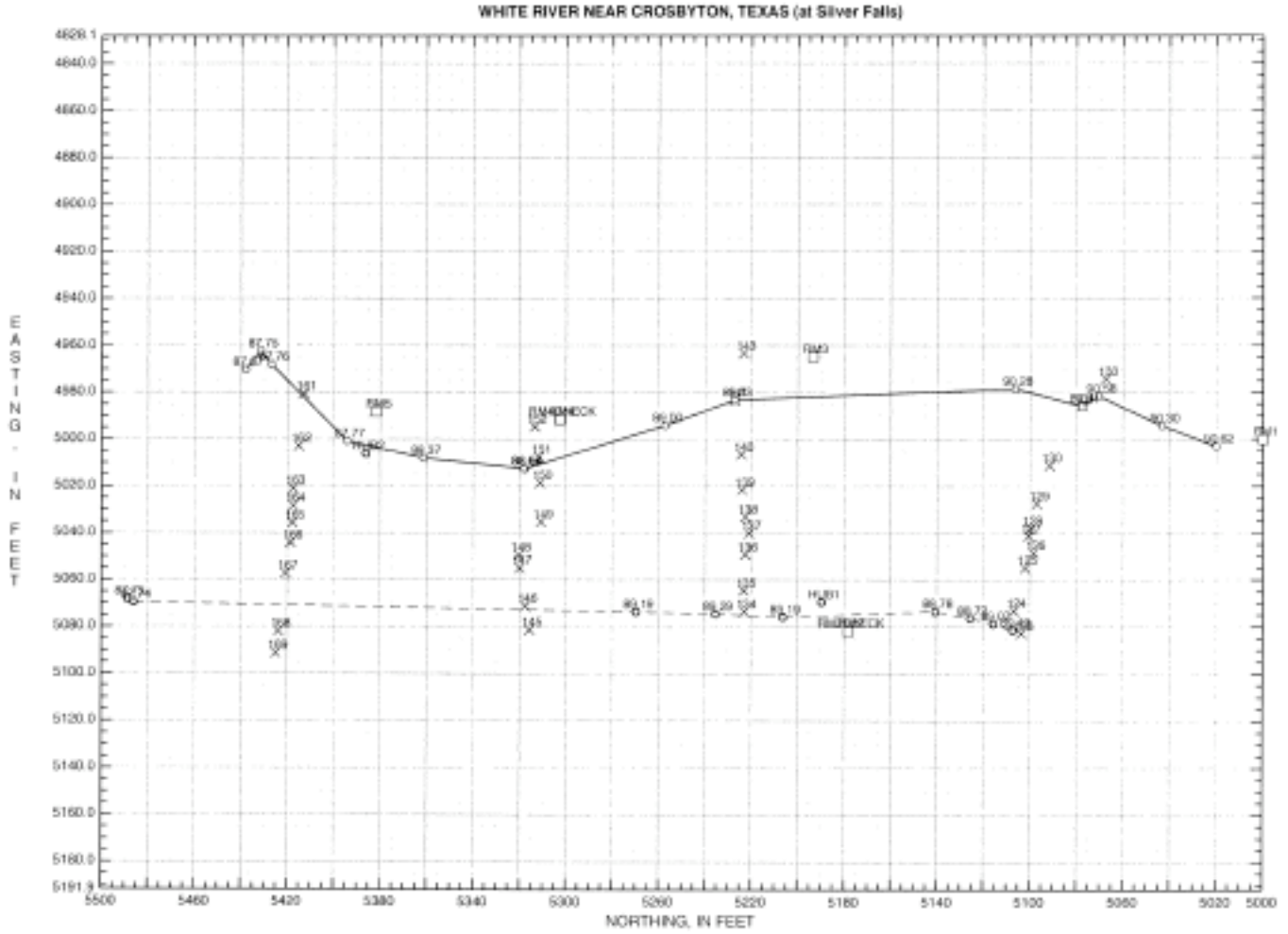
White River

- Used total station to produce conventional cross-sections from an indirect discharge measurement.
- July 4, 2010 remnants of TS Alex

White River


WHITE RIVER NEAR CROSBYTON, TEXAS (at Silver Falls)
ELEVATION - IN FEET
91.0
90.5
90.0
89.5
89.0
88.5
88.0
87.5
87.0
-25
0
40
80
120
160
200
240
280
320
360
400
440450
STATION FROM ORIGIN, IN FEET

