Pollutant Capacity within the Vadose Zone of Soils
Daniel P. Treese, Dr. Shirley E. Clark, J. Bradley Mikula, Dr. Katherine H. Baker
Environmental Pollution Control Program
Penn State Harrisburg, Middletown, PA 17057

Introduction
- Urban development’s tendency towards impervious surfaces has led to an increase in surface stormwater runoff volume and peak flow rates, amplifying erosion rates and flood occurrences while flushing increased levels of pollutants into waterways.
- Recently, infiltration has become seen as a partial solution to these problems.
- Unfortunately, contamination of groundwater (primarily salts and nitrates, but some metals and organics) has occurred at sites where soils were not suited for infiltration (Figure 1 highlights transport of pollutants in vadose zone).
- To prevent future accidental contamination events while also preserving infiltration devices as a way of reducing surface runoff, methods of evaluating a soil’s suitability for infiltration are required.

Phase I Summary
- Part 1 of this study used the SESOIL model to simulate the 1-year migration of two pollutants, zinc and sodium chloride [to represent a mobile metal and road salt], through eight unsaturated soils covering the highs and lows of several soil parameters (pH, organic content, intrinsic permeability).
- Results indicated that rainfall quantity is a controlling factor in the migration of Zn²⁺, Na⁺, and Cl⁻ ions (Figure 2).
- Pollutant concentration affected Zn²⁺ ion migration.
- The migration of Na⁺ and Cl⁻ ions was influenced by the intrinsic permeability of soils.
- Soil pH and organic content were found to be minor influences but this may have been due to the low zinc concentrations that were run through the system.

Phase II Objective and Environmental Significance
- The object of Phase II will be to validate the results of the earlier modeling using undisturbed natural soil columns, while also observing the behavior and changes over time of other pollutants and soil parameters.
- Results will be used to fill data gaps and develop guidance for stormwater managers in the selection of infiltration sites.
- There is limited field data of subsurface pollutant movement, but reductions in surface runoff concentrations indicate that pollutants must go somewhere.
- Prediction of groundwater contamination below stormwater infiltration basins primarily has been limited to black-box modeling based on prior field results and limited understanding of pollutant behavior in media filters and soil columns. Appropriate vadose zone models are needed to accurately predict the “life” of an infiltration structure.

Phase II Methods
- Part 2 of this study will use undisturbed natural soil columns to explore the results of the earlier modeling.
  - A Wharton silt loam (Figure 3) has been collected from Cambria County, PA and we are in the process of finding a sandy soil for comparison.
  - There will be 4 test groups representing soil horizon groupings of OAB, AB, A, and O.
- Stormwater will be filtered through these columns and the removal rates of nutrients and heavy metals will be documented through effluent sampling and analysis. In addition, columns will be sacrificed periodically to determine loads in the soil retained both permanently and temporarily.
  - Testing will include pH, soluble salts, total carbon, total nitrogen, total phosphorus, potassium, magnesium, calcium, zinc, copper, sulfur, cadmium, lead, nickel, soil texture, soil porosity, soil percent organic matter, and soil cation exchange capacity.
- Since the organic horizon is often removed in infiltration systems such as pervious pavement, this research will also consider soil’s removal capacity below the organic horizon.

Acknowledgements
We would like to thank Water Environment Research Foundation for their funding and J. Bradley Mikula for his Phase I research.