2D Floodway Modeling in Mecklenburg County, NC

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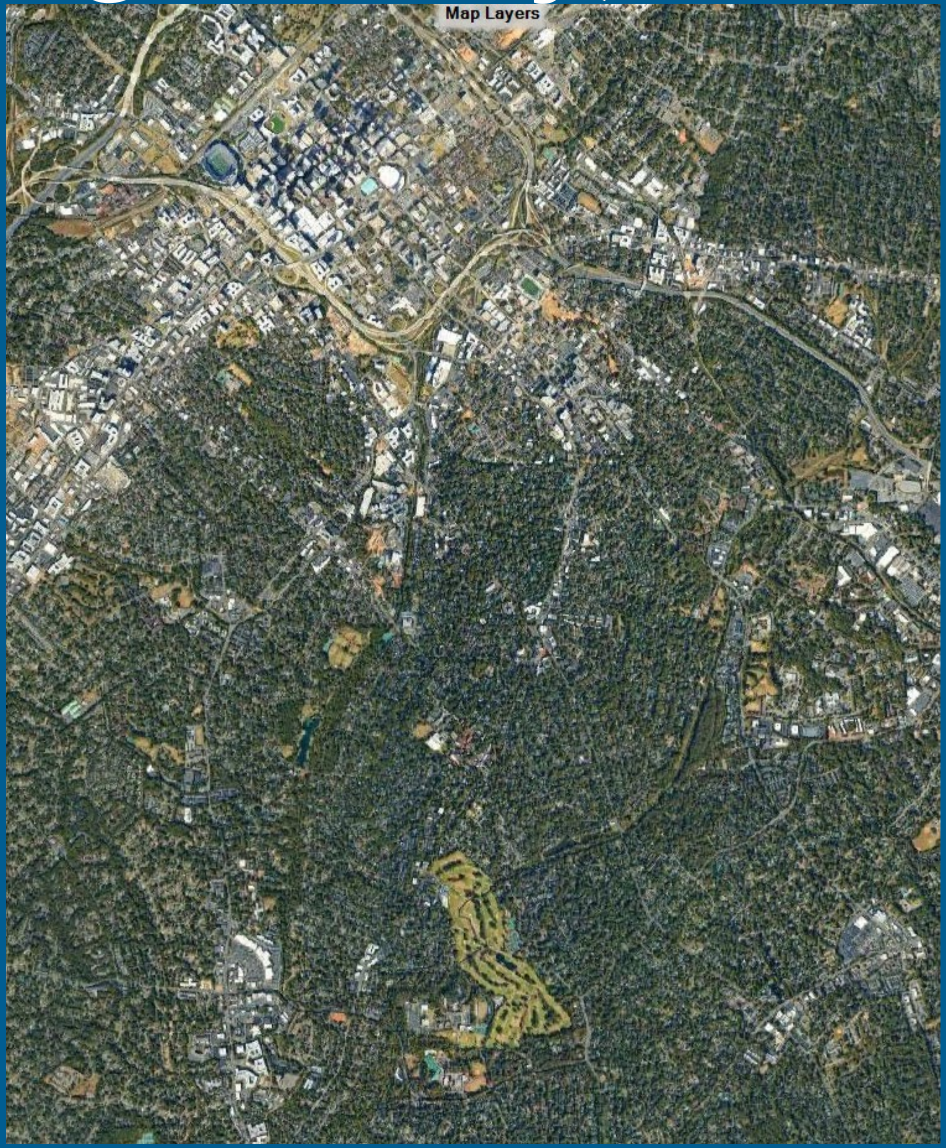
Agenda

- Study area - Mecklenburg County, NC
- FEMA's 2D floodway guidance
- Modeling 2D floodways:
  - Rain-on-grid (ROG) approach
  - Riverine approach
- Comparing 2D floodway results
- 2D floodway benefits, challenges, and tips

Study Area - Mecklenburg County, NC

- Contains City of Charlotte
- Highest population density in NC (2,260 people / sq mi)
- Highly urbanized city center and residential suburbs
- Hilly slopes



Mecklenburg Co. New Mapping Needs

FIS History

- Charlotte-Mecklenburg Stormwater Services (CMSWS) assumes primary responsibility of the FIS and FIRMs county-wide
- Effective models last updated in 2014-2016
    - 1D HEC-RAS Models

Changes Since 2014

- HEC-RAS 2D capabilities
- 17% population increase in Mecklenburg County
- Growth and development sparked the need for CMSWS to update FEMA and community floodplain maps

What is a Floodway (FW)?

Definition

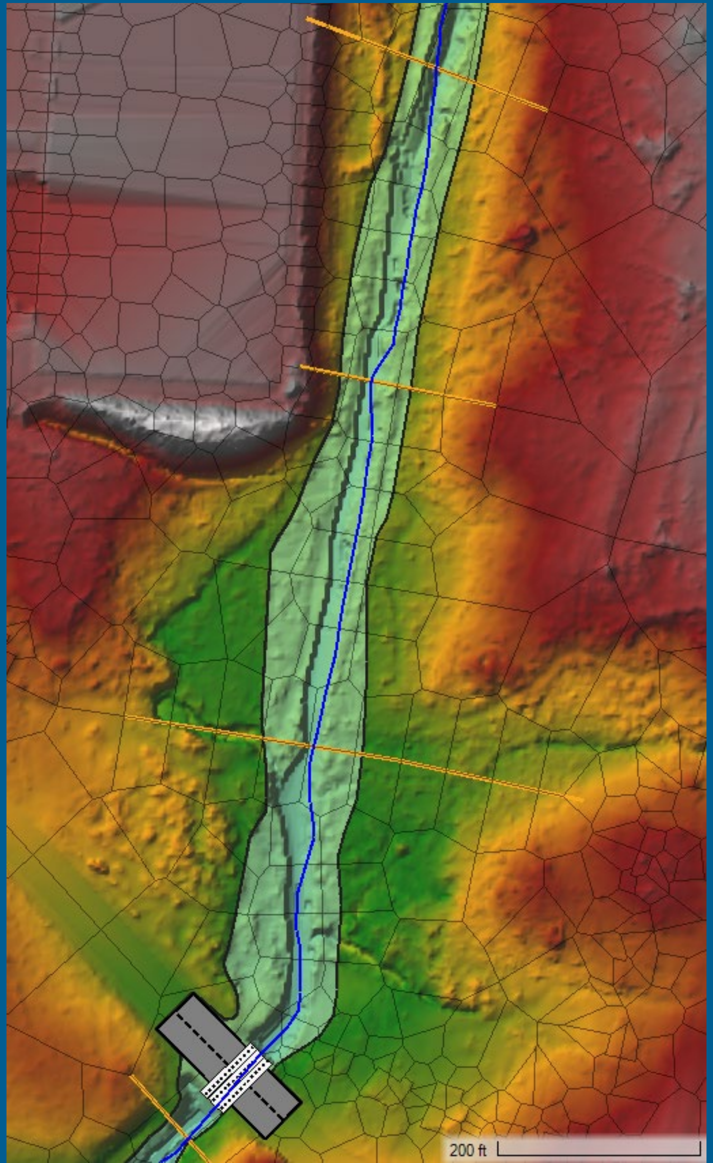
- The FW is the portion of the floodplain that conveys the most water
- Floodplain is encroached so that the 100-yr WSE does not rise (surcharge) more than 1ft
  - Encroached boundary is the FW

