A Fully Automated Generalized Framework for Estimating Urban Runoff in Philadelphia, PA

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How water and sediment move through and around urban areas?

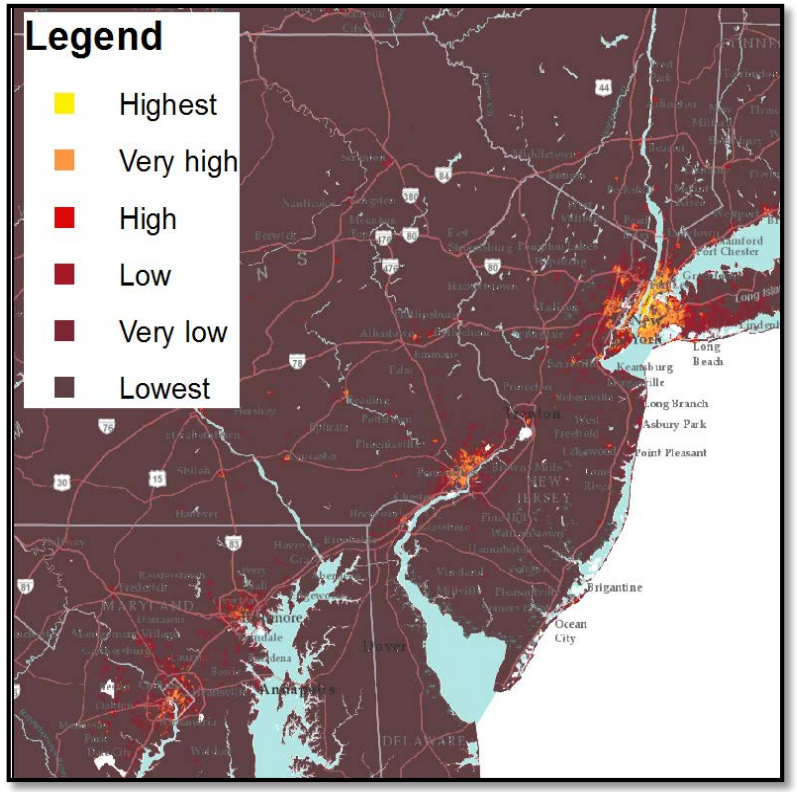
[City of Richmond, VA 2018]

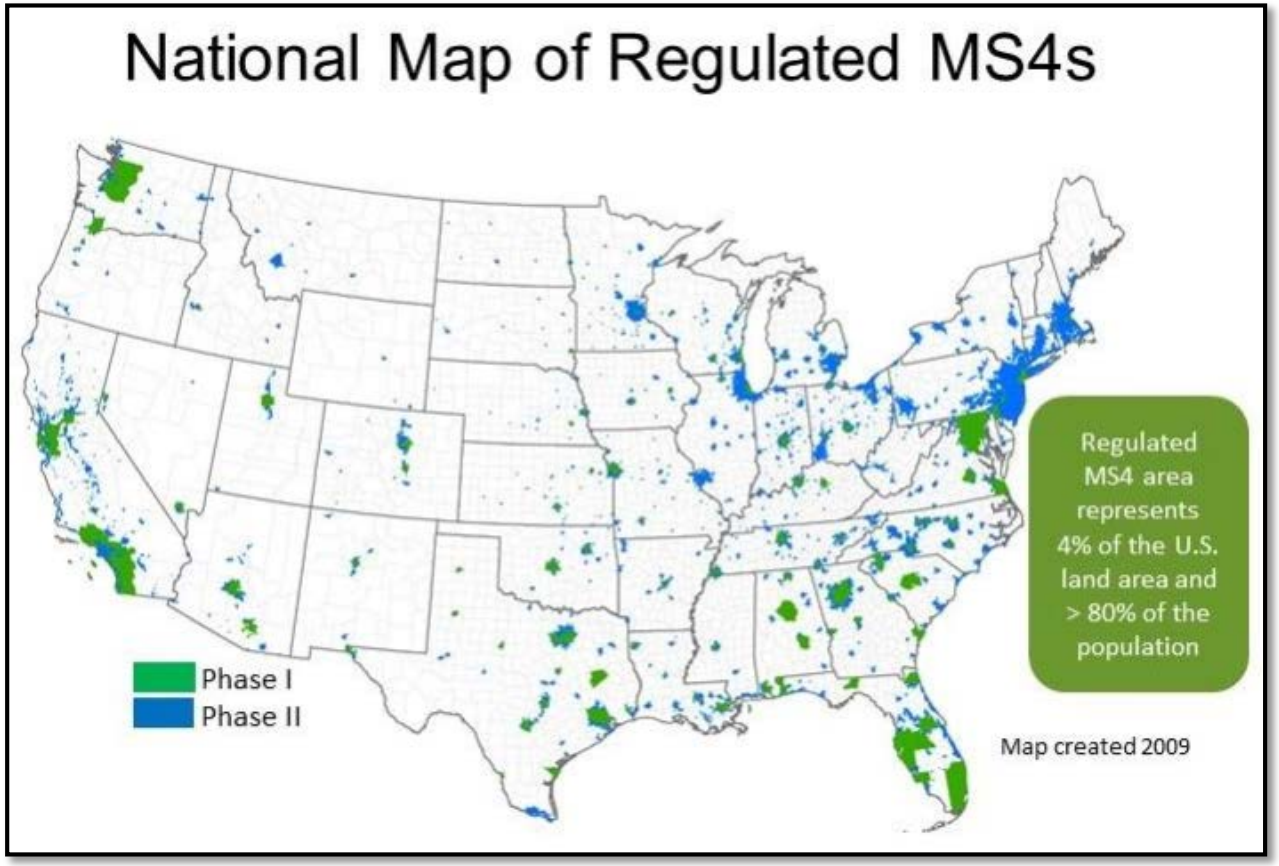
Drainage from I-95
Philadelphia, PA, 2018

[Albright, 2018 Dissertation]

[Mora Jerez et al., 2019]

Population Density





Municipal Separate Storm Sewer (MS4)

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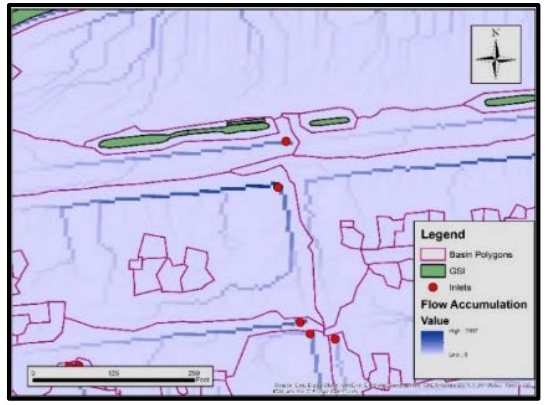
How water and sediment move?

1. Flow routing?



[Jahangiri et al, 2019; Vaughn et al, in prep]

2.Capture?

3. Budget?

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Flow Routing?

