

# The Puget Sound Stormwater Heatmap

Christian Nilsen, July 24, 2019

Geosyntec ▶  
consultants



# Problem Statement

## The Questions:

- How can we make sure that stormwater dollars are going to where they are most effective at reducing pollutants?
- Can we create a decision support tool that helps communities identify and prioritize stormwater projects?

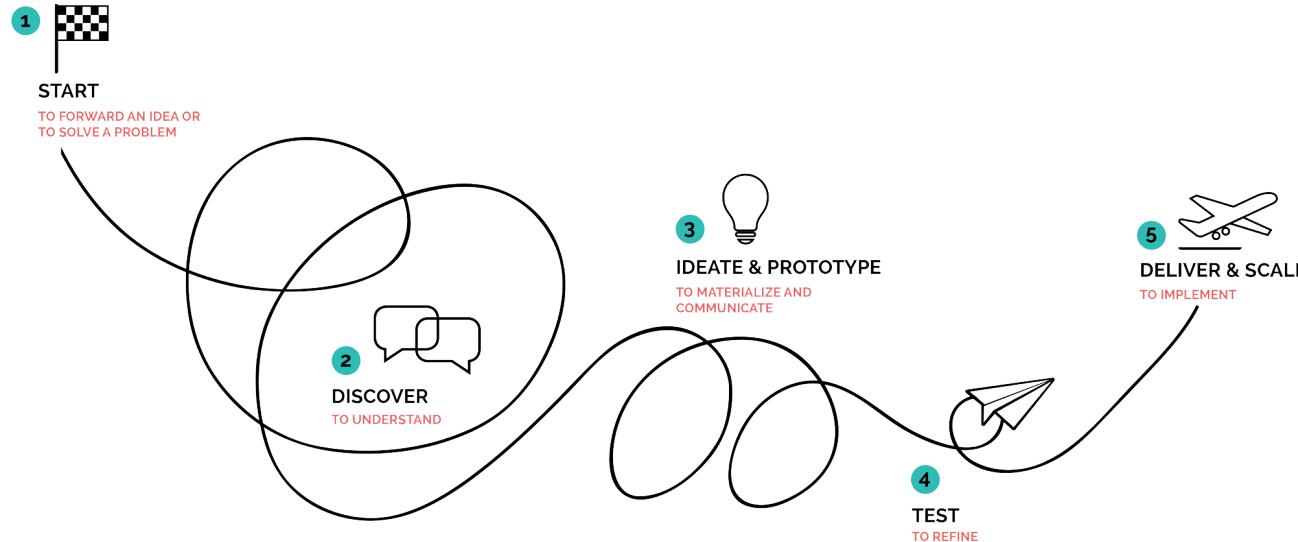


# Genesis of the tool



# Tool Development

Design thinking approach – non linear process



# What We Heard

# Design Principles for a Stormwater Decision Tool

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## Compelling visuals

Tools should help stormwater managers tell a story to different audiences

## Multiple scales

Stormwater planning takes place at the parcel, neighborhood and watershed scale

# Make it mine-able

Serve as a data platform and resource for use with other tools.  
Add land cover, hydrology and climate change impacts.