White River

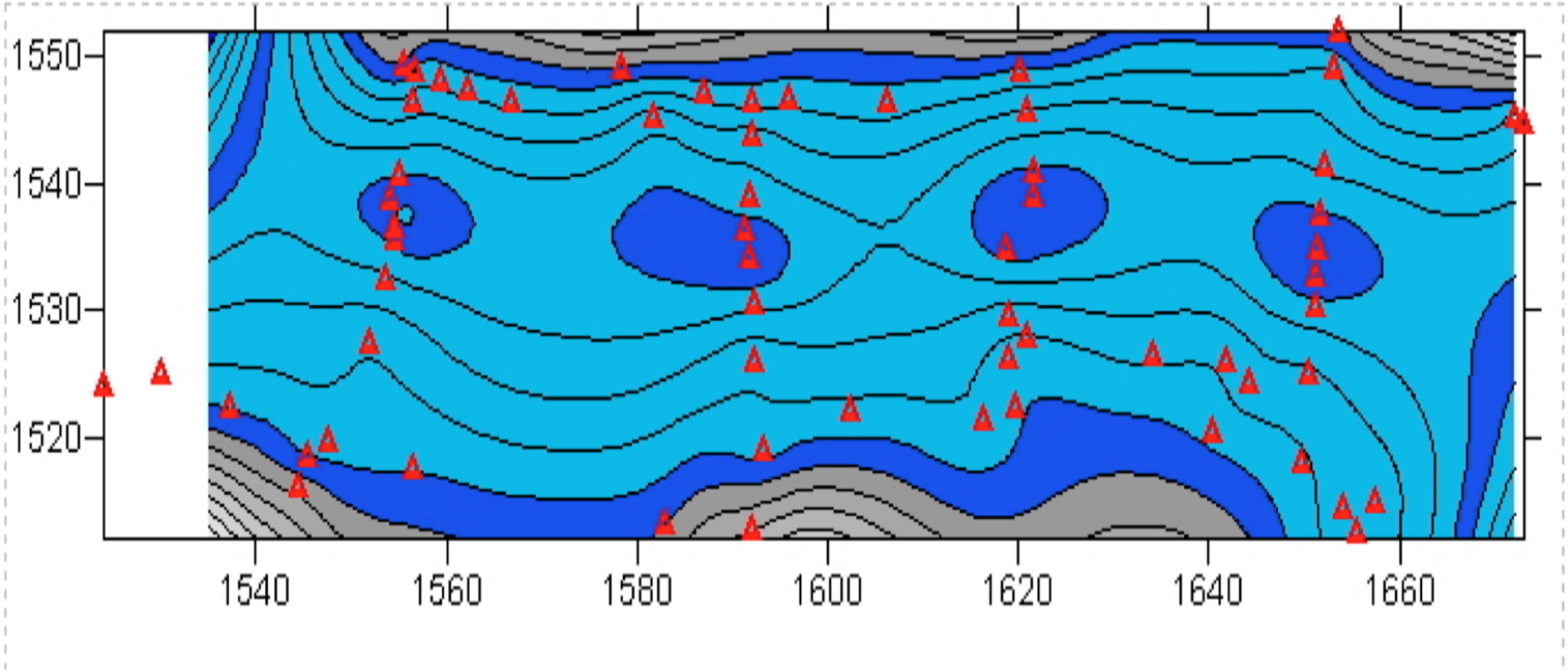

WHITE RIVER NEAR CROSBYTON, TEXAS (at Silver Falls)
EASTING - IN FEET
NORTHING, IN FEET
4628.1
4640.0
4660.0
4680.0
4700.0
4720.0
4740.0
4760.0
4780.0
4800.0
4820.0
4840.0
4860.0
4880.0
4900.0
4920.0
4940.0
4960.0
4980.0
5000.0
5020.0
5040.0
5060.0
5080.0
5100.0
5120.0
5140.0
5160.0
5180.0
5191.9
5500
5460
5420
5380
5340
5300
5260
5220
5180
5140
5100
5060
5020
5000

White River

- Used the sections to produce a topographic model.
- Direct application of sections were problematic, needed to grid.