Basin Analysis

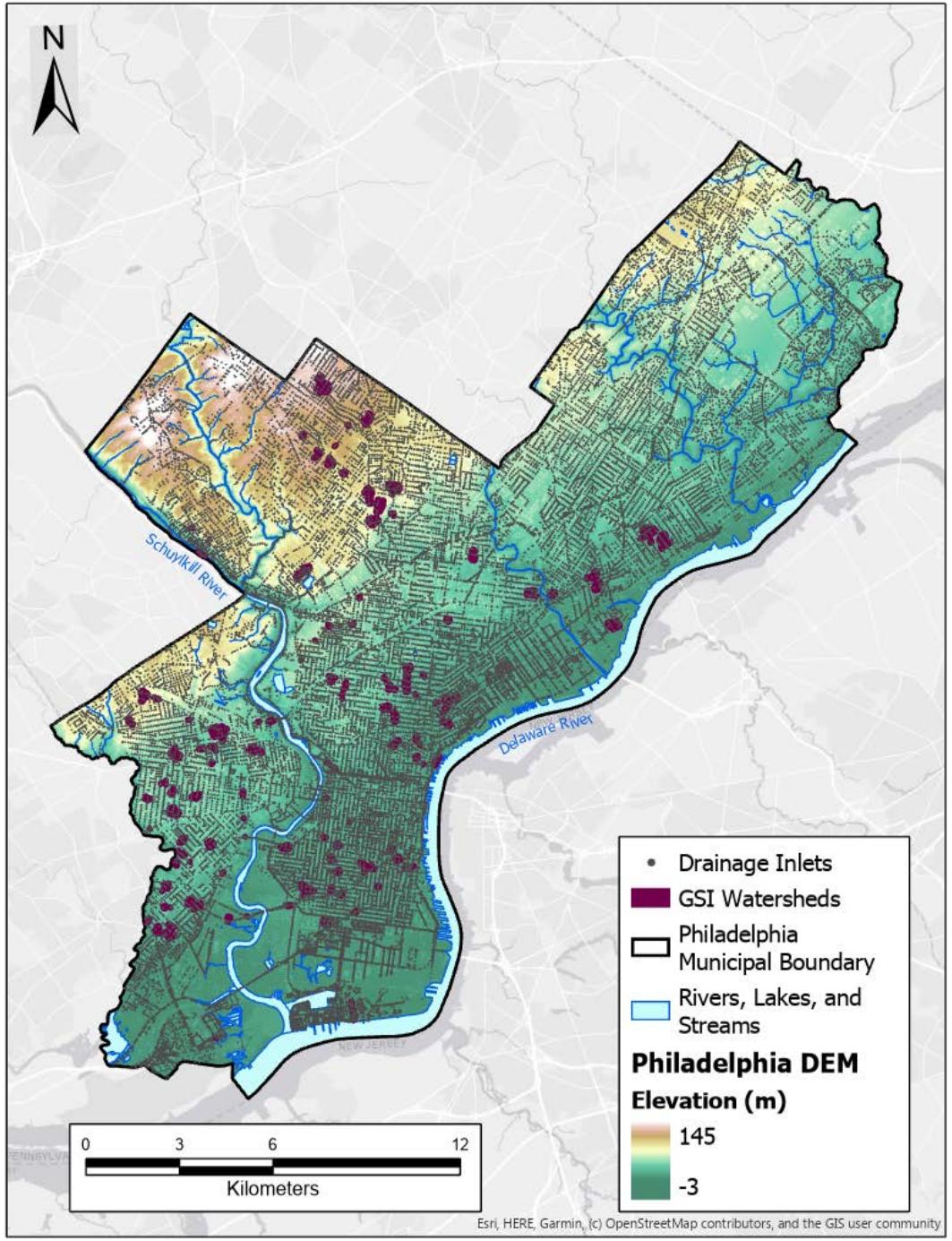
- Delineate subbasins

(Flow routing directions)

[Jahangiri et al., 2019]

- Tested with a range of DEM resolution

[Vaughn et al., 2019]



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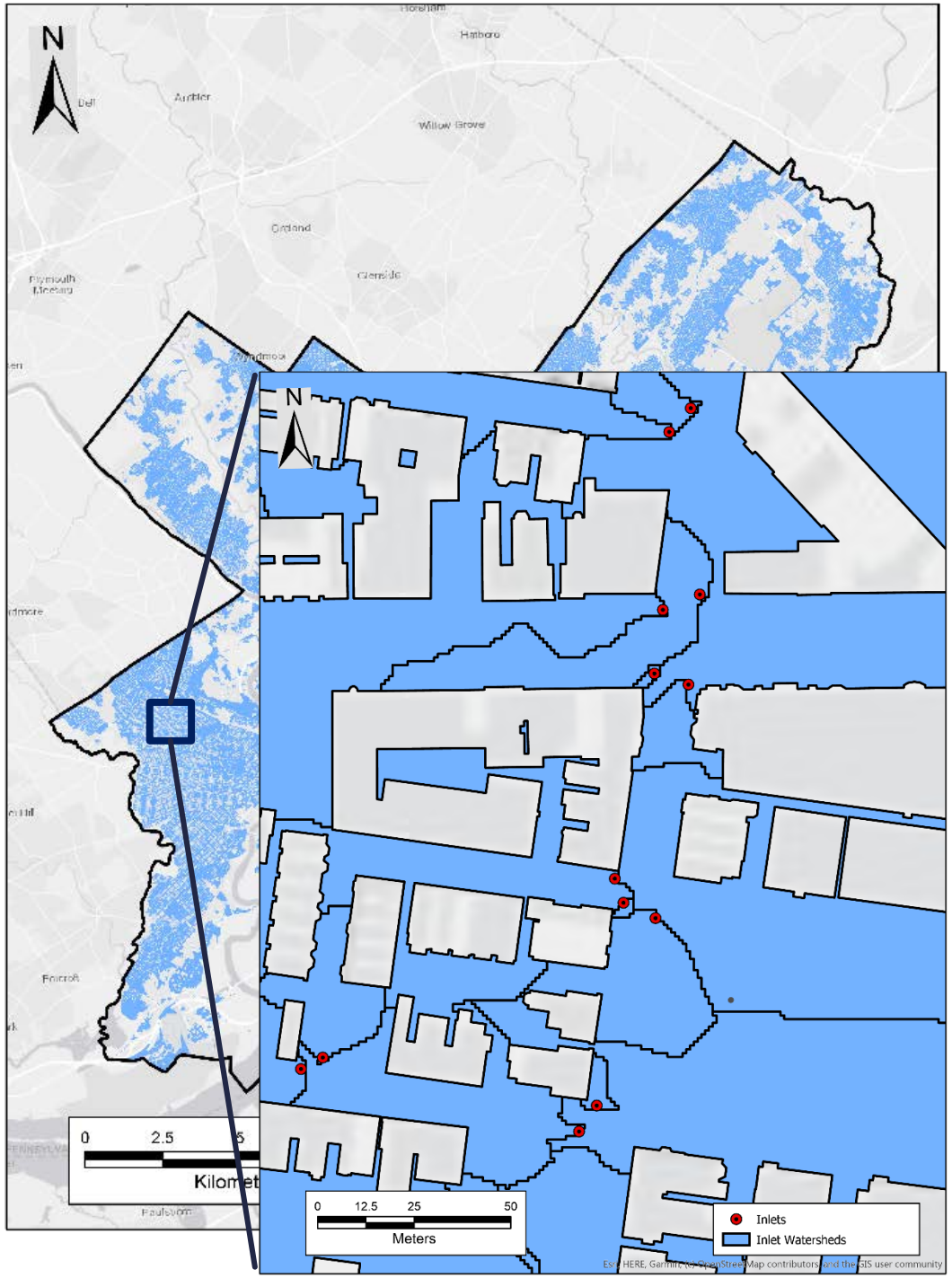
Flow Routing?

