Mike Talbot
Water Resources Engineer
Emmons & Olivier Resources, Inc.

BBAE, Biosystems & Agricultural Engineering
MS, Bioproducts & Biosystems Engineering
University of Minnesota

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Look ma, no model!

Evaluation of a GIS-Based Flood Hazard Assessment in Rochester, Minnesota

Mike Talbot

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Road Map

- Brief Overview of Flood Hazard and Flood Risk
- Description of a GIS-Based Flood Hazard Assessment
- Comparison with 2D Model Results

Inspiration

geosciences

MDPI

Article

Flood Risk Mapping Using GIS and Multi-Criteria Analysis: A Greater Toronto Area Case Study

Daniela Rincón [1], Usman T. Khan [1,*] and Costas Armenakis [2]

[1] Department of Civil Engineering, Lassonde School of Engineering, York University, Toronto, ON M3J 1P3, Canada; drincon@yorku.ca

[2] Geomatics Engineering, Department of Earth & Space Science & Engineering, Lassonde School of Engineering, York University, Toronto, ON M3J 1P3, Canada; armenc@yorku.ca

* Correspondence: usman.khan@lassonde.yorku.ca

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check for updates


Hazard
Risk
Vulnerability
Exposure

What is Flood Hazard?

Flood Hazard means…

"…the threat of an area being inundated by water due typically to excessive precipitation or obstructions to the natural flow." –Law Insider

A Flood Hazard Heuristic

Heuristic

"…proceeding to a solution by trial and error or by rules that are only loosely defined." –Oxford's English Dictionary

- See also: shortcut

Flood Hazard Component 1: Height

Flood Hazard Component 2: Distance

Flood Hazard Component 3: Slope

Flood Hazard Component 4: Land Cover

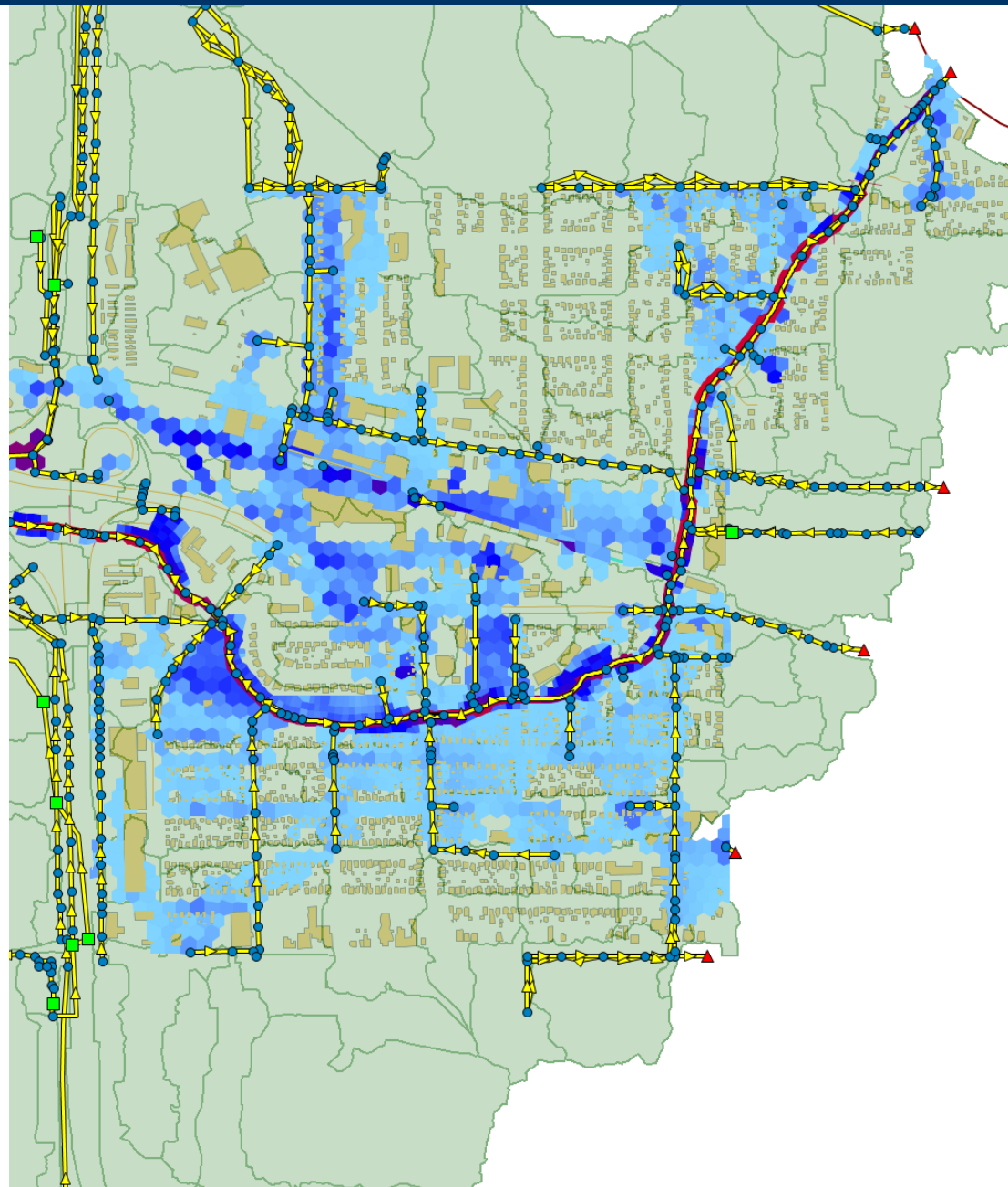
Why not just model it?