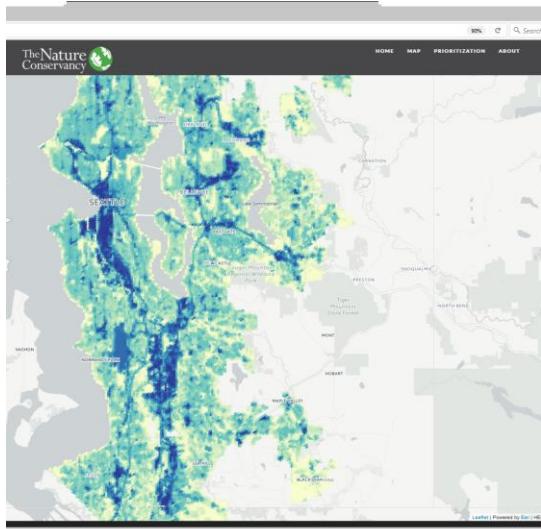
## Grounded in science

Data and calculations should be apparent and should meet current best practices

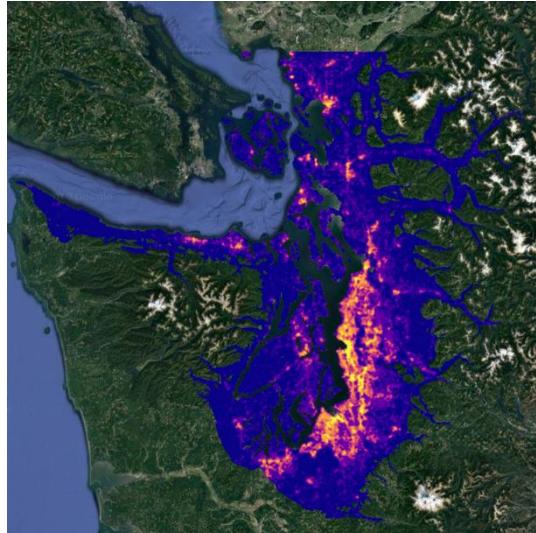


# Design Iterations

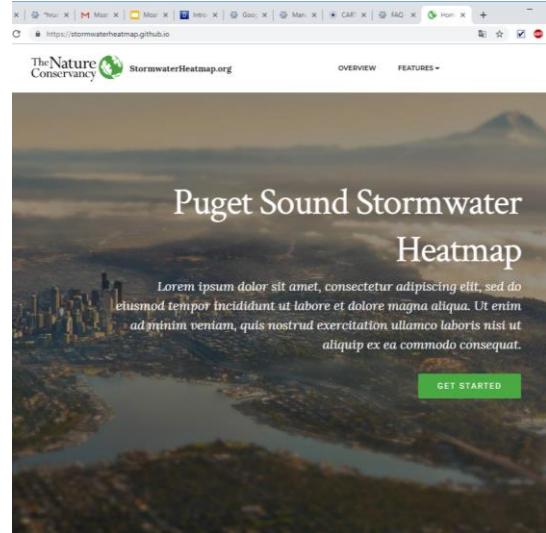
Western King County  
proof of concept



Puget Sound  
proof of concept



Beta version



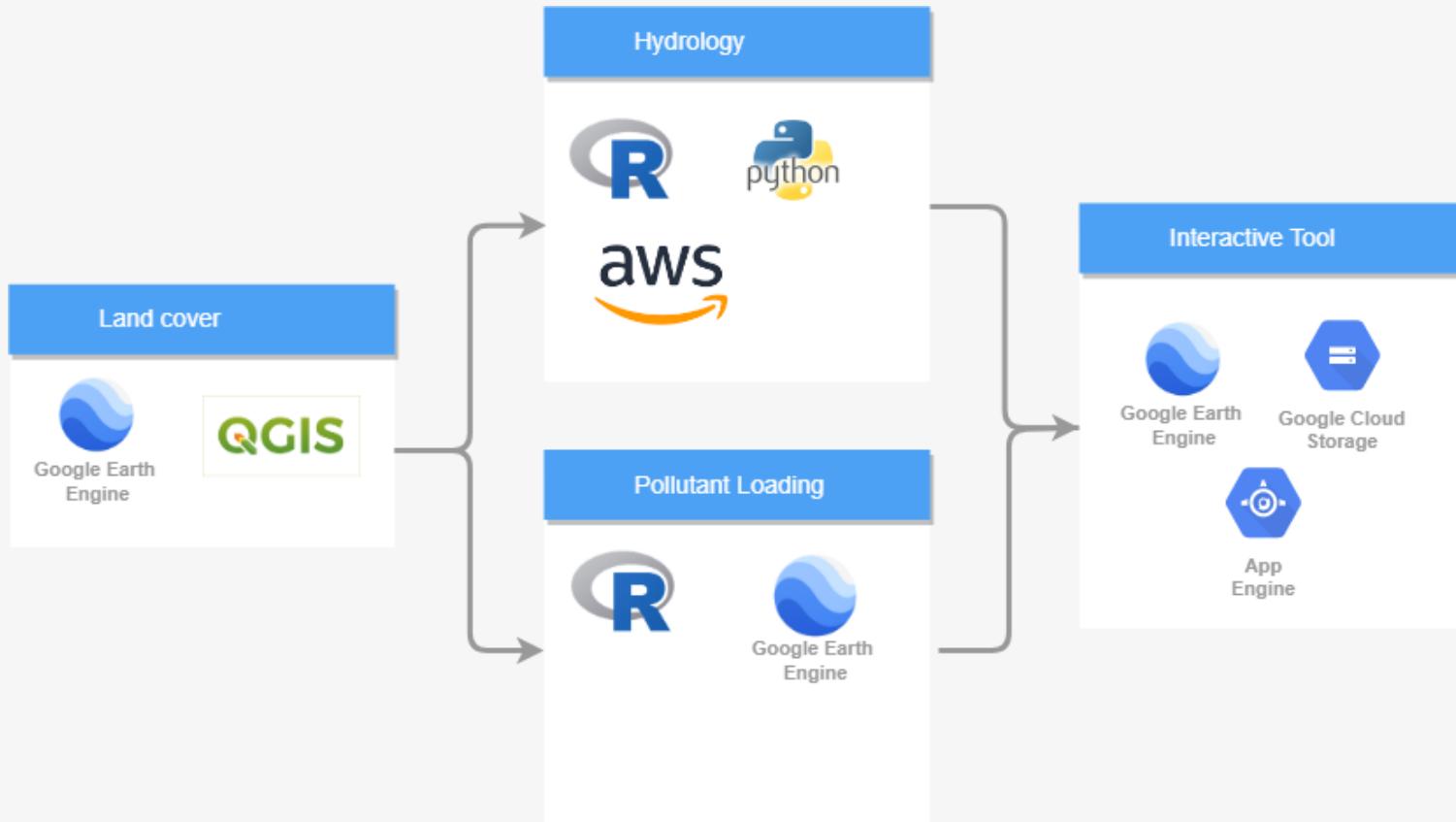


# Puget Sound Stormwater Heatmap

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GET STARTED

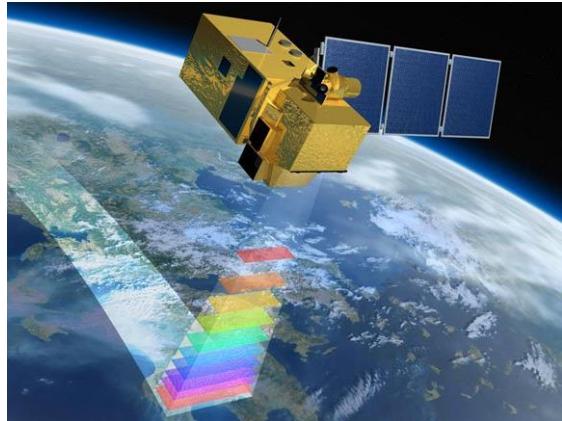
# Components



- Answers a variety of question for stormwater managers and the public
- Includes specific tools for basin planning
- Transparent and open source
- Data and scripts are available for download at no cost

# Features

- Cloud hosted
  - No software required
- Data continually up to date
  - Combines remote sensing with machine learning to stay current



# Google Earth Engine

Google Earth Engine Search places and datasets... Get Link Save Run Reset

Scripts Docs Assets ? Console Tasks

snicEverywhere\*

```
3 var sources = ee.Image().toByte().paint(roads, 20);
4 var cost = ee.Image();
5 .clip(geometry);
6 //Invert the cost function
7 var cumulativeCost = cost.fastDistanceTransform()
8
9 //Import NAIP this takes all images collected in the last four years
10 var bands = ["R", "G", "B", "N"];
11 var img = imageCollection
12 .filterDate('2017-01-01', '2019-01-01')
13 .filterBounds(geometry);
14
15 //Map NDVI over the image collection
16 var withNDVI = img.map(
17   function (image)
18   {
19     var ndvi = image.normalizedDifference(['N', 'R'])
20       .rename('NDVI');
```

Layers Map Satellite ?

