Sustainable Cities and Institutional Change: The Transformation of Urban Stormwater Management

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Submitted to the Department of Urban Studies and Planning in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Urban and Regional Planning at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 2018

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Abstract
It is widely argued that a sustainable future depends on the capacity of cities to substantially alter how they grow and consume natural resources. Research on sustainable cities has typically emphasized how this change ought to be achieved, outlining specific interventions in the form of new policies and technologies. Problematically, we know far less about why urban institutions change, when they do, in the support of sustainability objectives. Why have some cities progressed in translating ideas about environmental sustainability into enduring institutional reforms while other similarly situated cities persist under the status quo?

Over the past fifteen years, for example, sustainability advocates in the United States have touted green stormwater infrastructure (GSI)—a decentralized network of rainwater capture and infiltration systems—as a more sustainable and less costly alternative to building more and bigger underground pipes to control polluted urban runoff and sewer overflows, as required under the Clean Water Act. Yet the extent to which cities facing very similar municipal pollution problems adopt GSI varies widely. This dissertation seeks to account for the disparate adoption of, and investment in, this innovative, land-based practice through an in-depth investigation of four US cities: Boston, Philadelphia, Portland, and Washington, DC.

Some observers characterize the development of sustainable urban infrastructure as contingent on the commitment of environmentally-minded local decision makers or a supportive, engaged public. In contrast, my research shows that cities that have invested most heavily in GSI have done so to achieve compliance with the stringent National Combined Sewer Overflow (CSO) Policy. Yet whether or not a city adopts GSI to control CSOs it is a function of three things: the structure of municipal water management and infrastructure, which I term the “legacy system;” the existence of an effective change agent or “policy entrepreneur” within the local water utility; and the acceptance of GSI as a legitimate control technology in the regulatory policy system at the time a city planned and implemented its CSO program. Based on my analysis, I provide recommendations for how innovative stormwater management technology and practices might be stimulated in varied municipal planning contexts.

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Judith A. Layzer
ACKNOWLEDGEMENTS

Getting to the end of this project took a long time. A very long time. And I have many people to thank for their help along the way. I am particularly thankful for the brilliant Judy Layzer, who was my advisor, mentor, teacher, and friend over ten inspiring years. She helped me develop as both a scholar and as a human. Her wisdom, passion, compassion, hilarity, and absurd quantities of energy are truly missed. I’m fortunate for the time I spent with her, and grateful that her memory and voice is part of my daily life—even when she’s just correcting my grammar.

I’m equally grateful that three years ago Larry Susskind agreed to help guide me to this project’s finish line with his usual generosity and genius. Furthermore, I also could not have had better, smarter, or cooler readers; in addition to being the consummate insider for my study of green stormwater infrastructure, Anne Spirn unearthed new source material for me and provided thoughtful feedback and critiques that improved my thinking. Kathy Thelen’s recommendations, both at the beginning and end of this project, were hugely helpful in shaping how I collected, analyzed, and ultimately interpreted my data. I thank my entire committee for their patience, support, and enthusiasm—particularly at times when I felt undeserving of it.

I was also supported by a number of individuals and organizations. Many thanks to Professor Eran Ben-Joseph and the MIT Office of Graduate Education for their help in making sure I didn’t fall through any cracks while I worked remotely. Duncan Kincaid was a tech saint who also sent great emails when students needed them the most. Thanks also to the Martin Family Foundation for selecting me as an MIT Sustainability Fellow. Outside MIT, the Lincoln Land Institute’s Lowell Harris Dissertation Fellowship helped support my field work. The Brooklyn Writer’s Space in Cobble Hill, Brooklyn has been an oasis for the past six months.

In the most literal sense, I could not have completed this project without the individuals in Philadelphia, Boston, Portland, and Washington DC who shared their time, perspectives, wisdom (and files!)—even while they were on vacation or traveling abroad. They alone permitted me to piece together the stories conveyed in this dissertation, and I’m incredibly grateful to them. People who allowed me to pester them excessively, shared extensive documentation, and to whom I owe a particular debt: Marc Cammarata, Howard Neukrug, Anthony Iarrapino, Todd Borci, Dan Vizzini, Arnel Mandilag, and Jennifer Chavez. Jo Anne O’Hara was invaluable in the archives of the Southeast Branch of the Pennsylvania Department of Environmental Protection. Adam Levine, who maintains the fantastic historical site, PhillyH2O.org, was a delightful font of knowledge about Philadelphia’s dark and dirty past.

Although I complained a lot about the weather, Cambridge gifted me the most brilliant friends and colleagues. I can forgive the years of bitter cold and darkness because of Charlotte Cavaille, Victoria del Campo, Alix Lacoste, Alexandra Eurdolian, Kian Goh, Shomon Shamsuddin, Graham Clure, and Jeff Lieberman. Other friends from far and wide kept me sane and laughing through some tough days: Nerissa Cooney, Sam Beebe,
Eleven months ago, I was also fortunate to add two amazing new parents to my collection, and gain my first ever siblings. Thank you, Kate for being a great friend, and the best sister; and I couldn’t ask for a better brother than Seth Laucks. Many thanks also to Bonnie and Al for welcoming me into their family and home, taking care of me when I needed it, and producing the love of my life.

My mom has been a steadfast cheerleader and filled these past years with laughs, love, wisdom, and more laughs. My second mom, Chrissy, has had my back through thick and thin and has talked me through many tough (and not so tough) decisions. My dad has unconditionally supported me and always told me that I could succeed at anything; and if I couldn’t, I could always do something else—without any love lost. You three are truly the greatest.

Alfie. I love you infinitely. Thank you for everything. We did it... Onward.
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In an increasingly urbanized world a sustainable future depends on the ability of cities to change how they grow and consume resources. This is now a nearly three-decades old argument, articulated as international consensus by the United Nations' Brundtland Commission in 1987. Highlighting the ecological crises unleashed by conventional development—from acid rain, to climate change, to mass extinctions—the commission formulated what remains the most famous definition of sustainable development: meeting the needs of the current generation “without compromising the ability of future generations to meet their own needs” (UNWCED 1987). Recognizing that environmental problems could not be neatly compartmentalized within national boundaries, the commission advocated an international response. But their report, Our Common Future, also homed in on a locus for transformation: the city. Cities, they noted, accounted for the majority of the world’s resource and energy use, and pollution, and would soon house most of humanity (UNWCED 1987).

The need for urban transformation has only grown more urgent since “Our Common Future” was written. As its authors projected, by 2008 over 50% of the global population lived in urban areas; by 2050, 70% will (UNDESA 2015). But cities have yet to achieve the efficiencies supposedly enabled by their concentration and connectivity (Swilling et al. 2013, UNDESA 2010). As the developers of the ecological footprint methodology note, modern cities are marked by a dependence on a “vast and increasingly global hinterland of ecologically

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1 It is worth noting that there is still uncertainty and disagreement about how to define and measure so-called urban areas (Mason 2017). However, I focus my analysis on well-defined urban political jurisdictions.
productive landscapes for their survival and growth” (Rees and Wackernagel 1996, 236). Cities occupy only 2-3% of the world’s landmass but have been estimated to consume 60-80% of the world’s material and energy flows while producing a similar proportion of total wastes (IEA 2008; OECD 2011; Swilling et al. 2013). Added to this, since 1990 cities have not become denser but spatially expanded at a greater rate—up to 20% faster—than their populations have grown, compromising the ecology of the rural landscapes that form their resource base (Angel et al. 2011; Seto et al. 2011; Seto, Güneralp, and Hutyra 2012). While there is significant variation in intensities and trends across countries and social classes, taken together, cities in the industrialized North are the worst offenders, appropriating resources from landscapes up to one hundred times their own size to support their levels of consumption and waste disposal (Rees and Wackernagel 1996; UNDESA 2010). Analysts contend that development and resource use in these cities must change if the planet is to accommodate the projected growth of poorer nations (McGranahan and Satterthwaite 2003; Newton 2008; Swilling et al. 2013).

Optimistically, during the first part of the 21st century, municipal leaders in the United States—by many counts the most wasteful and voracious nation in the world in terms of consumption per capita—were taking up the sustainability mantle and unveiling cross-sector initiatives that sought to enhance their city’s livability while reducing its environmental impact. Some of the country’s most populous municipalities were even publicly competing on the basis of their “green” image. Perhaps most famously, throughout his final terms as mayor of Chicago, Richard Daley boasted that he was making Chicago the “greenest” city in the country—a 21st century metropolis—and he credited these efforts with attracting Boeing’s headquarters to Chicago instead of Denver in 2001 (Schneider 2006).

By the mid-part of the 2000s it seemed a large number of municipal leaders had come to a similar conclusion: a sustainable city was a desirable city; sustainability was the future. For cities struggling with decades of population loss, a declining industrial base, and disinvestment, promoting sustainability may have
appeared to be a promising and risk-free strategy to lure educated professionals, as well as the globally competitive businesses that want to employ them. Whatever the motivation, a 2009 study found that 25% of the largest cities in the United States had a formal sustainability plan, and 50% had just completed or were in the process of writing one (Living Cities 2009). The same study also reported that in 75% of the largest US cities officials ranked sustainability as one of their top five concerns.

Although sustainability advocates and municipal leaders in the United States have articulated transformative agendas for urban systems, implementation of these visions is uneven (Dernbach 2009; ICMA 2016; K. Portney 2013,). Where it has occurred, progress is often at the margins, in the form of policy resolutions, demonstration projects, or retrofits to government buildings (Svara 2011). While disappointing to sustainability enthusiasts, this should probably not be surprising. Modifying the rules, norms, and decision-making procedures (i.e. the institutions) that shape urban form and function is not easy to do, a fact well known to scholars and practitioners alike. Organizations and institutions are characterized by path dependency, the observation that “preceding steps in a particular direction induce further movement in the same direction,” which makes changing course costly and largely undesirable (Pierson 2000a, 252). In this sense, what is remarkable is that some cities have radically transformed aspects of their development in the support of sustainability objectives—not that most cities have struggled to do so.

This dissertation seeks to understand the dynamics of that change, in order to inform urban sustainability advocacy and policy. Research on sustainable cities has largely focused on the ways in which some cities have changed to become

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2 In distinguishing between institutions and organizations, I am largely in agreement with James March, who writes: “For me, an institution is a collection of rules and organizations can be thought as instruments for acting within rules. Organizations are also collection of rules, so I do not make a sharp distinction between institutions and organizations. I would say that some people emphasize the institutional aspects of organizations, which means to focus on stable rules and how they go over the time. However, suppose I make a distinction, what difference does it make?” (March, Friedberg, and Arellano 2011, 239).
more sustainable; or it has emphasized how cities ought to change, and outlined specific interventions in the form of new policies, designs, and technologies. Such studies have revealed numerous creative responses to the urban sustainability challenge, the sheer breadth and depth of which preclude their enumeration here. Needless to say, innovative approaches to energy efficiency and building policy, water conservation and pollution control, and land management and transit-oriented development abound. On the other hand, we know very little about why urban institutions change, when they do, in the service of sustainability objectives (K. Portney 2013; Saha 2009). This puzzle is at the heart of this dissertation: Why do some cities translate ideas about sustainability into enduring reforms, while others depart only modestly from (or decline to change) the status quo?³

Specifically, I examine transformation in one sector that is of interest to many sustainability advocates: urban water management. For most of history, engineers and developers have viewed water in the urban environment as a threat to be tempered with design. In the interest of avoiding flooding or controlling disease, wetlands were drained and built over; urban creeks and streams encased underground; surfaces paved, graded, and piped to rapidly convey rainwater out of the city and into local rivers and bays. As urbanization intensified this so-called “gray” water infrastructure spawned its own set of environmental problems. By increasing the percentage of land cover that is impervious to water, urban development transforms rainwater that would otherwise have been slowed and infiltrated by vegetation and soils into runoff. Channeled into water bodies at much greater volumes and velocities than pre-development and loaded with the urban pollutants it has mobilized, this surface flow has devastated aquatic habitats. Waterways near cities with combined sewer systems—where sewage and stormwater are co-collected in a single pipe—fare even worse. While modern

³ Sustainability is a fluid term. When I refer to sustainability, I mean ecological urban sustainability, which aims to reduce the footprint of cities and encourage design and land use development that works with natural processes instead of against them.
systems drain storm and sewer water separately, in the United States an estimated 722 of the oldest communities rely on archaic combined systems. In relatively dry conditions, wastewater flows directly to the treatment plants. But when it rains and water inflow exceeds treatment capacity, these sewage systems overflow, by design, at designated outfalls resulting in combined sewer overflows (CSOs). Every year these systems pour billions of gallons of raw sewage directly into local rivers and streams.

Since the 1960s landscape ecologists and architects have touted an alternative urban drainage and development paradigm, one that seeks to mimic the pre-development hydrology of the landscape. In the last two decades, this concept has been translated into a set of stormwater practices and technologies known as green stormwater infrastructure, or GSI, which is now widely viewed as a more cost-effective and environmentally sensitive approach to the challenges posed by urban runoff. GSI is a decentralized network of devices that retain, infiltrate and treat stormwater on site, keeping as much runoff out of the sewer systems as possible. This is generally accomplished through a variety of engineered surface level, soil-water-plant systems that can be integrated throughout even the densest city.4 Pioneered by municipal administrators and stormwater practitioners in the Pacific Northwest and the Chesapeake Bay region in the 1990s, individual GSI technologies include raingardens, bioswales, green roofs, pervious paving, and infiltration trenches, among others. According to its supporters, GSI offers a number of advantages over traditional infrastructure. Unlike gray infrastructure, GSI relies on passive technology. It does not require as much energy to construct, or to run; there are no pumps and no treatment plants. Vegetated infiltration systems also provide numerous other co-benefits to water quality and quantity control: they cool the surrounding area and reduce air pollution; create open space

4 Confusingly, GSI technologies are not always “green.” Pervious paving, dry wells, and underground cisterns that do not include vegetation but still retain stormwater and infiltrate it into the earth are also considered GSI.
and habitat; and can even raise property values in surrounding neighborhoods.\(^5\) Finally, as climate change alters rainfall patterns, large gray centralized systems may begin to fail more frequently than predicted, or may turn out to be oversized at considerable unnecessary expense. Because it is decentralized, a green infrastructure system is more easily modified and is more adaptive in the face of climate variability.

There are two primary reasons why I have chosen to study the development of sustainable cities using the lens of urban water management. First, the municipal systems that sustainability advocates propose to overhaul are managed by specialized departments and agencies, many of which operate with a great deal of independence from elected officials and within a policy community and regulatory framework that may span the local, state and federal. Energy, water, food, land development—decisions affecting each of these sectors take place within particular "subsystems," containing different, though sometimes overlapping, actors and organizations, technologies, historical trajectories, and institutional arrangements. Understanding modern sustainable urban transformation, therefore, requires looking in depth at these separate systems, where there are sure to be very non-generalizable processes at work; but it is also my belief that these systems are not so unique that lessons cannot be drawn from one domain to another—from urban water management to municipal energy systems, for example.

Second, conceptually and technically, GSI is a major departure from the status quo. It not only challenges traditional engineering techniques, but demands new operation and maintenance models, unprecedented levels of coordination among public and private actors, and extensive interagency cooperation. And yet despite these challenges, a number of cities have begun to radically embrace this innovative approach to manage their stormwater pollution problems.

\(^5\) For a comprehensive listing of relevant studies, see EPA’s Green Infrastructure Research webpage: https://www.epa.gov/green-infrastructure/green-infrastructure-research
Most significantly, in 2011 the City of Philadelphia— or more precisely the Philadelphia Water Department— began implementation of its CSO management plan, Green City, Clean Waters. Like many older cities that rely in whole or part on sewer systems that combine stormwater and sewage in a single pipe, Philadelphia’s system routinely overflowed during rain events, releasing a toxic mix of untreated sewage, industrial waste, and polluted runoff into local rivers and creeks. Green City, Clean Waters outlined how Philadelphia would curb its estimated 16 billion gallons of annual overflow. Although this “long-term control plan” is a standard federal requirement for all communities with combined sewer overflows, Philadelphia’s approach represented a stunning departure from precedent. While most of its peer cities were relying on conventional technology and separating sewer lines or building enormous underground water storage tunnels, Philadelphia committed $1.67 billion to a 25-year program that will transform 10,000 acres of the city into a stormwater sponge through the application of green stormwater infrastructure.

Although Philadelphia’s plan generated a great deal of excitement, it has remained something of a mystery why Philadelphia— as opposed to a more environmentally progressive city— suddenly emerged as the national forerunner in GSI implementation. Most public commentaries on Philadelphia’s decision highlighted the cost savings and multiple benefits conferred by choosing “green” over “gray” to meet federal water pollution regulations (Kessler 2011; Robbins 2018; Wise 2008). Particular individuals were also credited for the outcomes, including Philadelphia’s sustainability-friendly mayor, Michael Nutter, as well as the water department’s innovative and exceptionally persistent commissioner, Howard Neukrug (Madden 2010; Mittermaier 2016). Without denying the important role played by each of these factors, the financial calculus and leadership arguments are problematic when used to understand outcomes in other cities. These explanations alone cannot fully explain the pattern of uneven adoption of green stormwater infrastructure across the country. For example, other cities facing
similar pollution problems, with innovative utilities, and supportive mayors have not committed to implementing GSI on a similarly massive scale. Furthermore, every municipality and water utility is under pressure to save its ratepayers money. It is unclear why any city seeking to reduce water pollution would opt for more expensive technology when there is a cheaper and more sustainable alternative.

Inspired by the events in Philadelphia, two research questions drive this dissertation: Why are some cities widely implementing innovative green stormwater technologies and supportive policies, while other cities, facing similar water quality and quantity challenges and regulatory pressures, are not? What does this tell us about the dynamics of change in cities and the prospects for facilitating sustainable urban transformation? To answer these questions, I undertake an in-depth, historical analysis of the evolution of water management in Philadelphia and Boston, and use Portland and Washington, DC as shadow cases to test the validity of and qualify the conclusions drawn from my primary cases. A key premise of this study is that sustainable urban change cannot be understood apart from the broader regulatory and policy systems in which cities are embedded; for this reason, a large part of my study is also dedicated to tracing the historical developments and political dynamics of the federal water pollution control system, as it relates to municipal water management. My analysis, therefore, is best viewed as two distinct but interconnected parts. One part (“The Context”) is focused on the evolution of the federal water pollution policy, while the second part (“The Cases”) shows how that system is filtered through local institutions and organizations, leading to divergent water management and infrastructure outcomes.

The analysis presented in the remaining chapters supports the following general conclusions. Cities where GSI has been implemented to the largest degree, and in which we see the most extensive institutional change, are those in which wastewater utilities have used the technology to comply with federal policy on combined sewer overflows, which is much a more stringent policy than the one
governing municipal stormwater pollution. Whether or not a city adopts GSI to manage its CSOs, however, is a function of three things: the structure of municipal water management and infrastructure, which I term the “legacy system;” the existence of an effective change agent or “policy entrepreneur;” and the acceptance of GSI in the regulatory policy system at the time a city planned and implemented its CSO program.

As a result of unique historical trajectories, urban drainage infrastructure and the organization of water management powers— that is, who has responsibility to do what relative to sewage and stormwater— vary significantly from city to city. For example, while stormwater is almost always locally controlled, sewage systems may be managed by a local or regional body; some cities have tightly coupled water systems, and source their drinking water from the same waterbodies in which their sewers discharge. The particular characteristics of a city's legacy system may facilitate or discourage investments in GSI. Most significantly, where a single local utility is responsible for both sewage and stormwater conditions are favorable for integrative, land based water management, such as green stormwater infrastructure. This is because utilities with broad authority are well positioned to think holistically about urban water management. They tend to house a greater diversity of engineering skills; allow a cross pollination of ideas and approaches; and may have a history of land-based water pollution control. Furthermore, integrated water utilities directly benefit from infrastructure solutions that solve cross-sectoral problems— in this case, stormwater pollution and sewage overflows— as GSI does. In cities where responsibility for stormwater and sewer services is fragmented, conditions are less hospitable to the adoption of GSI. In particular, where a regional authority manages sewage, barriers to GSI are high. These barriers include a limited mandate that does not encompass stormwater management, the (perceived) costs and challenges of coordinating across multiple jurisdictions, and the agency's
relative inexperience with stormwater management tools. These all discourage regional sewage authorities from using GSI.

Second, before an organization can alter its operations, someone has to introduce and create internal support for new practices—a finding that substantiates the claim that leadership is critical to innovation and change. However, given the political autonomy of water utilities and the technical complexity of the work they do, the critical (i.e. successful) change agent is far more likely to be an administrator rather than an external, elected official. The cases also suggest that a GSI policy entrepreneur is more likely to emerge, and have more success, in an integrated water agency, where there are multiple incentives for holistic problem solving.

Finally, the federal Clean Water Act and the diverse set of actors (the “policy subsystem”) engaged in its implementation circumscribe the activities of every wastewater and stormwater agency. Indeed, since 1972, the Clean Water Act’s policies for municipal pollution control have been the primary drivers of the biggest and costliest upgrades to urban wastewater infrastructure, including CSO control infrastructure. What are considered acceptable technologies or best practices—primarily by regulators at the federal Environmental Protection Agency (EPA), which administers the Clean Water Act, but also by litigious environmental advocacy organizations—severely limit the options available to cities considering new pollution control programs. Best practices change over time, however. They change as new ideas take root in EPA through internal processes. But they also change through pressure exerted by external actors, like environmental advocates and local communities themselves, as they learn from their and others’ experiences, and work to translate new ideas into policy. The point is, timing and chronology matter. When and how the regulatory community accepted GSI as an acceptable CSO control technology has strongly influenced the extent of its implementation in cities. In fact, an unfortunate irony emerges within the cases: cities that began “early” sewage clean-up efforts in the late 1980s and 1990s were to
a large extent locked into spending billions of dollars on less sustainable approaches because at that time the only acceptable options were pipes, treatment plants, and tunnels.
PART I: THE FRAMEWORK
THEORIES OF INSTITUTIONAL CHANGE AND GREEN URBAN INNOVATION

Water departments that have committed substantial resources to implementing green stormwater infrastructure have changed their modes of operation in important ways; they have cultivated supportive organizational norms, rewritten internal policies, altered decision-making structures, as well as promulgated rules and formal plans that require or encourage GSI. That is, the institutions—the "norms, rules, and strategies"— governing how water pollution is understood and managed have transformed (Ostrom 1990). In this chapter I review several theories of institutional change that I use as alternative hypotheses against which I assess my cases of green stormwater infrastructure adoption. Those who study institutions do so from varying analytic perspectives, and even with different definitions of what constitutes an "institution." Furthermore, resulting theories are often derived from empirical analyses of political institutions at the national level (e.g. operational rules in Congress or welfare policy). For that reason, I attempt to be very precise in situating each model within its intellectual tradition and describing how I apply it to my study of institutional change in municipal water pollution management. In particular, I examine models from "new institutionalism" and policy sciences. I also discuss their relationship to "transitions management," an approach rooted in evolutionary ecology and management that has recently offered specific frameworks for understanding the adoption of sustainable technologies in varying contexts. I conclude by describing my methods for assessing and explaining the extent of GSI adoption in each of my four case study cities.
INSTITUTIONAL STABILITY: EFFICIENCY, HISTORY, AND IDEAS

It is useful to explore institutional change in the context of its opposite: stability. Although it is widely noted that institutions are relatively resistant to change, the source of that stability varies according to analytic perspective, with important ramifications for how institutional transformation can be explained. The behavioral revolution of the 1960s sparked a renewal of interest in the dynamics of institutions and their role in shaping political outcomes, producing a suite of approaches collectively termed the “new institutionalism” in political science. In the 1970s, for example, rational choice theorists introduced institutions as a way to correct for inconsistencies between their deductive agent-based models and reality. Institutions, they argued, could explain why one did not observe the rapid issue cycling in legislatures that their models predicted. The resulting theory of “structure induced equilibrium” posits that institutions act as scripts that regularize political processes; they assign roles to actors, sequence their strategic interactions, and order the availability of information (Shepsle 1979, 1986, 2006). Maximizing actors with stable preferences strategize around the constraints imposed by institutions, producing political equilibrium. In this view, institutions are designed by voluntarily contracting actors to solve a variety of collective action problems, producing value for their constructors (Hall and Taylor 1996; Moe 2006). Pierson (2004, 107)—who has roundly criticized this functionalist perspective—summarizes the approach:

...international regimes facilitate agreements through issue linkage and the reduction of monitoring costs...congressional committees prevent cycling and enable gains from ‘trade’ among legislators with different priorities...or rationalize the flow of scarce information.

In short “the effect of institutions explains their presence,” as well as their persistence (Pierson 2000b, 476). Taken together, the rational choice approach argues that institutions are created to efficiently solve collective action problems and produce a political structure where it is no one’s interest to provoke change.
Competing perspectives also arose to correct the excesses of rational choice: its emphasis on deductive theory, bias against normative explanations, methodological individualism and inputism (Peters 1999; Scott 2008). The theory of “path dependency” challenges the ahistoric and frictionless account of institutional functionalism. Path dependency is the observation that “preceding steps in a particular direction induce further movement in the same direction” (Pierson 2000a, 252). Instead of envisioning institutions as efficient coordinating mechanisms, or actors as voluntaristic negotiators, “historical institutionalists” argue that institutions emerge at critical periods or “junctures” and are propelled along a particular pathway, from which it is increasingly difficult to detour. In this view, it is just as plausible, if not more so, that a convergence of societal forces rather than the planning or negotiating of empowered actors produce institutional arrangements and that these arrangements contain parts that rarely fit into a “coherent, self-reinforcing, let alone functional, whole” (Thelen 1999, 384). In this view, institutional persistence, or reproduction, is not a choice; it is induced by increasing returns or “coordination effects” (Thelen 1999, 392). Sunk costs, learning, and adaptive expectations—i.e. commitments made with the belief that rules will stay constant—reinforce existing institutions, and make changing course not only difficult but also “unattractive” (Pierson 2000a). Thus Institutions formed in the past constrain and structure actors' policy choices (Peters 1999). Indeed, several decades of comparative empirical scholarship in this vein demonstrate how respective differences in institutional trajectories— as opposed to political culture or voter preferences—account for divergent national policy outcomes in the face of similar challenges.7

While historical institutionalists focus on the legacy effects and feedbacks of past decisions, many still assume political actors are driven by rational self-

7 For a review, see Steinmo (2008).
interest. Modifying—and in some cases rejecting—this economic model of human behavior, sociological perspectives have highlighted the power of shared ideas as stabilizing elements in political organizations (Berger and Luckmann 1968; DiMaggio and Powell 1983; DiMaggio and Powell 1991; Selznick 1949; Zucker 1977). These scholars emphasize the cultural-cognitive aspects of institutions—"the shared conceptions that constitute the nature of social reality and the frames through which meaning is made" (Scott 2008, 57). Layzer (2012) identifies three basic types of political ideas: Ideas about the overall political system, ideas about a specific policy system, and those pertaining to policy solutions. Each of these takes on a different form depending on whether they are internally held beliefs, or those intended for/promulgated by experts or the public. For example, ideas about the overall political system include individual world-views (ideologies), as well as political and public philosophies. Ideas about the policy system include assumptions and theories about how "a particular part of the world works" (Layzer 2012, 12). At the level of individual policies, Layzer also highlights two important types of ideas: those that characterize the extent and cause of a particular problem, and those that provide a related policy "solution." The former type is often characterized technically as "policy analyses" and "problem definitions," when formulated for the general public. The latter are better known as "policy prescriptions" or "policy images."

Shared ideas are understood to drive institutional development and persistence in several ways. First, these scholars argue that ideologies, such as taken for granted normative ideas, constrain policymakers by limiting the range of options that are considered "acceptable" (Campbell 2002, 22). For example, in his study of railway development in both France and England, Dobbin (1994, 3) argues that the different industrial development pathways taken by each country could be attributed to their "different conceptions of industrial efficiency" which originated in their unique political cultures, their "traditions" of political life. These taken-for-granted cognitive paradigms limited the events and practices that they saw as
problematic, while their programmatic repertoire “influenced the industrial strategies envisioned—the solutions conceived” (Dobbin 1994, 21). Other scholars note how policy images and storylines are essential to building the coalitions that lead to institutionalization. The political scientist Deborah Stone (2002, 15) argues that interests cannot be understood apart from how they are “defined and activated” in the political process. That is, interests vis-à-vis specific policies are ambiguous until they are linked to some selective and artistic representation—a policy image—or a more specific representation, such as a programmatic idea. Therefore, political advocates must garner support for their preferred policies through the careful construction of these images and prescriptions.

In addition to structuring the process of institutionalization, ideas stabilize policies once they are in place. Baumgartner and Jones’ (1993) theory of punctuated equilibrium contends that institutions are maintained by a widely held problem definition and agreed upon policy prescriptions. Public preferences or policy outputs have little influence on institutional stasis; instead ideas define who can and cannot legitimately influence the policy domain and secure the monopoly. On the other hand, Selznick (1949) links stability to a deeper, cognitive-cultural shift as institutional actors begin to operate according to a logic of “appropriateness,” as opposed to efficiency (March and Olsen 2006). In his study of the Tennessee Valley Authority, he outlines a process of stabilization whereby actions originally taken to solve certain coordinative challenges are brought within a normative order and activities are “infused with value.” In this view, rules and procedures are “sanctified,” administrative “rituals, symbols, and ideologies” develop, and maintaining relationships of reciprocity takes on import independent of its efficiency (Scott 2008).
THEORIES OF CHANGE

Theories of institutional development and stability are challenged to explain how institutions transform. Historical and sociological approaches suggest that institutionalization only deepens over time, locking society on a historically determined pathway and ossifying specific modes of behavior. For the rational choice theorists, the issue of change is particularly problematic; institutions were introduced to stabilize outcomes at (presumably) some Nash Equilibrium, where it is to no one’s advantage to alter the rules. The following lays out several theories of institutional change from the rational choice institutionalism, policy sciences, and historical institutionalism.

Rational Choice Institutionalism

Given its treatment of institutions as equilibrium producing “scripts,” rational choice institutionalism is hard pressed to explain change. The accounts that do exist primarily point to external events that serve as “shocks” to the system of interest. For example, the theory of “punctuated equilibrium”\(^8\) argues that institutions exhibit long stretches of stability punctuated by periods of extraordinary change. As originally formulated by Krasner (1984), and drawing on the work of evolutionary biologists, these transformations occur when extant institutions fail to adequately cope with external social or environmental changes and new demands on government. Under this model, exogenous forces result in moments of crisis that can do one of three things: alter the balance of political power, induce institutional restructuring, or cause institutional collapse. In these periods alone, sweeping changes can be enacted. For example, the Great Depression and the ensuing cross-national shifts in economic policy reflect a moment of punctuation.

\(^8\) Confusingly this is the same term used by Baumgartner and Jones (1993). However, Baumgartner and Jones argue that punctuations are socially constructed—contingent on the disruptive effects of a new policy image.
While most rational choice scholars rely on externally precipitated crises to explain large changes, the notion that these are the only opportunities political actors can exhibit agency appears to treat people as “hostages of the institutions they inhabit” (Steinmo 2008, 173). Other analysts note that institutional efficiency is an historical exception rather than a rule, and explore how inefficiency itself can become a motor of change (North 1981, 1989). For example, adopting Herbert Simon’s behavioral model of bounded rationality, Ostrom (1990) argues that although political and social institutions are solutions to coordination problems, they are not driving towards efficiency. Instead, when constructing institutions, satisficing actors attempt to meet their needs to the best of their ability, and very often their efforts produce suboptimal results. When actors are unhappy with institutional performance, she further argues, there are many things that inhibit attempts at reform: upfront costs, uncertainty, and losses. However, under certain conditions—low discount rates, low costs of information, enforcement and transformation, shared norms—inefficiency can serve as an internal driver of change, and rational actors can renegotiate institutions (Ostrom 1990). In her analysis of water management institutions in California, Ostrom found that exactly this type of institutional renegotiation occurred. However, this type of transformation is limited to very particular settings, where “there is consensus among actors accustomed to strategic action and of roughly equal standing,” such as certain state legislatures, or—as in Ostrom’s cases—relatively homogenous, self-governing communities (Hall and Taylor 1996, 20).

On the other hand, North (1981, 1989) proposes a unilateral pathway to institutional transformation. Viewing political leaders as relatively autonomous—as opposed to agents for their constituent’s interests—he posits that an empowered leader could shoulder the costs associated with producing institutional change for social benefit. However, North does not clarify why some political actors would choose to behave altruistically; he points to the influence of
“ideology” but critics argue that its introduction in his theory stretches the core principles of rational choice to a breaking point (Rakner 1996).

**Punctuated Equilibrium in Policy Sciences**

Baumgartner and Jones’ (1993) theory of punctuated equilibrium also relies on external forces to produce change; but it differs substantially from the rational choice approach in claiming that institutions are propped up by widely held beliefs. In seeking to account for the discontinuous nature of federal policy change in the United States, the authors argue that subsystem dynamics, rather than elections and preference shifts, explain the long stretches of stability along with periods of institutional upheaval. Like Ostrom, Baumgartner and Jones build on organizational theorist Herbert Simon’s theory of bounded rationality and information processing. They argue that because individual attention is limited, parallel processing of the vast number of national policy issues can only be accomplished by subdividing the policy universe into subsystems (Jones 1994). These insulated communities of experts are typically dominated by a particular interest with a “definable institutional policymaking structure” and sustained by a powerful policy image (Baumgartner and Jones 1993). In this way, subsystems maintain a relative equilibrium, marked primarily by “incremental change resulting from bargaining among interests and marginal moves in response to changing conditions” (True, Jones, and Baumgartner 2007, 158). Stability is further reinforced by the status quo bias that is built into the US political system, including multiple veto points and supermajority requirements.

Drawing on Schattschneider’s (1960) theory of conflict expansion, policy monopolies can be upset if the scope of the conflict is expanded and challenges to the status quo can be launched in new, formerly unengaged, jurisdictions. This process occurs through the contestation of the monopolies’ supporting policy image— the storyline and accompanying “tone” through which a policy issue is publicly conveyed (Baumgartner and Jones 1993). By altering these images
advocates of change can draw out previously uninterested audiences. Because policy redefinition reveals new aspects of an issue,

[outside] actors feel qualified to exert their authority...[and] may insist on rewriting rules ... which will be reinforced by new institutional structures as previously dominant agencies are forced to share their power with groups or agencies that gain new legitimacy. (True, Jones, and Baumgartner 2007, 159)

In this way, conservatively designed political institutions occupied by boundedly rational individuals can produce a system of relative stability, punctuated by periods of extreme transformation. Greatly aided by media coverage, redefinition of the policy issue drives a positive feedback process of increasing attention and political demands, which, when lodged in new venues, can upturn a policy monopoly and propel institutional transformation.

Rational choice theories of punctuated equilibrium point to exogenous shifts, such as changes in public preferences or in the governing coalition, which disrupt institutional stability and can lead to profound change. Baumgartner and Jones (1993) argue that a shift in preferences must be attended by an increase in attention to the policy issue, beyond the subsystem monopoly. Furthermore, although the authors acknowledge that rapid changes in economic or environmental conditions can set off an attention cycle, they do not directly produce change. As Stone (2002) has elaborated in detail, material disruptions and other focusing events are instead opportunities during which change agents can alter the policy image by identifying the event as a “public problem” and causally linking it to an institutional arrangement. Furthermore, as Kingdon (1973/1989) argues in his multiple streams framework, for change to occur during a so-called “window of opportunity” the change agent—typically cast as a “policy entrepreneur” as opposed to a coalition—must actively link the problem to a particular solution, which may emerge from an entirely different policy community. In short, it is the interaction of venue and meaning making in the face
of system shocks that determine whether extant institutions are maintained or altered, and what new form they take.

Although it can explain the macro dynamics of policy change, Baumgartner and Jones' theory of punctuated equilibrium does not attend to possible variation across policy subsystems and it provides very little predictive power in terms of the timing or characteristics (as opposed to relative frequency) of particular institutional reconfigurations. For example, the theory does not suggest when an attention cycle will be triggered, how strong it will be, and why some periods of mobilization produce change in some instances and issue subsidence in others. Are there particular qualities of change agents, the policy ideas, or the challenged institutions that make change more likely? (The authors posit that system stochasticity makes these types of predictions impossible.) Furthermore, although they argue that the engagement of media and attention of legislators are essential elements of the cycle of change they describe, but they pay little attention to other potentially critical actors, such as epistemic communities and non-governmental organizations and associations. Finally, by focusing predominately on policy monopolies and institutional inertia, the model appears to deny the possibility of gradual internal change, such as that brought about through policy learning.

The advocacy coalition framework (ACF) provides insights into some of these issues, particularly that of policy learning and change (Sabatier 1988). Like the theory of punctuated equilibrium, the advocacy coalition framework (ACF) originally positioned itself in opposition to the stages heuristic model of policy change. It too assumes that the majority of policymaking takes place within specialized sub-systems composed of a diverse range of actors from all levels of government as well as private organizations. For example, in his analysis of the United States' air pollution subsystem, Sabatier finds at least ten organizational actors, including the Environmental Protection Agency, relevant congressional committees, state and local pollution control agencies, journalists, and environmental and public health groups (Sabatier 1993, 25). Furthermore, the
framework rejects the rational choice view that actors are primarily motivated by short-term self-interest and that “coalitions of convenience’ of highly varying composition will dominate policymaking overtime” (Sabatier 1993, 27). Instead, coalition members are held together by a common set of policy beliefs, stemming from relatively immutable core beliefs or worldviews—what Sabatier call the “glue of politics” (1993, 27). The ACF designates three levels of relevant beliefs: deep core (i.e. worldviews or pre-analytic visions), policy core (i.e. the expression of deep core beliefs as relates to a specific policy area), and secondary beliefs (i.e. preferences related to specific policy instruments). Core beliefs are particularly resistant to change and therefore coalitions show a great deal of stability over periods of a decade or more.

However, the ACF suggests that policy subsystems are rarely homogenous or clear monopolies; instead they contain several sub-groups termed “advocacy coalitions.” Advocacy coalitions try to create institutions consistent with their near core and policy core beliefs by altering collective choice structures, advocating specific policy, and influencing implementation (Sabatier 1988). Outcomes of these efforts are shaped by characteristics of political institutions, coalition resources, as well as stable and more dynamic exogenous parameters. An updated model of the ACF outlines several pathways of belief and institutional change (Sabatier and Weible 2007). A key argument of the ACF is that change can come about through learning processes. The ACF posits that researchers in academia, the government, and private firms are central to policy dynamics; they are crucial purveyors of scientific and technical ideas that coalitions wield to achieve their policy goals. These new ideas can lead to shifts in secondary beliefs and result in policy adjustments through policy learning. However, the ACF suggests that dramatic, as opposed to incremental, change requires a shift in core beliefs, which are rarely shaken by new information. To explain transformation, the ACF also argues that shocks—from changing socioeconomic conditions or regimes, pressures from other systems, or environmental stressors— are a “necessary though not sufficient”
condition for major change. Sabatier and Weible (2007, 199) make the (familiar) argument:

The most important effect of external shock is the redistribution of resources or opening and closing venues within a policy subsystem, which can lead to the replacement of the previously dominant coalition by a minority coalition.

Updates to the ACF have also added negotiated agreements as an “alternative pathway” to major policy change (Sabatier and Weible 2007). Breakthrough agreements between battling coalitions can bring about substantial change after years of stalemate. To explain these mechanisms of institutional change, the ACF draws heavily on the alternative dispute resolution (ADR) literature and, more recently, multi-party public dispute resolution (PDR) (Carpenter and Kennedy 1988; Susskind 2008; Susskind, McKearnen, and Thomas-Lamar 1999; Ury 1991).

**Gradual Change in Historical Institutionalism**

Recently, analysts have challenged the hegemony of punctuated change as the primary driver of institutional change. In their theory of gradual institutional change, historical institutionalists Mahoney and Thelen (2010) note how subtle shifts within an institutional regime can over time lead to sweeping changes. To make this argument, they build on two key claims. The first is that institutions do not exist apart from how they are interpreted and enacted by individuals and they are therefore subject to different interpretations and levels of enforcement (Mahoney and Thelen 2010). Recasting institutional persistence as a socially constructed phenomenon enlarges possibilities for institutional change outside of episodic renegotiations or critical junctures. Once it is acknowledged that between the “context and response is the interpreting actor,” focus is drawn to actors, and how they interpret, leverage, and contest institutions, even during times of seeming stability (Scott 2008, 78). This approach breaks down the binary concept of structures as either institutionalized or not, and suggests there may be several
states of institutionalization, with unique values across a variety of dimensions, including “variance in implementation, failure rates, and theorization activities” (Tolbert and Zucker 1983, 185).

This concept can be traced back to Giddens’ (1979, 1984) theory of “structuration” which suggests a “duality of social structure,” where institutions are both a “product and platform” of social action (Scott 2008, 77); structure and agency are mutually constitutive. Structuration is foundational to sociological studies of institutions and organizations (Barley and Tolbert 1997; DiMaggio and Powell 1991, Sewell Jr 1992; Tolbert and Zucker 1983; Zucker 1977). Zucker (1988) has long argued that far from being self-reinforcing, institutional stability requires the sustained input of energy and resources, such as sanctions, social pressure, and education, to resist a natural tendency towards disorder and decay. Furthermore, during the reproduction of cognitive templates changes can occur and may diffuse. That is, reproduction is not a reliable process. Clemens and Cook (1999) argue that institutional schemas (or strategies) can be changed through their inherent properties of “mutability,” “internal contradictions,” and “multiplicity.” Yet even outside of sociological institutionalism, the observation holds: rules are frequently ambiguous resulting in contradictory interpretations and opportunities for change.

In sum, this approach draws attention to the role of agency in institutional dynamics: the ability of “reflexive and knowledgeable” actors to influence their environment by shaping the “rules, relational ties, or distribution of resources” (Scott 2008, 77).

The second premise of gradual institutional change is that whether institutions are the purposeful efforts of winning political coalitions to cement their victories, or the unintended confluence of social forces, they are all structures that constrain and obstruct some individuals and groups while facilitating the activity of others. As Schattschneider (1960, 71) famously stated decades ago, “organization is the mobilization of bias; some interests are organized into politics while others are organized out.” Mahoney and Thelen (2010, 8) argue that the
power-distributional effects of institutions make them inherently "fraught with tension." These tensions, furthermore, are the motor of institutional dynamism, as supporters and detractors of the status quo must engage in "ongoing mobilization of political support...and active efforts to resolve [institutional] ambiguities in their favor" (Mahoney and Thelen 2010, 9).

Mahoney and Thelen (2010) knit these observations together into a model of gradual—as opposed to punctuated—institutional change. In this view, institutions are not unequivocal but subject to ongoing interpretation that can reconsolidate dominant understandings or undermine them. As the authors write, "we expect incremental change to occur precisely in the 'gaps' or 'soft spots' between the rule and the interpretation or the rules and its enforcement" (Mahoney and Thelen 2010, 14). Drawing on Hacker (2005) they argue that characteristics of the political and institutional context—veto possibilities and level of discretion—facilitate specific types of change agents and make certain forms of gradual change more possible than others. For example, where veto possibilities are high and actors are granted considerable discretion in rule interpretation and enforcement, the model predicts the disproportionate success of change agents seeking to preserve institutions in law or dominant understanding, while undermining their spirit through lax enforcement or reinterpretation. This leads to institutional change in the form of "drift"—when "gaps open up between rules and enforcement," potentially undermining the institution in the long term (Mahoney and Thelen 2010, 21).

The Usefulness of Transitions Literature
In the last 15 years, an explicitly normative research program has emerged to better understand how to promote and manage societal transitions to the use of more sustainable technologies (Geels 2002; Kemp and Loorbach 2006; Kern and Howlett 2009; Smith, Stirling, and Berkhout 2005). Termed “sustainability transitions,” it draws from a range of approaches, including innovation studies, evolutionary
economics, organizational development, and management, among others (Markard, Raven, and Truffer 2012). The transitions literature is most useful in conceptualizing the structure of a so-called "socio-technical system" and the direction of possible interactions among its elements. Because it does not explicate a model of individual behavior and decision-making, methodologically tends to rely on single-case studies, and (perhaps most importantly) largely neglects power and politics, it is less helpful than other approaches in explaining institutional change. Where analysts attempt to redress these deficiencies, they do so by drawing on much of the literature already discussed above—particularly organizational sociology and neo-institutionalism (Geels 2010, 2011). However, because of its clear relevance to my research question, it is important to describe the field's contours and limitations in more detail.

Research in sustainable transitions is marked by its broad focus on so-called socio-technical systems— the interconnected network of individuals, organizations, institutions, knowledge, and material infrastructure that maintain a particular dominant technology (Geels 2004; Weber 2003). Analysts argue that the study of sustainable transitions requires a wide lens because they frequently, though not always, differ from other historic transitions in several respects: they are “purposive” transitions that aim to produce a public good— sustainability—and therefore would not be expected to arise naturally through private competition; relatedly, sustainable solutions typically are more expensive and underperform in conventional economic frames; finally, “complementary assets” give incumbent firms and organization major advantages over newcomers (Geels 2011).

