USGS

# WATER RESOURCES RESEARCH GRANT PROPOSAL

**Title**: Scaling of saturated hydraulic conductivity and dyed-stained flow pathways

**Investigator**: Daniel Giménez, Assistant Professor

**Amount requested**: $25,000

**Priority Issues addressed by the research**

Soils in natural conditions exhibit a high degree of heterogeneity resulting from soil composition, soil formation processes, and biological activity. According to Dexter (1988) the spatial heterogeneity of the different components or properties of soil is what constitute soil structure. Modeling transport processes in structured (heterogeneous) soils is of capital importance for a range of applications from hydrology to environmental planning. For instance, regulation of pesticide use and impact of present and future releases of nuclear waste to the environment rely increasingly on simulation models that predict transport and fate of contaminants in the soil subsurface. Models currently used by consultants and regulatory agencies to predict the fate and transport of chemicals in soils were generated from laboratory data using homogeneous soils, and do not perform satisfactorily under field conditions (Jury and Flühler, 1992).

Initial results from the National Water-Quality Assessment Program found pesticides in the groundwater of about 54% of the 1034 sites sampled in agricultural and urban settings across the United States (Kolpin et al., 1998). Preferential flow (a term used to explain the rapid and unpredictable movement of water and chemicals through soil) is now regarded as the most significant field-scale leaching process affecting groundwater pollution. Areas of soil contributing preferentially to the transport of water and chemicals have been identified by applying a dye to the infiltrating water and visually inspecting the excavated soil (Flury et al., 1994; Gish et al., 1998). Three types of preferential flow have been identified: (1) macropore flow (movement of water and chemicals through continuous voids created by biological or physical processes), (2) finger flow (column-like flow pathways induced by abrupt changes in pore-size distribution), and (3) funnel flow (movement along inclined textural boundaries).

A further complication in modeling transport processes through structured soil is the uncertainty in extrapolating results from the scale at which measurements are made to the scale at which predictions are needed. The transfer of information between different spatial or temporal scales (i.e., scaling) is an area of research that is receiving increasing attention in hydrology (Sposito, 1998). Application of fractal techniques has revealed that many geophysical processes are scale invariant and that information can be transferred between scales following simple rules (Sposito, 1998).

In this project we propose to work with a soil of the Freehold/Collington series to:

- integrate models and observations of saturated hydraulic conductivity and preferential flow pathways over scales ranging from a few cm to over one meter.
- develop functional relations between model parameters characterizing saturated hydraulic conductivity and preferential flow in soil.

This project will study scaling rules of water and chemical flow over scales crucial to understand the control of soil structure on flow processes. These scales are typically not explored by traditional methods of geostatistics. Knowledge gained from this project will provide the basis for formulating models of transport processes at a landscape level. Quantification of preferential flow pathways in relation to parameters quantifying saturated water flow has the potential of improving current prediction models; which in turn would result on better evaluation of management practices and on reduction of groundwater pollution risks.