Geometry Imports

Map data ©2019 Google | 5 km | Terms of Use | Report a map error

# Components

- Watershed characteristics
- Hydrology and climate change
- Stormwater pollutant loading

# Watershed Characteristics

- Landcover
  - 1-meter scale
  - Developed from a variety of sources
  - Calibrated and verified against existing datasets
- Landuse
  - Parcel-tax derived land uses from WA Dept. of Commerce
- Age of development
  - Landsat derived multitemporal data via EU Joint Research Centre
- Slope
  - USGS National Elevation Dataset
- Soils
  - USDA gridded soils
  - Oak Ridge National Laboratory gridded soils

# Land Cover

## Sources

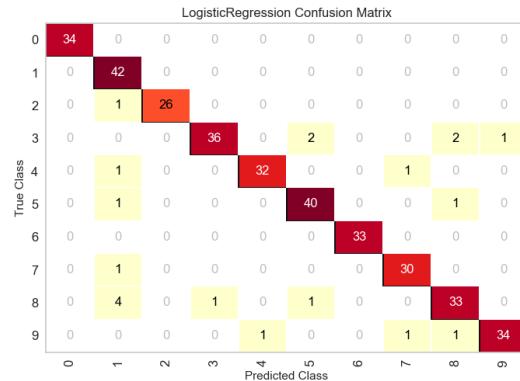
- NOAA C-CAP
- TIGER Roadways
- National Landcover Data
- USDA NAIP
- Microsoft derived rooftop data

## Training and Learning



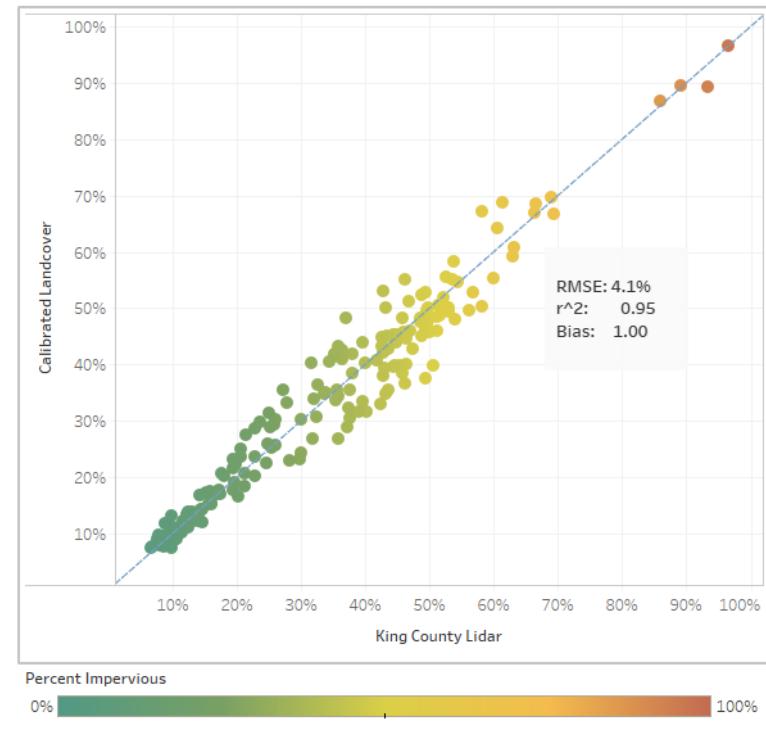
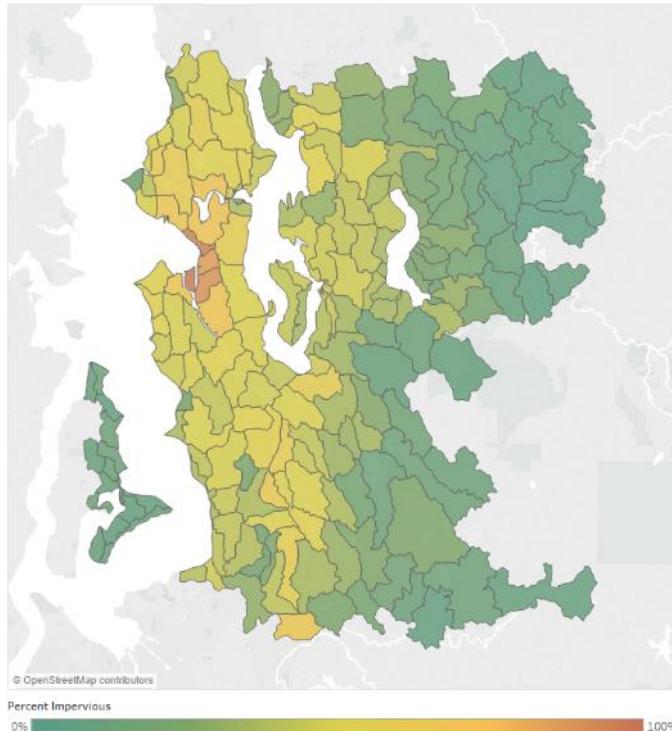
Source Vector  
Machine algorithm