Sustainable transitions researchers also pay special attention to importance of technological niches in disrupting stable regimes. “Strategic niche management” argues that these protected spaces, such as R&D laboratories or subsidized demonstration projects, allow radical innovations to develop without being subject to the competitive pressures of the broader regime (Kemp 1994; Raven and Geels
Niches are therefore the seeds of innovation, without which change could not occur. Geels and Schot (2010) propose a “bottom-up” process of change whereby innovative technologies move from niche to mainstream practice through the development of a unifying vision, alignment of learning processes, and the creation of a broader “social network” of supporters.

The field’s most prominent approach is the multi-level perspective (MLP) (Geels 2002; Rip and Kemp 1998). This framework is theoretically grounded in science technology studies and evolutionary economics. It incorporates niche development as one process of change, but supports several other pathways by envisioning three interacting arenas: the niche, the socio-technical regime, and the “exogenous socio-technical landscape” (Geels 2002). Transitions occur at the level of the regime, defined as the institutional arrangements that sustain the dominant technology. These institutions are conceptualized in Giddens’ terms: as both the “medium and outcome” of action (Geels 2011). Change is modeled as a bottom-up process (as in strategic niche management), but the framework also notes how pressures from the external landscape can destabilize the regime and produce “windows of opportunity” for niche technologies to disseminate (Geels 2011).

The MLP in particular provides a unique and useful conceptualization of the important interdependent elements in technological systems, and some hypotheses about their relationship to one another. Critics note, however, that the framework is still just that—a framework. The MLP does not posit particular theories about actor behavior or decision-making, or the interaction of ideas and institutions—all of which are critical given that “sustainability” itself and what constitutes a sustainable transformation are contested concepts (Genus and Coles 2008; Meadowcroft 2009; A. Smith 2005). Furthermore, in many applications of the perspective, the regime is treated monolithically and the landscape serves as a catch-all (Berkhout, Smith, and Stirling 2004; A. Smith 2005).
Increasing structuration of activities in local practices

Socio-technical landscape (exogenous context)

Socio-technical regime

New regime influences landscape

New configuration breaks through, taking advantage of "windows of opportunity. Adjustments occur in socio-technical regime.

Elements become aligned, and stabilise in a dominant design. Internal momentum increases.

External influences (via expectations and networks)

Socio-technical regime is 'dynamically stable'.

On different dimensions there are ongoing processes.

Socio-innovations

Small networks of actors support novelties on the basis of expectations and visions.

Learning processes take place on multiple dimensions (co-constuction). Efforts to link different elements in a seamless web.

Market/user preferences

Time


Figure 2.1. The Multi-Level Perspective on Transitions

As a result, the multi-level framework has a strong bottom-up bias, based on the field's early focus on niche development, but often lacks a clear "breakthrough" mechanism. Although it is actively developing, the MLP does not yet offer new insights into why transitions occur when they do. As it stands, other approaches are required to fill out the framework — many of which have been discussed above (Geels 2011). In addressing these critiques Geels (2011) has written that the MLP is better seen as an "heuristic guide" whose application requires "substantive knowledge of the empirical domain and theoretical sensitivity (and interpretive creativity)." Where it is used to direct my analysis, it is used in this spirit.
USING THE THEORIES TO UNDERSTAND GSI ADOPTION

The theoretical frameworks discussed above provide competing hypotheses to explain why some cities have fundamentally transformed their approach to managing water pollution by implementing green stormwater infrastructure. Four major processes emerge: punctuation (punctuated equilibrium theory), policy learning, negotiation or public dispute resolution, and gradual institutional change. Each related theory presents distinguishable framework elements as well as explanatory drivers and processes that can be used to assess individual cases as well as compare between them. The following briefly delineates these key elements and processes.

As already discussed, punctuated equilibrium points to external events, “shocks,” that can reshape institutional arrangements. As used in rational choice models, the external pressures can take several forms. A shift in public preferences may alter the balance of power, granting newly empowered actors the opportunity to change institutions in their favor. Alternatively, environmental events, such as a natural disaster or changes in availability of particular resources might alter actors’ payoff matrices, resulting in institutional restructuring. These external shifts might also become so disruptive that they are not reconcilable and lead to institutional collapse and replacement. In all cases, actors are assumed to be driven by a fixed set of preferences, which they set out to maximize in a “highly strategic manner that presumes extensive calculation” (Hall and Taylor 1996). Punctuated equilibrium in the policy sciences refers to a very different mechanism of change (Baumgartner and Jones 1993). According to this theory, institutional change is externally triggered but depends on how effectively challengers to the status quo can use focusing events to reshape dominant understandings of a problem and link that new understanding to their preferred policy solution. Upsetting the policy monopoly relies on increasing attention to an issue, drawing in previously uninterested actors, and lodging challenges in new, receptive venues. While voluntarily contracting actors are the key agents in the rational choice model,
Baumgartner and Jones' theory highlights the "policy entrepreneur" as the primary change agent.

These two models of punctuated equilibrium represent two distinguishable processes that should be present and traceable in cases where institutional change occurs and absent or muted in cases where change does not take place, or does to only a limited extent. For example, if water agencies in two different cities are subject to the same external pressure, but it only drives transformation in one of the cities, I should be able to point to differences in process, which may itself be tied to local structures, to explain this difference.

Institutional change via policy learning assumes that actors in policy systems are knowledgeable and reflexive and will adjust policy goals in light of new scientific and technical information. New information may come in the form of policy evaluations that seek to determine whether a policy is working, or from outside expert communities, such as researchers in academia or consulting. It may also result from personal experience or the experience of others in related fields. When this information conflicts with or enhances previously held beliefs, actors may update their mental models. Whether this learning is imposed from the outside or undertaken voluntarily by bureaucrats, institutional change can occur as policy-makers enact these new understandings (Hall 1993; Heclo 1974).

The ACF's theory of "policy-oriented learning" argues that learning primarily impacts so-called "secondary beliefs," those related to narrow concerns such as "rules and budgetary applications within a specific program...[or] public participation guidelines" (Sabatier and Weible 2007, 196). To produce more substantial policy change, as might be associated with the adoption of green stormwater infrastructure, learning must shift the "policy core preferences"—preferences that are system-wide in scope, highly salient, and grounded in personal ideology and values (Sabatier 1993; Sabatier and Weible 2007). According to the ACF, however, these preferences are exceptionally difficult to alter and learning is unlikely to affect them. Policy-oriented learning is therefore a weaker
potential explanation for largescale as opposed to more limited adoption of GSI. Nevertheless, if it is the driver of even limited change in urban water pollution management, it should be possible to map this process in my cases.

The idea that actors of relatively equal standing can renegotiate inefficient institutions is central to Ostrom's rational choice institutionalism and models of common pool resource management (Ostrom 1990). She argues that given low discount rates, low costs of information, enforcement and transformation, as well as shared norms, voluntarily contracting actors can commit to institutional redesign. However, Ostrom's theory of collective resource management applies to a very specific model: relatively homogenous, self-governing communities; actors are primarily self-interested, engaged in an economic negotiation, and seeking an arrangement akin to pareto efficiency. This is a very different setting from public utilities, where bureaucrats are serving multiple mandates and embedded in a highly regulated and often contentious political system.

The ACF's model of negotiated change applies much more readily. As already noted, the ACF conceptualizes policy subsystems made up of competing coalitions, seeking to enact policies that are in line with their core values. This model posits that long-standing stalemates between these coalitions can turn to breakthrough agreements that reshape institutions (Bingham, Nabatchi, and O'Leary 2005; Carpenter and Kennedy 1988; Susskind, McKearnen, and Thomas-Lamar 1999). Analysts postulate nine conditions affecting the likelihood of change along this pathway a hurting stalemate: effective leadership, consensus-based decision rules, diverse funding, duration of process and commitment of members, a focus on empirical issues, an emphasis on building trust, and lack of alternative venues (Sabatier and Weible 2007). For example, in her study of Swiss climate policy, Ingold (2011) found that a negotiated solution became desirable in the

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9 Added to this is the recognition that policy evaluation, ostensibly a process of learning and betterment, is itself a political activity. From the questions asked, to the boundaries drawn, to the definitions of success and failure, the process is imbued with subjective decision-making. It may not quell debate and what is learned is not always used to inform decision-making.
context of a “hurting stalemate,” where “neither side can win, but neither side wants to back down or accept loss either.” The negotiated outcome was made possible by a policy broker. In this case the brokers were representatives from a center-right political party and the Swedish energy agency who served as a bridge between multiple interest groups and found a political compromise (Ingold 2011).

Finally, gradual institutional change is driven by the power-distributional characteristics of institutions (Mahoney and Thelen 2010). It is made possible by the inherent ambiguity in institutions that political actors can exploit to perform subtle modifications. These include changing how rules are interpreted as well as how they are implemented. These gradual incremental changes can, over time, accrue to fundamental transformation. Given the veto potential in the political system (high or low values) and the discretion afforded to institutional actors in interpretation and enforcement (high or low values), the theory posits a very testable hypothesis regarding both the types of change processes and characteristics of change agents that are most likely to emerge.

<table>
<thead>
<tr>
<th>Political Context</th>
<th>Low Level of Discretion</th>
<th>High Level of Discretion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong Veto Possibilities</td>
<td>Agent Type: Subversives</td>
<td>Agent: Parasitic Symbionts</td>
</tr>
<tr>
<td></td>
<td>Change Type: Layering</td>
<td>Change: Drift</td>
</tr>
<tr>
<td>Weak Veto Possibilities</td>
<td>Agent: Insurrectionists</td>
<td>Agent: Opportunists</td>
</tr>
<tr>
<td></td>
<td>Change: Displacement</td>
<td>Change: Conversion</td>
</tr>
</tbody>
</table>


Table 2.1. A Typology of Gradual Change
As shown in Table 2.1, four modes of gradual change are proposed. Where opportunities exist for supporters of the status quo to prevent change (i.e. strong veto possibilities), change is most likely to come in the form of layering or drift. Layering is the introduction of new rules atop existing ones. Drift occurs in settings where actors with high levels of discretion are unlikely to be successful directly challenging existing institutions but can cease to adapt them to changing situations. This “neglect” in the face of a changing landscape slowly undermines the institution’s “traditional impact” (Mahoney and Thelen 2010, 19). On the other hand, where veto potential is weak, conversion or displacement is more likely. Displacement is the outright dissolution of an institution either abruptly or over time, and does not depend on exploiting ambiguities in rules. Thus it is likely to occur in settings where opponents of the status quo cannot exercise much discretion but also cannot be easily blocked if they launch a direct attack. Conversion occurs when rules are subject to vastly different interpretations, which “opportunists” can exploit to remake institutions according to their preferred reading. For example, Mahoney and Thelen (21) note how the Constitution’s commerce clause has “been harnessed in support of rather massive changes in economic and social policy in the United States.”

Although each theory serves as a relatively independent analytic guide, represented in Table 2.2, I am also attentive to the possibility that processes of change I observe in my cases might exhibit characteristics of one of more of these theories— and perhaps none in their fully theorized form.
<table>
<thead>
<tr>
<th>Model</th>
<th>Framework Elements</th>
<th>Change Driver(s)</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Punctuated Equilibrium A</td>
<td>- Self-interested actors engaged in voluntary, contractual relationships</td>
<td>External crisis or pressure that upsets equilibrium</td>
<td>- External event&lt;br&gt;- Change in payoff matrix&lt;br&gt;- Voluntary recalibration by institutional actors</td>
</tr>
<tr>
<td>(Rational Choice Institutionalism)</td>
<td>- Institutionally sustained equilibrium</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assumes: Agents are mostly rational</td>
<td></td>
<td></td>
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<tr>
<td>Punctuated Equilibrium B</td>
<td>- Policy subsystem: A policy monopoly and supportive policy image&lt;br&gt;- The Media&lt;br&gt;- Change Agents</td>
<td>Institutional challengers wielding their own policy image lodge attack in new venue</td>
<td>- Competing policy image(s)&lt;br&gt;- Spike in attention (media driven)&lt;br&gt;- Engagement of previously uninterested actors&lt;br&gt;- Institutions are contested in new venues</td>
</tr>
<tr>
<td>(Policy Science)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assumes: Agents are boundedly rational, parallel processors</td>
<td></td>
<td></td>
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<tr>
<td>Policy-Oriented Learning</td>
<td>- Policy subsystem: Advocacy coalitions&lt;br&gt;- Experts&lt;br&gt;- The Media</td>
<td>New information that challenges or improves prior understandings</td>
<td>- New Information&lt;br&gt;- Agent updating&lt;br&gt;- New understandings are applied to remake rules and policies</td>
</tr>
<tr>
<td>(ACF)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assumes: Agents are knowledgeable and reflexive, motivated by core beliefs</td>
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<tr>
<td>Breakthrough Agreements</td>
<td>- Policy subsystem: Advocacy coalitions</td>
<td>Escalated conflict where neither side can win yet each refuse to back down</td>
<td>- Hurting stalemate&lt;br&gt;- Policy broker&lt;br&gt;- Negotiated agreement</td>
</tr>
<tr>
<td>(ACF and PDR)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assumes: Agents are motivated by core beliefs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gradual Change</td>
<td>- Policy subsystem&lt;br&gt;- Broader political system with specifiable veto opportunities</td>
<td>Power-distributional effects of institutions</td>
<td>Observed: Layering, conversion, displacement, and/or drift Change process corresponds with hypothesized values of veto/discretion variables</td>
</tr>
<tr>
<td>(Historical Institutionalism)</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Assumes: Rational behavior shaped by ideas and historically derived institutions</td>
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</tbody>
</table>

Table 2.2. Competing Hypotheses of Institutional Change: Frameworks and Observable Evidence
AN EMPIRICAL INVESTIGATION

Using the theoretical inroads already discussed, I focus on explaining transformation in municipal water pollution management policy and infrastructure—the adoption of green stormwater infrastructure as a tool to abate urban water pollution. I take a theory-oriented explanation approach to my cases, examining them through the lenses of my competing hypotheses (Hall 2006; Yin 2013). I also seek to develop historically derived explanations for transformation and stasis in urban water pollution management—particularly where the theory does not adequately account for divergent outcomes in my cases. In addition to a separate analysis of the overarching municipal water pollution policy system, I conduct an intensive qualitative analysis of institutional change in two US cities, Philadelphia and Boston, using developments in two additional cities, Portland and Washington, DC, as shadow cases. Limiting my investigation to the United States reduces case variability and enhances my ability to generalize to other sectors—as each is embedded in the same federal system. Selecting a small number of cases allows me to examine each in depth, detailing developments over long periods of time and carefully mapping decisions and processes.

Case Selection

In order to overcome explanatory challenges raised by selecting on outcome, my cases vary across the dependent variable, which I define as “institutionalization of green infrastructure practices” (Geddes 1990; King, Keohane, and Verba 1994). I chose cases along this spectrum using the Natural Resource Defense Council’s “Emerald City Ranking,” which uses a six-point scale to rank fourteen major US cities’ commitment to GSI; approximate acres of green stormwater infrastructure constructed by the city and related expenditures; and estimated acreage and earmarked funding cited in enforceable plans—even if the GSI had not yet been built. In doing so, I presumed that these policy impacts are the culmination of
institutional changes in the city’s water and sewer agencies, and are relatively proportional to that level change.\(^{10}\)

On the one extreme, Philadelphia plans to reduce its combined sewer overflows by constructing over ten thousand, water infiltrating acres by 2030. It has committed over $1 billion to this city-wide infrastructure project. On the other end of the gradient, Boston has pursued business as usual. Aside from a handful of demonstration projects, the city has relied on gray infrastructure to manage stormwater runoff and combined sewer overflows. Between these two cities on the green gradient are Portland and Washington, DC. An early trailblazer in testing and building green infrastructure, Portland has been accelerating its implementation of green controls to manage stormwater pollution—although unlike Philadelphia it chose to manage its combined sewer overflows with three large underground storage tunnels, totaling $1.4 billion. In 2010 Washington, DC began exploring green infrastructure techniques to manage its combined overflows. In 2016 it finalized a renegotiation of its formerly gray CSO control plan to include green infrastructure on 700 acres of riparian land and reverse its commitment to one of its planned underground tunnel.

Furthermore, the cities are similar in ways that allow me to conduct a structured, focused comparison while controlling for potentially complicating variables (George and Bennett 2005). For example, there are some physical and environmental characteristics of cities that might make green infrastructure particularly unattractive. These characteristics include high building density that make siting GSI projects difficult and expensive, and flash flood susceptibility, which marks many desert cities. For this reason, all four of the cities I assess are of comparable size, population, density and face similar growth pressures. Climatically there is some variation, but not the most extreme as can be found in

\(^{10}\) Once I began data collection, I operationalized change in a less crude manner.
the United States. Like most major cities, they all manage extensive drainage and sewer systems, face similar stormwater and combined overflow pollution problems, and are subject to the same federal environmental regulations.

**The Subsystem and Data Collection**

Policy-making in the United States is divided into relatively independent and stable policy silos. These policy subsystems are made up of “communities of specialists operating out of the political spotlight” (True, Jones, and Baumgartner 2007, 158). The policy subsystem, therefore, serves as my basic analytic framework. Beginning with actors within my unit of analysis—the municipal water and sewer agency—I use snowball sampling to expand my investigation to incorporate other actors in the subsystem, at the local, state, and federal levels shown in Figure 2.2. These other subsystem actors included but were not limited to: bureaucrats and appointed officials at the US Environmental Protection Agency (EPA) at both headquarters and regional offices; state departments of environmental protection; municipal and environmental advocacy organizations; and university researchers.

Evidence for the individual cases is drawn from semi-structured interviews conducted predominantly between January 2013 and March 2016 with approximately forty informants, listed in Appendix A. Interviews averaged one hour in length, although they ranged from 30 minutes to three hours. The majority were conducted in-person, recorded, and transcribed. I also rely on a range of primary documentation, including archival records, internal memos, and formal plans from water and sewer utilities; legislative and regulatory policy, hearings, and reports; as well as a variety of secondary source assessments and news reports. Evidence for the policy subsystem analysis (“The Context”) is drawn primarily from

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11 Of all four cities, the sole west coast city, Portland, with its mild winters and long, steady rainy season is the outlier. In assessing that case, I am attentive to these differences.

12 In some cases, interviewees preferred to be identified by title only.
The White House
Congress

The Environmental Protection Agency:
Headquarters and Regional Offices

Universities
Consultants
Interest Groups

State Legislatures
State Departments of Environmental Protection

Table 2.3. The Municipal Water Pollution Policy Subsystem: Key Governmental and Nongovernmental Actors

secondary sources but occasionally from interviews as well. I triangulate among these sources to strengthen the validity of resulting claims, as well as reveal additional dimensions of the same phenomenon.

Measuring Change
The ability to identify institutional change and demark radical from incremental change is a critical component of this study. Hall conceptualizes change in three orders (Hall 1993). When policy-makers adjust the levels of specific policy instruments, but retain the same goals and suite of policy instruments, first order change has occurred. For example, according to Hall (1993), first order change in Britain's macroeconomic policy was manifest in changes in the lending rate and fiscal stance. When policy goals remain the same, but new instruments are used to attain them, second order change has occurred. Finally, radical shifts or third order change is said to occur when policy-makers reshape the "hierarchy of goals," as well as turning to new instruments and modulating their levels (Hall 1993).
Radical shifts reflect a changing understanding of the nature of the policy problem itself.

Similarly, Sabatier (1988) argues that change should be conceptualized in two classes. The first is the more frequent, less dramatic change that occurs as policy makers alter “secondary” aspects of policy, the level or types of instruments used to manage a public problem. These changes reflect an underlying shift in secondary beliefs, which are “relatively narrow in scope (less than system wide) and require less evidence and fewer agreements among subsystem actors” (Sabatier and Weible 2007, 196). More radical change occurs when basic assumptions about the policy system are altered. Sabatier links this change to shifts in the dominance of particular normative beliefs and ideologies within the policy subsystem. As Layzer (2012) writes, this type of change is manifest in the dominance of a new public “storyline” about the policy issue. Within expert communities, it is reflected in changes to the systemic framework. At an individual level it can be noted in changing “principled beliefs,” which consist of assumptions about how a “particular aspect of the world works” (Layzer 2012, 12)

My own operationalization of change draws on these two approaches. I use the definition of institutions as “rules, norms, and decision-making procedures that guide collective behavior” to develop a number of metrics I can use to measure extent of change, from low or incremental to high or radical change. For change to be considered transformative, substantial shifts must be seen in norms, rules, and decision-making, as expressed in Table 2.3. In addition to measuring this outcome variable, I also look at the corresponding “impacts” of policy change in each case; that is, how have these institutional changes translated into the physical implementation of GSI in each case?
Changes in Norms and Beliefs
- Salience and positive tone of GSI and land-based water management referenced in everyday and high-level communication
- References to GSI and/or sustainability are included in department goals/mission statements
- Bureaucrats express confidence in legitimacy and effectiveness of GSI
- Marked increase in those committed to practicing land-based water management over time

Changes in Internal Decision-Making
- Internal evaluation standards include sustainability criteria that reflect the more holistic approach (economy, equity, environment) and long-term values of sustainability
- Agency staff create/use formal and informal mechanisms for inter-agency cooperation related to GSI planning and programming
- Proponents of GSI hold high level positions

Changes in Rules and Policy Tools
- Agency budget lines reflects commitment to GSI
- GSI is incorporated in agency’s capital improvement plans (CIPs)
- Regulations promulgated to support GSI development outside agency activity
- Permits and long-term control plans, with enforceable vehicles, require GSI

Table 2.4. Sample Measures of Institutional Change in Water Agencies

I collect data on project implementation and expenditures (where available) because this is of the most importance to those who advocate for sustainable technologies. Institutional change is only interesting as far as it results in the displacement of unsustainable technologies with innovative ones. Furthermore, there may not be a precise relationship between institutional change in municipal agencies and the extent of GSI implementation in those cities. For example, an agency might be required to implement GSI demonstration projects as part of a negotiation with the regulators or a settlement proceeding. This project may be
implemented without internal organizational changes that support longer term commitments to using GSI. In short, it is important to take stock of changes to both institutions and physical infrastructure.

Process Tracing and Causal Inference
As noted, my approach is multi-level, historical, and process focused. I apply a method of structured, comparative analysis, as well as within-case analysis. Within cases, I rely on process tracing, which analysts argue is apt for assessing complex causal theories. As Hall (2006, 25) writes:

In contrast to multivariate explanation, this approach attaches less value to securing precise parameter estimates for a few key variables seen as the ‘ultimate causes’ of the outcome and more value to identifying regularities in the causal chain through which the relevant outcome is generated. The focus is on elucidating the process whereby the relevant variables have effects.

The effectiveness of process tracing depends on careful description (which ideally focuses on phenomena outlined in theory) and sequencing (Collier 2011; Hall 2006; Mahoney 2010, 2012). “Diagnostic evidence” is drawn from “good snapshots” of particular moments, linked together chronologically (Collier 2011). Valid causal inference depends on the accurate renderings of slices of time—events highlighted as significant by theory—as well as the ability to demonstrate connections between them over time.

In all four cases, I trace the twenty-five-year period from the promulgation of the first CSO and stormwater rules to the present. As I undertook this process, I realized that it was important to go much farther back in time to account for differences in water governance structure each city, by which I mean the variation in organizational form and local water policy found in my cities. In Philadelphia and Boston, I include a much broader historical account of the unique pathways that led to the particular organizational and infrastructural configurations that
existed at the end of the 20th century. This history is drawn primarily from secondary sources and examines the evolution of water and sewer management from each city’s founding—a set of unique developments that I argue is extremely relevant to outcomes in each city.
Part II: The Context
MUNICIPAL WASTEWATER AND
THE NATIONALIZATION OF WATER POLLUTION POLICY

If there were an episode in the history of US national policy that represented a clear example of punctuated change, it would be the period between 1969 and 1980. During these years the federal government inserted itself into what were historically state and local issues, and enacted one law after another aimed at protecting human health and natural systems from environmental threats. Driving these legislative changes was a broad-based popular environmental movement, arising from a combination of shifting demographics and public preferences as well as media attention. The Federal Water Pollution Control Act of 1972, also known as the Clean Water Act, was one of the key pieces of legislation passed during this time period. As this chapter details, the Clean Water Act had profound implications for urban wastewater management. The heart of the law was its proclamation that the nation’s rivers and streams could no longer be used as dumping grounds, and that municipal pollution should only be allowed as required by the “limitations of technology and economic achievability” (Adler, Cameron, and Landman 1993). However, the Clean Water Act did more than provide an imposing federal framework for municipal water pollution control. It also changed the actors and interests engaged in water pollution policy and embedded municipal sewage agencies in a new regulatory and political landscape that continued to influence and shape local decision-making and wastewater infrastructure investments decades after the Act’s passage.
THE HISTORIC CHALLENGE OF URBAN WASTEWATER

The first comprehensive American sewer systems were constructed in the mid-1800s as population in the nation's urban centers expanded exponentially. Between 1820 and 1880, Boston's population increased eightfold, New York's tenfold, and Philadelphia's increased thirteen-fold. New centralized waterworks piped millions of gallons of water into these cities each day, but there was no complementary drainage system. Wastewater, including that from privies, cesspools and water closets, ran through the streets or lay in stagnant pools, prompting widespread upset—most notably from the medical community. Municipal survey engineers charged with managing the problem looked to their European counterparts for solutions. Most modeled their approach on London's "water carriage" system, which used an underground hydraulic system to flush wastes out of the city and formed the basis for modern sewage disposal; stormwater and domestic wastewater were combined in a single pipe. Although there was debate on the matter, leading experts agreed that these combined sewer systems were as safe and effective as building two sets of pipes, so many US cities chose the former, cheaper option. By 1900 all of the major US cities used combined systems (Melosi 2008). Experts also generally agreed that waterbodies, particularly the large, fast-moving rivers of the North America, could effectively dilute sewage, rendering it harmless. Against the objections of some prescient health officials, municipal engineers used local waterways for sewage disposal. Each year cities piped billions of gallons of raw sewage into local rivers and streams—some of which were relied upon for drinking water.

Between 1880 and 1905, Chicago and Philadelphia expanded their sewer systems fivefold; Pittsburgh's system grew by fourteen-fold (Melosi 2008). Municipalities financed these and other infrastructure projects by taking on

13 This growth was not only from in-migration but also annexation and consolidation. For example, in 1855, Philadelphia annexed a number of outlying communities and expanded its boundaries from two square miles to 129.
enormous debt. Between 1840 and 1880 total state and local debt grew from $200 million to $1 billion. By 1920, total municipal debt had increased to $16 billion (Malanga 2010). Meanwhile, urban wastewater had overwhelmed the dilution and cleansing capacity of many local waterbodies. The urban pollution problem had not so much been remedied as relocated. Engineers finally conceded what public health officials had argued for decades: some form of sewage treatment was needed.

As early as 1860, scientists had developed effective primary sewage treatment technologies that filtered out large solids. Biologic (secondary) treatment technologies to reduce bacteria and biological oxygen demand (BOD) emerged in the 1890s. However, cities struggled to establish adequate revenue to cover their costs. Constitutional debt ceilings and competing local priorities reduced funds available for water system upgrades. The stock market crash in 1929 led to thousands of municipal defaults. In most cities, allocations from general funds barely supported sewerage maintenance and expansion, and because treatment primarily benefitted downstream communities, citizens regularly rejected general obligation bond issues for treatment upgrades (Andrews 1999, Melosi 2008). The successes of the sanitary movement of the 1800s—promoting urban drainage as well as drinking water treatment, particularly disinfection—also explained the inadequacy of available funding. By the 1920s, municipal investments in these sanitary projects had successfully limited human contact with the fecal bacteria borne in municipal wastewater and largely eliminated cities’ episodic typhoid and cholera epidemics. Improved public health conditions significantly reduced citizens’ demands for water pollution remediation.

States varied in their ability and willingness to help address local sewage challenges. In the early 1900s, health crises prompted a handful of states to pass pollution legislation. For example, in 1905, Pennsylvania established one of the nation’s first stream pollution laws in response to a typhoid outbreak in the community of Butler that sickened 10% of the population. Interstate conflicts also
resulted in compacts or lawsuits that curbed the disposal of untreated wastewater. By the 1930s, however, only a handful of states had laws requiring cities to provide some form of sewage treatment, and just eight states had comprehensive water pollution control laws (Dworsky 1971). State enforcement of pollution laws was notoriously lax, and state legislatures were dominated by rural interests indifferent to urban pollution problems (Melosi 2008). 14

In spite of these difficulties, cities made moderate progress. By 1909, 10% of wastewater received basic primary treatment. Investment in primary treatment facilities was often promoted by local officials concerned with the negative impact of visibly filthy water on tourism. Indeed, New York's famous Coney Island beaches, where a large primary treatment plant was built in 1886, were the first beneficiaries of this movement, and other cities with major waterfront attractions quickly followed New York's example (Stoddard et al. 2002). Litigious downstream neighbors provided another inducement for the construction of municipal treatment works. Because many of these conflicts were not based on aesthetic but rather chemical and biological impairment, the requisite response was secondary treatment for the offending wastewater. For example, in 1907 Gloversville NY constructed the nation's first trickling filter treatment plant in response to a "riparian rights" lawsuit filed by the neighboring city of Johnsville (Stoddard et al. 2002). Similarly, in 1916 Chicago constructed the first activated sludge facility to end its prolonged dispute with St Louis over Chicago's use of the Chicago River, a tributary to the Mississippi, as an open sewer. Some cities also succeeded in levying unpopular sewer rates based on water usage, thereby securing an independent revenue stream to pay for operation and maintenance. By 1938, more than 600 municipalities were using these rates to float revenue bonds and fund capital projects (Melosi 2008). Between 1933 and 1939, municipalities also took

14 Indeed, states were so disconnected from urban challenges that by the 1950s some observers predicted that state governments would be made obsolescent by an emerging "federal-city axis" (Otten 1962).
advantage of New Deal recovery loans and grants to help complete 65% of the 
nation's treatment plants and another 1,850 sewage projects (Melosi 2008).

Municipalities also turned to regional and metro-area models to improve 
service efficiency and insulate wastewater management from the exigencies of 
local politics. These arrangements avoided annexing suburban communities—
which was not always politically feasible—while reaping many of the same 
benefits (Tarr et al. 1984). Some communities began to jointly finance common 
sewer systems and treatment works that each municipality could not afford on its 
own. In other cases, a number of small communities signed agreements to have 
their wastes treated by a large, neighboring municipality (Mathewson 1964; Melosi 
2008). For example, by 1960 every community around Philadelphia had entered 
into contracts to send their wastes to Philadelphia’s treatment works. Because 
these cooperative agreements could result in jurisdictional conflicts, another 
option was to create a special purpose sanitary district to provide sewage services. 
Special purpose districts had the benefit of operating with substantial 
administrative and financial independence from general-purpose governments, 
although some district boards included elected officials. Depending on state 
authorizing law and the district’s governance structure, some districts could levy 
taxes and assessments; others, like public authorities, could only charge user fees. 
Special districts were especially desirable because they could circumvent 
municipal tax and debt limits.

Nevertheless by 1940, seventy-five million people (55% of the US 
population) were served by sewer systems but only a quarter of those systems used 
secondary treatment which was essential to breaking down the dissolved solids 
that remained after initial settling. 15 Half of all sewer systems used no form of 
treatment at all, and waste entered local waterways completely raw (Dworsky 1971, 
ASCE 2011). By 1946, inland waterways received the raw domestic wastes of some

15 The more rural remainder of the population relied on decentralized, on-site treatment such as 
septic systems.
47 million people. Throughout this same period, water-polluting industries routinely escaped local and state efforts to curtail their discharges through effective political lobbying that focused attention on the economic costs of pollution regulation. In 1951 the Federal Security Agency conservatively estimated that US waterways carried industrial and domestic pollutants equivalent to the raw sewage of 150 million people (Melosi 2008).

The prevailing assertion that water quality and pollution were local concerns meant that there was only modest federal involvement with these issues until well into the 20th century. Between 1899 and 1948, members of Congress introduced one hundred bills addressing water pollution that all failed for lack of support (Stoddard et al. 2002). During this time, just three relevant federal laws were passed and they applied to very limited cases. The first was the 1899 Refuse Act, which sought to keep interstate navigable waterbodies clear of refuse by requiring a US Army Corps of Engineers permit for solid waste dumping; this law exempted sewage or liquid discharges, leaving oversight to state and municipal powers. Then in 1914 Congress empowered the National Public Health Service to establish drinking water quality standards for interstate carriers, but the agency’s pollution control activities were otherwise limited to research and advisory roles. The federal government’s third foray into water pollution control, the Oil Pollution Control Act, applied only to ship discharges in coastal waters, and was difficult to enforce (Andrews 1999). A fourth pollution control bill, passed by Congress in 1938, was vetoed by President Roosevelt over budget concerns (Stoddard et al. 2002).

After WWII, the national government began laying the groundwork for expanded federal involvement in controlling water pollution, which was increasingly seen as a threat to economic growth (Andrews 1999; Brumley 1959; Milazzo 2006). Legislators on the House of Representatives’ Public Works Committee argued that water quality was as important to development as water quantity, yet little was being done to redress the problem (Milazzo 2006). Seeking
to spark more aggressive state and local action, in 1948 Congress passed the Federal Water Pollution Control Act. The Act relied primarily on the tools of knowledge dissemination and financial incentives to encourage, as opposed to require, local control efforts (Hines 1971). It authorized the National Public Health Service (PHS), within the Department of Health, Education, and Welfare (HEW), to help states and municipalities develop comprehensive plans to reduce pollution in interstate waters and initiated a federal loan program to support the construction of municipal sewage treatment facilities. The program remained unfunded, however, until Congress, exhorted by the secretary of HEW, amended the statute in 1956 (Barry 1970). The loan program was replaced with a large-scale construction grant program to provide $50 million annually and up to 30% of wastewater facility construction costs. The 1956 amendments also created a three-stage cooperative enforcement mechanism—conference, hearing, then court action—to address pollution originating in one state but endangering the “health or welfare” of individuals in another (Cohen and Jerome 1962). The first stage was an “enforcement conference,” which could be convened by the head of PHS (the Surgeon General) or a state governor. The conference engaged relevant agencies, industries, and other affected groups in the development of a voluntary cleanup plan. Federal court action was a last resort and could only be taken with the approval of the governor of the affected state.

Overall, the Act yielded mixed results. Although some states and municipalities chaffed at the perceived federal intrusion, the grant program proved incredibly popular and resulted in a burst of local construction activity unseen since the 1930s (Spivak 1960). Between 1957 and 1969, states, municipalities, and intergovernmental agencies spent a total of $5.4 billion on 9,400 treatment...
projects. The White House sought far lower appropriations, but the federal
government contributed $1.2 billion of this total (Barry 1970). As a result, the
number of people served by secondary treatment doubled from 32 million to 60
million—nearly half the US population—between 1950 and 1960. However,
wastewater treatment investments proceeded in fits and starts; treatment levels
and effectiveness varied substantially across municipalities; and funding for
upgrades lagged need. The wastes of ten million people still entered local
waterways completely raw (ASCE 2011).

The federal enforcement program fared particularly poorly. Tracing
pollution across state boundaries turned out to be extremely difficult. So too was
measuring the vague standard of "harm to health or welfare." Critics argued that
PHS' powers were insufficient and that unabated industrial pollution was
undercutting the water quality benefits of upgraded treatment plants (Barry 1970).
By 1961 the federal government had initiated only fifteen enforcement actions,
none of which proceeded beyond conference (Cohen and Jerome 1962). That same
year, Congress responded to the criticism that federal power was too weak by
expanding its authority from the nation's 4,000 interstate waters to all 26,000
"navigable" waters, making it possible for the federal government to intercede in
intrastate pollution issues (Barry 1970; Cohen and Jerome 1962). The amendments
also transferred enforcement power to the Secretary of HEW, authorizing the
agency to litigate interstate violations without state approval (Cohen and Jerome
1962). By 1965, the federal government had convened thirty-three conferences
impacting 680 municipalities and 7,000 miles of streams (Mathewson 1965). Still,
serious water quality problems remained. Critics argued that the enforcement
conference's reliance on "consensus, discretionary authority, and voluntarism"
undermined its effectiveness (Barry 1970; Cohen and Jerome 1962). Industries had
little incentive to undertake expensive upgrades—particularly if they perceived

17 In 1950, of the 11,784 treatment plants in the US, only 3,529, serving an estimated 32 million
people, provided secondary treatment (Melosi 2008).
that their competitors were not facing similar costs. Yet without stronger political support, the federal government was reluctant to pursue more aggressive enforcement action.

THE US ENVIRONMENTAL MOVEMENT CHANGES THE STORYLINE, AND THE RULES

Meanwhile, the national mood was shifting. WWII was followed by an era of unprecedented affluence. Homes, cars, and other goods and services once out of reach for most Americans were now accessible to many. The postwar increase in mass consumption was facilitated by national policy on housing and energy but also depended on the expansion in industrial extraction and production that had supported the war effort. In peace-time these industries did not demobilize but pivoted to supply (and create) civilian markets and applications for their products: “cars, airplanes...fuels, fertilizer, pesticides, synthetic fabrics, plastics” as well as nuclear energy (Andrews 1999, 182). America’s burgeoning middle class, however, demanded more than just consumer goods. They also sought a particular “quality of life” that included access to education, a healthy and aesthetically pleasing environment, opportunities for recreation, and freedom from environmental hazards (Hays 2000). As Andrews writes, this period produced a powerful and contradictory set of political pressures, as “demand rose both for material goods and for the environmental amenities threatened by their production” (Andrews 1999, 199).

In this context, the 1960s saw the emergence of the modern environmental movement: an alliance of environmentally engaged, though topically and geographically heterogeneous, organizations that were supported by an increasingly activist lay public. These organizations included traditional landscape

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18 In 1959, a Georgia State department of public health official summed up this contradiction neatly when he stated: “Our people want to clip the coupons of industrialization during the week, but when they go fishing on Saturday or Sunday, they want the river clean” (Brumley 1959).
preservation groups, such as John Muir's Sierra Club and the Audubon Society; a
growing constituency of outdoor recreationists and related economic interest
groups like the American Automobile Association, recreational vehicle
manufacturers, and park concessionaires (Andrews 1999, 200); as well as public
and community health organizations. These advocates reframed symbols of
economic progress as threats to landscape preservation and individual wellbeing,
engaged in extensive local, state and national organizing, and directly lobbied
federal political leaders (Hays 2000, Andrews 1999). In doing so, environmental
advocates demanded democratic access to a policy-making apparatus dominated
by commodity interests. For decades, special interest groups— timber, energy, and
mining companies— had shaped national policy on land and water in their favor
by forging alliances with congressional leaders and natural resource bureaucracies.
Environmentalists sought to break these so-called “iron triangles” of influence.

Although nongovernment organizations (NGOs) functioned primarily as
political action groups, their credibility largely derived from their scientific and
technical expertise (Fiorino 1995). In addition to lawyers and lobbyists, many
environmental advocacy organizations were staffed with talented scientists, skilled
at interpreting, promoting, and producing new scientific research. Environmental
NGOs thus played an important role as purveyors of policy-relevant knowledge. As
Kraft (2001, 144) writes, while academic or government scientists were often
reluctant to wade into public policy debates, environmental NGOs filled this gap
by bringing scientific discoveries to public and policymaker attention and by
“clarifying” the technical and policy-relevant issues. They did this in part through
the release of their own studies, summaries, and reports. These publications
presented data and analyses that challenged government positions and highlighted
new concerns and issues that might otherwise have been overlooked during
decision-making (Kraft 2001).

Environmentalists of the 1960s and 1970s were particularly effective at
focusing the public's attention on the new and widespread chemical and toxic
pollutants resulting from industrial and agricultural activities. Studies suggested that these compounds were long lived, transported across media (air, water, and soil), and had potentially devastating effects at the cellular level on human and animal health and reproduction. Rachel Carson’s book *Silent Spring*, a popular-science treatise on the dangers of the pesticide DDT and industrial chemicals, became a national bestseller in 1962. Television and other media coverage of an array of alarming events—the “cranberry scare” of 1959, the conflagration of the Cuyahoga River in Ohio, and a massive oil spill in the Santa Barbara Channel—heightened public concern and mobilization, particularly among the suburban middle class.

Although not perfectly unified in perspective or goals, environmental advocates of this period also espoused a holistic vision, one grounded in the science of ecology that highlighted the interconnectedness of organisms and natural systems. The environment, they argued, did not respect political boundaries; water pollution from one jurisdiction, for example, threatened all downstream neighbors. Successful management strategies, therefore, required cooperation and standardization across states and localities. The federal government, they posited, was in the best position to oversee this. Environmentalists further argued that the objectives of pollution management should be broader than the historic goals of protecting human health and economic development; they should include concern for other recreational and aesthetic uses and ensure the overall health of ecosystems for both human and non-human species. In the area of water pollution, environmental advocates sought to commit public energy and resources to addressing the impacts of domestic wastewater, in addition to industrial discharges. ¹⁹

¹⁹ Andrews (1999) argues that industry groups may have had more influence on early nationalization efforts than the environmental movement, which was still nascent, and thus paved the way for an expanded federal role. As states began to toughen pollution laws, industries saw a clear benefit from uniform, “moderate” national standards. Of course, as he further notes, local civic and conservation groups were responsible for the increasing stringency of water policy in states like Pennsylvania and California.
A number of political events in the 1960s facilitated the relatively rapid translation of these demands into national policy. First, the Kennedy-Johnson administration's "Great Society" initiative—which reflected progressive-era optimism in government's ability to solve society's ills, particularly through domestic spending—provided both the "precedents and momentum" for strengthened environmental legislation (Susskind and Weinstein 1980, 316).

Second, court mandated congressional redistricting lent environmentalists' interests greater weight at the national level. The balance of power swung from rural to urban, reflecting the gains in population density in the nation's Northeast and Midwest cities and developing suburbs—and the widespread declines in predominately rural areas. The majority of the representatives who supported environmentalist positions came from urban districts and their surrounding suburbs, particularly along the northeast corridor (Andrews 1999, 222). The interests of entrenched commodity interests were eroded through Congressional turnover and by alterations to committee structure that spread power over environmental issues more widely in the 1970s (Andrews 1999).

The early impact of these developments on water pollution control policy was first evident in the Water Quality Act of 1965. With this Act, Congress laid out a national policy for the "prevention, abatement, and control of water pollution" and for the first time mandated state action. Spearheaded by environmental champion Senator Edward Muskie (D-Maine), the Act required states to develop ambient interstate water quality standards based on use—taking into consideration recreation, fish and wildlife, and agriculture, among others. The Act further directed states to calculate acceptable pollution discharges, and divvy up this total among polluters. States were responsible for monitoring outcomes and ensuring compliance. The Act also expanded the construction grants program and authorized $150 million per year for sewage treatment projects (CQ Weekly 1966). The maximum federal subsidy per sewage treatment project was increased from $600 thousand to $1.6 million, and up to $4.8 million for facilities serving several
communities. However, the maximum subsidies for large facilities were only a fraction of their total costs and too low for major cities to leverage—a problem that had plagued the construction grants program from its outset (Melosi 2008).

In addition to prompting new legislation, the changing objectives of pollution control policy resulted in the transfer of authority from the National Public Health Service—the historic oversight agency—to a series of other agencies with expertise and missions deemed more relevant. In 1965, President Johnson vested water pollution control in the newly created Federal Water Pollution Control Administration. Like the Public Health Service, the Administration also reported to the Secretary of Health, Education, and Welfare. Five years later, the Administration was renamed the Federal Water Quality Administration and moved to the conservation-oriented Department of the Interior, which was tackling a number of related issues, including “river basin planning, water resource development and research, fish and wildlife conservation, and outdoor recreation” (Andrews 1999). The administration became the symbol of the federal government's new role as “activist agent” in water quality regulation (Melosi 2008, 190).

A year after the passage of the Water Quality Act, the National Academy of Sciences released a report predicting that by the year 2000 two-thirds of the nation’s annual stream flow would consist of the polluted water returns from industry, municipalities, and farmlands, unless action was taken (NAS 1966). The report further estimated that it would cost “tens of billions of dollars” to meet the nation’s treatment needs, and another “20-30 billion” to separate the flows of combined systems and prevent sewage overflows (NAS Committee on Pollution 1966, 191). While hesitant to support the “extreme” position that “all criteria, standards, and enforcement be federal,” the report’s authors encouraged the federal government to assume a much larger role in pollution control—particularly by initiating “large-scale experimentation and demonstration models” (NAS 1966, 6).
In response, Congress unanimously passed the Clean Waters Restoration Act of 1966, a fusion of a Johnson administration proposal to support river basin planning and the recommendations of the Senate Subcommittee on Air and Water Pollution. Senator Muskie, the subcommittee chair, stated that the purpose of the legislation was to provide the “muscle” to support the “tools” of the Water Quality Act (Congressional Quarterly Almanac 1966). In particular, the 1966 Act provided grants to state planning agencies to devise watershed level pollution control plans consistent with state water quality standards. The Act extended the construction grants program, which was set to expire in 1967. The Act also included a major increase in funds and authorized $3.55 billion over five years. The government would continue to fund up to 30% of a project’s costs, but the dollar ceiling was eliminated if states agreed to match federal dollars—an important boost to large municipalities (Stoddard et al. 2002). Congress also authorized $313 million for research and demonstration projects, including studies of advanced wastewater treatment and new methods for controlling pollutants from stormwater and combined sewer systems.