Purpose

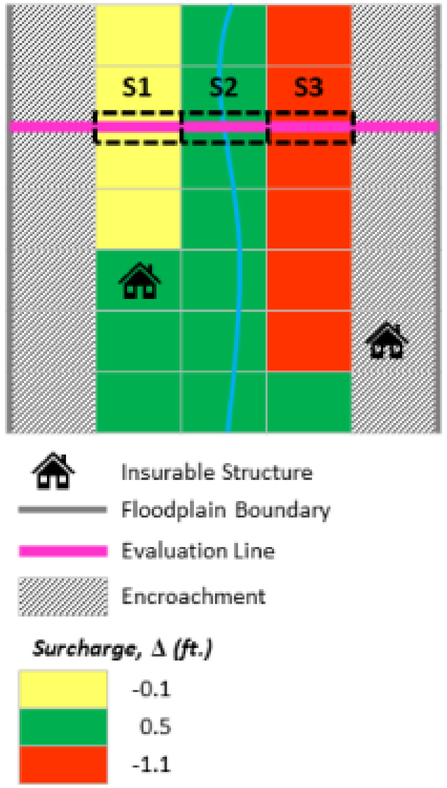
- To prevent building in the FW and to prevent a rise in WSE at insurable structures

FEMA 2D Floodway Guidance

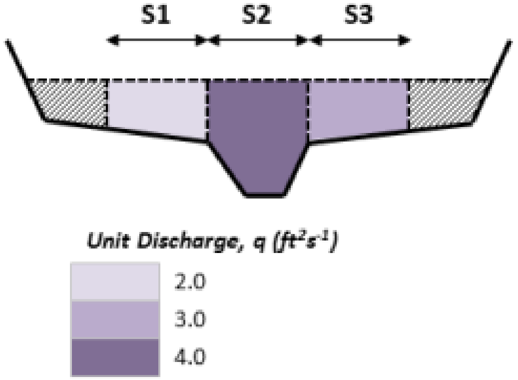
- Continuous encroachment boundary
- Flows – ROG or riverine
- Tie into effective floodways at modeling limits
- Modifying floodway width – use equal unit discharge or depth x velocity
- Measure weighted average surcharge at evaluation lines
  - Surcharge between 0-1ft



1 Calculate surcharge at each model cell, and divide BFE line into segments



2 Determine appropriate surcharge weighting for each segment (unit discharge shown here)



3 Calculate surcharge average ($\bar{\Delta}_{BFE}$) for all segments along BFE line using suitable averaging technique (unit discharge averaging shown here)

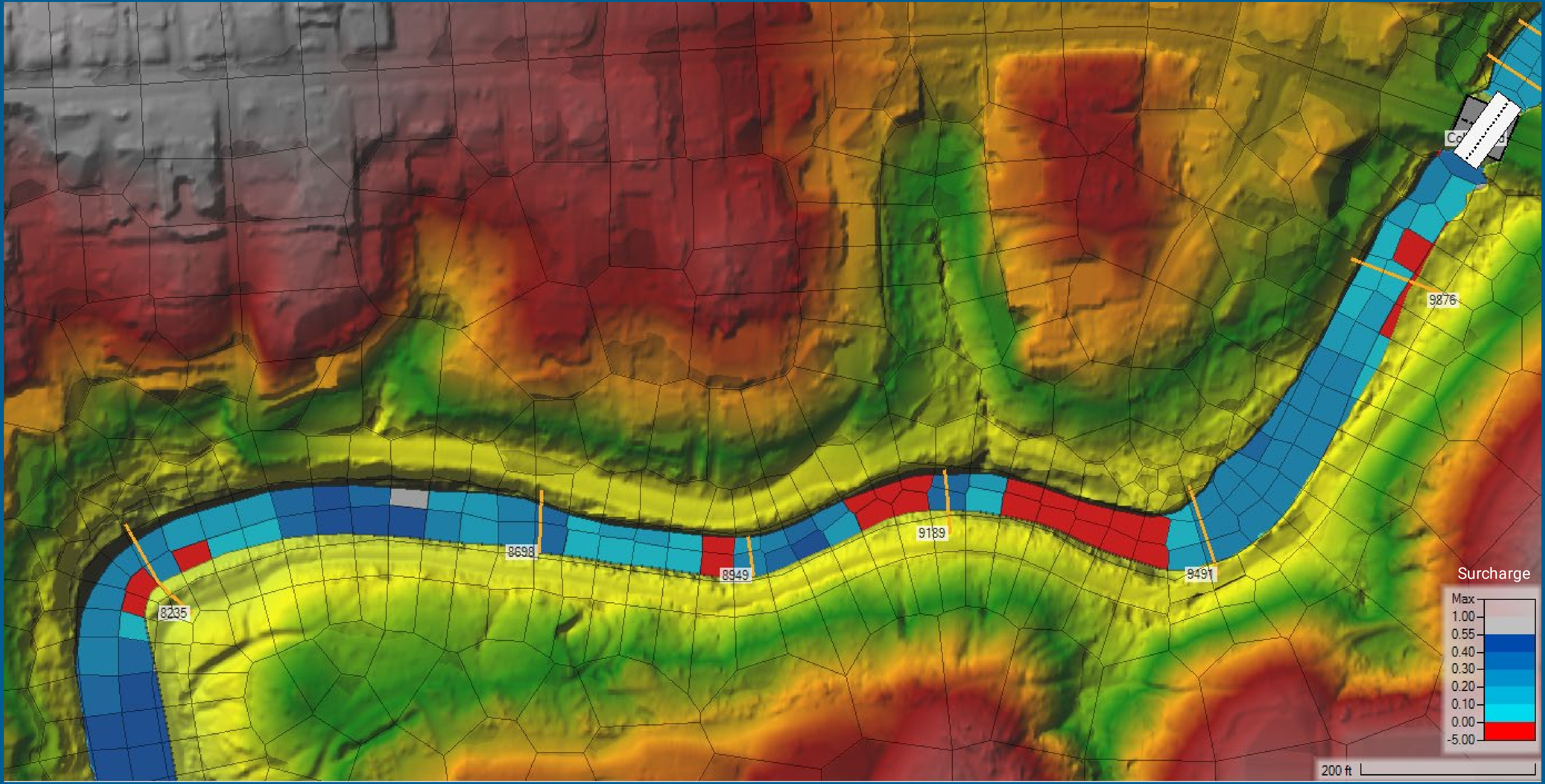
$$\bar{\Delta}_{BFE} = \frac{\Delta_{S1} q_{S1} + \Delta_{S2} q_{S2} + \Delta_{S3} q_{S3}}{q_{S1} + q_{S2} + q_{S3}}$$

$$\bar{\Delta}_{BFE} = \frac{(-0.1)(2.0) + (0.5)(3.0) + (1.1)(4.0)}{2.0 + 3.0 + 4.0}$$

$$\bar{\Delta}_{BFE} = \mathbf{0.63}\ \boldsymbol{ft}.$$

4 Evaluate weighted surcharge average and individual model cell surcharges against criteria. Adjust criteria where more restrictive state surcharge requirements exist.

