Stormwater models: Effective tools for tracking contamination during response and recovery

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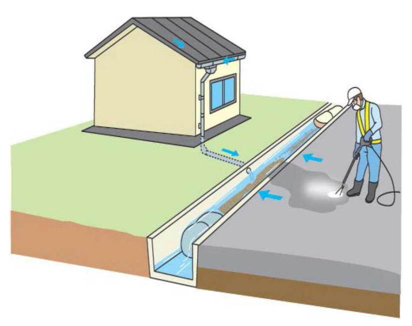
1. Background & Motivation: Why use stormwater models?

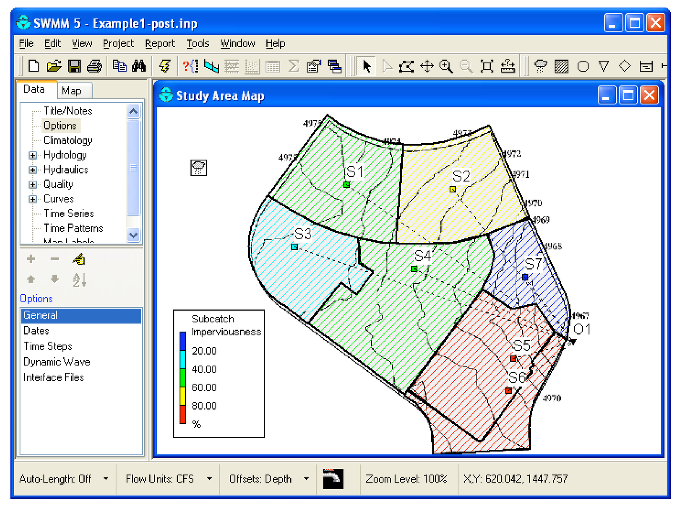
- Goal: To better understand the impacts of wet weather and water application (for mitigation) on the fate and transport of chemical, biological, and radiological (CBR) agents released in wide-area urban environments following natural and man-made disasters *(aligns with EPA Homeland Security Research Program Priorities)*
- Fate and transport challenges:
  - CBR agents can be hard to detect
  - Urban environments are dynamic (rain, wind, foot/vehicle traffic)
  - Incidents may take years to remediate
  - Mitigation activities may further spread contamination



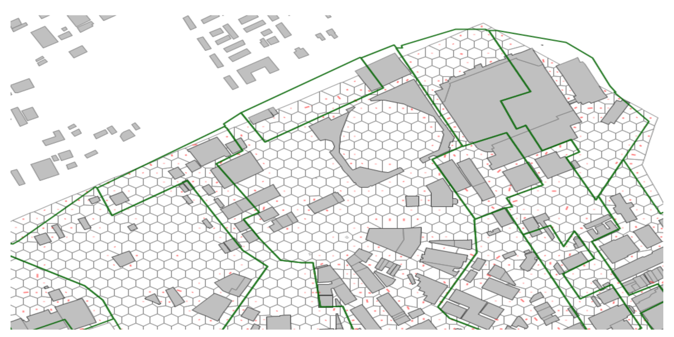
- We can use modeling tools to expand surface & subsurface mapping capabilities to help:
  - Support site characterization & sampling
  - Estimate contaminant concentrations
  - Determine cleanup plan & waste staging areas
  - Track decontamination efficacy
  - Allocate resources more effectively

2. Repurposing EPA's Stormwater Management Model (SWMM)

- EPA SWMM5 engine selected for this application after a broad & comprehensive survey of potential models
- What is SWMM?
  - A public domain hydrologic and hydraulic model developed by the EPA
  - Used for single event or extended period simulation of runoff quantity and quality
  - Used widely by cities in the US and globally
- Use GIS and/or proprietary software (e.g., PCSWMM) to:
  - integrate air plume information (e.g., IMAAC or QUIC)
  - develop overland flow 2D mesh (for finer spatial resolution)
- Need additional contaminant tracking functionality →developed though PySWMM & SWMM API