Even with this increase in federal support for comprehensive planning and treatment works construction, implementation of the Water Quality Act was rife with problems. Water quality monitoring was expensive (as it still is), while modeling science was in development. State authorities struggled to definitively link water quality violations to a particular discharger (McMahon Jr. 1973; Poe 1995). In most cases the data to support a case against a facility had to come from the discharger itself (Barry 1970). In addition to raising concerns over such data’s accuracy, critics argued that this process reduced the likelihood that an industry would take part in pollution studies that might later be used against them (Barry 1970). Critics also noted that that the law was reactive, not preventative. Its language precluded action from being taken until after water quality standards had been exceeded, and damage was already done (McMahon Jr. 1973). The Act did not explicitly prohibit the use of waters for waste conveyance, and did nothing to
discourage industries situated on pristine waterways from degrading water quality to the minimum acceptable standards (Harrington and Nelson 2006). Finally, states varied considerably in resources, agency expertise and talent, commitment to pollution control, and willingness to “resist the temptation to compete for new industries” by relaxing enforcement (Freeman 2000, 173). By 1970, the federal government had called just four hearings and litigated only one case—against St. Joseph, Missouri (Mathewson 1965; Spivak 1960). Twenty-three states still did not have approved water quality standards, precluding the possibility of any federal enforcement actions at all. The General Accounting Office criticized the effort as “inadequately financed, badly organized, [and] poorly planned” (Congressional Quarterly Almanac 1970).

Although the Water Quality Act was ultimately branded unworkable due to its analytic complexity, uneven implementation, and weak enforcement, its failures did inform ensuing federal rules and legislation (Copeland 2016; Freeman 2000). For example, in 1968 the Federal Water Pollution Control Administration attempted to address the problems associated with controlling pollution exclusively through water quality standards by proposing wastewater effluent standards based on “best practicable treatment,” which the Administration defined as secondary treatment (Stoddard 2002). The Administration also attempted to impose an “anti-degradation” policy for interstate waterways that would require states to maintain and protect existing instream water uses and high-quality waterways (Barry 1970). States and municipalities immediately challenged the authority of the Administration to issue such regulations, and in the face of potential legal action, the Administration retreated. Ultimately it would take an act of Congress—the Federal Water Pollution Control Act of 1972—to provide a statutory basis for the federal regulation of wastewater effluent.

Indeed the Cuyahoga River’s approved state designation was for waste disposal. Its water quality did not fall below its use standards until the river finally caught fire in 1969—and became the public symbol of the nation’s deteriorating water quality (Hodas 1995).
THE PASSAGE OF THE CLEAN WATER ACT

In 1970 the environmental movement was at its peak. On April 22, the first Earth Day—a national teach-in on the environment—attracted over twenty million participants. Opinion polls revealed that the public was as concerned about pollution as it was about crime, and over 60% of the public believed that the federal government was not spending enough to address environmental degradation (Dunlap 1991). On July 9th President Richard Nixon submitted an executive order that would redress the fragmentation of federal pollution-related research and regulatory activities by consolidating them in one new independent agency: The Environmental Protection Agency. The agency would be composed of one national office, located in Washington, DC, 56 research laboratories, and ten regional offices. EPA’s national headquarters would produce regulations, standards, and policy, fund research and development, and ensure national consistency. Federal permitting, compliance, enforcement, and authorization programs would be administered at the regional level, where states and regulated communities would have day-to-day contact with EPA. The plan easily found support in Congress. By December of 1970 the Senate confirmed EPA’s first head, William Ruckelshaus, a former deputy attorney general of Indiana’s Board of Health and outgoing majority leader in Indiana’s House of Representatives. The agency’s first major charge was the monumental federal Clean Air Act. Passed in 1970, the act sought to achieve “healthy air” through reductions in six primary pollutants—particulate matter, sulfur dioxide, carbon monoxide, photochemical oxidants, nitrogen oxides, and hydrocarbons—by 1975.

Spurred by President Nixon, who offered his own water pollution control proposal, both houses of Congress turned to drafting new water pollution legislation responsive to the public’s sweeping demands. In 1971, after eight months of hearings, senators on the Public Work’s Subcommittee for Air and
Water Pollution, chaired by Edward Muskie, crafted Senate Bill 2770 (S. 2770). Although the bill would amend the Federal Water Pollution Control Act of 1948, it represented a comprehensive overhaul of that legislation. The testimony of public interest and environmental advocacy groups played a large role in shaping the legislation. Yet, as Milazzo (2006) notes, in many ways the bill was less policy “upheaval” than “synthesis.” In seeking to protect ecosystem “integrity,” the act adopted the language of ecology, but the bill’s tools—enormous authorizations, end-of-pipe technological interventions, and implementation timelines—reflected the more traditional political priorities of career legislators; the technical input of civil engineers long associated with the Public Works Committee; and the management tools of military systems analysts, who recommended the use of firm deadlines linked to clearly defined deliverables (Milazzo 2006).

Nevertheless, S. 2770 broke with the past two decades of incremental policy adjustments and offered an ambitious national pollution policy: to ensure that all US waterways could support fish propagation by 1981 and to eliminate pollutant discharges by 1985. It granted the federal government authority to regulate the quantity of pollutants in wastewater discharges and develop other programs to eliminate pollution from navigable waters. It also expanded the construction grants program by an order of magnitude in response to the testimony of state and local political leaders—represented by the National Governors Association and the US Conference of Mayors. The bill passed in the Senate by a unanimous vote on November 2, 1971.

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21 At this point, Muskie had his sights set on the 1972 presidential election, where he hoped to run as the democratic nominee during Nixon’s re-election campaign. In the run-up to the election he and Nixon were engaged in a political one-upmanship. Although Nixon privately viewed environmentalism as a “fad,” he was eager to publicly demonstrate his leadership on the issues. Muskie hoped to outdo the president, and handed him a particularly aggressive water pollution control law.

22 More troubling, even as Congress was passing landmark environmental laws like the Clean Water Act, the science underpinning those laws was quickly becoming outdated.
On March 14, 1972, the House passed its own version of the bill with adjustments to industry deadlines, construction grant payment methods, and spending levels, among others. Although the House bill increased authorizations for construction grants—an unsurprisingly popular provision among constituents but a source of contention with the White House who favored a much smaller amount—environmentalists argued that it also weakened a number of the Senate provisions by limiting opportunities for citizen oversight and making continuation of the program contingent on a two-year follow-up vote. After what observers called a “torturous” reconciliation process “complicated by the Nixon Administration’s opposition,” on October 3rd, 1972 Congress passed the Federal Water Pollution Control Act of 1972, hereupon called the “Clean Water Act,” to be administered by EPA (CQ Almanac 1973). Environmental and citizen associations mostly praised the final result—at least as a “reasonable compromise” (CQ Almanac 1973). Major industries as well as some states and municipalities strongly opposed it as inflexible and too costly for them to implement. They were particularly critical of the move away from water quality based standards to uniform technology based standards. They argued that it was inefficient to require facilities to undertake millions of dollars in upgrades in locations where water quality standards were being met. Many state officials also chafed at the unprecedented levels of Federal control and oversight.

On October 17th, the last day of the 1972 congressional session, President Nixon vetoed the bill. In his veto message, Nixon praised the act’s “laudable intent” but objected to the “unconscionable” and “budget wrecking” price tag of $24 billion, of which $18 billion was for construction grants (CQ Almanac 1973). Congress had ignored Nixon’s recommendation of $4 billion for construction grants and $6 billion in total authorizations in favor of one of the largest non-

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23 The Clean Water Act gets its name from mid-course revisions passed in 1977. The main statute is called the Federal Water Pollution Control Act of 1972. For simplicity, I use “Clean Water Act” to refer to the 1972 law and its subsequent amendments.
defense authorizations in the history of Congress. But in the early morning of October 18th, Congress delivered the President a major defeat by overriding his veto with votes of 74-0 and 366-11 in the Senate and House respectively. In response to the President’s concerns, Senator Muskie reaffirmed that the authorized spending was based on “a very careful evaluation of needs” (CQ Almanac 1973). Citing the warnings of the administration’s own Council on Environmental Quality, he added “It will cost more in the end to quit than to fight” (CQ Almanac 1973).

Key Provisions of the Clean Water Act
Although the act is still being revised and implemented, the 1972 Clean Water Act (PL 92-500) established a uniform national framework that remains the foundation for modern day water pollution control. Prior to the Clean Water Act’s passage, EPA had been experimenting with federal water pollution permitting by resurrecting the 1899 Refuse Act, but the Clean Water Act reflected a novel integration of a permit system with a comprehensive water pollution control program based on “definite goals, clear standards, and strong enforcement” (McMahon Jr. 1973). The Clean Water Act sought nothing less than to “restore and maintain the chemical, physical, and biological integrity of the Nation’s waters.” The act advanced two non-binding national goals: fishable and swimmable US waterways by 1983 and the complete elimination of pollutant discharges to navigable US waters by 1985. To achieve these goals, Congress created the National Pollutant Discharge Elimination System (NPDES), the centerpiece of the Clean Water Act. The NPDES program replaced the permitting process under the Refuse Act and required any person responsible for the disposal of pollutants into the “waterways of the United States” from “any point source” to obtain and comply with a NPDES permit delimiting legal discharges.

Moving away from the challenging water quality-based criteria of the unsuccessful Water Quality Act, Congress directed EPA to establish uniform
NPDES effluent limits based on the efficiency of available pollution control technologies in each category of polluter. Congress did not mandate a particular design standard but rather laid out a "technology forcing" mechanism modeled on the Clean Air Act that called for a gradual phase-in of increasingly stringent performance standards (Copeland 2016). First, dischargers had to meet the standards of "best practicable control technology currently available" (BPT) by July 1, 1977. Congress required municipal treatment plants to meet "secondary treatment standards" by the same date. Industrial dischargers were to eliminate pollutant discharges, or meet "best available treatment economically feasible" (BAT) by July 1, 1983. Congress defined BPT as an "average of the best" and BAT as the "best of the best" performance, in an industry category (McGaffery and Moser 2011). Congress directed EPA to promulgate enforceable industrial and municipal effluent guidelines based on BPT, BAT, and secondary treatment by 1973 and issue the first round of NPDES permits by 1974. Congress also required EPA to impose a second round of technology-based requirements on wastewater treatment facilities to move performance closer to the act's zero discharge goal. Known as "best practicable waste treatment technology" (BPWTT), Congress broadly defined this level of treatment as water recycling and reclamation as well as the "confined disposal of pollutants." EPA was directed to review (and as necessary, revise) effluent limits every five years. NPDES permits themselves were to cover a term of no more than five years, with the expectation that each subsequent permit would increase in stringency. Importantly, Congress retained the state water quality standards first imposed under the 1965 Water Quality Act and subject dischargers to the stricter of the two sets of standards.

The act required EPA to consider only marginal costs when setting effluent standards. Environmental advocates viewed efforts to include more demanding cost analyses as attempts to undermine strict abatement requirements (Davies and Mazurek 1999). These groups had urged lawmakers not to require EPA to undertake extensive cost benefit analyses that might hinder the agency's ability to
meet statutory deadlines or result in weak effluent limits. Furthermore, they argued that it was impossible to fully enumerate the social benefits of clean water, which they insisted, nonetheless, were enormous. The act largely reflected this position. In setting BPT levels, EPA had a limited burden—to “limit the application of technology only where the additional degree of effluent reduction is wholly out of proportion to the costs” (McGaffery and Moser 2011, 36). This amounted to a partial cost-benefit analysis that did not take into account broader social impacts (McGaffery and Moser 2011). In setting BAT levels, costs were to play even less of a role. EPA only had to consider whether such limits were “economically achievable.” However, the act also created the 15-person National Water Quality Commission, chaired by the Vice President, to deliver a report to Congress on the costs and benefits of achieving the 1977 and 1983 goals. This provision replaced a controversial requirement in the House’s version of the bill to initiate a two-year study by the National Academy of Sciences and Engineering and make further implementation of the BAT standards contingent on the National Academy’s findings.

The Clean Water Act further declared it the “policy of Congress to preserve and protect states’ rights in pollution control” and anticipated that states would serve as the frontlines for permitting, oversight, and enforcement. The act authorized EPA to delegate these powers to state programs that demonstrated the capability to administer a NPDES program and the legal authority to enforce compliance. States could establish more stringent rules as they saw fit, but were required, at minimum, to meet federal standards. Consistent with a cooperative or “conjoint” federalist model, the federal government remained the dominant partner (Fiorino 1995). Thus even in states with so-called “primacy,” EPA retained the right to oversee state permitting, reject permits, take independent enforcement actions, and rescind parts or all of a state program that did not meet the objectives of the Clean Water Act. Similarly, EPA had to review and approve state water quality standards and adopt its own standards in states that failed to do
so adequately. Waterways failed to meet water quality standards after the application of technology and water quality based controls, states were required to enter them onto a list of "impaired waters." These listed waterways were subject to strict national limits, "total maximum daily load" (TMDL), that allocated specific daily pollution loads across all contributing point sources.

To help municipalities meet the act's substantial pollution reduction requirements, Congress authorized $18 billion over a three-year period for secondary or more advanced treatment upgrades. Although strongly opposed by the White House, this provision expanded construction grant funding by an order of magnitude. The maximum federal share for projects was increased to 75%, which guaranteed that large municipalities would benefit as well as small ones. Congress directed EPA to distribute funds to states on the basis of need; however, importantly, the act also obligated municipal agencies that received grants to institute wastewater user fees—as had been widely adopted in drinking water systems—to ensure a sustainable revenue source for ongoing maintenance and operation.

Water Quality Standards (WQS) allow regulators to impose more stringent effluent limits than those required by technology based standards. WQS contain several pieces of information. First, they define a waterbody's designated use(s)—for example, as a public water supply or for recreation. Multiple designations may apply to one segment. The CWA distinguishes designated uses, which are often aspirational, from "existing" uses—those achieved on or before November 28, 1975. Existing uses are subject to an "anti-degradation" policy and cannot be rolled back. Designated uses that are higher than existing ones can be removed through a process known as "use attainability analysis." EPA has ruled that only six conditions allow for the removal of a designated use, including unfeasibility; permittees must demonstrate the existence of at least one of these six. WQS also include so-called "ambient criteria," composed of numeric chemical concentrations as well as narrative statements. These criteria translate broad use goals, such as "swimmable," into measurable and enforceable parameters. Furthermore, EPA interpreted CWA to mean states should seek at minimum fishable and swimmable uses for all waters. In practice, regulators only began to focus on water quality standards in the 1990s, once compliance with technology based standards was more widespread (Andrews 1999). The act required states to review and modify water quality standards every three years.

Because the Clean Water Act is unclear as to when states must establish TMDLs and the process of establishing such limits is analytically complex and expensive, the program is controversial and has been implemented unevenly.
Environmentalists were mindful of the government’s record of weak enforcement and the strong economic incentive polluters had to disobey the law in the absence of a credible enforcement system. They had pushed legislators to include language in the act that required EPA to take action against all violations. Congress’ decision to maintain discretionary enforcement was met with frustration. In a press release, the Environmental Policy Center wrote, “By leaving the government free not to prosecute politically powerful polluters, the bill virtually guarantees abusive under-enforcement” (CQ Almanac 1973).

Nonetheless, the Clean Water Act granted EPA substantial enforcement “teeth,” empowering the agency to take range of actions against a discharger that failed to meet the terms of its NPDES permits or other provisions of the law. These actions included the right to take civil administrative actions ranging from informal notices of violation to formal compliance orders. Legislators also recognized that compliance depended on dischargers’ perception that violating the law would be costlier than investing in pollution control upgrades. Therefore, the act also empowered EPA to commence a civil action in district court seeking injunctive relief as well as a monetary penalty up to $10,000 per day. (1987 amendments to the act granted EPA the right to levy administrative fines as well.) As a “strict liability statute,” a defendant’s “good faith” or ignorance was “irrelevant to establishing civil liability” under the act (Ginsberg et al. 2011, 233). EPA could also bring criminal charges against violators who “negligently” and “willfully” broke the law, an act punishable by up to $50,000 per day of violation and a maximum prison sentence of two years.

Finally, the act included a “citizen suit” provision that granted any person legal standing to pursue a civil lawsuit against a polluter in federal court as well as the right to sue the EPA administrator for failing to perform a non-discretionary duty. The substantial (and contentious) impact of this provision on rulemaking and enforcement is discussed in the next section, but some historical notes are useful here. Although it would become a mainstay of future environmental
legislation, the citizen suit provision was an innovation\textsuperscript{26}. Prior to the 1970s, only public officials—attorney generals and district attorneys—could litigate in the public interest. Unless she could demonstrate economic injury, a private citizen could rarely establish standing in a pollution related lawsuit (Lutz and McCaffrey 1971). Supporters of citizen suits argued that agency officials could not be trusted to act in the public interest when writing and enforcing environmental regulations. Citing an abundance of historical evidence, they argued that legitimate channels of public participations—such the 1949 Administrative Procedure Act's (APA) requirements for comment periods and opportunities for public hearings—were far too limited to effectively counter administrative inertia and the influence of commercial interests (Lutz and McCaffrey 1971; Sax 1971; Zwick and Benstock 1971). Furthermore, the public often lacked the technical expertise, finances, and organizational capacity that private interests wielded to achieve legislative and administrative concessions—frequently out of the public eye. Supporters of citizen suits concluded that the court system could provide an antidote to this imbalance, but was largely inaccessible to the general public due to standing requirements. They therefore urged the passage of legislation that would empower individual citizens to act as “private attorney generals” and to “challenge agency action...and complement administrative efforts which fall short of supplying environmental protection” (Lutz and McCaffrey 1971, 575).

Congress first included a citizen suit provision in the 1970 Clean Air Act and two years later it served as the model for the Clean Water Act's.\textsuperscript{27} Unsurprisingly, the concept had many detractors and was heatedly debated in Congressional hearings between 1969 and 1972. During the Clean Air Act debates, representatives of industry and skeptical congressional members warned that a citizen suit

\textsuperscript{26} This is not to say it was without precedents; see Meidinger and Boyer (1985).

\textsuperscript{27} At the same time, a handful of legislators under the leadership of Senator Phillip Hart and George Mcgovern were promoting the ultimately unsuccessful Environmental Protection Act that would have given citizens nearly "unlimited powers" to challenge administrative policy and seek relief from "unreasonable pollution impairment or destruction" (Kewortbey 1971).
provision would likely encourage "frivolous or harassing" lawsuits and lead to the proliferation of court-clogging cases (Schwartz and Hackett 1984, 328).

Furthermore, as Meidinger and Boyer (1985, 837) write, many viewed citizen suits as more than an "occasional prod...or remedy. It [was] the means of seeking a major—perhaps permanent—realignment of roles and power in important areas of regulation." While supporters celebrated such a shift in power, critics worried that the public's enforcement priorities would come to supplant EPA's or result in redundancies and conflicts. For example, a memo from the Automobile Manufacturer Association noted that the administration of "new, highly technical regulatory statutes" required manufacturers to "work out with the agency technical interpretations of what regulations mean, how they are to be enforced." The memo went on to argue that citizens would upset these negotiated understandings, making "effective daily compliance...infinitely more difficult" (Schwartz and Hackett 1984, 329).

In response to this opposition, supporters of the provision argued that litigation was expensive and time consuming, and this alone would prevent frivolous suits. In defending the provision's inclusion in the Clean Air Act, Muskie argued that weak cases would also be discouraged by the requirement that losing plaintiffs pay the legal expenses of vindicated defendants. (Losing defendants were required to do the reverse.) In response to fears that there would be multiple suits against the same violation, citizen suit supporters noted that the courts frequently consolidated similar cases; furthermore, the public was required to give enforcement agencies 60 days-notice before commencing a suit and was not permitted to litigate a violation that EPA or the delegated state was already "diligently prosecuting." EPA could also intervene in any citizen suit to which it was not already a party. Given limited administrative resources, they argued, citizen suits would complement—not displace—agency efforts. The Senate Committee on Public Works further reassured industry that citizen enforcement suits would not be able to "substitute a 'common law'...or court definition [of air or
An alleged violation...would not require reanalysis or technological considerations at the enforcement stage" (Schwartz and Hackett 1984, 330). That is, citizens would not be able to sue a discharger to require them to install a technology not specifically required under the statute or by agency regulations.

During the passage of the Clean Water Act, Congress re-argued many of these same points (Schwartz and Hackett 1984). Environmentalists, meanwhile, campaigned doggedly for the inclusion of a broad citizen suit provision. In its 1971 report “Water Wasteland,” the research team led by the high profile and influential public advocate Ralph Nader reiterated that bureaucratic discretion “invites pressure from polluters to see it is exercised in their favor” and it was therefore the right of every citizen to “compel officials to carry out their duty...or move against polluters themselves” (Zwick and Benstock 1971, 396).

The final agreement represented another win for environmentalists, albeit with some compromises. The Clean Water Act reflected what Muskie termed a “restrictive” citizen suit provision (Schwartz and Hackett 1984). It provided a “permit shield”— protecting dischargers from lawsuits under the Act while they were in compliance with the terms of their permit. It required that plaintiffs demonstrate that they had been “adversely affected” by pollution—although courts have interpreted this broadly as “a reasonable concern that pollution has harmed their aesthetic or recreational interests in a waterbody” (Ginsberg et al. 2011, 260).

Furthermore, in the interest of balancing agency discretion and public accountability, legislators rejected the position of more liberal environmentalists that all agency actions be reviewable. Instead only non-discretionary actions—those required under statute—could be challenged in court. On the other hand, the provision went farther than its predecessor: reflecting the argument that citizen suits should serve as deterrents to would-be-polluters, the Act empowered the courts to assess monetary penalties on guilty parties—a departure from the

28 The more radical proposal by Hart and McGovern (ibid.) may have helped shore up support for the Clean Water Act’s citizen suit provision, which by comparison appeared quite mild.
Clean Air Act. To discourage self-interested lawsuits, however, penalties were not awarded to plaintiffs but deposited in the US Treasury as miscellaneous receipts.
THE POLITICS OF IMPLEMENTATION AND SUBSYSTEM DYNAMICS

Prior to the 1970s, policy implementation was considered a relatively straightforward stage in the policy cycle; analysts assumed that once a law was passed, the administrative arm of government would "simply carry it out" (Howlett, Perl, and Ramesh 2009, 163). Since that time, this view of implementation has been upended by the recognition that policies are rarely executed as prescribed by legislatures or other policy-making bodies (Bardach 1977; Pressman and Wildavsky 1973; Sabatier and Mazmanian 1980). Instead implementation is influenced by the unique characteristics and capacities of the bureaucracies that carry it out, as well as by a range of other government and non-government actors—many of whom use the process as an opportunity to continue prior conflicts that they "lost" in earlier stages and resolve new conflicts in their favor (Howlett, Perl, and Ramesh 2009). In this way, implementation is better understood as low-level policy-making.

In the case of the Clean Water Act, members of Congress and the White House, regulated communities, and environmental advocates—actors in the policy subsystem—did not fade into the background after the act's passage. They continued to use a variety of formal and informal mechanisms to influence how the Act was interpreted, implemented through regulations and permitting, revised through amendments, and enforced. Therefore, before discussing the particular developments in municipal water pollution policy of most relevance to the cases (i.e. the stormwater amendments of 1987 and the 1994 National CSO Policy), I provide a broad overview of the key municipal water pollution subsystem actors that have shaped administrative decision-making, statutory revisions, and compliance outputs. Because these actors appear, to varying extents, in the cases
but are not thoroughly described therein, it is crucial to discuss their interests, strategies, and relationships to one another here.

First, I review the creation of EPA, the independent federal agency that—among its many responsibilities—was charged with overseeing the implementation of the Clean Water Act and at the center of the new federal pollution control system. Although EPA was publicly hailed as a work of bipartisan consensus, it was not the reorganization that the White House had set out to achieve and was received with considerable mistrust on all sides. This resulted in a fragmented organization that—even without the political attacks that reinforced its divisions—struggled to evolve in concert with new understandings about environmental management, particularly as focus shifted from pollution and individual media (air, water, land) to integrated, holistic problem-solving.

Second, I describe the adversarial dynamics of EPA rulemaking and the oversight pressures exerted on the agency from all three branches of government. Among EPA's many powers, rulemaking— the quasi-legislative process of clarifying, defining, and describing the wording of laws through legally binding regulations—was one of its most critical and impactful responsibilities. In seeking to influence these rules, stakeholders made excessive use of EPA's built in checks and balances, resulting in the "whipsawing" of EPA between two opposing forces that are still recognizable; one sought strict implementation of the era's sweeping environmental statutes and the other sought to significantly reduce the agency's impact (Lazarus 1991b, 316). Incapable of appeasing both these conflicting interests, EPA was faced with an increasingly adversarial Congress and White House, and as a greater number of environmental organizations turned to the courts for help, the judiciary came to play an unexpectedly important, albeit controversial, role in rulemaking and agency decision-making.

At times these oversight activities provided important and healthy checks on EPA and other branches of government, but they were also harmful. They diverted EPA resources from meeting statutory goals to defending its own
decisions from real and potential external challenges. Most importantly for the interests of this study, the constant threat of lawsuits also produced an "ossification" of agency rule-making and reduced internal incentives for experimentation and innovation at all levels of administration.

Finally, I discuss the other "half" of implementation: permitting, monitoring, and enforcement which was delegated to state agencies and overseen by EPA regional offices. The decentralized cooperation model produced many of its intended benefits but also produced a fragmented, and at times, inconsistent system. One of the most significant results of this fragmentation was a compensatory increase in the 1980s of civil enforcement suits brought against polluters by environmental organizations. These suits drove major clean-ups and multi-million dollar settlements. The organizations involved came to be perceived as players of nearly equal standing and importance as those formally charged with monitoring and enforcement. Both the decentralized nature of this system and the activity of litigious NGOs help explain why there are such large differences in both the timing and substance of various municipal CSO clean-up efforts.

In these sections, I primarily discuss the first two decades of the Clean Water Act’s implementation, and focus, where practicable, on the municipal program. However, the key actors, mechanisms of influence, and general dynamics of this subsystem remained largely unchanged well into the 21st century. The most notable development over the past two decades is the increasing partisanship around issues of environmental protection. Furthermore, since the mid-1990s, when Democrats lost control of the House and Senate after nearly 40 years of political dominance, gridlock in Congress has stymied any major amendments to the Clean Water Act, as well as to the other major pollution control laws. The last major Clean Water Act amendment passed in 1987. (The last major revision to any of the nation’s key pollution control laws occurred in 1990, when the Clean Air Act was reauthorized.) Indeed, the failure of Congress to reform water pollution control accounts for the stability of the municipal water pollution control
subsystem. It also has increased the importance of lower level actors—regional offices, state departments of environmental protection, and environmental advocacy groups—in creating pollution policy and shaping outcomes on the ground.

THE ENVIRONMENTAL PROTECTION AGENCY: A COMPROMISE WITH CHECKS AND BALANCES

The Environmental Protection Agency was the unexpected product of an executive reorganization process initiated in 1969. In the lead-up to then President Nixon’s 1970 “Message on the Environment,” a Domestic Council task force recommended consolidating environmental management functions in a single Department of Natural Resources. This “super department” would work closely with the newly created President’s Council on Environmental Quality and help shape Nixon’s new national growth policy—one that espoused balancing economic development with ecological limits (Marcus 1980; Nixon 1970). Nixon charged the President’s Advisory Council on Executive Organization (the so-called “Ash Council,” named after its head, the industry executive Roy Ash) to investigate the feasibility of a comprehensive environmental department.

The idea for an independent environmental protection agency emerged from a five-member subset of the Ash Council staff. Responsible for studying pollution control and waste disposal, this group was deeply skeptical of the environmental super department concept. As Alfred Marcus (1980) recounts in his analysis of EPA’s formative years, this group made a three-part argument against the creation of a federal department of natural resources. First, they contended that implementing a balanced growth policy would be far beyond the capacity of a natural resource agency; other departments—Housing, Transportation, Education—would continue to make independent decisions that affected environmental quality. It was more likely that a consolidated natural resource
department would be overwhelmed by the issues of public land management in the West and neglect urban and public health concerns. Second, they argued that such a department would be too big and unwieldy—a mere "holding company" where various programs remained isolated from one another. Finally, they pointed out that such a major reorganization was unlikely to find support among the agencies and departments that would lose large programs and bureaucratic components; the affected congressional oversight and appropriations committees; and the constituents of impacted programs. In contrast, they posited, a smaller independent pollution control agency might be more appealing to other federal agencies and also better equipped to achieve effective and comprehensive management of the "unwanted by-products of an affluent society" (37). Furthermore, they argued, by separating pollution control and economic development, the agency would keep the "fox out of the chicken coop" (37). That is, if able to "possess" their own agency, pollution control regulators stood a better chance of defending environmental values against superiorly organized and financed commercial interests (42). Finally, they pointed out that an independent expert-driven environmental agency could give the federal government a much-needed organizational apparatus to identify and manage new and emerging environmental threats.

Ash and the Domestic Council's task force initially opposed the proposal for an environmental protection agency and continued to push for an environmental super department to "streamline the bureaucracy and give the president greater control over it" (Marcus 1980, 47). However, as predicted, the creation of a Natural Resource Department was rejected by the secretaries of the departments from which the Department would draw its programmatic components. Indeed, HEW, the Departments of Commerce and Agriculture, as well as Housing and Urban Development, were resistant to any reorganization at all (Marcus 1980). Ultimately, a smaller, pollution focused agency represented the only option that the various parties could agree upon. Eager to take advantage of a political climate
favorable to executive reorganization, on April 29, 1970 Ash submitted a memorandum to the president advocating the creation of an independent Environmental Protection Agency. Nixon accepted the Ash Committee’s plan and on July 9, 1970 proposed to Congress a reorganization that would endow EPA with ten major pollution control units—including the Federal Water Pollution Control Agency—formerly housed across five agencies. Thus at its inception, EPA had 6,000 employees. Its budget of 1.4 billion was a relatively modest sum considering 80% of it was construction grant dollars (Davies and Mazurek 1999; P. Portney 2000). This arrangement appeased department heads who had feared much larger programmatic losses, as well as congressional committees and interest groups who had opposed a larger reorganization. It also pleased environmentalists, who praised the creation of an agency with a single-minded focus on pollution regulation.

At the same time, EPA was also regarded with a great deal of mistrust and subject to competing ideas about how it ought to administer its charge. Environmental advocates, both inside and outside government, who were successfully enshrining the fervor of the environmental movement in a suite of aggressive pollution laws, were concerned that their work would be undone during implementation. Specifically, they worried that EPA would either be “captured” and begin to serve the interests of the industries it was supposed to regulate, or that it would bargain away environmental values, particularly as public and media attention waned. Industrial interests and their sympathizers in Congress and within the White House expressed nearly the opposite worry: that EPA would take its mandate too far and impose excessive or unnecessary economic costs in the name of environmental quality.

These competing concerns were translated into a complex system of checks and balances that divided EPA and ultimately curtailed the ability of its administrator to integrate programs or establish overarching priorities for the agency (Andrews 1999; P. Portney 2000). Although Nixon publicly contended that
he created EPA to lead a “coordinated attack on pollutants,” privately he suggested that environmentalism was a passing political fad (Marcus 1980; Nixon 1971). He and other White House officials were particularly worried that EPA’s expansive regulatory authority, with potential impacts on nearly every economic sector, would be abused. To limit EPA power, Nixon strengthened the environmental programs in the pro-business Department of Commerce and added the 12,000 employee National Oceanographic and Atmospheric Administration, with its budget of $270 million, to the department. Nixon was particularly wary of the influence of EPA’s career research and program staff, whom he believed would support stringent regulations with little regard for economic impacts (Lazarus 1991b). He ensured that the White House would retain the ability to reign in agency activities and influence internal policy by providing that EPA’s administrator, deputy administrator, and all nine assistant administrators serve at the pleasure of the president. He also required the agency to formally report to the president through the powerful Executive Office of Management and Budget (OMB), an office inherently critical of EPA activities.

Congress-members—both supportive and skeptical of EPA’s mission—also fought to maintain their influence over agency decision-making, with the effect of reinforcing EPA’s early programmatic divisions. Because EPA was an executive reorganization, without a congressional mandate, its powers were initially fragmented among its numerous separate statutory programs, each reporting to a different set of subcommittees and each with its own identity, interests, and expertise (Landy, Roberts, and Thomas 1990; McGarity 1991a). For example, air pollution experts were health scientists whereas the water pollution specialists transferred from the FWPCA were primarily municipal engineers. The early challenge of creating a functional and effective organization from multiple disparate parts was complicated by the fact that for its first three years, EPA’s reorganization “only existed on paper;” until 1973 EPA had no central location and no “single identity,” and new EPA employees remained at their “old desks in their
old offices...doing the things they had been doing before EPA was created" (Marcus 1980, 88).

The White House encouraged EPA's first Administrator, William Ruckelshaus, to transition the agency to an integrated organization with only functional units. However, Congress members who would lose influence over EPA strongly opposed consolidation and pressed Ruckelshaus to maintain internal divisions that mirrored subcommittee organization. Ruckelshaus was attentive to these Congressional concerns and also feared that too fast a transition would upset program managers, who had previously enjoyed considerable autonomy in regulatory development, and result in a confused and ineffective bureaucracy (Fiorino 1995; Marcus 1980). Thus, instead of moving to an integrated organization that could better facilitate the management of cross-media pollution issues, Ruckelshaus let stand EPA's long-lived hybrid organization (Landy, Roberts, and Thomas 1990). Under this structure, media specific program offices, themselves subdivided by legislative issue and responsive to Congress, sat alongside functional offices for planning, enforcement, and research—reporting primarily to the White House.

In addition to constraining EPA through its organizational structure, Congress also sought to directly control agency decision-making by writing laws that included a litany of detailed tasks for the agency to accomplish by particular dates. In so doing, environmental advocates in the legislature aimed to limit agency discretion, while simultaneously holding "EPA's feet to the fire"—i.e. maintaining urgency within the agency (Groseclose 1994, 535). Such comprehensive direction for an expert agency was without precedent, but part and parcel of environmental legislation passed in the 1970s and 1980s; it reflected Congress' interest in achieving rapid environmental improvements, as well its

29 Congress' own resistance to internal consolidation also meant that by the 1980s, 20 committees and 100 subcommittees, covering authorizations, government operations, and appropriations, shared environmental jurisdiction (Lazarus 1991a).
mistrust of EPA’s ability to withstand counter-pressure from industry groups and the White House. In the exceptionally detailed, 90-page long Clean Water Act, for example, Congress gave EPA one year to promulgate the BPT effluent guidelines for all industrial point sources; this amounted to over 60,000 point sources, organized into a still daunting 30 categories and 250 subcategories. The Clear Air Act required 55 rule-makings and 30 guidance documents within two years—a fivefold increase over prior air program activities (Groseclose 1994). One-third of the statutory tasks assigned to EPA were to be completed in under six months (EESI 1985).

Of course it was impossible and undesirable for Congress to completely eliminate administrative discretion, but many worried that imprecision in the statutory language (i.e. “best practicable,” “economically feasible,” or “point source”) still left too much room for EPA interpretation. Thus, Congress also invited judicial oversight of EPA’s activities and rule-making to serve as an ex post facto check on agency decision making. In addition to citizen suit provisions, legislation also frequently expanded upon the judicial review provisions of the Administrative Procedure Act (APA) of 1946, which established uniform procedures for federal administrative rule-making; required federal agencies to provide public notice and comment periods for proposed rules; and allowed affected parties to challenge administrative actions in court. For example, section 509 vested the federal court of appeals with direct judicial review authority (or “pre-enforcement review”) over six of EPA’s administrator’s actions, limited to the first 120 days of the action. Directly reviewable actions included the promulgation of effluent limitations, decisions related to state permit programs, and permit issuance or denial.
AN EMBATTLED AGENCY: RESOURCES, RULEMAKING, AND OVERSIGHT

Almost as soon as EPA was created, stakeholders began using the many available channels to influence its activities. These forces were often deeply contradictory. For example, although the Clean Water Act and other environmental statutes passed by substantial margins in the House and Senate, Congress remained more divided than vote tallies suggested. Congressional critics privately doubted the efficacy of the laws or perceived them as overly ambitious, disapproved of their large authorizations and worried about their broader economic impacts. These critics were actively lobbied by regulated industries seeking to reduce the laws' economic burdens and supported by a series of skeptical presidential administrations. While detractors in Congress could not publicly oppose the laws because of their vast popular support—in 1974, one Congressman explained his reluctant vote in favor of the Clean Drinking Water Act by saying that to vote against it was akin to “voting against home and mother”—they could constrain the agency’s activities through less visible means, particularly appropriations (Fiorina 1989; Lazarus 1991b, 323). Concerned with a growing deficit tied to social programming, appropriations committee members showed considerably less enthusiasm about EPA’s mission than the congress-members on Muskie’s pollution control subcommittee. Critics used the appropriations process to limit resources for the agency and, at times, to publicly challenge its activities. For example, in 1973 the House subcommittee chair on independent agency appropriations conducted lengthy oversight inquiries into the “details of the agency’s implementation;” questioned whether or not Congress “intended full implementation of the laws it passed;” and described his interest in limiting EPA funds to curtail environmental regulations (Lazarus 1991b, 338).

Thus Congress spoke to EPA with “two voices” (Lazarus 1991a). On the one hand, pro-environment legislators demanded decisive and aggressive agency action with quantifiable environmental improvements. On the other, congressional detractors ensured that EPA’s budget requests to fulfill those
directives were only partially met. Indeed, as EPA's statutory burden increased through the late 1970s with the passage of the Safe Drinking Water Act (1974), the Toxic Substance Control Act (1976), and the Resource Conservation and Recovery Act (1976), the agency's appropriations actually decreased and were routinely lower than that requested by EPA administrator, sometimes as little as half (Bartlett 1984).

The White House, particularly under Republican administrations, also sought to limit EPA's resources. Perhaps the most extreme example was Nixon's impoundment of $6 billion in Clean Water Act construction grant money that Congress authorized for fiscal years 1973 and 1974. The issue was not resolved until 1975, when the Supreme Court ruled that Nixon had exceeded his executive authority. Nevertheless, the White House continued to oppose fully funding EPA through other, less provocative, means. Throughout the 1970s and 1980s, presidential budget requests for EPA were consistently lower than what Congress eventually appropriated. In the first term of the Reagan White House (1981-1989), the President, a vocal critic of federal environmental regulation, was successful in achieving a 22% reduction in EPA's operating budget, which included a 50% reduction in research and development (Bartlett 1984). Over the course of the 1980s, EPA research staff, which enabled the agency to produce independent studies and reduced its reliance on industry data, fell from 2,300 to 1,800 (Lazarus 1991b).

As Lazarus (1991b, 329) writes, this "coalition" for restricted EPA funding proved "virtually unbeatable," and EPA "constantly faced the question of how to prioritize the various issues on its statutory agenda." Ruckelshaus, who headed the agency from 1970-1973 and again in 1983, famously contended that EPA had the resources to accomplish only 10% of its duties (Ruckelshaus 1996). Resource constraints, however, were only one of several major organizational challenges. EPA's hybrid structure contributed to frequent "turf battles" between units with overlapping responsibilities but different priorities and approaches to pollution
control (Landy, Roberts, and Thomas 1990; McGarity 1991a). Furthermore, given the enormous scope of information that EPA had to integrate from economic, engineering, and medical sources, among others, Congressional deadlines gave agency staff little time to develop the expertise it needed to defend its decisions from external attack. Ultimately, EPA’s exacting—and, some argued, impossible—statutory burdens resulted in delays across the board. By 1985, EPA had missed approximately 85% of its congressionally mandated deadlines (EESI 1985).

Critics cited missed deadlines, and subsequent confusion and delays among the regulated community, as evidence of the statutes’ unrealistic and costly objectives. In some cases they were successful in relaxing requirements or extending compliance deadlines through statutory amendments. In the case of the Clean Water Act, industry and its allies in Congress were able to leverage a series of early EPA missteps to achieve substantial concessions for when lawmakers revisited the Act in 1977.

In the case of the municipal program, EPA promulgated the secondary standard for publicly owned treatment plants on schedule, but the agency struggled to efficiently distribute construction grant dollars. By the 1977 deadline, EPA had made 9,443 grants for a total of $1.9 billion, but more than $6 billion was unobligated (CQ 1977). Whereas nearly 90% of industrial dischargers were in compliance with BPT guidelines by 1977, less than one-third of 12,800

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For example, the Clean Water Act granted EPA scarcely a year to promulgate industrial BPT and BAT guidelines, which would serve as the critical basis for discharge permits—to be finalized by 1974. In order to calculate BPT and BAT guidelines for the 200,000 industries regulated by the Clean Water Act, EPA had to assess 250 sub-types of industry on the basis of age, size, and process. As Marcus (1980, 149) notes, it took several months for EPA officials to simply “read the statute, debate its ambiguities, and set a strategy for carrying out the program.” Setting effluent guidelines required a massive nation-wide data collection and analysis program with results that frequently defied generalization. EPA researchers, who highlighted their uncertainty, clashed with EPA rule-makers who required a firm scientific basis for the regulations. By the statutory deadline, EPA had not issued a single guideline. In many ways, the ensuing turn of events encapsulated the difficult position in which EPA frequently found itself: in 1974, facing pressure from environmental groups, EPA prematurely issued permits to all "major" polluters (those processing more than 1 million gallons per day), but were promptly slapped with 150 industry lawsuits for issuing permits before finalizing effluent guidelines. This public embarrassment partially contributed to a weakening of industrial pollution control requirements in the 1977 amendments.
municipalities that needed to upgrade to the secondary treatment technology had done so. Cities and states cast the blame on EPA’s “inefficient” handling of grant applications, and they complained that a slowing economy and inflationary trends were rapidly increasing their estimated cost share and discouraging some municipalities from even beginning construction (CQ Almanac 1977). In its defense, EPA claimed that it had found many grant applications unacceptable. Nixon’s impoundment of construction funds, extensive paperwork, and the general newness of the program to federal, state, and local officials also contributed to delays (CQ Almanac 1977).

As they had done for industrial dischargers, Congress used the 1977 amendments to ease the pressure on cities and states. Congress granted municipalities that had experienced funding delays an additional six years to upgrade to secondary treatment technologies. Coastal communities that discharged to the sea also found lawmakers more sympathetic to their argument that the water quality benefits of installing secondary treatment were negligible due to the ocean’s dilution capacity—particularly on the Pacific coast. Congress added section 301(h) to allow marine dischargers to apply to EPA for a waiver of secondary treatment.

Continuing problems with the construction grant program led to yet another set of extensions and concessions to municipalities in the early 1980s. By this time, only half of the nation’s treatment plants had installed secondary treatment technology; for the others, the necessary upgrades “appeared a long way off” (Stoddard et al. 2002, 39). Bureaucratic delays, inflation, and population growth had nearly doubled the estimated total costs of compliance from $63 billion in 1972 to $120 billion (CQ Almanac 1981). Meanwhile, facing pressure from newly elected President Reagan, Congress began to taper off funding for the construction grants program—though more slowly than the President wanted. The Construction Grant Amendments of 1981 reduced annual authorizations from $5 to $2.4 billion and planned a reduction in cost-share from 75% to 55% beginning
in 1985. In recognition of the shortfalls in federal funding, Congress again pushed back the secondary treatment deadline to July 1, 1988, on a case-by-case basis. And Congress repealed the requirement that treatment plants meet even stricter performance standards based on recycling and reclamation technologies (the so-called BPWTT standard) by 1983.

Many environmental organizations decried these and other amendments as steps backward for pollution control, but the changes were still far from the major rollbacks that the regulated community sought (CQ Almanac 1977). Efforts to significantly weaken statutes like the Clean Water Act were stymied by congressional environmental advocates, who continued to find strong public support for federal environmental laws and vehemently opposed efforts to undermine them. Advocates in Congress not only defended against direct, legislative attacks but also stepped up their oversight of EPA, who they accused of buckling to anti-environment pressures. Throughout the 1970s and 1980s, pro-environment Congress members exercised the full range of their oversight powers: they requested investigations by the General Accounting Office (now the Government Accountability Office, GAO) and EPA's Inspector General, established new reporting requirements for EPA, held hundreds of hearings, and worked informally through agency contacts.

Congressional oversight received extensive media attention and served as a critical counter-weights to industry attacks on EPA. However, as environmental statutes multiplied in the 1970s so too did committees that claimed environmental jurisdiction. By 1985 there were eleven such standing House Committees and nine standing Senate committees, with up to 100 subcommittees (Adams Jr and Cox 1990; Reilly 1989). The demands placed on EPA's time and resources grew accordingly. In some periods, Congressional enquiries into EPA's activities were comparable to those made on departments of similar size, but observers contended that EPA was subject to unusually close scrutiny "given the pervasiveness of environmental hazards...the large number of committees with
jurisdiction over the agency...the uncertainty over their consequences...[and] the lack of consensus over priorities“ (NAPA 1988, 30). The most striking measure of this scrutiny was the number of times EPA officials were called to give congressional testimonies. Between 1971 and 1988, EPA testified before each Congress between 92 and 214 times, twice as often as the Federal Trade Commission and in some sessions even more than the Department of Defense (Lazarus 1991a). In 1989, Congress commanded EPA to produce between 100 and 150 reports, respond to approximately 5,000 formal congressional inquiries (in addition to many more informal ones), and enlisted dozens of GAO reports (Adams Jr. and Cox 1990).