White River

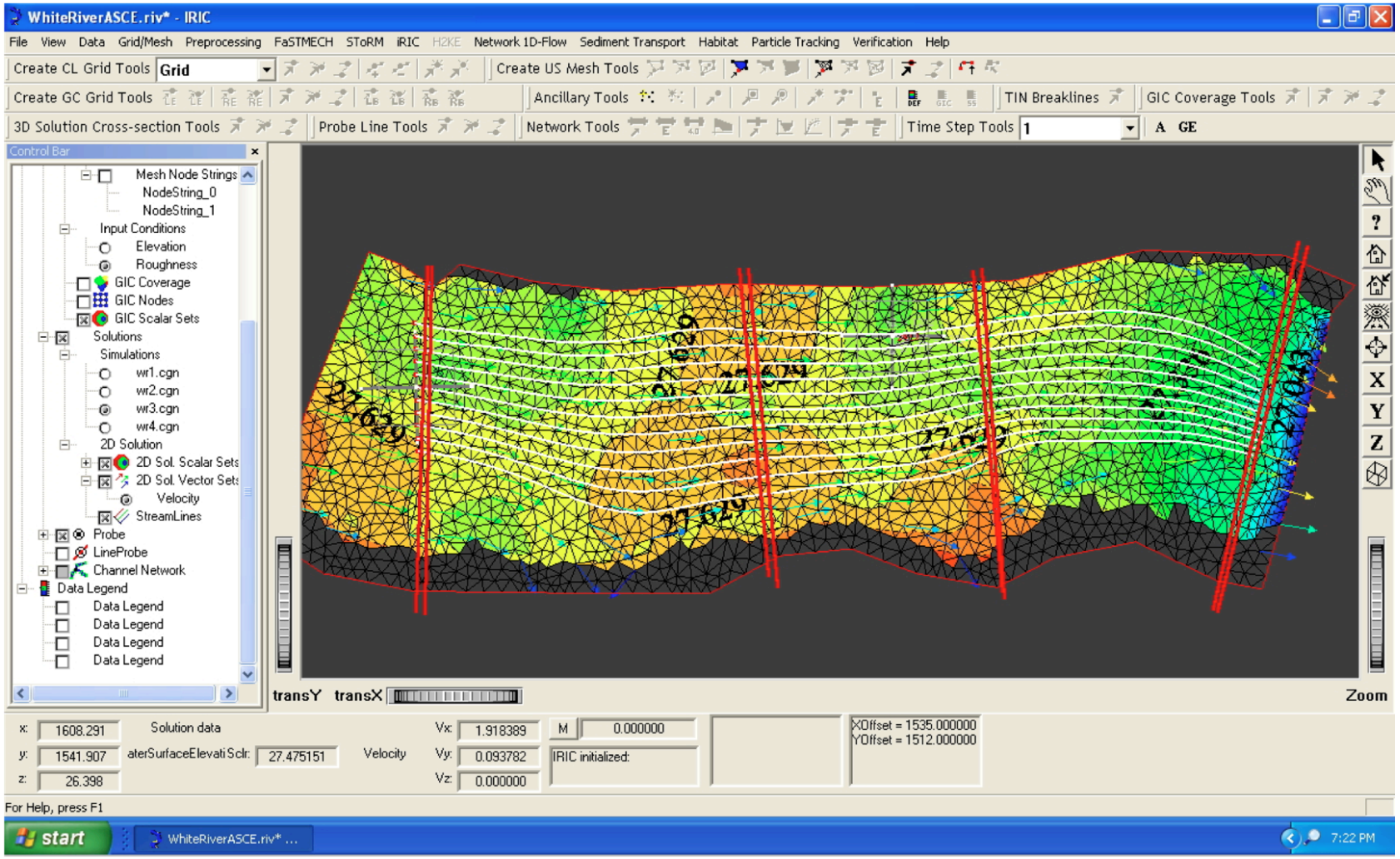
- Gridding (or the internal TIN) introduces "artifacts."