Hydrologic and Hydraulic Models

- Pros
  - Accurate
- Cons
  - Expensive to build
  - Time consuming to run
  - Spatially discrete

GIS

- Pros
  - Fast and inexpensive to generate
  - Uses commonly available data
  - Spatially continuous
- Cons
  - Approximate



Flood Hazard in GIS

Distance to Stream

- Lidar-derived DEM
- SAGA “Overland Flow Distance…” (Vertical)

Height Above Nearest Drainage

- Lidar-derived DEM
- SAGA “Overland Flow Distance…” (Horizontal)

Slope

- Lidar-derived DEM
- SAGA “Slope”

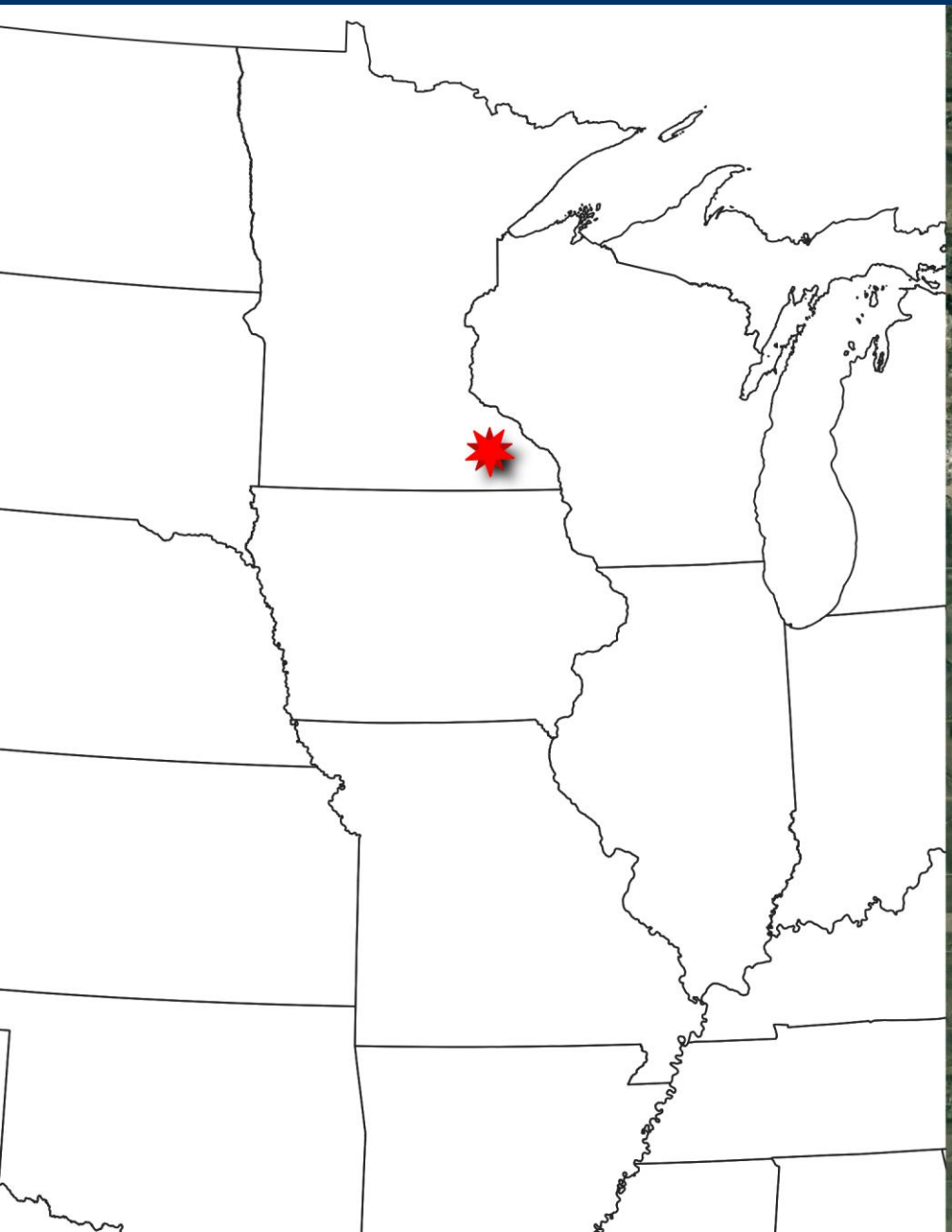
Land Cover

- Curve Number
  - SSURGO
  - NLCD

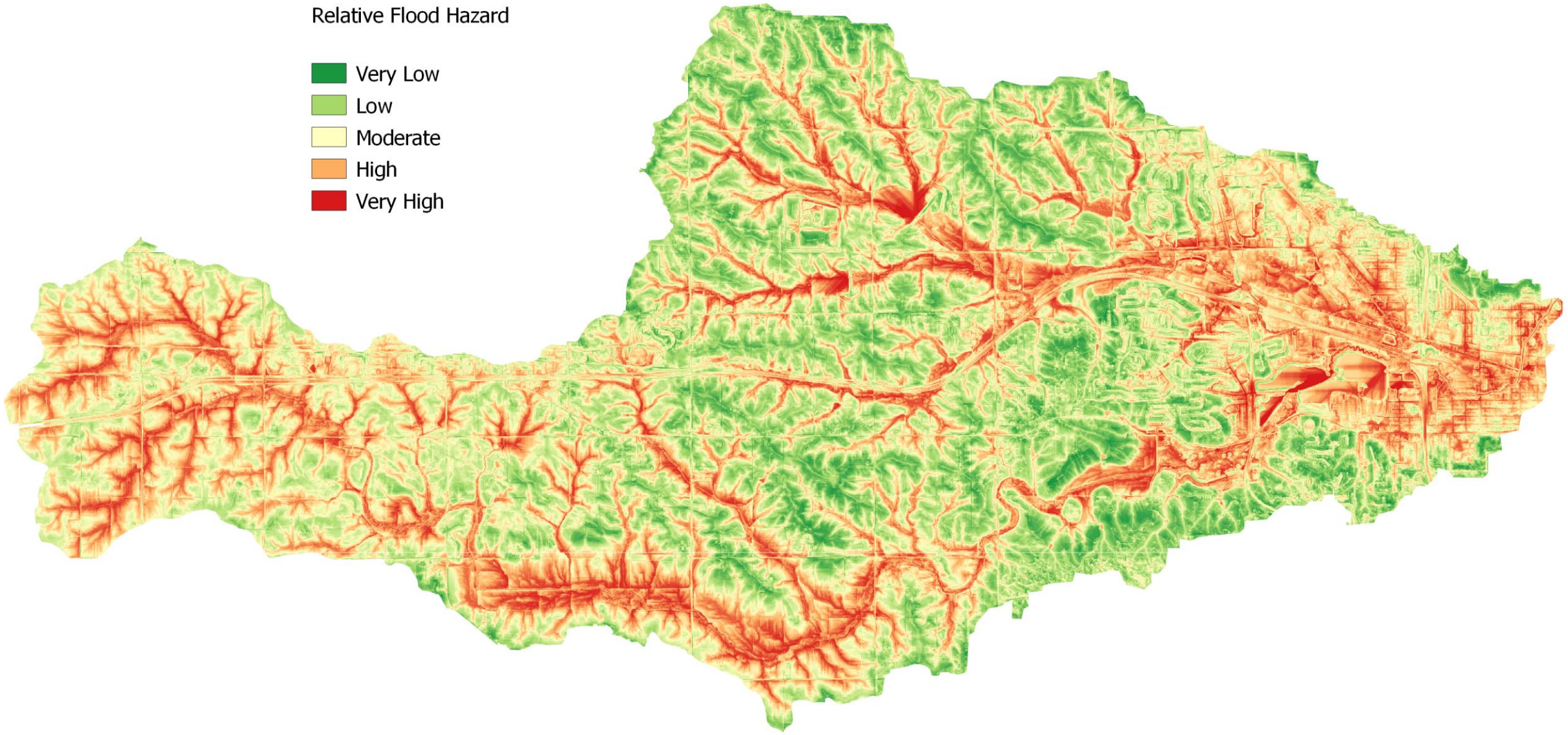
Flood Hazard in GIS

Criterion	Flood Hazard	Rincón et al. (2018)	Scenario Quantiles				
			A	B	C	D	E
Height Above Nearest Drainage (m)	5	< 2	< 1.16	< 0.26	< 0.26	<0.25	<0.25
	4	2 - 4	1.16 - 2.49	0.26 - 0.77	0.26 - 0.77	0.25 - 0.79	0.25 - 0.79
	3	4 - 6	2.49 - 4.30	0.77 - 1.37	0.77 - 1.37	0.79 - 1.42	0.79 - 1.42