Congressional oversight only intensified in response to perceived attacks by the White House on EPA’s regulatory powers. Tensions between the White House, with its focus on the economic costs of pollution control, and environmental advocates in Congress had been brewing since Nixon. But they came to a head in the 1980s under President Reagan. The controversial tenure of EPA administrator Anne Gorsuch, who reflected Reagan’s hostility towards federal regulation and was accused of attempting to gut the agency, instigated widely publicized hearings and investigations. In 1982 alone— the only full year of Gorsuch’s tenure— Congress requested an unprecedented forty GAO reports on EPA activities (Lazarus 1991a). The revelations that emerged awoke the ire of a public that was distracted from but still deeply concerned about environmental quality and led to Gorsuch’s resignation in 1984. Between 1981 and 1984, twenty high level officials also resigned amidst accusations that they had used their position to reward or punish political friends and foes (Johnson 2003).

But perhaps the most influential and constant form of EPA oversight has been that exercised by the judiciary and initiated by public and private interest groups, as well as municipalities and states. While White House and Congressional attention to EPA fluctuated and changed in tone depending on the political party in power, the regulated community and environmental groups were dogged
overseers of relatively static interests. They made use of all mechanisms for review under APA as well as the judicial review and citizen suit provisions included in individual statutes. Although comprehensive data on litigation was not collected until the mid-1990s (and then suffered from collection challenges and deficiencies), the most telling and remarkable statistic was reported by the Council on Environmental Quality in 1985: over 80% of EPA's major rules were challenged in court, a trend that continues to this day (Davies and Mazurek 1999; Ruckelshaus 1985). Rulemaking came to be perceived by all parties as a prelude to litigation. The actual effects of environmental statutes were not considered settled by agency rule, but only after challenges to agency interpretation were resolved in court, including the Supreme Court. Thus EPA regulations were as much a product of internal deliberation and APA mandated procedures as they were of negotiated settlement and court decision. Currently, if one desires a full understanding of the Clean Water Act one must not only decipher the 180 pages of amended statute, but a sprawling body of case law. Adler (2013) notes that in 2013 the federal case annotations for the Clean Water Act alone cover more than 750 pages of the US Code Annotated.

Regulated entities use of the courts was unsurprising given how much they stood to lose from stricter pollution regulations. For example, industry compliance with the BPT standards of the Clean Water Act was projected to cost tens of billions of dollars, with the petroleum industry alone estimating it had spent nearly $6 billion in upgrades by 1977 (CQ Almanac 1977). Industrial representatives contended that compliance with BAT guidelines would have cost another $60 billion (CQ Almanac 1977). In 1973 states and municipalities anticipated spending $25 billion to meet secondary treatment standards, assuming the federal government delivered on their promised 75% cost-share and that costs did not rise. (As discussed above, neither assumption held.) Between 1972 and 1989, EPA estimated that the annual compliance costs of its pollution control programs increased from $33 billion to $117 billion, in constant dollars (USEPA 1990).
On the other hand, the rapid growth of lawsuits launched by environmental advocacy organizations against EPA was a stunning and novel development. The citizen suit provision in the Clean Water Act and other environmental statutes led to the proliferation of litigation-focused environmental groups in the 1970s. Funded by philanthropies such as the Ford Foundation, the Natural Resources Defense Council (NRDC) and the Environmental Defense Fund (EDF) were among the first groups to use litigation as opposed to traditional lobbying to force more aggressive implementation of environmental laws. Between 1970 and 1975 litigation and administrative actions accounted for 80% of the NRDC's workload (Andrews 1999). In 1977, NRDC and EDF spent $1.5 million and $854 thousand respectively—over half of their budgets—on lawsuits (Susskind and Weinstein 1980). These groups were supported by a growing network of other politically-oriented environmental advocacy groups who established headquarters in DC, as well as thousands of local organizations. Between 1970 and 1990, the number of environmental organizations in the United States tripled, and by 1985 membership had swelled from 500,000 to over 2.5 million (Ausubel, Victor, and Wernick 1995).

When seeking to influence legislators and the White House, better organized and funded private interest groups held an advantage over public interest groups. The courts were therefore particularly attractive venues for environmental organizations who perceived them as more level playing fields (Lutz and McCaffery 1971). Environmental advocates were also keenly aware that they frequently held a courtroom advantage given the specificity and ambitiousness of environmental statutes, and they benefitted from detailed legislative histories that generally supported their interpretation of Congressional intent (Melnick 1992). The media attention court cases attracted was an added bonus, which environmental organizations used to build public support.

These perceived advantages were reflected in important early victories (Glicksman 2004). For example, under section 307(a) of the Clean Water Act, EPA had ninety days to develop a list of toxic pollutants and 180 days to
propose effluent standards for each listing. When EPA missed both deadlines, environmentalists launched a series of suits that resulted in the landmark "Flannery Decision"—a consent decree issued in 1976 and named after the presiding judge. A product of negotiations among the various parties, in the settlement EPA agreed to regulate a list of sixty-five toxins—significantly more substantial than the nine toxins EPA had earlier proposed. This list was later ratified in the 1977 Clean Water Act amendments. Advocates used such citizen suits to encourage the most stringent application of the environmental law, but also to maintain influence on agency activities. As Lazarus writes (1991b, 334):

whenever EPA failed to meet a deadline, or otherwise satisfy a statutory obligation which was inevitably often, environmentalists used litigation to compel EPA to negotiate with them in drafting a consent decree. Environmentalists utilized the consent decree and threat of contempt sanctions to control the agency's future actions.

Indeed the battle between industry, EPA, and environmentalists over toxic regulation continued for another fifteen years and the Flannery settlement was reopened fourteen times (O'Leary 1990).

Although it is no longer true, environmental groups brought nearly all citizen suits cases between 1970 and 1990. In those years, the number of reported judicial opinions (which include cases against alleged polluters) grew from seven in 1973 to sixty-six in 1988 (May 2003). Most citizen suits against the government never made it to trial. The vast majority were settled beforehand, as the Department of Justice, who represented EPA in these cases, determined the government was likely to lose. Industrial groups, however, complained about an emerging pattern they pejoratively termed "sue-and-settle:" environmental groups would sue EPA for failure to undertake non-discretionary actions and instead of launching a defense, EPA and the litigants would negotiate the terms of a consent

31 May (2003) suggests that EPA was more responsive to judicial deadlines than legislative ones.
decree behind closed doors. Industry argued that environmental groups were thus undue influencing agency activities without public input. Regulated entities, however, have brought many more cases than public interest organizations that challenged EPA’s final actions (Andrews 1999). Indeed, EPA’s first set of industrial effluent guidelines under the Clean Water Act alone were subject to 150 industry lawsuits in 1974 (Marcus 1980). Industry benefitted from the courts’ early subscription to the “hard look” doctrine of review and saw nearly all of these guidelines remanded to EPA for revision (McGarity 1991a).

**Oversight and Regulatory Ossification at EPA**

Many observers have, and continue to express, misgivings about this extensive reliance on the court (Elliott 1992; Horowitz 1977; Melnick 1983; Susskind and Weinstein 1980). The possible benefits of judicial review notwithstanding—which include improved quality of agency decision-making and combatting overreach from other branches of government—critics question whether or not judges with only generalist knowledge should be trusted to understand and properly parse highly technical environmental issues (Melnick 1983). Others—including EPA’s own former administrator—have gone farther, arguing that given the inherent uncertainties of scientific understandings and the “wicked” complexities of environmental issues (that boggled even the experts in EPA) adversarial court hearings are unlikely to produce reflective, wise policy outcomes (Jasanoff 1995; Ozawa and Susskind 1985; Ruckelshaus 1985).

The courts are also inconsistent arbiters. Different decisions on the same issue can create periods of uncertainty and paralysis for both regulators and the regulated. Additionally, the federal courts’ orientation towards environmental regulation changes over time. For example, the court’s “early enthusiasm for the project of environmental protection” and close review of EPA decision-making gave way in the 1980s to “neutrality towards environmental values” and greater deference to agency decisions (Glicksman and Schroeder 1991, 249). This shift
presented risks to environmentalists' court strategy. As did Reagan and George H. Bush's appointment of conservative federal judges, who were predicted to increase the courts' use of cost benefit analysis as well as make it more difficult for public organizations to demonstrate standing—a trend confirmed by later studies (Davies and Mazurek 1999; Lazarus 2002; May 2003).

Furthermore, judicial review, combined with the competitive pressures from Congress and the White House, affects the process and substance of EPA's rulemaking in ways that trouble agency officials and analysts. First, it drains already limited resources, diverts staff attention from other agency priorities, and increases delays in rule finalization. Regulators at EPA have consistently faced enormous technical challenges; a shortage of resources; difficulties negotiating agreement between personnel from various offices that did not always see eye-to-eye; and an adversarial APA mandated public comment period. Congressional inquiries and directives, White House reporting and review requirements, and judicial challenges can add months and even years to the rulemaking process, if they do not simply kill the process entirely (Groseclose 1994; Percival 1991).

There is also evidence that oversight affects the substance of rules. Managers prioritize "survival of the rule:" producing regulations that will survive judicial and political review (Groseclose 1994). Oftentimes this means agency lawyers in the General Counsel's Office have as a great a role as issue experts in crafting rules—to the point that supporting documentation resembled "legal briefs more than candid presentations of competing arguments" (Lazarus 1991b). For example, when EPA revised the new air quality standards in 1987, the preamble grew from a single page in 1971 to thirty-six pages supported by a "100-plus-page staff paper, a lengthy Regulatory Impact Analysis that cost the agency millions, and a multi-volume criteria document" (McGarity 1991b, 1387). Similarly, agency staff viewed notice-and-comment periods more as opportunities to compile a record for judicial review than to earnestly weigh public input (Elliott 1991).
Analysts have also noted a hesitance among agency officials to engage in new, discretionary rule-making efforts and a reluctance to update existing regulations rather than simply let “sleeping dogs lie” (McGarity 1991b; Pierce Jr. 2011). Although there is debate about the extent of the problem, they argue that this “ossification” of rulemaking is a direct result of excessive oversight, which reduces opportunities for innovation and inculcates a status quo bias (Lazarus 1991b; McGarity 1996). Indeed, despite technological advances, most of the Clean Water Act’s present day effluent limitations— including the secondary standards for municipal wastewater—are identical to those promulgated in the 1970s (R. Adler 2013).

For many, this “chilling of innovation” is one of the most deleterious outcomes of excessive oversight. In a summary that is particularly apt to the issues that have surrounded the use of GSI for CSO control, the lawyer Thomas McGarity (1991b, 1392) has written:

Experimentation is welcome in an atmosphere in which rules can be undone if they do not produce the anticipated changes or cause unanticipated side effects. But experimentation is riskier in an atmosphere in which any change is likely to be irreversible. This inflexibility is especially unfortunate in the context of programs in which agencies must regulate on the "frontiers of scientific knowledge" with particularly treacherous "facts." New scientific discoveries can erode the technical basis for a rule that was promulgated only a few years ago. New technologies can make available fresh alternatives that were not considered at the time the agency first examined the issues. However, the agencies are understandably reluctant to rock the boat when to do so requires an enormously expensive rulemaking in which a successful outcome is by no means assured.

As opposed to independently rising to meet new environmental challenges or keeping pace with the capabilities of new technologies, agency officials prefer to wait for direction from Congress or the White House before initiating potentially controversial rule-making (Marchant 2011). Costly oversight and the threat of
litigation also encourages a more extensive decentralization of power, as EPA to turn towards non-legislative mechanisms to enact policy. These options include adjudicative decision-making (via individual permitting and enforcement decisions, typically made at the regional level) as well as “non-rule rules:” interpretive rules, policy statements, guidance documents, and enforcement manuals—which avoid notice and comment and limit judicial review, but also remove opportunities for public input (Coplan 2014; McGarity 1991b; Susskind and Secunda 1998). Meanwhile, states, municipalities, and private entities have little incentive to innovate or improve environmental performance beyond that required by federal law.

This mode of environmental policy implementation and dispute resolution—what Kagan (2001) terms “adversarial legalism” because it is characterized by high levels of formal legal contestation—has not gone unchallenged. Widespread disappointment with its limits and costs inspired multiple efforts to produce a less rigid and combative regulatory system; one that relies less on the prescriptive tools of command and control enforcement and more on cooperation and voluntarism. For example, in the early 1980s, several high-level EPA officials embraced the experimental use of “negotiated rulemaking,” a consensus based process that seeks to enhance the legitimacy of regulations and reduce litigation by engaging public stakeholders along with agency staff in rule development (Harter 1982; Susskind and McMahon 1985). Negotiated rulemaking, which was used to devise the 1994 Combined Sewer Overflow Policy (see Chapter 5), was supported by multiple administrations and streamlined through the passage of the Negotiated Rulemaking Act (1990). In 1985, EPA issued its first negotiated rule (on noncompliance penalties under the Clean Air Act). Over the next decade, EPA produced another eleven rules by negotiated rulemaking, more than any other federal agency, although only a small fraction of its total rulemaking effort (Coglianese 2001). In the 1990s EPA appointees also spearheaded a set of initiatives aimed at “reinventing” rule-making by partnering
with the regulated community to develop innovative approaches to produce “better and more cost effective” solutions to environmental challenges (USEPA 1996). One of the best-known pilots, Project XL (“eXcellence in Leadership”) encouraged the regulated community to devise initiatives that would produce superior environmental outcomes, above and beyond that required by law, in exchange for some form of regulatory flexibility. A total of fifty such projects were approved before the program ended in 2002 (Kraft and Vig 2013).

For a variety of reasons, these and other efforts to reform pollution regulation have only affected change at the margins. The primary reason for this is that the underlying legal framework of the regulatory system remains intact and is reinforced through EPA’s historic deterrence-based enforcement philosophy as well as its legalistic structure. Statutory mandates, “long-standing, inflexible interpretations of existing regulation,” the powerful influence of EPA’s legal counsel, and the mistrust that has grown up between stakeholders all make change difficult (Susskind and Secunda 1998, 113). Implementing staff also have much more to fear from failure than the political appointees in EPA Headquarters who champion partnerships, flexibility, and innovation. The frequent disconnect between higher and lower levels of the agency is manifest in the greater resistance to risk-taking observed among Program XL’s regional career staff. These staff noted that there were few organizational incentives for innovation. On the other hand, a failed project, that resulted in environmental harm, could not only set-back careers but also damage agency credibility and ruin opportunities for future experimentation (Susskind and Secunda 1998). These concerns are also echoed in my case studies, and I discuss them more in Chapter 8.

Finally, although many groups are frustrated with the system, there is no agreement on what a “better” one looks like. In particular, many environmental advocates have watched or participated in reform initiatives with considerable mistrust. Some suspect that “flexibility” and “cooperation” are code for a weakening of environmental protections. These groups show a readiness to turn
back to the courts, which they still view as their primary leverage over powerful municipal and industrial groups. They remain committed to the current system that—while flawed—is nevertheless still perceived as the “fruits of their labor” (Fiorino 1999, 2).

**REGIONAL IMPLEMENTATION AND CITIZEN ENFORCEMENT**

While staff and officials at EPA’s national headquarters control national policy and rulemaking, the day-to-day implementation of environmental laws—including permitting, monitoring and inspections, and enforcement—is administered by the ten regional offices. Early proponents of this structure argued that it was desirable for several reasons: permitting and enforcement would be more efficient than if all decisions had to be made in DC headquarters; regional staff would be more attuned to local political and pollution concerns and ostensibly produce more tailored and effective approaches; and states would benefit from the inflow of job opportunities and federal funds, increasing support for EPA’s activities (Andrews 1999).

Similarly, the Clean Water Act and other environmental statutes further decentralized implementation by authorizing EPA to delegate aspects of administration to the states, including inspections, permitting, and enforcement. The public objectives of delegation were to reduce overlap with state and local functions and foster flexible implementation that could respond to varied local conditions. As EPA asserted in its 1985 policy statement, delegation “is a means to return decision-making authority to the level of government closer to the people whose lives are actually touched by these decisions” (USEPA 1985). However, in authorizing and promoting delegation Congress and EPA also aimed to reduce backlash from states and localities who were accustomed to exercising near autonomy over environmental management, as well as to reduce the financial and administrative burden on the federal government. Most states took advantage of
this opportunity for primacy. By 1985, for example, thirty-seven states had
developed EPA-approved Clean Water Act NPDES programs, typically housed in
state environmental quality departments. At the time of writing, that number
stands at forty-six. EPA regional offices have taken the lead for Washington, DC
and for the few states, like Massachusetts, that resist delegation because of cost
and other concerns.

The regional focus and cooperative design of implementation at this level
has produced many of its intended benefits. For example, EPA curries support
among the states and congressional districts in which regional offices are located;
and the staff in these semi-autonomous offices are able to accommodate the
different political cultures and environmental conditions that exists between
regions in ways that a centralized office cannot (Andrews 1999). Likewise,
delegation has enabled states to develop their own comprehensive environmental
programs and associated technical expertise, frequently with EPA's assistance
(Ringquist 1993). Between 1970 and 1994, totally state expenditures on air and
water quality increased from $249 million and $155 million (in constant 1992
dollars) to $516 million and $1.8 billion, respectively (Davies and Mazurek 1999,
42).

State officials have complained—particularly in the early years of EPA's
existence—about the agency's encroachment on their autonomy. But many
privately welcome the arrangement with the federal government. EPA serves as
"...the scapegoat [states] could blame as they imposed new controls on powerful
industries" (Andrews 1999, 231). EPA has generally embraced this role. Indeed,
when Ruckelshaus returned to EPA's helm in 1983 after Gorsuch's resignation, he
exhorted the agency to revive the same aggressive, deterrence-based enforcement
stance he had promoted during his first tenure.32 In a speech to EPA staff in

32 Ruckelshaus believed that the political support behind the environmental movement was also
critical to EPA's success. He worked to gain credibility with the public and environmental groups
by taking vigorous and immediate enforcement actions and sought-out extensive media coverage.
January of 1984, Ruckelshaus argued that unless the states “have a gorilla in the closet, they can’t do their job” (Stanfield 1984). And EPA, he asserted, should be that gorilla.

For the most part, state programs have functioned well; for a variety of reasons, others have not. At times, poor state performance was caused by inadequate technical capabilities, misunderstandings or confusion, inadequate EPA guidance, and even natural disasters (Lester and Lombard 1990; USEPA 2001, 2011). Some states were vastly overspent by others. For example, California spent $66 per capita on environmental programming in 1994, whereas Michigan spent $20 (Davies and Mazurek 1999, 42). State officials also have a greater incentive than federal regulators to exploit “regulatory gaps”—instances that had not been contemplated by rule-makers or language that suggested multiple interpretations—to benefit state and local business interests (Mintz 2012). As Sivaram (2013) writes, “the political, economic, and environmental impacts of decisions are felt most acutely at the local level” and some state officials are “under more pressure to deviate from federal programs.” This can take the form, for example, of weak permit terms or lax enforcement.

Whether states are acting in good faith or not, EPA’s primary enforcement role—a role enshrined in formal policy—is to step in and fill perceived gaps, thereby ensuring that no state or industry receives an unfair economic advantage over another (USEPA 1986). However, regional offices are often forced to take more flexible and conciliatory approaches with states and polluters because EPA’s resources for enforcement and oversight are limited and never commensurate to an office’s work load (OIG 2011). It is well known that EPA does not have the capacity to closely and consistently monitor the effectiveness of state programs or prosecute all outstanding offenders (Davies and Mazurek 1999). Furthermore, the

Few other administrators took such an aggressive, public stance against polluters, but most realized that EPA had to pose a credible threat to states if they were to accomplish their pollution control objectives.
most serious penalty EPA can levy against a recalcitrant state is the withdrawal of NPDES authorization. This threat is largely viewed as “moot” because of the “general understanding” that no EPA region had the resources to operate a state program (Hodas 1995; USEPA 2011). Indeed, despite petitions for such action, EPA has never withdrawn a state delegation decision.

EPA, therefore, has had an interest in maintaining good working relationships with the states. According to analysts, a reluctance to strain federal-state relationships and an interest in avoiding the legal complexities associated with concurrent enforcement explains why EPA rarely directly challenges state actions (Hodas 1995; Rawson 1999; Zahren 2000). For example, a 2000 study found that only in a handful of cases each year did EPA use its authority to bring a separate enforcement action when it felt a state’s own action was inadequate, a process known as “overfilling” (Zahren 2000) A 2004 review found that EPA only overfilled in 0.1-3% of federal enforcement suits, most commonly under the Resource Conservation and Recovery Act (Rechtschaffen 2004; Rechtschaffen and Markell 2003). Between 2000 and 2002, EPA overfilled in only six instances—none of which were Clean Water Act cases (Rechtschaffen 2004).

In bringing its own actions against polluters who eluded state enforcement, EPA regions prefer to rely on negotiation and bargaining—formal and informal administrative actions—over litigation. One obvious reason is EPA's interest in conserving its limited resources, as well as that of the Environment and Natural Resources Division of the DOJ, to whom EPA refers its judicial cases. However, the fragmentation of enforcement power also encourages regional offices to pursue these lower level enforcement actions; relying on threats and bargaining allows regional offices to retain control over enforcement outcomes and avoid the disagreements that inevitably emerged as DOJ and EPA's Office of General Counsel stepped into the fray (Mintz 2012).

Citizens, on the other hand, are free from many of the political and organizational challenges facing EPA's enforcement offices. In the 1980s
environmental advocacy groups began to expand their court strategy beyond agency-forcing suits (cases against EPA) and take advantage of their right to sue polluters directly. In 1981 environmental groups filed 6 notices of intent (NOIs) to sue an alleged polluter under the citizen suit provision of the Clean Water Act. In 1983, that number had climbed to 110 (Hodas 1995). The rise in these so-called “enforcement suits” was a general consequence of advocates’ perception that federal and state enforcement of environmental laws was inadequate and inconsistent—a characterization that EPA and the states largely contested. However, the triggering event was Reagan’s policy of regulatory devolution and defunding and his appointment of ideologically conservative leadership at EPA. Under EPA Administrator Anne Gorsuch, EPA funding for enforcement activities was slashed, offices were reorganized over the objections of senior career enforcement managers, and staff were directed to adopt a “non-confrontational” approach to enforcement (Mintz 2012). A water enforcement division director later called these changes “very obviously a deliberate plan to paralyze if not totally dismantle the enforcement program” (Mintz 2012). During this period, EPA’s civil referrals to the Department of Justice—viewed by many as a key measure of enforcement rigor—fell from a peak of 262 in 1978 to 112 in 1982; administrative actions declined to 1972 levels (Russell 2000).

By 1984, DOJ referrals were rebounding. That same year, EPA initiated the National Municipal Policy on Publicly-Owned Treatment Works, an enforcement based approach to bringing all treatment works into compliance by the 1988 deadline. But EPA’s credibility among environmental advocates was badly damaged. By confirming environmentalist groups’ worst fears about EPA’s institutional weaknesses, the Gorsuch period cemented what Hodas (1995) calls a “triangulated” environmental enforcement system, consisting of EPA, the states, and environmental advocacy groups—although some individuals and municipalities instigate enforcement suits independently.

Citizen suits have been used to enforce many environmental laws, but play
a particularly important role in water pollution enforcement. Between 1980 and
1988, individuals and groups filed over 1000 NOIs under the Clean Water Act, and
as state budget deficits undermined enforcement programs in the early 1990s,
citizen enforcement suits grew to fill some of the gaps. By 1993 NOIs under the
Clean Water Act greatly outstripped federal filings and almost matched the
judicial referrals of all the states combined (Hodas 1995).

Over the next decade, citizens filed nearly 1,500 NOIs and the DOJ logged a
total of 360 Clean Water Act citizen enforcement cases (May 2003). The federal
government does not maintain comprehensive data on citizen suits, but analysts
estimate that more citizen suits have been brought under the Clean Water Act
than any other environmental statute (Coplan 2014). This is partly explained by the
courts’ liberal construction of standing— even in the face of repeated judicial
challenges (Coplan 2014; Ginsberg et al. 2011). Most significantly, in the landmark
Friends of the Earth v. Laidlaw Environmental Services (2000), the Supreme Court
affirmed in a 7-2 opinion that damage to an individual’s aesthetic or recreational
interest was enough to confer standing— a much simpler test than requiring that
the plaintiff demonstrate ecological damage.

The large number of cases is also explained by the ease with which litigants
can acquire evidence of violations. Unlike a smokestack, wastewater outflow pipes
are usually publicly accessible; many forms of pollution— such as raw sewage—
are visible to the naked eye; and water quality sampling and testing is a relatively
straightforward and affordable undertaking (Coplan 2014). Furthermore, in the
case of numeric permit violations, direct sampling is obviated by the fact that the
Clean Water Act requires every permittee to measure the pollutants in its effluent
and report them to regulators in monthly Discharge Monitoring Reports (DMRs).
If a discharger exceeds its permit limits, it must also file a separate noncompliance
report explaining the length and type of violation. Noncompliance reports are
collected and filed with EPA on a quarterly basis, and courts have accepted DMRs
at face value as proof of civil liability. DMRs thus provide a ready source of self-
reported and certified violation data.\textsuperscript{33}

Citizen enforcement suits under the Clean Water Act have typically been brought by environmental advocacy organizations. To optimize and leverage their resources, advocacy groups choose enforcement cases strategically and frequently file them in cooperation with other environmental groups who share similar objectives. These organizations seek monetary penalties and injunctive relief—the two types of remedies offered under the Act. But their strategic goals are almost always much broader. They aim to set the terms for a source's future actions and performance, deter other potential violators, establish legal precedent based on their interpretations of the law, shape public opinion, or simply spur government action and bring a source into compliance. In the latter case, groups may find that filing a sixty-day NOI is sufficient.

In the majority of cases, environmental groups prefer to negotiate a consent decree—a legally binding set of agreements between parties that is signed off and overseen by a judge but does not include an admission of liability. This option gives advocacy groups greater control over the case's resolution, expands remedial options, and avoids the costs of a trial. Negotiated settlements are also attractive to dischargers who have witnessed over the years a string of unfavorable Clean Water Act final judgements, some associated with multi-million dollar penalties and large courts fees.

Indeed, citizen enforcement suits follow a now familiar set of steps. First, environmental groups will submit an NOI to EPA, state, and alleged violator. Because there is usually strong interest on both sides in a pre-trial settlement and entry into a consent decree, the litigant will also invite the targeted discharger to a pre-suit meeting to lay out its settlement goals. These typically include four major provisions: civil penalties and/or commensurate Supplemental Environmental

\textsuperscript{33} An environmental group need only visit the state environmental protection department or file a Freedom of Information Request to access this data, which is also increasingly available online through EPA's Enforcement and Compliance History Online (ECHO).
Projects (SEPs); a set of remedial measures and schedule for achieving compliance; penalties for failure to meet the compliance schedule; and reimbursement for the plaintiff’s litigation and lawyer fees, as well as any compliance oversight costs (Schwartz and Hackett 1984).

Through the use of citizen suits, environmental advocates have been exceptionally influential in shaping both the timing and character of pollution clean-up activities under the Clean Water Act. Indeed, citizen suits are behind some of the most famous municipal efforts, and they drive three out of the four cases I examine in Chapters 6-8. Although some critics have questioned whether citizen enforcement suits lead to improved environmental outcomes (J. Adler 2001), EPA and DOJ have publicly acknowledged their role as critical stop-gaps. In 1994, for example, the Chief of the General Litigation Section of the Land and Natural Resources Division of DOJ noted that the number of enforcement suits “out there” greatly exceeded the resources of federal and state regulators, and that citizen enforcement suits should be embraced as a “natural adjunct” to government enforcement (Hodas 1995). EPA officials also recognize that the threat of environmentalist lawsuits has given EPA bargaining power that it would not otherwise have with polluters. In the same way that EPA has served as the states’ “gorilla in the closet,” environmental advocacy groups have provided EPA with a (willing) scapegoat for aggressive implementation of the law (e.g. “If we don’t do it, they will.”) Although the relationship between environmentalist organization and EPA is not as positive as it was in EPA’s formative years, there exists between them “a symbiosis;” the groups “use each other” to achieve particular policy and enforcement objectives they could not achieve unilaterally (Ruckelshaus 2001). This is particularly true when EPA is overseen by administrations more supportive of environmental protection goals.
The Challenges and Costs of Wet Weather Pollution Control and the Evolution of GSI

Over the years, analysts have used a variety of metrics to assess the “success” of the Clean Water Act in controlling water pollution. A sampling of these metrics includes: the amount of money invested in water pollution control measures; the number of municipal treatment plants built or upgraded and the number of people served by them; the number of waterways that meet state designated uses, as reported in the Clean Water Act mandated biennial “state water quality inventories;” changes in water quality in specific waterbodies as well as the national scale changes in water quality (Stoddard et al. 2002).

By all counts, the Clean Water Act had major impacts on water pollution management and led to significant pollution reduction in the three million miles of rivers and streams, twenty-seven million acres of lakes, and 35,000 miles of estuaries under its jurisdiction. Between 1972 and 1989, the federal government spent $56 billion to support the construction and upgrades of municipal treatment plants—the largest nonmilitary expenditure since the National Highway Program (Copeland 2012). During that same time, state and local governments spent another $166 billion (Davies and Mazurek 1999). The number of people relying on treatment plants with less than secondary treatment decreased rapidly after 1972. By 1988, EPA reported that the National Municipal Policy had been successful and 86% of cities met secondary treatment deadline. The remainder were put under an administrative or court-ordered deadline. By 1996, 42% of the population served by public wastewater systems received secondary treatment and the percent served by more advanced treatment surged from to only 5% in 1972 to 43%. (Most of the remaining population was connected to systems that EPA granted marine discharge waivers.) In 2000, EPA estimated that these upgrades resulted in a 45%
reduction in major pollutants (specifically BOD) since 1972, even as sewage inflow increased by 35% (Stoddard et al. 2002). Industrial treatment achieved similar gains (R. Adler 2013).

In 1998, EPA estimated that the percent of water supporting fishing and swimming increased from 36% in 1972 to 63% in 1998 (USEPA 1998). Other national studies that relied on US Geological Survey data or water quality models reported only slight gains in pollution reduction and use attainment (Bingham et al. 2005; Freeman 1999). Nevertheless, analysts point out that water quality improvements have occurred even in the face of tremendous economic growth and increases in pollutant discharges. In the absence of the Act, at least some deterioration of water quality would be expected (Freeman 1999; Magat and Viscusi 1990). Furthermore, the most substantial water quality gains are evident in waterways that suffered under the worst industrial and municipal pollution. In these cases, the observed improvements are “tremendous” (Stoddard et al. 2002).

These successes, however, are complicated by several factors. First, they have come at a great cost; by some estimates, nearly $1 trillion as of 2017. Second, the most significant pollution reduction occurred between 1968, as the 1965 Water Quality Act was implemented, and 1990—with the greatest gains occurring in the 1970s (Davies and Mazurek 1999). Since that time, the Clean Water Act has primarily prevented water quality from worsening. Pollution production, due to economic development and population growth, is beginning to outpace improvements in treatment efficiency, however. Stoddard et al. (2002) predicts that by 2026, the trend of decreasing BOD in wastewater effluent will have reversed, and BOD loading will be equal to that in 1968—when oxygen demanding material discharged by treatments plants was at its historic peak.

Furthermore, an estimated 35-40% of the nation’s waters still do not meet the Clean Water Act’s 1983 interim goal of fishable and swimmable— to say nothing of the Act’s abandoned “zero discharge” goal (EPA 2004). Although facility noncompliance is an ongoing problem, the Clean Water Act has been most
effective in curbing the so-called "point source" pollution that is discharged from the outflow pipes of industrial and municipal plants and regulated under the NPDES program.

By the 1980s, however, it was apparent that a variety of other sources, with substantial water quality impacts, were eluding control. In addition to "non-point source" pollution, managed under section 208 (and, later, section 319) of the Clean Water Act and not discussed in depth as part of this study, two major sources of municipal pollution continued to enter waterways unabated and often unpermitted: urban stormwater discharges and sewage from combined sewer overflows (CSOs). Although urban stormwater discharges and CSOs have historically been managed by cities as distinct municipal pollution problems, they are frequently studied as related phenomenon because they are both caused by surface water runoff and exacerbated by the hydrologic changes wrought by urban development—earning them the moniker "wet weather pollution."

In the following chapter, I outline the evolving realm of wet weather policy, politics, and control technology that undergird my four cases. Although the discussion is quite detailed, the nuance and timing of the laws, regulations, and technological developments turn out to be critical to understanding wet pollution control in cities presently, and where it might be headed in future. Below I review the risks associated with CSO and municipal stormwater discharges; the ways in which environmental advocacy organizations have driven legislative and regulatory control over these sources through a successful court strategy that has generally resolved Clean Water ambiguities in their favor; and the conventional treatment and control technologies used to mitigate their effects on water quality. I conclude with an overview of the origins, development, and dissemination of the innovative water pollution management approach that I refer to as GSI.
MUNICIPAL STORMWATER RUNOFF: THE WATER QUALITY ACT OF 1987 AND THE MS4 PERMIT PROGRAM

With the exception of some municipalities in the southwest, nearly all cities in the United States have municipal separate stormwater systems (MS4s). As combined systems fell out of favor in early 1900s and cities started treating their sewage, municipal engineers began constructing separate stormwater systems to remove rainfall and snowmelt from developed areas while avoiding the costs associated with treating huge quantities of rainwater that they considered relatively clean. Like the early combined systems, engineers designed urban drainage systems to eliminate excess surface water as rapidly as possible, thereby reducing nuisance conditions and more serious flood risks. Graded sidewalks and streets, curbs, inlets, and lined channels all worked to quickly move stormwater from urban surfaces and into underground pipes, which discharged to the nearest watercourse. A large city could have hundreds of such stormwater outfalls. For example, Philadelphia’s system has 455 stormwater outfalls which drain approximately one-third of the city’s land mass—the remaining two-thirds is served by a combined sewer.

As development intensified throughout the 20th century, the urban landscape grew increasingly impervious to water, resulting in major changes to the landscape’s hydrology. Trees, open space, and wetlands were replaced with buildings, streets, and parking lots, reducing opportunities for evaporation or infiltration and increasing the amount of surface runoff produced during storm

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34 According to EPA’s regulatory definition (40 CFR 122.26(b)(8)): “municipal separate storm sewer means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains): (i) Owned or operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to state law)...including special districts under state law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act that discharges into waters of the United States. (ii) Designed or used for collecting or conveying stormwater; (iii) Which is not a combined sewer; and (iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.”
events. Compared to pre-development scenarios, urban areas can produce up to five times more surface runoff that leads to much higher peak discharge rates in receiving waters. In addition to the physical impacts these flows have on stream morphology—which includes bank incision and sedimentation—urban runoff also mobilizes the plethora chemical and microbial pollutants found on urban surfaces and deposits them directly into local rivers, streams, and lakes. These pollutants include high levels of heavy metals, such as lead, copper, and zinc, from automobiles, bridges, and corroding metal; bacteria and viruses from animal wastes and sewer cross connections; nutrients from fertilizers and atmospheric deposition; pesticides from lawns and gardens; oils and grease from roads, gas stations, and parking lots; organic material from commercial landscaping and animal waste; and sediment from construction activities and erosion. Runoff also raises the temperature of receiving waters, a phenomenon termed “thermal pollution.”

The impacts of stormwater pollution are diverse and can be severe. Drinking water sources are compromised; waterways are closed or unsafe for fishing and recreation; habitat for fish and wildlife is degraded; biodiversity declines; and the natural aesthetics of lakes, streams, and beaches are damaged. In 2015, the National Resource Defense Council estimated that ten trillion gallons of urban runoff enter US watercourses each year, much of it through MS4s (Garrison and Hobbs 2013). EPA’s most recent national water quality inventories have consistently found municipal stormwater runoff to be the leading cause of impairment in estuaries and ocean shorelines, and it accounts for 22% of the impaired acres of surveyed lakes and 14% of the impaired miles of rivers. Compared to the percent of waterways polluted by agricultural activity—the leading cause of water quality impairment—the latter percentages are small. However, developed land covers only 4% of the United States, therefore the impact of urban areas on water quality is outsized.
Environmentalists Push for Action on Stormwater

Whereas the impacts of municipal wastewater and treatment have been a research focus and funding priority for over a century, wet weather pollution, caused by urban runoff, CSOs, and sanitary system overflows (SSOs) only began to attract national attention in the 1960s. In 1964, the Public Health Service published a report that first identified the national significance of stormwater pollution (Lager 1974). In 1966 the federal government earmarked funding for demonstration projects aimed at reducing its impact. Around this time, states such as Florida and Maryland and municipalities like Austin, Texas, and Portland, Oregon began implementing their own programs to mitigate stormwater's effects on surface water quality (NRC 2009). In 1974, the City of Bellevue, Washington, was the first municipality to create a stormwater utility that supported the development of open spaces and drainage features for both of pollution reduction and flood protection.

By not mandating a particular control level, the 1972 Clean Water Act left the regulation of urban runoff and municipal stormwater systems to EPA's discretion. In 1973, citing "administrative infeasibility," EPA exempted channelized and piped stormwater discharges from any permitting requirements under NPDES—unless such discharges were judged "significant contributors" to local pollution. EPA justified this decision by arguing that because municipal stormwater pollution was variable and unpredictable it would be better managed at the local level through non-point source control programs rather than federally established end-of-pipe effluent limits. The agency also estimated (accurately, as it would turn out) that regulating stormwater discharges from small stormwater ditches, temporary construction sites, and municipal outfalls would add hundreds of thousands of new permittees to their system. Already overwhelmed by permitting and promulgating guidelines for some 75,000 industrial and municipal facilities, EPA contended that regulating stormwater would divert agency resources from controlling high priority pollution discharges (USEPA 1995). At this
time, there were no comprehensive, national studies of urban stormwater pollution's characteristics or impact on water quality, and thus no scientific basis for new rules.

The NRDC immediately challenged EPA's decision to exclude channelized stormwater from regulation under NPDES. The courts sided with the nonprofit. In 1975, and as affirmed on appeal in 1977, the federal courts ruled that regulating stormwater was not an "impossibility," and therefore EPA did not have the authority to exempt categories of point sources from the NPDES program (NRDC vs Train, 1975, aff'd NRDC vs Costle, 1977). Subsequently, in 1976, EPA promulgated a rule that would see all stormwater discharges permitted under a NPDES "general permit." Because this rule only required that dischargers file for a notice of intent, and do little to control or study stormwater pollution, environmentalists took EPA back to court. EPA issued new regulations in 1979 and 1980 that created a more rigorous permit application process and required that stormwater dischargers test for a number of pollutants. But these new rules led to an expanded set of court battles that grew to include a number of major trade associations and member companies, in addition to environmental NGOS.

In the midst of this legal maelstrom, EPA initiated the landmark National Urban Runoff Program (NURP), a five-year, nation-wide study of stormwater runoff that the agency hoped would provide a scientific basis for a comprehensive stormwater regulatory scheme, as well as state and local planning efforts. Completed in 1983, the study characterized the water quality of runoff from industrial, commercial, and residential areas in 28 urban sites. The NURP study found that the runoff water quality and its impact on receiving waters were "highly site specific" (USEPA 1983). Nevertheless, the study confirmed that urban runoff contributed significant amounts of varied pollutants to the nation's waterways. Its most important findings were that urban stormwater contained numerous toxic priority pollutants in concentrations that could pose human health risks if discharges were near drinking water intake pipes; researchers detected all 13 heavy
metals on EPA’s priority pollution list in concentrations that frequently exceeded EPA’s water quality criteria and drinking water standards; stormwater BOD levels rivalled and often exceeded those found in secondary treatment plant effluent; the concentration of total suspended solids in urban stormwater was much greater than that found in secondary treatment plant discharges; and fecal coliform concentrations were present in levels that would be “expected to exceed EPA water quality criteria during and immediately after a storm in many surface waters” (USEPA 1983).

In their publication, NURP researchers also briefly reported on a handful of popular and experimental stormwater controls and examined their performance characteristics. The most widespread stormwater control in use was the detention basin. Commonly used to reduce flooding downstream of suburban developments, these large basins were constructed either as “dry ponds”— which only held water for a limited time — or as “wet ponds,” which retained water year-round. During storms, runoff was conveyed to the basin and slowly released through a piped outlet to a local stream, or to the municipal storm sewer. While properly sized wet ponds could provide limited water quality treatment by allowing sedimentation and supporting biological degradation of nutrients, dry ponds provided no treatment benefits. Street sweeping, a popular form of source control, was also found to have no significant water quality benefit (USEPA 1983).

According to NURP researchers, the most promising stormwater controls were “recharge” devices, a set of emerging technologies that worked to retain and infiltrate runoff. These devices included large offsite retention structures, as well small, onsite technologies like pervious paving, infiltration pits, and percolation trenches. The report confirmed that these devices were practical to apply; could significantly reduce the amount of runoff entering local waterways; and provided water quality treatment through settlement, filtration, and biologic degradation. For example, the researchers reported that an experimental set-up in Long Island composed of percolation trenches— ditches filled with gravel or crushed stone
that allowed runoff to infiltrate into permeable soils—reduced runoff by 99%. A porous pavement site reduced pollutant concentrations through filtration and natural biologic degradation by between 85-95%. The authors of the study advocated greater study of the performance characteristics and limitations of recharge technologies (USEPA 1983).

**Complexity and Costs Result in a Weak and Contentious Stormwater Control Program**

A year after the NURP study was released, EPA’s issued its updated stormwater rule, pursuant to a 1982 settlement agreement. Yet again it was contested by interest groups who argued they could not meet the associated deadlines. The ongoing controversy, coupled with the alarming results of the NURP study, led Congress to explicitly address stormwater regulation in the 1987 Water Quality Act—the last major amendment to the Clean Water Act, as of 2018. The 1987 legislation added section 402(p) and created a tiered and phased approach for permitting MS4s of varying sizes, as well as other non-municipal sources of stormwater from industrial and construction processes, among others—although these are not discussed here. Congress required EPA to promulgate permit application requirements for large MS4s, serving over 250,000 people, by 1989 and medium MS4s, serving between 100,000 and 250,000 people, by 1990. Permits for large and medium MS4s were to be issued a year after EPA promulgated the requirements. Municipalities had three years to comply with their MS4 permit terms. Approximately 855 separate systems were covered by 250 individual permits.

Congress also made important changes to the permit standards for municipal storm sewers. First, Congress provided that EPA could issue individual MS4 permits for medium and large municipalities on a system or jurisdiction-wide basis. Second, Congress required that MS4 permits “effectively prohibit non-stormwater discharges into the storm sewers.” That is, Congress wanted regulators to prioritize the remediation of leaks (“infiltration”) or illegal connections of
sanitary sewage or other non-stormwater flows to separate stormwater systems ("inflow"). Third, Congress established a new municipal stormwater pollution control level—albeit one that left a great deal of its meaning open to EPA and permit writers' judgement. Instead of including a technology based limit, MS4 permits were to impose pollution controls to the “maximum extent practicable” (MEP). The amendments stated that such controls might include “management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants." Congress directed EPA to devise appropriate regulations for the remaining small MS4s as well as other lower priority stormwater sources after a period of study, but no later than 1993.

After missing its statutory deadline, EPA promulgated “Phase I” of its stormwater permitting program on November 16, 1990, pursuant to a 1989 consent decree. The regulation established a two-part permit application process for MS4s serving populations greater than 100,000. Part one of the permit required MS4 operators to provide general information about their MS4 system, screen for illicit connections, and describe existing structural and nonstructural stormwater controls. Part two required municipalities to conduct more in depth quantitative analyses of stormwater pollutant discharges, examine and establish, where necessary, their legal authority to implement a stormwater management program, and assess fiscal resources and needs. Prior to the MS4 NPDES program, few cities had characterized their MS4 systems or developed stormwater management programs dedicated to improving receiving water quality. The permit application’s data collection activities were intended to create a comprehensive baseline of technical knowledge to inform the core element of the MS4 application: The Stormwater Management Plan (SWMP). In its management plan, the permittee demonstrated how it would control, to the maximum extent practicable, stormwater water pollution from commercial, residential, industrial and construction sites, as well as non-stormwater discharges from illicit connections.
and improper disposal of contaminants into storm drains. Upon approval, the management plan would be incorporated into the MS4 permit and serve as the “blueprint” for municipal stormwater management activities over the permit’s five-year term. Phase I permits also required MS4 operators to develop an inspection program for “high risk” industrial sites in their jurisdiction, devise a monitoring program to assess the impacts of their SWMP on stormwater discharges, and summarize their progress in publicly available annual reports.

As envisioned by Congress and crafted by EPA, the municipal stormwater program was intended to provide municipalities with maximum flexibility in addressing their stormwater pollution. This flexibility was deemed critical given the enormous variation in the characteristics of stormwater runoff across municipalities, the diffuse nature of stormwater’s pollutants, and the intermittent and heterogeneous quality of its flows. Critics, however, charged that this flexibility granted permittees too much discretion and resulted in an inconsistent and largely ineffective program (NRC 2009).