## Results and verification



# Lidar Calibrated Imperviousness

King County Lidar



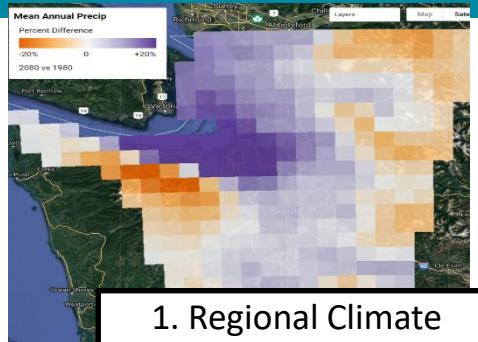
# Land Cover

- Sound-wide coverage at ~1 meter
- 1.6 billion pixels
- Six classes
  - Open water
  - Forest
  - Grass
  - Pasture
  - Bare soil
  - Impervious
  - Rooftop
- Verified and Calibrated

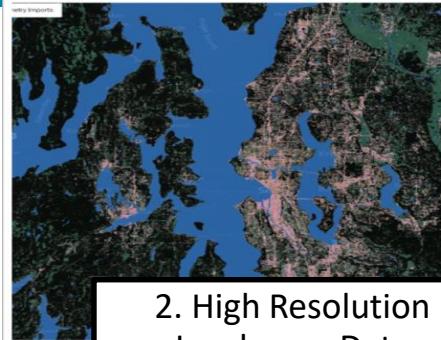


# Hydrology and Climate Change

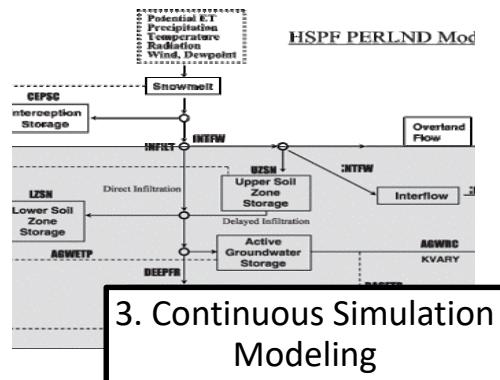
- Pixel-level annual runoff generation
- Embedded continuous simulation results
- Included future climate change scenarios



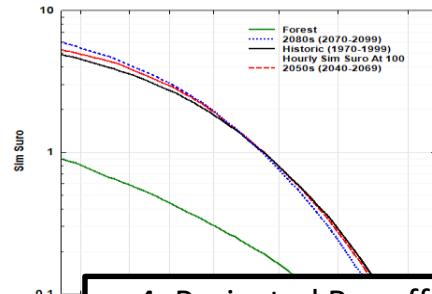
1. Regional Climate Predictions



2. High Resolution Landcover Data



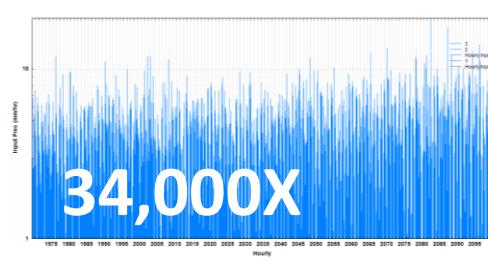
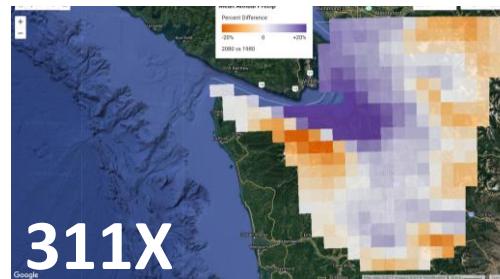
3. Continuous Simulation Modeling



