ABSTRACT

ADVANCING GREEN STORMWATER INFRASTRUCTURE THROUGH UNIQUE APPLICATIONS, UNDERDRAIN IMPROVEMENTS, AND DESIGN CRITERIA

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Urban stormwater runoff contributes to flooding and surface water pollution, issues exacerbated by aging infrastructure, changing climates, and urbanization. Green stormwater infrastructure (GSI) can address these challenges by capturing and treating runoff near its source. However, its benefits are limited by unclear performance under unique conditions, ineffective treatment of specific pollutants, and variability in design criteria. This dissertation addresses these challenges through four investigations.

First, it evaluates an interconnected rock swale and bioretention system in treating runoff from an elevated highway interchange, which is a unique setting that generates runoff with high energy and pollutant concentrations. Results showed that total suspended solids and total phosphorus concentrations in highway runoff are orders of magnitude greater than other surfaces, yet rock swales and bioretention in series effectively reduced concentrations and pollutant loads.

Second, runoff from highways may contribute to thermal pollution of urban waters, and it is unclear how specific treatment steps implemented to manage highway runoff, particularly rock swales, mitigate or exacerbate stormwater temperatures. Findings revealed that rock swales warmed runoff to a greater degree than highway decks, while sequencing bioretention downstream reduced temperatures below thresholds for cold-water species such as trout.

Third, while bioretention effectively treats many pollutants, it often increases dissolved phosphorus concentrations, which can harm downstream ecosystems. To address this, an end-of-pipe filter containing activated alumina and iron filings was developed and installed at two bioretention systems. After several months, the filters reduced the mean concentrations of dissolved reactive phosphorus (39-49%).

Finally, individual states and localities prescribe GSI design guidelines; however, it is unclear how design criteria vary or why. To address this, data was compiled from 59 GSI design guidelines across the U.S., and significant variations were found in design elements such as slope, soil, and geometry, much of which correlated with factors that follow east-west trends (e.g., longitude, annual rainfall volume, and topography). Overall, this dissertation helps advance GSI by demonstrating the utility of well-designed interconnected GSI practices for treating highway overpass runoff, proposing an approach to reduce dissolved phosphorus concentrations through underdrain filters, and revealing underlying reasons for variability in GSI designs.