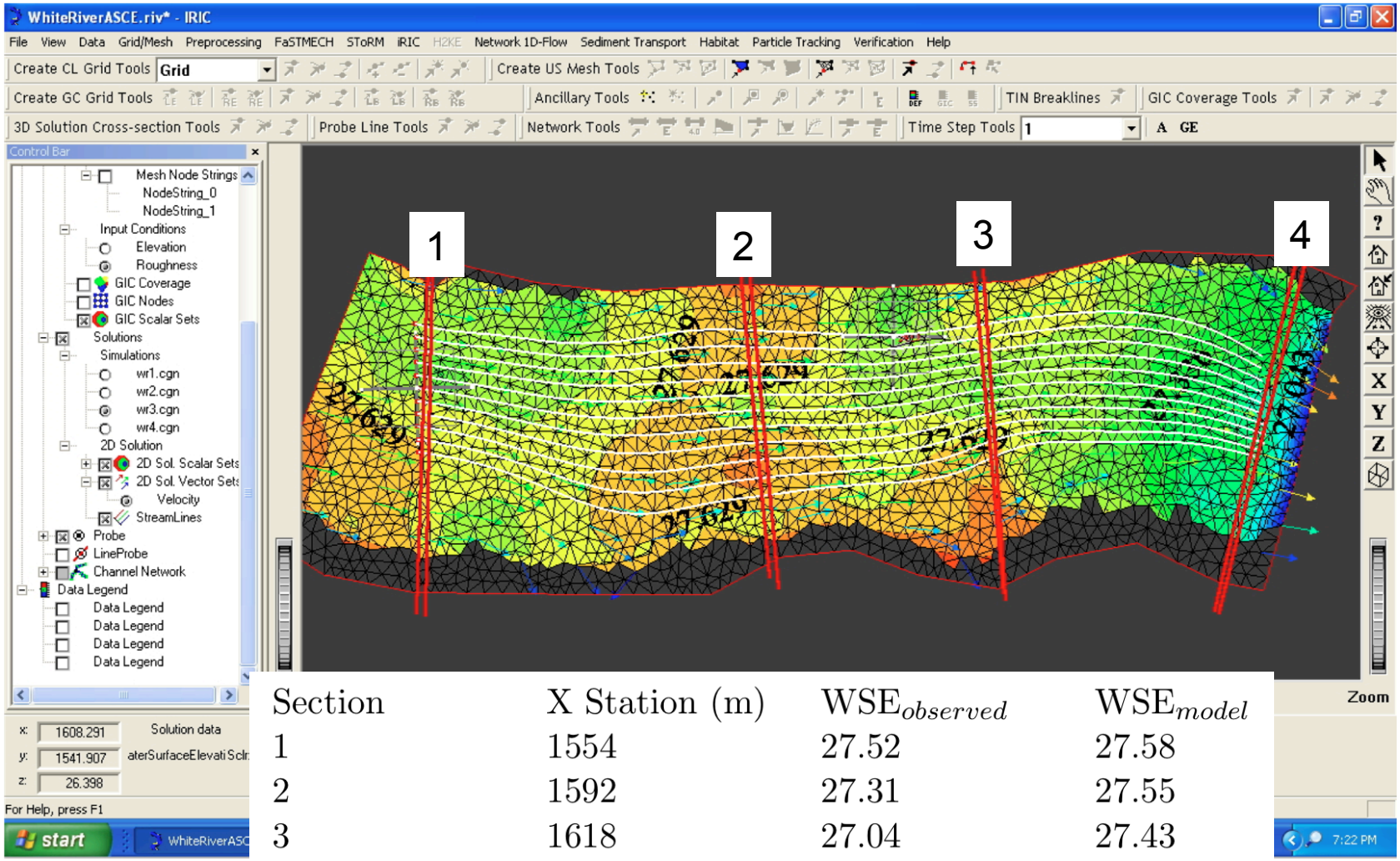
White River

- Manning's resistance model
- Boundary conditions from the indirect Q and WSE.
- Initial condition - set to downstream flow depth
- Time step selection – trial and error

White River


WhiteRiverASCE.riv* - IRIC
File View Data Grid/Mesh Preprocessing FaSTMECH SToRM iRIC H2KE Network 1D-Flow Sediment Transport Habitat Particle Tracking Verification Help
Create CL Grid Tools
Grid
Create US Mesh Tools
Create GC Grid Tools
Ancillary Tools
TIN Breaklines
GIC Coverage Tools
3D Solution Cross-section Tools
Probe Line Tools
Network Tools
Time Step Tools
1
Control Bar
Mesh Node Strings
NodeString_0
NodeString_1
Input Conditions
Elevation
Roughness
GIC Coverage
GIC Nodes
GIC Scalar Sets
Solutions
Simulations
wr1.cgn
wr2.cgn
wr3.cgn
wr4.cgn
2D Solution
2D Sol. Scalar Sets
2D Sol. Vector Sets
Velocity
StreamLines
Probe
LineProbe
Channel Network
Data Legend
Data Legend
Data Legend
Data Legend
Data Legend
transY
transX
Zoom
x: 1608.291
y: 1541.907
z: 26.398
Solution data
aterSurfaceElevati Sclr: 27.475151
Velocity
Vx: 1.918389
Vy: 0.093782
Vz: 0.000000
M
0.000000
IRIC initialized:
XOffset = 1535.000000
YOffset = 1512.000000
For Help, press F1
start
WhiteRiverASCE.riv* ...
7:22 PM

White River



Section	X Station (m)	$WSE_{observed}$	WSE_{model}
1	1554	27.52	27.58
2	1592	27.31	27.55
3	1618	27.04	27.43
4	1650	26.83	27.04

Tierra Blanca Creek

- Used total station to produce conventional cross-sections from an indirect discharge measurement.
- What are the effects of the nearby (recent) culverts on crest-stage gage?