Criteria	Description	Pass	Fail
1	BFE average is within allowable surcharge range of 0.0 to 1.0 feet.	✔	
2	All model cells overlapping insurable structures are within the allowable surcharge range of 0.0 to 1.0 feet.	✔	
3	All model cells considered in the BFE average are within the allowable surcharge range ± 0.5 feet (-0.5 to 1.5 feet)	✔	
4	All model cells *not* considered in the BFE average are within the allowable surcharge range ± 0.5 feet (-0.5 to 1.5 feet)	✔	



8235
8698
8949
9189
9491
9876
Surcharge
Max
1.00
0.55
0.40
0.30
0.20
0.10
0.00
-5.00
200 ft

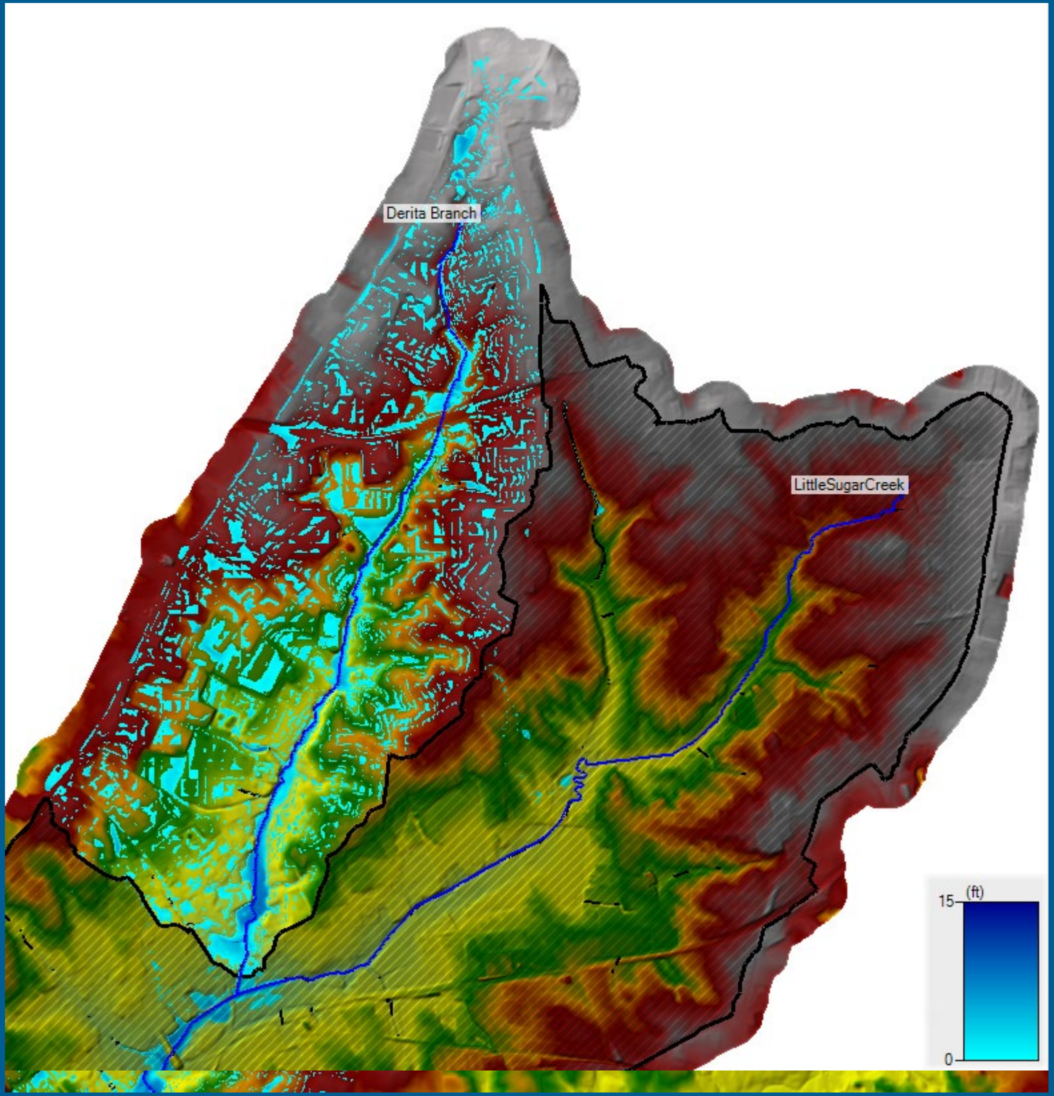
2D Floodway Base Run

Main Watershed Stream

- Base run – floodplain model with 100yr ROG precipitation

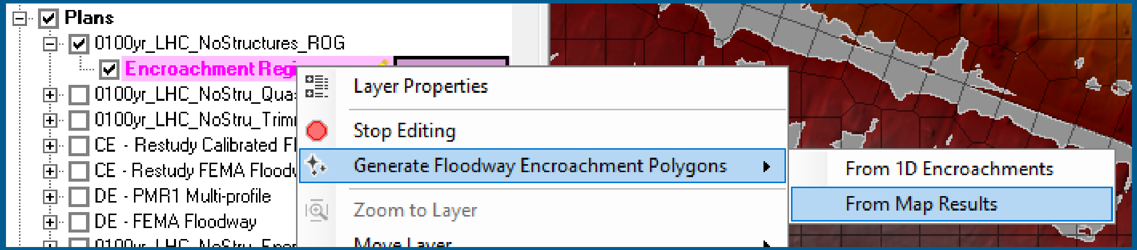
Tributaries

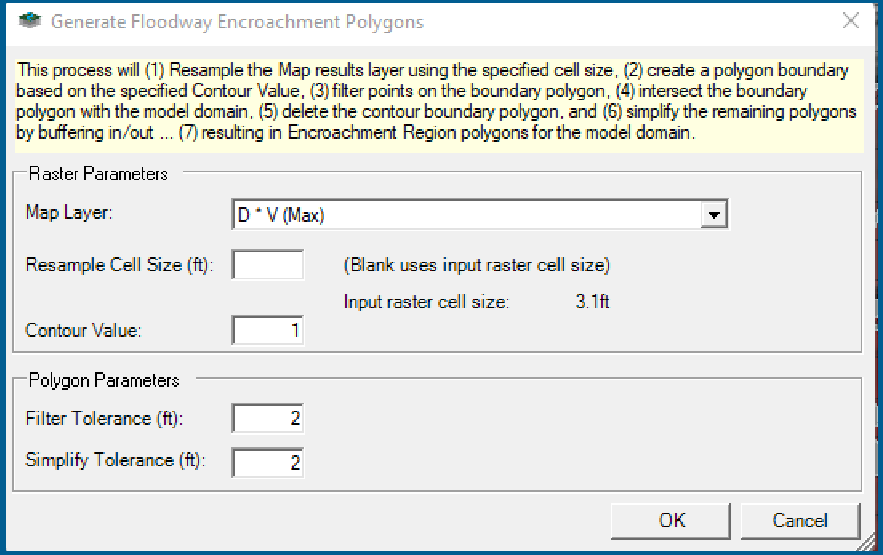
- Base run – 100yr ROG precipitation with high infiltration rate applied to other drainage areas



2D Floodway Encroached Runs

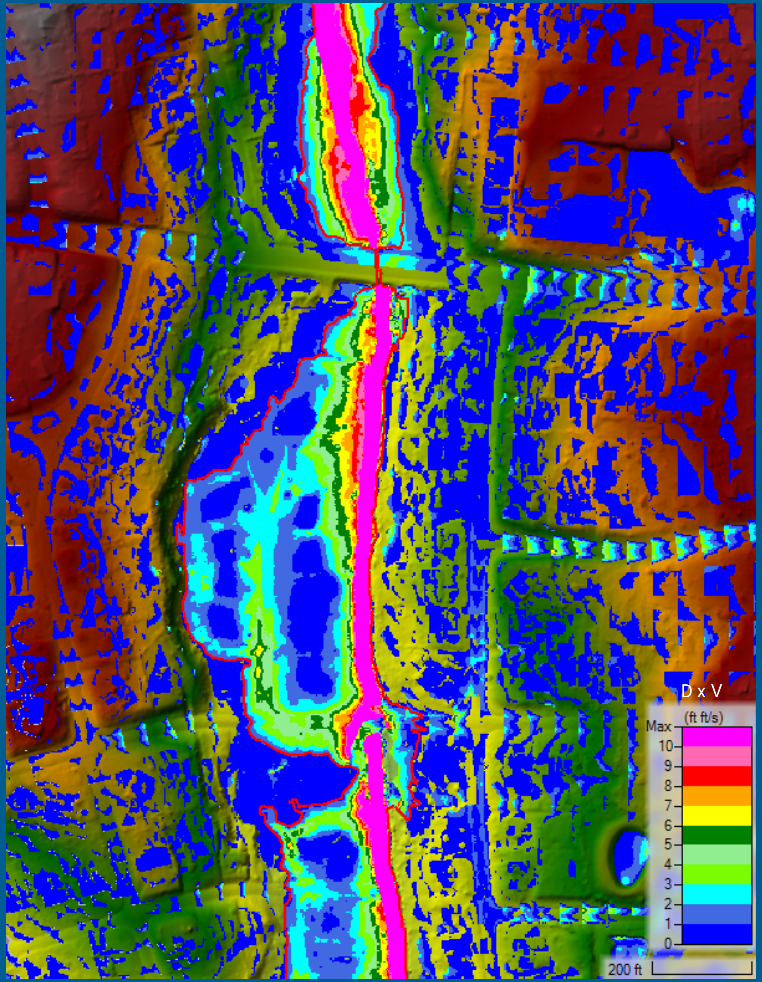
- Create initial encroachment along DxV contour
  - Generate Encroachment Polygons tool in RASmapper
  - May need run without SA/2D connections
- Filter and smooth polygon
- Cut SA/2D connections out
- Add encroachment as raised terrain modification



