Project Summary

Intellectual Merit. Despite the growing footprint of urban landscapes and their impacts on hydrologic and biogeochemical cycles, comprehensive field studies of urban water budgets are few. The cumulative effects of urban infrastructure (buildings, roads, culverts, storm drains, detention ponds, leaking water supply and wastewater pipe networks) on temporal and spatial patterns of groundwater stores, fluxes, and flowpaths are poorly understood. Any environmental observatory network must include efforts to understand critical processes in urban landscapes, and urban groundwater can fairly be characterized as a missing link in our understanding of the integrated functioning of the natural and built environment. The goal of this project is to develop expertise and analytical tools for urban groundwater systems that will inform future environmental observatory planning and that can be shared with research teams working in urban environments elsewhere.

Our work plan draws on a robust set of information resources in Maryland provided by ongoing monitoring efforts of the Baltimore Ecosystem Study (BES), USGS, and the U.S. Forest Service working together with university scientists and engineers from multiple institutions. Consent decrees, signed by both Baltimore City and Baltimore County with U.S. EPA to mitigate failures in the sanitary sewer network, are leading to increased deployment of rainfall, groundwater and wastewater flow sensors including wireless telemetry for real-time data collection. The proposed project will leverage these resources with strategic investments in monitoring, modeling and database development to establish protocols for quantifying groundwater systems in urban areas.

A key concern is to bridge the gap between small-scale intensive field studies and larger-scale and longer-term hydrologic patterns using synoptic field surveys, remote sensing, numerical modeling, data mining and visualization tools. Using the urban water budget as a unifying theme, we propose to estimate the various elements of the budget in order to quantify the influence of urban infrastructure on groundwater. Proposed efforts include: (1) comparison of base flow behavior from stream gauges in a nested set of watersheds at four different spatial scales from 0.8 to 171 km^2, with diverse patterns of impervious cover and urban infrastructure; (2) synoptic survey of well water levels to characterize the regional water table; (3) use of airborne thermal infrared imagery to identify locations of groundwater seepage into streams across a range of urban development patterns; (4) use of seepage transects and tracer tests to quantify the spatial pattern of groundwater fluxes to the drainage network in selected subwatersheds; (5) development of a mass balance for precipitation over a 170 km^2 area on a 1x1 km^2 grid using recording rain gages for bias correction of weather radar products; (5) calculation of urban evapotranspiration using the Penman-Monteith method compared with results from an eddy correlation station; (7) use of numerical groundwater model in a screening mode to estimate depth of groundwater contributing surface water flow; and (8) data mining of public agency records of potable water and wastewater flows to estimate leakage rates and flowpaths in relation to streamflow and groundwater fluxes.

Broader Impacts. The project will provide guidance for development of environmental observatories, which are envisioned as providing critical information not only for basic science but for management of vital resources affecting the future health and well-being of both human populations and ecosystems. The project also will contribute to the education of graduate and undergraduate students. Graduate students will participate as research assistants during the summer field season, as coordinated through UMBC's Center for Urban Environmental Research and Education. We will emphasize recruitment of undergraduate student assistants from UMBC's Meyerhoff Scholars program, which has a national reputation for training of talented minority students committed to graduate education in science and engineering. Through the Baltimore Ecosystem Study LTER, an extensive outreach educational program managed by the BES education coordinator is already in place with inner city Baltimore schools and with suburban Baltimore County schools, which includes a hydrologic science module within the environmental science curriculum. Results from the proposed work can contribute to/enhance this ongoing curriculum development effort.