Basin Analysis

- ❑ DEM preprocessing
  - Fill sinks
  - Sink GSIs and stormwater inlets
  - Raise buildings
- ❑ Watershed delineation
  - Generating flow lines
  - Inlets' subbasin delineation

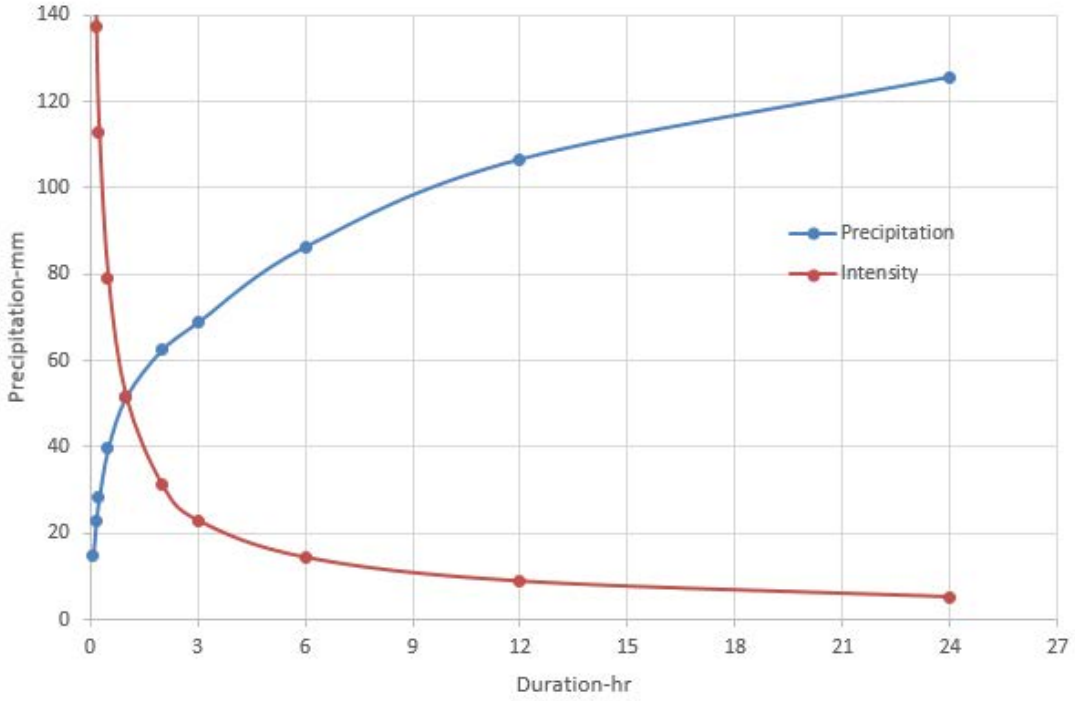


Flow Routing?

Runoff Analysis

- Design storm
  - NRCS 10-year, 24-hour storm for Philadelphia

Duration	10-year Precipitation (mm)	Intensity (mm/hr)
5 min	14.7	176.8
10 min	22.9	137.2
15 min	28.2	112.8
30 min	39.6	79.2
1 hrs	51.6	51.6
2 hrs	62.5	31.2
3 hrs	68.8	22.9
6 hrs	86.4	14.4
12 hrs	106.7	8.9
24 hrs	**125.7**	**5.2**



Flow Routing?

Runoff Analysis

- Runoff estimate
  - NRCS (depth)

$$S = {}^{1000}/_{CN_{Avg}} - 10$$ Initial Abstraction- Land cover land use

$$\boldsymbol{H\ (\mathrm{in}) = \frac{(P - 0.2\,S)^2}{(P + 0.8\,S)}}$$ **Runoff Depth**

  - Modified rational (discharge)

$$Q_p\,(cfs) = \left[\left(0.95 * A_{imp}\right) + \left(0.35 * A_{per}\right)\right] * i$$ Maximum Discharge

$$V = Q_p\,D$$ Volume

$$\boldsymbol{H = V/Area}$$ **Runoff Depth**

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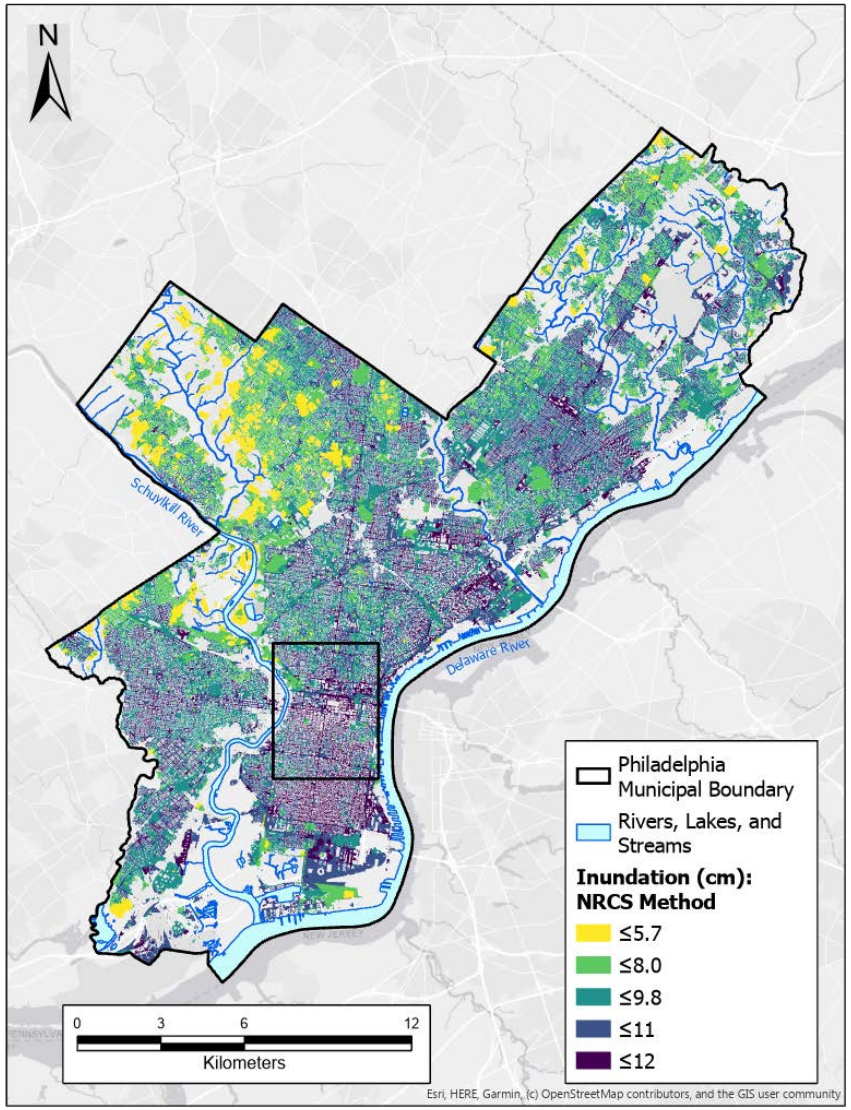
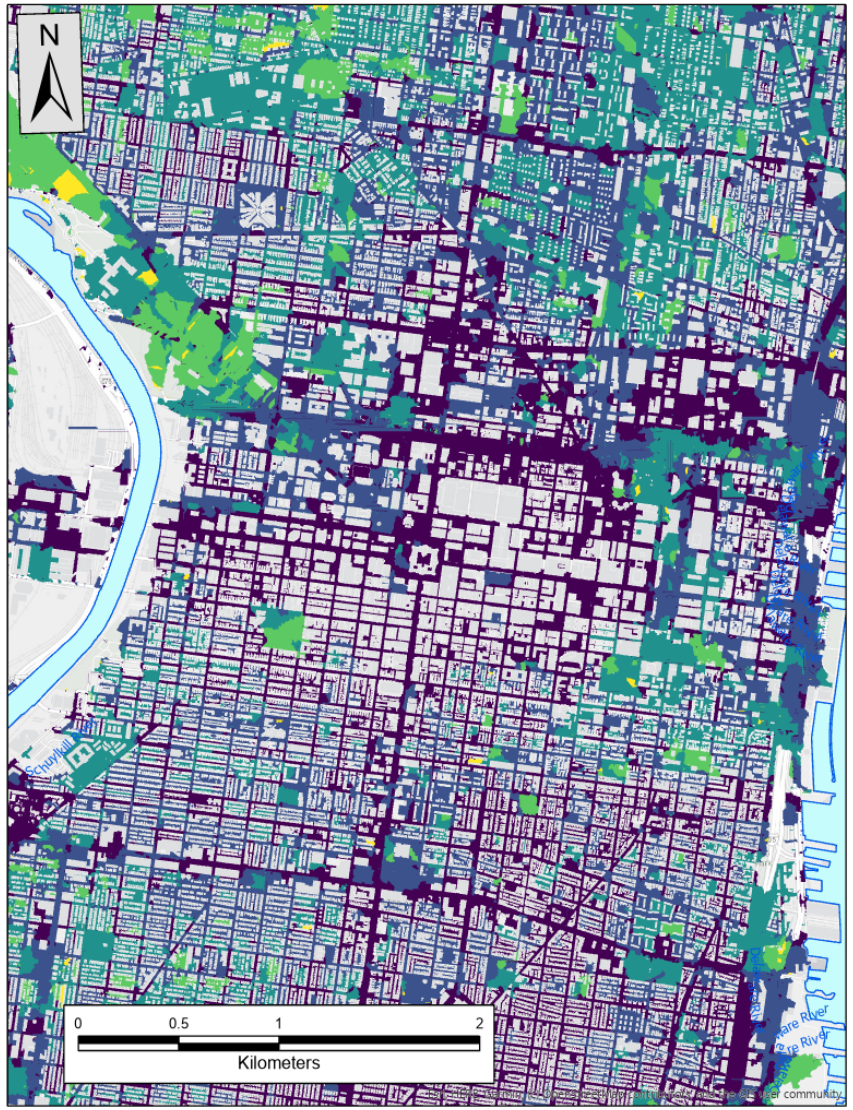
Runoff model results