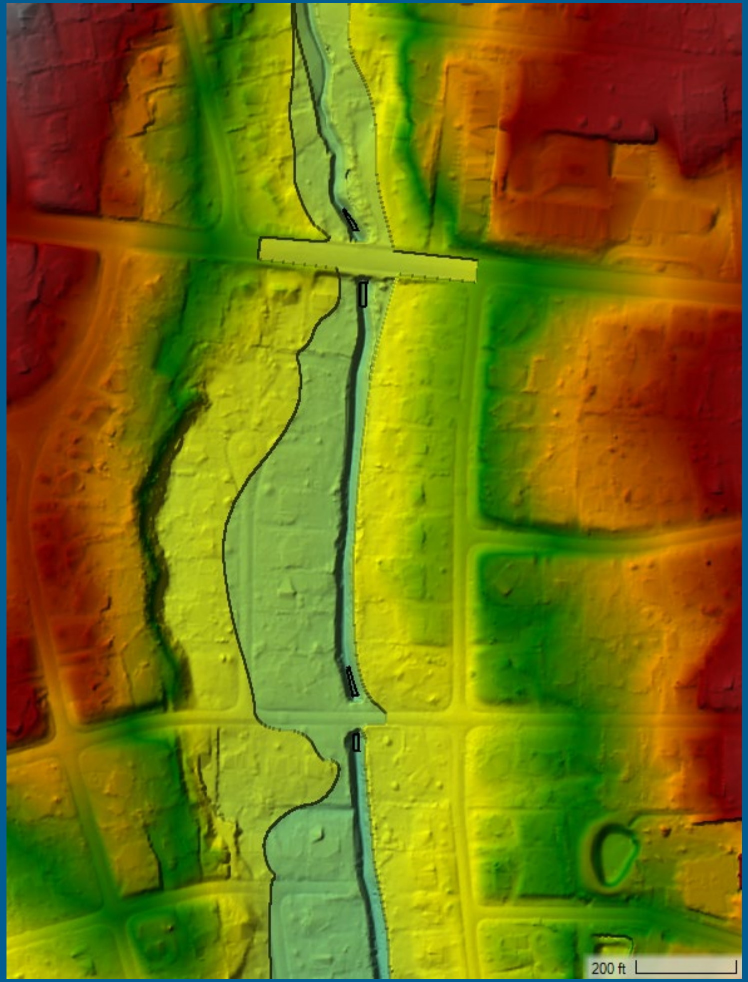


Creating Encroachments

Follow DxV Contours



Raise Terrain



Two Different Methodologies

ROG

- Base run
  - 100yr ROG precip
- Encroached run
  - Encroachment
  - 100yr ROG precip

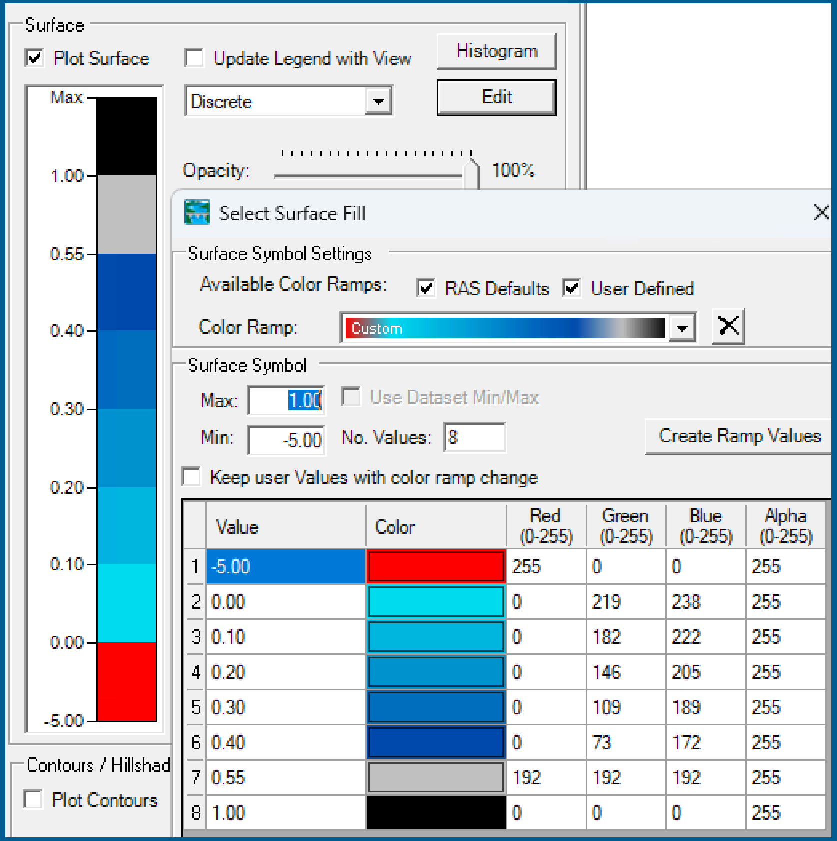
Riverine

- Base run
  - 100yr ROG precip OR peak flows input at internal BC lines
- Encroached run
  - Encroachment
  - Peak flows input at internal BC lines