Tierra Blanca Creek

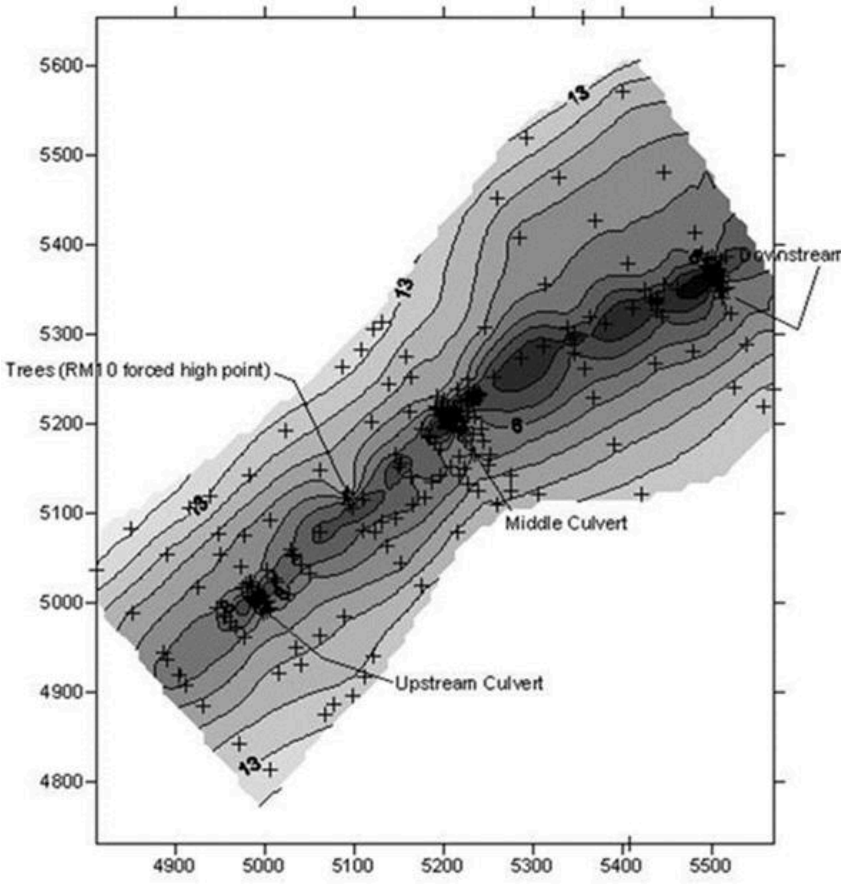
- Crest-stage gage is on golf course

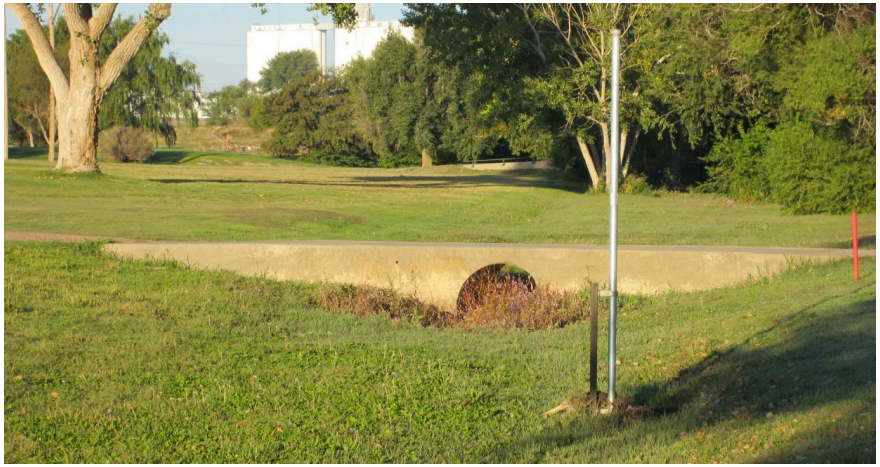
Tierra Blanca Creek

- Culverts were recently added and are close to gage

Tierra Blanca Creek

- Topographic Survey



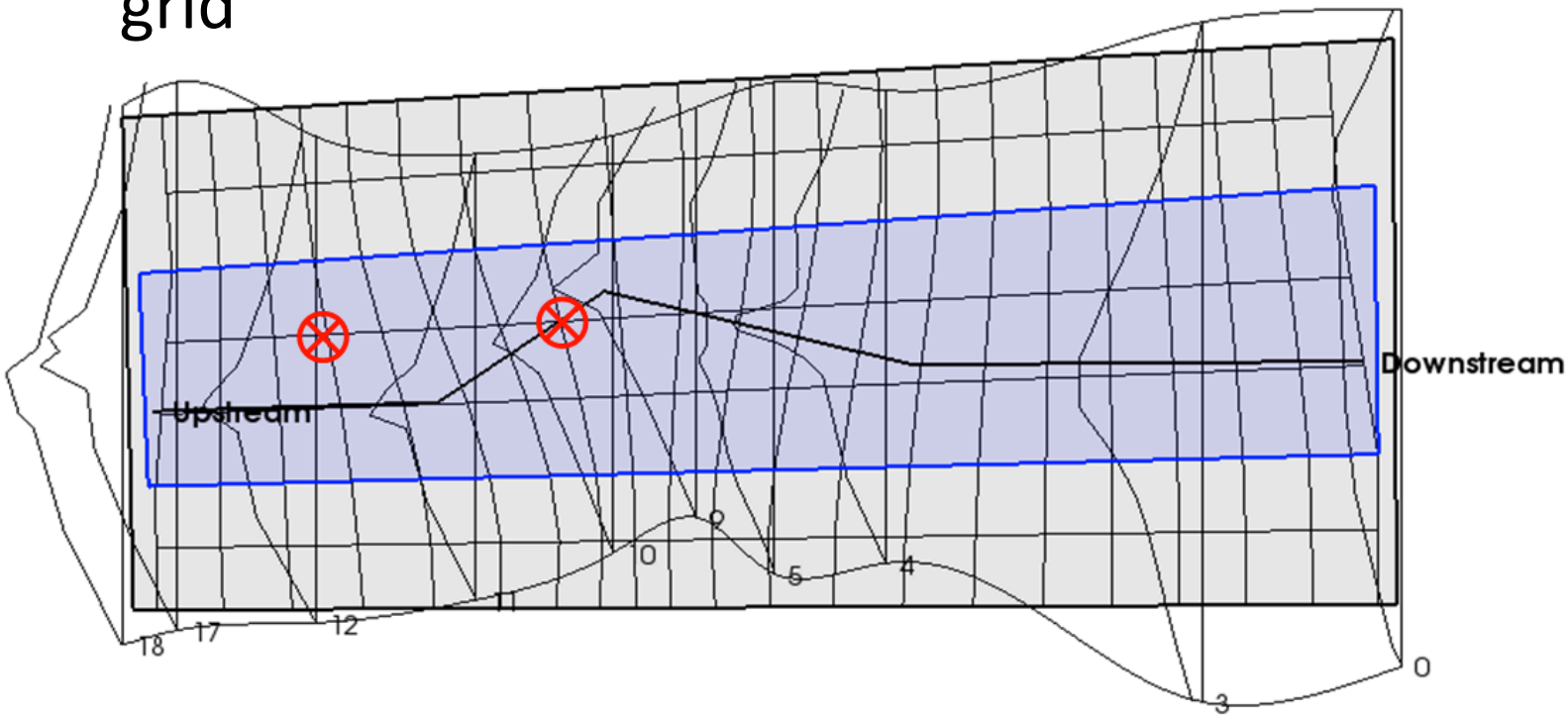


Tierra Blanca Creek

- Used the sections to produce a topographic model