Two particular areas of confusion and disagreement emerged between EPA, regulated entities, and environmentalists, and remain a source of contention and litigation. The first issue was what exactly was meant by “maximum extent practicable?” In 1996, EPA argued that Congress intended the MEP standard to exempt stormwater from the technology-based limits imposed on other point sources. EPA went on to outline its intention to use “best management practices” (BMPs), alternatively known as “stormwater control measures” (SCMs), in lieu of numeric effluent limitations—e.g. 30-day average 30g/L of total suspended solids—in stormwater permits. EPA defined BMPs as:

Schedules of activities, prohibitions of practices, maintenance procedures and other management practices to prevent or reduce the pollution of waters of the United States. BMPs include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. (40 CFR §122.2.)
Although EPA did not rule out using “more specific conditions and limitations in permits,” policy-makers noted the difficulty in establishing numeric limits for stormwater. The methodologies for deriving numeric limits, EPA explained, were designed for wastewater discharges that occurred at “predictable rates and with predictable pollutant loads”—conditions that did not extend to stormwater flows. EPA further noted that alternative methods, derived specifically for stormwater flows, were technically more difficult, more expensive, and more prone to error. For these reasons, EPA chose to rely almost entirely on BMPs for municipal stormwater permitting. Though not required, the states followed suit.

In 1999, EPA issued its Phase II stormwater rule (64 CFR 68.722) and formalized six areas where municipalities must focus programmatic control measures in their management plans. Referred to as the “six minimum controls,” these areas included 1) public education and outreach 2) public participation and involvement 3) illicit discharge detection and elimination 4) construction site runoff control 5) post-construction runoff control, and 6) pollution prevention and good housekeeping. Within each of these areas, municipalities could propose a variety of BMPs that would best serve their community’s stormwater priorities and objectives. In 2000, EPA published a “menu” of BMP options in each of these six areas to help guide municipalities and permit authorities in developing and assessing SWMPs. These BMPs primarily focused on low-cost measures to reduce the quantity of pollutants mobilized by stormwater, as opposed to more expensive structural controls to capture and treat stormwater entering waterways. For example, possible BMPs for construction runoff control included: requirements to implement erosion and sediment control; procedures for reviewing construction site plans; and procedures for inspections and enforcement of stormwater requirements at construction sites.

EPA and most states, however, declined to define what level of BMP implementation constitutes “maximum extent practicable” and it is therefore a
highly subjective concept. MEP is negotiated between a municipality and permitting authorities who are expected to use their "best professional judgement" to weigh the "technical feasibility, cost, and state and public acceptance" of the BMPs proposed. Even in states where MEP has been articulated more precisely, the concept remains vague. For example, the State Water Quality Resources Board of California’s Environmental Protection Agency—a leader in progressive and rigorous stormwater programs—described their process of assessing MEP as follows:

There must be a serious attempt to comply, and practical solutions may not be lightly rejected. If, from the list of BMPs, a permittee chooses only a few of the least expensive methods, it is likely that MEP has not been met. On the other hand, if a permittee employs all applicable BMPs except those where it can show that they are not technically feasible in the locality, or whose cost would exceed any benefit to be derived, it would have met the standard. MEP requires permittees to choose effective BMPs, and to reject applicable BMPs only where other effective BMPs will serve the same purpose, the BMPs would not be technically feasible, or the cost would be prohibitive. (CAEPA 2004)

Unsurprisingly, the flexibility inherent in the MEP standards has led to great variability in how stormwater programs are implemented. In 2008, the National Research Council’s review of EPA’s stormwater program echoed many longstanding complaints from environmental groups. In particular, the review found that the “self-defined compliance threshold has translated into a wide range of efforts at program implementation” and that meaningful regulation of stormwater was undermined by the ability of the regulated community to set their own standards and self-monitor (NRC 2009, 79). For example, the program does not encourage or reward communities that implement more stringent or innovative stormwater controls, thereby increasing the likelihood that permittees will devise the bare minimum set of obligations (i.e. the cheapest) that pass muster with regulators. This tendency is exacerbated by the fact that—unlike in the case
of drinking water and sewage—many communities have not established a stormwater utility to provide a dedicated revenue stream for stormwater management. In these cases, stormwater management programs compete directly with other local priorities. Furthermore, EPA’s stormwater program may actually discourage permittees from developing ambitious programs for monitoring and analyzing the efficacy of their SWMP because such data can provide an incriminating paper-trail. Instead rational operators can take advantage of the “wiggle room” afforded by the MEP standard and “develop ambiguous requirements that leave them with considerable discretion in determining whether they are in compliance” (NRC 2009, 86).

A second, related source of contention is whether or not MS4 permits must ensure compliance with state water quality standards. In particular: if a municipality is implementing controls to the “maximum extent practicable” and in compliance with the terms of its permit, but still contributing to or causing the violation water quality standards, is it liable under the Clean Water Act? This issue was not clearly addressed in the 1987 amendments. In 1991, EPA’s General Counsel articulated the agency’s position that the amendments did not exempt stormwater permits from including conditions to ensure water quality standards were met. In its 1996 Interim Permitting Approach for Water-Quality Based Effluent Limitations in Stormwater Permits, EPA outlined its own permitting process whereby “expanded or better tailored BMPS” would be used in subsequent permits to “provide for the attainment of water quality standards.” Thus EPA laid out an iterative process of implementing, evaluating, and revising BMPs to reduce the deleterious impacts stormwater discharges and, where necessary, bring the discharges into compliance with water quality standards. Only where “adequate information exists to develop more specific conditions” would non-BMP limitations, such as numeric effluent limits, be included in permits (USEPA 1996). For example, as EPA and the states accelerated the development of long-overdue TMDLs for impaired waterways in the late 1990s, numeric limitations based on
applicable waste load allocations (WLAs)—the maximum amount of pollutants a discharger can release into an impaired waterbody—began to appear in some MS4 permits.

The courts have upheld EPA's decision to make the inclusion of numeric limits in MS4 permits discretionary. In 1999, environmental advocacy groups Defenders of Wildlife and the Sierra Club sued EPA for issuing stormwater permits to five municipal systems without requiring numeric limitations to ensure compliance with state water-quality standards (Defenders of Wildlife v. Browner). In a precedent setting decision, the Ninth Circuit Court reviewed EPA's interim permitting policy and rejected the NGOs' claim that MS4 permits must include numeric limits. Interestingly, the Court also disagreed with EPA's interpretation that Congress intended to subject to municipal stormwater water discharges to the water quality provisions in the Clean Water Act. The Court, however, allowed that EPA could require strict (or less strict) compliance with water quality standards. Following this judgement, EPA reaffirmed its interim permitting approach for water quality limits (Hill and Horowitz 2011).

However, without requiring permittees to undertake expensive hydrologic modeling of their SWMP, it is virtually impossible to ensure that municipal stormwater does not violate water quality standards. Without numeric effluent limits and adequate monitoring, violations are also difficult to prove. Therefore, so long as municipalities remain in compliance with the BMPs and other terms outlined in their MS4 permit, regulators have generally considered them in compliance with the Clean Water Act. In some cases, permits have even included “safe harbor” clauses that explicitly protect MS4 operators from enforcement action if they are complying with the terms of their permit. Environmental groups have argued that this approach allows municipalities to skirt the water quality requirements of Clean Water Act and continue to impair local waterways; in recent years, these groups have begun to bring citizen suit test cases that allege water quality violations from MS4 discharges, thus far with little success.
Municipalities, meanwhile, have contended that strict adherence to water quality standards in MS4 permits would result in exorbitant costs—perhaps even requiring the construction of new storage and treatment facilities specifically designed to treat stormwater. Municipalities' worries are well founded. In 1978, EPA estimated the costs of stormwater storage and treatment to ensure recreational water use at $61 billion, in 1978 dollars (USEPA 1978).

Regulators' sensitivity to these local affordability concerns is a primary reason why many have resisted pushing MS4 operators to go beyond their self-defined level of MEP. This more conciliatory position can be traced to the reduction in federal aid for water infrastructure that was also included in the 1987 amendments. With the majority of the nation's sewage treatments plants providing secondary treatment or higher, the administration argued the construction grant program had fulfilled its objectives and was no longer needed. In a major concession to the Reagan Administration, Congress agreed to conclude the construction grants program in 1990. The 1987 Act authorized $18 billion for wastewater treatment plants over nine years, and it was passed over Reagan's veto. $9.6 billion was authorized to fulfill outstanding grant commitments but the remaining $8.4 billion would capitalize state-run revolving load funds, known as the Clean Water Revolving Funds program. States agreed to pay into the funds at least 20% of the federal contribution. Under pressure from the states and municipalities, Congress continued to appropriate grants for the revolving fund long after 2004, the last year of authorized payments. As of 2016, the total federal investment was $41 billion (Copeland 2012).

The conversion to a loan program released states and municipalities from the constraints imposed by the federal construction grant program and expanded the types of projects eligible for support. For example, separate stormwater system upgrades which were not eligible for construction grant money are eligible for loans. However, it also made municipalities—or more precisely tax and rate payers—responsible for 100% of the costs of water infrastructure projects, as
opposed to just 45%, because loans must be repaid in full. At the same time, the local costs of Clean Water Act compliance (in addition to other federal water-related programs, such as the Safe Drinking Water Act) continued to grow. In 1990, EPA's Wastewater Needs survey estimated that cities still required nearly $65 billion in capital investment to upgrade sewage plants to secondary and advanced treatment, fix leaky pipes, rehabilitate old sewerage, and build new collector and interceptor sewers. That same year, the Phase I Stormwater Program added an estimated $1.5-2.5 billion in annual Clean Water Act costs. And many of the nation’s oldest cities were only just beginning to address a pollution problem that threatened to add tens of billions more to that tally: fixing their combined sewer overflows.

COMBINED SEWER OVERFLOWS AND THE 1994 NATIONAL CSO POLICY

Prior to the construction of sewage treatment works in the mid-1900s, combined sewer systems (CSS) discharged raw sewage and stormwater from hundreds of sewer main outfalls along local water courses. These combined systems were therefore designed to carry large quantities of storm water. Engineers typically sized them based on the ten-year storm flow, which meant they could carry up to 1000 times the “dry-weather” flow—the flow in the system when it was not raining (Field, Sullivan, and Tafuri 2003). In order to collect these flows and divert them to newly constructed wastewater treatment plants, municipal engineers built aptly named “interceptor” pipes to cut off the sewer mains before they reached waterways. However, wastewater treatment plants were not designed to treat large quantities of stormwater-diluted sewage, for which the treatment technology was less effective and the costs were much higher. Therefore, treatment plant and interceptor capacity was based on the flow in the system when it was not raining, and sized for 2-3 times the dry-weather flow. To handle the mismatch between the wet-weather flows in the mains and the dry-weather capacity of interceptors and
treatment plants, engineers constructed “flow regulators” — or CSOs. When wet weather flows exceeded the interceptor’s capacity, these regulators released the excess wastewater from outfalls directly into waterways, a phenomenon termed a “CSO event.” Large systems could have hundreds of CSOs. For example, prior to 1994, Philadelphia’s modern system had 164. New York City’s had nearly 460.

Flow regulators effectively prevented household sewer back-ups, street flooding, as well as damage to pipes and treatment plants. They also obviated the need for much more expensive solutions, such as building separate sewers to replace combined ones. However, they created a massive secondary pollution challenge by dumping huge quantities of raw domestic sewage, untreated industrial wastewater, and stormwater into lakes, rivers, and streams each year. In 1967 a survey by the American Public Works Association (APWA) estimated that combined systems served some 36 million people— twice as many served by separate systems— and discharged overflows into streams, lakes, and tidewaters (APWA 1967). Since then, numerous additional studies have revealed the full universe of CSOs, the extent of their discharges, and their impact on receiving waters.

In 1972, EPA estimated that there were approximately 1,100 communities with 15,000 overflows points, which released on the order of 3–5% of the systems’ sanitary sewage (Field 1972). Over the next few decades these numbers dropped as municipalities made improvements to their systems. In 2001, NPDES permits covered a total of 9,463 CSOs affecting 772 communities in 32 states; three-quarters of all CSOs were located in eight states: ME, NY, PA, WV, IL, IN, MI and OH (USEPA 2001). Nevertheless, in 1994, EPA calculated that on average, each CSO discharged 50-80 times per year and released approximately 1.2 trillion gallons of polluted wastewater annually. CSO discharges, however, varied substantially from city to city. For example, in 1992, NRDC estimated that New York released eighty-four billion gallons of untreated waste water via CSOs, while Philadelphia released twenty billion, and San Francisco released 1.7 billion (R.
Adler 2013).35

CSO discharges contain all the contaminants associated with urban stormwater, in addition to the pollutants contained in commercial and industrial wastewater, and domestic sewage. After wastewater treatment plants upgraded to secondary treatment or higher, CSOs became the largest source of raw sewage in US waterways. Indeed, their greatest risk to humans is exposure to CSO-borne fecal bacteria, viruses, and protozoa. Swimmers and recreational users of waterways impacted by CSOs can contract a variety of diseases including hepatitis, gastroenteritis, and respiratory and ear infections. Other forms of bacteria present in discharges can cause cholera, typhoid, and dysentery. CSOs events are also linked to beach and shellfish bed closures and drinking water contamination. In its 1992 report Testing the Waters, NRDC calculated that CSOs were primarily responsible for 2,433 beach closures and advisories annually. Sanitary sewer overflows (SSOs) and sewage line breaks also contributed to the closures.36 That same year, NOAA reported that CSOs accounted for 10-20% of shellfish limited acres, approximately 600,000 acres in total (Field, Sullivan, and Tafuri 2003).

Furthermore, although not a direct health risk, the impact of CSO events on waterway aesthetics is significant. A study by the Center for Marine Conservation found that New Jersey and Massachusetts’ beaches and harbors—major tourist destinations—had five times the national average of sewage-associated debris. These “floatables” included condoms, fecal matter, and medical wastes (Neiter, Zarzecki, and Steinhauer 1992).

As measured by acres or miles of waterways affected, CSOs are only a

35 To provide some reference for those number, Philadelphia treats approximately 470 million gallons of wastewater every day and approximately 170 billion annually.
36 In addition to urban stormwater discharges and CSOs, SSOs are another form of wet weather pollution. Stormwater can find its way into sanitary systems through infiltration (e.g. through leaky pipes when there is low pressure in the system) as well as through inflow via bad connections (e.g. a stormwater pipe inappropriately connected to the sanitary system). The results of inflow and infiltration are water main breaks, backups, and flooding that release raw sewage, which can then enter waterways.
moderate source of water impairment nationwide. In 1998 EPA reported that CSO events were responsible for 5% of impaired estuaries, 11% of impaired ocean shoreline, and were not a significant cause of impairment in sampled rivers (USEPA 1998). However, like urban stormwater discharges, their impact is outsized given the amount of land area that is drained by combined systems. Furthermore, because CSOs are located in some of the densest urban areas and have severe localized affects, millions of people are directly impacted by the risks posed by CSO pollution.

The Long Road to a National CSO Policy

In the same 1964 report that highlighted the impacts of stormwater discharges, the Public Health Service identified CSOs as a significant cause of water quality degradation. In 1966, PHS initiated a national urban wet weather research program that was transferred to EPA in 1970. Between 1966 and 1972, the program provided $39 million in grants that supported over 100 studies aimed at better understanding the scope of the problem and feasible interventions. By 2004, the program had funded a total of 400 studies at the cost of $125 million. One early study—the aforementioned 1967 APWA survey—concluded that local efforts to actively control CSOs were impeded by two major obstacles. The first was a dearth of information to “evaluate the extent and effect of the problem.” The second was the exceptionally high cost of control projects. Indeed, at that time, the only well understood control technology was sewer separation—that is, replacing the combined sewer with two new sets of pipes, one for sanitary wastes and one for stormwater. APWA estimated that sewer separation would cost municipalities a total of $70 billion, in 1972 dollars. Furthermore, separation would increase the amount of stormwater discharged to waterways and thus reduce the water quality benefits of the intervention by an estimated 50%. The Association urged study of alternatives to sewer separation (APWA 1967).

As with stormwater, after the passage of the Clean Water Act, the
regulation of CSOs became a source of contention, disagreement, and confusion among states, municipalities, NGOs, and EPA—with little progress made on controlling their impacts. It would take two decades for EPA to devise a uniform CSO policy and as of 2018, many cities are still in the planning or construction phase of CSO control plans. Several factors led to the slow regulatory and local response. First the Clean Water Act did not explicitly mention CSOs and EPA was under no obligation to develop discharge guidelines. Second, EPA's municipal water pollution priority in the 1970s and 1980s was not wet weather pollution, but to ensure that all cities upgraded their treatment plants to meet Congressionally mandated secondary standards; as discussed in Chapter 4, EPA had few organizational resources to devote elsewhere.

Not surprisingly, the regulation of CSO's was initially determined through case-law. One of the early CSO court battles concerned CSO treatment requirements. EPA's position was that although CSOs were municipal point sources that must be permitted, they were not sewage treatment plant discharges and were therefore exempt from secondary treatment standards. Instead CSOs were to be controlled using the BCT standard for conventional pollutants, the BAT standard for toxic pollutants, and any additional water quality based standards. Environmentalists disagreed. In the landmark 1980 case Montgomery Environmental Coalition vs. Costle, however, the courts upheld EPA's interpretation against a challenge from a coalition of environmental groups, who argued that CSO discharges should comply with the secondary treatment standard. After the decision, and for many of the same reasons EPA resisted defining "maximum extent practicable" for stormwater discharges (e.g. intermittence and variability across systems), the agency continued to leave the regulatory definition of BCT and BAT to the best professional judgement of permit writers. EPA thereby also side-stepped what surely would have been a costly and contentious rulemaking process.

Meanwhile, state and regional NPDES authorities were hampered by the
fact that while basic knowledge about CSOs— including their impact on receiving waters, sewer-system characterization, control and treatment technology, and cost feasibility analysis—was growing, the field was still young. Municipalities were reluctant to make costly investments that might prove ineffective and regulators were similarly disinclined to force such investments without a deeper understanding of the problem and its options.

Early research funded by EPA’s urban wet weather program pointed to a number of viable alternatives to separation. Some of these options included reducing pollutants entering the system through street sweeping and other forms of good “housekeeping,” as well as reducing the volume of water entering the system by replacing pervious surfaces with permeable paving that allowed rain to infiltrate and recharge groundwater (Field 1972). Engineers viewed these as helpful measures, but inadequate in most cases to meet water quality standards. The more promising alternatives built on sanitary engineers’ traditional toolkit and focused on optimizing sewerage capacity and treatment in existing centralized systems. System operators were urged to maximize transmission and storage capacity in the sewer system, reduce infiltration or extraneous inflow, and fix or replace malfunctioning CSO regulators (Field 1972). These were low cost measures that could provide an immediate reduction in overflow events. For the inevitable remaining flow that would still have to be managed, “off-line” storage emerged as the vanguard for direct control of CSOs, and the technology was “convincingly demonstrated” in various studies (Field 1972). Off-line storage described large underground or offshore concrete or steel tanks, basin, or tunnels built adjacent to the existing sewer system. These facilities were sized to hold millions of gallons of wastewater flow during storms, and then release the water for treatment when in-line capacity became available again. Lastly, decentralized treatment, such as disinfection or screening, was recommended for reducing pollutant loads from CSO discharges that could not be captured. Although cheaper than separation, CSO off-line storage and treatment was still costly. In 1978, EPA’s estimated that to
ensure that impacted waterways were fishable and swimmable through the year 2000, municipalities would need to spend $21 billion, in 1978 dollars, on CSO control technologies (USEPA 1978).

The technical and economic challenges posed by CSOs, paired with the lack of a clear national policy and little oversight in the 1970s and 1980s, resulted in very different local approaches during this time period. A handful of CSO communities—particularly coastal municipalities and those with overflow-related flooding problems, began planning or constructing CSO controls in the 1970s and paid for their projects by leveraging federal construction grant dollars. Chicago’s multi-billion-dollar Tunnel and Reservoir Plan (TARP) is a notable example. Initiated in 1972, the first phase of TARP saw the creation of a massive off-line storage system consisting of 109.4 miles of large diameter rock tunnels providing 2.3 billion gallons of volume to capture CSO discharges. Most cities, however, were able to ignore their CSO problems with little fear of enforcement action while they worked to build or upgrade their sewage treatment plants.

A turning point for CSO policy came in the mid-1980s. In a final push to meet the 1988 secondary treatment deadline, federal and state regulators began cracking down on non-compliant municipal treatment plants, particularly those discharging into impaired waters. A number of these enforcement actions, one of which was in Boston, MA, included CSO discharges and initiated early action on their control. Indeed, during this time, regulators took a total of twenty-nine CSO civil judicial actions, about half of which were brought under the National Municipal Policy (EPA 2001). These actions focused on NPDES permit violations, including water quality effluent limits, violations of consent decrees, and failure to meet construction schedule deadlines (EPA 2001). The uptick in CSO-related enforcement actions and litigation from environmental groups alarmed municipalities. In 1988, the National League of Cities—an advocacy group representing nearly 20,000 American cities and towns—requested that EPA provide clear guidelines that reflected a “rational approach to CSO control that will
protect the environmental yet be implementable and affordable” (quoted in Mee 1997).

In response, EPA released its National CSO Control Strategy in 1989 (54 FR 37,370). Because CSO discharges contained untreated domestic and industrial wastewater, controlling overflows was a higher priority for EPA than controlling stormwater pollution. Nevertheless, EPA continued to avoid issuing detailed, uniform directives that could be formally contested. Instead, the non-binding national strategy passed the responsibility to lower levels of administration. The strategy formally reiterated that CSO discharges were point sources of pollution and made explicit three federal objectives for CSO regulation under NPDES: CSO discharges should only occur during wet weather; permits ought to include BCT and BAT standards based on best professional judgment of state or regional regulators and any necessary water quality based standards; and CSO controls should minimize the negative effects of wet weather overflows on human and aquatic biota. EPA also laid out six recommended control measures, based on the growing body of CSO research: proper operation and regular maintenance of the CSS; maximum use of the collection system for storage; review and modification of industrial pre-treatment programs; maximum flow delivery to the treatment plant; prohibition of dry weather overflows; control of solid and floatable material in CSO discharges.

NGOs, regulators, and municipalities, however, continued to disagree about what constituted “best conventional” and “best available” treatment as well as how to balance costs with water quality outcomes. Because even one overflow could violate water quality standards, communities did not feel the strategy adequately clarified EPA’s expectations for control levels. They argued that the strategy appeared to leave CSS communities vulnerable to legal action, unless they spent hundreds of millions on new secondary treatment facilities or off-line storage to fully abate CSO events. Furthermore, the phase-out of the construction grant program meant that these communities would bear the full costs of any CSO
program they developed. Measurable action was again delayed.

**A CSO Policy with Clear Standards and Enforceability— For Gray Infrastructure**

In an effort to overcome the continuing conflict and inertia, EPA initiated a negotiated rule-making process in 1992 with the goal of providing clear and financially "realistic" guidance on how CSO communities could meet Clean Water Act goals. As Siobhan Mee (1997) details in her study of the CSO negotiations, the agency convened stakeholders from fifteen organizations, including the National League of Cities, the Association of Metropolitan Sewer Agencies (now the National Association of Clean Water Agencies, NACWA), the APWA, EDF, NRDC and EPA. Draft legislation circulating in Congress that proposed stringent CSO controls, including secondary treatment at an estimated cost of $120 billion, helped to add a "sense of urgency" to the negotiation (Mee 1997). After three months of contentious mediated negotiations, the parties reached consensus on a majority of the issues. The negotiated agreement formed the basis of the agency's framework document, published for comment in 1993. After addressing public feedback, EPA finalized the framework in its 1994 National CSO Policy (59 FR 18,688), which was endorsed by all the major stakeholders (Mee 1997).

The 1994 policy departed from its predecessor in several ways. It aimed to provide municipalities with clear levels of control to meet environmental objectives while offering them regulatory flexibility to consider the "site specific nature of CSOs and determine the most cost-effective way to comply with Clean Water Act standards." The Policy provided this flexibility by sanctioning phased implementation of CSO controls to allow communities to focus on high priority waters and to spread the costs of its program across many years. It also permitted states to conduct a "use-attainability analysis" to modify a water quality designation to one requiring less stringent criteria, subject to EPA approval. In essence, it allowed states to downgrade water quality standards by removing (or refining) particular uses. Finally, EPA included some interesting language about
“watershed planning,” a holistic approach to water management that used the river basin or sub-basin as a planning unit and was increasingly advocated by the Clinton White House.\textsuperscript{37} The policy therefore recommended that CSS communities coordinate CSO control activities with ongoing water pollution planning and control efforts within the relevant drainage basin. The watershed planning recommendation was not at all the centerpiece of the policy. However, as I discuss in the next chapter, it provided an opening to cities like Philadelphia, where the integrated water department was struggling to find cost effective solutions to deal with EPA's new wet weather regulations and policies.

The policy specified three actions that CSO communities should take to meet Clean Water Act standards. First, CSO communities were expected to immediately characterize their combined storm sewer and its hydraulic response to storm events. Using this data, sewer agencies were to implement the so-called “nine minimum controls” (NMC) shown in Table 5.2—measures that would provide limited relief from CSO discharges without major engineering studies, construction, or expense. Implementation of the nine minimum controls was to be completed no later than January 1, 1997. Second, CSO communities were directed to develop a long-term control plan (LTCP) that would evaluate and select from a “reasonable range” of alternatives for controlling CSOs, including options that achieved 100% capture of CSO discharges. EPA expected that the LTCP would include modeling and monitoring to characterize the CSS system and CSO

\textsuperscript{37} After nearly a century, watershed-based approaches to resource planning were enjoying a resurgence in US policy circles. In 1991, EPA formally signaled its support of watershed planning for pollution prevention by issuing a Watershed Protection Approach Framework, which was re-issued in 1996. By 1998, watershed planning would be a central element in the Clinton Administration’s Clean Water Action Plan. As defined by EPA’s Office of Water, the watershed approach was guided by three core principles. First, the planning domain was defined by geographic, as opposed to political, boundaries; typically a particular drainage basin. Second, public and private actors with impacts on or interests in local water resources worked together, forming partnerships to undertake research, planning and implementation. Third, decision-making relied on the development of sound-science and data. The watershed approach was less a solution than a process to uncover more efficient and long-lasting ways to reduce water pollution and improve environmental quality.
impacts; prioritize environmentally sensitive areas for immediate CSO relief, either by elimination or relocation; and provide opportunities for public input.

EPA outlined two distinct approaches communities could use when selecting a control program from the evaluated alternatives: the “presumptive approach” or the “demonstrative approach.” Under the presumptive approach, a CSO control program that achieved one of the following would be presumed to meet Clean Water Act requirements:

1. no more than an average of four overflow events per year;
2. the elimination or capture for treatment of no less than 85% by volume of the combined sewage in the CSS during precipitation events on a system-wide annual average basis; or
3. the elimination or removal of no less than the mass of pollutants identified as causing water quality impairment...for the volumes that would be eliminated or captured for treatment under option 2, above.

EPA directed communities to remove solids and floatables and disinfect any residual flows.

Table 5.1. 1994 CSO Policy Nine Minimum Controls

1. Proper operation and maintenance of the combined sewer system
2. Maximum use of the collection system for storage
3. Review and modification of pretreatment requirements
4. Maximization of flow to the publicly owned treatment works (POTW) for treatment
5. Prohibition of CSOs during dry weather
6. Control of solid and floatable materials in CSOs
7. Pollution prevention
8. Public notification of CSO occurrences and impacts
9. Monitoring of CSO impacts and the effectiveness of CSO controls
Under the demonstrative approach, EPA allowed communities to implement CSO controls that did not meet the standards of the presumptive approach—so long as those communities could show that the planned control program provided the “maximum pollution reduction benefits reasonably attainable” to meet water quality standards and protect designated uses. The control program also had to allow for expansion or retrofitting if, once completed, the program proved inadequate. The demonstrative approach was oriented towards permittees that believed they had sufficient data to demonstrate that their LTCP met water quality standards (Field, Sullivan, and Tafari 2003).

As was standard for Clean Water Act rules and policy, EPA did not dictate a particular control technology. However, its multiple LTCP guidance documents—which EPA issued to assist utilities and regulators that were devising and approving (respectively) long-term control plans—made clear that it assumed communities would adopt some combination of well-studied, conventional gray approaches, including decentralized treatment, sewer separation, and off-line storage (USEPA 1995b).

Because of its rigorous standards for compliance under the presumptive and demonstrative approaches, the CSO Policy was much more demanding than the NPDES Stormwater program. In particular, the LTCP would require major investments in new infrastructure. EPA estimated that implementation of the policy would cost municipalities and states $45 billion and acknowledged that it would amount to a substantial financial burden for many CSS communities. For this reason, the policy encouraged regulators to consider a permittee’s financial capability when negotiating designated use modifications, implementation timelines, and the LTCP’s level of control. For example, it recommended using cost-performance analysis to determine where incremental benefits diminished as compared to increment costs—also referred to as “knee of the curve” analysis. These analyses, the policy stated, should “help guide” the choice of CSO programs. At the same time, the policy made clear that flexibility should not be confused
with leniency, and stated that each permittee was nevertheless responsible for "aggressively pursuing financial arrangements" to implement its LTCP.

In its Financial Capability Assessment and Schedule Development Guidance document, EPA (1997) laid out its own interpretation of what constituted a substantial financial burden, and established cost per household (CPH) as a percentage of median household (MHI) income as a key metric of financial capability. Specifically, if capital expenditures for CSO control required utilities to raise rates such that its residential customers were paying more than 2% of a municipality's median household income, EPA considered the financial burden to be "high." In communities with high CPH to MHI ratios, EPA encouraged regulators to further consider the sewage agency's bond ratings, net debt, as well as the financial characteristics of the municipality served (i.e. the poverty and unemployment rate, property tax collection rates and revenue). For communities with "medium" to "high" financial burdens, EPA recommended extending the standard engineering and construction schedule by an additional 10 to 20 years.

**The CSO Policy Becomes Federal Law**

Although the national CSO framework was devised through a negotiated process, EPA ultimately chose to issue the final document as non-binding policy and avoid the delays and costs associated with rule-making. Because the CSO Policy did not establish or effect legal rights or obligations, EPA requested that state and regional NPDES authorities create appropriate enforceable obligations, with associated implementation deadlines. For example, the nine minimum controls as well as the LTCP were to be included in reopened or reissued NPDES permits. The policy also encouraged the use of administrative orders or consent decrees to ensure compliance with CSO related permit terms and schedules.

In November of 1996, with the 1997 deadline looming, EPA issued a memo to state and regional NPDES authorities (Perciasepe 1996). The memo "reminded" them that EPA's enforcement policy—to not seek civil penalties on past CSO
discharges—would not apply unless a permittee had no dry weather CSO discharges and had met the 1997 deadline for implementing the nine-minimum control. As an effort to goad local authorities and permittees into meeting the deadline, the memo largely failed. By 1998, implementation of the CSO Policy was far behind schedule. In another memo to NPDES authorities, officials from EPA’s Office of Water and Office of Enforcement and Compliance in DC Headquarters estimated that only 52% of permittees were implementing the nine minimum controls and only 42% had submitted documentation of their efforts (Cook and Schaeffer 1998). LTCPs were also slow coming. Only 33% of CSS communities were implementing an LTCP and just 28% were under an enforceable agreement to develop one. Furthermore, it was unknown if the finalized LTCPs—most of which were negotiated between state NPDES authorities and permittees—were consistent with the national CSO Policy (Cook and Schaeffer 1998).

EPA found that despite stakeholder support of the CSO Policy, many states resisted using enforcement mechanisms to implement the policy and permittees were reluctant to implement costly controls without an enforceable mechanism in place (Perciasepe and Herman 1998). EPA itself lacked a statutory endorsement of the policy and had minimal leverage with state authorities and permittees (2004). After multiple requests from EPA and other stakeholders seeking regulatory consistency, in December 2000, Congress passed the Wet Weather Quality Act as part of the Consolidated Appropriations Act for Fiscal Year 2001. The Act amended the Clean Water Act and required that Clean Water Act permits, orders, and decrees conform with the national CSO Policy. Congress also recognized that local progress in controlling CSOs was impeded by its costs and competing local and state priorities. It authorized a $1.5 billion grant program for the control of CSOs and sanitary overflows. In a demonstration of its seriousness on the issue, that same year EPA issued a new wet weather compliance and enforcement strategy (EPA 2000). The strategy required regional offices to ensure that every CSO community was under an enforceable obligation to implement the nine minimum
controls and LTCP. The strategy also established eliminating dry weather discharges and implementing the NMC and LTCP as regional enforcement priorities.

Four years later, CSO Policy implementation statistics showed substantial improvements. In 2004, EPA reported that 94% of CSO permits required implementation of the nine minimum controls. Furthermore, 86% of permits required the development of an LTCP, 59% of LTCPs had been submitted, and 35% of the plans had been approved (EPA 2004). Local investments in CSO control also had increased. For example, revolving loan expenditures for CSOs nearly doubled from $280 million in 1999 to $440 million in 2002 (EPA 2004). EPA has spent the last decade working to increase the compliance of large combined systems—those serving more than 50,000 people—through various mechanisms, including enforcement actions and consent decrees. According to EPA’s “ECHO” database, by 2016 EPA had assessed all the 213 of the large combined systems and, along with the states, had brought nearly 100 enforcement actions since 1998.38

FROM LID TO GSI: POPULARIZING A NEW STORMWATER MANAGEMENT PARADIGM

At the same time EPA was finalizing its policies on MS4 discharges and CSOs, a new, comprehensive approach to stormwater management was being pioneered in Prince George’s County, Maryland. In 1990, Larry Coffman, a biologist and the director of the Programs and Planning Division in the County’s Department of Natural Resources, began to explore a set of site planning practices he would later call “low impact development” (LID)39. Coffman was motivated by the need to stem the tide of non-point source pollutants entering the nearby Chesapeake Bay.

38 ECHO stands for Enforcement and Compliance History Online, a public database searchable at: https://echo.epa.gov/

39 The term LID appears to have been coined in 1977 (Fletcher et al. 2014); but Coffman articulated it comprehensively for the first time and the County’s work accounted for LID’s spread to the regulatory community—EPA in particular.
the largest estuary in the United States and one of the most productive aquatic ecosystems in the world. In 1970, scientists studying conditions in the Bay had identified one of the world's first “deadzones,” an area with oxygen levels too low to support most aquatic life. Nutrient rich stormwater runoff from agriculture and urban development in the region was largely blame. Given the ecological significance of the Chesapeake as well as the regional importance of its fisheries and the tourism industry it supported, in 1983 EPA helped forge a collaborative management partnership among the states of Maryland, Virginia, Pennsylvania, and the District of Columbia. Through the 1987 amendments, the partnership was enshrined in the Clean Water Act as the “Chesapeake Bay Program” and the partners committed to a 40% reduction in nutrients entering the Bay by 2000.

Like many others, Coffman recognized that conventional approaches to stormwater management were ill-suited to address emerging concerns about runoff quality and quantity because they 1) prioritized swift removal of runoff from sites and 2) had been developed in response to flash flood disasters. For example, after several catastrophic flood events in urbanizing watersheds in the 1970s, local flood control authorities began mandating that developers maintain the pre-development peak discharge rate (the amount of water flowing per time unit) for large storms, such as the 20, 50 or 100-year storm. As the 1983 NURP study had highlighted, site engineers commonly accomplished this by constructing centralized detention basins at the bottom of the drainage area. As designed, detentions basins successfully “shaved the peak” runoff rate during large storms by detaining and then slowly releasing stormwater to the local stream or stormwater sewer. However, basins did not reduce the total quantity of runoff entering a stream and instead extended the duration and frequency of runoff flows, causing heavy erosion, changes to the width and depth of stream channels, and loss of aquatic habitat. Furthermore, because basins were designed to manage large storms, they did not moderate runoff resulting from more frequent, smaller storms, which quickly passed through the structure. Although wet ponds
optimized for treatment could reduce pollution concentrations, dry ponds provided little to no treatment—a finding also reported in the 1983 NURP study. Improper design and inadequate maintenance, however, frequently resulted in water leaving both types of basins dirtier than when it entered.

In contrast to the conventional approach, Coffman and his collaborators aimed to mimic the natural, pre-development hydrologic cycle by capturing and treating rainfall as close to the source as possible. LID laid out a highly flexible, site-specific planning and design process that aimed to conserve sensitive resource areas like wetlands; minimize impervious surface; establish post-development goals based on pre-development hydrology; and implement decentralized stormwater infrastructure to meet these goals. Specifically, LID called for the use of many small, distributed, onsite runoff controls that disconnected flow paths instead of quickly conveying runoff to large off-site detention structures. They included an array of simple designs: dry wells, filter strips, vegetated buffers, rain barrels, cisterns, which—to varying degrees—facilitated rainfall interception, evaporation, filtration, storage, and infiltration. Coffman also pioneered and promoted the use of bioretention devices—vegetated, earthen depressions shown in Figure 5.1—and coined the term “rain garden” to appeal to a broader audience. Developers and engineers could select and configure one or more of these technologies based on site conditions and hydrologic goals. A vegetated buffer could be used to slow runoff from a parking lot before delivering the remaining flow to a filtration device, such a rock filled trench or a wet swale. A rain barrel could be used to capture and store roof runoff during storms and then provide water to vegetated swales during dry periods. 40 Taken together, these controls could maintain the predevelopment runoff rate, volume, and frequency, while providing physical, chemical, and biologic water quality treatment through settling, filtration, microbial activity, and plant uptake.

40 Coffman actually named these “integrated management practices”, but for simplicity I call them LID technologies.
Of course, LID had important precedents. As discussed above, many of the control technologies, such as pervious paving and other filtration devices, were first developed and researched by stormwater engineers in the 1970s. By the 1980s, these controls had been implemented in a handful of communities, as well as by the National Highway Administration. Additionally, LID's underlying principle—that human development could benefit from the protection and thoughtful use of natural systems—had a long intellectual history in landscape architecture. In the 1800s, Fredrick Law Olmstead, designer of New York's Central Park and a founder of American landscape architecture, argued that a landscape's natural features and functions should be maintained to the greatest degree possible during urbanization. His creations reflected this philosophy. In his design of Boston's linked greenways (the "Emerald Necklace") Olmstead restored the Back Bay Fens, a heavily polluted saltwater marsh, to a functional wetland and public park that
provided flood and water pollution control during heavy storms. Amongst more modern influences, Ian McHarg’s 1969 treatise *Design with Nature* presented one of the most influential and eloquent cases for development that respects and maintains natural systems. As opposed to seeking to thwart and dominate land and water, McHarg proposed using ecology as a basis for design and planning. Then, in 1985, Anne Spirn’s *Granite Garden* demonstrated, through countless historical and modern cases, how the principles of ecological planning and design could effectively create safer, healthier, and less wasteful cities. In a chapter dedicated to urban water systems, Spirn (1985, 167) argued that every new urban project:

“should address the relationship between the project’s site and the city’s critical flooding, water pollution, and water supply problems...[and] exploit the ability of rooftops, plazas, parking lots, and the earth to detain or retain stormwater runoff.”

Spirn also highlighted how several American and European cities had used LID-like principles (called by other names) to retrofit dense urban spaces with pervious paving and vegetated retention devices, like green roofs.

However, LID was unique in the way it adeptly communicated how ecological planning and site design could address the interests and concerns of modern engineers, local officials, and regulators. As a trained biologist and chemist, Coffman saw obvious benefits to using vegetation for stormwater management and conserving a site’s natural hydrologic function. At the same time, as a county official, his work was framed by the constraints of local budgets, water regulations, and the influence of civil and environmental engineers who were trained to think in terms of centralized, structural controls based on pipes, ponds, and treatment plants. Coffman worked to make the philosophy of ecological planning relevant to decision-makers in several ways. First, Coffman presented and discussed LID in terms that mattered to developers and engineering professionals:
curve numbers and runoff volume, peak runoff rates, time of concentration, and removal efficiency (Prince George’s County 1999). Second, he advocated the use of many experimental technologies first developed and researched by stormwater engineers and he compiled existing engineering data on their performance, providing a ready defense against engineering professionals who questioned their efficacy. Then in 1996, Coffman’s department partnered with the University of Maryland’s School of Engineering, which housed the Maryland Water Resources Research Center, to build and monitor LID sites and disseminate findings based on sound engineering research designs. Because stormwater engineers rarely showed interest in the capabilities of recharge systems that included vegetation, Coffman and his UMD colleagues reported extensively on the performance of bioretention devices, which were found to provide some of the highest removal rates for nutrients and heavy metals (Davis et al. 1999).

Not only did this research provide early evidence that LID techniques could outperform conventional approaches to water quantity and quality control, it also suggested that LID was more cost effective, a finding that Coffman broadcast in public talks, articles, and Prince George’s first LID Guidance Manual, published in 1997. Case studies and pilots in Prince George’s County demonstrated that the use of distributed runoff control techniques could eliminate, or vastly decrease, the need for centralized drainage. In such cases, developers realized cost savings of at least 25% by reducing grading, and the use of pipes, ponds, curbs, and paving (Coffman 1998). Maintenance costs could also be reduced by using LID. Whereas conventional structural controls necessitated dam repairs or pond dredging, LID typically only required routine landscape care and the maintenance of vegetation (Coffman 1998).

Coffman argued that the applicability of LID extended beyond new developments and non-point source control in suburbs. Although there would not be the same opportunity for comprehensive site design, Coffman noted that micro-scale infiltration practices could be applied even in dense urban areas during
redevelopment or through site retrofitting, including the routine maintenance or repair of public spaces like parkland or streetscapes. (Ten years earlier, Granite Garden had independently provided such examples.) Furthermore, LID could serve as a one-stop shop for the many water related challenges facing stormwater program managers in cities. LID showed promise as a multi-functional tool for controlling the quantity and quality of stormwater entering MS4s, reducing combined sewer overflows, restoring riparian and aquatic ecosystems, and protecting drinking water sources. If applied widely, Coffman argued, LID could reduce the stress on aging sewage systems and obviate expensive expansions or repairs. An added bonus was that failure of one decentralized control technology—a gravel filter that clogged, for example—would not compromise the system in the way that a water main break or dam collapse would. Overall, Coffman contended, the potential costs savings associated with LID coupled with its multiple benefits and adaptability made it a more efficient and practicable investment for cities than conventional structural approaches (Coffman 1998).

Through a process probably deserving of its own study, over the next decade, decentralized stormwater management moved from local experiment to EPA wet weather policy. First—thanks in large part to the interest and support of staff in the non-point source control branch of EPA's Office of Water in Washington DC—in 1998 EPA awarded Prince George's County a grant to produce a two volume LID manual and literature review that showed how the concept could be applied on a national scale (Coffman, Goo, and Frederick 1999). The manual was completed and widely disseminated in 2000, the same year Coffman established the Low-Impact Development Center to assist local, state and national governments with training, research, education, and demonstration. The Center, Coffman joked, was necessary so that he would not have to directly field the

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41 LID does not substitute for flood control. Infiltration technologies usually are most practicable for controlling the 90% percentile storm event, and not outlier events. Although infiltration devices can mitigate flood risks, cities still must design and maintain appropriate (typically centralized) flood control infrastructure for large storm events that overwhelm on-site practices.
enormous influx of questions and phone calls about LID and get back to his “day job...cutting red-tape lengthwise” (Coffman 2001). Coffman’s efforts also dovetailed with, and were probably amplified by, a number of other municipalities, such as Portland, Oregon, Seattle, Washington, and Denver, Colorado, that were independently piloting and reporting on similar “natural drainage” techniques, which some had begun to call green stormwater infrastructure.42

Importantly, the credibility of the approach was bolstered by the stormwater engineering and research community, both within and outside EPA. In 1999, EPA’s National Risk Management Laboratory published its own lengthy report on innovative and “sustainable” wet weather management practices and guidelines (Heaney, Pitt, and Field 1999). Citing the damage done by traditional urban stormwater management, the report focused on the efficacy of various source controls, including bioinfiltration, which the engineers termed “structural best management practices (BMPs)” (Heaney, Pitt, and Field 1999). Then in 2001, EPA’s Office of Research and Development began to modify their widely used Storm Water Management Model (SWMM) to allow cities to model the impacts of various site-level stormwater controls, from raingardens to green roofs, on their storm and sewer systems. Academic studies of the approach also accelerated. After a decade of little interest and funding support, between 2000 and 2005, papers referencing LID increased by an order of magnitude.43 University engineering departments began establishing urban stormwater research programs, often in partnerships with state and federal agencies, that focused on evaluating and communicating the ecological benefits of LID and source control techniques. These centers notably included Villanova University’s Urban Stormwater Partnership (founded in 2002) and the University of New Hampshire’s Stormwater Center (founded in 2004).