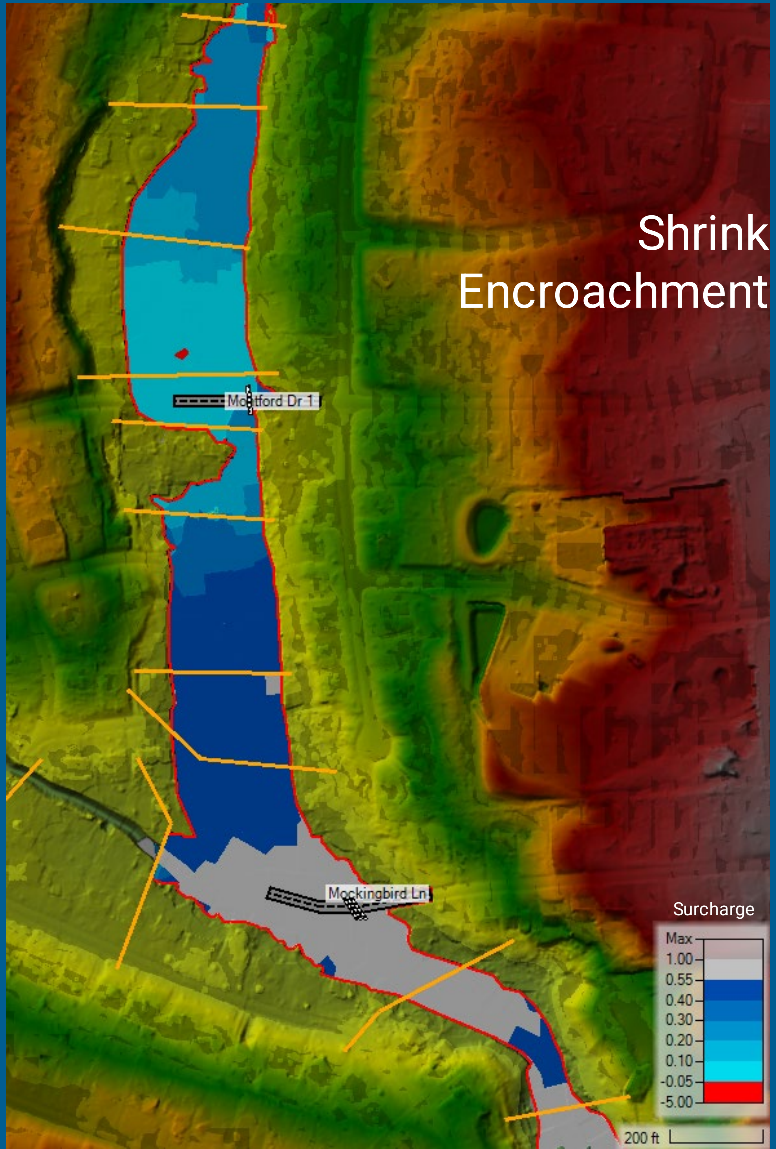
Iterate Until Acceptable Surcharge

Tips

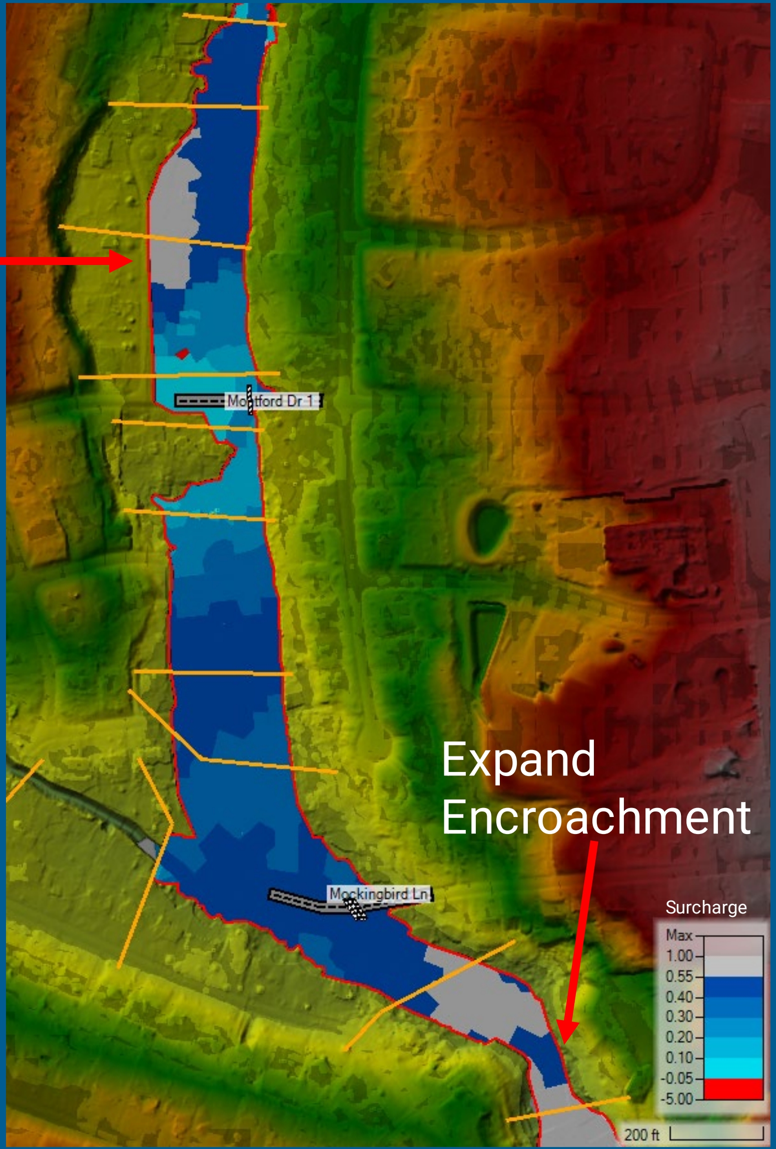
- Symbolize surcharge in RASmapper
- Modify encroachment equitably on both overbanks
- Don’t make too many changes to the encroachment with each iteration
- Work downstream to upstream
- Check flows of encroached run frequently
- Encroachments around bridges/culverts have the greatest impact on WSE