- Knowing the sections would be gridded influenced the survey
  - namely more sections per length than White River, and several points far from thalweg.

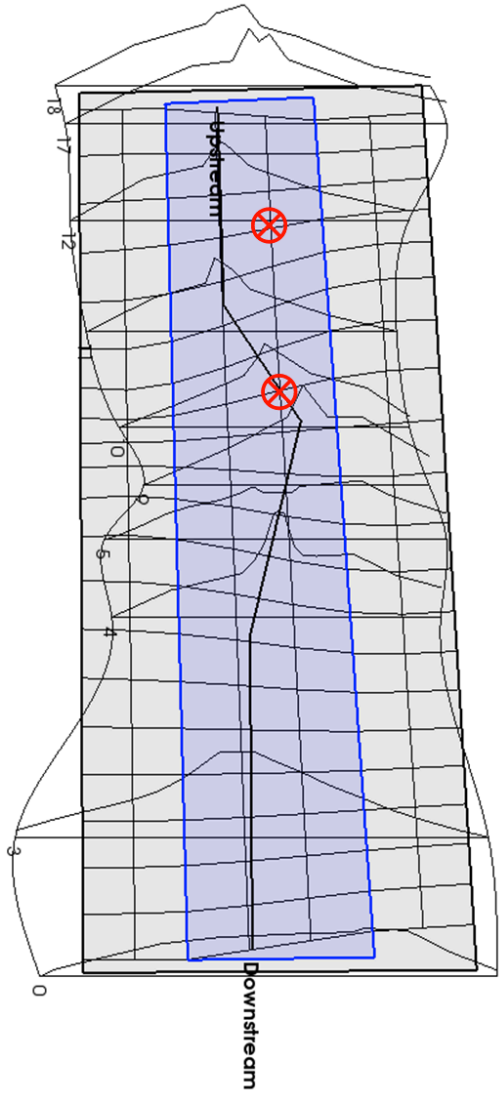
Tierra Blanca Creek

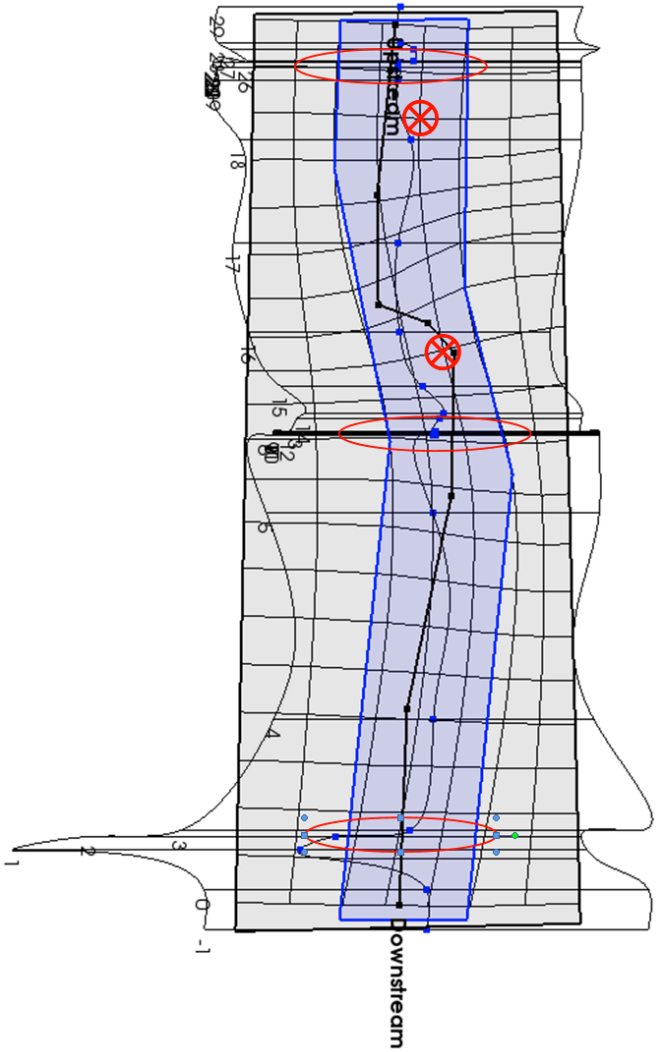
- SToRM upgraded during study
  - Graphics changed, also results on quasi-regular grid