	2	6 - 8	4.30 - 6.97	1.37 - 2.45	1.37 - 2.45	1.42 - 2.50	1.42 - 2.50
	1	> 8	> 6.97	> 2.45	> 2.45	>2.50	>2.50
Distance to Stream (m)	5	< 100	< 100	< 24	< 24	<27	<27
	4	100 - 300	100 - 215	24 - 58	24 - 58	27 - 68	27 - 68
	3	300 - 500	215 - 339	58 - 98	58 - 98	68 - 114	68 - 114
	2	500 - 1000	339 - 506	98 - 150	98 - 150	114 - 174	114 - 174
	1	> 1000	> 506	> 150	> 150	>174	>174
Slope (degrees)	5	< 10	< 0.97	< 0.97	< 0.97	< 0.97	< 0.97
	4	10 - 20	0.97 - 1.45	0.97 - 1.45	0.97 - 1.45	0.97 - 1.45	0.97 - 1.45
	3	20 - 30	1.45 - 2.14	1.45 - 2.14	1.45 - 2.14	1.45 - 2.14	1.45 - 2.14
	2	30 - 50	2.14 - 3.38	2.14 - 3.38	2.14 - 3.38	2.14 - 3.38	2.14 - 3.38
	1	> 50	> 3.38	> 3.38	> 3.38	> 3.38	> 3.38
Curve Number	5	> 94	> 94	> 94	-	> 94	-
	4	86 - 94	86 - 94	86 - 94	-	86 - 94	-
	3	80 - 86	80 - 86	80 - 86	-	80 - 86	-
	2	74 - 80	74 - 80	74 - 80	-	74 - 80	-
	1	< 74	< 74	< 74	-	< 74	-
Percent Impervious	5	-	-	-	> 95	-	> 95
	4	-	-	-	90 - 95	-	90 - 95
	3	-	-	-	30 - 90	-	30 - 90
	2	-	-	-	0 - 30	-	0 - 30
	1	-	-	-	0	-	0