NRCS





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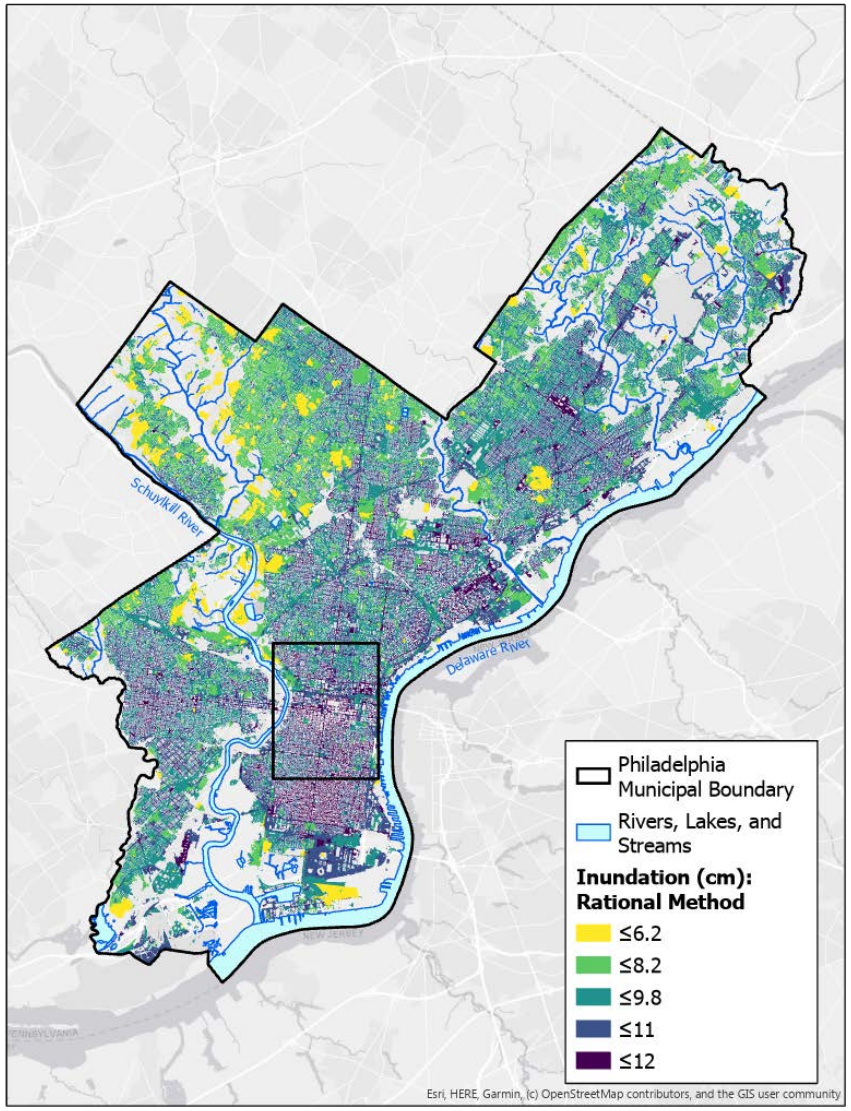
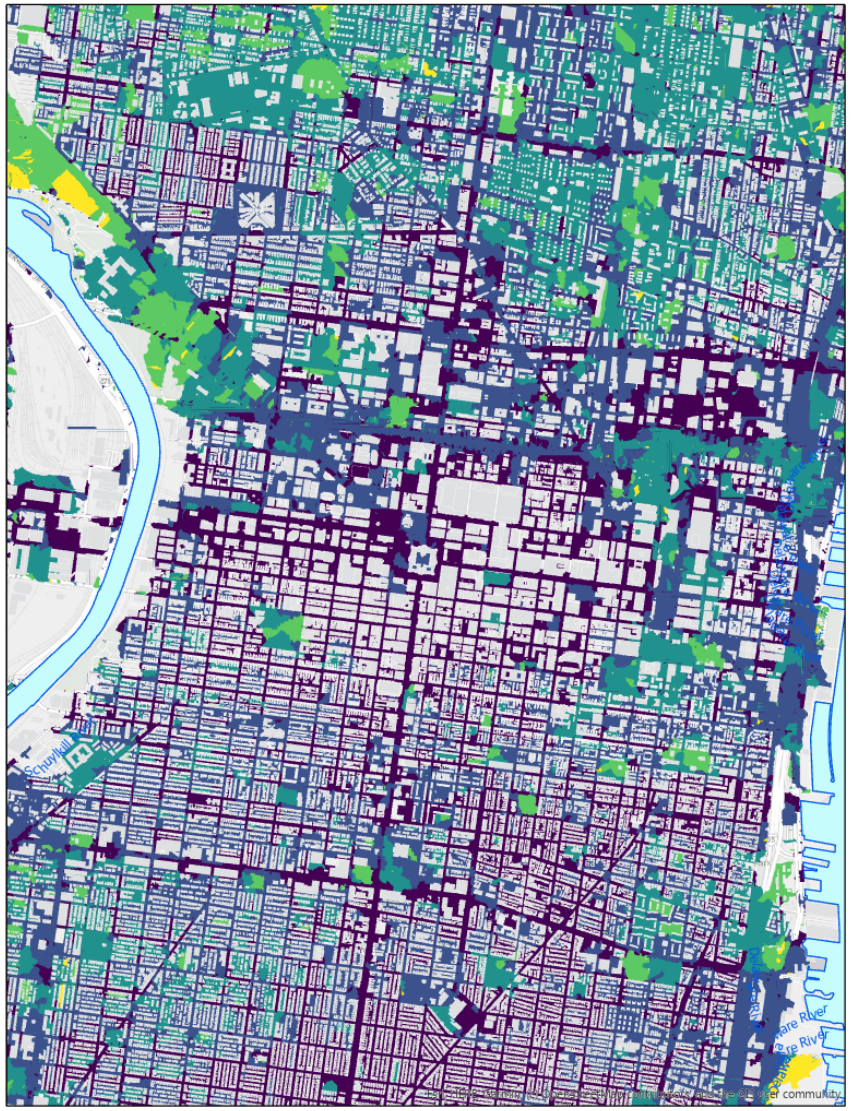
Runoff model results

