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Research article

A tale of two rain gardens: Barriers and bridges to adaptive management of urban stormwater in Cleveland, Ohio

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ABSTRACT

Green infrastructure installations such as rain gardens and bioswales are increasingly regarded as viable tools to mitigate stormwater runoff at the parcel level. The use of adaptive management to implement and monitor green infrastructure projects as experimental attempts to manage stormwater has not been adequately explored as a way to optimize green infrastructure performance or increase social and political acceptance. Efforts to improve stormwater management through green infrastructure suffer from the complexity of overlapping jurisdictional boundaries, as well as interacting social and political forces that dictate the flow, consumption, conservation and disposal of urban wastewater flows. Within this urban milieu, adaptive management—rigorous experimentation applied as policy—can inform new wastewater management techniques such as the implementation of green infrastructure projects. In this article, we present a narrative of scientists and practitioners working together to apply an adaptive management approach to green infrastructure implementation for stormwater management in Cleveland, Ohio. In Cleveland, contextual legal requirements and environmental factors created an opportunity for government researchers, stormwater managers and community organizers to engage in the development of two distinct sets of rain gardens, each borne of unique social, economic and environmental processes. In this article we analyze social and political barriers to applying adaptive management as a framework for implementing green infrastructure experiments as policy. We conclude with a series of lessons learned and a reflection on the prospects for adaptive management to facilitate green infrastructure implementation for improved stormwater management.

1. Introduction

Managing stormwater runoff from impervious surfaces that dominate urban areas poses a constant challenge for networks of governance tasked with providing municipal water and sanitation services. In the U.S., there is a combination of aging, degraded wastewater conveyance infrastructure and a dominant public perception that stormwater runoff is not an immediate environmental and public health concern. These circumstances combine to create complex economic, social and political barriers to effective stormwater management (Keeley et al., 2013). As a result, many major U.S. urban areas suffer from recurring combined sewer overflow (CSO) events. A CSO event involves the discharge of combined sewage and stormwater to water bodies, many of which are relied on as drinking water sources. CSO events are a result of stormwater runoff volumes pushing wastewater systems beyond

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design capacity and intruding into the sanitary portion of the sewer systems (Fig. 1). CSOs are regulated under the National Pollutant Discharge Elimination System (NPDES—pollution permitting system under the U.S. Clean Water Act, 33 U.S.C. § 1342), and as of this writing (2016), there are 859 active permits for CSOs under the covering approximately 11,000 outfalls nationwide (Authors' personal communication with U.S. EPA Office of Water, 26 May 2016).

Due to a combination of factors—underground location, deferred maintenance and ongoing urban development—sewer infrastructure has become increasingly expensive and difficult to retrofit or replace, especially given the climate of fiscal austerity associated with declining tax and ratepayer bases in post-industrial U.S. cities (e.g., Cleveland, OH, Detroit, MI, Milwaukee, WI, and others) (Hoornbeek and Schwarz, 2009). Green infrastructure (GI) installations (e.g., rain gardens, green roofs, constructed wetlands) have the potential to reduce costs and transform large tracts of land into ecosystem service-producing landscapes (Green et al., 2015a). GI is an attractive alternative for managing stormwater because it can increase the capacity for stormwater volume capture and detention within urban watersheds (U.S. EPA, 2010; Autixier et al., 2014). By utilizing natural processes including interception and infiltration, GI can slow the timing of runoff conveyance to receiving waters and can also reduce the actual amount of runoff volume reaching engineered 'gray infrastructure' (i.e., wastewater conveyances). Recent U.S. EPA (2014) research has shown that certain GI designs can significantly improve water quality by, for example, removing approximately 90% of total suspended solids, organic pollutants and bacteria, as well as up to 98% of sediment-associated heavy metals and 83% of total phosphorus. The impression that GI may also produce a host of co-benefits (social, economic and environmental), including contributions toward urban revitalization and provisioning of multiple ecosystem services, may provide additional incentive for implementation (Keeley et al., 2013).

However, GI suffers from many of the same barriers to implementation and acceptance as stormwater management in general, as well as additional barriers specific to the non-traditional nature of its hybrid natural-engineered approach. GI implementation is clouded in uncertainty: there are very few field studies on GI effectiveness (e.g., Autixier et al., 2014); straightforward financing mechanisms are rare; land ownership and maintenance issues detract would-be adopters; and there is a general lack of coordination among government agencies potentially involved in GI design, implementation and maintenance processes (Keeley et al., 2013; Shuster et al., 2008). Thus, stormwater managers are often unsure of how to site, design and implement GI, in addition to how to finance it (Hoornbeek and Schwarz, 2009). There is very little data to correlate decreased volumes (or adjusted timing) of stormwater runoff with GI capacity.