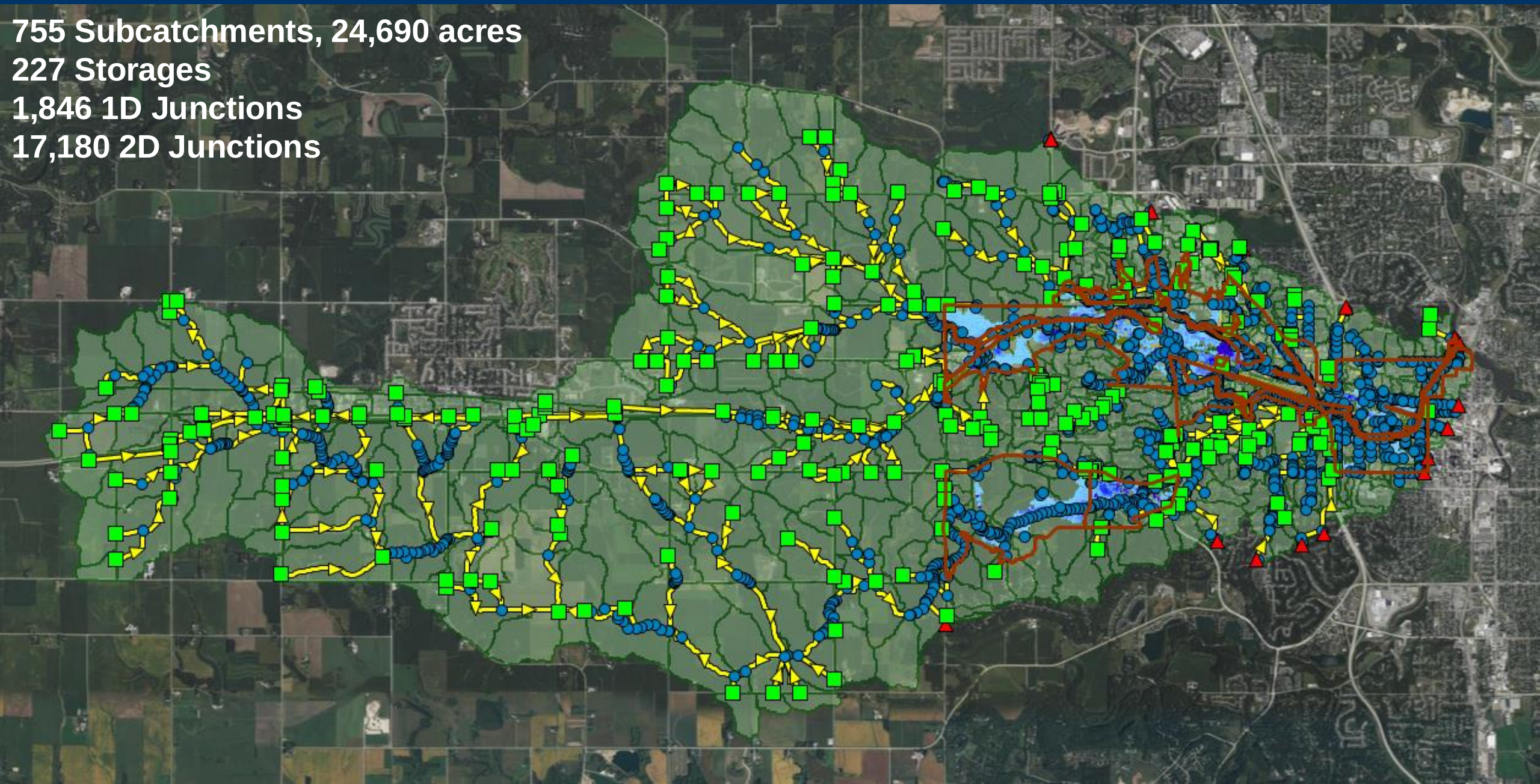
Study Area



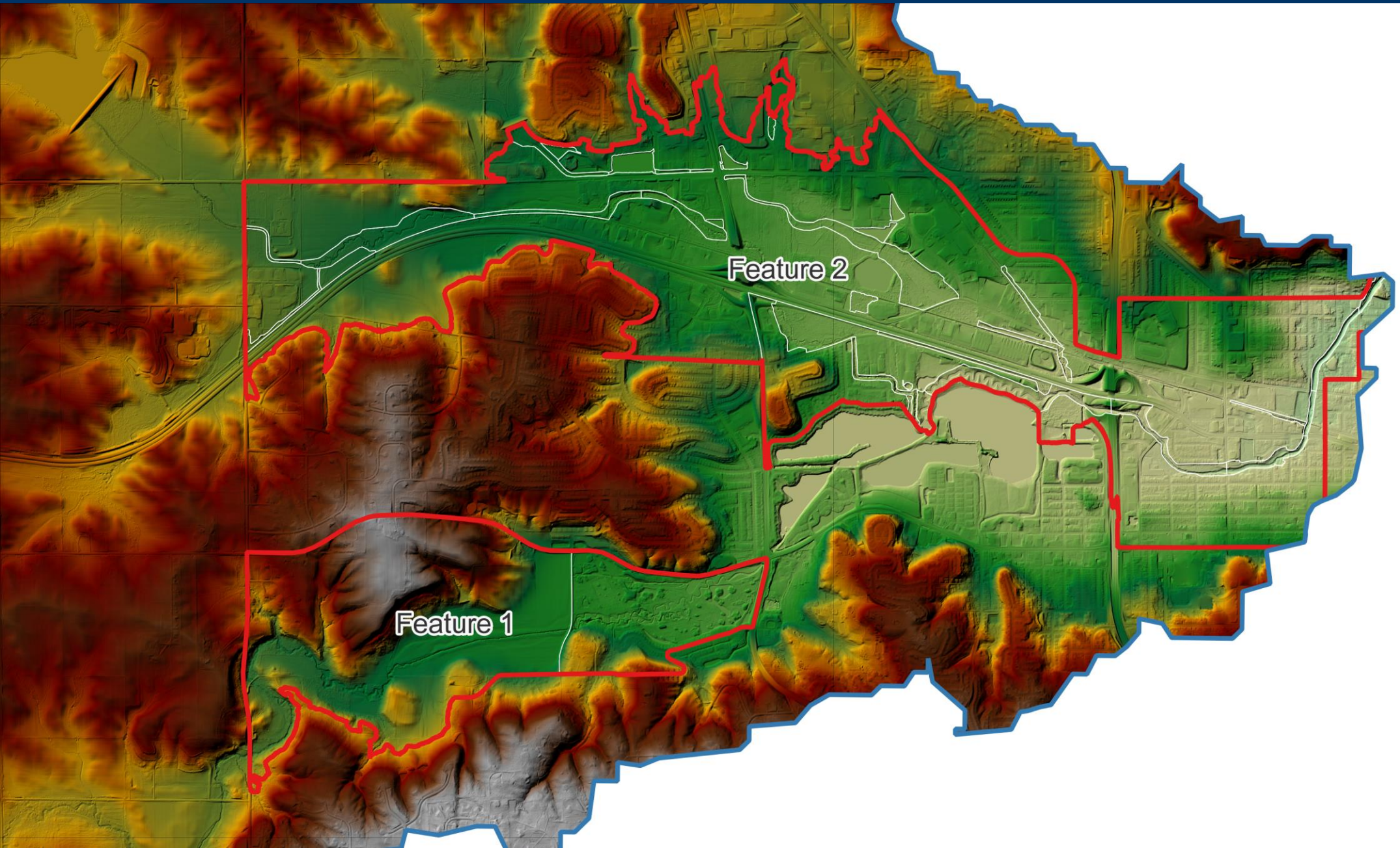