SWMM5 Graphical User Interface

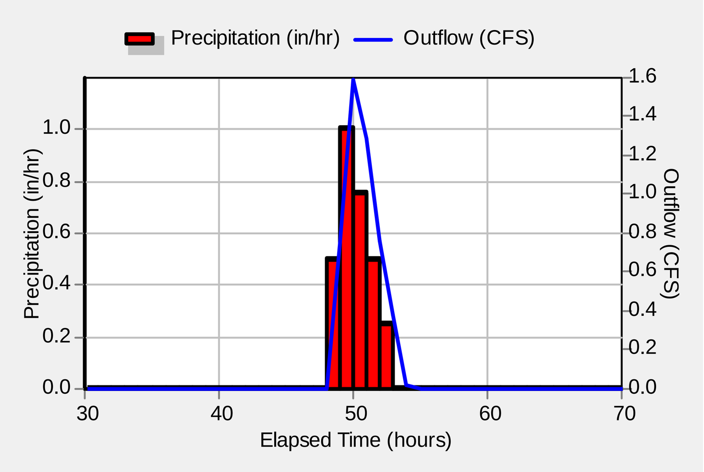


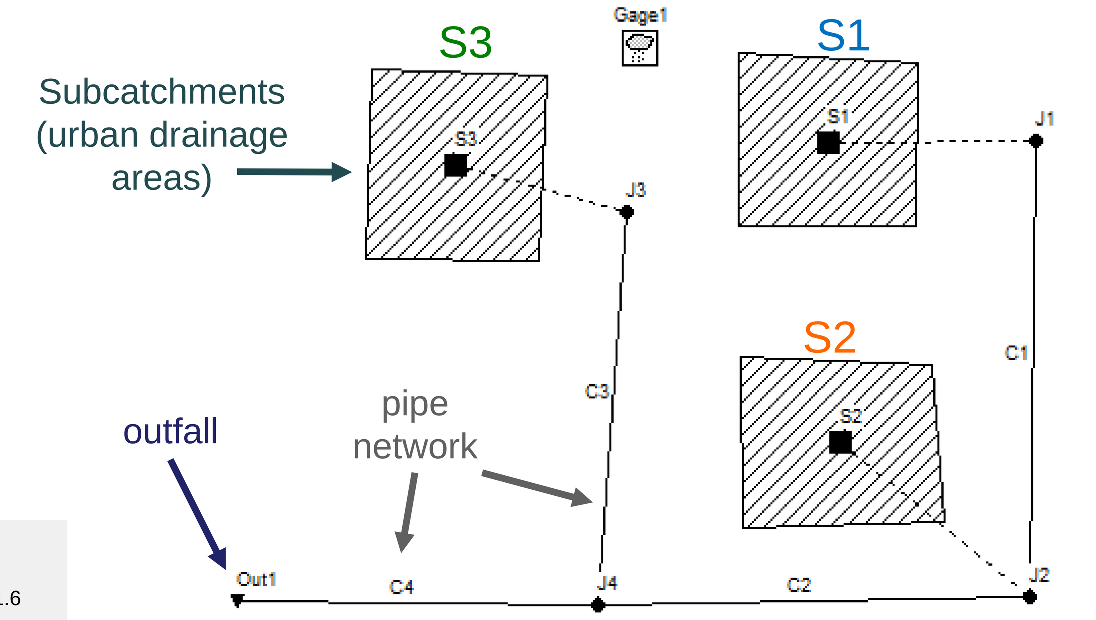
Example of 2D overland flow mesh

3. Model Development with Open Water Analytics: PySWMM and the SWMM Toolkit Application Programming Interface (API)

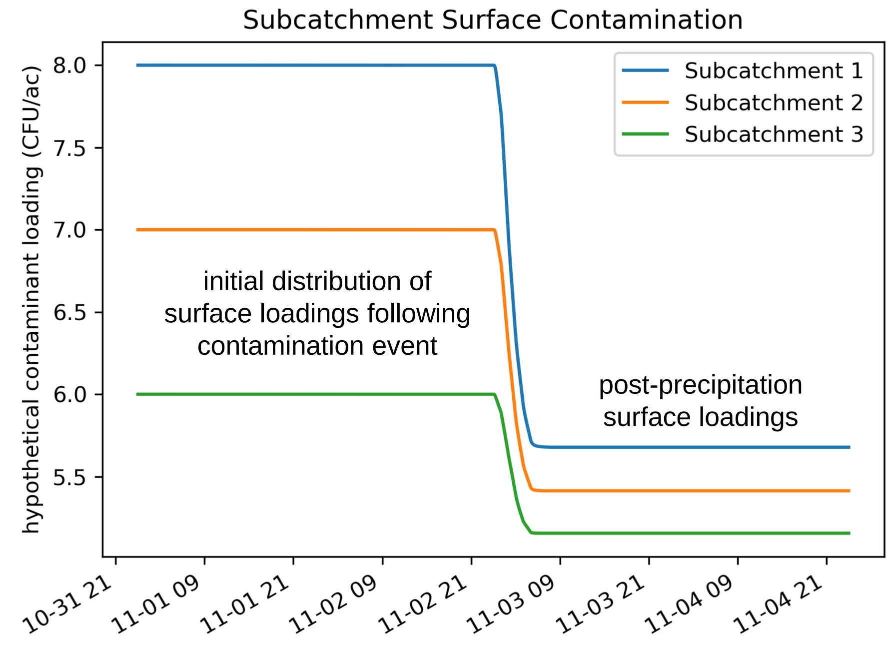
- Working with Open Water Analytics (OWA) to develop response-related functionality of the SWMM Toolkit Application Programming Interface (API) and the PySWMM Python wrapper for the SWMM API
- Added functionality to track contaminant concentrations on SWMM subcatchment surfaces throughout model simulations
- Future development will include additional contaminant tracking capabilities and rule-based controls to simulate different types of decontamination strategies

