1D/2D Modeling

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Gulf Coast Hurricanes: Mitigation and Response
April 10-11, 2012, Houston, Texas

HARRIS COUNTY FLOOD CONTROL DISTRICT

Overview of Presentation

- **Importance of Hydrology & Hydraulic Models**
- **How to select a model**
- **Example : Project location and issues**

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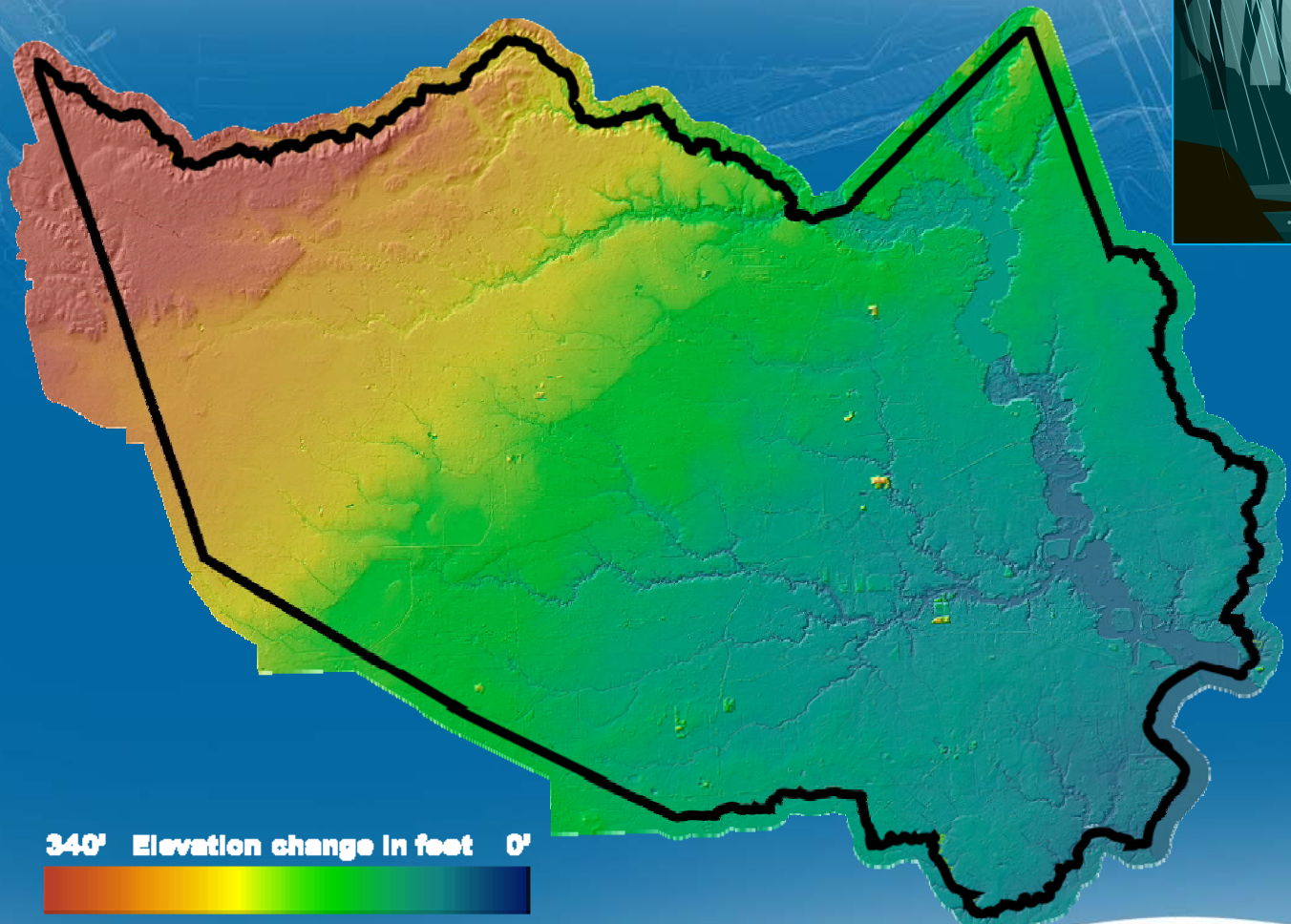
Harris County Terrain



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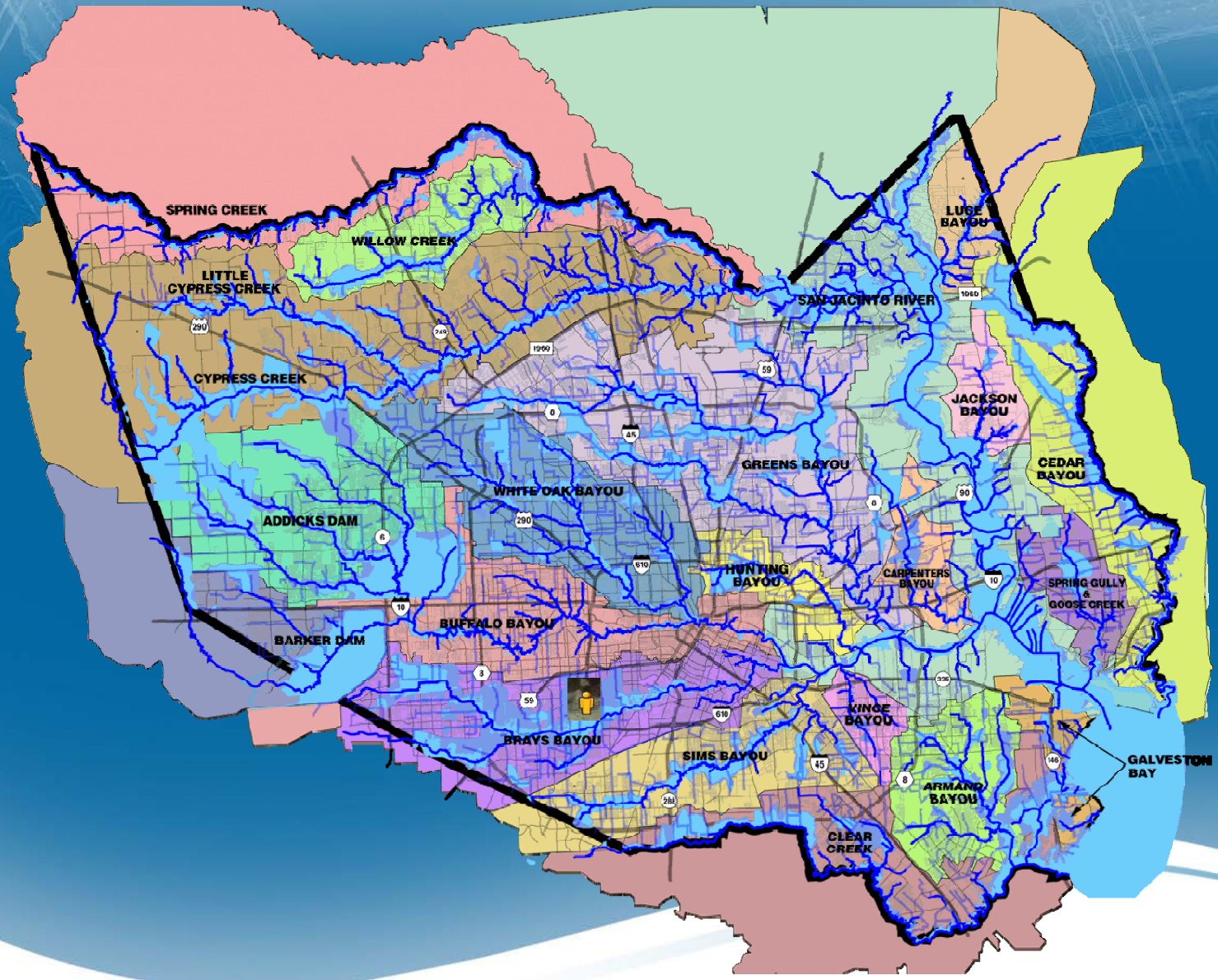
Harris County



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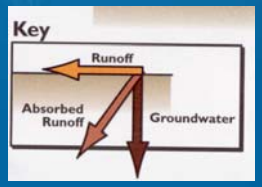
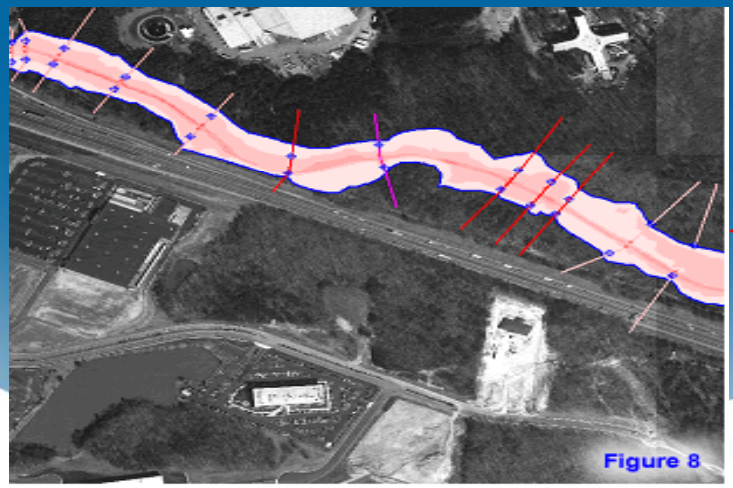
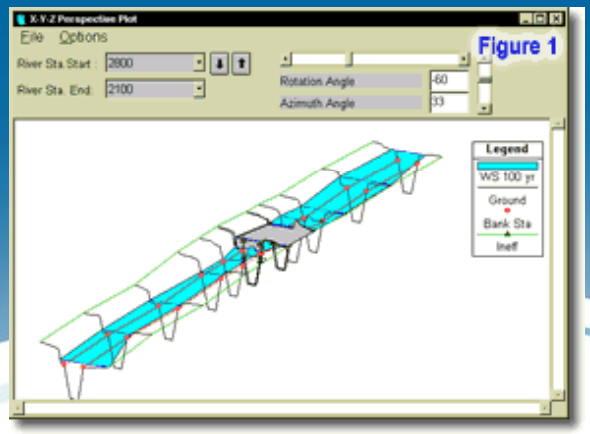
Process







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Who Owns The Raindrop

The House

?

The Ditch

?

The Street

?

The Bayou

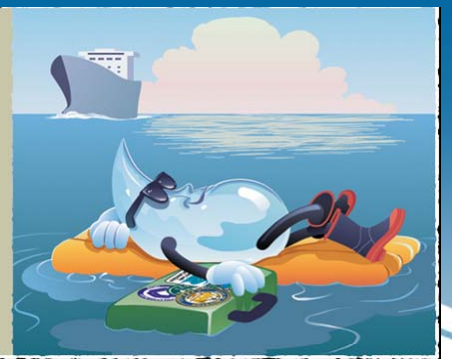
?

The Storm Sewer

?

The Bay

?