Flood Hazard Index



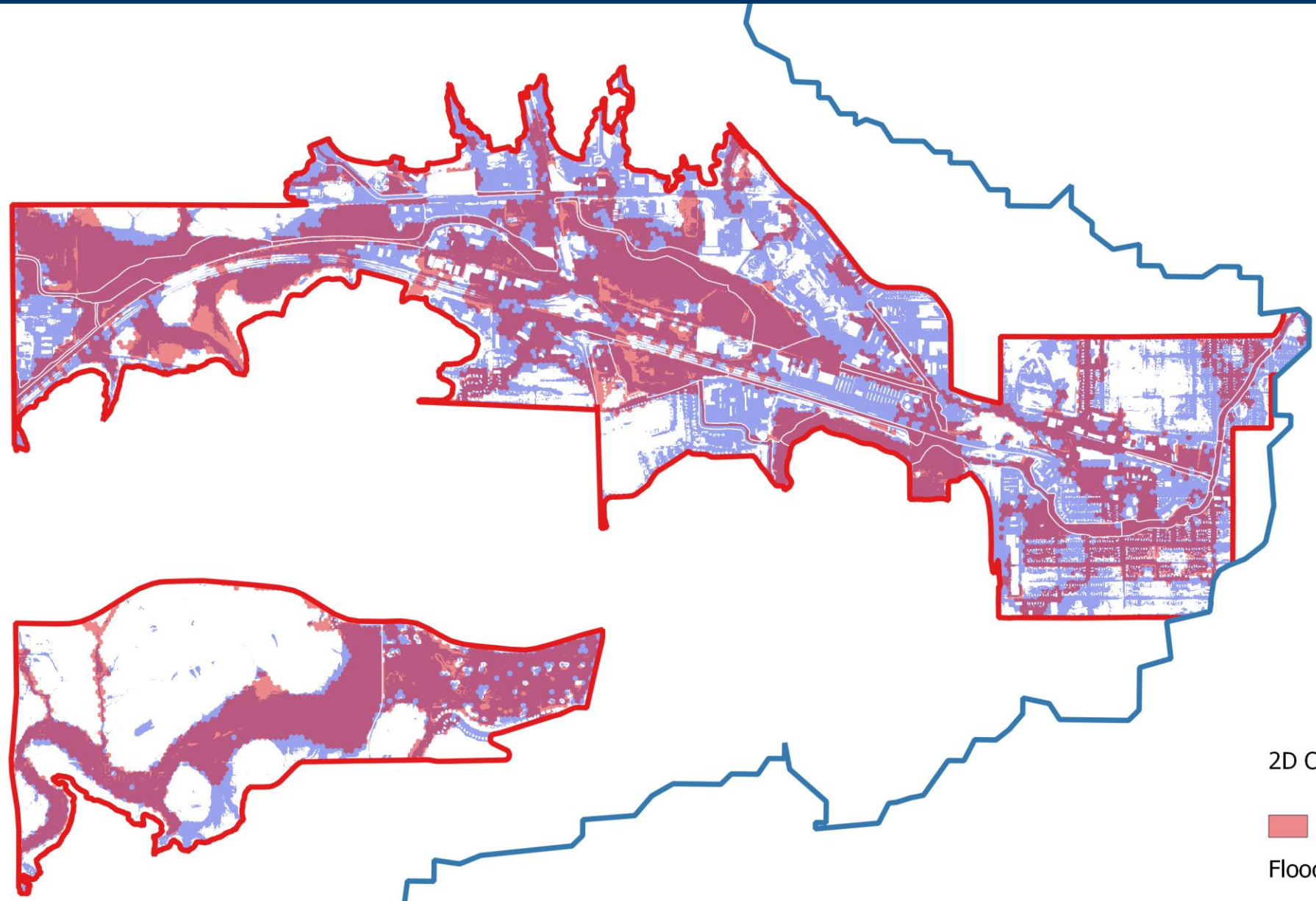
Cascade Creek Integrated 1D-2D PCSWMM Model