42 It is unknown who coined the term “GSI,” but one of its earliest uses was by the Washington Stormwater Center and Seattle Public Utilities, pioneers of LID/GSI in the Pacific Northwest in the 1990s.
43 Based on a Google Scholar search using the keyword “low impact development.”
Although there was not consensus on terminology, by the early 2000s, most advocates of LID, GSI or one of the many other terms in use, at least agreed on the common urban water management principles: reduce impervious surface; manage stormwater where it falls; prioritize runoff infiltration; and to the extent possible (given site constraints) integrate green elements. Regarding the latter principle, GSI technologies, like cisterns or pervious paving, did not always include vegetation. However, advocates noted that when they did, they often had higher pollutant treatment efficiencies and produced a slew of local benefits above and beyond their hydrologic ones. Drawing on the growing body of literature in “urban ecology,” supporters of GSI also noted the multiple “co-benefits” produced by vegetated stormwater systems, including improved air quality, mitigation of the urban heat island effect, enhanced community well-being, and expanded natural habitat (multiple citations).

There were, of course, those who critiqued GSI on the basis of its practicability and long-term upkeep. These detractors listed a variety of obstacles to implementation including maintenance costs and complexity, prohibitive local land use regulations, flooding and groundwater risks, and the expense of retrofits (cite). While not denying these challenges, GSI advocates turned their attention to producing more nuanced guidance and disseminating case studies to help communities overcome potential political and technical pitfalls (Hager 2003). At the same time, GSI pioneers argued that no new technology should be expected to work perfectly all of the time, particularly in the early years of its development and implementation. As the landscape architect and long-time GSI advocate, L. Peter MacDonagh (2015), quipped: “if the Department of Defense took the ‘we will not build anything until its perfect’ approach...the US Army and Navy would still be firing cannonballs.”

As the preceding story shows, GSI was innovated largely from the bottom up, through experimentation by stormwater practitioners—including, engineers and landscape architects—and local government administrators. Interestingly,
EPA (and most environmental NGOs for that matter) lagged behind these developments—a fact that is perhaps not surprising given the contentiousness of nearly every major EPA policy change. Although parts of the agency were engaged in and supported research and education on GSI, by 2006 the Office of Water had yet to establish a policy position on the application of these practices to meet regulatory obligations under the Clean Water Act. To the consternation of municipalities and wastewater utilities, many state and federal regulators were blocking efforts by communities to use these new approaches in lieu of more expensive conventional systems for CSO control.

In 2007, however, an unlikely alliance of critical stakeholders instigated EPA's first policy statement on the use of GSI for compliance with the municipal CSO and MS4 programs. Issued on Earth Day, EPA's Green Infrastructure Statement of Intent outlined a collaborative commitment to promoting and encouraging the use of GSI "as a prominent component of [municipalities'] CSO...and MS4 programs" (USEPA 2007). The statement, which was initiated by assistant administrator Benjamin Grumbles, signaled the growing acceptance of the approach among agency leaders and committed EPA to pursue strategies to promote GSI and its integration into EPA's regulatory programs. This included developing policy and guidance memoranda to explain how regulatory and enforcement officials should "evaluate and provide appropriate credit" for the use of GSI in meeting Clean Water Act (USEPA 2007, 3).

The statement was co-signed by Coffman’s Low-Impact Development Center, the Association of State and Interstate Water Pollution Control Administrators, and NACWA, which had been lobbying Congress and EPA to do more to support and promote GSI, in large part to reduce compliance costs for...

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44 EPA continued to refer to decentralized stormwater technologies as LID until 2007, when it switched to using the term Green Infrastructure (GI). Until then, most of its LID programming was run out of the Water Office's non-point pollution control branch. Interestingly, the nonpoint program was managed in a separate division from EPA's wastewater branch, where the MS4 and CSO programs were housed. This separation may have been one cause of EPA's slowness to connect LID/GSI to its wastewater management programs.
their member communities. These groups were joined by NRDC, which was one of the first—and certainly the most influential—national environmental organizations to advocate for broader implementation of GSI, particularly in the nation's largest municipalities. Indeed, NRDC, under the leadership of Nancy Stoner, director of the clean water program, emerged in the early 2000s as a trailblazer in national GSI policy, especially as it pertained to urban wet weather pollution. Through multiple reports, congressional testimony, and direct lobbying, NRDC played a key role in elevating GSI to the national policy level. In 2002, for example, NRDC published Out of the Gutter. The report outlined how Washington DC, which was planning a major CSO tunnel project, could and ought to use low impact development to mitigate pollution from its separate and combined sewers (Woodworth et al. 2002). Then in 2006, NRDC published its first iteration of "Rooftops to Rivers," which presented the ecological and economic benefits of GSI and reported on its successful application in nine major US cities for the control of stormwater and sewer overflows (Kloss, Calarusse, and Stoner 2006). As NRDC conveyed in its reports and Congressional testimonies, the superiority of GSI as compared to conventional techniques was clear: it was cheaper, more effective for pollution reduction, and more ecologically sensitive (Stoner 2002). In a rare showing, NRDC and wastewater utilities finally found themselves in agreement, a fact that almost certainly encouraged EPA's movement on the issue.

45 In fact, it was "Rooftops to Rivers" that encouraged assistant EPA administrator Benjamin Grumbles to initiate EPA's GSI program in 2007. In a memo to regional administrators on March 5, 2007, Grumbles wrote: "EPA Water Programs are in a pivotal position to exert leadership in the consistent and reliable implementation of green infrastructure approaches. This memo is to highlight opportunities for the Regions, States, and Headquarters efforts to increase the development and use of green infrastructure in water program implementation....I strongly support the use of green infrastructure approaches described in the NRDC report" (Grumbles 2007).
PART III: THE CASES
PHILADELPHIA: AN INTEGRATED UTILITY HARNESSES THE GREEN WAVE

INTRODUCTION

In 2016, the Philadelphia Water Department hit the 5-year mark of its GSI-based CSO control plan, Green Cities, Clean Waters. As a “proof of concept” period for regulators, it appeared to have been a success. The agency surpassed their goals of creating 744 new green acres. With 441 GSI projects created since 2011, the city added a total of 837.7 green acres that would keep an average of 1.5 billion gallons of combined sewer overflow out of the City’s rivers each year.

In this chapter I seek to explain why Philadelphia’s PWD transformed from a traditional water agency into one of the most innovative wastewater and stormwater utilities in the country, and a national expert on GSI policy and engineering. I show how three key factors resulted in PWD’s unprecedented adoption of this sustainable technology: the structure of its water system and water department; the policy entrepreneurship of a planning manager in the department; and the growing acceptance of GSI within the policy community as PWD devised its multi-billion-dollar long term control plan. First, I trace the history of Philadelphia’s public water and sewer system from the 1800s, showing how the legacy system that developed was built piecemeal by independent decisions taken over the course of 150 years, but resulted in an integrated and politically autonomous utility that was well poised to embrace GSI. Second, I show how a PWD administrator took advantage of a period of instability within the organization to pursue an innovative watershed-based approach to wet weather pollution management. Finally, I discuss how evolution in the broader regulatory policy community facilitated approval and implementation of PWD’s plan.
WATERS FROM THE RIVER

Late in the summer of 1793, after an especially wet spring, yellow fever landed in Philadelphia. A gruesome illness marked by internal bleeding and black vomit, as well as liver failure and yellowing of the skin (thus its name), it rapidly spread throughout the commercial port city. Although Philadelphia was not a stranger to disease or even yellow fever specifically, the outbreak of '93 was exceptionally virulent and reached into the homes of the city's elite. By the time the November frosts ended its reign, over 5,000 people, 10% of the population, had died; 20,000 people, including all the city's public officials, had fled to the countryside; 200 children were left orphans (Powell 1949). Suspicion fell on the city's filthy thoroughfares and contaminated drinking water supply.46 The prevailing miasma theory of disease— popularized in medical circles in London— attributed illness to “foul air,” which permeated the streets of Philadelphia. Moreover, citizens still received their drinking water from cisterns and drinking wells that tapped groundwater. Located in the shallow portions of the city, these sources were routinely inundated with garbage strewn stormwater and leachate from cesspools and overflowing privies (Olton 1974).

Additional fever epidemics in 1794, '95, and '97—though less severe—perpetuated panic over the city's conditions. In 1797, an “unprecedented” number of Philadelphia's most “respectable citizens” brought a petition before city leaders that exhorted them to oversee the construction of a new water supply (City of Philadelphia 1799b, 45). Recalling the victims of the epidemics, the petitioners argued that future losses could be avoided or at least greatly allayed by “cleanliness and a copious supply of water” (City of Philadelphia 1799b, 46). Although the epidemics increased the urgency of their case, petitioners also argued that a new water supply would meet additional critical city interests, including improved fire

46 It would take nearly a century for the medical community to discern that yellow fever was transmitted by mosquito, which had likely traveled to Philadelphia’s ports with French colonial immigrants fleeing slave rebellions in the Caribbean islands.
control and street cleaning. The expense of such a project, they contended, would be more than offset by the prevented losses in life and property. As such, they wrote, “there is no object or ornament to which a liberal portion of city Funds can be more acceptably applied...even if no return of interest on capital were to be expected” (City of Philadelphia 1799b, 47).

The petitioners' references to “city Funds” reflected a critical post-independence development in the city government's fiscal authority. Following English precedent, Philadelphia and other colonial cities were established as judicial rather than administrative organizations, with limited legislative functions; and Philadelphia’s corporate charter, granted in 1701 after decades of provincial resistance, denied it the power to directly levy taxes (Fairlie 1898; Kimball 1922). The corporation was restricted to funds from various business fees and violation fines, which it struggled to collect with regularity (Bronner 1982; Fairlie 1898). Thus even as Philadelphia swelled from a 350-person settlement at its founding in 1683, to the 18th century’s most populous US city and major commercial center, water distribution, surface water drainage, and waste removal remained the responsibility of individual private effort or collectives, as in the case of fire and policing. While some of this activity was voluntary, much of it was required under city ordinances that sought to make property owners shoulder construction costs—and therefore bypass paltry city coffers (Bronner 1982). Such an approach made sense when Philadelphia was a still a small town, but by midcentury, as the population surpassed 20,000 people, these services were grossly underprovided. Streets were clogged with trash, rutted by carriage wheels and poorly lit; waterways amassed rotting carcasses; and too deeply dug privies contaminated neighbor’s drinking wells. Widespread rabble rousing and petitioning—of both the local and provincial leadership—made clear that the public wanted city leaders to address these issues of collective concern. The municipal corporation, however, hamstrung by its restrictive charter, lacked both the authority and resources to take major action. The city government was in such
ill repute that the common council had to devise a fine to penalize those who, once chosen, refused to serve in office. By the 1750s, the fines were collected “often enough as to form a reasonably important part of the city’s constricted revenues” (Bronner 1982, 62).

Following independence, however, the colonial corporation was abolished. On March 11, 1789 the Pennsylvania Assembly reincorporated the city of Philadelphia and established a citizen elected council with expanded legislative and executive functions, including the appointment of city officers. The following year the Assembly amended the city charter to grant the council authority to levy taxes upon “single men, and upon the estates, real and personal, of the inhabitants...for lighting, watching, watering, pitching, paving and cleansing the streets, lanes, and alleys of the city” (quoted in Miller 1982, 166). Thus ten years later, with this newly vested power, city leaders were able to commit to the petitioners’ request by creating a uniquely empowered committee: the Joint Committee on Bringing Water to the City, known simply as the Watering Committee. Composed of four members from the city’s bicameral council, the Watering Committee initiated studies for what would become the city’s first major public works project, and the first public water works in the United States. The high-level consensus about the desirability of new water infrastructure and its worthiness of city funds did not obviate the need to answer other fundamental questions. These included whether or not the new system should be publicly managed or privatized; what technology to adopt; what water source to use; and how to justify and structure the public expenditures. Two years and several reports later, the Watering Committee settled on its approach. Bucking the privatization trend that would dominate in the 1800s and expressing concerns both pragmatic and ideological about the proposal, the committee rejected a plan from the Delaware and Schuylkill Canal Company to dig a canal from Spring Mill Creek, (nearly 20 miles northwest of Philadelphia) to the another of the Company’s projects along Vine Street. Instead, the committee opted to finance the plans of
the young engineer and architect Benjamin Latrobe, who was in the city designing the Bank of Philadelphia.

Latrobe, who had also assessed the Canal Company’s plan, proposed to draw water from the swift flowing Schuylkill River, which then formed Philadelphia’s western border. Had Latrobe and others foreseen the extent of urbanization that would take place in the region over the next century, they may have thought twice about drawing on local surface waters. But at the time, Philadelphia was only two square miles. The Delaware River formed its eastern boundary and was the site of most of the city’s activity. With little development on either bank, the Schuylkill appeared to be a proximate and plentiful source of high quality drinking water. The challenge was how to distribute it. Although pumping technology was experimental, Latrobe outlined a plan for a steam powered public system, that would pump water from a basin on the Schuylkill above Chestnut street to another pump-reservoir station at Centre Square at present day Broad and Market. From there river water would flow by gravity to private subscribers and public hydrants throughout the city. In addition to impressing the councils with his knowledge and showmanship, Latrobe estimated that his project would cost only $127,000, whereas the canal project was expected to require $327,000 (City of Philadelphia 1799b; C. Smith 2013). To fund Latrobe’s vision, the councils authorized a $150,000 series of loans, pledging the entire city revenue as backing (City of Philadelphia 1799a).  

Perhaps not surprisingly given the novelty of steam engine technology and Latrobe’s relative inexperience, financial and operational challenges plagued the new system, which was completed in 1801. Seeking to salvage the failing infrastructure and save face after massive cost overruns, in 1812 city leaders

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47 Although the city raised capital by selling “shares” in the water works venture, what it actually issued more closely resembled modern day municipal revenue bonds. Subscribers (the name given to those who purchased shares) were granted some special benefits, such as preferential hookups and free water, but were promised full repayment of, including interest on, their investment using revenue from water fees. The loans were further backed by the full taxation power of the city (City of Philadelphia 1799a).
embraced a redesign put forth by the superintendent of the works, Fredrick Graff. Graff had served as Latrobe’s assistant engineer and spent years trying to make the original system function. Graff advocated moving the water intake farther up the Schuylkill to the base of Faire Mount Hill where hydropower from a new dam, instead of steam engines, would pump water to a reservoir atop the hill. Although the decade-long project cost the city another $300,000 (also raised through bond sales), in 1824 the waterworks were efficiently and inexpensively supplying an uninterrupted supply of water to the city and the neighboring boroughs of Spring Garden, Southwark, and Northern Liberties, which contracted for the Philadelphia’s surplus (Richardson 1982; C. Smith 2013).

**LINKING LAND AND WATER: EARLY SOURCE CONTROL IN PHILADELPHIA**

Philadelphia’s early decision to source drinking water from its local surface waters established a precedent that would be challenged during future health crises, but never successfully undone. Cities like Boston that followed Philadelphia’s lead and built their own public water systems did so at a time when it was more rational—because of urbanization pressures—and more feasible—because of technological advancements—to tap purer waters in rural hinterlands, feeding them through systems of aqueducts and reservoirs. In Philadelphia, the prospect of building a costly new system, even as risks associated with waste disposal into the river grew, was politically untenable. By the mid-1800s, Philadelphia had in fact expanded the number of pumping stations on the Schuylkill from one to five and added a station at Kensington, on the Delaware (McCarthy 1987, 6).

The health of the rivers was, of course, a primary concern to city leaders and water department engineers, and the link between activities on land and local
water quality was not lost on either group. In fact, land based efforts to head off development pressures and concomitant industrial pollution in the Schuylkill watershed began as early as 1828, with the purchase of 28 acres of land adjacent to the original Fairmount water works (Ristine 2005). These activities continued in 1844 with the acquisition of the Lemon Hill estate, a 43-acre tract of land just north of the waterworks intake. Then in 1854, a bid to consolidate the 13 townships, six boroughs and nine districts surrounding Philadelphia was at last successful in state legislature. The city-county consolidation expanded the municipality of Philadelphia from two square miles to 129 and extended its control over the Schuylkill river for several miles above the waterworks. The city councils quickly availed themselves of this development “to protect and improve the purity of the Schuylkill water supply” (Weigley 1982, 376). In 1855 they passed an ordinance setting aside Lemon Hill to be held in trust for the citizens of Philadelphia as public parkland. Within three years the city increased its holdings north of Fair Mount to 110 acres of land, which would come to be known as Fairmount Park.

Reflecting their common interest in the park, the chief engineer of the waterworks and the commissioner of city property initially shared control of Fairmount (Beers 1982). Then on March 26, 1867, following state authorizing legislation, Philadelphia passed an ordinance creating a Fairmount Park Commission to oversee its management. As a permanent member of the commission, the chief engineer at the water department retained a leadership position in the park system, but was now joined by key city officials and ten citizen

48 In 1854, the city created a water department, which was overseen by the city council. In 1887, under the Bullet Bill, the department was renamed the Bureau of Water and managed within the new Department of Public Works until 1951.

49 Proposed unsuccessfully several times earlier, the state bill could not come soon enough. As Geffen (1982) notes: “Officially the city’s jurisdiction [originally] extended only from the Delaware to the Schuylkill, north as far as vine and south as far as South street. But its burgeoning population had continued to spill over into the surrounding area. By 1854... the result was an administrative nightmare...especially for law enforcement.”

50 Philadelphia is currently 141.7 square miles.
appointees (Allinson and Penrose 1887). The ordinance also included a substantial expansion in park boundaries and a mandate that the land should be “laid out and maintained forever as an open public place or park for the health and enjoyment of the people...and the preservation and purity of the water supply” (As cited in Beers 1982, 427). Following the commission’s creation, the city councils supported its members’ recommendation to extend park boundaries in both its western and eastern sections, and to expand northward to “protect both banks” of the Wissahickon, a pristine Schuylkill River tributary (Beers 1982, 427). By 1870 Fairmount Park was a 12-mile long protected system of over 3,000 acres on either side of the Schuylkill river above Fair Mount. This acreage remains the heart of the now 9,000-acre city park—one of the largest urban park systems in the nation.

Unfortunately, as the primary mechanism to maintain the purity of the city’s drinking water, Fairmount Park proved inadequate. Just upstream of Philadelphia the industrial towns of Norristown and Conshohocken continued to dump pollution into the watercourse unabated. As early as 1846, engineers at the water department expressed concerns about industrial pollution coming from the upper reaches of the river and entering the city’s water supply (Geffen 1982). In 1883, the head of the Water Department noted that the pollution in the Schuylkill was “as diversified as the occupation of the people: sewage, chemical, wool-washing, dye stuff, butcher and brewery—there is almost nothing lacking” (McCarthy 1987, 6).

The massive expansion of Philadelphia’s sewer system after the Civil War added another toxic burden to the local waterways against which Fairmount Park was impotent. In fewer than three decades, Philadelphia’s Department of Surveys transformed the city’s privately built, 35 mile stormwater drainage system into a 1,000 mile, publicly managed combined storm and wastewater system—a so-called “water carriage system,” or combined sewer system in modern parlance.
WASTES TO THE RIVER

The development of Philadelphia’s combined sewer system was a response to the urban drainage problems created by the new waterworks, which facilitated the spread of indoor plumbing and the widespread adoption of the water closet, a precursor to the flush toilet. The additional water overwhelmed the existing privy-vault cesspool system of drainage. Instead of percolating into the soil, privies and cesspools overflowed and wastewater and excrement easily found their way into the streets, streams, and sewer catchments. With the city experiencing unprecedented growth in population and density, these haphazard disposal methods bred disease. Disease related mortality rates, which dropped temporarily after the water works came online in the 1820s, climbed steadily again after 1850 (Geffen 1982). Cyclical epidemics of waterborne illnesses, notably cholera and typhoid fever, prompted calls for a public waste management solution more permanent than the emergency street cleaning programs city leaders organized during the epidemics of 1849 and 1866 (Geffen 1982).

Reflecting the professional and administrative disconnect between wastewater, drinking water, and public health management, the challenge of solving Philadelphia’s waste water fell solely to the engineers in the Department of Surveys who had overseen the regulation of streets, sewers, and watercourses since 1769. After consolidation, the department relentlessly advocated that the city lift its ban on the connection of privies to the city sewers, making way for a city-sanctioned system that would combine surface and waste water into one set of pipes, discharging the effluent into the local rivers. Arguing that it would reduce rampant illegal connections, in 1855 they were successful in their bid to allow department-approved private connections to city sewers (City of Philadelphia 1864). Then in 1864 Philadelphia’s Chief Engineer and Surveyor, Strickland Kneass, presented councils with a report and a proposed ordinance broadly entitled “An Ordinance to promote Public Cleanliness and Health.” If approved, the law promised to dramatically remake the urban environment. It would outlaw
cesspools and their connection to sewers, but permit any lawful premise to
connect other wastewater, including that from water closets, and require such
connections on all new developments (City of Philadelphia 1864).

The Department of Health’s Sanitary Committee, who had opposed the 1855
ordinance, greeted this newest proposal with vehement disapproval. In their own
report to the mayor— an exercise in persuasion, given their limited influence on
the Councils— the Committee lauded the ordinance’s goal of removing the city’s
stagnant and polluted surface water. However, they balked at the ordinance’s
unqualified encouragement of all manner of private connections— “water closets,
yards, kitchens, factories”— to the city’s already overburdened and disjointed
sewer system (City of Philadelphia 1864, 17). In a slew of critiques that would
resonate with a more modern perspective on sewage management, the committee
pointed to the existing build-up of industrial waste at the “terminus of sewers on
the river front” responsible for “scattering desolation and death in every direction”
(City of Philadelphia 1864, 26). The proposed “privilege of connecting… water
closets,” the Committee wrote, “could not fail to be fraught with numerous
sanitary evils” (City of Philadelphia 1864, 23). They cast doubt on the ability of the
city’s aged pipes to successfully flush out solids and not leave them festering and
fuming beneath the city streets, and they challenged the popular belief among civil
engineers that the rivers could dilute pollution to safe levels. Instead, the
Committee argued that even if the pipes were resized and received sufficient
flushing flow, the tidal currents of the city’s “sluggish” waterways would
continuously bear back “this half-dissolved putrescent material” (City of
Philadelphia 1864, 27). “The feeling is becoming very general,” they stated, “that
wherever practicable sewage should not be allowed to pollute water-courses of any
kind” (City of Philadelphia 1864, 29). The committee acknowledged that ideal
solutions to Philadelphia’s wastewater challenges were elusive and “as yet
unsettled;” nevertheless the issue, they contended, was “far too grave for hasty
legislation” (City of Philadelphia 1864, 29).
Nevertheless, in March of 1867, the councils approved the ordinance. And by the 1880s, survey engineers were drawing up the city's first comprehensive sewer plans, designed expressly for the purpose of conveying a mixed flow. Specifically, they argued for culverting most of the city's urban streams and creeks—essentially appropriating them as sewer mains—with surface water and domestic and commercial wastewater connections to these pipes (Levine 2010). This system, they contended, would provide the greatest benefits in the least costly manner: By taking advantage of the city's natural drainage, which already flowed via the path of least resistance into the Schuylkill and Delaware River, the city would avoid expensive excavation and pumping; furthermore, because urban expansion resulted in the pollution of local streams, engineers reasoned that burying them in advance of development would reduce future disease spread; finally, culverting waterways obviated the need to construct costly bridges and maximized the amount of land available for development (Levine 2010). By the turn of the century, more than 100 sewer outlets were dumping the untreated wastes of a one million-person city directly into the rivers that citizens relied on for drinking water (Levine 2010). The combined sewer system and the practice of

51 This most likely came as no surprise to members of the Board of Health, who in their letter to the mayor had thanked him for his "uniform interest and attention" in the opinions and affairs of the Board, while regretting that "the same interest has not been shown by the City Councils and other Departments of the city, to whom many suggestions relative to matters, deeply affecting the health and welfare of the city have been referred without any actions ever been taken" (City of Philadelphia 1864, 32).

52 In the late 1800s, the bicameral council not only held the city purse strings but, to the chagrin of many, were running nearly all aspects of city administration. Being so, their support was critical, and they threw their weight behind the surveyors once again. The councils approved the comprehensive sewerage plan and over the next decades provided funds from both the general budget and loans amounting to over $30 million for its rapid implementation (City of Philadelphia 1914). There was very little conflict over these appropriations which had much to do with the additional benefits beyond urban drainage that the councilmembers perceived. Although sewers were not (yet) revenue generating like the water works, which charged usage fees, sewers contributed to land development and raised property based tax revenue, by this time a mainstay of local financing (Levine 2010, 52; Melosi 2008). Furthermore, a Republican political machine, notorious for its corruption, dominated city government; for many decades, Philadelphia earned its unfortunate moniker as "the most corrupt and contented" (Steffens 1903). As with most capital-intensive projects in the city, sewer construction offered council members the opportunity to
encapsulating streams fell out of favor in the early 20th century, but by then city engineers had also already removed nearly every small waterway from the urban landscape, leaving only five streams uncovered (Levine 2014).

**AN INTEGRATED LEGACY SYSTEM**

As a result of choices made independently by separate decision-makers over the course of a century, Philadelphia produced an interdependent, and highly problematic, water and waste system. As the Board of Health had predicted, the combined system did not so much solve Philadelphia’s pollution problem as re-locate it. Although it alleviated the city’s poor surface drainage, the sewage it transported quickly overwhelmed the natural cleansing properties of the rivers, particularly that of the smaller Schuylkill. The fact that the city was growing at a steady clip, adding 200,000 people per decade between 1860 and 1900 did not help matters. In 1883 the chief engineer of the water department called the Schuylkill, which supplied 90% of the city’s water, a “natural sewer;” on the Delaware, he wryly noted, the Kensington Water Works, surrounded by industry, was getting the “full benefit” of all the city sewage (City of Philadelphia 1883, 45).

Having already committed tens of millions to Philadelphia’s water and wastewater systems, city engineers and elected officials looked for ways to make beneficial adjustments that, although costly, were still less onerous than finding a new water source for the city. For example, city council approved the construction of an interceptor pipeline to carry wastes from the sewers of Manyunk and East Falls to an outlet below the Fairmount dam; the exceptionally polluted water from this industrial part of the Schuylkill was thereby routed around the four pumping stations it had previously flowed past. Council also approved the expansion of

reward their supporters or even family members with lucrative construction contracts (Melosi 2008, 53).
several reservoirs to increase the amount of time for sedimentation and avoid instances of “direct pumpage,” when river water was sent straight into delivery lines with no period for “resting” (McCarthy 1987, 15). The city closed the Kensington pump station, which had the poorest quality water of Philadelphia’s six stations.

Nonetheless, water borne disease rates worsened. Rates of typhoid infection, an illness caused by the consumption of food or water contaminated with infected feces, climbed steadily. All told, some 16,000 people died between 1860 and 1890, and for each another 10-15 were made ill (Brown, Levin, and Schultz 2009/2010). Even those unconvinced by the claim that typhoid was caused by the microscopic organism *Salmonella typhi*, discovered in 1880, knew that Philadelphia’s drinking water, pumped straight from its polluted rivers, was to blame. Among large US cities, Philadelphia’s typhoid mortality rate was one of the highest. By 1899, typhoid related fatalities stood at 75 per 100,000 people—approximately 750 deaths in one year (McCarthy 1987). At the other side of the state, Pittsburgh had the nation’s worst rate, with 11 deaths per 100,000 people. It too relied on local rivers for source water. Cities like New York City, which used aqueduct systems and upland sources, fared much better at 15 (McCarthy 1987).

As public pressure mounted in the 1890s, Philadelphia’s leaders again considered their options. Council understood that to solve Philadelphia’s drinking water pollution problem the city would have to make a substantial investment in one of three approaches, which the MIT chemist T.W. Drown reiterated to an audience of Philadelphians in 1895: The city could address the problem at the source by curtailing the flow of sewage to the river; it could at last abandon the rivers and develop an aqueduct system that tapped more pristine water sources; or it could adopt an end-of pipe solution and purify its own supply with sand filtration, a new technology that had been widely demonstrated as effective (McCarthy 1987). After a nearly a decade of delay, warped by political corruption and personal vendettas, a newly elected mayor helped shepherd a filtration bill to
passage in 1900. The city doubled down on its commitment to its historic water source and built five slow-sand filtration plants at the cost of nearly $30 million.

Over the next decades, a series of increasingly stringent “Clean Stream Laws” passed by the state legislature also forced Philadelphia to develop a comprehensive plan to treat its waste water. In 1914 the Bureau of Surveys, at the time administered under the Department of Public Works, released *Report on the Collection and Treatment of the Sewage of the City of Philadelphia*. Based on their studies at a local experimental treatment station and extensive review of systems in Europe and the eastern United States, the Bureau engineers (along with their consulting engineer Rudolph Herring) recommended a system composed of hundreds of miles of interceptor sewers to carry Philadelphia’s sewage to three treatment plants, two of which would be situated along the Delaware at the northern and southern ends of the city and one in West Philadelphia at the mouth of the Schuylkill (City of Philadelphia 1914). The Bureau of Surveys prioritized construction of the Northeast Sewage Treatment Plant to protect the massive Torresdale drinking water plant, and completed it in 1923 (Walker 1987). Work on the Southwest and Southeast plants— which did not benefit drinking water quality— stalled as the national economic depression and WWII thwarted improvements to local infrastructure.

Finally, in 1945, a new sewer fee combined with nominal assistance from the Federal Water Pollution Control Act of 1948 facilitated the completion of the Southwest and Southeast plants in 1954 and 1955 respectively (Brown, Levine, and Schutz 2015). The following decade also saw the completion of the interceptor network, with included nearly 200 combined sewer regulators that emptied by design — and also frequently by malfunction— into the Delaware and Schuylkill rivers, as well as three of Philadelphia’s urban streams: the Pennypack, the Cobbs, and the Tacony creeks.

These projects, while substantial, did not fundamentally alter the drinking and wastewater systems established between 1800 and 1900.
remained tightly coupled. And these links were reinforced by the modern Philadelphia water utility, created in 1951 under Philadelphia’s Home Rule Charter. Passed by ballot measure in a special election, the 1951 Home Rule Charter sought to undo over five decades of Republican machine rule, which controlled Philadelphia’s local government structure “at every level...[d]etermining who was elected, whom the city employed, and to whom lucrative city contracts were awarded” (Committee of Seventy 1980, 11). Previous reform efforts—including the Bullitt Charter of 1885 and the Charter of 1919—had been easily corrupted by Republican forces at both the state and local level (Committee of Seventy 1980). The state legislature thwarted a third attempt in 1937, but at the end of WWII a new reform movement coalesced to bring about a substantial remaking of Philadelphia’s government.

Beginning in 1947, the energetic trial lawyer and war hero Richardson Dilworth led several unrelenting crusades against the incumbent machine, first in a failed mayoral campaign and then in a successful bid for the position of city treasurer. Under the slogan “sweep the rascals out,” Dilworth created a bipartisan committee to investigate municipal corruption (Clark and Clark 1982, 654). The exposure of over $40 million in unaccounted for city spending led to four years of grand jury investigation. Over the course of the investigation, several municipal employees including a water department inspector, killed themselves (Clark and Clark 1982). Throughout the process, civic groups and the press ensured that the municipal scandals and the topic of reform never left the public’s attention. As Clark and Clark (1982, 652) write, “one revelation after another rocked the city and amazed observers in the nation whose interest was focused on Philadelphia.”

In 1948 reform efforts won an important victory when five democratic congressmen from Philadelphia were elected to the state legislature. Then several members of Philadelphia’s business leadership along with respected Republican

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53 This included stormwater, which was also shunted to local waterways as the city turned to building separated systems in the early 1900s.
local leaders joined the reform campaign, named the “Greater Philadelphia Movement” (Clark and Clark 1982). Backed at the state level by the ALF and the CIO, the coalition oversaw the passage of legislation in the General Assembly to create the Philadelphia Home Rule City Charter Commission, who brought their proposal before voters on April 17th. Although Republicans withheld support, voters passed the proposed charter by nearly 120,000 votes (Clark and Clark 1982).

Among its significant reforms, the charter created the Philadelphia Water Department (PWD), a remarkably modern reorganization that reflected the charter’s broader goal of rationalizing city governance. The characteristics of the new department demonstrated the Charter Commission’s attention to sources of past failure in Philadelphia’s supply of water and sewer services, as well as its faith in remedying these problems by relocating decision-making authority and redesigning the relevant bureaucracies. In recognition of the interconnected nature of water and sewer systems in the city of Philadelphia, these services were merged under one organization for the first time in Philadelphia’s 300-year history.

In light of the city’s history of crisis driven investment in water and sewer management, the charter’s authors paid special attention to reducing the influence of political interests and actors on the organization. The debate over water filtration at the turn of the century, as thousands died of typhoid fever, was particularly memorable as an “urgent project that went too long unfunded” (Committee of Seventy 1980, 16). Instead, the PWD was organized to function with a large degree of autonomy, both in terms of its technical decision-making and financial planning. The charter sought to ensure that organizational decision making was guided by the technical know-how of its resident experts—primarily civil and sanitary engineers—rather than political expediency. Therefore, PWD’s employees, including its leadership, were removed from council control. As with the other departments created under the charter, the PWD’s only appointed position was that of its commissioner, chosen by the city’s managing director, but
subject to mayoral approval. The commissioner, in turn, selected deputy commissioners to lead each division—subject to city manager approval. All other positions were to be governed by civil service regulations based in “merit principles and scientific methods [for the] “appointment, promotion, demotion, transfer, lay-off, removal and discipline of its employees, and other incidents of City employment” (City of Philadelphia Home Rule Charter 1951, § 7-300).

Most significantly, the framers attempted to insulate the department’s revenue stream and expenditures from the meddling of city council. Under the 1919 Charter, the service fees for drinking water and sewer services were collected in the city’s general fund and managed as part of the city’s overall finances. Rate setting was controlled by council. The Home Rule Charter vested PWD with authority to “fix and regulate” its own rates and charges, including “charges for supplying water, charges to be made in connection with water meters, and for supplying sewage disposal services” (§ 5-801). Although the new charter granted council the authority to set standards for rate-setting “from time to time,” it required that the standards not prohibit the department from fully recouping its expenses, inclusive of interest or charges on any debt (§ 5-801). Beginning in 1953, pursuant to the Home Rule Charter, the city created a separate enterprise fund (a type of proprietary fund) to manage the PWD’s financial operations. As a user fee dependent department, this so-called “Water Fund” established a separate accounting and reporting mechanism for the PWD and facilitated its creation as a self-sustaining and largely autonomous integrated utility (Holst 2007).

In 1968 PWD had also begun charging a separate stormwater fee to cover costs associated with the transfer of responsibility for the city’s 79,000 stormwater inlets from the department of streets (NRDC and Chris Crockett). Thus, by the passage of the Clean Water Act, Philadelphia’s urban water systems were both physically and administratively integrated and local. The Delaware and Schuylkill, within city limits, continued to supply Philadelphia with its drinking water and the city had not seriously considered abandoning this traditional water source since
1945. Three of the city's original drinking water plants pumped some 250 million gallons daily (mgd) to Philadelphia and several contracting suburbs. The Torresdale Plant, constructed in 1907 on the Delaware, provided nearly 60% of this supply, with the Belmont and Queens Lane Stations on the Schuylkill, dating back to 1870 and 1895 respectively, making up the rest. Approximately 3,000 miles of sewer line transported wastes from Philadelphia as well as outlying townships, to one of the its three treatment plants: The Northeast, Southeast, and Southwest plants. Once treated, the wastewater was discharged to the rivers. As chartered, PWD civil and environmental engineers oversaw operation and maintenance of the drinking water and sewer systems, as well as the separate stormwater system, which drained nearly 40% of the city from 434 stormwater outfalls. PWD continued to operate exclusively from rate payer fees.

As I argue in the following sections, this extensive level of integration poised PWD to be particularly receptive to a holistic, land based water pollution management approach. As an integrated local utility, PWD had much to gain from a technology that could address both CSO and stormwater policies; potentially improve source water quality; provide local neighborhood, environmental, and economic benefits for the city; and save ratepayers money. However, I also argue that structure alone is not sufficient to explain PWD's transformation from a very traditional utility to a pioneer in GSI. Skillful leadership and good timing were also critical. In particular, the remarkable transformation that took place within PWD from 1999-2009 was guided by an administrator, Howard Neukrug, who during a time of organizational uncertainty, perceived the advantages of an innovative approach, created a persuasive narrative and opportunities for development, and actively built coalitions of support and valuable political alliances. In doing this, however, Neukrug and his team also benefited from fortuitous timing. PWD's ability to elude enforcement actions for its CSO discharges until 2007, allowed Neukrug to take advantage of advancements in GSI technology and increased
support among environmental organizations and high-level EPA officials for its use in municipal compliance programs.

WET WEATHER REGULATIONS ARE A SHOCK AND AN OPPORTUNITY

As EPA turned to addressing wet weather pollution in the early 1990s, PWD entered a period of uncertainty, where the agency was organizationally and financially unprepared to meet the new regulatory demands. As a Phase I community, Philadelphia was required to comprehensively assess its separate stormwater system and devise a management and monitoring plan to reduce stormwater pollution by the “maximum extent practicable.” The regulations also required Philadelphia to undertake the challenging task of identifying and eliminating all illicit connections—where sewage lines illegally connected to a storm sewer and sent raw sewage directly into city streams. Reflecting the low priority of stormwater pollution control for federal and state regulators until this time, PWD’s historic management of its stormwater system was reactive: a user group or citizen would call to report a problem and the PWD would respond to the complaint. “We were always thought of as a water and wastewater utility,” said a PWD engineer, who joined PWD’s CSO program in 1998. “No one really thought about stormwater.” The new rules, however, demanded proactivity and preplanning, a task that fell largely to a single stormwater program manager buried in the operations department.

The CSO Policy, however, was the agency’s most serious wet weather concern. Given the scale of the problem and the scarcity of the resources, PWD leadership had cause for alarm. PWD had seen developments in cities like Chicago, where huge billion-dollar underground storage tunnels were built to collect that

54 Author interview with Marc Cammarata, Director of the Office of Watersheds, Philadelphia Water Department, June 14, 2014.
city's overflows. Philadelphia's own system had 176 CSO regulators discharging 17 million gallons annually to five separate waterways. With a poverty rate over 20% and median household income of $27,000, Philadelphia was also one of the poorest large cities in the country. Many Philadelphians were already considered "highly burdened," under professional classifications, by water and sewage fees (PWD 1997b). Rate hikes to support a multi-billion-dollar infrastructure project— even spread over 15-20 years—threatened to produce major upset. The conventional approaches to CSO control that EPA championed appeared out of reach.

Furthermore, PWD's had done very little to stem its CSO events. Throughout the 1970s and 1980s, capital dollars were instead directed to treatment plant upgrades to comply with the first round of NPDES permits in 1974. The Southwest facility, near the airport, and Southeast facility, below the Walt Whitman Bridge, had only primary treatment. The Northeast facility near the Torresdale drinking water intake was upgraded to secondary treatment in 1951, but was operating well below the national standard (Levine 2010). Although Philadelphia had devised an upgrade plan in 1970 for all three plants— an effort to comply with a 1962 order from the State Sanitary Board and the regulations of the

55 PWD's first formal assessment its CSO discharges came in the early 1970s, when the State Sanitary Board ordered PWD to produce a study on the "quantity, quality and possible effects" of CSOs on receiving waters in 1968. After challenging the order and losing, PWD retained the engineering firm Watermation, which completed the study in late 1973 at the cost of $50,000. The report offered the first coarse characterization of Philadelphia's combined overflows. It identified 176 overflow regulators that released roughly 15 billion gallons of wastewater, or 10 million lbs of BOD, during rainstorms each year. One hundred of these CSOs discharged to the tidal portion of the Schuylkill and Delaware river; the remaining 76 outlets emptied into three of Philadelphia's five smaller tributary streams: Darby/Cobbs Creeks, Tacony/Frankford Creeks and Pennypack Creek. As the state had suspected, the system was also releasing large amounts of pollution when it was not raining. Regulator gates were on average 30 years old, with some as old 60 years. They frequently malfunctioned, releasing sewage even when the interceptor system and treatment plants had additional capacity. Complicating matters, pipe blockages, another cause of unnecessary overflows, were only located through manual inspection. With approximately 2,000 miles of combined sewer to inspect, blockages could go unnoticed for days. Finally, malfunctioning tide gates, which were incorporated in 88 of the CSO regulator chambers, permitted up to 3 million gallons of sea-water to enter the system daily. PWD estimated that by 1990 wet and dry overflows would account for 30% of BOD loads to local waterways, preventing the city from meeting local water quality standards even after the implementation of secondary treatment at its sewage plants (PWD 1973).
interstate Delaware River Basin Commission (DRBC)—over the next five years construction deadlines for the costly project, estimated at over half a billion dollars, slipped dramatically. By the end of 1977, work on the Northeast plant had only just commenced and the Southeast plant remained untouched. Each day, the city discharged 450 million gallons of partially treated sewage into its rivers, making it, by far, the largest polluter of the Delaware river and its estuary (Hornblower 1979).

Relative to the flows from its treatment plants, the impacts of CSOs on the rivers were negligible, which might explain why when EPA sued the city in 1978, the resulting consent decree did not address them. With the State of Maryland, DRBC, and five regional environmental groups, including the Sierra Club, Friends of the Earth, and the Delaware Valley Diving Club as intervenors, the suit (lodged in the District Court for Eastern Pennsylvania as City of Philadelphia v. EPA 1978) cited Philadelphia’s failure to meet the 1977 deadline as well as its own permit construction deadlines and NPEDS effluent limits, and its disregard for reporting requirements. The intervenor’s petition complained of over a decade of resistance and delay by the city to address its sewage pollution, which had been linked to 50% of the chemical load in the city’s drinking water. Under the decree, Philadelphia agreed to upgrade its treatment plants to provide greater than secondary treatment (90% pollutant removal) by 1983 and to pay $2.16 million into an environmental trust fund. The Pennsylvania State Department of Environmental Resources (now the Department of Environmental Protection, DEP) gave Philadelphia’s facilities funding priority under the construction grant program and 75% of the project’s unprecedented $900,000 price-tag was ultimately paid by the federal government. All three plants were on-line by 1986, although it would take nearly another decade for the plant operators to master their operation and optimize their performance (Walker 1987)

\[56\] 1978 petition and consent decree on file with author.
Thus, by the early 1990s, PWD had only just completed a $2 million rehabilitation of its malfunctioning CSO regulators and tidal gates and $6.5 million upgrade to its flow monitoring network—part of a CSO control plan originally conceived in 1976. The system continued to experience dry weather discharges, in addition to wet weather overflows triggered by as little as one tenth an inch of rainfall. Furthermore, of the 300 employees in the Operations Department's Waste and Storm Water Collector Group, PWD's CSO Program was staffed by only two full time engineers in a collector systems support group. To assist these engineers in developing a CSO compliance program, PWD contracted with the engineering firm Camp Dresser & Mckee (CDM), who formed a program office inside PWD's building in 1994.

The tension between PWD's capabilities and the new EPA policy prompted the engineers working on the CSO programs to look for more cost effective, alternative approaches for long term control planning. The CSO Policy language appeared to provide an opening by encouraging permit writers to "evaluate water and pollution needs on a watershed basis and coordinate other CSO control efforts with other point and non-point source control activities." Although far from the focus of the document, the Office of Water's 1995 guidance on writing long-term CSO control plans briefly expanded upon EPA's position, noting that a watershed based approach could lead to a "greater flexibility...[and] a fairer allocation of resources and responsibilities;" in particular, because "CSOs could well be less significant contributors to [water quality] nonattainment than stormwater or upstream sources...a large expenditure on CSO control could result in negligible improvement in water quality" (USEPA 1995, 1-18).

PWD had never engaged in watershed planning but the concept was appealing for several reasons. First, whatever it actually meant in practice, it was clearly sanctioned by EPA. Second, it made sense for an integrated utility with broad authority to look for synergies between its various, overlapping programs. Furthermore, the watershed based approach was premised on the recognition that
the causes of aquatic degradation were multifaceted and cumulative. Landscape modification, dirty runoff, overharvesting, changes in flow, and invasive species all had compounding effects on water quality: death by a million cuts. The watershed approach thus offered an opportunity for PWD to alter the problem definition and implicate other actors; it shifted the focus from pollutant loads exiting PWD’s system, to the whole suite of activities within Philadelphia’s watersheds that were compromising its creeks and rivers, and about which little was known. It also opened up the possible solution-set to options, as yet undiscovered, that might be more efficient and effective than building huge underground tunnels, and whose costs could be borne by multiple parties.

In 1997 PWD delivered its first long term CSO control plan, consisting of three distinct “phases” of work (PWD 1997a). In addition to continuing implementation of the nine minimum controls (Phase I), PWD outlined a package of traditional “gray” capital improvement projects. Specifically, PWD proposed to spend over $50 million over approximately 5 years on 17 enhancements to its combined system and treatment plants that would increase in-line storage and minimize inflow, thereby reducing annual CSO overflows by a modeled 2 billion gallons—out of newly estimated 17 billion gallons. PWD, however, stopped well short of a plan to meet control standards under the demonstrative or presumptive approach. Instead, the LTCP outlined Phase III: a $4 million, 3-step watershed-based planning initiative, an idea that PWD and CDM engineers had fleshed-out with the help of an outside integrated water resource planning specialist (HN interview). First, PWD would undertake “reconnaissance” surveys and compile existing and novel data on watershed land use characteristics and resources, as well as information on the biological, chemical, and physical health of all seven of the city’s watersheds—including the portions outside city boundaries. Second, PWD would use this data to build out its watershed models and support a stakeholder driven planning process that 1) defined the water quality problem(s) 2) established water quality goals, and 3) evaluated an array of management
solutions, including practices, policies, and water infrastructure. The product of these watershed planning partnerships would be an integrated watershed management plan (IWMP), that allocated roles and responsibilities among major regional stakeholders. Finally, PWD would work with its watershed partners to implement the plan and monitor outcomes. Because each IWMP was estimated to cost $1-2 million, PWD proposed to initially focus its planning resources on two CSO impacted tributaries— the Cobbs and the Tacony, shown in Figure 6.1.