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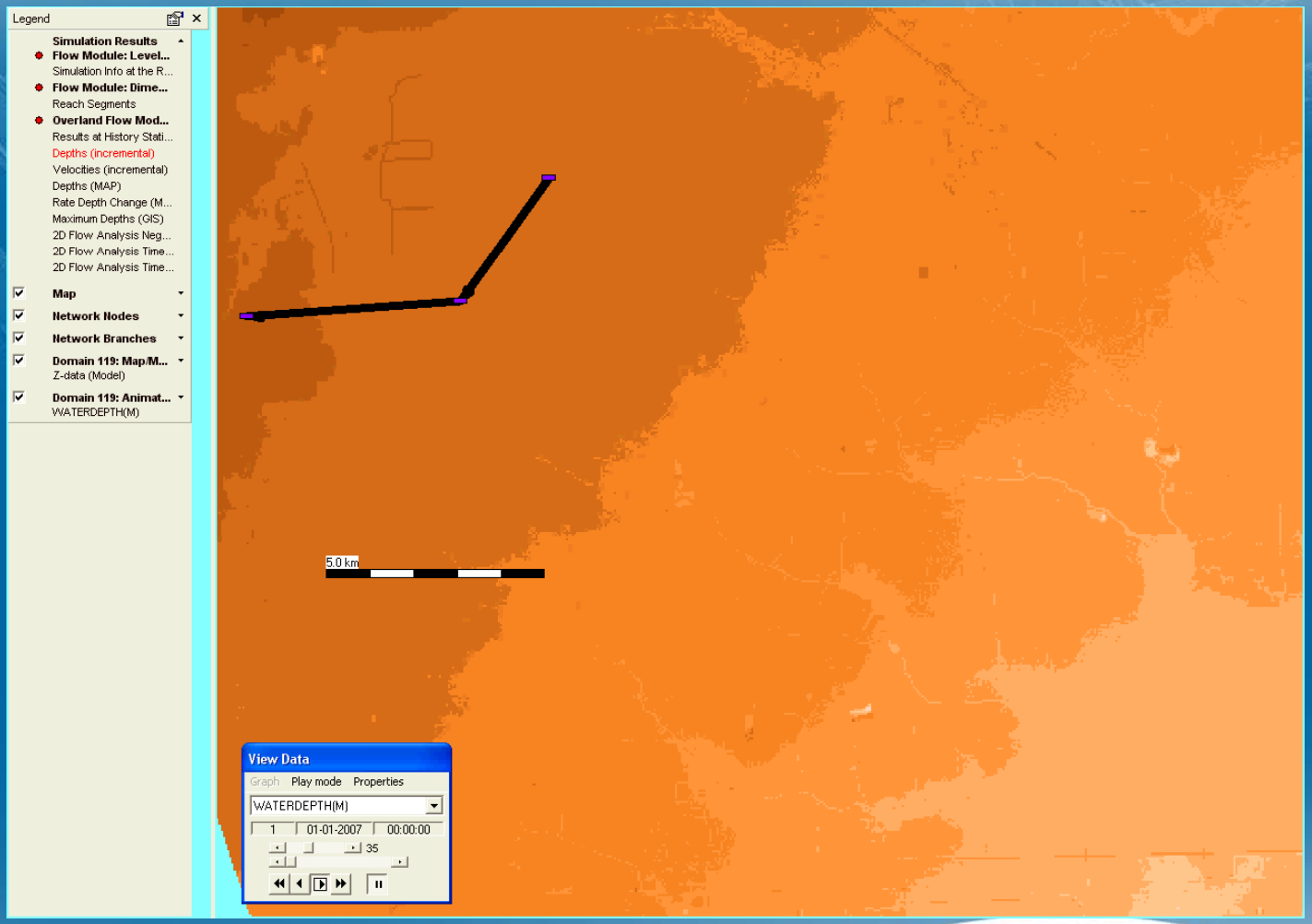
Rainfall on Land



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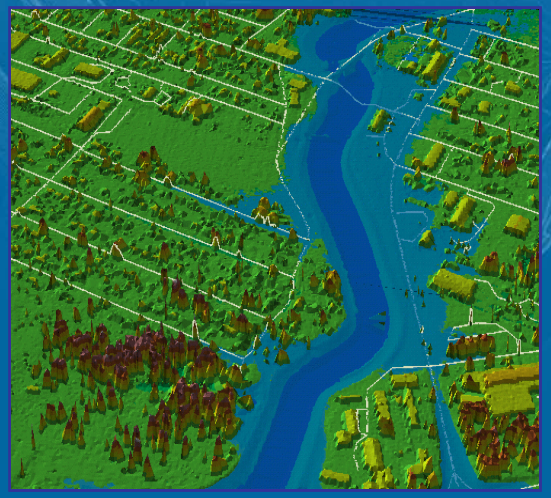
Model



Steady

If depth and velocity do not vary with time, the flow regime is considered to be steady

Unsteady

If depth and velocity vary with time, the flow regime is considered to be unsteady

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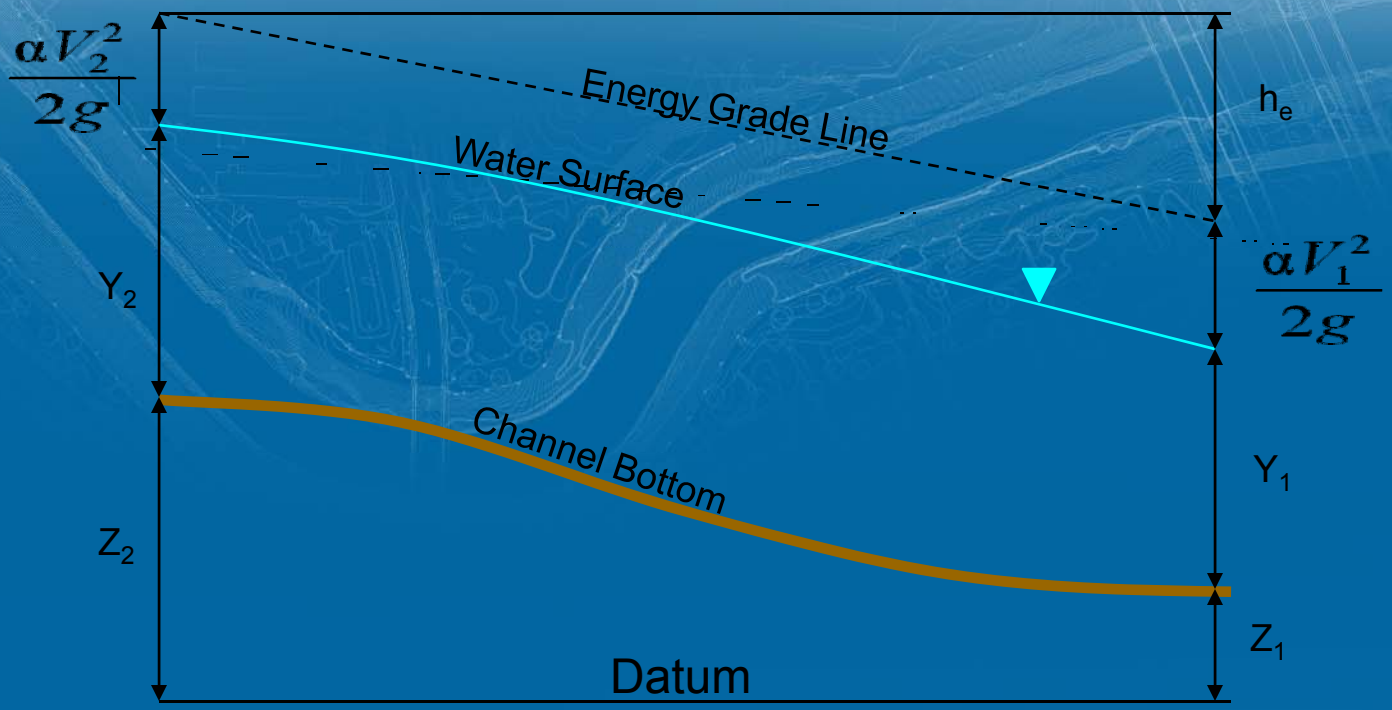
Energy Principles



$$Z_2 + Y_2 + \frac{\alpha_2 V_2^2}{2g} = Z_1 + Y_1 + \frac{\alpha_1 V_1^2}{2g} + h_e$$

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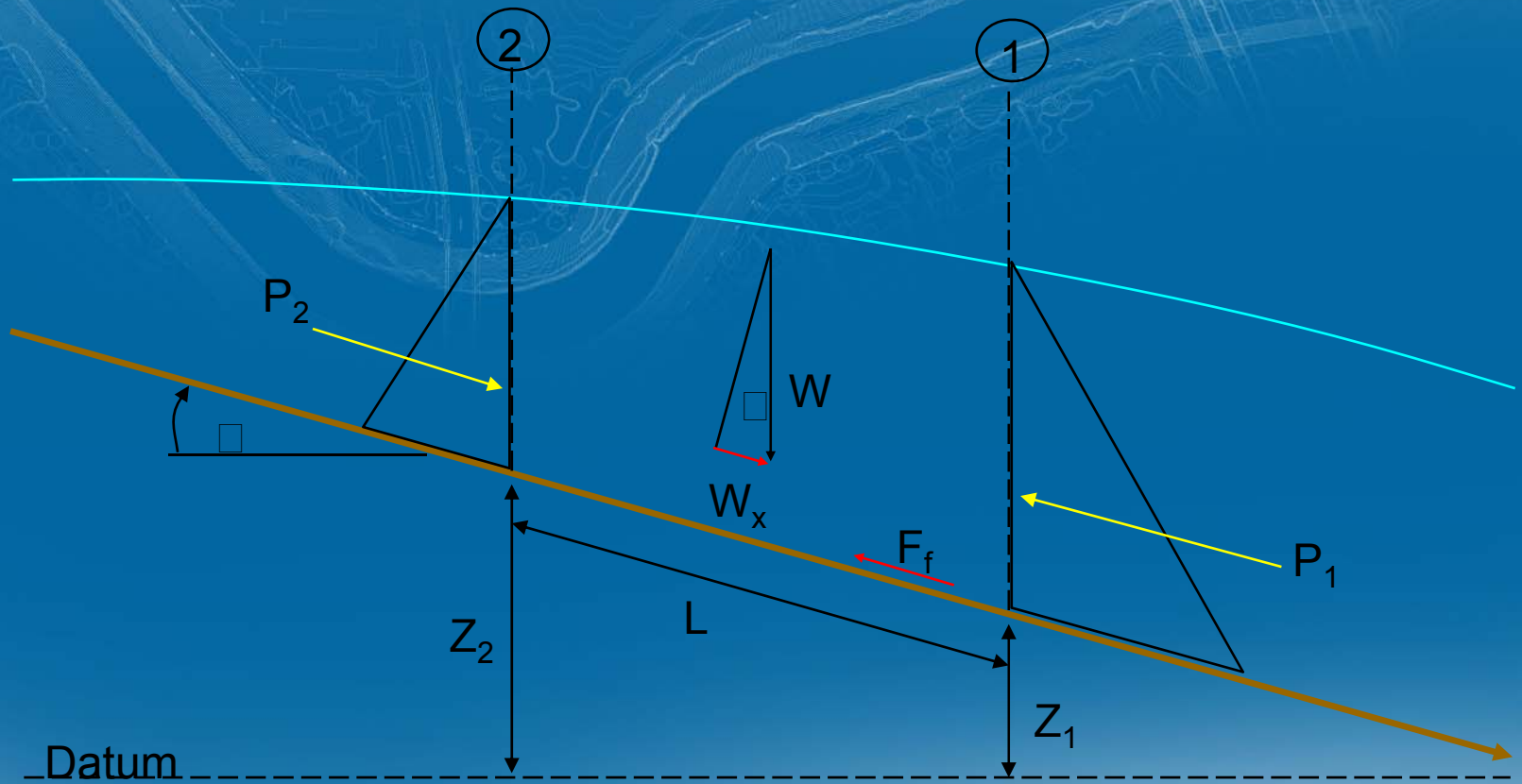
Momentum Equation

$$\Sigma F_x = m\,a$$



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Steady Flow Equations

Energy Equation:

$$\frac{\partial(\alpha Q^2/A)}{\partial x} + gA\left(\frac{\partial h}{\partial x} - S_o + S_f\right) = 0$$

Continuity Equation:

$$Q = VA$$

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Unsteady Flow Equations

Momentum Equation:

$$\frac{\partial Q}{\partial t} + \frac{\partial(\alpha Q^2/A)}{\partial x} + gA\left(\frac{\partial h}{\partial x} - S_o + S_f\right) = 0$$