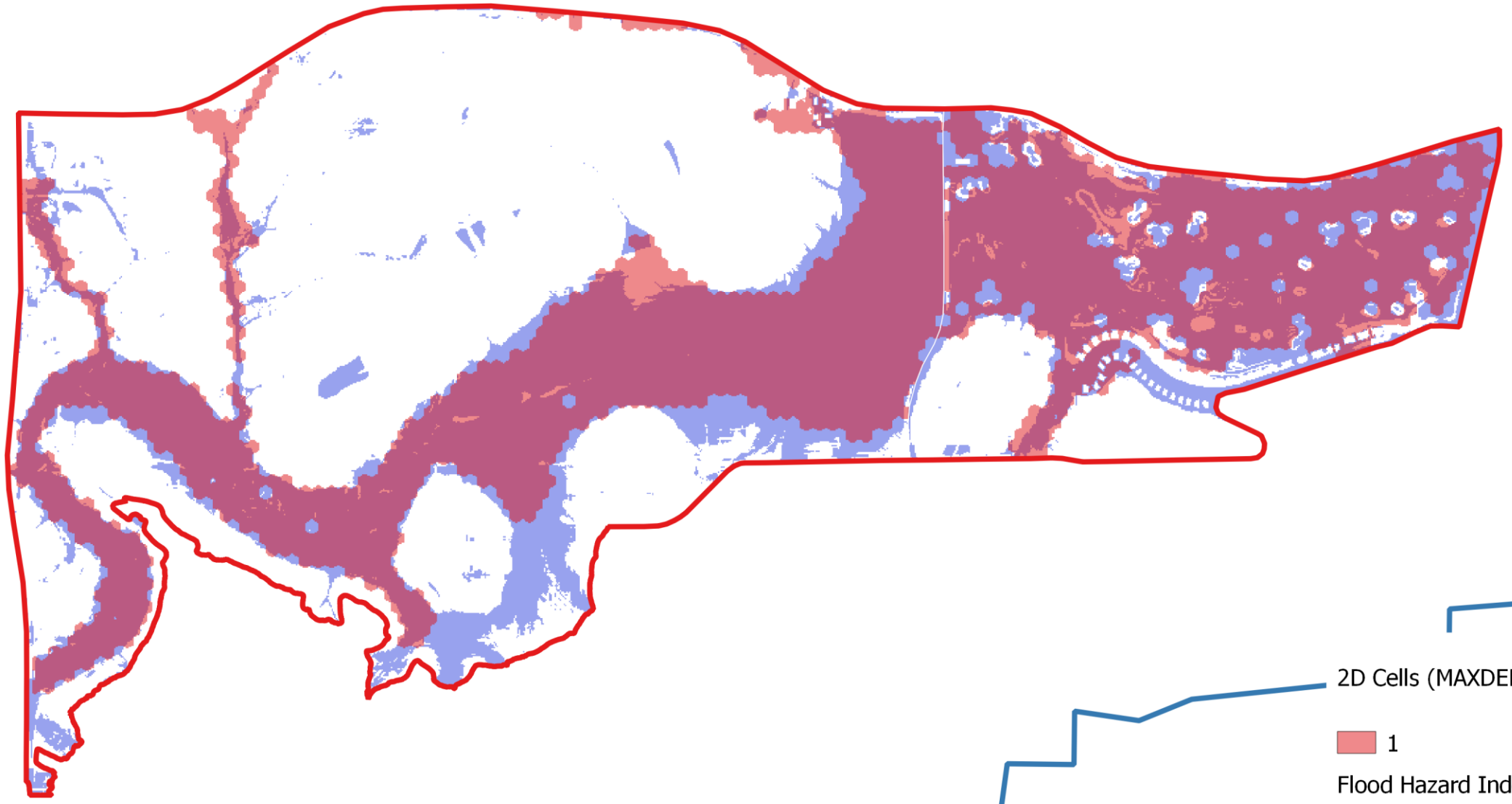
Cascade Creek 2D Domain



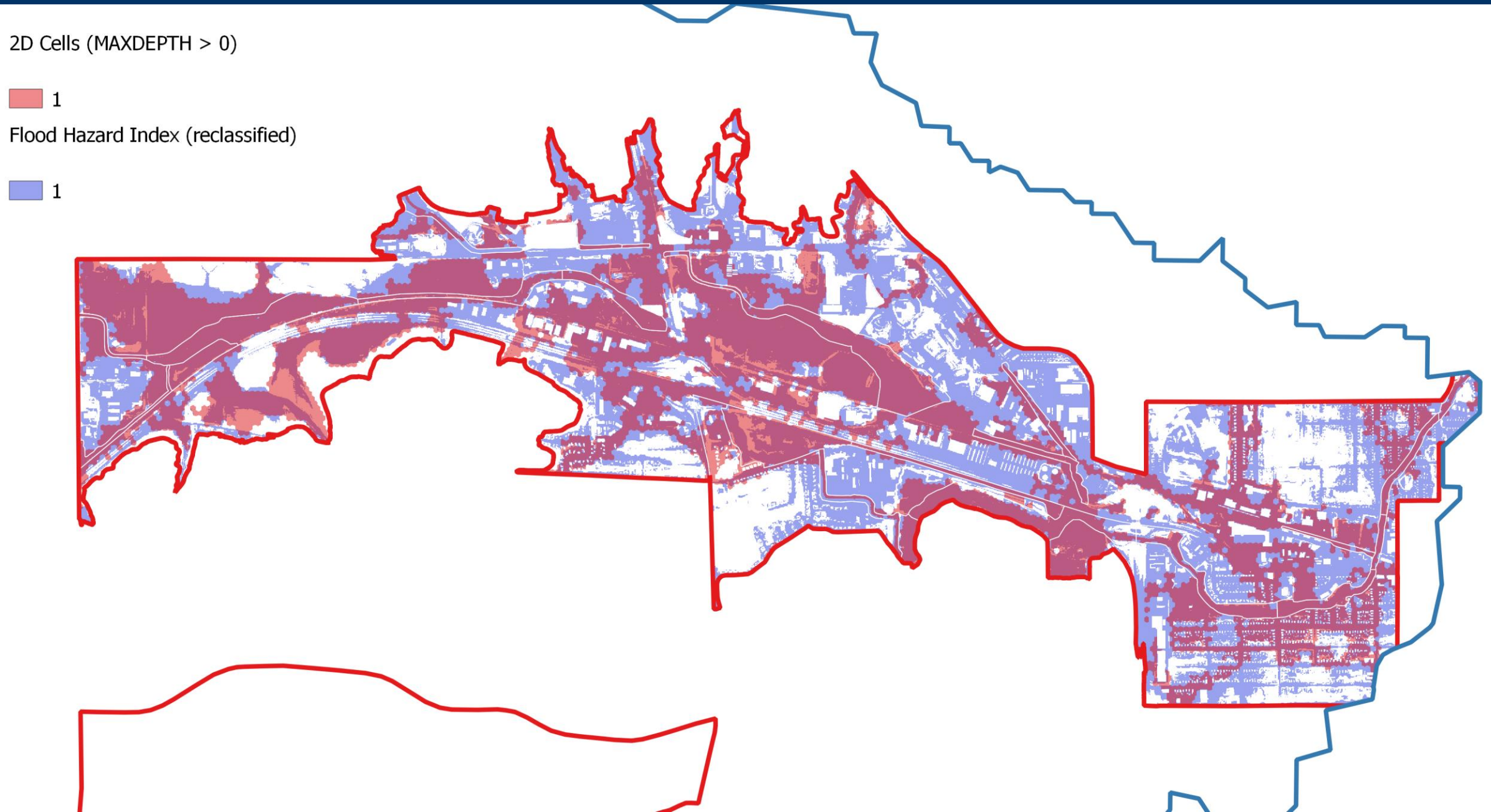
Comparison, 100-year 24-hour (Overall)



Comparison, 100-year 24-hour (Feature 1)



Comparison, 100-year 24-hour (Feature 2)



