# Data Driven Approach to Enhance Street Sweeping in Urban Areas

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## Introduction

- Urban runoff is a major transport of pollutants into surface waters, causing human health and environmental implications [1, 2]
- Heavy metals, nutrients, PAHs, and microplastics accumulate from a variety of anthropogenic and atmospheric sources [3]
- Street sweeping can be an effective nonstructural pollution control; however, several parameters affect its performance:
  - Tandem passes of vacuum and mechanical sweepers, dependent on particle size [4]
  - Optimal frequency between rain events to capture maximum accumulation [4]
  - Prioritization of street sweeping location based on accumulation


## Project Goal

Develop a data driven approach to optimize street sweeping in urban areas considering site and road characteristics, pollution compositions, and climatic conditions.

## Methods

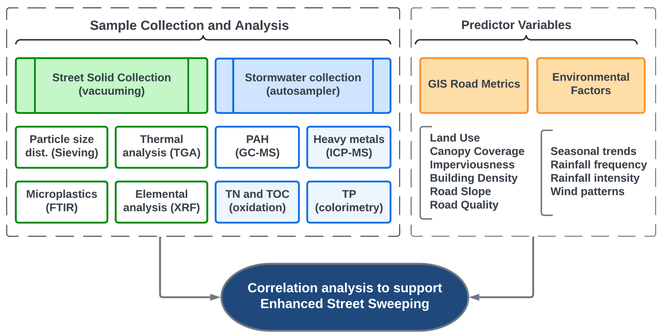


**Figure 1:** Methodology map outlining the framework and variables included in the enhanced street sweeping program. Highlighted boxes shown on this poster

- Street solids are vacuumed from 8, 1000ft road segments, are sorted into particle size ranges and analyzed for elemental compositions; results used to understand accumulation rates
- Stormwater samples are collected by an ISCO autosampler integrated with a flowmeter and analyzed for water quality; results used to understand runoff concentrations
- Street solid and stormwater pollutant characteristics are analyzed to determine correlations between season, land use, and other road characteristics to determine prioritization of sweeping events

## Road Prioritization Model

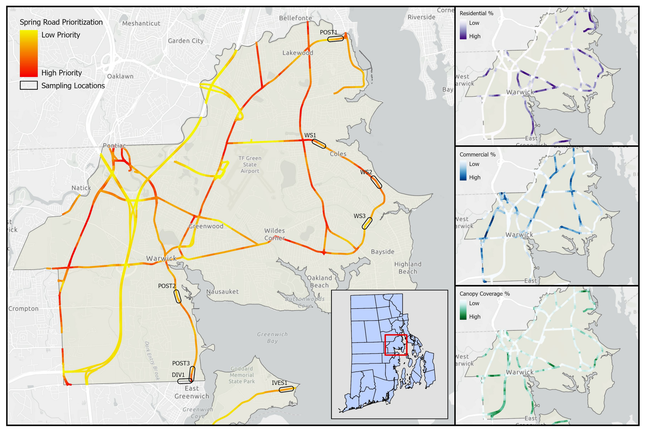


**Figure 2:** Distribution of spring road prioritization (A) based on residential (B) and commercial (C) land uses and canopy coverage (D), calculated using GIS processing

- Spring prioritization calculated by weighting residential (0.2), commercial (0.7), and canopy coverage (0.1) percentages within 250 feet of 0.1 mile road segments, followed by normalization
- Prioritization calculations changes seasonally based on land use, for example, fall priority scores weigh canopy coverage much higher

## SSWEEPR Tool

- Street SWeeping Enhancement and Estimator of Pollutant Reduction (SSWEEPR) tracks pollutant accumulation (exponential buildup), washoff, and street sweeper removal across different scenarios [5]
- Street sweeper removal efficiency set to a constant 85% [6]
- Washoff rate is 90% if rainfall is > 0.5” and 50% if rainfall is > 0.2” [4]

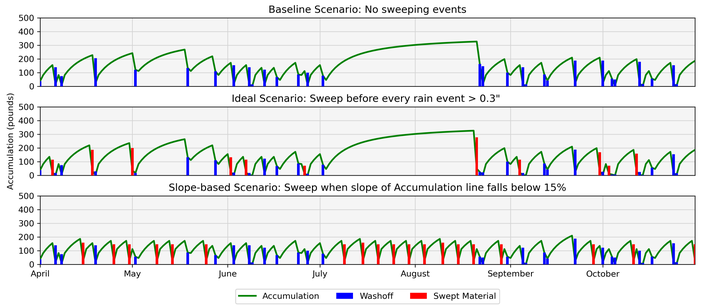


**Figure 3:** Preliminary results from Python-GIS tool to track pollutant accumulation and washoff considering different street sweeping scenarios

**Table 1:** Comparison of swept and washed off material between scenarios

| Scenario | Swept material (lbs) | Sweeping Events | Washoff material (lbs) | Washoff Reduction |
|---|---|---|---|---|
| Baseline | - | - | 6201.5 | - |
| Ideal | 1610.7 | 11 | 4617.8 | 25.5% |
| Slope-based | 2816.9 | 19 | 5518.1 | 11.0% |

## Stormwater Analysis Results

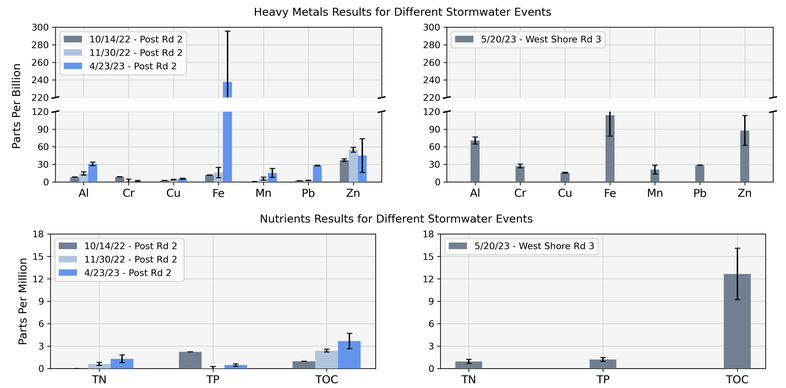


**Figure 4:** Stormwater analysis results of heavy metals and nutrients across four rain events and two sampling locations

- Significantly higher concentration of most metals (except Cd, Ni) from fall to springs samples , ranging from 16 – 1092% increase, however antecedent dry days were also much higher for spring samples
- WS3 (forested land use) showed higher average concentrations of nutrients than POST2 (residential/commercial land use) by 32% - 438%

## Conclusions

- Frequency and timing of sweeping events can have a significant impact on the transport of pollutants through stormwater runoff
- Land use and season has shown significant trends in pollutant accumulation, particularly in commercial areas during spring months, and forested areas during fall months

## Future Work

- Continue stormwater collection and analysis to further understand trends in pollutant accumulation, land use, season, and storm intensity
- Develop a SWMM model to simulate rainfall-runoff and the transport of pollutants in response to various street sweeping frequencies
- Conduct an LCA to evaluate the environmental impacts of enhanced street sweeping activities

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## References

[1] Pitt et al., Sources of Pollutants in Urban Areas, 2005.
[2] Othman et al., Pollution characteristics, sources, and health risk assessments of road dust, 2020.
[3] Müller et al., The Pollution Conveyed by Urban Runoff: A Review of Sources, 2020.
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[6] Molloy et al., Street Sweeping Pollutant Reductions and Crediting Memo, 2020.