Continuity Equation:

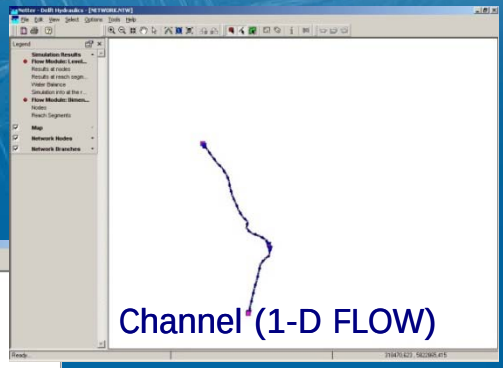
$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} = 0$$

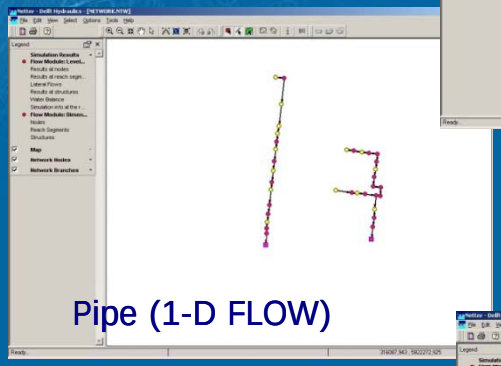
Steady Vs Unsteady

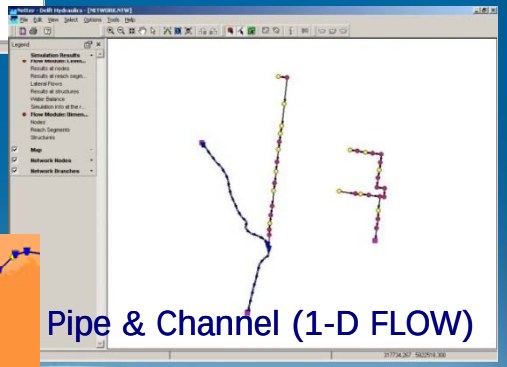
- Difference in handling friction and other losses
- Difference in numerical solution algorithm
- Difference in computation of X-Sec properties
- Difference in handling non-flow areas
- Difference in flow and boundary condition data requirements
- Difference in calibration strategy
- Difference in application strategy

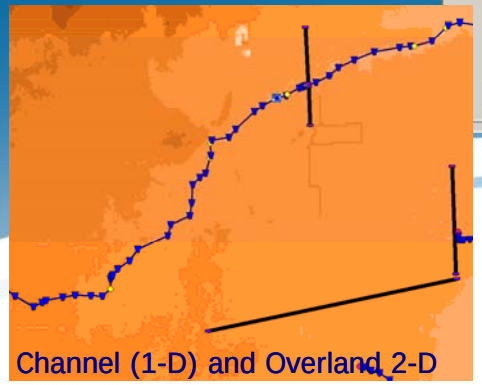
1D/2D Model

- **Integrated one environment, one hydrodynamic simulation 1-D and 2-D engine**
- **Automated software environment for Channel, Overland and Pipe systems**


Channel (1-D FLOW)


Pipe (1-D FLOW)


Pipe & Channel (1-D FLOW)


Channel (1-D) and Overland 2-D

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Modeling

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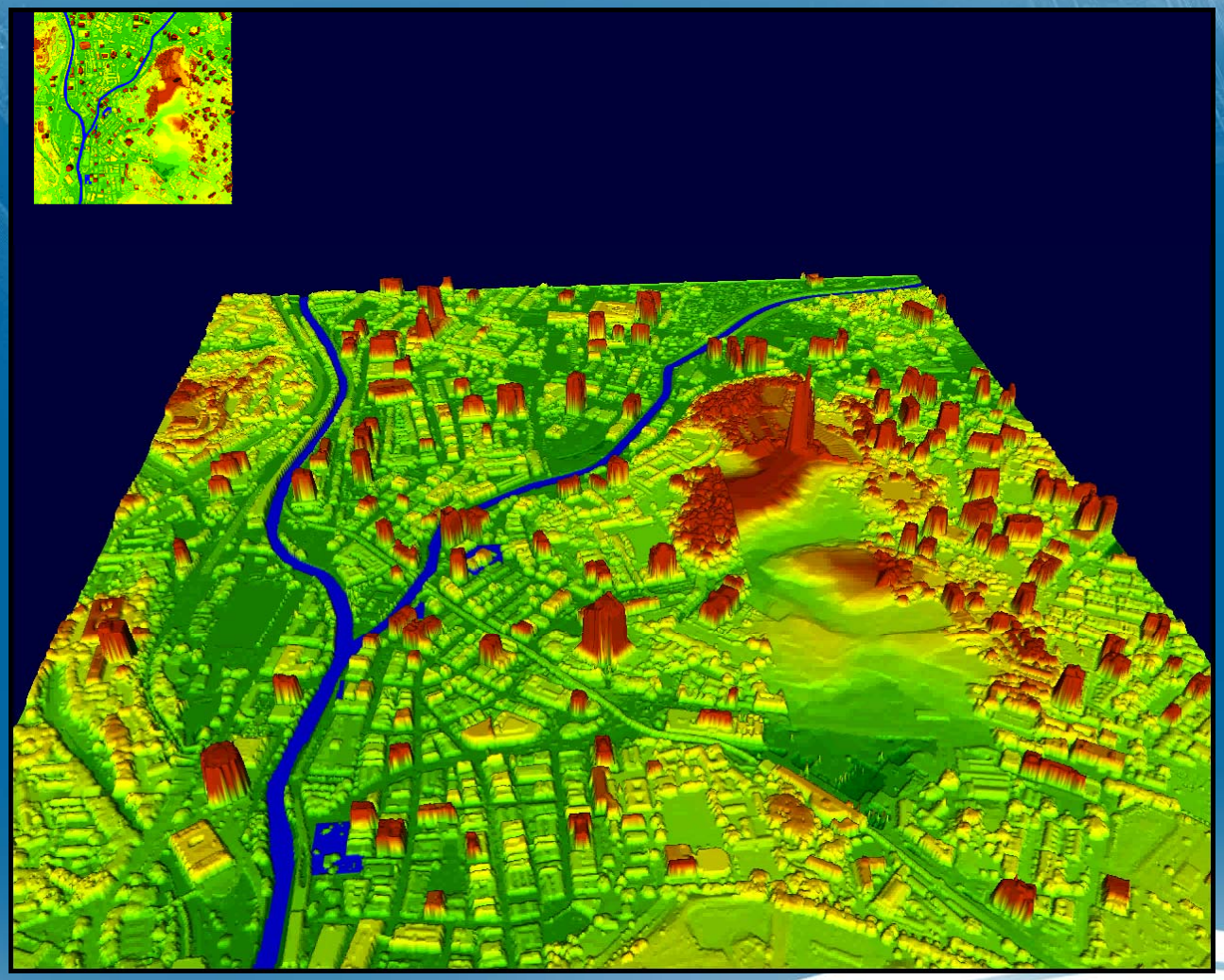
Modeling



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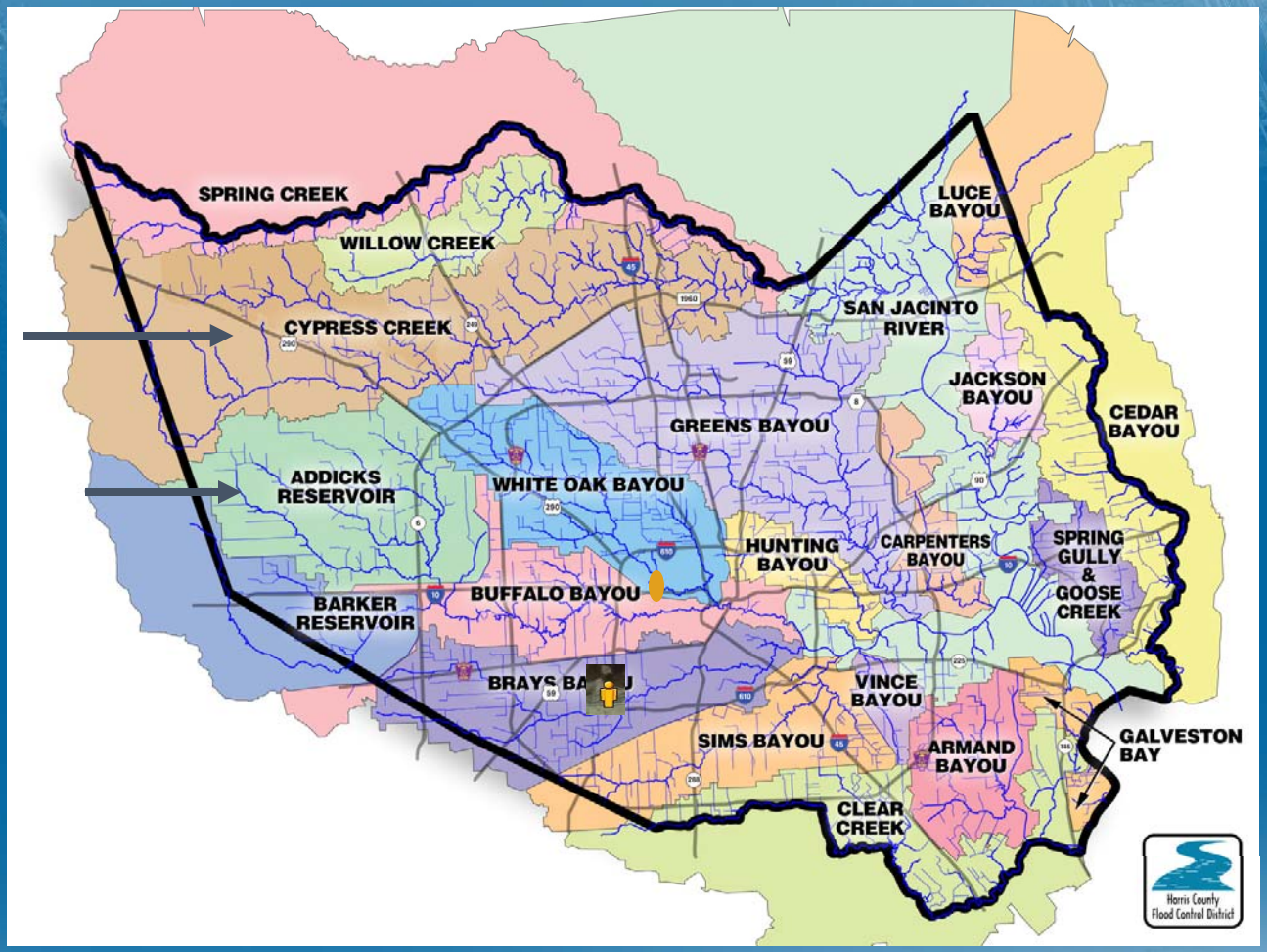
Floodplain Map