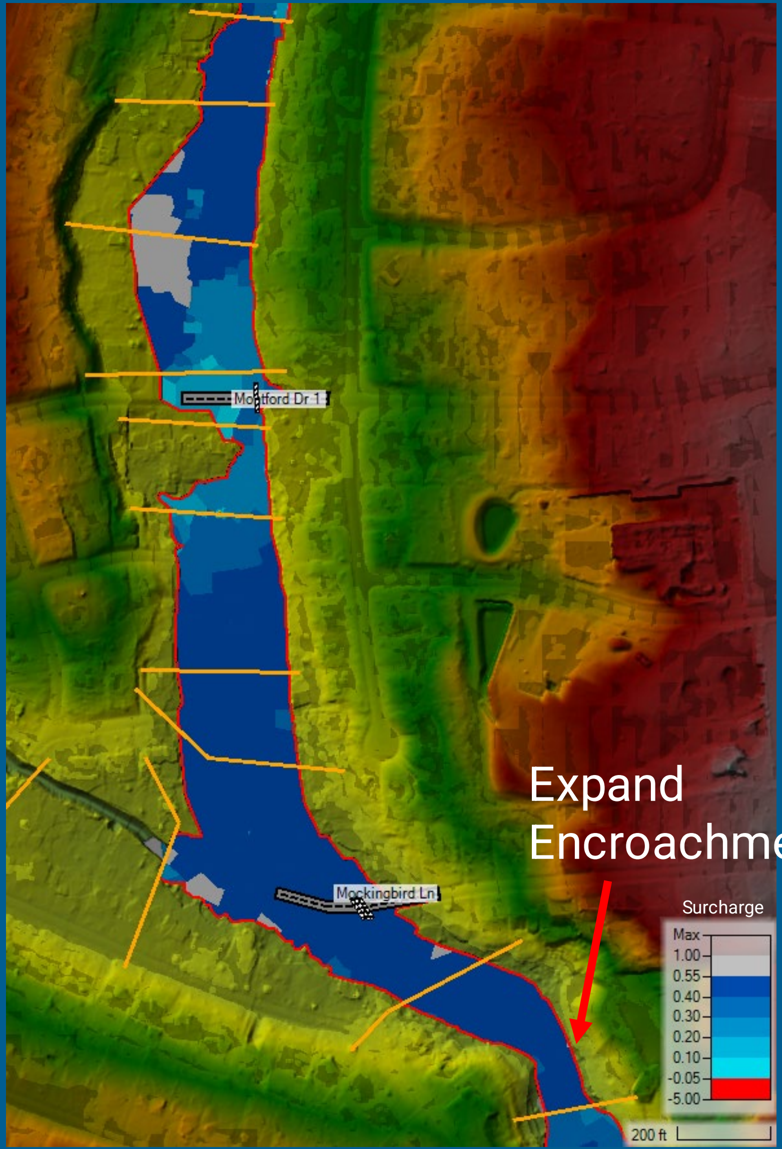
Iteration 1



Iteration 2

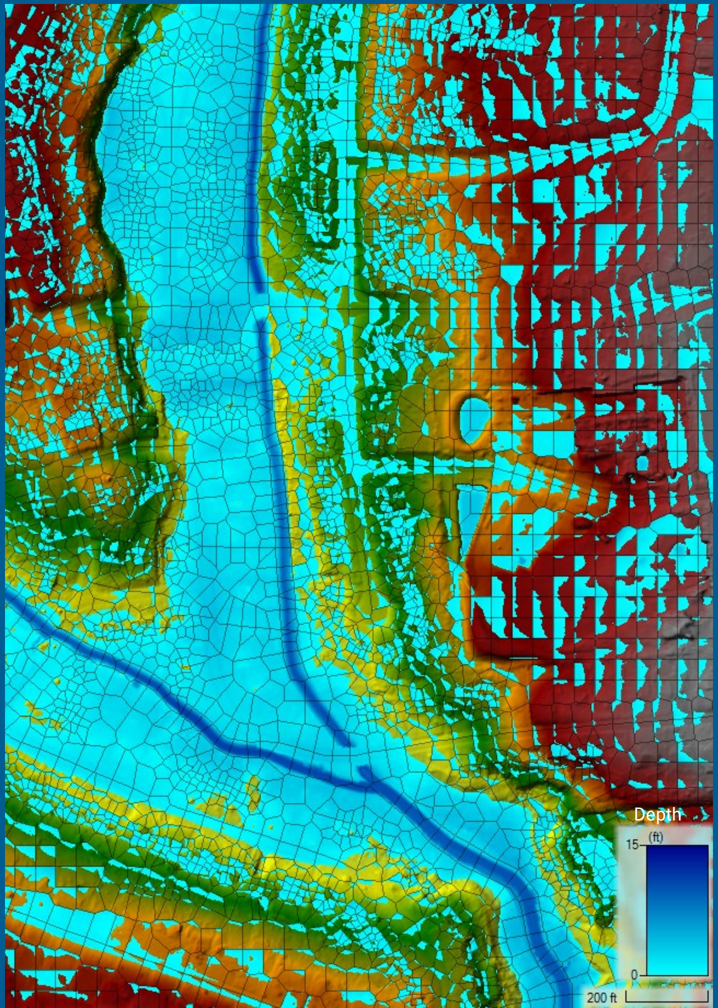


Iteration 3

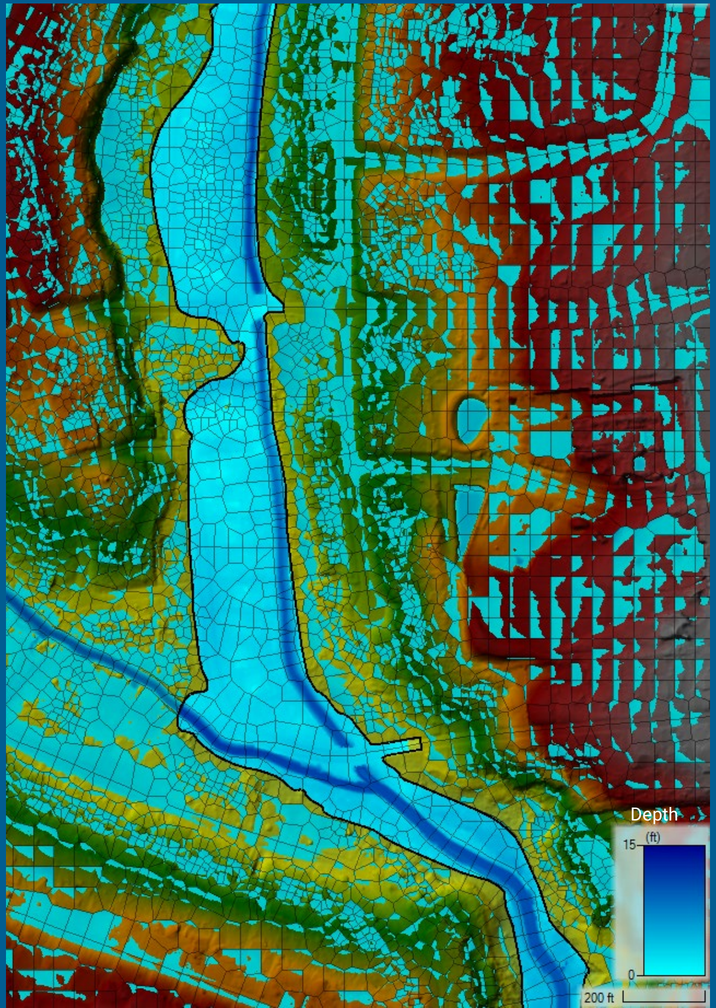


Encroached Run Results

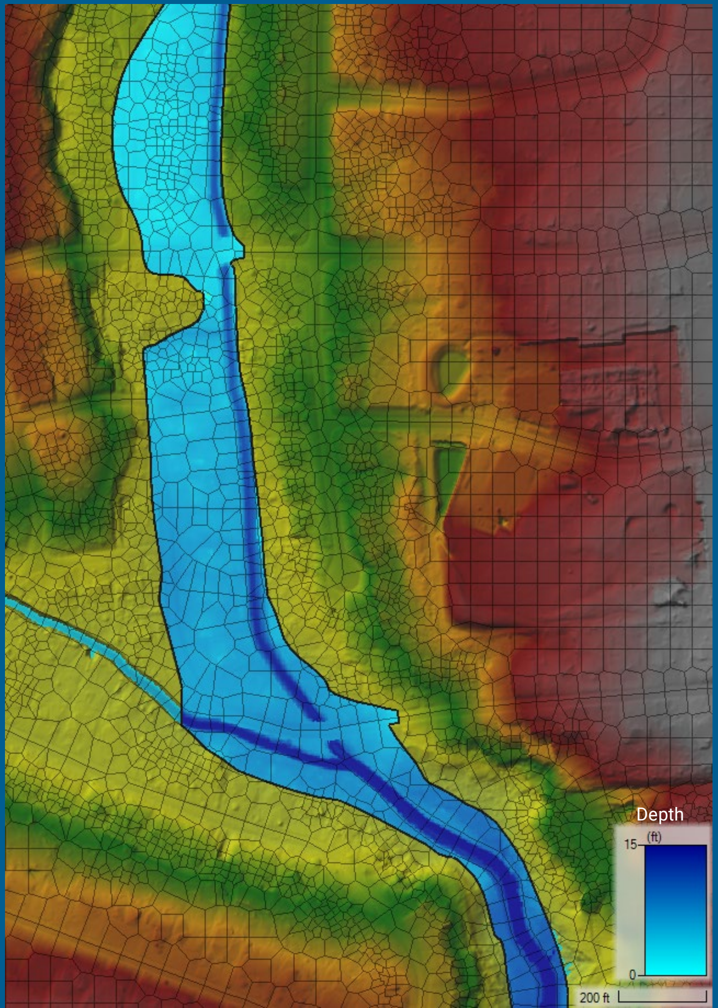
ROG Base



ROG Encroachment

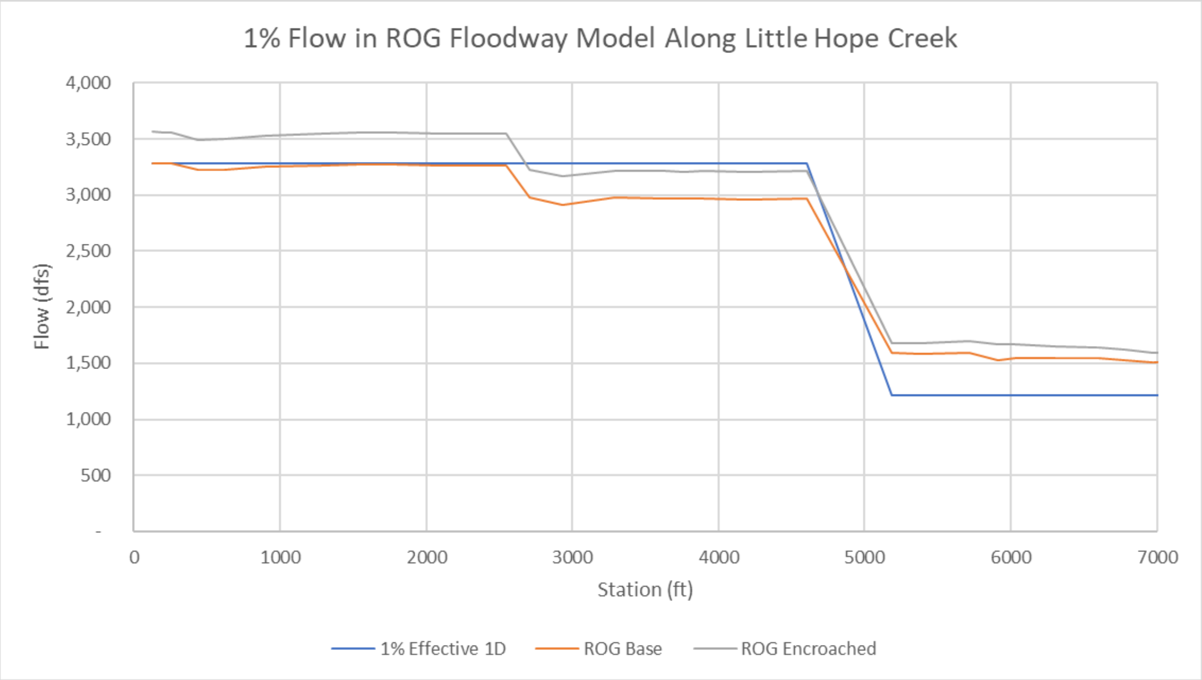


Riverine Encroachment

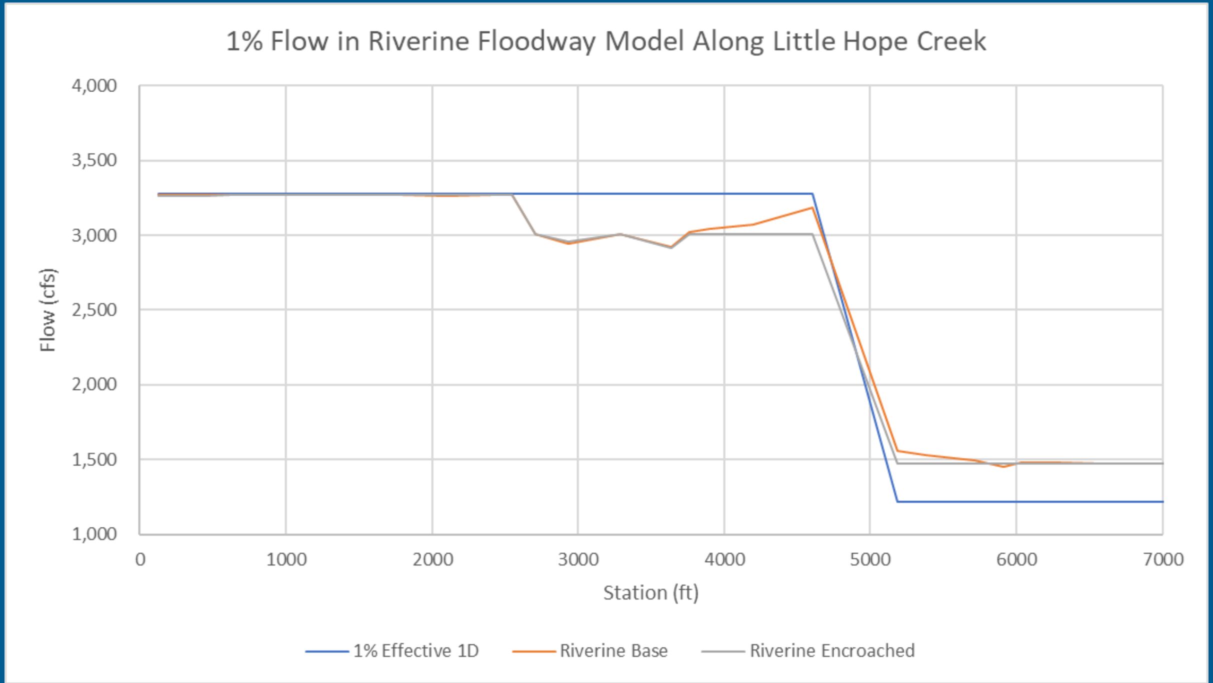


Floodway Comparison - Discharge

ROG Model

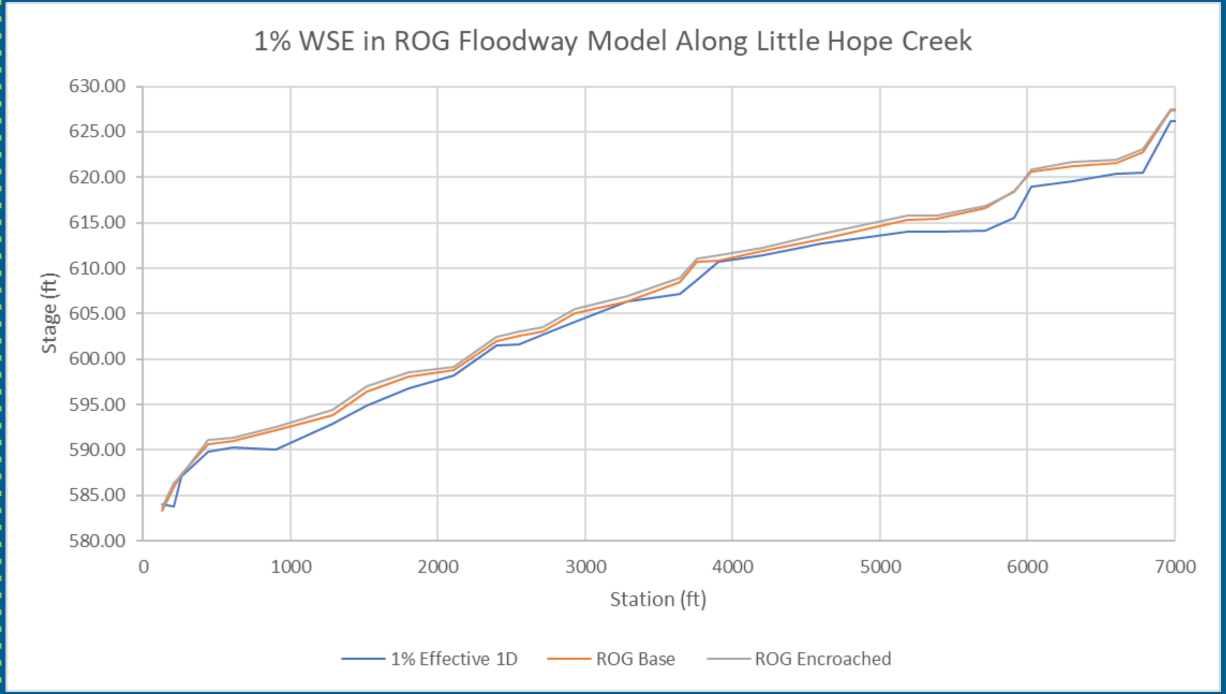


Riverine Model

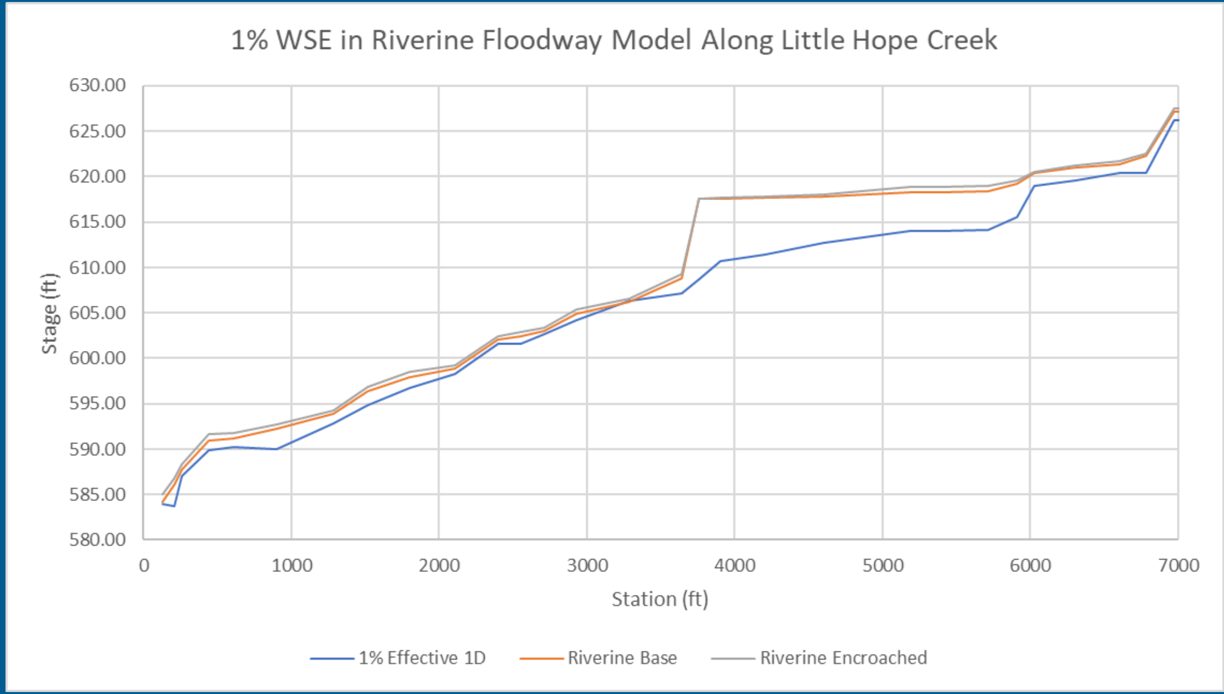


Floodway Comparison - Stage

ROG Model



Riverine Model



Floodway Comparison - Width

	ROG Approach					Riverine Approach				
Distance (Feet Above Mouth)	Floodway Width (ft)	Base Discharge (cfs)	Floodway Discharge (cfs)	Discharge Percent Difference	Average Surcharge (ft/ft)	Floodway Width (ft)	Base Discharge (cfs)	Floodway Discharge (cfs)	Discharge Percent Difference	Average Surcharge (ft/ft)
Little Hope Creek										
259	67	3283	3557	8%	0.19	58	3283	3263	-1%	0.42
900	134	3254	3531	8%	0.48	89	3254	3269	0%	0.30