Modified rational





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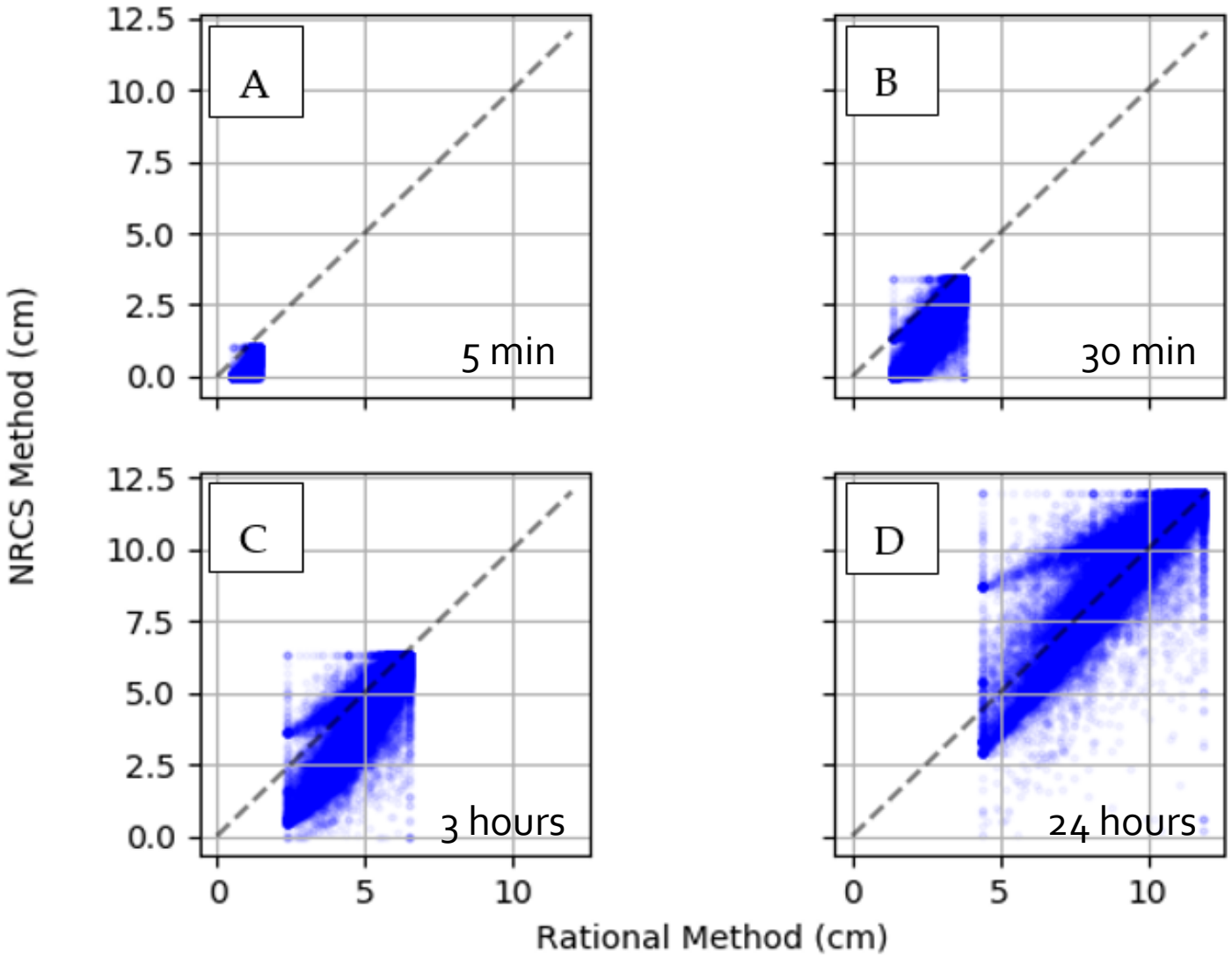
Runoff model results

NRCS vs Modified rational



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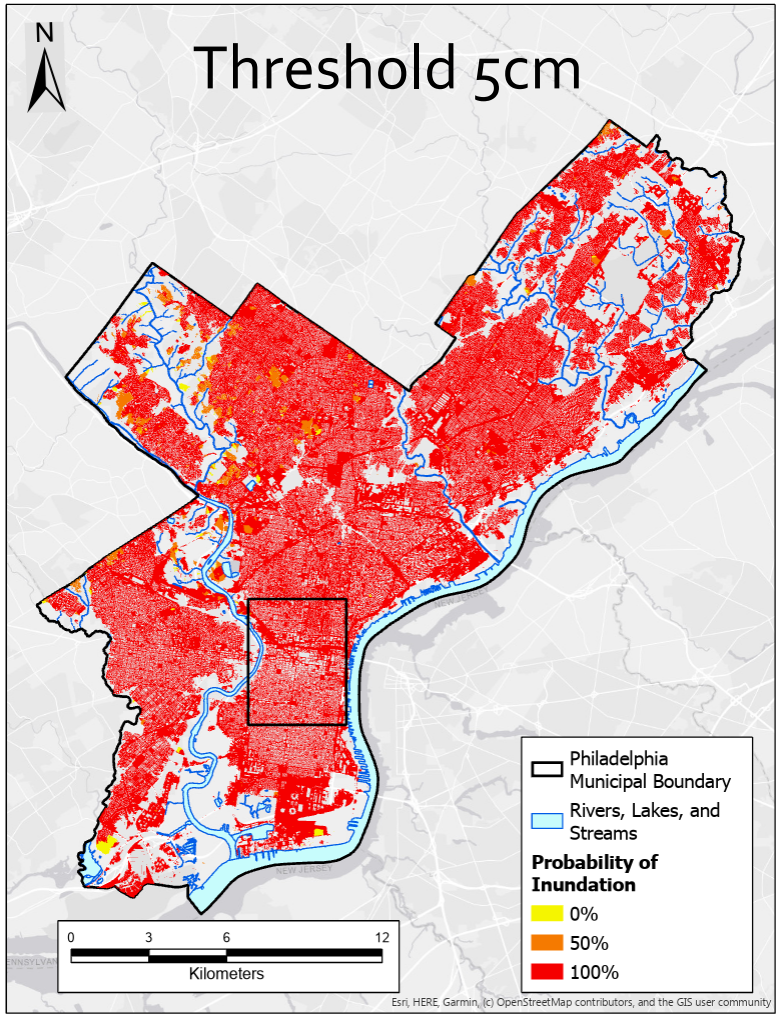
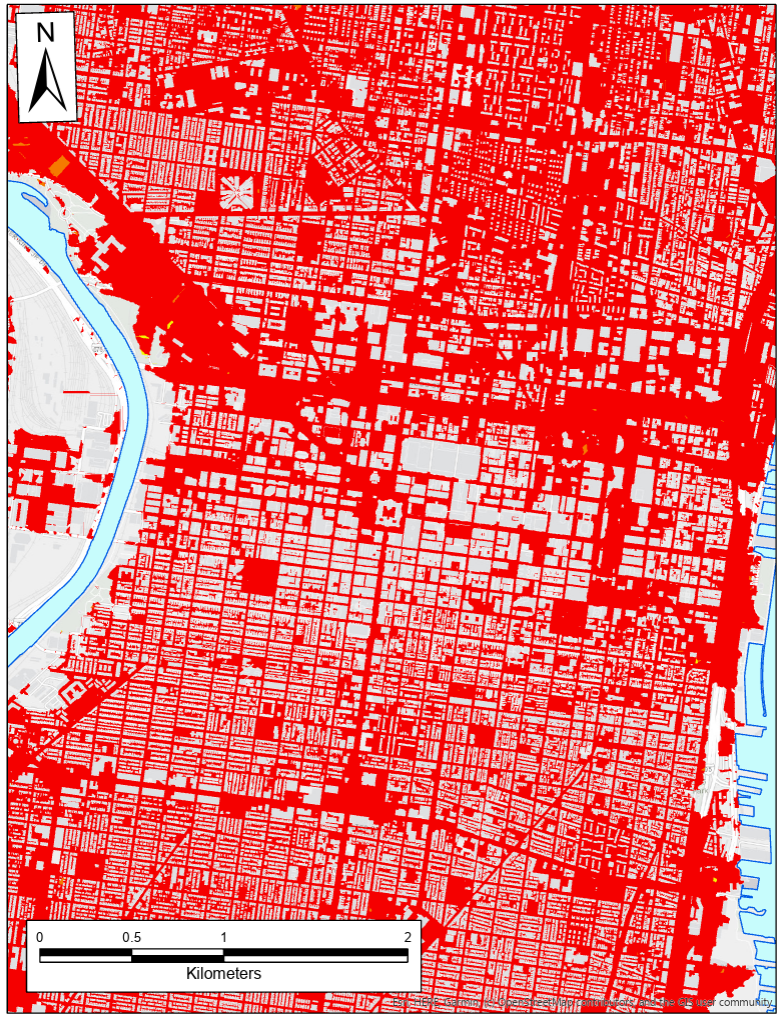
Results integration