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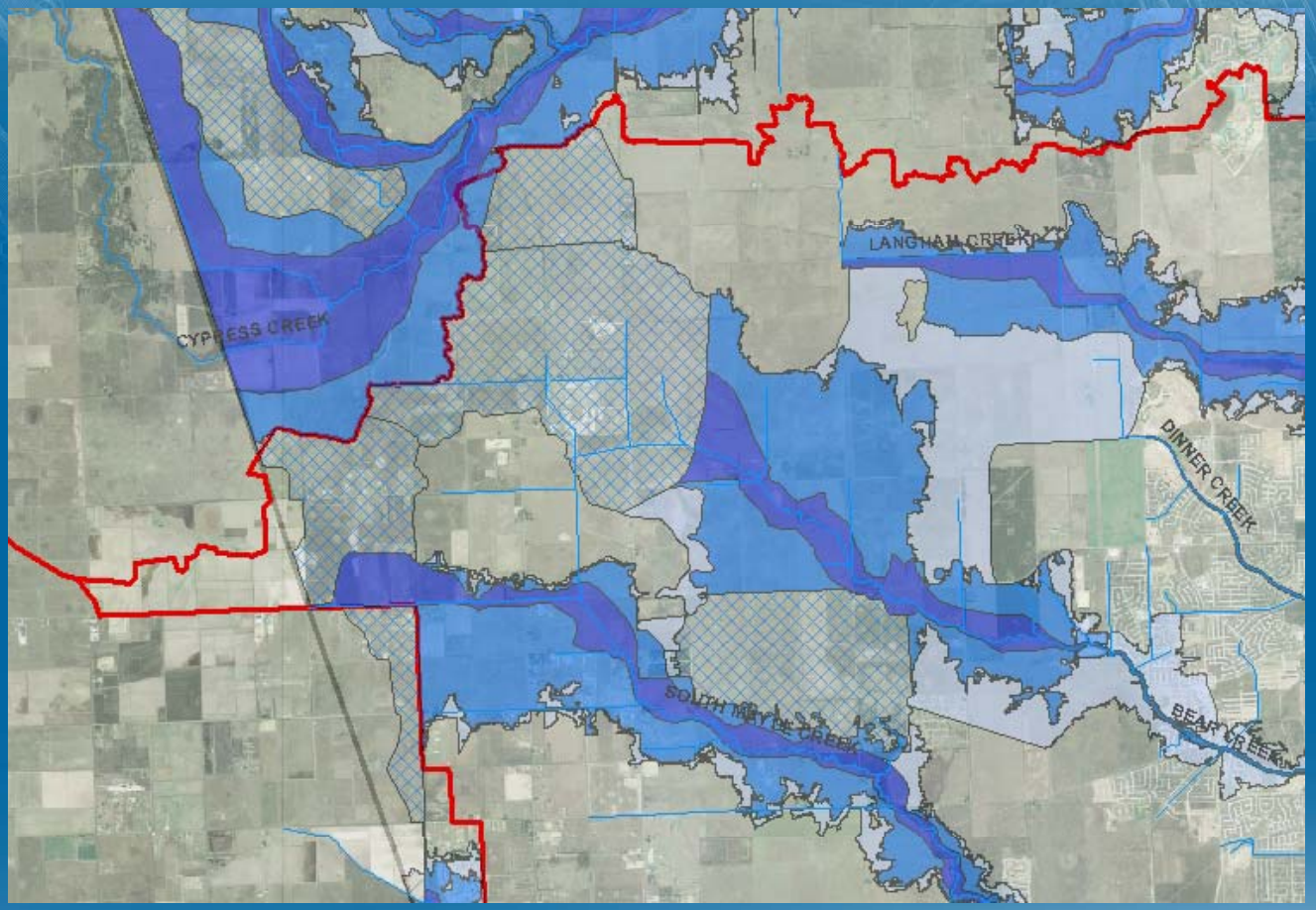
Floodplain Map



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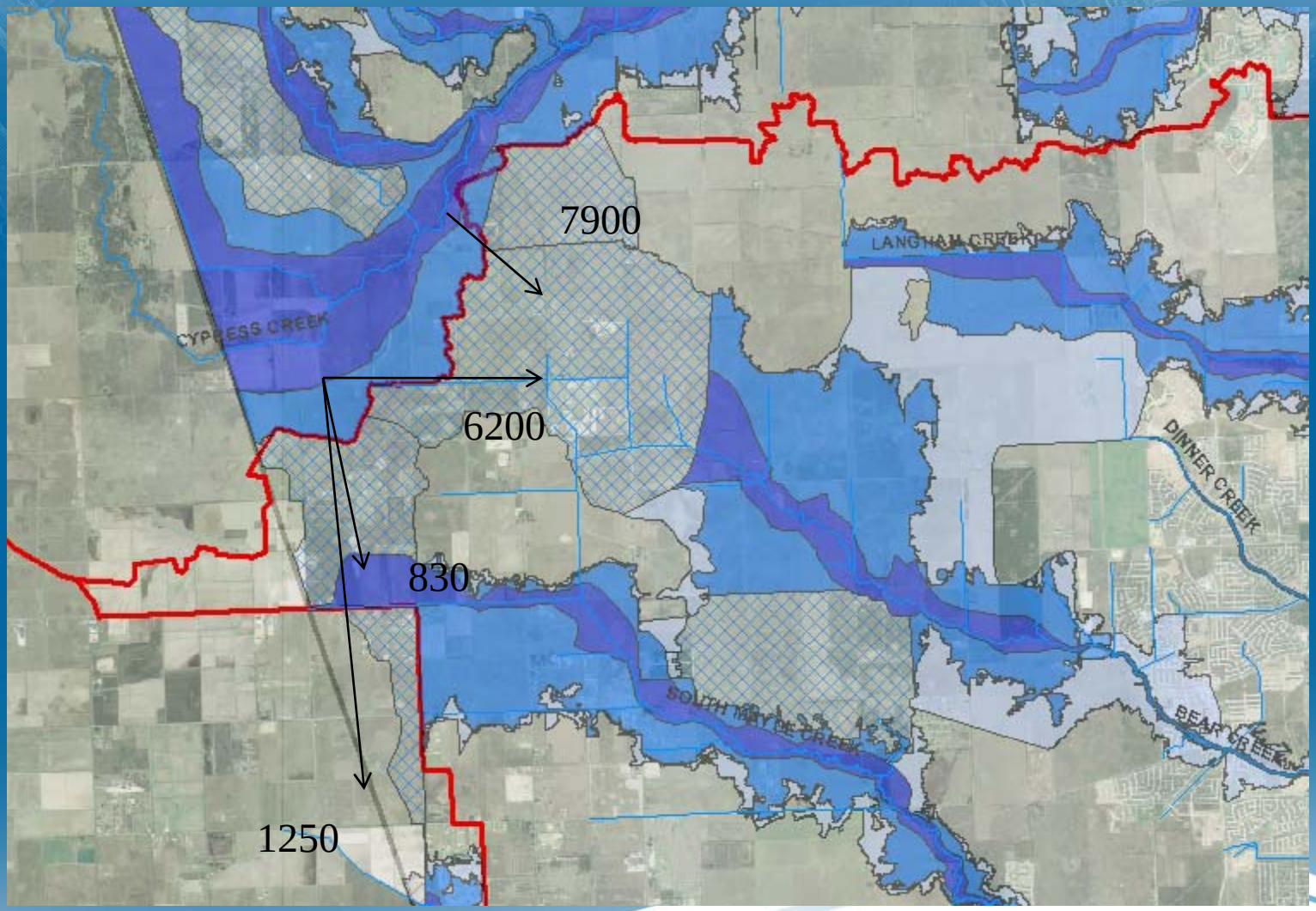

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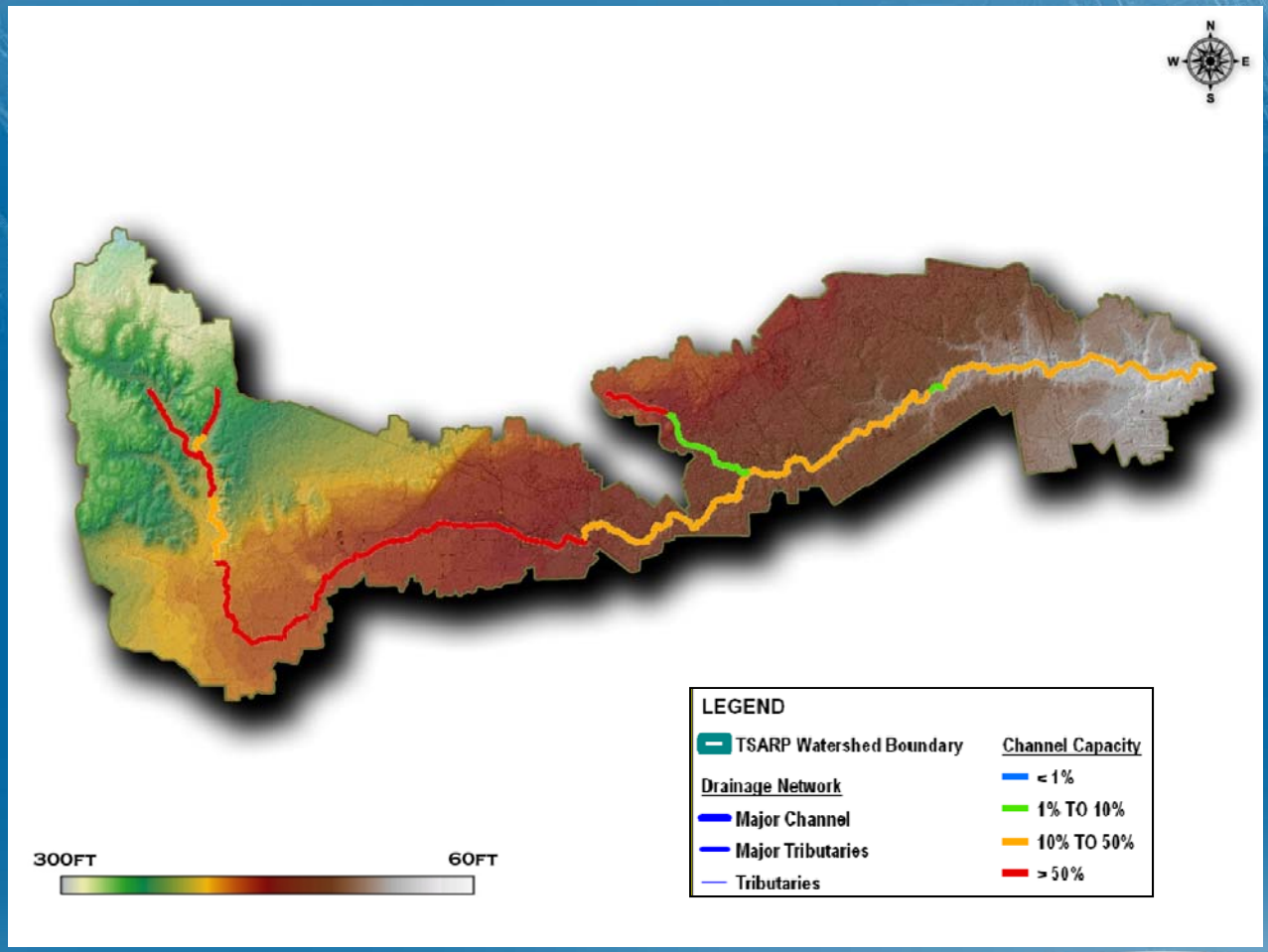
Elevation & channel Capacity