Tierra Blanca Creek

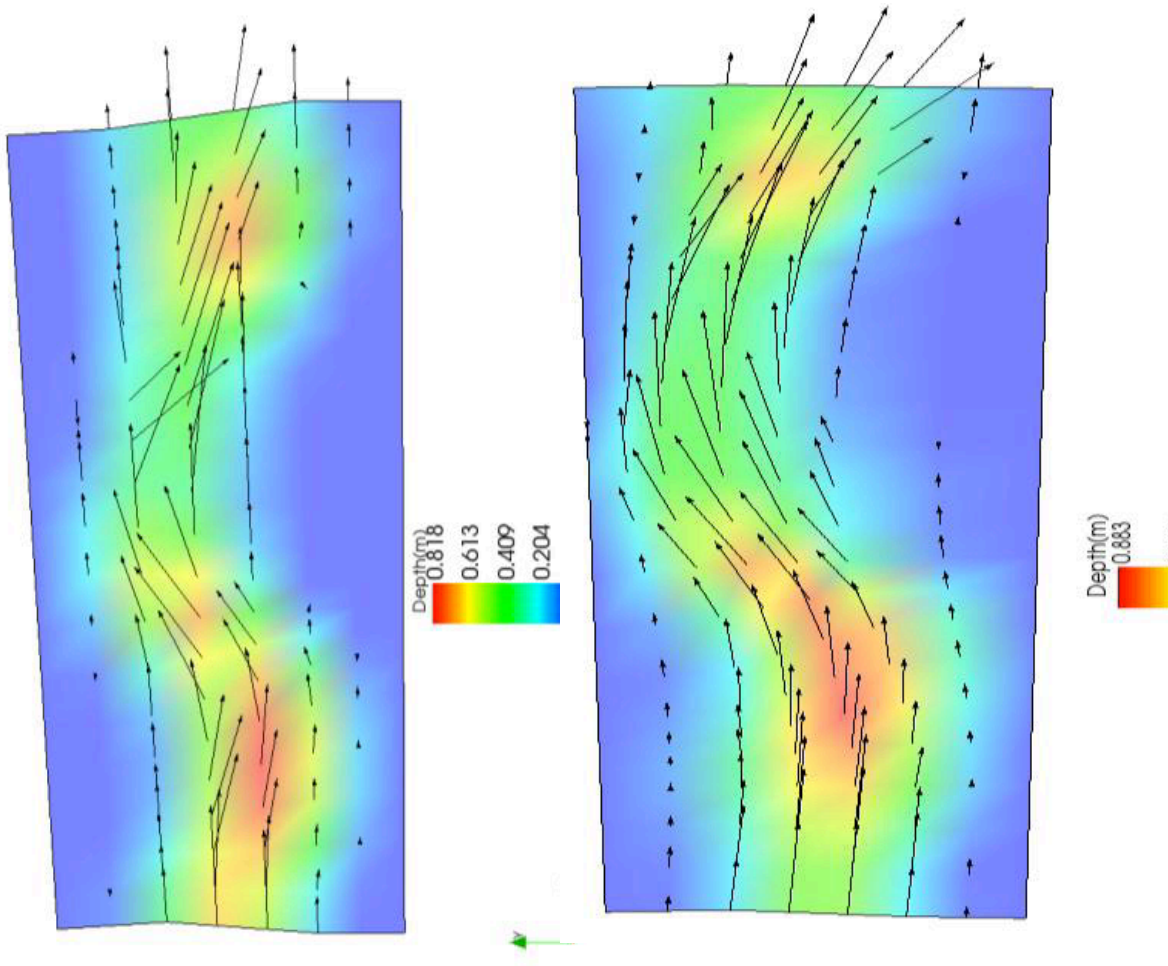
- Two models
  - Without
  - With culvert





Tierra Blanca Creek

- Two models
  - Without
  - With Culvert



Tierra Blanca Creek

- Modeling the culvert
  - Treated as a notch
  - 2D model needs to "see" the sky

Figure #. View of the most upstream culvert and the upstream gage.

