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 pass of vacuum and mechanical sweepers, dependent on particle size [4]
  - Optimal frequency in between rain events to capture maximum accumulation [4]

Project Goal

To develop a data driven approach to optimize street sweeping considering site and road characteristics, pollution compositions and climatic conditions

Methods

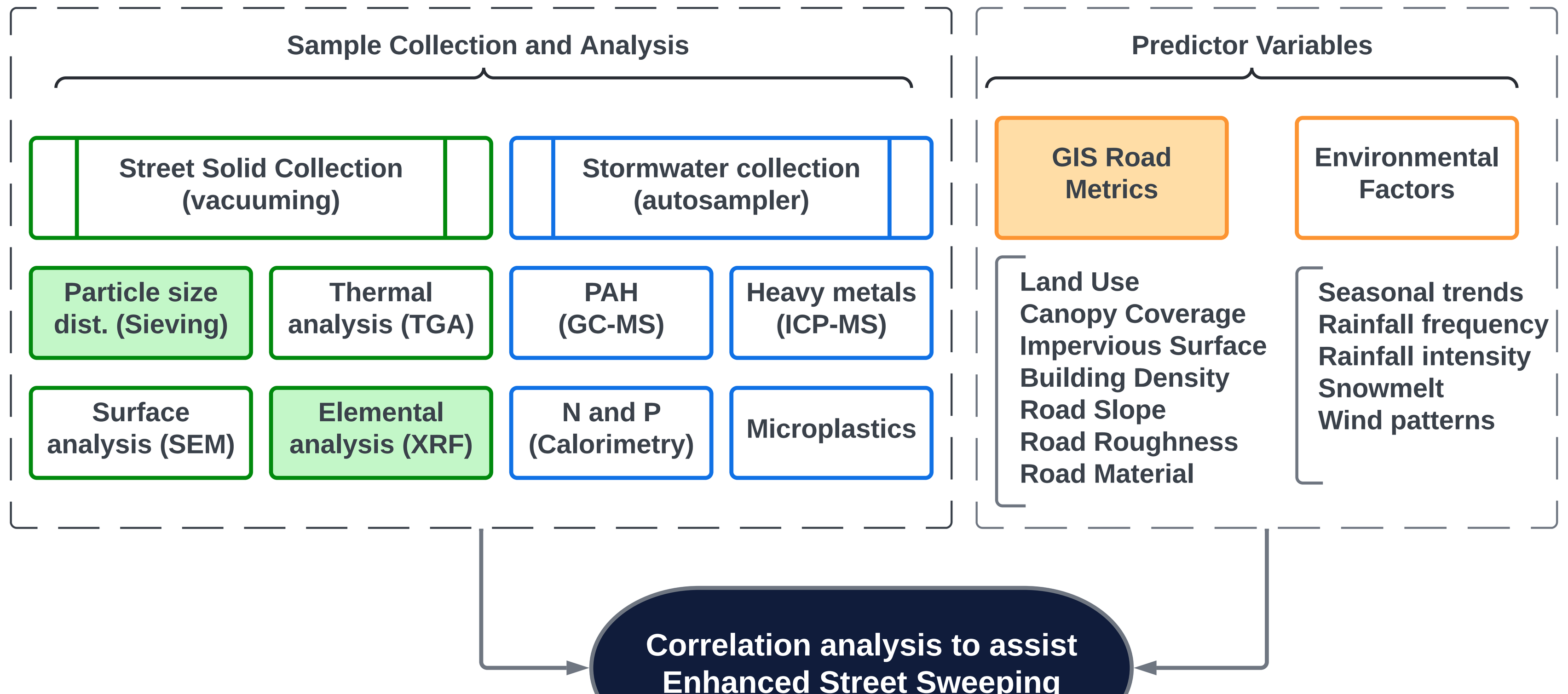

Figure 1: The methodology map outlines the framework of the enhanced street sweeping program. The highlighted boxes are represented on this poster.

For this stage:

- Street solids and stormwater samples are collected from 8, 1000ft, road segments using a vacuum and ISCO autosampler
- The samples are analyzed to understand the accumulation rate and characteristics of the various pollutants of concern
- Geographic and environmental metrics will be analyzed to determine relationship and trends in pollutant loadings