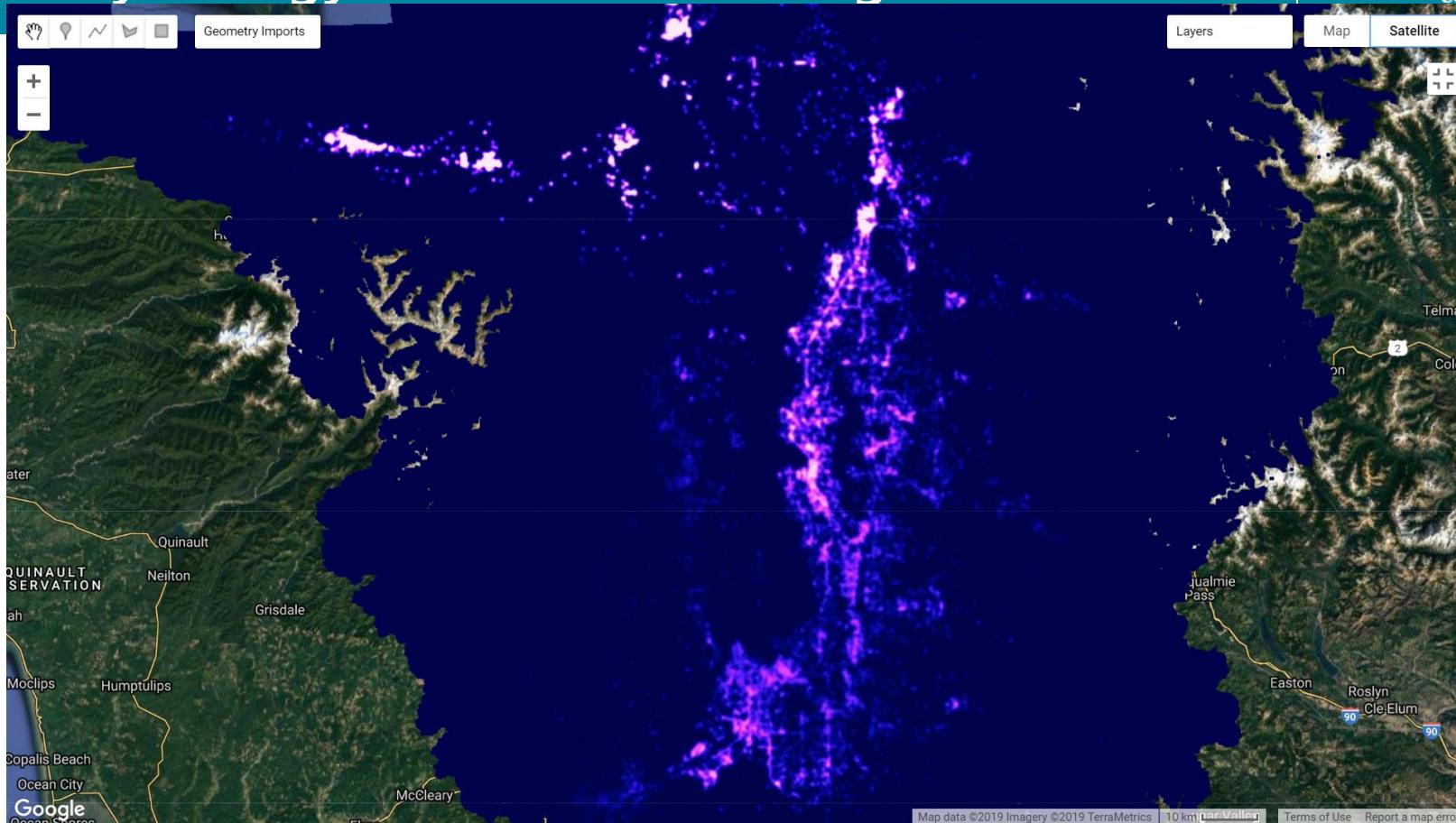
4. Projected Runoff Responses

# Batched Hydrology Simulation

- 311 Grid Cells
- 30 HRUs
- 4 Epochs
- 33,588 Timesteps of hourly rainfall
- **= 7 billion results**



# Hydrology and Climate Change Results



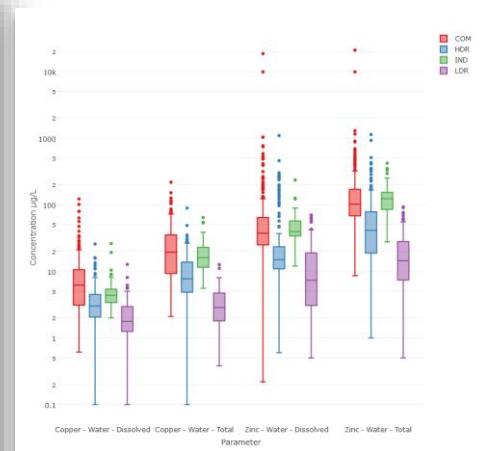
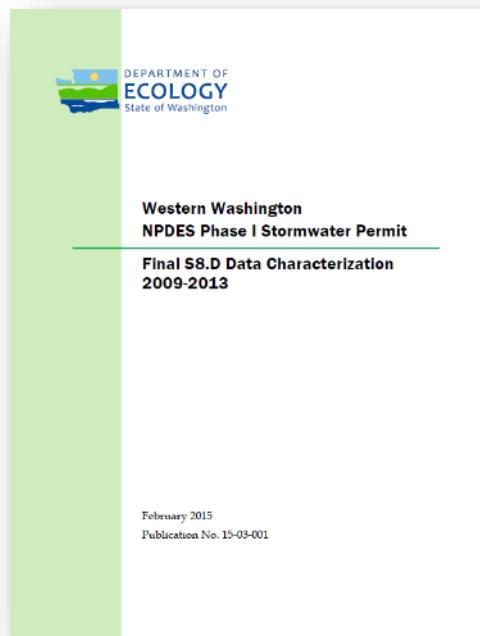
# Hydrology and Climate Change Results



# Pollutant Loading

## Metals

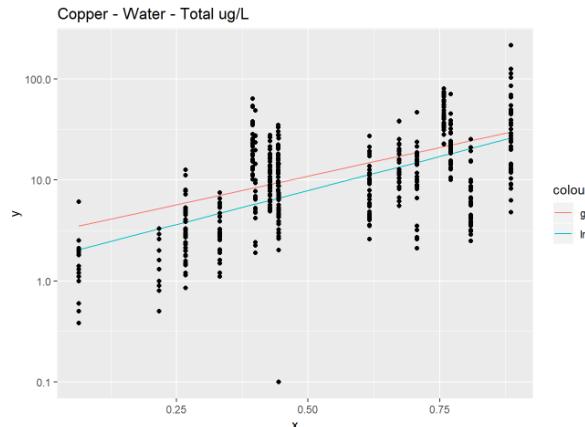
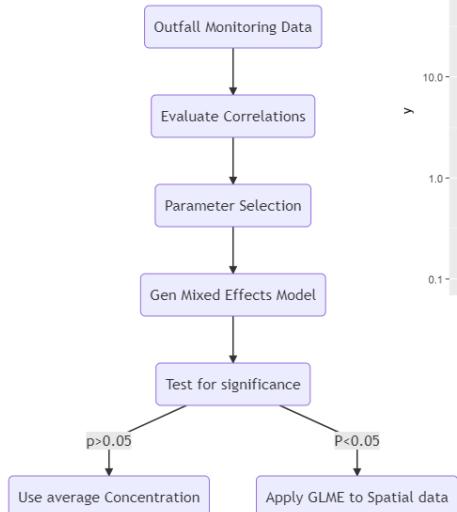
- Total Copper
- Dissolved Copper
- Total Zinc
- Dissolved Zinc
- Nutrients
  - Nitrite-Nitrate
  - Total Kjeldahl Nitrogen
  - Total Phosphorus
- Total Suspended Solids
- PAHs
- PCBs (maybe)



Sources:  
Western Washington NPDES Phase I Stormwater Data Characterization  
(Ecology)  
Highway-Runoff Database (USGS & FHWA)