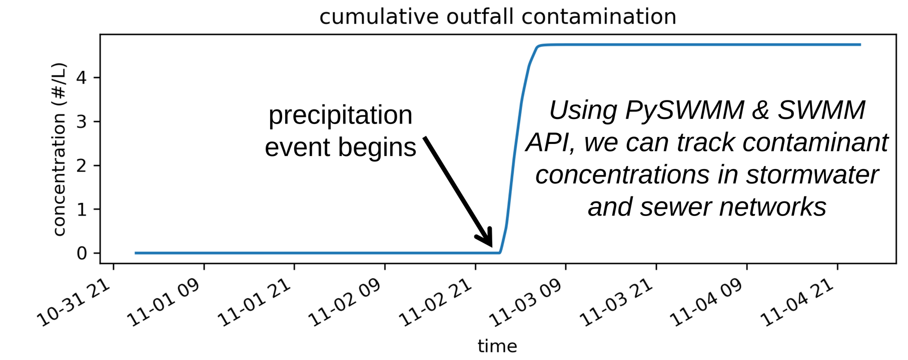
Hypothetical example of a simple SWMM model and simulation with a single rain event to illustrate contaminant tracking capabilities with example biological contaminant, rain event, and subcatchment characteristics





Subcatchment ID	Initial Loading (log CFU/ac)	% Impervious Cover
S1	8	75
S2	7	50
S3	6	25

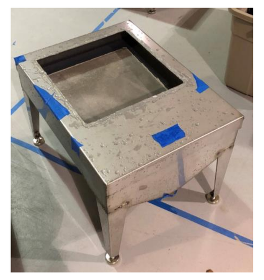




4. Informing the Models: Laboratory and Field-Scale Experiments

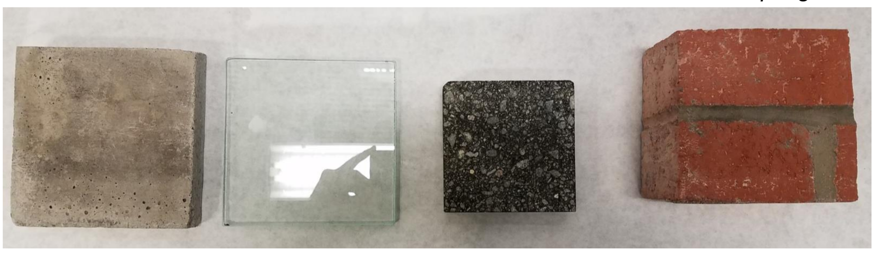
- Need to refine equations and parameters to better model the washoff processes of chemical, biological, and radiological agents
- Testing a variety of decontamination strategies over a range of urban materials (concrete, asphalt, etc.)
- Lab-scale experiments:
  - Rainfall simulator with varying intensities
  - Power washing and garden hose rinsing
  - Overland flow
  - Measuring Zeta Potential to characterize adhesion forces between particles and urban surfaces
- Field-scale experiments:
  - EPA Urban Watershed Facility, Edison, NJ
    - ✓ Testing sampling and decontamination strategies in an outdoor setting
    - ✓ Collecting runoff to measure washoff rates with 'real' rain events
- Developing a scaled 3D printed model to conduct transport and decontamination experiments