Jaccard Coefficient

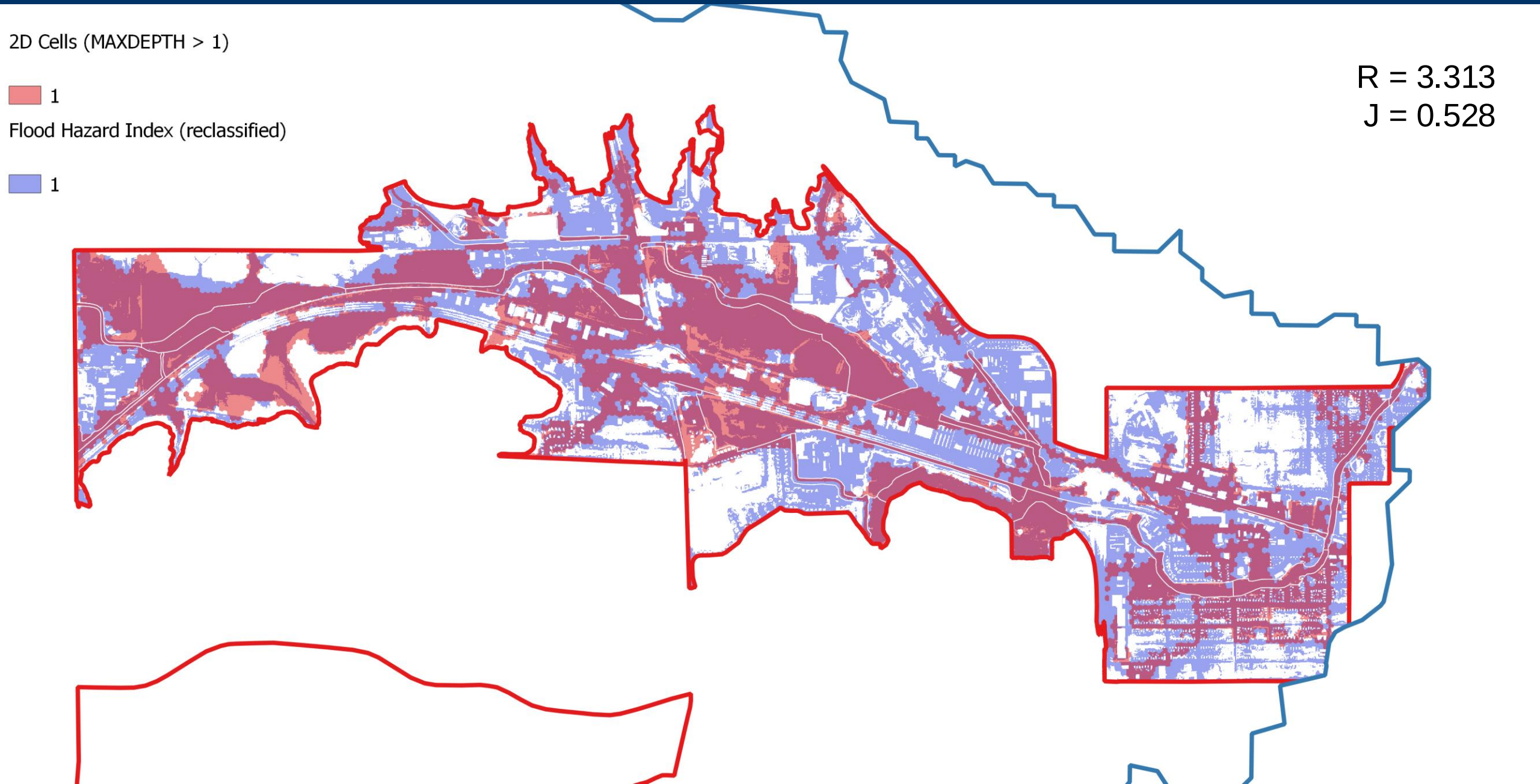
$$J(A,B) = \frac{|A \cap B|}{|A \cup B|} = \frac{|A \cap B|}{|A| + |B| - |A \cap B|}$$

Where:

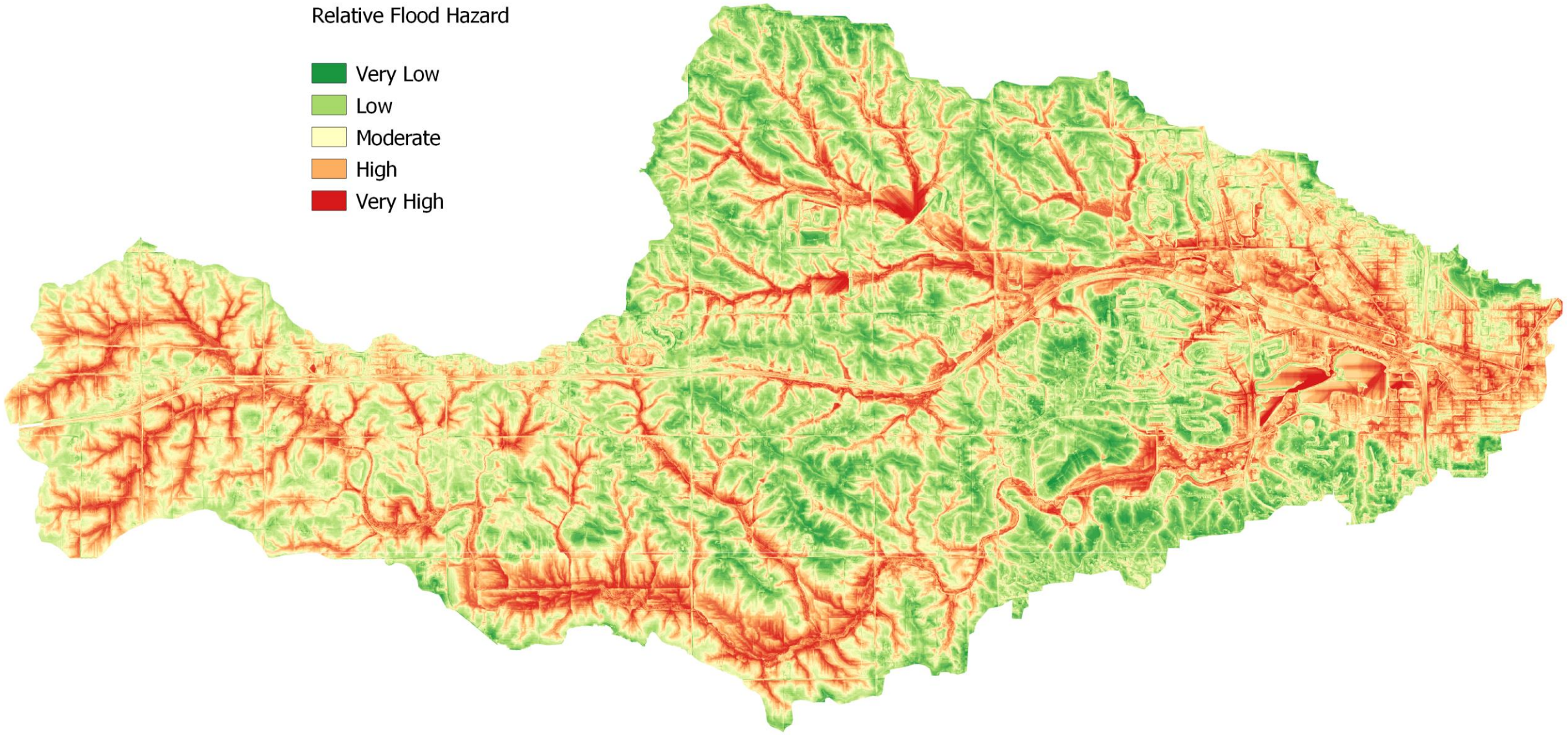
A = 2D Cells, MAXDEPTH > 0

B = Flood Hazard > X, 1 < X < 5 (optimized)