- Probability index

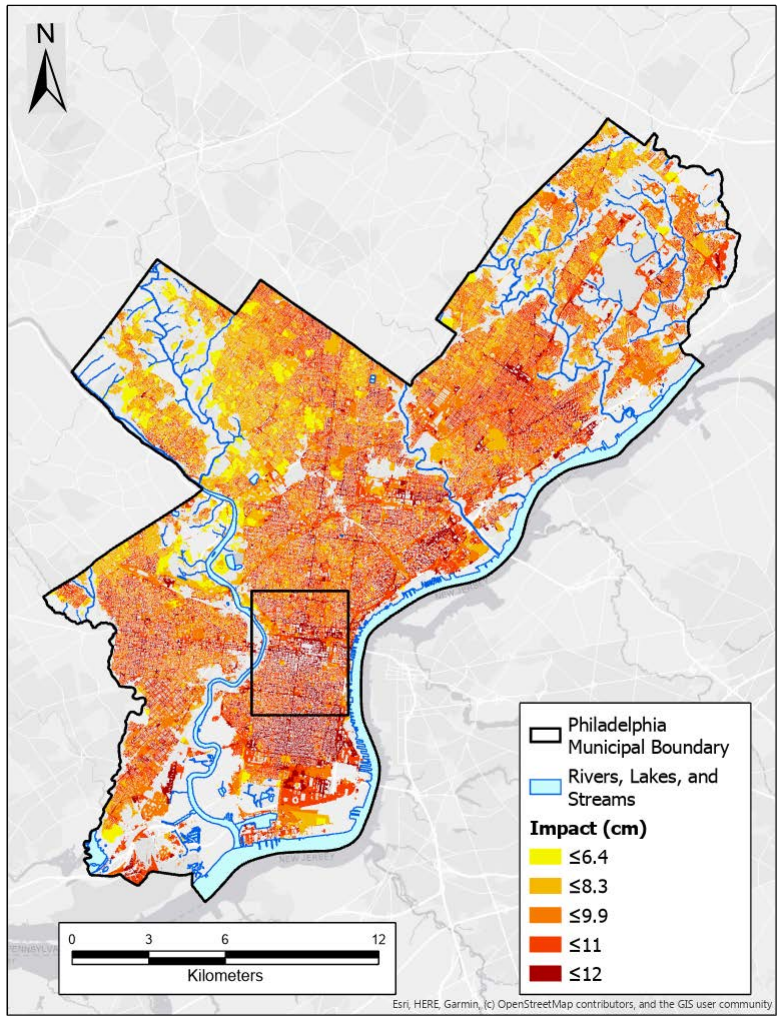
Condition	Probability
$(H_{Rtl} > Thr)$ AND $(H_{NRCS} > Thr)$	100
(H_{Rtl}) OR $(H_{NRCS}) < Thr$	50
$(H_{Rtl} < Thr)$ AND $(H_{NRCS} < Thr)$	0





