In 2009, the American Society of Civil Engineers gave the country’s water and sewage treatment, energy, and transportation backbone a barely passing grade of D, citing long-overdue maintenance and lack of much-needed upgrades. Patricia Culligan believes she can begin to address some of these inadequacies by changing the way engineers design infrastructure. At the same time, her work may help improve conditions for millions around the world living in rapidly growing urban slums who lack basic services.

Culligan would replace or augment these with smaller, more decentralized systems and facilities that can either meet the needs of a fast-growing population or help take the strain off an existing, aging network. One way is studying the role of small-scale infrastructure projects by examining the effectiveness of green roofs—flat roofs covered in a thin layer of vegetation—to cool buildings and reduce or mitigate storm runoff that flows from buildings into overburdened water treatment facilities.

Despite their growing popularity, Culligan has found that many arguments in favor of green roofs are lacking. “A lot of the claims being made are simply not proven,” she said. “If this is going to work, there needs to be a scientific rationale behind it.”

Culligan began her career studying the transport of chemical and radioactive contaminants through porous media such as soil, fractured rock, and ocean sediments, and later focused on mitigating contaminated groundwater. Since green roofs contain a thin layer of porous media through which water passes before being taken up by the plants or released, it was a natural segue to quantifying the technology’s function and effect.

Old wastewater treatment systems in places such as New York City are routinely overwhelmed by street and building runoff, resulting in millions of gallons of raw sewage being dumped in local waterways each year. Green roofs may help absorb some of the runoff.

Columbia has seven green roofs, many of which Culligan and her colleagues have instrumented to study heat and fluid flows through the system. But the heart of the local green roof movement is the South Bronx, where many neighborhoods, finding themselves politically isolated, have begun to look for their own community-based solutions to such socially complex problems as environmental pollution. For this reason, Culligan has made community partnerships and interdisciplinary research the core of her approach.

“Our work is about giving people a better life,” said Culligan. “It’s about helping society prosper.”

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