THESIS PROJECT PORTFOLIO

Sustainable Redevelopment of Fashion Square Mall

(Technical Report)

Value-Based Analysis of Sociotechnical Approaches to Green Infrastructure Implementation

(STS Research Paper)

An Undergraduate Thesis

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Urban development in the United States, marked by the rapid replacement of permeable land cover (grasslands and forests) with impermeable cover (roadways, parking lots and roofs) necessitates intervention from civil engineers to prevent urban flooding caused by stormwater runoff. Up until roughly the turn of this century, that intervention has consisted of the use of gray infrastructure – gutters, channels and pipes – that routes urban stormwater runoff off of roofs, parking lots and streets and into surface waterbodies as fast as possible. While these techniques are adequate at preventing urban flooding during average rain events, they curtail natural infiltration processes and result in the accelerated discharge of immense amounts of water into waterways. This overwhelms aquatic ecosystems by causing extreme erosion and exposing native organisms to large amounts of harmful chemicals picked up by the stormwater as it runs off of manmade surfaces. Erosion leads to excess sedimentation which further hinders natural processes that sustain aquatic and riparian life. In addition, in extreme storm events, where rainfall exceeds the capacity of existing gray infrastructure, these management practices can lead to dangerous flash floods. With climate change causing an increase in both frequency and intensity of storms, ecosystems and residents that are already at risk due to the use of grey infrastructure face ever-increasing risk in the future unless changes are made to the way that stormwater is managed.

The Meadow Creek watershed in Charlottesville, VA has not been immune to these issues associated with grey infrastructure. Meadow Creek is nestled within a vast sprawl of shopping centers, housing structures and roadways, all of which contribute to the watershed's high percentage of impervious surfaces. This, in conjunction with the use of grey infrastructure to manage stormwater running off of these impervious surfaces has meant the severe ecological degradation of Meadow Creek. In 2012, the Nature Conservancy conducted a stream restoration

project in response to Meadow Creek earning "impaired waterway" status from the Virginia Department of Environmental Quality (VA DEQ). While the restored stream reach appears more natural now and likely contributes less to excess sedimentation due to its newly stabilized state, the restoration project only addressed issues on a small portion of the stream and did little to address the root cause of the stream's impaired state – uncontrolled urban stormwater runoff. To address these issues, the project team utilized green infrastructure and imperviousness reduction techniques to redesign the Fashion Square Mall site, which the team identified as one of the sites within the Meadow Creek watershed in greatest need of stormwater management improvements. Stormwater models developed by the project team in EPA SWMM and i-Tree predict that this updated design will significantly reduce total runoff and peak flow from the site, into Meadow Creek. Further analysis done by the team suggests that the new design will make Charlottesville and Meadow Creek more resilient to climate change by making the site better prepared to handle runoff from more intense storms and by adding vegetation that will reduce the urban heat island effect.

Green Infrastructure (GI) – stormwater infrastructure that mimics natural infiltration, detention and filtration processes has recently been introduced and widely accepted as an eco-friendly and economically viable alternative to grey infrastructure. Common examples of green infrastructure include rain gardens, green roofs and bioretention ponds. These infrastructure techniques greatly alleviate water quality issues by allowing water to be filtered through porous soil media before entering waterways. In addition, by allowing water to infiltrate into the ground or be held in some sort of storage vessel, these techniques also greatly reduce issues associated with accelerated urban stormwater runoff like erosion and excess sedimentation. Along with benefits regarding stormwater management, analyses of the efficacy of GI often report the

positive effects that GI can have on the quality of life of people living in nearby communities. While GI shows so much promise for resolving urban stormwater issues, evidence shows that it has been distributed inequitably in such a way that its benefits rarely reach low-income communities of color (LICC). In the event that GI is located near LICC, gentrification often occurs, driving out LICC. The STS portion of this thesis portfolio sought to address the question: how can engineers and planners work to distribute GI equitably without causing green gentrification? An analysis of was conducted on two proposed frameworks for GI implementation that focused on using community engagement and policy as tools to avoid unintended social consequences. By focusing on the values associated with each approach the analysis provides insight on how the shortcomings of these frameworks arise and how understanding the values of all of the actors associated with GI implementation can help avoid these shortcomings.

Both the technical and STS portion of this portfolio provide valuable insights regarding urban stormwater management, GI and GI equity. The technical portion offers a thoughtful design plan that could actually be implemented at the Fashion Square Mall site. The impacts of this proposed design are backed up by sophisticated stormwater models that can be used to isolate specific features of the design and quantify the stormwater management benefits associated with them. Future work on this project would include making the more detailed design choices associated with the various buildings, courtyards and green spaces that were outside the scope the team's work. The STS portion offers a new approach to assessing GI implementation frameworks that illuminated policy and community engagement as key strengths and narrow focus as a key weakness associated with the frameworks that were assessed. In doing

so, it also laid the groundwork for further development of a more comprehensive value-based assessment of GI implementation.