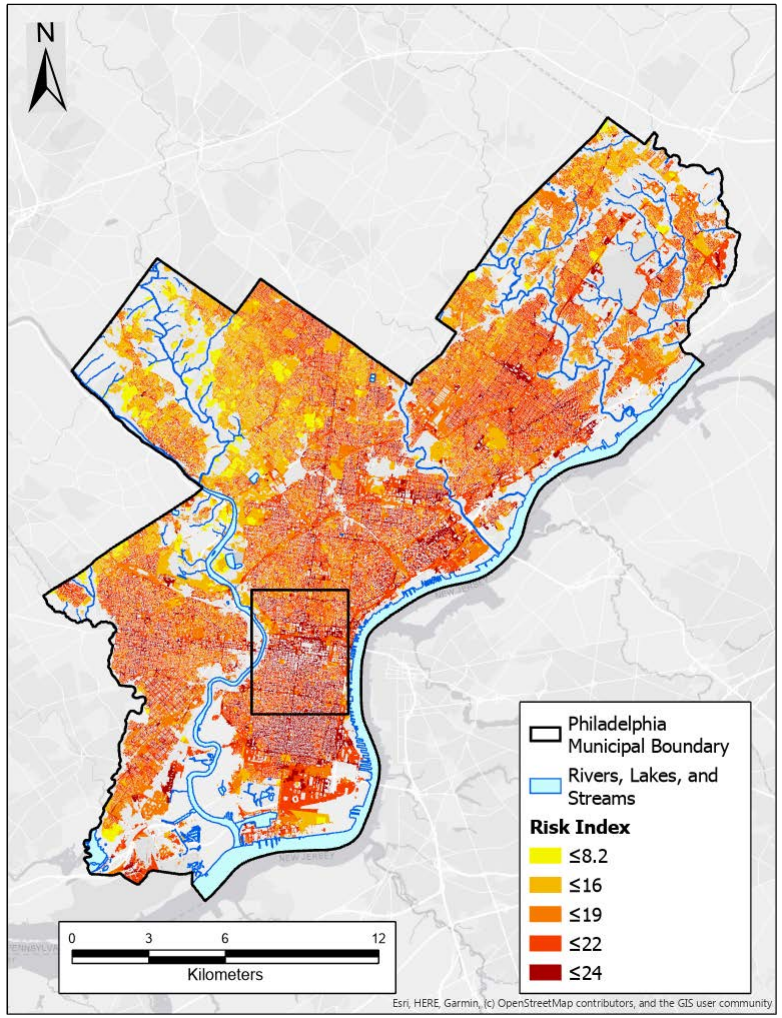
Results integration

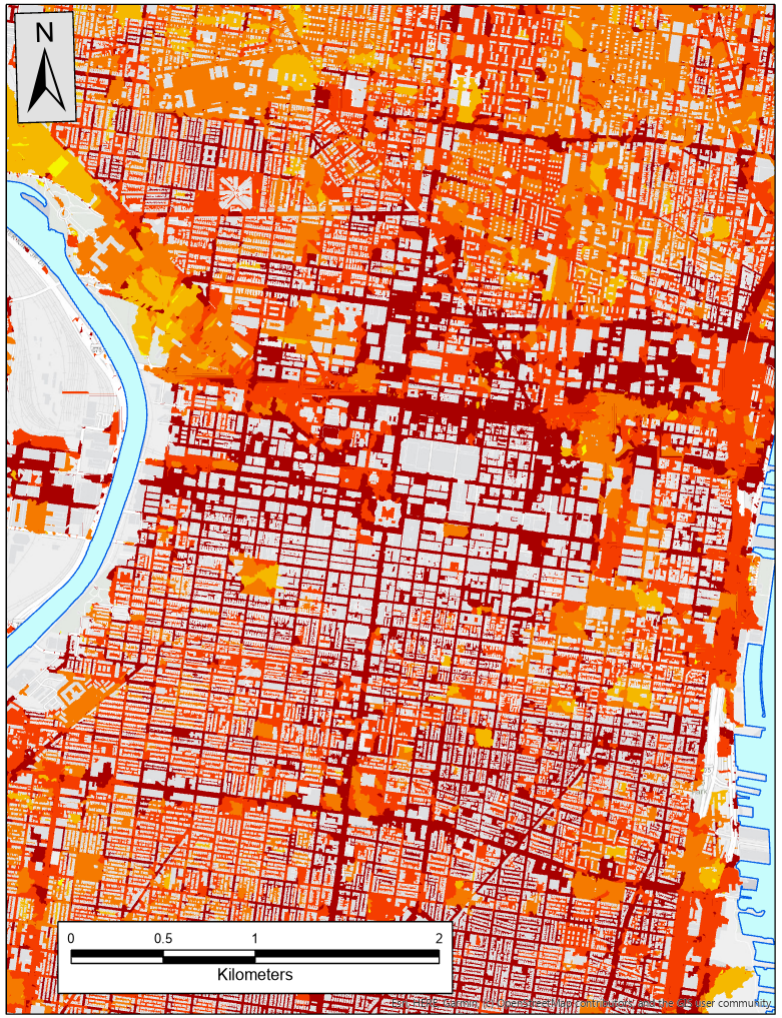
- Impact index (maximum runoff)



Results integration

- Risk index (average runoff)





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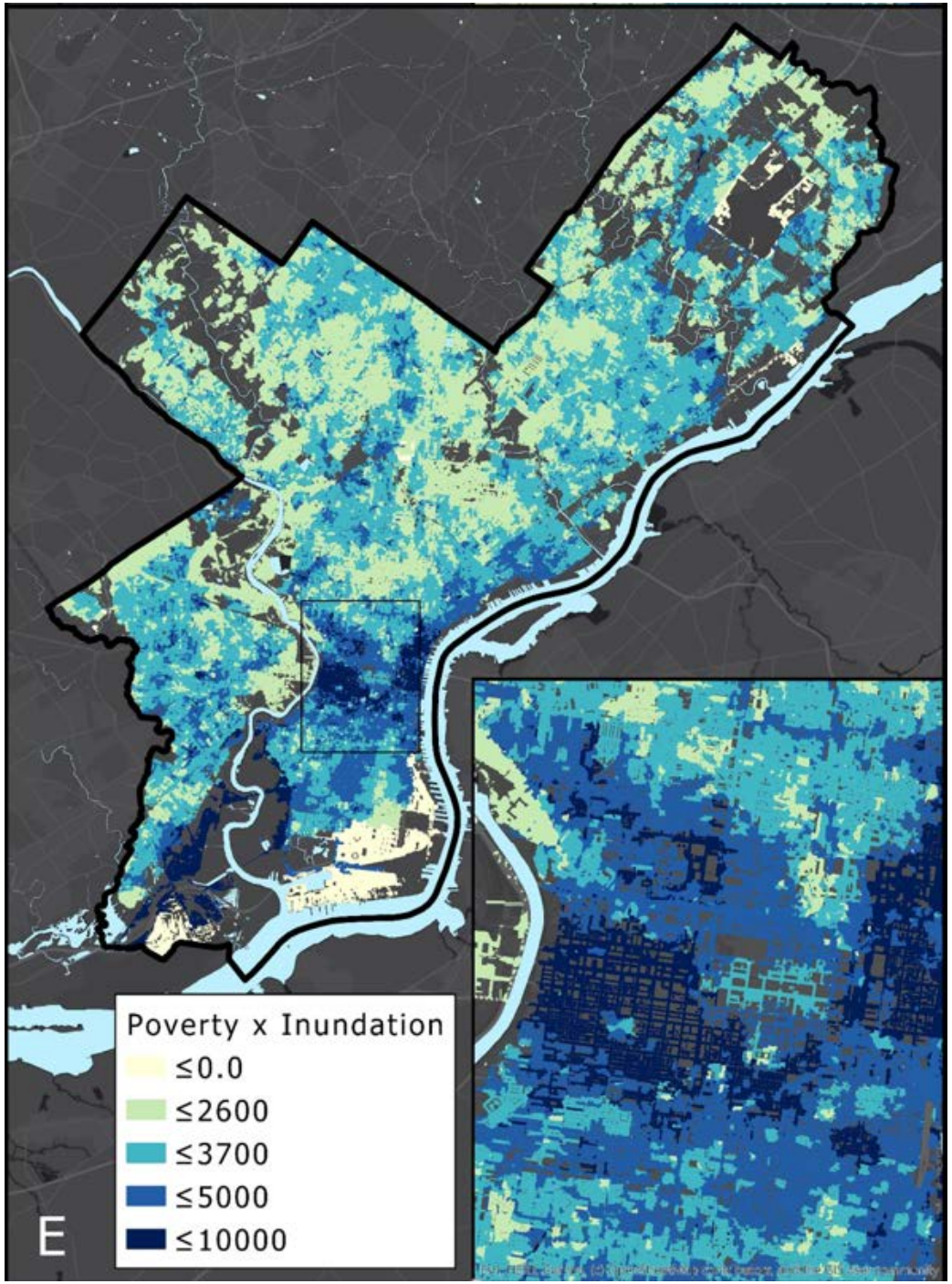
Future Work