Site Characterization

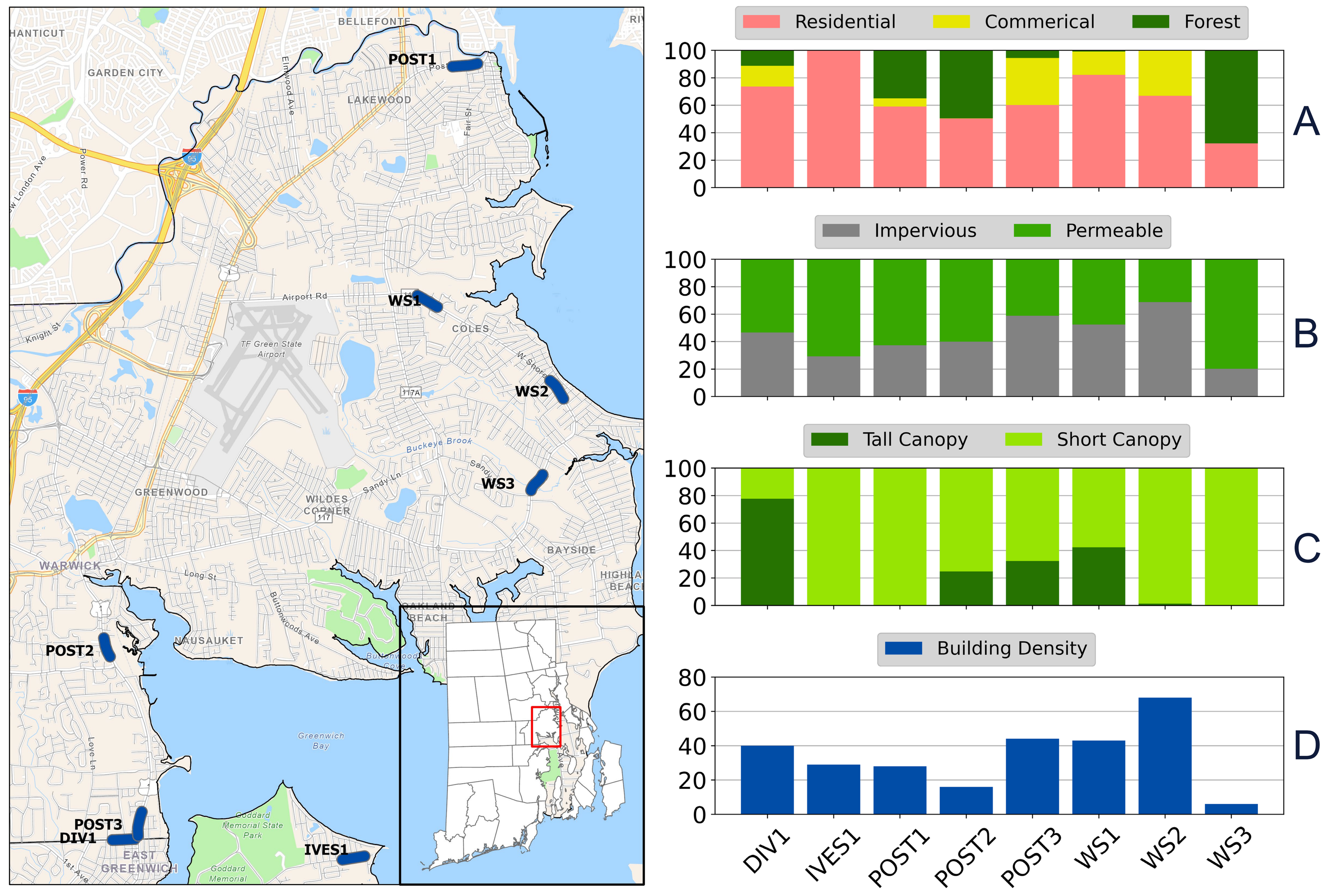

Figure 2: The map shows the 8 road segments in Warwick, RI, in which sampling will occur. The graphs each reveal the road metrics calculated using GIS geoprocessing

- Land usage (A), impervious surface area (B), canopy coverage (C), and building density (D) shows variances among each road segment
- A 250ft buffer zone was used to summarize each road segment