concrete coupon holders



Sediment channel for overland flow experiments

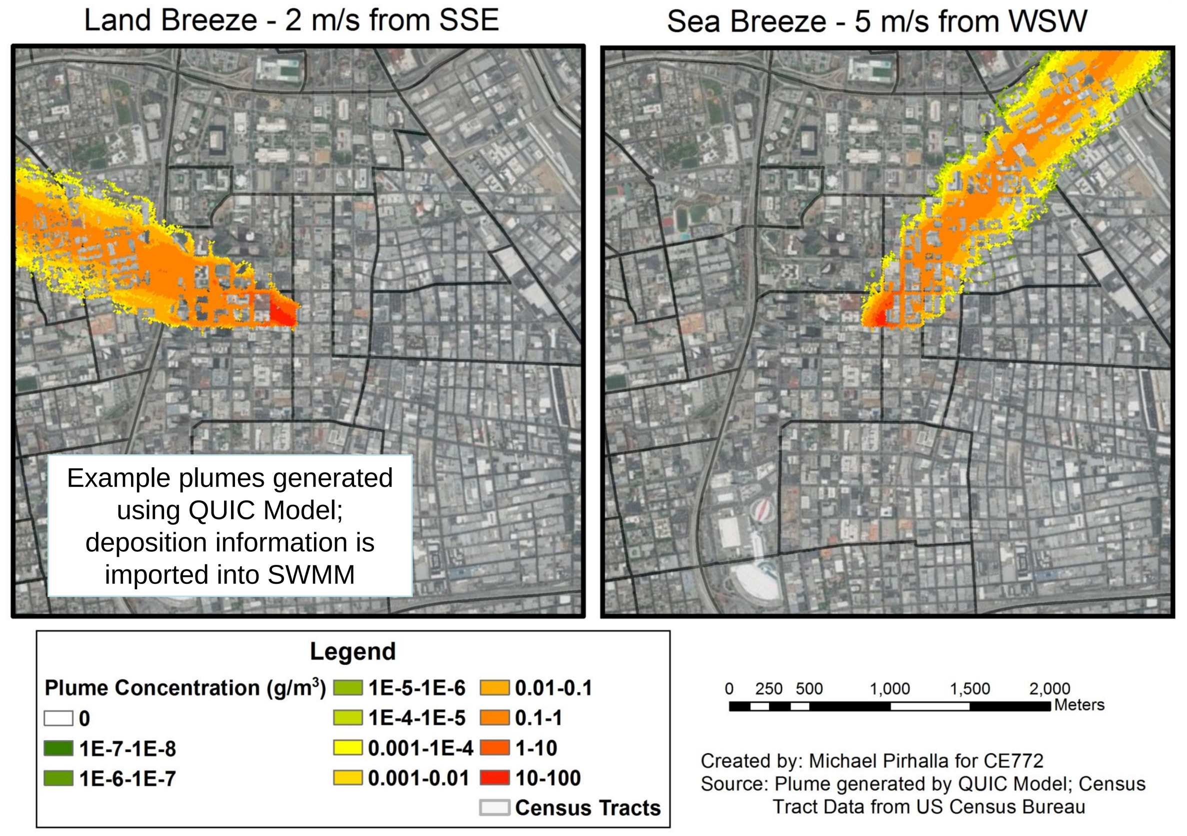
Robotic vacuum and wet-vac sampling



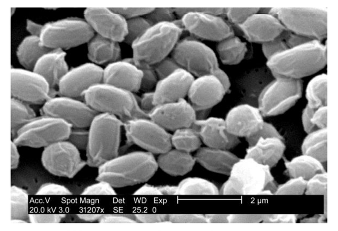
Different types of materials tested: (left to right) concrete, glass, asphalt, brick

5. Case Studies: Applying the Modeling Framework

Simulated Chlorine Gas Concentration Plumes from a 15,000 kg Release in Los Angeles, CA



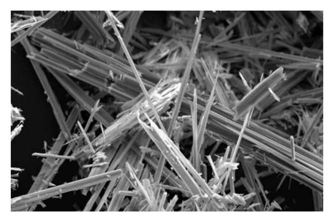
- Conducting case studies with different contaminants to streamline the process of using stormwater models for decontamination applications
- Identified challenges:
  - Working with models developed using other software packages
  - Creating 2D overland flow mesh (deciding on cell size, structure)
- Important questions:
  - How far to extend model?
  - Plan for more routine (smaller) precipitation events, or 'the big one'?