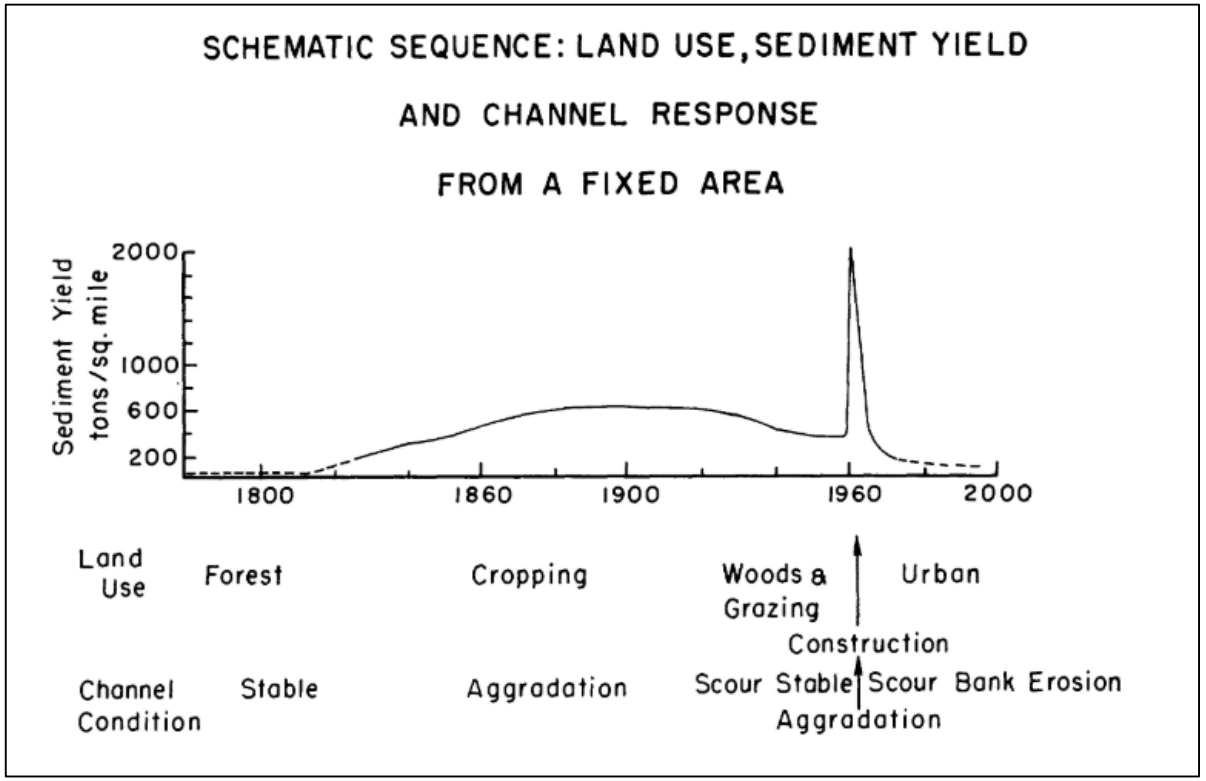
Include social and demographic data to find vulnerable areas in city



Future Work

Sediment coming off the landscape?

Sediment Impact on Downstream Waterways



[Wolman 1967]


Wetland-Villanova University


Raingarden-Villanova University


Outfall- Wissahickon Creek

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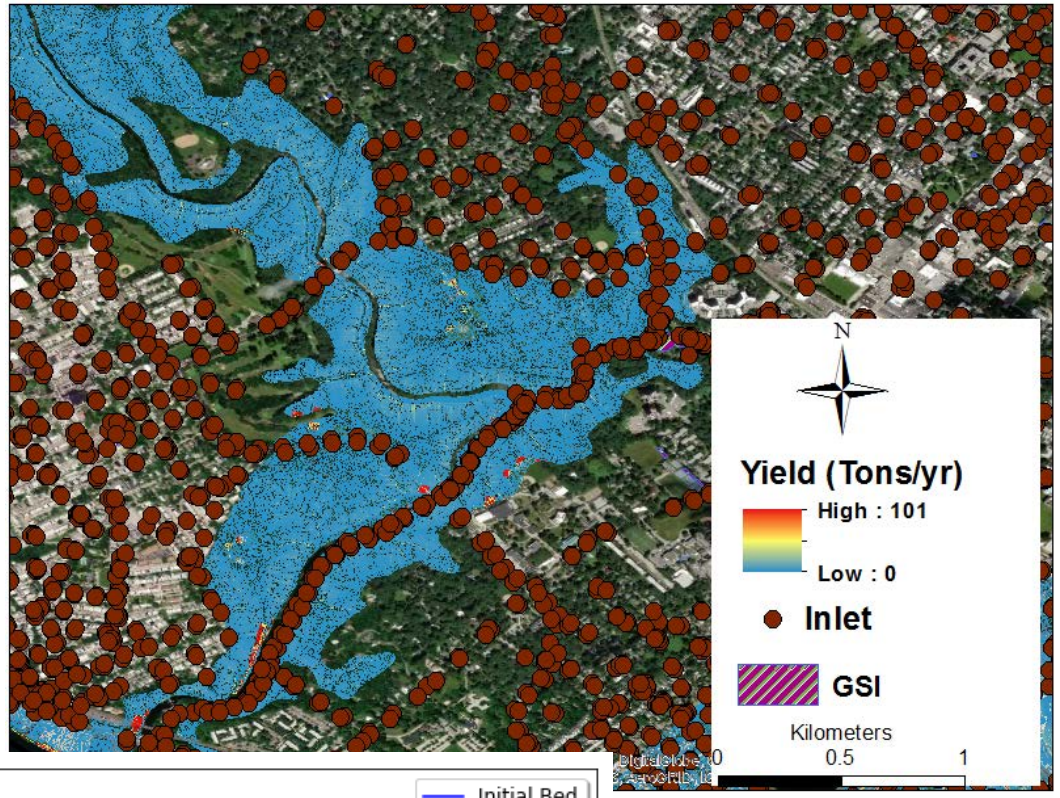
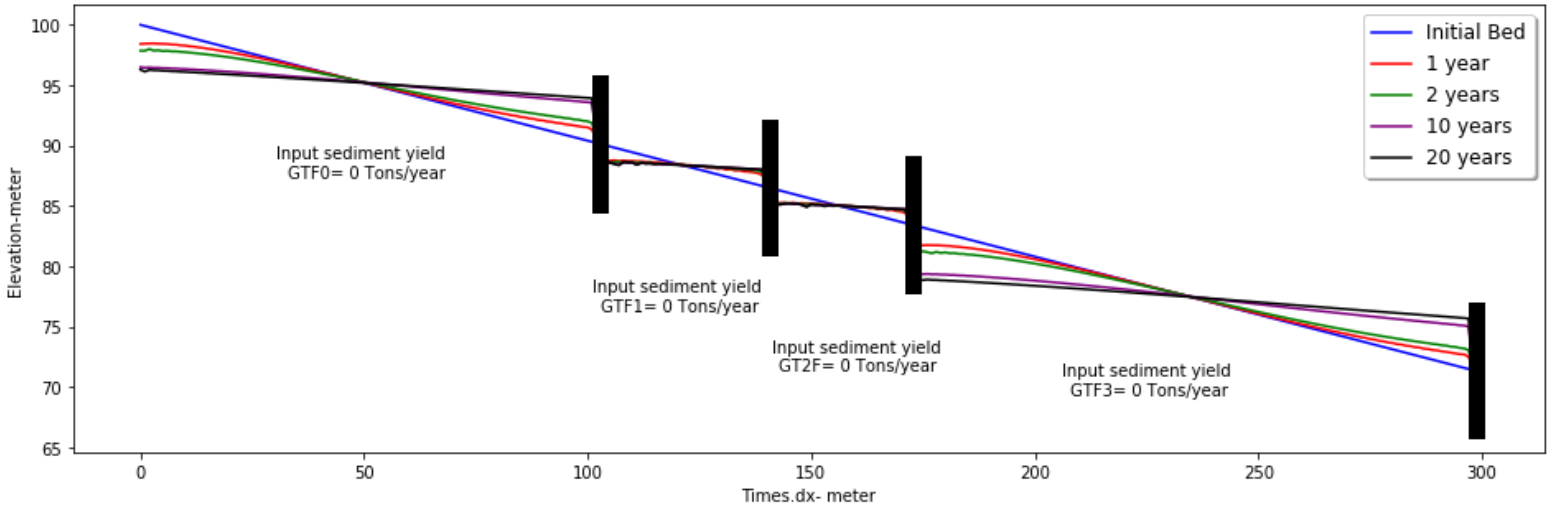
Future Work

- Water and sediment budget
- **Link** flow and sediment routing to stormwater **outfalls**
- Analysis impact on **instream response**





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