Size Distribution of Street Solids

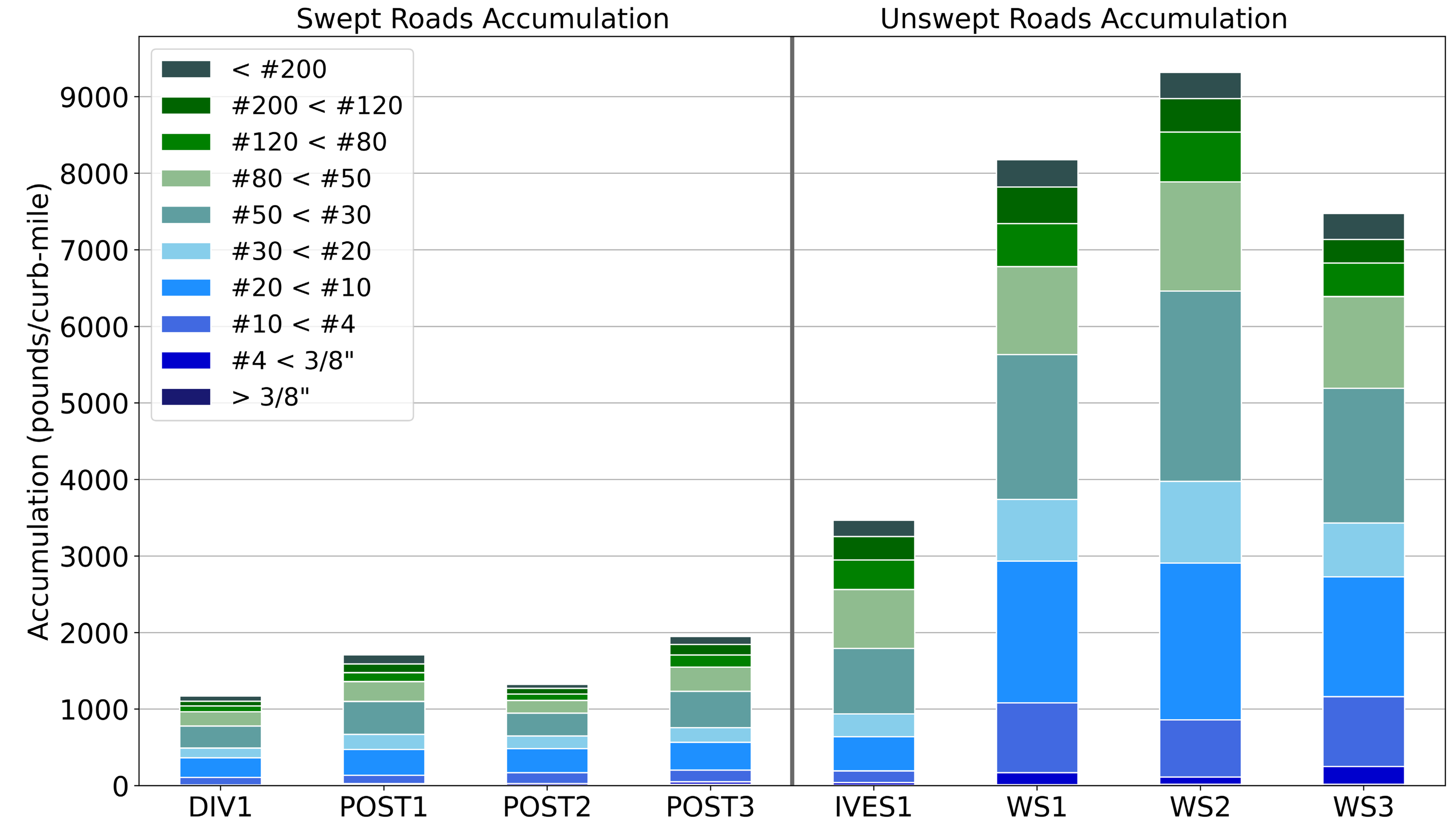

Figure 3: Street solid accumulation dry sieved into ten size ranges (gravel to silt, in mesh)

- Street solid accumulation shows 78% reduction on swept roads
- Similar trends in particle size distribution among each road, with the highest abundance in the #20 (coarse sand) and #50 (fine sand) ranges

Chemical Analysis of Street Solids

X-ray Fluorescence:

- XRF analyzers measure the elemental composition of materials
- Si was the most abundant in all samples from it's sandy complexion
- Fe, Ti, and Al were the most abundant heavy metals. Trace amounts of Zn, Cu, Pb also appeared

Table 1: XRF results of most abundant elements between different particle sizes

Particle Size Range (mesh)	Abundant Elements
#20 < #10	Si >> Fe = Ti > K = Ca > P
#80 < #50	Si >> Fe > K > Ca > Al > P
< #200	Si >> Fe > Al > K > Ca > S

Thermogravimetric Analysis:

- TGA measures moisture and volatile content by plotting weight loss against temperature (up to 950℃ at 20℃/min).
- The smallest particles often lost more weight than larger particles

Conclusions

- Results show similar trends among the particle size ranges, however some differences exist between varying land uses
- Commercial areas yield the most street solid accumulation
- Some correlation exists between residential areas and small particles, as well as commercial areas and large particles, however more data is needed

Future Work

- Collection of stormwater samples to analyze pollutant transport during rainfall. Rain intensity will be measured with a flowmeter
- Collect more street solid samples to interpret seasonal trends and to measure pollutant accumulation rates
- Determine street sweeper removal efficiencies as a function of accumulation, particle size, and sweeper type
- Richer data will help create a more accurate predictive model to assist the enhanced street sweeping program

Acknowledgements

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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.
[4] Pitt et al., The Role of Street Cleaning in Stormwater Management, 2004.

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