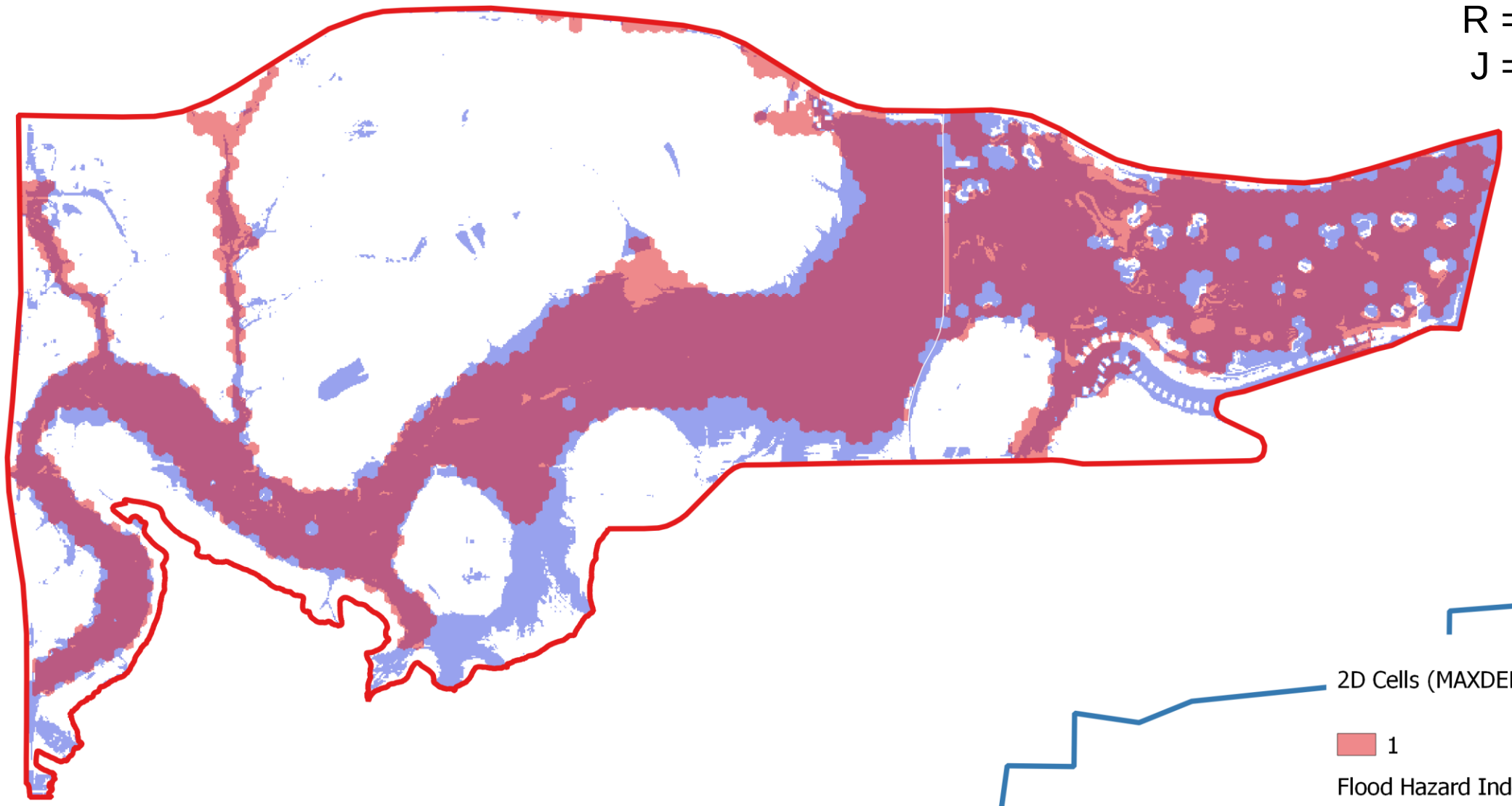
Comparison, 100-year 24-hour (Feature 2)



Flood Hazard Index



Comparison, 100-year 24-hour (Feature 1)



Comparison Summary

Precipitation Event	Feature	Optimal FHI	Jaccard's Coefficient
10-year, 24-hour	Overall	3.486	44.2%
10-year, 24-hour	Feature 1	3.426	58.6%
10-year, 24-hour	Feature 2	3.479	40.9%
25-year, 24-hour	Overall	3.426	50.3%
25-year, 24-hour	Feature 1	3.398	67.3%
25-year, 24-hour	Feature 2	3.423	46.4%
50-year, 24-hour	Overall	3.398	53.6%
50-year, 24-hour	Feature 1	3.364	69.8%
50-year, 24-hour	Feature 2	3.319	49.9%
100-year, 24-hour	Overall	3.320	56.2%
100-year, 24-hour	Feature 1	3.257	71.4%
100-year, 24-hour	Feature 2	3.313	52.8%
200-year, 24-hour	Overall	3.255	58.4%
200-year, 24-hour	Feature 1	3.275	73.0%
200-year, 24-hour	Feature 2	3.259	55.1%
500-year, 24-hour	Overall	3.255	60.4%
500-year, 24-hour	Feature 1	3.248	73.7%
500-year, 24-hour	Feature 2	3.258	57.3%

Conclusions

- Performed better in Feature 1 (rural)
  - Less influence of drainage infrastructure?
  - Fluvial vs pluvial?
  - Subcatchment resolution too low?
- Performed better for larger events
  - Drainage infrastructure increasingly overwhelmed?
  - Larger floodplain?
- Outstanding questions
  - Removing the storm sewers?
  - Weighting for depth of flow?
- Useful for planning and prioritization
- Not as useful for detailed analysis

Acknowledgments

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Thank you!

Mike Talbot
mtalbot@eorinc.com

visit us at: www.eorinc.com