Some interviewees questioned the seriousness the watershed portion of PWD’s 1997 LTCP, which was devised by engineers who are no longer at the agency. To some degree it may have been stalling tactic to avoid committing to building The Tunnel. It also took advantage of the ambiguity surrounding the inchoate federal CSO program. One regulator told me that during this period,
state and federal permit staff were “operating in a vacuum.” This was reflected in internal communications between state DEP officials, who were the front lines for reviewing and approving the LTCP. In emails, they demonstrated a mixture of enthusiasm and bemusement towards Philadelphia’s plan. Although the plan was philosophically responsive to many high-level policy priorities, it was unclear how the watershed portion would lead to compliance. In one memo, a permit review official at the Southeast Regional DEP office asked: “from a national perspective, are other large CSO systems using this same type of watershed planning approach? It seems to fit in with the current thinking, but...” (Crickman 1997). Another staff member replied: “Preliminarily, this reads like an EPA speech promoting watershed approaches. Good buzz words!” (Rehm 1997).

DEP’s ensuing consultations with EPA officials in Region III and HQ suggested that Philadelphia’s watershed-based approach to the National CSO policy was highly unusual. Nevertheless, EPA perceived PWD’s $50 million commitment to traditional capital improvement projects as a solid first step towards compliance, and one that could be strengthened through future permits as knowledge about the system’s impacts developed. In 1997, with EPA Region III’s support, DEP approved Philadelphia’s LTCP and concluded that Philadelphia’s plan sufficiently demonstrated the city’s commitment to addressing its CSO impacts and that its exploratory watershed approach was also “reasonable,” particularly in light of an ongoing multi-year water quality modeling effort by the DRBC, the results of which could alter local water use-designations for the tidal portions of the Delaware and Schuylkill Rivers (Newbold 1997).

However earnest the drafters of the 1997 LTCP were, there was at least one person in the agency who was taking the idea of watershed planning seriously: Howard Neukrug. Over the next two years Neukrug, then a middle manager in the planning division, would leverage the CSO-related anxiety within the organization

57 Author interview with EPA Region III enforcement official, Philadelphia, May 15, 2014.
to create an unprecedented functional unit to explore integrated urban water management and GSI within PWD: The Office of Watersheds.

AN ENTREPRENEUR SEIZES AN OPENING: CREATING A VISION AND STRUCTURE FOR CHANGE

In the mid-1990s, 15 years before he would be appointed Commissioner of PWD, Howard Neukrug was a middle manager, leading the Water Department’s Planning and Technical Services Group within the agency’s Planning and Engineering Division. Trained at the University of Pennsylvania in civil and environmental engineering, Neukrug joined PWD after graduation in 1978. He quickly established himself as a drinking water quality expert, working on a range of technical and national policy issues. In 1996, Congress amended the Safe Water Drinking Water Act, an effort to focus more national attention and resources on safeguarding the rivers, lakes, and groundwater that municipalities relied on for drinking water. The amendments required states to develop a source water protection program to inventory known and potential sources of contamination across the landscape and implement measures to reduce their risks. Subsequently, Neukrug was tapped to represent PWD and the American Municipal Sewerage Agency (now the National Association of Clean Water Agencies, NACWA) on a source water protection workgroup providing input to EPA as they developed policy guidance.

During this time Neukrug was also becoming more involved in the regulatory compliance end of the national wet weather policies, and was seated on the Federal Advisory Committee on Urban Wet Weather Flow. In 1997, as he looked across the agency’s nascent source water, stormwater, and CSO programs, he saw an opening to take advantage of PWD’s structure as an integrated utility with tightly coupled waste and water systems, and use the watershed framework outlined in the CSO LTCP to coordinate the agency’s activities more broadly. The
Department's pollution and drinking water programs were managed in silos, but Neukrug saw their interconnections. From a source water perspective, for example, even with advanced treatment, the quality of Philadelphia’s drinking water was still inextricably linked to CSO and stormwater discharges. This lesson had been hammered home during a drinking water crisis in 1995, when Philadelphia detected cryptosporidium in its water supply; resistant to water treatment technologies, this pathogen was linked to raw sewage and stormwater runoff polluted by animal wastes.

On a personal level, Neukrug was interested in helping PWD innovate and allocate its resources more efficiently. He was particularly disturbed that the agency might be forced to spend huge sums on a series of underground storage reservoirs, which remained a very real possibility. As a self-described “drinking water guy,” who entered the field with an interest in water reuse and recycling, Neukrug was not professionally or philosophically inclined to think only in terms of pipes and tunnels.58 A strategic forward thinker, he wondered, “How ridiculous would it be in one-hundred years that we are taking rainwater, mixing it with sewage, and putting it in a big pipe?”59 Furthermore, after twenty years at the Water Department, Neukrug was eager to undertake an initiative that could redefine his role in the agency; by becoming a leader in watershed management he might open new professional opportunities in a bureaucracy where career advancement was notoriously difficult.

During this period, Neukrug says, his thinking was greatly influenced by Bradford and Cohen’s concept of “influence without authority”—how one can produce change in the absence of critical decision-making power through persuasion, consultation, and coalition building.60 In line with this theory, one of

58 Author interview with Howard Neukrug, Water Commissioner, Philadelphia Water Department, June 20, 2014.
59 Author interview with Howard Neukrug, Water Commissioner, Philadelphia Water Department, June 20, 2014.
60 Ibid.
his first steps was to set up exploratory meetings with local environmental groups like Clean Water Action and the Pennsylvania Environmental Council to better understand the fundamentals of watershed planning and local opportunities for partnerships. In doing so, he noted that there were a number of watershed based initiatives taking root in the Philadelphia area that PWD could partner with to achieve its objectives. These initiatives included the Schuylkill River Watershed Project and the Wissahickon Watershed Partnership, both of which engaged a suite of local environmental organizations and community groups, as well DEP and EPA Region III.

Troublingly, Neukrug found that few members of the local environmental community perceived the Utility as a key stakeholder, or even as a regional environmental steward. This finding underscored a one-day workshop Neukrug and one his lead engineers organized in the summer of 1997 with the support of the Water Commissioner, Kumar Kishinchand. The workshop, entitled “Total Water Management,” was an opportunity for over 40 of PWD’s high level managers and program leaders to familiarize themselves with the watershed approach; explore interconnections between their goals and projects; and identify efficiencies (PWD 1997a). However, Neukrug also used the meeting to demonstrate how watershed management resonated within the agency’s past, present, and future, and develop a collective agency vision around the approach. To do this he recast PWD as more than a water utility: it was an environmental leader with a critical role to play in regional water management partnerships. Whether or not PWD managers and engineers recognized it, he argued, the agency was already a key contributor to watershed protection: each year the utility spent upwards of $250 million on more than 40 distinct activities and programs that directly benefited local waterways. This included management of the sewer and treatment plants that prevented half a billion gallons of raw sewage from entering

61 Before serving as Water Commissioner from 1992-2004, Kishinchand had directed PWD’s Bureau of Laboratory Services.
waterways each day. Neukrug also outlined how the watershed approach was responsive to the practical demands facing the agency. Most significantly, it was popular with regulators as well as local environmental and civic groups, and (hypothetically) it would result in more cost-effective ways for the agency to achieve regulatory compliance and its multi-objective mandates.

Lastly, he reminded participants that the foundations of water management in Philadelphia were integrative. The move away from the holistic approach that created Fairmount Park had coincided with 100 years of worsening water quality. The workshop summary report, *Between Two Rivers*, reiterated this point and concluded with the final statement:

As PWD approaches its 200-year anniversary, and marches into the 21st century, it is important to look back our storied history and the many lessons learned...The PWD began its long journey 200 years ago with a watershed based perspective and now it would appear is an ideal time to return to those traditional roots, and embrace the watershed philosophy once again. (PWD 1997a, 6)

As Neukrug had hoped, the meeting generated considerable enthusiasm, and he guided participants through the development of a number of “next steps.” Among these were to 1) alter PWD’s mission statement to “invoke the spirit of watershed planning” 2) adopt watershed management as a strategic objective and incorporate it into the agency’s strategic planning process 3) explore possible organizational changes to coordinate watershed activities. In 1998 Commissioner Kishinchand agreed to these recommendations. The agency rewrote its mission to include the need “to sustain and enhance the region’s watershed and quality of life by managing wastewater and stormwater effectively” and its new strategic plan recommended the creation of a structure within PWD to coordinate watershed management and planning.

Soon after, Neukrug presented Kishinchand with a reorganization plan to establish an “Office of Watersheds” (OOW or the “Office”) within the Planning
and Engineering Division. The Office would exploit PWD's integrated structure and consolidate the Department's CSO program, stormwater program, and newly created source water protection program. Its major goals would be to assess each of the city's watersheds, foster city and regional partnerships, and implement a regulatory affairs initiative to "proactively respond" to EPA, DEP, and DRBC proposals and programs. The Office would not require immediate new hires but rather relocate the CSO and stormwater program engineers from the Operations. They would be joined by the manager of the source water protection program, and the developer of BLS' pathogen and source water research program, as well as the handful of engineers in CDM's program office. All these staff were already on PWD's informal "watershed management committee," created soon after the Total Water Management Workshop, and were supportive of the reappointments. Neukrug would lead the office as its director. On December 10, 1998, Commissioner Kishinchand announced the creation of the Office of Watersheds, which was hailed in PWD's 1999 Annual Report as "one of our most important policy initiatives" (PWD 1999, 7). The Office was also praised by DEP officials, who congratulated Kishinchand on its creation. Kishinchand had always been supportive of Neukrug's watershed-based vision, but he was especially motivated by a sense of urgency. Indeed, much of the traction Neukrug's plan achieved within the agency was attributable to how it offered solutions to a number of organizational challenges. In particular, it was generally understood that the wet weather programs would only become more resource intensive and were not getting the strategic support that they needed in the Operations Division. The stormwater program manager, for example, was working nearly entirely on her own and struggling to implement PWD's Illicit

62 The operations manager, who was relieved of responsibility for the onerous CSO and stormwater programs, was equally satisfied with the plan.
63 Letter from Joseph Feola (Director, Southeast Regional Office, DEP) to Kumar Kishinchand (Commissioner, Philadelphia Water Department), September 3, 2009. (On file with author.)
Connections Program, which required PWD to identify hundreds of improperly connected and leaking sewage pipes that were sending raw wastes into the stormwater sewers; and then compel responsible property owners to fix them.\(^{64}\)

The slow pace of progress, a growing number of public complaints, and ultimately a citizen suit in 1998, forced DEP to take administrative action against PWD for continued noncompliance with its MS4 permit. On June 30, 1998, PWD and DEP entered into a consent agreement that would see the City shoulder a portion of the cost of repairs.

However, the commissioner’s primary concern was the PWD’s CSO Program. As it was being run, it encompassed a multimillion dollar contract with CDM but was overseen solely by one, albeit very skilled, CSO engineer; while the LTCP’s capital improvements were moving ahead on schedule, little progress was being made on the proposed watershed planning. Given the CSO Policy’s potential to force PWD to undertake a major infrastructure project of unprecedented expense, Commissioner Kishinchand was eager to give the CSO Program more structure and guidance. Embedding the program in a new integrative office, under the leadership of a manager with nearly two decades of national policy experience, appeared to be a very promising strategy. As one PWD manager noted:

No commissioner wants to [be] the one on the hook for a multibillion investment where [he] has to raise rates and be the one whose legacy is about putting a substantial burden on [ratepayers.] There was kind of a ‘whatever you can do to get us out of this sticky wicket that we may be in, I support it.’ So [Kishinchand] had the trust, he had the faith, and a bit of the vision. And he had the smarts to say: Howard, have a crack at it.\(^{65}\)

\(^{64}\) It had been agency policy that once a defective pipe was identified, the property owner was responsible for repairs. Property owners resisted this charge, and argued that PWD should cover the costs which amounted to an estimated $210 million.

\(^{65}\) Author interview with Marc Cammarata, Director of the Office of Watersheds, Philadelphia Water Department, June 14, 2014.
To be sure, there were also many skeptics of Neukrug's vision within PWD. The watershed planning approach was slowly making its way into professional engineering circles— in 1995, for example, ASCE organized a conference called "Integrated Water Resource Planning for the 21st Century"— but it was still alien to the training, perspectives, and duties of most of the personnel within PWD. Nevertheless, even those who doubted that OOW's work would amount to anything new thought it was a shrewd response to regulatory demands. "There were people in the department who thought I was greenwashing: Every year I succeeded talking about watersheds is another year we don't spend millions on a tunnel." Neukrug has said, adding, "But I wanted to do this...and I knew I was going to succeed." 66

BUILDING CAPACITY AROUND A NEW APPROACH

Over the next decade, and under Neukrug's leadership, OOW would develop the data, expertise, relationships, and public support that would ultimately give it the ability to credibly propose the "greenest" CSO control plan in the nation in 2009—committing nearly $1 billion to green stormwater infrastructure. This outcome was not obvious at the outset, however. When OOW began operations, it was an unassuming office of six PWD staff, approximately five CDM consultants, and an operating budget of a few hundred thousand dollars (MC 2014). GSI was not a term in use, and OOW staff knew little about structural stormwater controls. Instead, OOW's broad objective was to use the watershed planning framework to locate and take advantage of "connection points" between its programs. 67

PWD's CSO program, which had been made enforceable through its inclusion in Philadelphia's NPDES permits, was the primary driver of OOW's early

66 Author interview with Howard Neukrug, Water Commissioner, Philadelphia Water Department, June 20, 2014.
67 Ibid.
watershed planning efforts and commanded the bulk of the Office's budget. However, Neukrug quickly began leveraging these internal commitments to acquire additional funding through a variety of relevant state and federal grant programs. “We started scouting for money, because we didn’t have the influence to get much more [from PWD]...we went grant hunting and acted like a non-profit,” Neukrug recalled. Outside funding from PADEP, the PA Department of Conservation and Natural Resources (DCNR), and EPA, among others, allowed OOW to expand its activities, both programmatically and geographically, develop its technical capabilities, hire consultants, and justify increases to its internal funding and staffing.

By the early 2000s OOW had more than doubled in size and was working extensively with government, NGO, and civic partners across all seven of its regional watersheds on three interlinked initiatives: building a detailed, data-driven understanding of the water quality issues confronting its watersheds; engaging stakeholders in watershed-based planning; and exploring a range of urban water quality management practices. In all these activities, OOW benefitted from the growing interest, research, and dissemination of integrated urban water management practices. But it was though the latter efforts in particular that OOW became familiar with GSI and came to see these practices as the most promising technology to meet CSO policy standards.

**Data Collection and Partnerships**

Immediately after its formation in 1999, the Office initiated its “reconnaissance” studies of Philadelphia’s watersheds. OOW engineers began collecting a broad range of data, including existing information on land uses, soils, topography, stream flow, and meteorological trends. Working with scientists in BLS and in cooperation with the US Geological Survey, the Office also initiated a slew of new

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68 Ibid.
water quality, biological, and hydrologic monitoring surveys; infrastructure surveys; physical assessments of stream channels and corridors; and a wetland assessment program supported in part by a $175,000 EPA grant. "[Within PWD, we were looked at as the crazy, hippy, 'go play in the stream and turn over rocks' people," an OOW engineer recalled. Nevertheless, by the early 2000s OOW had completed comprehensive baseline assessments for the Cobbs, Frankford, Pennypack, Poquesing, and Wissahickon watersheds. These data were supplemented by state source water assessments for the Lower Delaware River and Schuylkill River, which OOW finalized in 2002 under DEP contract.

These regional data sets, which OOW continued to update at regular intervals, served several functions. They supported the Office's development of SWMM-based hydrologic and water quality models, helped create an extensive GIS database, provided a snapshot of local waterway conditions, and gave the Office information about activities and stressors within and outside city boundaries. Critically, they also provided a scientific foundation for the plethora of watershed planning initiatives that OOW spearheaded or supported between 1999 and 2007.

Of these, the most significant planning initiative was the development of the IWMPs, which aimed to incorporate existing watershed plans and also respond to federal regulatory requirements, including the stormwater regulations, TMDL designations, and, most urgently, the National CSO Policy. Because of programmatic overlaps between these policies, one integrated plan would ostensibly facilitate the coordination of resources and actors across the watershed, resulting in "significant savings" (PWD 2005b). As proposed in its LTCP, the Office formed the first of its integrated planning partnerships in two of its CSO impacted watersheds; in 1999, Office staff formed the Cobbs Watershed Partnership and then the Frankford Watershed Partnership the following year, in October 2000. OOW contracted with the Pennsylvania Environmental Council, a 30-year old

69 Author interview with Marc Cammarata, Director of the Office of Watersheds, Philadelphia Water Department, June 14, 2014.
NGO with watershed planning expertise, to facilitate the multi-year, multi-million dollar efforts, which brought together municipal, county, and state representatives, local and regional NGOs, and civic associations.  

The first step for each group was to characterize the watershed conditions and come to agreement on causes of any degradation, impairment, or flood risk. The Office’s comprehensive assessments confirmed what most already suspected: Philadelphia’s streams were in very poor condition. They were diverted, dammed, and sewerized; incised and eroded; trash strewn in dry weather and bacteria filled in wet; the fish and bugs were highly tolerant or invasive species and not representative of a healthy native aquatic community. The assessments also showed that CSO discharges, followed closely by stormwater discharges, were the leading cause of water quality impairment, which was widespread. As the reports noted, both were exacerbated by development and concomitant increases in impervious surface and runoff (PWD 2004). Indeed, it was apparent that stormwater runoff was the common link between many of the watersheds’ ills, and OOW staff began to agree that a different regional approach to stormwater management could also significantly reduce the need for costly centralized CSO control infrastructure and also ameliorate source water degradation, aquatic habitat and biodiversity loss, and flooding.

Conversations with stakeholders in the watershed planning meetings, however, illuminated another set of issues and concerns that many in OOW had not considered: aesthetics, safety, and access. Although the two communities had very different racial compositions (Tacony was majority white, while Cobbs was predominantly African American), both were low income neighborhoods in Philadelphia with high crime rates and few local resources. Community members wanted to reduce pollution, but they prioritized improving the amenity value of their streams. They wanted trash removed, banks restored, and greenways and

79 OOW planned to develop an IWMP for all of its urban streams, but as of 2018, has not yet done so.
trail systems created. For example, Cobbs Creek stakeholders consistently ranked “quality of life” and restoring “streamflow and living resources” as their top planning priorities (PWD 2004). This finding broadened OOW’s understanding of the problems they were trying to solve through their watershed planning efforts. In addition to identifying more efficient solutions to Philadelphia’s water quality issues, Neukrug and his staff became increasingly excited about how their work would maximize benefits to local neighborhoods. OOW’s watershed coordinator between 2001 and 2010, said, "For a city in such desperate need, with community investment lacking, using water dollars to meet regulations and also fulfill community beautification and other [community] goals was very compelling.” The finding also encouraged the Office’s third major initiative: gaining familiarity with emerging land-based water quality management practices, which unlike traditional infrastructure could be designed to provide a variety of social benefits.

**LID/GSI Demonstration Projects**

Throughout this period of watershed data collection, assessment, and planning, the Office was amassing and screening information on “virtually all” water quality management options applicable to the urban environment that could meet planning goals and reduce the need to expand traditional infrastructure (Darby IWMP). In this activity, OOW benefited substantially from the acceleration in LID/GSI studies and models, which staff culled from academic studies, environmental advocacy reports, regulatory guidance, discussions with other agencies and municipalities, and professional experience. OOW explored a variety of approaches to implementing source control through regulations and financial incentives, education and outreach, and direct investment on schools, parks, streets and other public spaces. The Office also took field trips, including one to

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71 Author interview with Glen Abrams, Director of the Sustainable Communities, Pennsylvania Horticultural Society, May 5, 2014.
Portland in 2002. “Howard would get us the newest and brightest ideas, throw them at us, and force us to think bigger,” said a PWD engineer who joined OOW at its inception.\(^{72}\) When faced with skepticism— he recalled one meeting in 1999 with the agency’s engineering department where he was “laughed out the room” for advocating green roofs— Neukrug was steadfast.\(^{73}\) Neukrug would respond: “Don’t worry about that; they are thinking about yesterday and you are thinking about tomorrow.”\(^{74}\)

To get experience in these new approaches— particularly the more complex structural source controls— Neukrug and his staff began looking for local partnerships and grant opportunities. Given the national salience of non-point source and urban stormwater pollution issues, neither were in short supply. By the early 2000s, the Office was planning or implementing a range of demonstrations on public land around the city. Some of the first projects were stream restoration projects, identified through OOW’s watershed planning partnerships or by the Fairmount Park Commission, who was fast becoming an important partner given its control over vast quantities of stream corridor. These projects, such as stream bank stabilization, wetland rehabilitation, and buffer revegetation, aimed to restore the resilience of local waterways, protect them from polluted runoff, and improve recreational opportunities. For example, in the fall of 2000, DEP awarded PWD $150,000 through Pennsylvania’s Growing Greener Program—a nearly $1 billion environmental grant-making initiative signed into law in 1999—to restore of a reach of Cobbs Creek.

However, in recognition that restoration and buffer enhancement would only get them so far in controlling pollution, the Office also began exploring stormwater LID and other source control technologies that were being applied in

\(^{72}\) Author interview with Chris Crocket, Deputy Commissioner, Philadelphia Water Department, May 13, 2014.
\(^{73}\) Ibid.
\(^{74}\) Ibid.
the Pacific Northwest and Chesapeake Bay, and promoted by EPA as part of a suite of "structural best management practices" (BMP) for urban stormwater management (see Chapter 5). One of the first people in Philadelphia that Neukrug solicited for input was the Landscape Architect Anne Spirn.

Since joining the University of Pennsylvania’s faculty in 1986, Spirn had been investigating the link between the city’s buried flood plains, subsidence, and land vacancy in the Mill Creek neighborhood of West Philadelphia (WPLP). In a series of award winning collaborative projects, papers, and reports, collectively known as the West Philadelphia Landscape Project (WPLP), Spirn made the case for re-appropriating land in the Mill Creek floodplain as open space for water quality and flood control; a similar call to action as that she had made in Boston several years earlier (Spirn 1986, 2000). As opposed to rebuilding the largely derelict public housing that had been constructed over the buried and sewerized Mill Creek channel—one of the largest combined sewers in the city—Spirn proposed to use the land for stormwater management, urban gardens, and other community-building spaces (Spirn 1991). Spirn had been attempting to involve PWD in these efforts since the early 1990s. In 1994, she even presented a ready-made plan for land-based stormwater management in Mill Creek. But, in what had become a familiar pattern, her contacts at PWD ruled her concepts “impractical.” 75 The CSO policy had changed that.

OOW staff and Spirn had met briefly in the late 1990s at several watershed conferences, including one organized by EPA Region III. Soon after the Office was formed, Neukrug asked if Anne would take several of his engineers and a visiting urban stormwater expert from Colorado State University, Larry Roesner on a tour of her projects in West Philadelphia. Spirn agreed and explained her vision for utilizing vacant land for stormwater infiltration. Although Spirn believed OOW’s engineers were most compelled by the endorsement of Roesner, who perhaps

75 Author interview with Anne Spirn, Professor of Landscape Architecture and Planning, Massachusetts Institute of Technology, June 26, 2014.
bridged a perceived disciplinary divide, she found a receptive as opposed to discouraging audience. Over the next months, Spirn would collaborate with the Office on a grant proposal to create a bioretention facility and outdoor educational classroom on a vacant lot next to Sulzberger Middle School, a WPLP partner. Although the project was not funded, and Spirn moved to MIT in 2000, OOW continued to pursue stormwater demonstration opportunities in Mill Creek. Through meetings with the neighborhood Mill Creek Coalition, the Office identified a handful of publicly owned sites on which to construct a suite of controls to minimize stormwater entering the combined system while providing educational resources and open space. In 2001, with the cooperation of the Department of Recreation and the Philadelphia Housing Authority, OOW developed a conceptual site plan that included a stormwater quality trench, a rain barrel and roof downspout disconnection, a butterfly garden, and a bioretention berm. Soon after, DEP awarded PWD grant another Growing Greener grant to begin construction on a number of the proposed Mill Creek projects, including a basketball court retrofitted with porous paving. As Madden (2010) writes, these early projects "highlighted the public benefit" of LID and also increased the Office's confidence in its efficacy.

In the following years, OOW's LID demonstration work gained considerable momentum. The Office continued to find external support for stormwater retention demonstration projects and its efforts were formalized into PWD's Low Impact Demonstration Program. In 2003 PWD partnered with the non-profit Pennsylvania Horticultural Society (PHS) which ran one of the Nation's preeminent urban greening programs, Philadelphia Green. PHS was undertaking a vacant land reclamation and community development initiative in a large swath of North Philadelphia as part of the Mayor's 2001 Neighborhood Transformation Initiative. PWD proposed to integrate stormwater controls into several of the project sites using Growing Greener funding. The first of many joint projects, five sites were landscaped as stormwater sensitive open spaces, estimated to retain
90,000 gallons of stormwater each year (Mandarano 2011). The Office also received a major $1 million grant through the EPA-administered State and Tribal Assistance Grant (STAG) program for its “Urban Watersheds in Philadelphia Using Decentralized Water Resources Management” initiative. OOW proposed to design and construct a wide range of LID projects throughout the city and evaluate their “environmental effectiveness, stakeholder acceptance, and the watershed-based life cycle cost benefit” (PWD 2005a). Although the Office hired a design firm to work out the details, OOW staff oversaw each of these projects from start to finish. Not only did the staff’s knowledge of the technologies and how best to implement it in a variety of urban settings mature and improve, the Office’s monitoring studies were confirming that the technologies worked: the installations retained and treated stormwater, and reduced the loads on the sewers.

AN IMPLEMENTABLE VISION AND THE ROLE OF STATE “COVERAGE”

By 2005, the Office’s various initiatives were beginning to gel into a coherent and implementable vision for integrated water management in Philadelphia; one in which LID technologies played a central role. This vision was best expressed in the non-binding Cobbs and Tacony IWMPs, which were completed by 2005 and laid the foundation for Philadelphia’s LTCP update. In the IWMPs, the Office and its regional partners presented a “water-land-infrastructure” management strategy to meet three planning targets:

A) Dry Weather Water Quality and Aesthetics;

B) Healthy Living Resources; and

C) Wet Weather Water Quality and Quantity.

This approach combined riparian and wetland restoration (the “water”), gray infrastructure rehabilitation and improved maintenance (the “infrastructure”) and source controls (the “land”).
For Philadelphia to meet Target C, which included compliance with the CSO policy, OOW proposed to greatly expand the use of infiltration technologies throughout the city via direct investment and supportive regulations. Extensive internal analyses, supplemented by a growing body of external literature, showed that LID technologies could out-performed off-line storage both in terms of cost effectiveness and stakeholder support. Meanwhile, the Office's calibrated and updated SWMM-based hydrologic models, which EPA had released earlier that year, confirmed that various combinations of infiltration technologies, from pervious paving to enhanced tree canopy, could be implemented across the watersheds to significantly reduce runoff and pollutant loads from CSOs and stormwater at a vastly reduced cost than comparable gray infrastructure. For example, in the Cobbs Creek IWMP, the highest ranked alternative to meet a short-term (5-year) target of 20% reduction in CSO overflows and stormwater runoff was to retrofit 50% of the watershed's parking lots with bioretention gardens and pervious paving, and install dry wells in 40% of sewer inlets.

As opposed to laying out a detailed 20-year plan with specific LID investments, the IWMP presented a phased, “adaptive” approach. Interim objectives would be set and PWD would make adjustments to implementation based on monitored outcomes. Because certain urban stormwater technologies, like green roofs, might become cheaper and more socially accepted over time, the Office argued that PWD required the flexibility to adjust course in order to the maximize cost effectiveness of its investments. OOW proposed to use the five year NPDES and MS4 permits terms to “define the time frame” for review and modification. Whereas Target A and B could be met in a 5-10-year time frame, OOW estimated that Target C would require two or more decades.

As a result of the IWMP analyses, several new capital projects were approved by PWD leadership, including a $56 million commitment to relining the CSO interceptor sewers in the Cobbs and Tacony watersheds to curb leaks and unnecessary overflows. OOW also continued to expand and implement its LID
demonstration and restoration projects on public land. By 2006, the Office was planning or had completed 30 such projects, half of which were LID retrofits on schools, parks, vacant land, and public rights of way. These included a stormwater wetland at a local public high school; a bioretention garden in a parking lot; an infiltration tree trench with overlaid porous pavers; and a traffic triangle retrofit that diverted runoff from streets and sidewalks into a planter (PWD 2006).

The Office also oversaw the development of two critical PWD regulatory policies aimed at decreasing impervious surface on private lands, which represented over 40% of the impervious surface in Philadelphia. The rules were influenced in part by NRDC’s report “Out of the Gutter” (see Chapter 5), which Neukrug had adopted as OOW’s informal strategic plan in 2002. The policies were expected to reduce the public costs of CSO and stormwater control by requiring and incentivizing private landowners to implement on-site retention. On January 1, 2006, PWD implemented new post-construction stormwater regulations applicable to any development or redevelopment of 15,000 square feet or larger. In addition to addressing channel erosion and flood control, these new rules included a water quality requirement: the first inch of runoff from a property’s “directly connected impervious area” (i.e. surface draining to city sewers) must be infiltrated on site. Several factors facilitated the implementation of this rule, known as a retention standard. First, PWD’s participation in a state planning process (“Act 167”) required Philadelphia to implement an agreed upon stormwater ordinance, which included a retention standard. This “regulatory hammer” gave Neukrug leverage when pitching the policy to high level PWD decision makers. Second, the city’s stormwater ordinance and zoning code, drafted in the mid-1990s when the city and state were negotiating construction of a new sports stadium, gave PWD authority to implement a retention standard for any development over 15,000 sq. ft. — without requiring action by Philadelphia City Council. Third, resistance from the development community was partially headed off by communicating the cost savings associated with LID, and restructuring and
streamlining site plan review. For example, PWD worked with other city agencies to require conceptual approval for stormwater management plans prior to zoning approval, thereby reducing the likelihood of costly site redesigns, and staff from OOW were moved laterally to the Planning and Research Division to assist in plan review. Said one engineer, “We went from being the last [agency] developers saw, to the first.”

In addition to the post-construction retention standard, OOW began building the case for linking non-residential customers’ stormwater fee to their property’s impervious surface cover, an urban water quality policy touted by NRDC and pioneered in several Chesapeake Bay communities. This proposal, called “parcel based billing,” also had a useful precedent in Philadelphia. In the 1960s, when PWD introduced a stormwater fee to recoup costs associated with managing the City’s stormwater inlets, that charge had been based on a customer’s water meter size. In the mid-1990s, several property owners challenged the fairness of the charge, and PWD convened an advisory group to recommend changes to the fee structure. In 1996, the group presented a case for basing 80% of the stormwater fee on a property’s impervious area and 20% on its gross area. In 2002, charges were adjusted for the city’s 450,000 residential customer based on the median residential parcel characteristics. However, PWD lacked the GIS and aerial data needed to implement the change equitably for its larger customers, which were highly dissimilar in size and land cover. In 2006, Neukrug and his staff revisited the proposed fee restructuring, which now appeared to be a promising mechanism to encourage large and highly impervious commercial and industrial sites to implement infiltration technologies to reduce their stormwater bill. In cooperation with PWD’s finance office, OOW spent the next 3 years gathering the parcel data and making the case for the rate changes. Implementation of the rate restructuring

76 Author interview with Chris Crocket, Deputy Commissioner, Philadelphia Water Department, May 13, 2014.
was facilitated by the release of the LTCP update in 2009 and approved by the Commissioner that year. They were phased in at the end of 2010.

For the nearly ten-year period that Neukrug and the Office of Watersheds worked to devise this innovative approach to urban water quality management, regulators had played a critical, dual role. On the one hand, DEP and EPA provided the regulatory hammer—primarily through the National CSO Policy—that drove the Office's activities and gave Neukrug and his staff influence within PWD. Regulators served as OOW's own “gorilla in the closet,” providing a scapegoat to blame as the Office fought to implement its vision in an organizational environment with a strong status quo bias. On the other hand, PADEP was also a collaborator, acting as a key partner and funder for many of the Office's initiatives, which frequently dovetailed with DEP's own mandates: PWD's watershed assessments provided useful water quality data, and its demonstration projects and partnerships with outlying suburbs helped those communities better understand their obligations under DEP's new Phase II stormwater rules. Most critically, DEP permit officials supported OOW's activities over the course of two full NPDES permits terms—without requiring PWD to demonstrate precisely how it would meet the CSO National Policy. While other cities were being sued by environmental advocates, the state provided coverage—a permit “shied”—that gave the Office the time it needed to develop expertise in a non-traditional approach.

For its part, EPA deferred to the state. There were several reasons for this. First, during the early years of the National Policy, program expectations and “gray areas” were still being clarified through permitting, implementation, and negotiation. As the program matured in the early 2000s, regional enforcement officials began taking a closer look at Philadelphia's sewer overflow issues. However, there was no clear entry point for an enforcement action as the agency was well insulated by its agreements with the state. PWD also enjoyed strong public support from regional leadership. In 2005, EPA’s regional water division
director, Jon Capacasa, who was earning a reputation as a “behind the scenes” innovator (Blankenship 2017), told the Philadelphia Inquirer: “Many cities take a more structural approach to these things, building tunnels and storage tanks and larger treatment systems. I think it’s tremendous that Philadelphia is investing in more preventative approaches” (Avril 2005). Finally, the more politically complex pollution issues in Pittsburgh and Washington DC—both of which were federal CSO enforcement priorities at this time—likely reduced EPA’s attention to Philadelphia’s own problems. 77

On one hand, a cynic could see the state’s actions as weak oversight or regulatory capture by an agency that did not want to spend more money to control its wastes. I have no evidence to point one way or the other, but I do think it is important to note that, first, EPA only got serious about CSO LTCP enforcement after 2000, when Congress made the policy law. Second, if the state forced Philadelphia’s hand earlier, it is unlikely that PWD would have produced Green Cities, Clean Waters. Third, PWD remained in excellent standing with the terms of its Pennsylvania permits throughout this time. In 2000, all three of its treatments plants were honored by NACWA for multiple years of nearly perfect compliance that exceeded national standards, and unlike the majority of other CSO communities in the US, PWD had delivered all its required National CSO studies, documentation, and plans on-time. Furthermore, although PWD’s LTCP was not fully in accordance with the National Policy standards, Philadelphia was making progress on implementation. By 2005 PWD had invested over $200 million in its CSO capital projects, nine minimum controls, and watershed planning, was spending $4 million annually on site-plan reviews and education and public outreach, and had committed another $50 million to CSS rehabilitation projects. By comparison, ALCOSAN—Pittsburgh’s regional sewer utility in western Pennsylvania—had yet to produce any of its required CSO documentation. Its

77 in 2007 ALCOSAN entered into a consent decree with the state and EPA that would see it invest 3.8 billion in storage tunnels over 20 years.
system, serving 83 different communities in western Pennsylvania, was releasing 16 billion gallons of sewage overflow from more than 250 outlets.

**GREEN CITIES, CLEAN WATERS: PHILADELPHIA'S LTCP UPDATE**

In 2006, with Philadelphia’s NPDES permit renewal one year away, DEP notified PWD that it would have to develop a new LTCP. This requirement was included in the City’s 2007 permits as well as a 2008 consent order with the state. The demand for an updated plan was not wholly a surprise for anyone familiar with Philadelphia’s CSO problem. Its progress aside, PWD had only made a small dent in its overflow volume, reducing it to some 15 billion gallons per year from 17, and it still suffered from dry weather discharges. At the same time, federal actions against CSO communities were accelerating nationwide. It seemed only a matter of time before Philadelphia’s activities fell under more serious Federal scrutiny.

What was a surprise to observers, including PWD’s regulators, was the content of the plan that PWD submitted on the September 1, 2009 deadline. Titled Green Cities, Clean Waters, the long-term control plan update (LTCPU), laid out a 20 year, $1 billion (NPV) commitment to controlling Philadelphia’s combined sewer overflows (PWD 2009a). Adopting EPA’s own terminology from its 2007 Statement of Intent, PWD proposed to initiate the “largest green infrastructure program ever envisioned in the country, thereby providing for the capture of 80%” of Philadelphia’s overflows. Although Philadelphia was not the first city to propose using infiltration practices to manage its CSOs, it was the first city to propose using them as the primary control technology. Portland, OR for example, had initiated a downspout disconnection program in the early 1990s to reduce its overflows, but the vast majority of its $1.4 billion CSO control investments were directed towards traditional pipe and tunnel solutions, an outcome discussed in more detail in Chapter 8.
The introductory chapter to Green City, Clean Waters made several references to the evolving CSO regulatory context at EPA regarding GSI. The authors noted that the LTCPU was informed by PWD's broader integrated watershed management program, and that the plan's development had been "fortified by the recent green infrastructure guidance and policy documents developed by the United States Environmental Protection Agency (US EPA)." They continued:

With this vision, the LTCPU takes the emphasis off of capital investments that are implemented out of the public view (i.e., underground or in pipes) and instead focuses a program on specific benefits to the residents of the City of Philadelphia by restoring environmental amenities for our constituents and "greening" our City. (PWD 2009a, 1-i)

In particular, PWD proposed to capture and infiltrate stormwater runoff from 34% of the impervious surfaces in the combined sewer shed through the application of GSI. This would be accomplished by creating nearly 10,000 "greened acres:" land that retained the first inch of runoff, equivalent to approximately the 80-90% percentile storm event. (That is, historically, only 10-20% of storms in Philadelphia exceeded 1 inch of rainfall.) PWD would meet its 10,000 greened acres goal primarily through direct investments on public lands, including joint projects with partner agencies such as Parks and Transportation. These efforts would also be complemented by PWD's new regulatory programs. PWD estimated that, given the rate of redevelopment in Philadelphia, between 3,000 and 6,000 greened acres or more could be created by private investment alone.

Although vastly expanded GSI was the plan's keystone ($1 billion investment over 20 years), PWD also committed a total of $320 million to "targeted upgrades" of traditional infrastructure, including interceptor rehabilitation and a secondary treatment bypass— which would increase the amount of wastewater that received primary treatment during wet weather. In addition, the agency
would spend upwards of $300 million over 20 years on riparian restoration projects to support the natural cleansing property of its urban streams and achieve fishable and swimmable water quality standards. The latter investment would also help meet the agency’s integrated management goals of improving dry weather aesthetics and stream corridor preservation (Target A and B from the IWMP). The LTCPU reiterated PWD’s commitment to a “land-water-infrastructure” perspective, first laid out in the Cobbs and Tacony IWMPs (PWD 2009a).

Producing the over 3,000 page LTCPU had required two years of extensive economic and hydrologic modeling, in addition to grueling negotiations that engaged every PWD department. In 2007, after a decade of experimentation and development, Neukrug and his staff were primed for a green update: they were philosophically opposed to “burying” rate-payer dollars underground and technically prepared to include a range of green options in the LTCP alternative analysis. Nevertheless, as the most expensive capital project in PWD’s history, the plan required agency-wide consensus. To oversee plan development, PWD formed a LTCP steering committee composed of the majority of PWD’s executives and all the agency’s deputy commissioners. They expressed an array of common concerns and doubts about a GSI based plan, many of which would be echoed over the next three years as PWD hashed out agreements with its regulators. Could site level practices be scaled to control overflows across a dense urban landscape? How would the agency ensure proper maintenance to keep the green infrastructure functioning? What if other city agencies refused to cooperate? “There was skepticism everywhere,” an OOW engineer said. “We felt it meeting after meeting. Monthly meetings turned into weekly meetings, and then pretty much daily.”

These meetings were made more difficult by the fact that Kishinchand had retired in 2004 and been replaced by a water commissioner who was much less enthusiastic about OOW’s mission.

78 Author interview with Marc Cammarata, Director of the Office of Watersheds, Philadelphia Water Department, June 14, 2014.
Ultimately, PWD leadership was swayed by both the technical competence of plan as well as two critical supporting analyses that provided a compelling public case to present to rate payers and their representatives in City Council. First, agency skeptics were faced with OOW’s rigorous alternative evaluation, which showed that an approach reliant on traditional infrastructure would far exceed the City’s financial capability. Given Philadelphia’s median household income, rates could only be increased enough to produce an estimated $1.6 billion over 20 years. Complete separation would cost $16 billion; off-line storage or large-scale satellite treatment would cost at least $4 and $5 billion respectively. Direct investment in GSI—with the agency’s retention standard and parcel billing acting as policy “bookends”—was the only alternative that could meet high performance standards without surpassing Philadelphia’s affordability limit.

OOW staff also returned time and again to another argument, one that it had honed through discussions with its external partner groups: unlike traditional infrastructure, the benefits of GSI began to accrue immediately and included many secondary benefits to local communities and the environment. Neukrug and his staff argued that choosing GSI over tanks and tunnels ensured that “every dollar spent provides a maximum return in benefits to the public and the environment” (PWD 2009a, 9-6,7). To make the case quantitatively, Neukrug hired Stratus Consulting to conduct a so-called “triple bottom line” (TBL) analysis which was included in Green Cities, Clean Waters as supplemental material. A relatively novel corporate “sustainability accounting” practice that was not part of traditional utility financial analyses, the TBL analysis assessed the economic, social, and environmental benefits of investing in GSI versus off-line storage. The LTCPU noted:

79 Author interview with Chris Crocket, Deputy Commissioner, Philadelphia Water Department, May 13, 2014.
Traditional engineering economic analysis compares the construction cost of various alternatives to the effectiveness of those alternatives, such as percent capture of combined sewage. In this traditional framework, the alternative that meets the performance goal at least cost will be selected for construction. However, the traditional framework misses a number of costs and benefits that may not affect the utility directly, but affect the environment and the public at large. (PWD 2009a, 9-7)

The analysis compared two CSO control scenarios: one in which LID technologies were implemented across 50% of Philadelphia; the other in which the city built a 30’ storage tunnel system. In contrast to the traditional approach, the TBL incorporated a suite of frequently overlooked benefits, including job creation, ecosystem improvements, and public health benefits. The analysis also calculated associated external costs related to project construction and maintenance. The results of the assessment were stark. By 2049, the present value benefits of the GSI-based alternatives were estimated at $3 trillion. The tunnel option produced only $122 million in benefits, and also resulted in more than 7 million metric tons of emissions and twice the vehicle delay hours than the green approach (PWD 2009b).

THE POLITICS OF REGULATORY INNOVATION: 2009-2012

As discussed above, in getting to Green Cities, Clean Waters, PWD and the Office of Watersheds benefitted, in part, from very good timing: The Office’s exploration of integrative practices for urban water management was synchronous with the growth of a larger, national network of innovators. This network helped translate ideas about water sensitive landscapes into physical GSI technologies, and best practices for their application in dense urban areas. National policy also began to shift just as OOW went to work on their LTCP. 2007—when OOW began planning its update—was that same year that EPA signaled its support of cooperative efforts to support the integration of GSI for CSO compliance.
However, when PWD released its plan in 2009, EPA—now under a new administration—had yet to take any formal steps to clarify its Statement of Intent or offer guidance to regional and state regulators about what exactly this “integration” could and should look like. Reaching internal agreement within PWD, therefore, was not assurance that Green City, Clean Waters would be implemented. The agency still had to navigate the regulatory compliance system, and it faced serious obstacles on the path to approval. For example, although the efficacy of GSI at the site level was well understood, the collective performance of decentralized systems spread across the urban landscape remained hypothetical—demonstrated primarily by models. No other city had completed any green infrastructure project at the scale Philadelphia was proposing. Furthermore, in contrast to centralized gray infrastructure, which could be constructed and operated by one entity, the implementation and performance of GSI depended on a multitude of external actors, including private property owners and other city agencies who would help build and maintain the systems. Adding additional complexity, the cost-effectiveness of Philadelphia’s LTCPU relied on an opportunistic approach to implementation. PWD proposed to use “adaptive management,” similar to that outlined in the IWMP. However, in doing so, the GSI implementation plan diverged from conventional capital projects planning, which provided precise details about who would be constructing what and when and around which a compliance schedule could easily be developed. In these ways, Green Cities, Clean Waters upended regulators’ standard approach to technical review and compliance assurance and introduced new quantities of uncertainty and risk, to which EPA was particularly sensitive.