# Pollutant Concentrations

## Censored Generalized Linear Mixed Effects Model



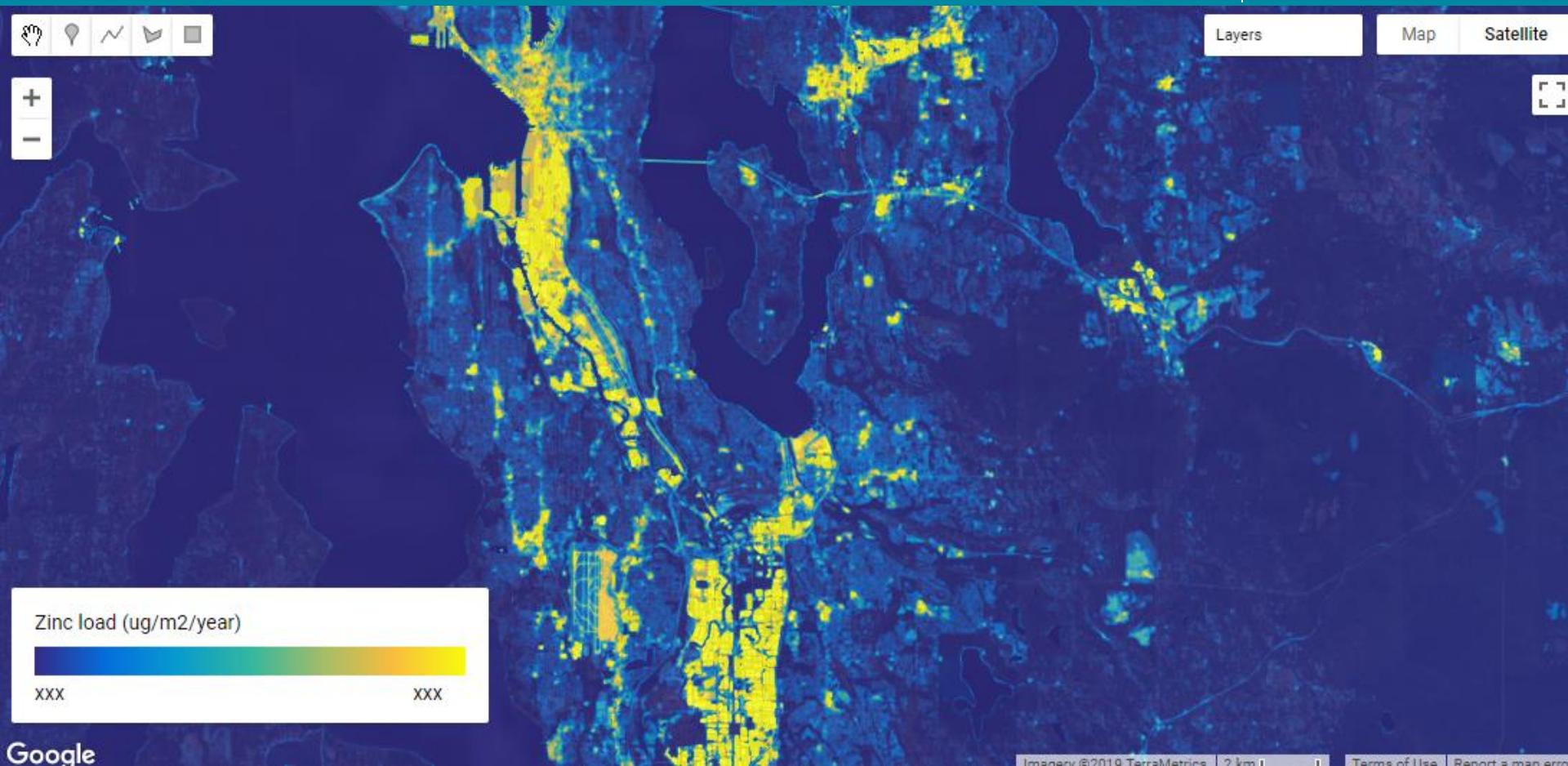
### Land use / land cover significance

- Total Copper
- Dissolved Copper
- Total Zinc
- Dissolved Zinc
- PAHs
- PCBs

### No significance found

- Nitrite-Nitrate
- Total Kjeldahl Nitrogen
- Total Phosphorus
- Fecal Coliform

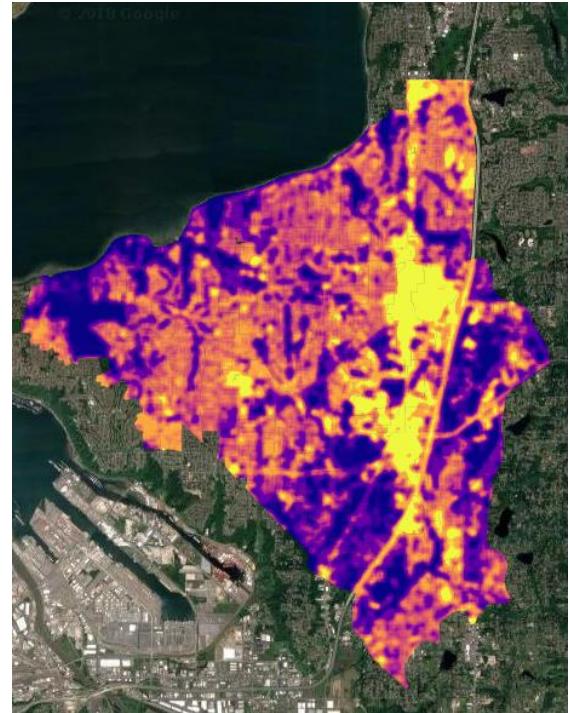
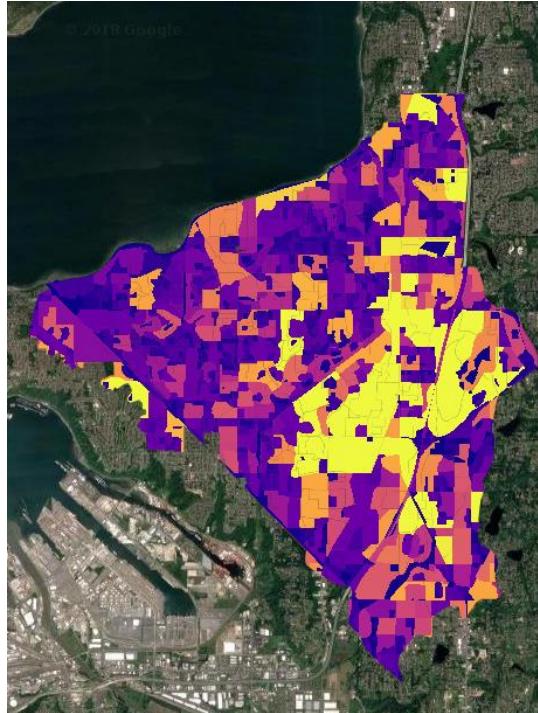
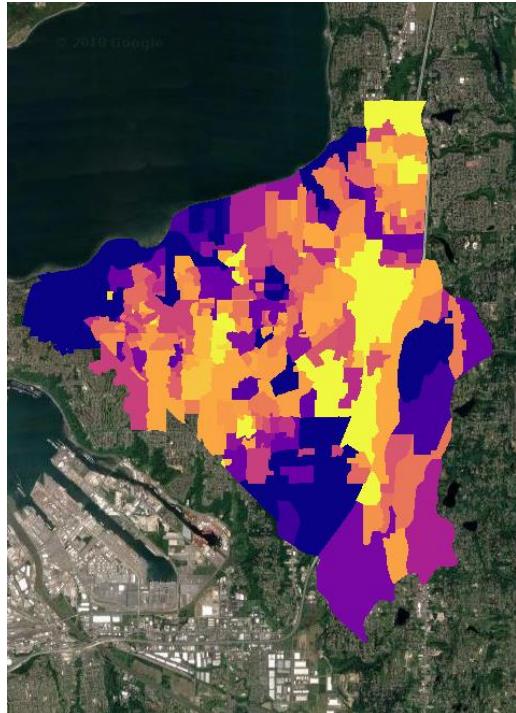
# Results