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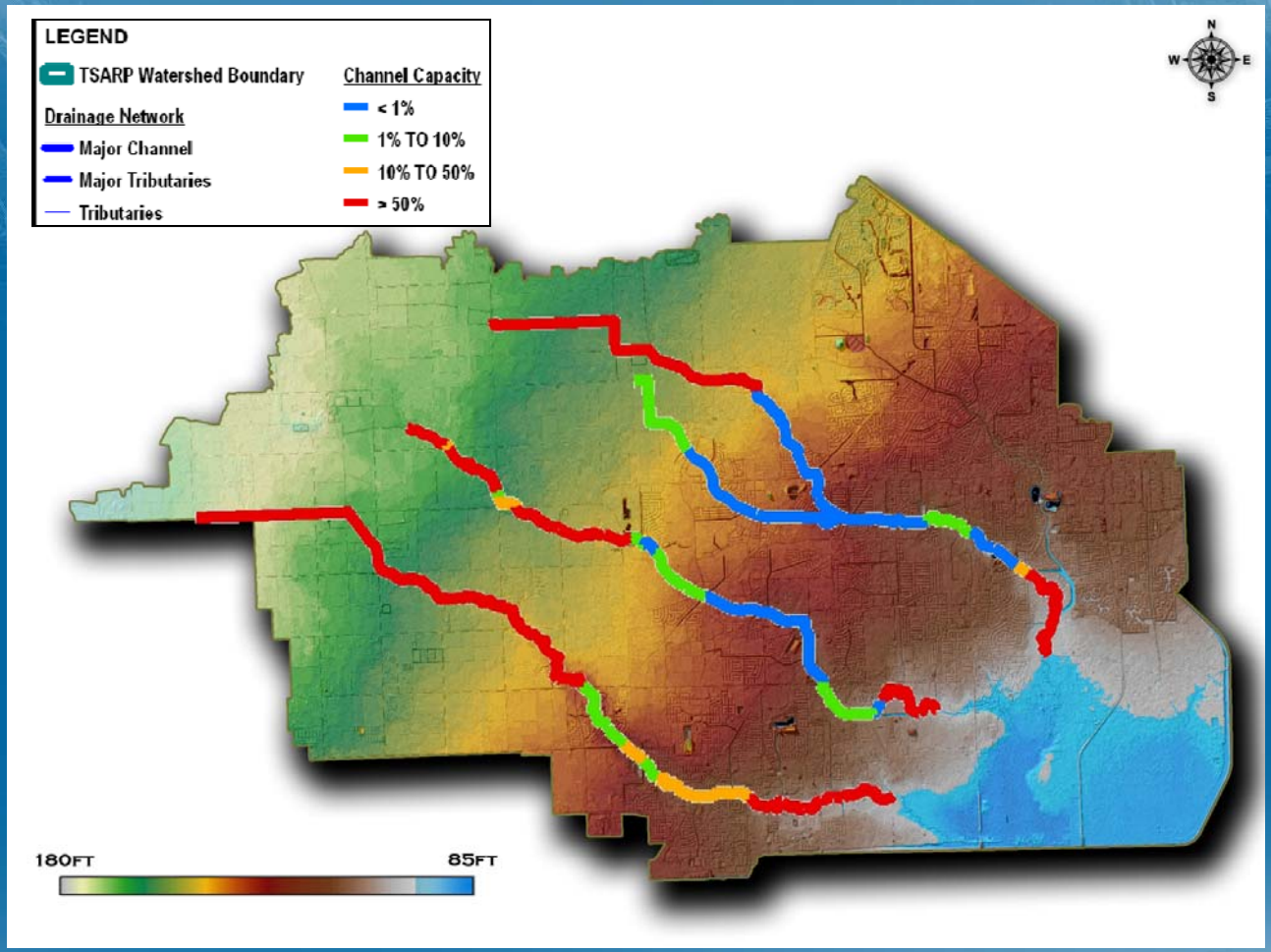
Elevation & channel Capacity



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1994 Flooding

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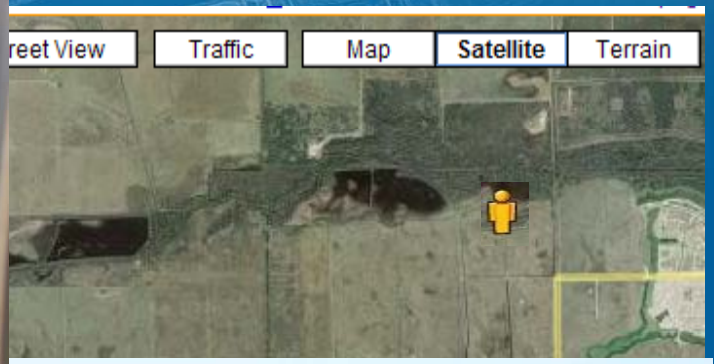
Study Area



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Study Area

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Study Area

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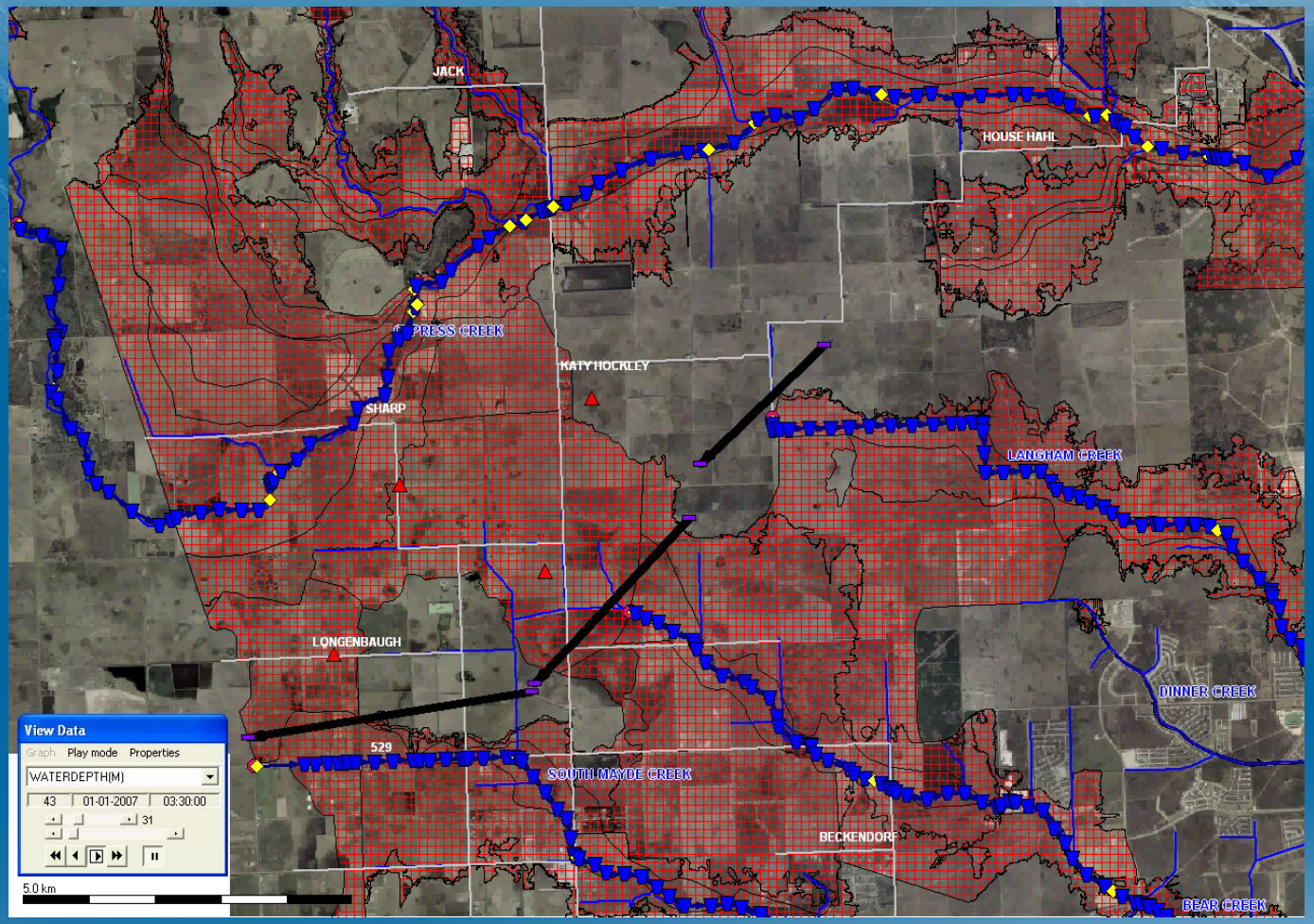
Modeling



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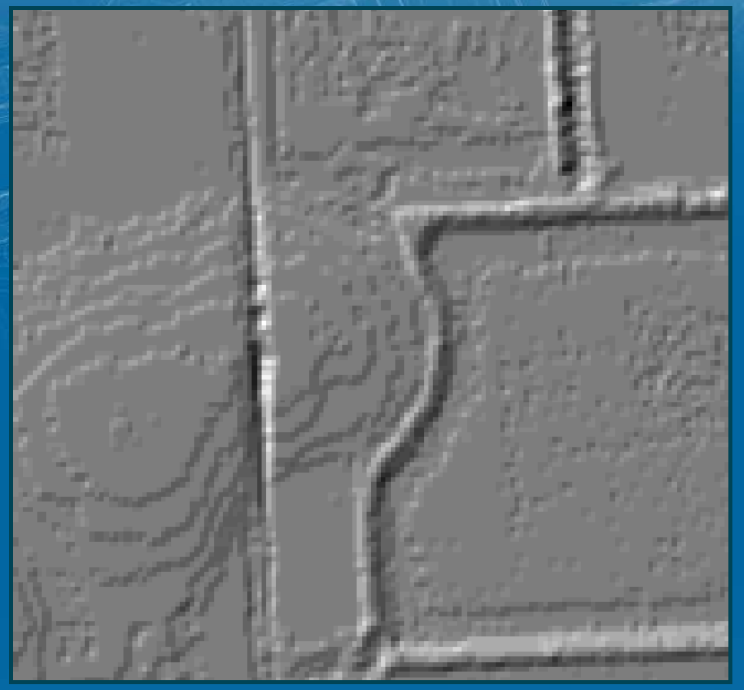
Overflow LiDAR Hillshade

Raw 1-ft LiDAR



Bare Earth 15-ft LiDAR

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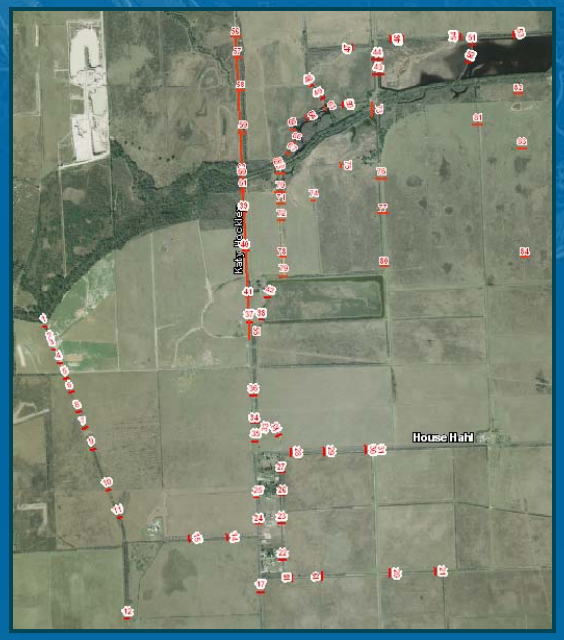
LiDAR Rectification