1521	95	3268	3555	9%	0.39	64	3268	3269	0%	0.35
2105	121	3265	3550	9%	0.38	108	3265	3269	0%	0.25
2550	208	3266	3549	9%	0.47	121	3266	3269	0%	0.39
2931	95	2909	3172	9%	0.42	93	2909	2955	2%	0.31
3287	91	2974	3217	8%	0.46	94	2974	3004	1%	0.31
3638	143	2959	3205	8%	0.35	90	2959	3004	2%	0.30
4200	101	2971	3212	8%	0.35	123	2971	2913	-2%	0.07
4601	193	2959	3205	8%	0.48	151	2959	3004	2%	0.14
5184	280	2969	3212	8%	0.42	259	2969	3004	1%	0.52
5909	103	1590	1681	6%	0.23	169	1590	1475	-7%	0.38
6301	258	1524	1670	10%	0.50	241	1524	1475	-3%	0.25
6784	162	1548	1649	6%	0.22	98	1548	1475	-5%	0.20
6971	101	1526	1619	6%	0.37	161	1526	1476	-3%	0.30

ROG vs Riverine Approach

ROG

- Long run times
- Base ROG precipitation
- Unsteady flows over time
- Realistic flows within all cells
- Accurate flow volumes
- Complex mapping

Riverine

- Quick run times
- Determine inflows
- Constant, peak flow over time
- Constant flow between BC lines
- Potentially higher flow volumes
- Simplified mapping