# Applications

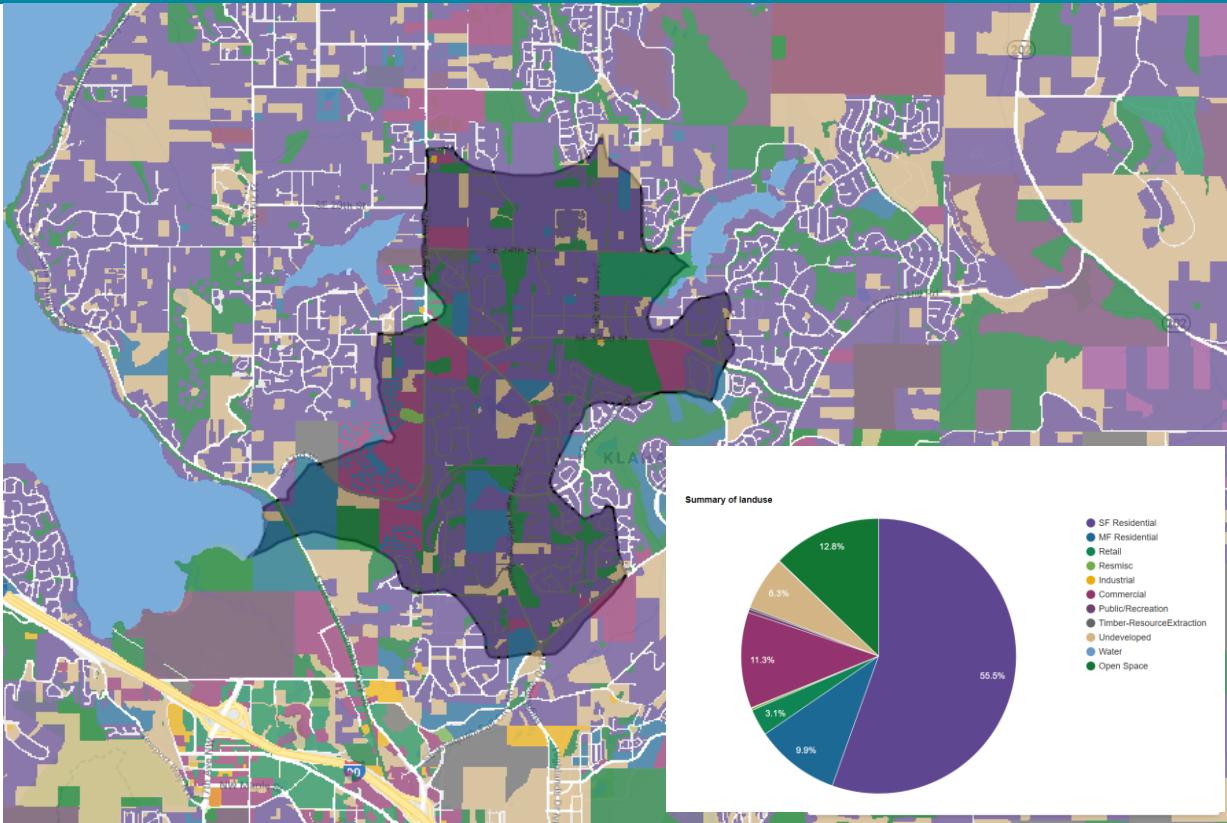


# Analysis at any scale and any region

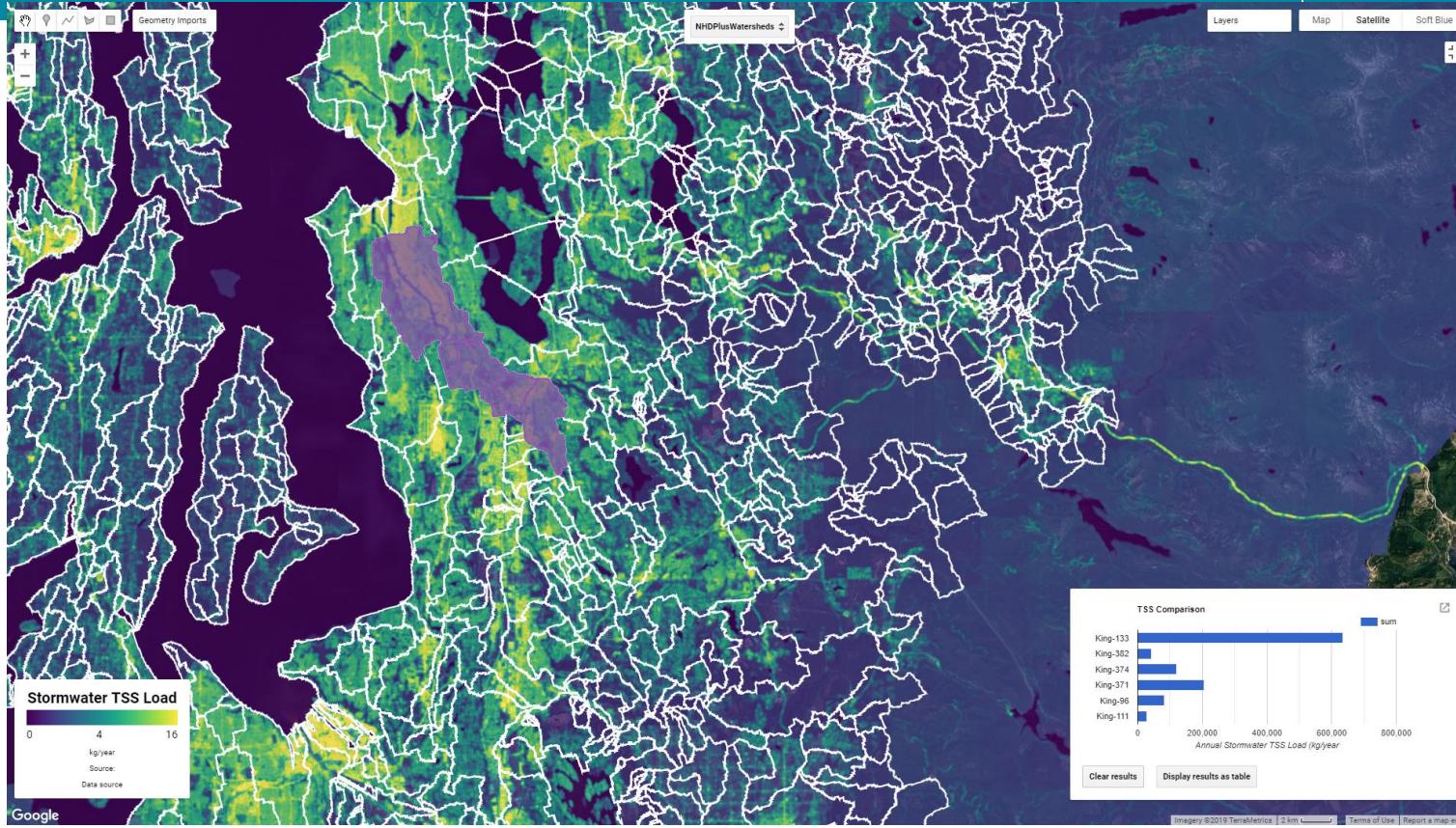


# Watershed Reports

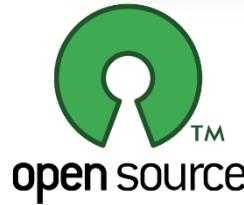
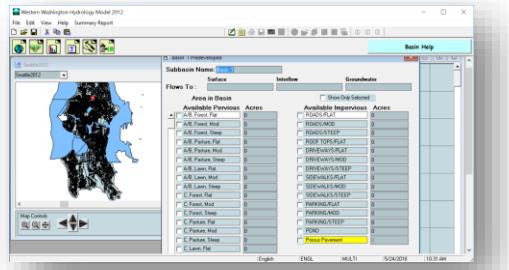
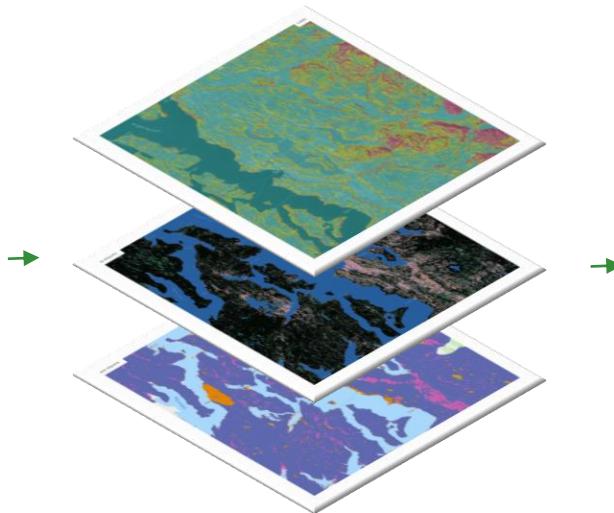
- LU/LC
  - Land use
  - Land cover
  - Imperviousness
- Hydrology
  - Hydrologic Response Units
  - Mean Annual Runoff
  - Flow-control metrics
  - Climate change impacts
- Pollutant loads
  - 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup> quantiles
- Other
  - Age of Development
  - Estimated population



# Watershed Comparisons



# Extract and Download data For use in GIS or WWHM





# Puget Sound Stormwater Heatmap

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exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.*

GET STARTED

## Funding and in-kind support from:



# Thank you

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