The uncertainty surrounding GI for stormwater management can be addressed by applying the structured decision-making processes of adaptive management (AM) to implement GI as experiments, and to collect multidisciplinary data to assess both the social and biophysical outcomes from these experiments. Under a framework of AM, new information can be diffused throughout complex networks of urban stormwater governance (governments, agencies, non-governmental organizations (NGOs) and residents), leading to increased social learning and adjustments in GI policy based on assessments of ongoing monitoring and data collection. This has been the goal of an informal coalition of U.S. EPA scientists and compliance officers, Regional Sewer District officials and NGO practitioners working on GI implementation in the Slavic Village neighborhood of Cleveland, Ohio. Individually each group pursued different organizational goals, but collectively they leveraged interests toward applying an AM process to better understand the potential of GI for stormwater management, the provisioning of ecosystem services and urban revitalization.

In places like Cleveland, Ohio, there is a window of opportunity arising around the potential to use GI as a stormwater management tool to reduce CSO events that negatively affect public health by degrading water quality. While Cleveland suffers from the problems of a shrinking city (e.g., declining tax base for infrastructure improvements), there is an abundance of vacant land potentially available for GI implementation. In addition, there are multiple organizations working at the neighborhood-scale in Cleveland interested in applying GI for the associated co-benefits that have the potential to address additional environmental and social concerns beyond stormwater management. Documented co-benefits include greater urban ecosystem services such as increased food production, benefits to pollinators and improvements in water quality and environmental aesthetics (Keeley et al., 2013; Green et al., 2015a). As a result of implementing a regional green infrastructure plan, the Northeast Ohio Regional Sewer District (NEORSD) anticipates realizing additional co-benefits that range across community (e.g., recreation opportunities, improvements to blighted communities, stabilization of localized depopulation), environmental (e.g., climate change mitigation (Mason and Montalto, 2015), air and water quality improvements) and financial (e.g., project life-cycle cost savings, real property value increases, job creation and economic development) categories, including $810,000 in annual direct and indirect economic benefits (NEORSD, 2015). As Cleveland struggles to right itself after decades of disinvestment, these co-benefits have positioned GI as an important component of local planning efforts around vacant land reuse (Cleveland City Planning Commission, 2011). The challenge of implementing GI in local planning is scaling up local vision and capacity to match the legal and environmental constraints of stormwater management, including the federally mandated CSO

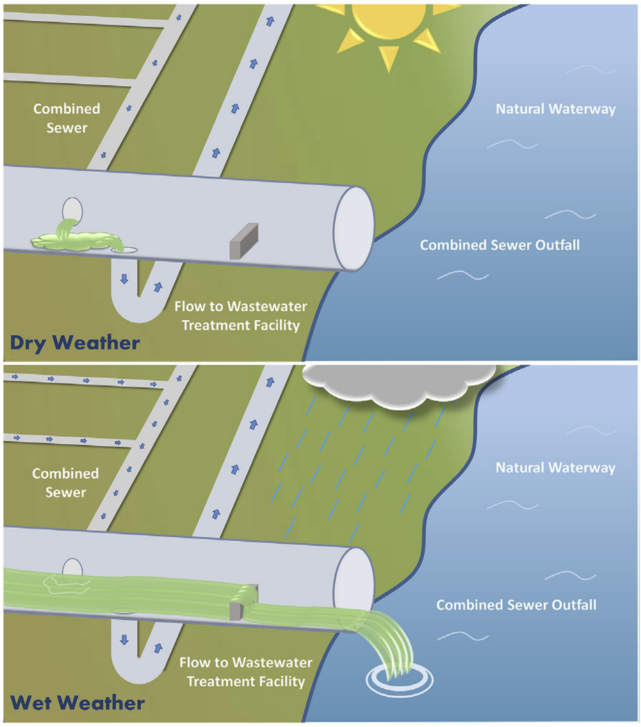

Fig. 1. Stylized representation of a combined sewer during dry and wet weather conditions. Wet weather can result in a CSO, where raw sewage and toxic substances are discharged into water bodies.