Choose Best Approach for Your Project

- FEMA accepts riverine and ROG approaches
- Choose approach based on:
  - Riverine or ROG base floodplain model
  - Level of detail
  - Model size / run times

Thank you

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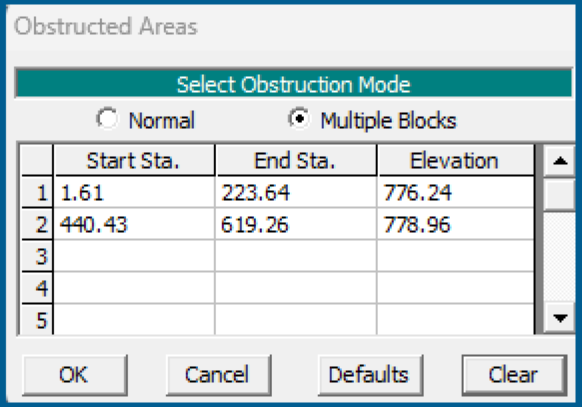
Backup Slides

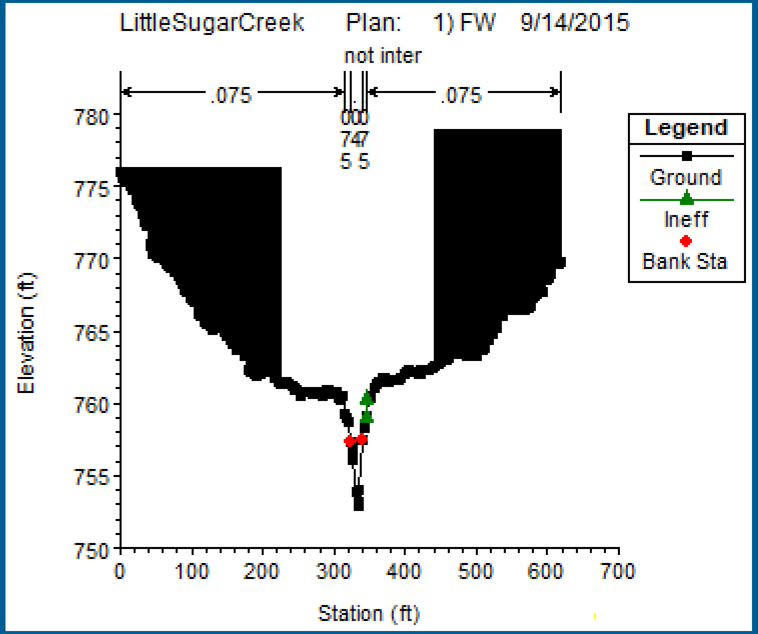
Next Steps

- Community Encroachment
  - Prevent future increases of more than 0.1ft through development
  - We will use **ROG approach** so that we feel confident we are accounting for hydrologic changes from the future landuse

1D Floodways

- Encroachment boundaries are identified on each cross section
- “Engineering judgement” is used to interpolate the floodway boundary between cross sections
- Conveyance on both sides is reduced by an equal percentage until surcharge is achieved
    - If this doesn’t work, manually encroach floodplain





References

- HEC-RAS 2D Modeling Advantages/Capabilities (army.mil)
- Guidance for Flood Risk Analysis and Mapping (fema.gov)