Rectification of 15-ft Bare Earth LiDAR



Study Area Cross-Sections for Terrain Rectification

Berms Added to 15-ft Bare Earth LiDAR

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Project

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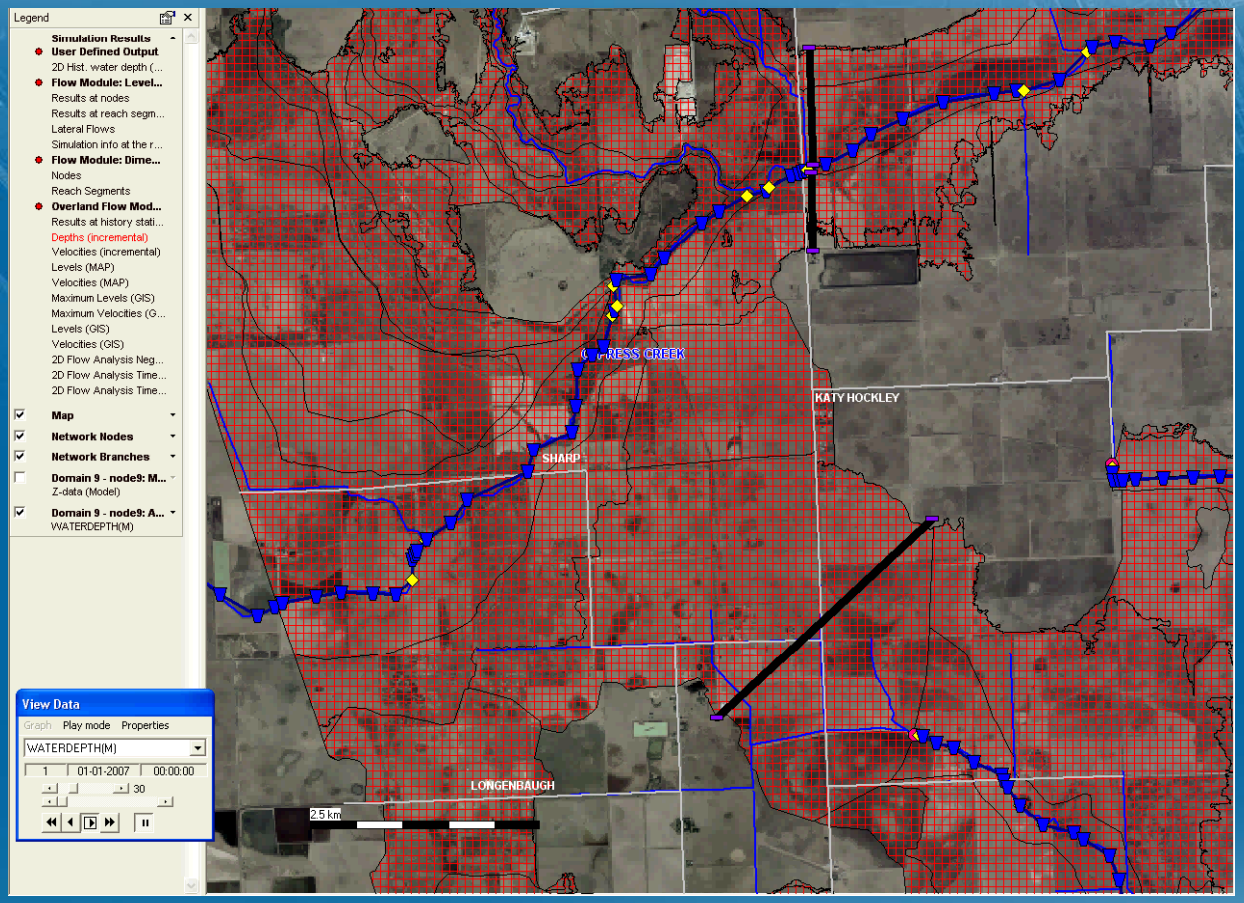
Final Run



1% Flood

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Result

CYPRESS CREEK K100-00-00

Comparison of Highwater Marks and Sobek Computed Water Surface Elevations for 1994 and 1998 Flood Events

ROAD NAME/HEC-RAS Station	OEM STAGE	USGS	HWM'S FOR STORM EVENTS (ALL ELEVATIONS 2000 ADJ)						SOBEK COMPUTED ELEVATION	
	GAGE	GAGE	HCFCD 10/94	USGS 10/94	OEM 10/94	HCFCD 10/98	USGS 10/98	OEM 10/98	Oct-94	Oct-98
TELGE ROAD			134.55			135.45				
BARKER CYPRESS						139.90				
U.S. 290	1178		143.17			138.40				
HOUSE HAHL ROAD		8068740	146.24	146.90		147.50	147.80		146.20	145.41
KATY HOCKLEY ROAD	1179	8068720	162.90	162.80	162.90	162.80	162.80	159.60	161.54	160.63
SHARP ROAD			168.50			166.40			167.82	167.10

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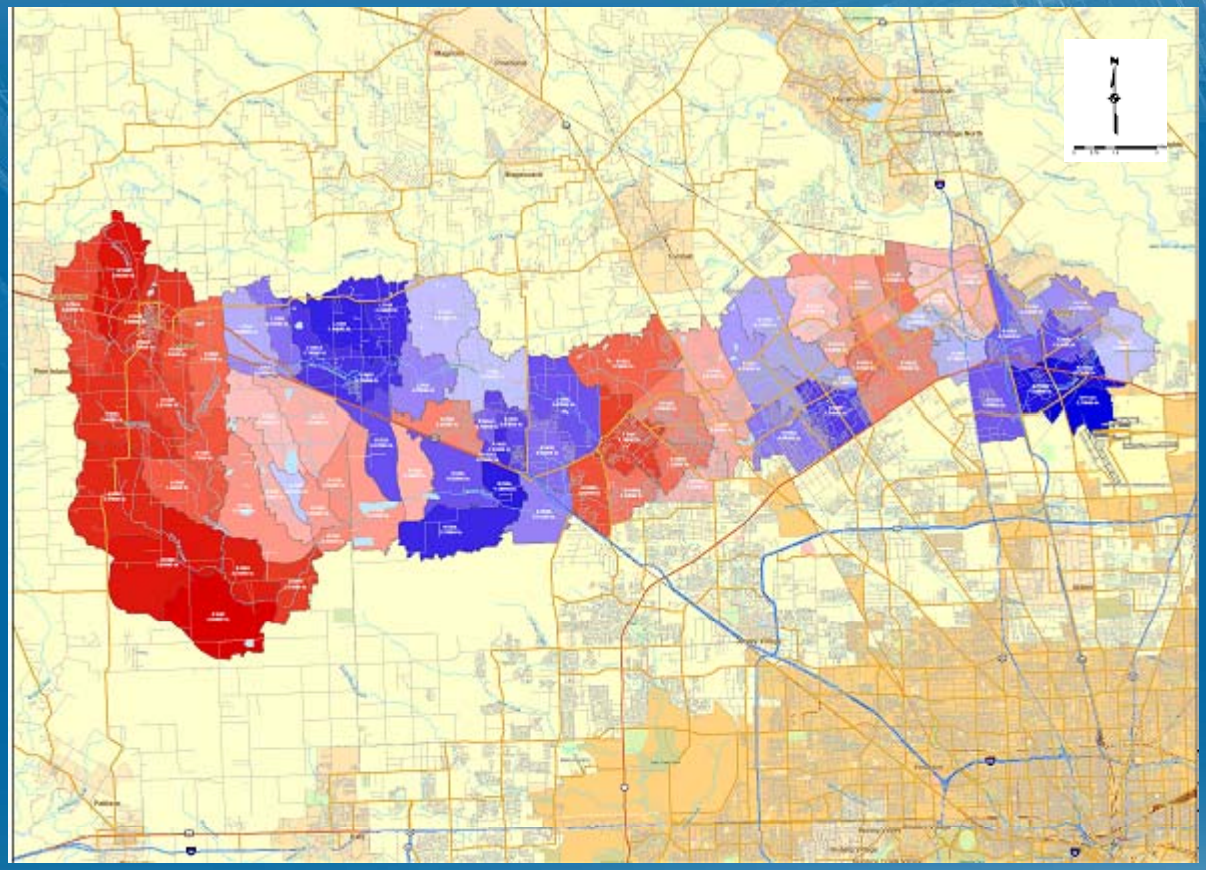
1998 Rainfall Comparison



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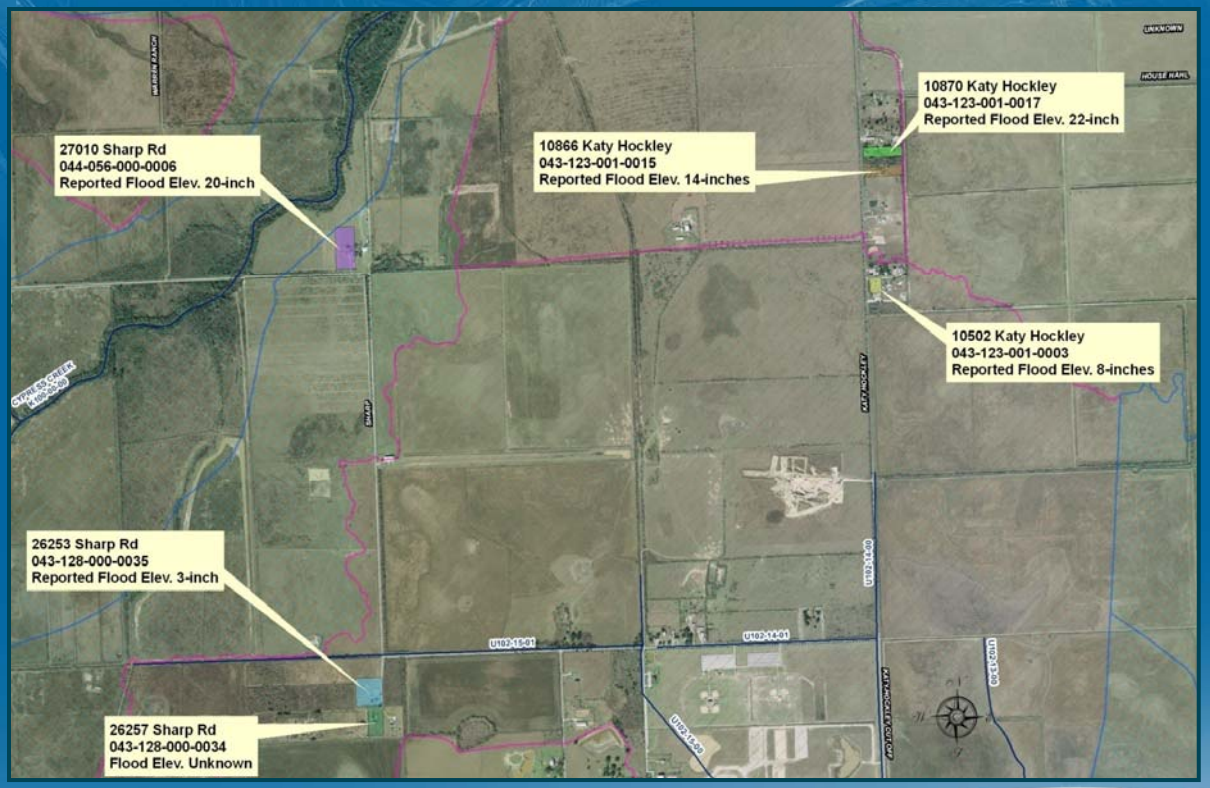
1998 Flooded Structures