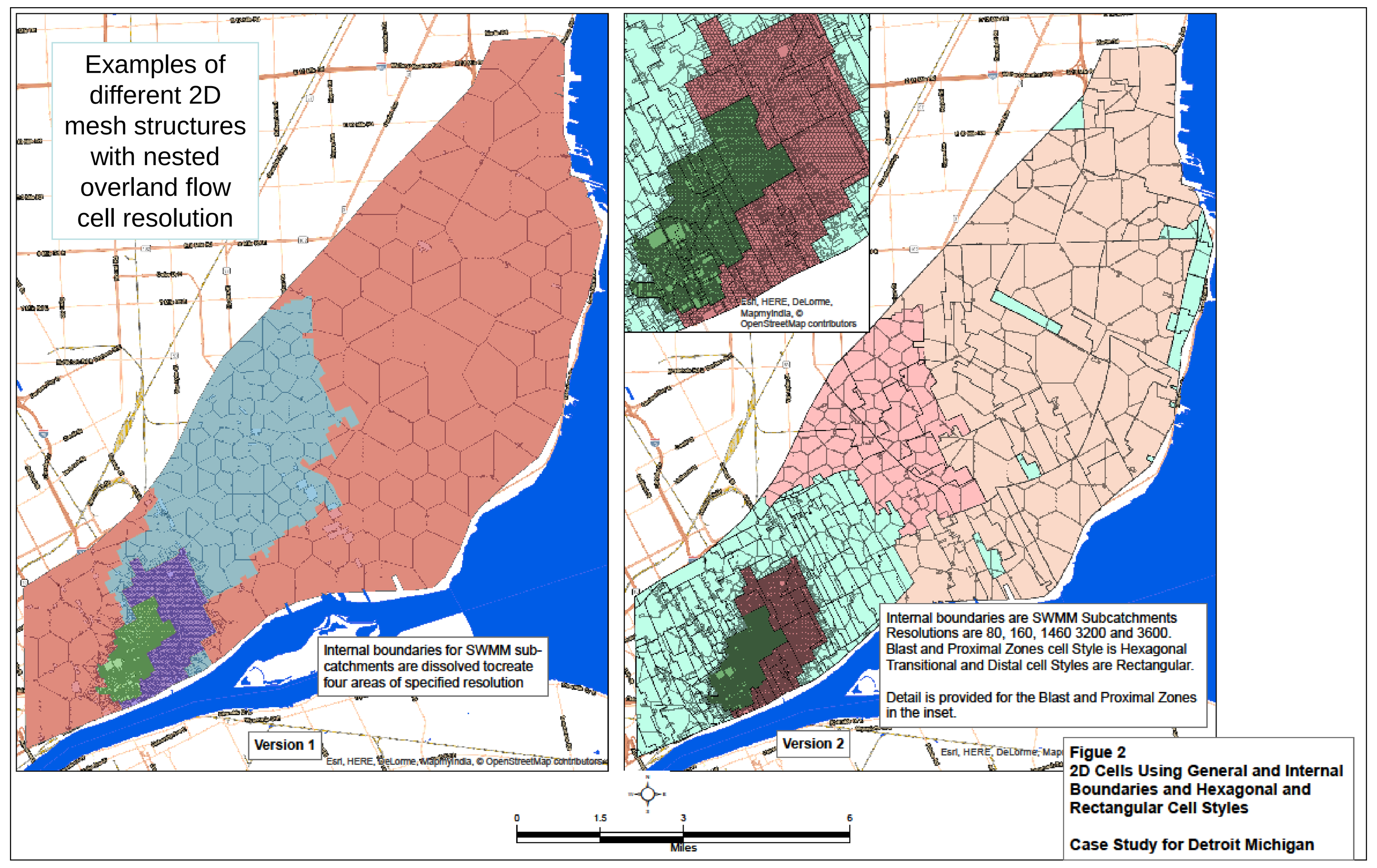
Bacillus anthracis spores

Case Study Contaminants

Radiocesium (RDD) following National Planning Scenario 11



asbestos



6. Want to learn more?

http://wateranalytics.org/

To find out more about the models and our work, check out these sites:
https://www.epa.gov/water-research/storm-water-management-model-swmm,
https://github.com/OpenWaterAnalytics,
https://www.epa.gov/homeland-security-research,
or email me at ratliff.katherine@epa.gov