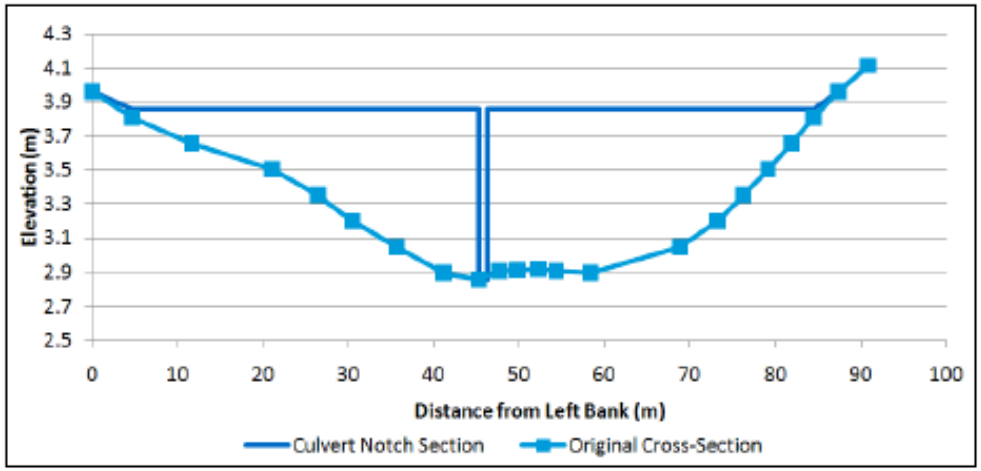
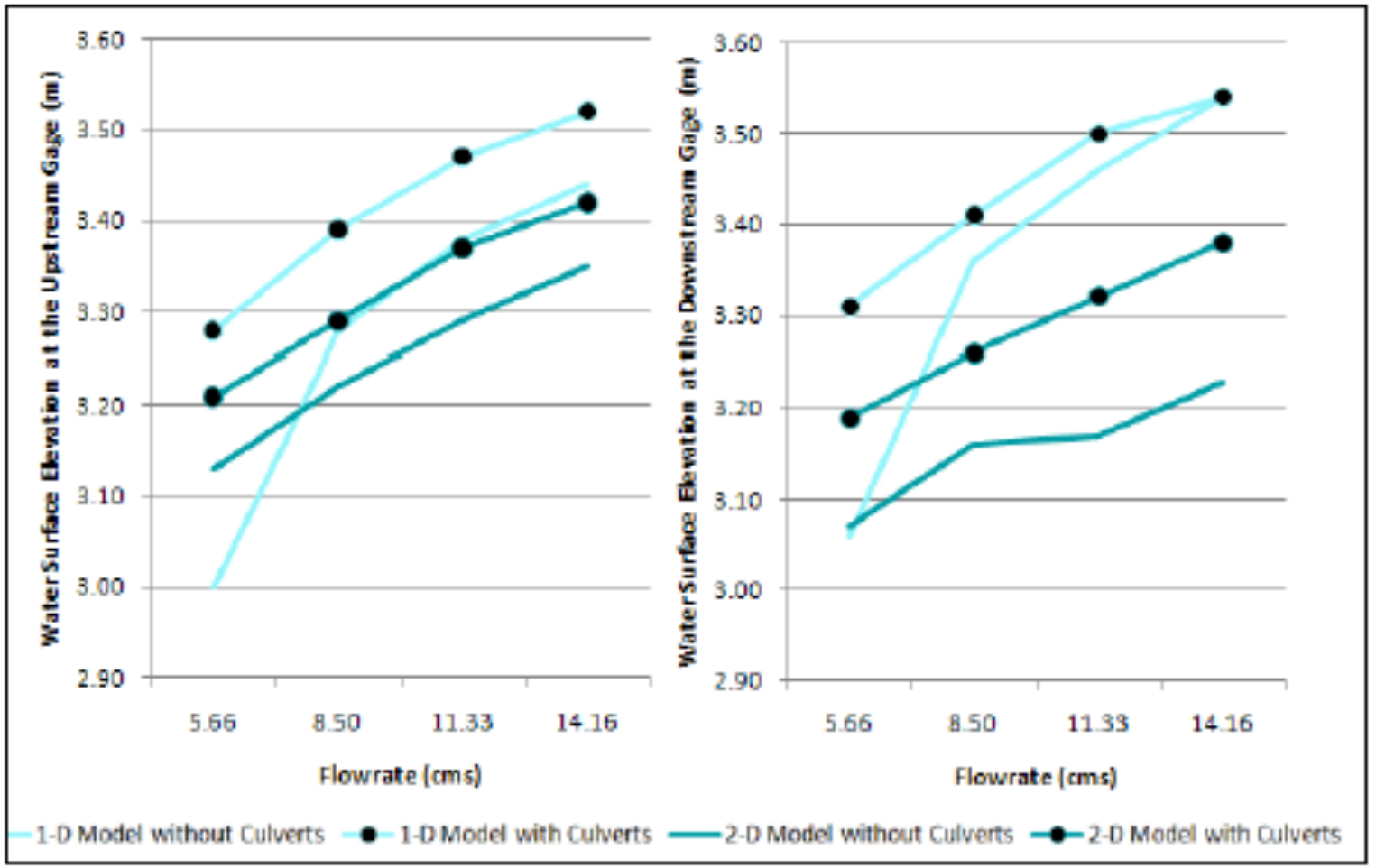


Figure #. Cross-section of the most upstream culvert represented in iRIC as a notch.

Tierra Blanca Creek

- Culvert effects (whole point of the work)



Conclusions

- Can produce meaningful results.
- Substantial reverse engineering to make models run.
- Topographic requirements are severe – will typically need some external processing; conventional cross-sections insufficient.
- Convergence is an issue (semantics)

Conclusions

- Substantial effort involved, thus one would really have to need the 2D results.
  - Recirculation.
  - Flow around arrays of piers.
  - Need to discriminate between tangential and normal forces on an object.
- Within realm of non-experts to use, but not quite state-of-practice.