From HCPID Permits Group



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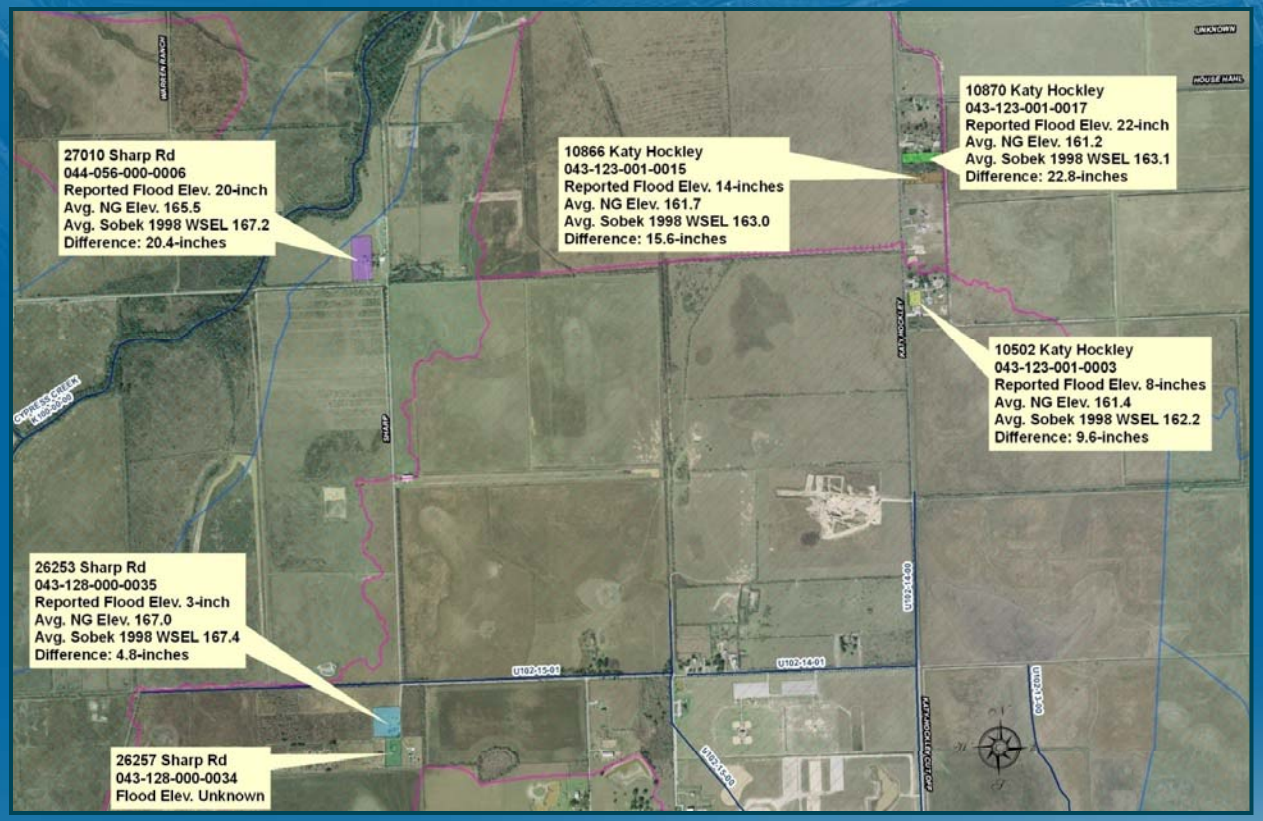
1998 Flooded Structures

Computed vs. Observed



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1998 Flooded Structures

Computed vs. Observed

Address	Ponding in Inches		Remarks
	Observed (1)	Computed (2)	
10502 Katy Hockley	8 -inch	9.6 -inch	Finish Floor Unknown
10866 Katy Hockley	14 -inch	15.6 -inch	Finish Floor Unknown
10870 Katy Hockley	22 -inch	22.8 -inch	Finish Floor Unknown
26253 Sharp Rd	3-inch	4.8 -inch	Finish Floor Unknown
26257 Sharp Rd	Unknown	4.0 -inch	Finish Floor Unknown
27010 Sharp Rd	20 -inch	20.4 -inch	Finish Floor Unknown

(1) Observed is from the HCPID permits group

(2) Based on Sobek Computed Elevation

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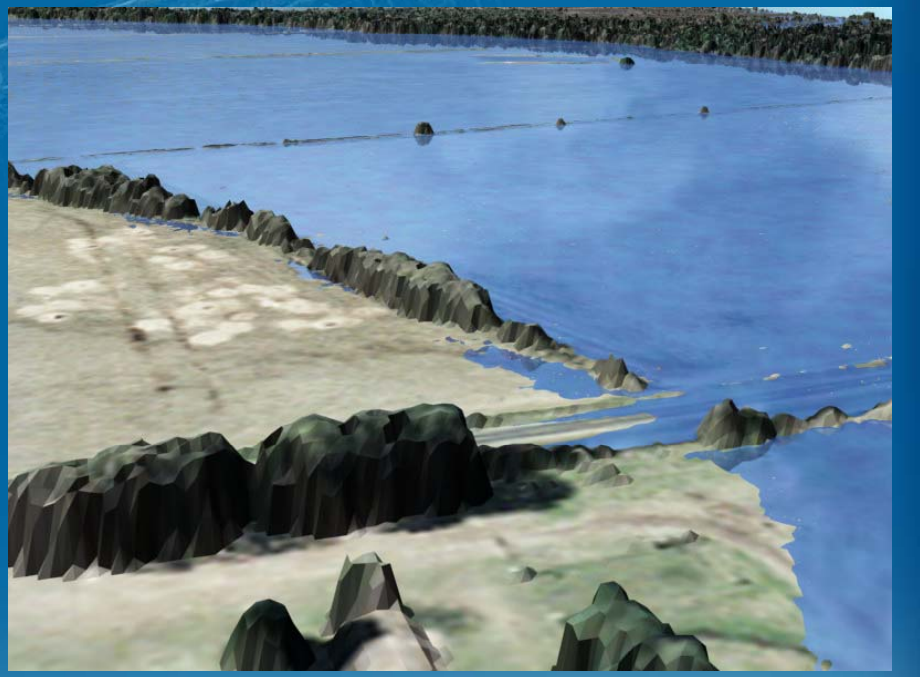
October 1998 Event



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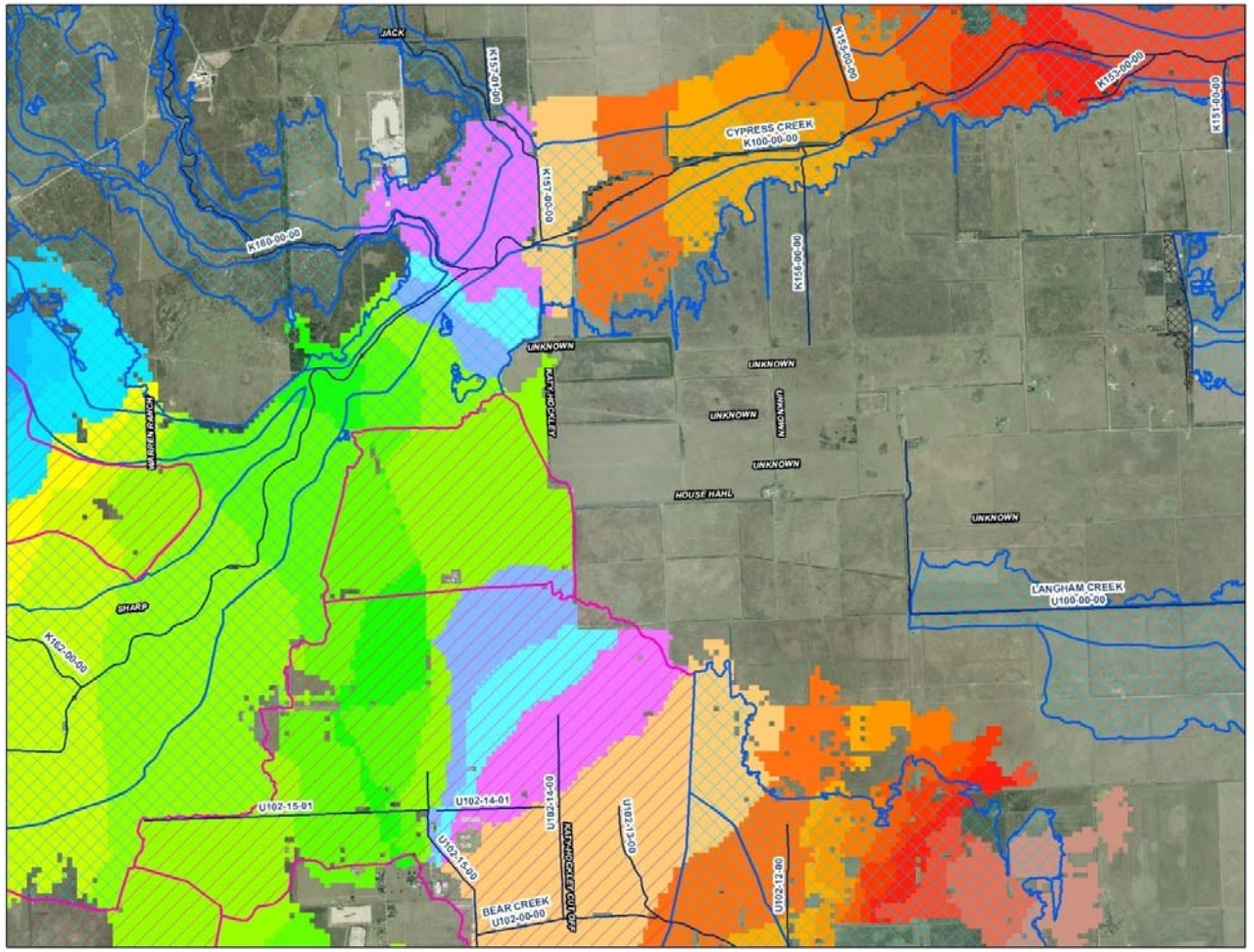
Comparison of Floodplain

FEMA vs. 2-D Model (1% Flood)



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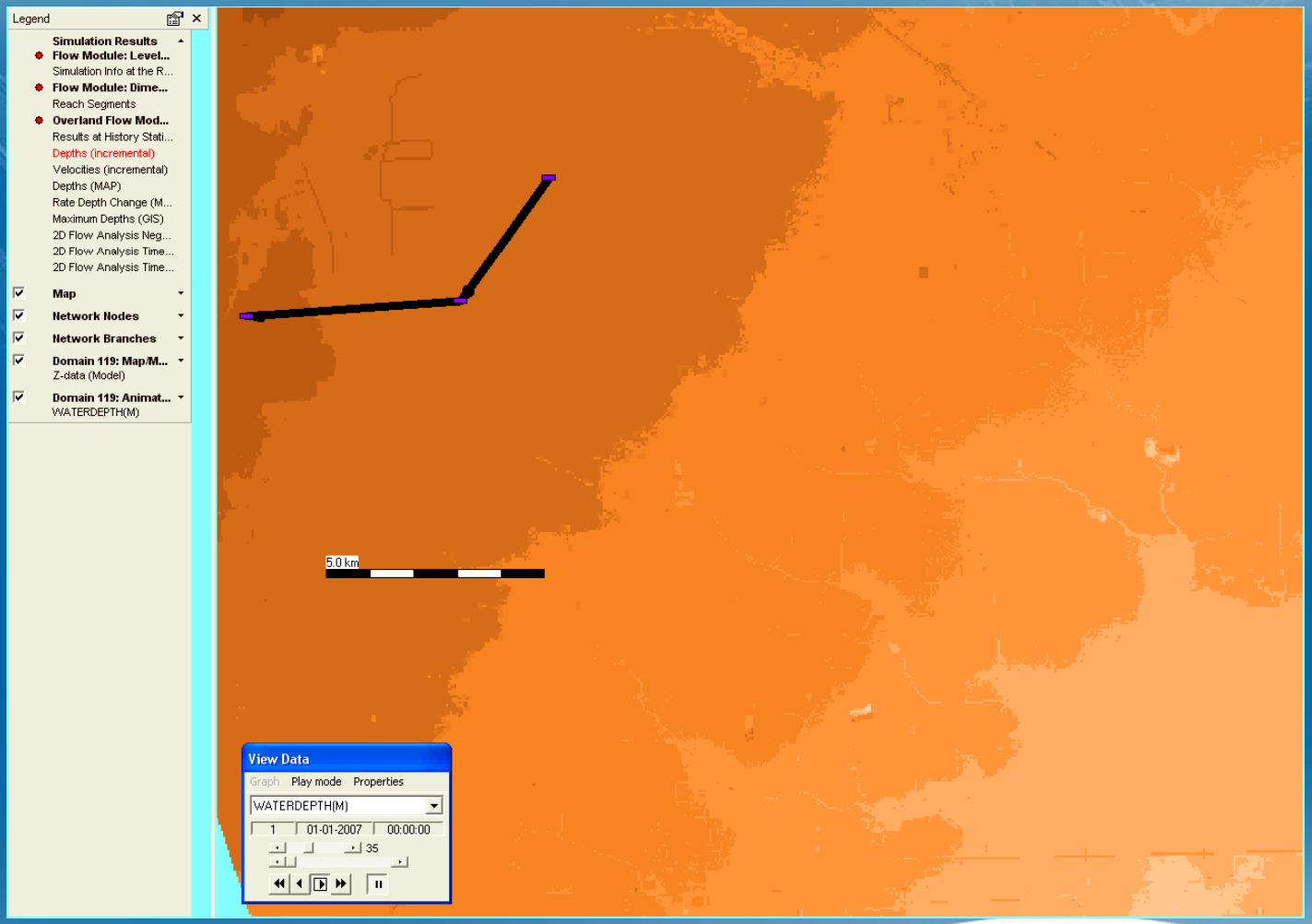
Rainfall on Land



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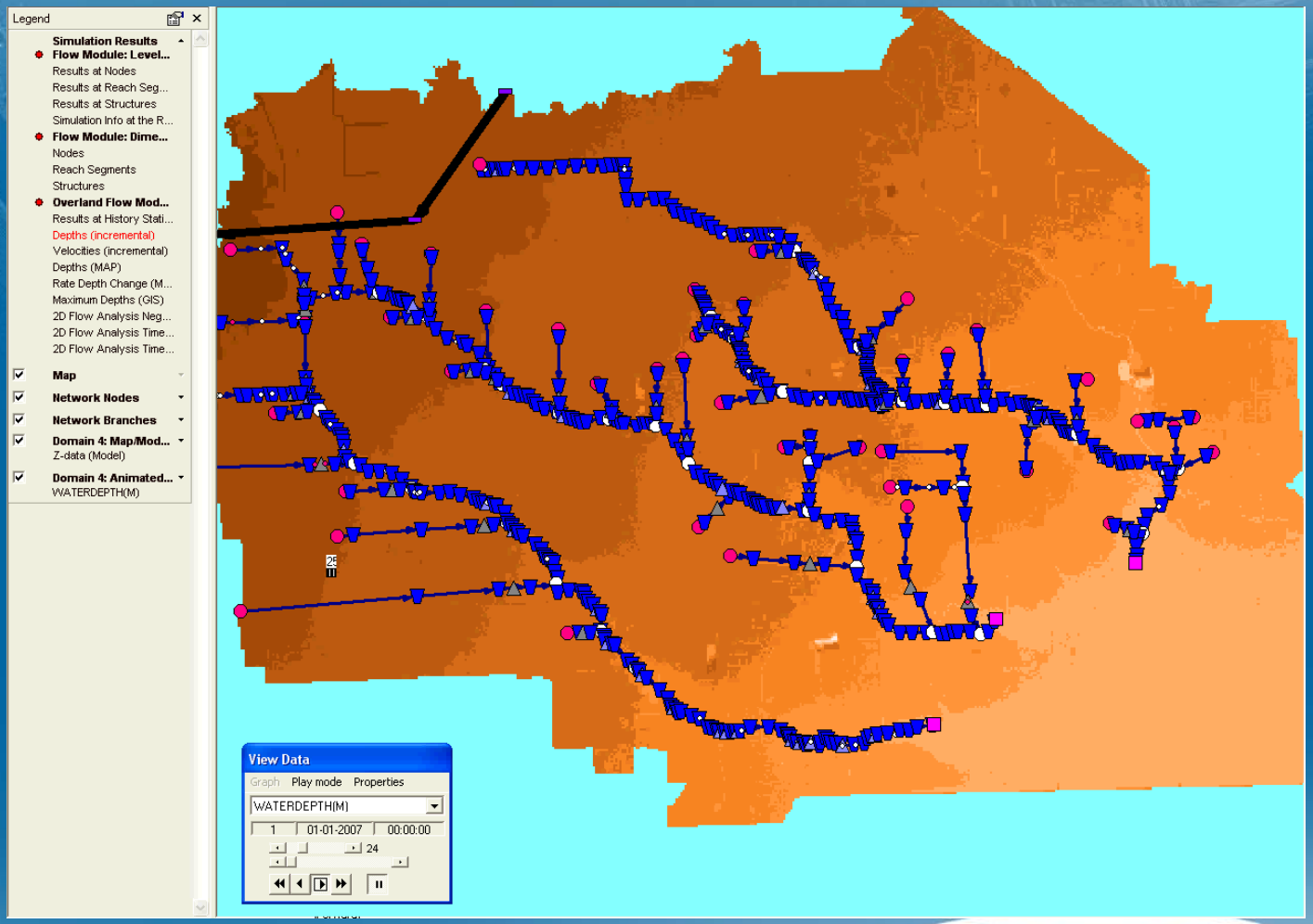
Grid Rainfall



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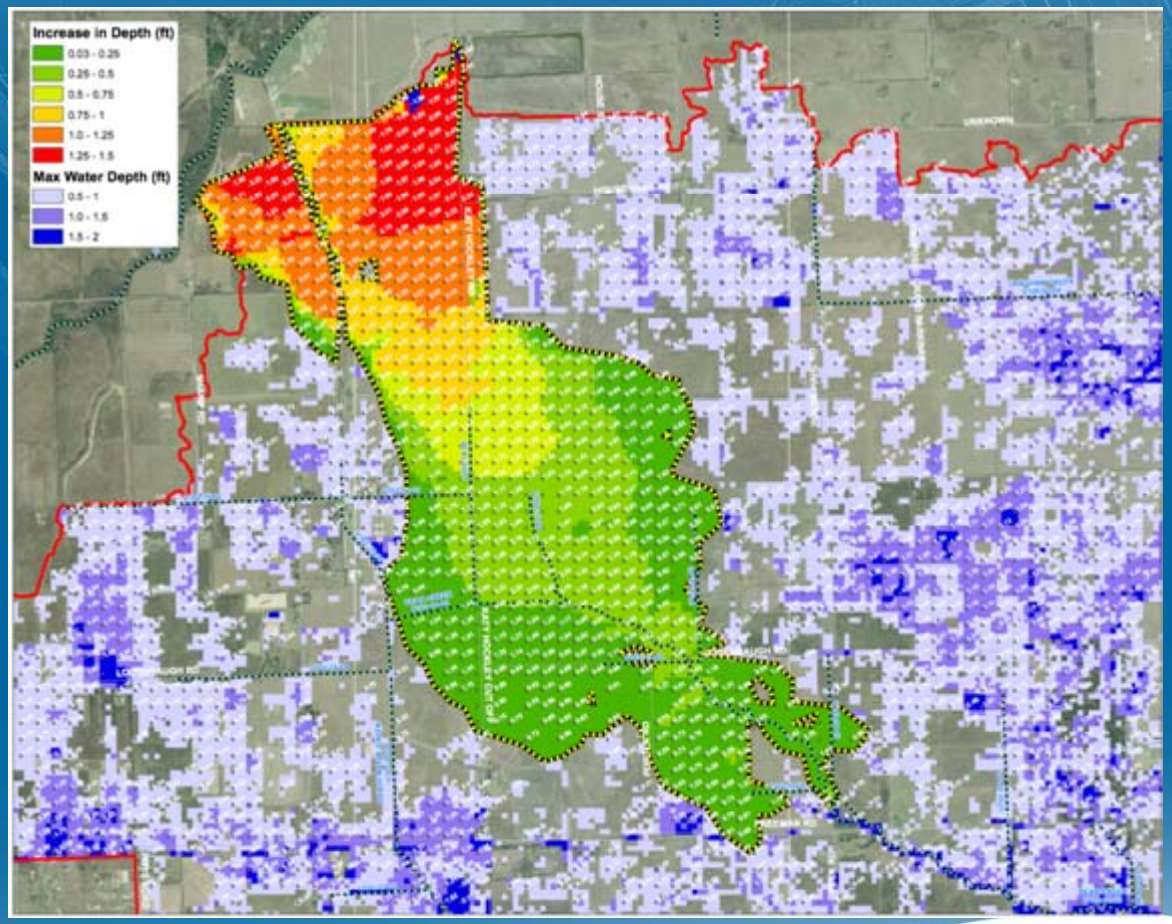
1% Flood Increase in Ponding Depths Due to Cypress Overflows



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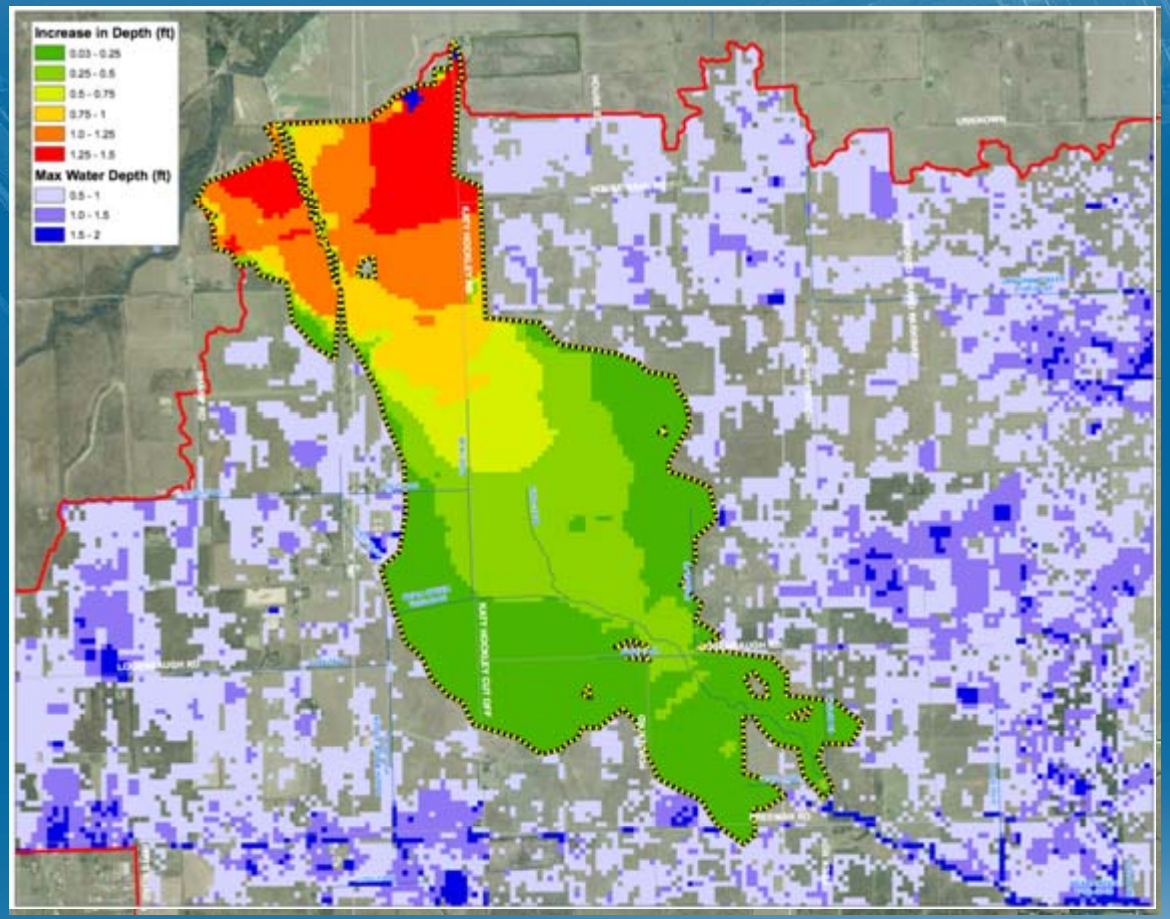

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Thank You