While some of this uncertainty could be reduced through discussion, clarification, and additional studies, much could not. As this next section shows, approval of Philadelphia’s LTCPU was therefore also contingent on skillful politicking and coalition building. In particular, PWD overcame real and potential resistance by garnering the input and support of litigious NGOs early in the review
As part of this effort, Neukrug made the unusual and savvy decision to invite several influential local and national NGOs (NRDC, Clean Water Action, and the Pennsylvania Environmental Council) to review the updated plan from a policy, legal, and technical perspective—at the same time it was sent to regulators. Led by Nancy Stoner, then NRDC's Senior Director of Water Initiatives and an influential GSI advocate and urban water policy expert (see Chapter 5), the NGO coalition also acquired grant support from the Philadelphia-based William Penn Foundation to support two additional independent expert reviews of the plan’s modeling and cost estimates.81

80 Author interview with Howard Neukrug, Water Commissioner, Philadelphia Water Department, June 20, 2014.
81 Neukrug helped secure these funds. The Foundation would go on to support several more NRDC led technical reports, including 2013 on private land.
In explaining his decision to open the LTCPU up to external review, Neukrug said: "We wanted to show [the NGOs] that this is real and we can do this. We are not hiding behind the skirts of the regulators."82 Larry Levine, an attorney for NRDC and GSI legal expert, noted that the invitation was nonetheless unique, as NRDC more frequently found itself in the position of adversary, intervening in administrative or legal proceeding to argue that a municipality’s actions were inadequate. In some ways, Levine said, the invitation was seen as a natural extension of OOW and Neukrug’s ethos of transparency and collaboration. At the same time, it was also in PWD’s interest to have external validation of its approach, given that it was the first time a city had attempted to secure regulatory approval for such a plan.83

Furthermore, although regulators have many technical and legal considerations to balance when approving a control plan or permit, political concerns are also significant—though less publicly discussed. No regulator wants to approve something that will immediately become the sources of multiple lawsuits. Therefore, NGO buy-in was an important part of garnering regulators’ approval. As one OOW engineer noted, “If NRDC had said ‘We hate this plan’ we would not have ended up where we are now.”84

On December 16th, 2009, as regulators were still poring over the update, the NGO coalition released a joint memo. The memo included the results of its two expert reviews as well as a set of recommendations aimed at ensuring that the LTCPU would meet regulatory requirements. The first review, conducted by Dr. Robert Traver from Villanova University and Michele Adams from the sustainable design firm Meliora Design, had examined the plan’s underlying models and

82 Author interview with Howard Neukrug, Water Commissioner, Philadelphia Water Department, June 20, 2014.
84 Author interview with Marc Cammarata, Director of the Office of Watersheds, Philadelphia Water Department, June 14, 2014.
projections and confirmed that they were valid and based on reasonable assumptions. The second review, by the design and construction consulting firm Becker and Frondorf, validated the cost estimates for PWD's alternative evaluation. Far from hating the plan, the NGOs hailed the "extraordinary vision exemplified in the LTCPU," which it called the "most ambitious green infrastructure plan," and thanked PWD, DEP, and EPA for the opportunity to help "ensure its success" (Stoner, Glass, and Wendelgass 2009, 6).

In addition to serving as an early and important vote of confidence, the NGO coalition also helped resolve a major compliance stumbling block. The LTCPU was based on an 80% volumetric reduction, which represented the affordability limit in PWD’s models. However, the National Policy’s presumptive approach required at least an 85% reduction in overflow volume. NRDC and its partners noted, however, that the pollutant removal efficiency of GSI was typically higher than that of primary or secondary treatment, and that the National Policy also sanctioned a "mass equivalency" approach. That is, if PWD could show that its GSI-based plan could eliminate the same amount of pollutants (e.g. TSS, bacteria, and BOD) that would otherwise be removed by the capture and treatment of 85% of the overflows, the plan would meet national standards (Stoner, Glass, and Wendelgass 2009). “We said ‘that is great idea’” said Marc Cammarata, who was, at the time, a ten-year veteran of OOW. “And we did a whole bunch of analyses and came back saying, yes we can: we can meet the terms of the policy.”

The following year, as PWD and the DEP inched towards an enforceable agreement, the NGO review team weighed in on the LTCPU’s unusual adaptive implementation plan. In a June 23rd memo to PWD, DEP, and Region III, the coalition affirmed PWD’s adaptive approach, writing: “we agree with PWD’s premise that ‘adaptive management’ is appropriate for a green infrastructure approach to CSO control” (Levine, Glass, and Russell 2010). They also commended

\[85\] Ibid.
regulators’ insistence on a “level of detail...that will ensure its success” and argued that plan approval should be contingent on enforceable, quantitative targets associated with specific dates; opportunities for review and course corrections every five years; monitoring at multiple scales; an inspection and maintenance program; and annual progress reports. At the same time, the groups exhorted regulators to complete their review “as quickly as possible” so that PWD could begin implementation (Levine, Glass, and Russell 2010, 2). Levine, who co-authored the second memo, summed up the groups’ perspective:

We were able to say to regulators: Look, from technical perspective what they are proposing makes sense and is workable. Here are some important technical considerations that need to be watched closely and further refined in early stages to be sure it is set up for success. And, policy-wise, we support approving it provided that you incorporate the following sorts of accountability mechanisms and checks and balances that will make sure that the AM approach works. 86

On June 1, 2011, after nearly two years of review, analysis, and deliberation, DEP formally approved PWD’s LTCPU and simultaneously executed a Consent Order and Agreement (COA, a so-called “enforcement vehicle”) with the agency for the plan’s implementation. By this time, Neukrug had been promoted twice. In 2010, he was tapped to lead the new Planning and Environmental Services Division as deputy commissioner, and Cammarata took over directorship of OOW. Then on February 2, 2011, Philadelphia’s mayor, Michael Nutter, appointed Neukrug to replace outgoing Bernie Brunwasser as PWD’s water commissioner. The COA, therefore, was executed with Neukrug as PWD commissioner. It included several modifications to the original LTCPU, but the fundamental vision—greening 34% of the combined sewer area—remained intact. The amended plan lengthened the

implementation schedule from 20 to 25 years, while also increasing the total monetary commitment to $1.2 billion (NPV). Of that, $800 million ($1.67 billion over 25 years) was earmarked for the GSI construction, an amount based on a more conservative estimate of private greened acres; $200 million was committed to traditional infrastructure improvements; and another $200 was set aside as “adaptive spending,” to compensate for unforeseen plan changes or problems (PWD 2011). Although DEP and the NGO coalition supported crediting pollutant reductions from riparian restoration—provided there was adequate monitoring to demonstrate its impact—restoration funding was cut. Illuminating another challenge of adapting the regulatory regime to a green infrastructure paradigm, EPA contended that, under the Clean Water Act, the stream corridor could not be used for pollution management. Nevertheless, PWD still pledged to invest a total of $260 million in restoration projects in the Cobbs and Tacony watersheds, as outlined in the IWMPs. “We, as a department, said that it is still part of our ethic,” Cammarata explained. “And so we earmarked some money. It is still part of the city vision, if not part of the regulatory [commitment].”  

The COA also outlined an enforceable and adaptive implementation schedule based, in part, on compliance with its water quality based effluent limits—performance metrics that signified the agency’s progress towards compliance. In addition to meeting 25-year, cumulative targets for sewage plant upgrades, miles of interceptor lined, overflow reduction volume, equivalent mass capture, and total greened acres, PWD was expected to meet 5 year benchmarks, as the NRDC and its partners had recommended, shown in Table 6.1. DEP also required PWD to submit for state approval 12 deliverables over the next five years. These included an “Implementation and Adaptive Management Plan” that explained the agency’s adaptive framework and detailed the first five years of Green City, Clean Water’s programmatic elements, including capital planning.

87 Author interview with Marc Cammarata, Director of the Office of Watersheds, Philadelphia Water Department, June 14, 2014.
policy coordination and streamlining, operation and maintenance, program monitoring, and public outreach; a comprehensive monitoring, modeling, and inspections plan for Philadelphia's natural systems, sewer systems, and green infrastructure; and the first edition of a GSI maintenance manual, that provided consistent guidelines for other agencies and groups with responsibility for GSI maintenance.

![Table 6.1. Philadelphia's LTCPU Performance Standards](image)

A DEP official who helped review the plan, noted that state approval was based partly on PWD's modeling work and the independent technical assessments overseen by NRDC that demonstrated the GSI-based approach would achieve regulatory compliance. But he acknowledged that "with a program this big and complex, there are always uncertainties about how well it will work. Those uncertainties are based on the plan's technology, logistics...and on the capacity of
the organization to actually [carry it out]."\textsuperscript{88} The five-year benchmarks therefore provided a crucial form of built-in accountability as well as assurance that the state would have regular opportunities to say: "it’s not enough and you need to change direction."\textsuperscript{89}

\textbf{A Skeptical Regional EPA}

With the backing of the state and support from NRDC and local NGOs, Philadelphia’s LTCPU faced one last obstacle. PWD was pushing EPA to formally commit to supporting the LTCPU, but there were indications that EPA might instead choose to challenge the upcoming NPDES permit issuance or even recommend a separate enforcement action against PWD, possibly upending Green Cities, Clean Waters. Regional officials in the Office of NPDES Permits and Enforcement cited several technical problems with the plan that remained unresolved in the state COA. First, they expressed concern that PWD’s decision to seek an 85\% mass reduction across the entire combined sewer area would lead to an uneven distribution of GSI, given that some areas of the city were less dense and more amendable to intervention than others. The entire combined sewer-shed, they argued, was unlikely to be the optimal scale at which to measure performance and ensure overall water quality protection. Second, officials continued to convey skepticism about the adaptive management plan and the absence of detail regarding who would be constructing what and when. And finally, officials were unnerved that— due to the interval of uncertainty— PWD’s monitoring data would only begin to confirm actual, as opposed to modeled, CSO volume and pollutant reductions between years 15-20. They exhorted PWD to commit to a "verification program" within the first five years of the program that

\textsuperscript{88} Author interview with David Burke, Watershed Manager, Pennsylvania Department of Environmental Protection, Norristown, PA, May 2, 2014.
\textsuperscript{89} Ibid.
would saturate a select sub-portion of the sewer shed with GSI to confirm the validity of PWD models and the efficacy of the technology.

In response, PWD laid out several counter arguments. PWD contended that given the close proximity of outfalls to one another, and the fact that all Philadelphia’s tributaries connected to the tidal portions of the Schuylkill and Delaware, the City’s CSO system “should be regarded as discharging to a single CSO receiving body” (Cammarata 2010). Furthermore, it was PWD’s position that all parts of the City should be treated equally, through an even “spatial distribution of burdens and benefits” (Cammarata 2010). This “equitable investment” ethos discouraged PWD from undertaking a verification program that focused the majority of the PWDs early investments on one neighborhood. Furthermore, a verification program would require PWD to bear nearly 100% of the construction costs. When built solely for demonstration purposes, GSI was actually cost-comparable to gray infrastructure in Philadelphia; one demo greened acre cost anywhere from $200 thousand up to $1 million. The savings inherent in the GSI approach came from implementing the practices during “business as usual,” such as redevelopment and public works projects. Program staff reiterated that this fact discouraged PWD from embracing EPA’s verification project, and was also the rationale for the adaptive approach that EPA continued to fault.

Region III’s continued resistance into early 2012 was a source of frustration and even bafflement for PWD leadership. CSO program staff reiterated that the state, high level EPA leadership, and NGOs—the groups most likely to be a legal threat—all supported the plan. Regional enforcement officials themselves acknowledged this, and noted that PWD’s technical analyses was sophisticated, its TBL assessment compelling, and the plan appeared to have no enemies. “Pretty much every environmental group was pushing for it,” one regional official said in
2014, adding that, “even the development community is quiet; it’s hard to be against it.”

Nevertheless, Philadelphia was asking EPA to sanction the use of a new technology, at more than 1,000 times the scale ever allowed and permit officials felt they lacked fundamental clarity about how Green Cities, Clean Waters was going to be accomplished. As one regional official explained, when looking at an LTCP, EPA asks several questions:

Is it implementable? Do we understand what they are doing? Are the time frames relatively copacetic? Because there is a great deal of slop in these models and they don’t necessarily tell you beyond a shadow of a doubt what the truth is.91

The official continued:

So we say to Philadelphia: How are you going to do this? What exactly are you going to do?...And they don’t want to actively plan and place things. They are planning on redevelopment and development to put [GSI] wherever. But that is not an engineering solution.92

Underlying this ostensibly technical debate was another set of issues. EPA’s permit and enforcement officials and the legal counsel who assisted them faced a very different set of incentives than EPA’s political leadership and policy makers. Permitting and compliance was where the proverbial rubber met the road, and the individuals overseeing it were particularly sensitive to the potential costs of a failed Philadelphia LTCP. These costs included damage to the natural environment and human health, as overflows continued unabated, as well as wasted public funds. The professional risks were also great. As the final line of defense between

90 Author interview with EPA Region III enforcement official, Philadelphia, May 7, 2014.
91 Author interview with EPA Region III enforcement official, Philadelphia, May 15, 2014.
92 Ibid.
polluters and the environment, these regulators, along with regional leadership who signed off on the plan, would bear the brunt of blame if Philadelphia’s plan turned out poorly. As one observer in Philadelphia’s city government remarked, “If it fails...and a bunch of public advocates sue the city...you are stuck being the one who supported it. And if it is successful, no one is going to mention you. There is very little incentive to say yes to something new and a lot of risk to the people who sign off on it.”93

Finally, at the back of many regional water protection staff’s minds was the knowledge that allowing Green Cities, Clean Waters to proceed would set a national precedent— a concern that state regulators did not face. Up to this time, EPA had been proceeding incrementally and cautiously with the incorporation of GSI into CSO consent decrees. Sanctioning Philadelphia’s plan—which would see GSI implemented at more than 1000 times the scale of anything approved prior—would likely lead to many other city’s demanding similar arrangements. The fact that data validating Philadelphia’s approach would not be available until 15 years into the program was understandably disconcerting. One regional official stated bluntly, “If this winds-up a total screw-up...If it looks like a waste of money at the end of the day, it’ll throw [GSI] back a generation. It needs to be done well.”94 Seen in this way, these officials were being asked to do more than provide technical and legal verification of Philadelphia’s approach. They were being asked to make EPA policy on innovation and risk tolerance.

Ultimately, the stand-off between regional officials and PWD would not be worked out through technical negotiations. As it probably needed to be, it was resolved at the highest levels of EPA as a result of lobbying by Philadelphia’s Mayor, Michael Nutter on behalf of Green Cities, Clean Waters.

93 Author interview with Andrew Stober, Philadelphia, August 16, 2016.
94 Author interview with EPA Region III enforcement official, Philadelphia, May 15, 2014
Getting to Yes: Final Approval Comes from Above

Described alternately as “too intellectual,” an outsider in an “insider game,” and “black, but not black enough” for a majority African American city with deep racial divides, Michael Nutter was never supposed to win Philadelphia’s mayoral race in 2007 (Popp 2008). A former city councilman with a degree from Wharton Business School, Nutter was the only candidate polling in single digits three months before the Democratic primary. Businessman Tom Knox, a self-financed multimillionaire, was considered the easy favorite in a five-candidate race. A close Nutter campaign aide later joked: “I was working for [Nutter], I was friends with him, I supported him, but I was looking for another job while on the campaign.”

Nutter’s dark horse victory was retrospectively credited to his successful positioning as the reform candidate, an image bolstered by an eleventh-hour ad campaign that included the Dilworth-reminiscent slogan “THROW OUT THE BUMS” and another that featured his daughter, Olivia, and highlighted his commitment to improving Philadelphia’s public-school system. After his win, Nutter said:

I considered my base to be people who wanted change. People who were tired of politics as usual and business as usual in Philadelphia. That’s a harder base to identity, versus a geographic area or a racial constituency or class constituency or a specific area of the city. But my base was people who wanted change (quoted in Popp 2008, 37).

In line with his reformist positions, Nutter was also the only candidate to publicly endorse and speak intelligently about the progressive platform espoused by The Next Great City Coalition, which organized one of the first mayoral forums. Funded the William Penn Foundation, the Coalition brought together a diverse collection of over 100 civic associations, environmental groups, and community

95 Author interview with Katherine Gajewski, Director of the Office of Sustainability, City of Philadelphia, May 14, 2014.
development organizations. With the message of making Philadelphia the nation’s “next great city,” their platform drew on the sustainability narrative emerging in major cities like Chicago, NYC, and Seattle and promoted municipal investment that would make “all neighborhoods...clean, safe, and healthy places to live and work and ...served by an effective city government.”

Once elected, Nutter quickly made good on his campaign commitment to the Next Great City coalition. In his 2008 inaugural address he proclaimed his goal of making Philadelphia “the greenest city” in the county. And the following year he created the City’s first Mayor’s Office of Sustainability and charged the staff with developing a city-wide sustainability plan, a la New York City’s PlaNYC. Katherine Gajewski, who worked on Nutter’s campaign and would go on to lead the Office of Sustainability noted that the Office of Watersheds had been on the Nutter campaign radar as early as 2007 (“we knew that there was a kind of ‘rogue faction’ within the water department”), but the sustainability planning process elevated the administration’s interest in the LTCPU. When Nutter released his sustainability plan, “Greenworks”, in 2009, OOW’s work on GSI and stormwater retention in Philadelphia figured prominently. Of the plan’s 15 targets, number 8 called for “managing stormwater to meet federal standards” using GSI. The report lauded PWD’s nontraditional approach to stormwater management and its beneficial externalities, and called for Philadelphia to “get in the game” of building green (City of Philadelphia 2009).

When the recession hit Philadelphia that same year, the value of Green Cities, Clean Waters in the mayor’s agenda increased. With a contracted city budget, the Water Department’s LTCPU represented one of the few large-scale sustainability initiatives that the mayor could still pursue. It also helped that the plan supported his other priorities, including neighborhood revitalization,

96 Author interview with Katherine Gajewski, Director of the Office of Sustainability, City of Philadelphia, May 14, 2014.
environmental justice, and climate resilience. “It was politically a boon for the mayor to have this plan go through,” said a former chief of staff. Therefore, when Nutter learned in 2011 that PWD, now headed by his Commissioner pick, Howard Neukrug, was struggling to win EPA’s approval for the plan, he agreed to help facilitate the conversation at a higher level.

As a leading voice in the national urban sustainability and climate resilience movement, Nutter was already acquainted with EPA administrator Lisa Jackson: “They had met before and hit it off; they felt excited to do things together.” This relationship deepened in 2011, when Nutter was the only US mayor invited to participate in a new international partnership between Brazil’s Environmental Minister, Izabella Teixiera, and Administrator Jackson that focused on cities and sustainability. Funded by the Rockefeller Foundation, the US-Brazil Joint Initiative on Urban Sustainability, or JUIS, emerged out of conversations between Jackson and Teixiera leading up to Rio +20, the United Nations Conference on Sustainable Development. The stated purpose of JUIS was to increase the implementation of niche technologies; identify emerging opportunities to improve urban environmental quality; and advance innovative financing based on sustainable design. A spokesperson for the Rockefeller Foundation proclaimed that another goal was to support Philadelphia and Rio in becoming “models for sustainable growth around the world.”

In August of 2011, Nutter, his deputy mayor for transportation and utilities, Neukrug and their staff all traveled to Rio De Janeiro with Jackson, and a cohort of business and academic leaders, to meet with their Brazilian counterparts. For staff in the Philadelphia delegation, an important objective of the three-day trip was to improve Nutter and Jackson’s working relationship and comfort level, as well as begin to lobby for EPA’s support of Philadelphia’s LTCPU. “We were getting in

97 Author interview with Andrew Stoiber, Philadelphia, August 16, 2016.
98 Ibid.
everyone’s ear about the plan,” a former staffer said. “And we were forming relationships with Jackson’s staff and talking to them about the importance of the plan.”

When Jackson and the Brazilian delegation came to Philadelphia for a JUIS meeting in January 13, 2012, there was a concerted effort to see the mayor use the opportunity of her visit to negotiate an agreement on the LTCPU. Staffers who helped orchestrate it recalled a private dinner at a local hotel, following the day’s meeting. One noted, “the technical details were almost irrelevant at this point; the question was: are you ready to say yes?” After 45 minutes, the dinner ended, and Nutter announced to his waiting staff that he and Jackson had agreed to issue a formal partnership statement on Green Cities, Clean Waters.

Jackson had several reasons to find Philadelphia’s plan compelling. First, one of Jackson’s goals as EPA Administrator was to integrate sustainability into EPA’s regulatory framework, a project that aligned well with Philadelphia’s efforts. Indeed, in 2011, the Office of Water at last issued two separate policy memos on the development of an integrated municipal stormwater and wastewater planning framework (Achieving Water Quality through Integrated Municipal Stormwater and Wastewater Plans) and another supporting the use of green approaches for stormwater and sewer overflow management to the maximum extent practicable (Protecting Water Quality with Green Infrastructure in Water EPA Permitting and Enforcement Programs). Furthermore, her administration was facing several political crises. With the financial collapse, impoverished populations, and multiple unfunded EPA mandates, municipalities were increasingly rejecting EPA’s traditional water enforcement and compliance tactics, particularly over CSOs, as punitive and unfair; and these cities were mobilizing through an array of advocacy groups like NACWA and the US Conference of Mayors. Such attacks on EPA were

100 Ibid.
101 At this time, having left NRDC in February 2010, Nancy Stoner was Acting Assistant Administrator of the Office of Water.
unusual and concerning to the Obama administration, particularly given the fact that US cities are often democratic strongholds. And they also led to a new acknowledgment among EPA leadership that the agency couldn’t just “issue [cities] consent decrees and have them build tanks and tunnels. It was not going to work anymore.” In addition, EPA was having little to no success advancing the Obama administration’s environmental agenda through the Republican controlled US Congress, and was increasingly looking to do so through administrative channels. Green Cities, Clean Waters thus offered one opportunity to advance President Obama’s policy goals during the upcoming presidential election year.

A Partnership and Consent Order
On April 10, 2012, at a public signing attended by several state representatives, EPA and the City of Philadelphia issued their Partnership Agreement, a demonstration of “EPA’s strong support for sustainable stormwater management yielding multiple benefits for community livability and other urban environment improvements.” Signed by Jackson, Nutter, Neukrug, and Regional EPA Administrator, Shawn Garvin, the Agreement outlined EPA and Philadelphia’s commitment to “advance green infrastructure for urban wet weather pollution control.” Under the agreement, Philadelphia committed to several early demonstration projects, including the creation of a stormwater enhancement district, as well as additional research on GSI cost-effectiveness and performance in highly urbanized areas and “next generation techniques.” EPA agreed to help streamline the implementation process, in part by creating a EPA “Green Team” to address policy concerns and other measures that would ensure the “successful integration of GSI on a large scale,” and to support the City’s water quality assessment and monitoring.

Consistency with EPA’s national CSO enforcement policy, however, required EPA to devise a separate, enforceable agreement with Philadelphia. After

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102 Author interview with PWD CSO engineer, Philadelphia Water Department, May 2014.
first suggesting that they might need to execute a consent decree to protect the city from lawsuits, EPA’s lawyers retreated. On September 21, 2012, EPA and PWD signed an Administrative Order for Compliance on Consent, a far more flexible enforcement vehicle, with the City of Philadelphia. Along with several minor modifications, the Order required the City to submit LTCPU documentation to EPA, simultaneous with its submissions to PADEP, placing EPA in a formal review and comment role for the lifetime of the project. Regional officials confirmed that the directive to allow Philadelphia’s LTCPU to commence came down from headquarters. “At this point,” a regional official stated in 2014, “Our job is to sort of stand aside, take notes, and see what happens.”

CONCLUSION

As this chapter has shown, the remarkable shift in PWD’s approach to urban water management was driven by developments in the broader regulatory community, specifically EPA’s 1994 CSO Policy. In the language of punctuated equilibrium theory, the CSO Policy was a “shock” to the organization. Because PWD perceived it would cost billions to attain compliance with the policy through conventional solutions, it produced a period of instability within the organization and an openness among PWD leaders to exploring alternative ideas— even if they were just to delay the inevitable.

However, this instability was not enough to produce change; it simply opened up an opportunity for it. The developments that transitioned PWD from a traditional water utility to a pioneer in sustainable urban water management and GSI were a function of three things: its structure as a fully integrated water utility with a tightly coupled water and wastewater/drainage system; a skillful administrator who emerged as a policy entrepreneur and leveraged the agency’s

103 Author interview with enforcement official, EPA Region III, Philadelphia, May 15, 2014.
instability to create a new organizational structure for innovation; and the concurrent growing acceptance of GSI as legitimate CSO control technology among influential environmental advocates and high level EPA officials.

The structure of PWD as an integrated local utility with a direct link between its wastes and drinking water was a fact of historical serendipity rather than rational design. Nevertheless, it made emerging "integrated solutions" to urban water pollution challenges more attractive than in utilities where wastewater and stormwater responsibilities were bifurcated between local and regional utilities, as is the case in Boston and Washington DC. In the context of an integrated local utility, managing stormwater to reduce CSOs promised to address many of the agency's other pollution related responsibilities and challenges, including stormwater pollution reduction and source water protection. The secondary benefits of GSI for Philadelphia's neighborhoods and environment were an additional boon, which created much greater levels of public interest and support for PWD's plan.

While not as critical as its integrated structure, other aspects of PWD's broad authority facilitated the organization's adoption of GSI as a technology to meet its CSO compliance. These included the existence of a stormwater fee (also a relic of an earlier era), which could be redesigned to promote retention on private properties, thereby reducing public expenditures. Similarly, PWD's power to independently establish retention standards ensured that all new developments in the city would include infiltration devices.

Although PWD had many internal incentives that supported GSI, institutional transformation required that someone within the organization take advantage of this favorable context. This individual was Howard Neukrug who used the regulatory anxiety within the organization to convince PWD leadership to elevate the CSO program from traditional operations to planning. Working at this level, he was able to create a new organizational space to build expertise in alternative approaches to meeting CSO compliance, among other related
regulatory requirements. In the language of Kingdon (1973/1989), Neukrug acted as a policy entrepreneur, linking solutions emerging in the stormwater pollution sector to PWD’s many municipal wet weather problems, including its CSOs. Although it’s impossible to say which of his many skills mattered the most, Neukrug reflected all three of Kingdon’s criteria for an entrepreneur: a “claim to hearing;” exceptional persistence in the face of naysayers; and useful political connections and strong negotiation skills (or, as Neukrug would call it “persuasion”). I’d add to the latter quality, that Neukrug’s understanding of the policy and regulatory system—both how and by whom decisions were made—as well as his intuition about where and when to create and use strategic partnerships and alliances were probably the most important aspects of his political savvy.

It is also useful to note that unlike some “entrepreneurs” who sit in wait for the right opportunity to push a specific agenda or solution, Neukrug was not, at the outset, a GSI advocate or watershed planner. He did, however, have a somewhat unique interdisciplinary training in engineering; a managerial position and set of responsibilities that allowed him some freedom to diverge from “pipes and tunnels;” and an openness to ideas and innovations emerging beyond his professional community. These characteristics turned out to be essential. Combined with the integrated structure of the utility, which facilitated his ideas and the creation of OOW, Neukrug perceived the potential in pursuing a holistic approach to urban water management, from which GSI quickly emerged.

Had Neukrug been in a regional wastewater utility with no responsibility for stormwater, he would have faced a much harder time winning support for integrated planning—had he even considered the idea at all. Furthermore, had PWD not had such a productive, collaborative relationship with its state regulators, who gave the agency time to explore alternatives and protected it from lawsuits, it might have ended up on a much different path, much earlier.

Finally, and perhaps most critically, fortuitous timing also played an influential role in Philadelphia’s outcomes. As OOW began its watershed planning
in the late 1990s, it benefitted from the accelerating availability of information on LID/GSI and its elevation from local experiment to the national stormwater management policy arena. By the time PWD began planning, EPA’s policy makers and traditional environmental adversaries like NRDC were increasingly supportive of using GSI to meet regulatory compliance. There were still gaps to be bridged between policy and enforcement. This was accomplished through high level political negotiations, which were also brokered by Neukrug. However, as I discuss in the following chapter, overall, the regulatory policy context was much more supportive of GSI than in was in the late 1980s, when Boston began its CSO planning.
BOSTON: A FRAGMENTED SYSTEM AND AN EARLY CLEAN-UP

INTRODUCTION
Relative to Philadelphia, the City of Boston has done very little to support or implement GSI to manage its wet weather pollution challenges. Instead, over the last 30 years, over $1 billion has been invested in conventional gray infrastructure—tunnels, pipes, and treatment station—to manage pollution to Boston's rivers, beaches, and bay. In this chapter, I argue that these responses to regulatory demands make sense within the context of a Boston's fragmented water management system, where stormwater and wastewater are the responsibility of two separate organizations facing very different challenges and opportunities. Furthermore, because of a Clean Water Act citizen suit lodged in the 1980s, Boston was forced to address its CSO discharges at a time when the only legitimate options for CSO control were gray. However, the situation in Boston is now shifting, due to another federal regulatory driver: the federal stormwater program. Developments in this policy arena tentatively suggest that stormwater management in Boston is only at the early the early stages of a much longer process and that we will see a much more significant investment in GSI from the Boston over the next decades.

WATER FROM THE WEST
When Boston was named the capital of the Massachusetts Bay Colony in 1632, the town was only 1.2 square miles; a hilly peninsula of forests and marshes, it was connected to the mainland by a narrow isthmus known as Boston Neck and bound to the north by the Charles River and to the east by Boston Harbor and the Massachusetts Bay. The colonists who had settled there in 1630 were drawn to the
land, known as Shawmut, after receiving word of its substantial fresh water spring. Although abundant fresh water was critical to every new settlement in the Americas, it was particularly valuable in Southern New England, where rivers were flat and tidal and groundwater was often too mineral or brackish for basic uses. Indeed, the colonists had abandoned Charlestown for Boston after a number of them were sickened by the water there.

Shawmut's so-called “Great Spring,” located steps from the site of the original State House, and other groundwater supplies served Boston well when it contained no more than a few thousand people. However, by the turn of the 19th century, Boston faced the intertwined waste and water problems endemic to nearly all urbanizing commercial centers in the newly independent United States. Now a community of nearly 20,000 people, Boston’s poor surface drainage and haphazard disposal of household and industrial wastes were slowly polluting its groundwater and threatening the wells and cisterns that most residents relied on for drinking water. Beginning in 1795, those who could afford it began to buy their water from the privately-owned Boston Aqueduct Company, which tapped Jamaica Pond. Located in neighboring West Roxbury, Jamaica Pond was a proximate and relatively plentiful source of fresh water, and also had the advantage of sitting 60 ft. above sea level so it could be fed to low lying parts of Boston by gravity flow at a time when steam powered pumps were still experimental.

The existence of a fairly competent private water supplier in the early 1800s might explain why Boston’s leaders did not begin to seriously contemplate creating a comprehensive public water system until the 1820s, and waited another 20 years to actually construct one. The lack of political urgency, as compared with Philadelphia, may also have been related to the fact that while Boston was affected by yellow fever outbreaks (which the medical community mistakenly associated with poor drainage and waste buildups), they never reached the proportions seen
in Philadelphia, where the climate was more amenable to mosquito reproduction (C. Smith 2013).

Furthermore, Boston was not incorporated as a City until 1822. Until this time it was governed by town meeting, a form of direct democracy practiced to this day across New England. Upon incorporation, Boston’s government was restructured to a mayor-council system, which was deemed more effective for governing its 40,000-person population. Under Boston’s first mayor, Josiah Quincy Sr., the city’s water challenges quickly rose to the top of the municipal agenda. In 1825, Quincy used the occasion of two major fires—which overwhelmed Boston’s water supply and pumping system—to focus public attention on Boston’s inadequate and patchwork water infrastructure. That same year, Quincy appointed a joint water committee, drawn from the Common Council and Board of Alderman, to report on the “practicability, expense, and expediency” of procuring and delivering a new, comprehensive water supply for household use and fire protection (Bradlee 1868, 9). Although there was near consensus on the desirability and feasibility of a pure water system to meet the Boston’s growing demand and replace its failing infrastructure, a fractious debate raged over the various proposed solutions (C. Smith 2013). Persuasive arguments were put forth in favor of both public and private systems and over 20 different water sources. Another three reports were delivered over the next 15 years, in addition to two failed public referenda on the issue.

By 1845, Boston’s population had doubled to nearly 115,000 people. A perfect storm of drying wells, deteriorating water quality, and multiple cholera outbreaks seemed to at last create the urgency necessary for municipal action. One of the few advantages of Boston’s delay was that the city benefitted from advancements in water delivery technology that had taken place over prior decades. For example, by the 1840s, cast iron pipes were displacing wooden ones, which had been found to swell, rot, and leak large quantities of water over long distances. Such innovations made tapping distant water bodies more feasible at the same time that these
sources became more attractive as the basis of Boston's water supply; in the intervening years, nearby fresh water sources like the non-tidal portions of the Charles River and Mystic Pond—both of which had been advocated in one or more of the city's water reports—had grown more polluted by local development.

By this time, two waterworks options had the most public support. The first would see Boston contract with a private company to draw water via aqueduct from Spot Pond, located ten miles north in Stoneham. The second option, crafted by the respected engineer Loammi Baldwin Jr. in 1835, was to bring water to Boston from Long Pond—a much larger water body 14 miles to the west in Natick, Massachusetts—through a series of aqueducts and reservoirs (Baldwin 1835). Supporters of the Spot Pond plan argued that Baldwin's proposal would be inordinately expensive and politically complicated, as it required the state legislature to grant Boston new taxation and eminent domain powers (Hubbard 1845). Spot Pond investors also had strong ties to a number of Boston city council members and were able to generate more enthusiasm than their project probably deserved.

Nevertheless, the Long Pond proposal benefitted from public confidence in Boston's future economic growth and ability to pay off incurred debt. Many public advocates and City leaders also raised objections to water privatization. Mayor Quincy Sr. had been one of the earliest and most strident opponents of privatization. After consulting with Philadelphia's leaders in 1826, he argued that profit maximization would drive a private water company's decision-making (C. Smith 2013). Under a privatization scheme, he argued, water would be channeled in the cheapest way possible to the highest bidders, thereby undermining the City's goals of providing affordable and accessible clean water to all its citizens.

The debate was at last squelched in September 1845, when a visiting independent commission, headed by the well-respected Chief Engineer of New York City's water system, deemed Spot Pond's water supply inadequate for Boston's future growth. A ward mobilization campaign successfully produced a
groundswell of local support, and the Long Pond proposal (called the Water Act) passed easily in the State Legislature and was affirmed by Boston voters on April 13, 1846. That same year the city began construction on the aqueduct system to carry water from Long Pond, renamed Lake Cochituate, to Boston. By the time the system was completed in 1851, its price tag had soared to $5 million—nearly double early projections—but it was reliably supplying 10 million gallons each day to 12,000 customers and 900 hydrants in the City of Boston (C. Smith 2013).

Whereas Philadelphia’s early decision to draw drinking water from the same waterbody that received its wastes established a tightly linked system that would later facilitate PWD’s case for integrated water planning, Boston’s drinking and wastewater system were decoupled. The Cochituate aqueduct and reservoir system set Boston on the path of reaching farther west as the city’s demand for fresh water grew. Over the next decades, Boston’s water system expanded upland, tapping more distant watersheds and creating ever larger reservoirs: the Sudbury Reservoir in 1879; the Wachusett reservoir in the Nashua Watershed at the turn of the century; and then, in the 1930s, the Quabbin Reservoir in the Swift River Valley, 65 miles west of Boston. At the same time, Boston’s sewer systems pushed its wastes deeper to the east, from the inner harbor out to the harbor islands and the ocean.

WASTES TO THE EAST
Boston’s first comprehensive sewer system was initiated in the late 1870s. By this time, Boston’s poor surface drainage and wastewater disposal issues had escalated from an annoyance and occasional inconvenience to a major public health crisis. Between 1820 and 1880 Boston saw its population increase eightfold, through annexation of outlying towns as well as unprecedented immigration. (The 1880 census estimated that over one hundred thousand people, fully one third of the city’s population, were immigrants.) The Cochituate Aqueduct helped bring piped
water and flush toilets to tens of thousands of these new households, but the city's wastewater removal was still reliant on an antiquated sewer system that had been created hotchpotch— primarily by private landowners— over the prior two centuries. Boston's wastewater challenges were further exacerbated by a massive land reclamation process that began in 1800 and ultimately created over 15 square miles of new shoreline, seen in Figure 7.1— a sixth of Boston's modern land area (Seasholes 2003). Landfill for the first of these projects— Mill Pond in 1800 and parts of Back Bay in the 1850s— was taken from Boston's hill-tops. The flattening of the city and extension of low lying development deprived Boston of the landscape's original drainage capacity. In the mid-1750s a visitor to Boston had called the inner Harbor, which served as the informal dumping ground for the city's wastewater, garbage, and night soil, a "very stinking puddle" (Dolin 2008). One hundred years later that "puddle" was backing up into Boston's streets and homes.

As the sanitary movement swept Europe and the States, Boston's sewers were the focus of multiple reports from the newly formed local and state boards of health and several city-led sewer commissions. In their second annual report, in 1873, the city's board of health declared Boston's sewerage "clearly wrong;" not only was Boston "encircled by the mouths of sewers discharging their contents into shoal water or upon flats" but there were large parts of the city entirely lacking sewers or "any proper means" of disposing their privy wastes (quoted in Dolin 2008). That same year, the Massachusetts Board of Health released a particularly influential report that examined a variety of extant waste collection and disposal methods, including separated sewer systems and wastewater irrigation. The authors, however, argued that there was "in the present state of human knowledge and experience... no better receptacle than the ocean" and advocated that Boston construct a combined sewer system that took advantage of Boston's coastal siting and discharged into the sea (quoted in Dolin 2008). In line with the state's recommendations, in 1876 a mayoral-appointed commission consisting of two civil
engineers and one sanitary scientist presented a proposal that would see Boston construct two large combined intercepting systems. The first would carry sewage from neighborhoods south of the Charles to the Neponset river (which now formed the southernmost boundary of Boston) and transport the wastes through pumping stations and reservoirs to an outlet point off Moon Island, in Quincy Bay. The second system, discharging from a channel off Deer Island, would serve parts of Boston north of the Charles bisected by the Mystic River, as well as the adjacent cities of Cambridge, Somerville, and Chelsea (MDC 1899).

Although a prescient minority of the public worried that wastes would simply accumulate around the Bay Islands and wash inshore, the majority of public petitions supported the plan (Dolin 2008). Boston’s recently appointed Joint
Sewer Committee also urged elected city officials to adopt the commission’s recommendations—at least for the areas of the city south of the Charles River. The committee argued that because the northern system depended on the cooperation of other municipalities the process would likely be fraught. Instead, they discouraged constructing the northern system in order to focus on completing the more urgent and politically uncomplicated southern system. The council agreed, and on July 12, 1977 Boston’s leaders overwhelmingly voted to begin construction on an interceptor pipeline that would carry Boston’s waste to the Calf Pasture pumping station in Dorchester, from which it would flow by gravity for 2.5 miles beneath Dorchester Bay to storage tanks on Moon Island and be released as tides ebb and flow. This so-called “main drainage system” was completed in 1884.

THE RISE OF WATER REGIONALISM AND THE LEGACY SYSTEM

Although Boston’s leaders were satisfied with the limited scope of the main drainage system, the communities left unserved by it were not. As construction on the system progressed in the 1880s, public outcry increased, particularly north of the Charles. In 1887 the state legislature directed the board of health to issue recommendations on how best to meet the entire region’s growing sewage disposal needs. The board’s subsequent report argued that the construction of sewage works in metropolitan Boston was complicated by the difficulty, “in many cases amounting to impossibility,” of managing sewage within the boundaries of the affected municipalities (MDC 1899, 11). The geographic clustering of numerous, autonomous municipalities—a somewhat unique characteristic of New England’s political organization—meant that any sewers constructed to drain one city or town would cross through another jurisdiction. Given Boston’s resistance to serving as the broker for regional sewerage planning, the report’s authors argued that the state was in the best position to oversee the development of a
comprehensive regional system. At the time, this recommendation was somewhat remarkable because, if implemented, it would be the first time in the nation's history that a special district was empowered to provide a public service. As Dolin (2008, 49) writes, the transfer of power away from locally elected officials to a quasi-independent regional authority ran counter to “deep seated suspicions about regionalism and local autonomy.” Nevertheless, the urgency of the situation, the absence of an appealing alternative structure, and the growing belief that water management should be the domain of experts, insulated from political meddling, effectively stifled opposition.

In 1889, the state legislature adopted the board’s recommendations and created the Board of Metropolitan Sewerage Commissioners to oversee the new Metropolitan Sewer District, which encompassed two distinct service areas: The North Metropolitan District and the Charles River Valley District. Comprised of three governor-appointed members, the commission was directed to “build, maintain, and operate” the interceptors and sewer works for these districts and was also granted authority to charge district municipalities proportionally for the costs of services rendered; payments were deposited in the state treasury (MDC 1899). Three years later the commission completed construction on the Charles River Valley system, which drained Brighton and parts of Back Bay, and linked to the City of Boston-owned main drainage infrastructure and Moon Island outfall. In 1896, the commission completed the more complex northern system—essentially the same one deferred by Boston in the 1870s—that carried wastes to an outfall on Deer Island. Then in 1899, the state legislature approved a plan to relieve excessive demand on the main drainage system, as well as the “heavy and increasing rentals” paid by the Sewage Commission to the City of Boston for use its system, including the Calf Pasture pump station (MDC 1899, 13). Serving part of Roxbury, West Roxbury, Dorchester, and the entirety of the City of Quincy, the Southern Metropolitan System came online in 1904 and drained by gravity to Nut Island, where it was discharged into the Bay. By this time, the entire metropolitan sewage
district covered approximately 185 square miles, 21 municipalities, and over half of Boston.

Over the next decades, authority for water management in and around Boston was further consolidated at the regional level. Motivated by many of the same issues and challenges that led to the creation of the sewage district, state legislature passed the “Water Act” in 1901 and created a Metropolitan Water Commission. The Act charged the commission with providing wholesale drinking water to a 13-member water district, which included Boston, and permitted the entry of any other city within ten miles of the state house that controlled its own distribution system. Boston's upland drinking water sources and conveyance facilities were sold to the commission. In 1904 the separate metropolitan water and sewage commissions, which served many (though not all) of the same municipalities, were merged. Then in 1919, the state created the Metropolitan District Commission (MDC). The MDC combined the regional Water and Sewage Commission with the Metropolitan Parks Commission, which was responsible for preserving and protecting the land around the district's upland drinking water sources. (As in Philadelphia, land based pollution controls were established to protect source waters, but in parts of the state remote from district communities.) Throughout this same period there were also multiple proposals to more deeply unify the region through, for example, a metropolitan development board or even the creation of a one vast mega-city; all of which, however, failed due to local opposition (Marstall 2012)

Thus, by the passage of the Clean Water Act, wastewater infrastructure and management in metropolitan Boston was a complex and multi-level web of authority and ownership, stretched between the state and numerous local communities. In 1972, the MDC provided sewage collection services to 43 different municipalities and continued to dispose of these wastes into the Bay from its stations on Deer Island and Nut Island, where primary treatment facilities had been constructed in 1968 and 1952 respectively. The City of Boston retained
ownership of the main drainage system and the Moon Island reservoir and outfall, although this facility was put on emergency stand-by status in 1968 and wastes were rerouted to Deer Island. As was the case with the other MDC communities, Boston was also responsible for its local drainage network. Managed by the Boston Department of Public Works, this system consisted of over two-hundred miles of combined sewers, and over 1000 miles of separate sanitary and storm sewers, which had displaced combined sewerage in the early 1900s. Ownership of the 84 CSOs that overflowed to the Mystic River, Charles River, Neponset River, and Boston Harbor was divided between City of Boston, which owned approximately sixty of the outfalls, the MDC and the cities of Somerville, Cambridge, and Chelsea.

As the following sections show, this fragmented system discouraged the pursuit of holistic control solutions (like GSI) for Boston’s wet weather pollution—given that any such endeavor would require the collaboration of multiple jurisdictions with little history of or incentive for cooperative action around water management. Added to these challenges was the fact that the timing of legal developments in the Boston region, following the passage of the Clean Water Act, reinforced the divisions between wastewater management silos. Specifically, two citizen lawsuits in the early 1980s, which culminated in the creation of the Massachusetts Water Resources Authority and the landmark, court-overseen Boston Harbor Clean-up, caused Boston’s CSO and stormwater issues to be addressed by two different agencies and along nonsynchronous pathways. This outcome further reduced incentives for integration as well as opportunities for conceptual cross-pollination between stormwater and CSO control technologies, and resulted in an entirely gray CSO control plan.

THE BOSTON HARBOR CLEAN-UP FORCES EARLY ACTION ON CSO CONTROL

As nearly every popular account of the Boston Harbor Clean-up is keen to point out, the $3.8 billion infrastructure project was set into motion by one man,
Quincy’s city solicitor William Golden, who on one of his regular jogs over Wollaston Beach ran through a slick of what he first assumed was seaweed but quickly realized was actually human feces; most likely washed ashore from the MDC’s Nut Island outfall (Levy and Connor 1992). Disgusted, shocked, and then simply outraged by the ongoing disposal of partially treated and raw sewage into the Bay, Golden convinced the mayor of Quincy to sue the MDC in state superior court for violating its discharge permit as well as Massachusetts law prohibiting the disposal of substances potentially injurious to human health or shellfish beds. In June of 1983 the Quincy suit was expanded to include a number of other state actors as co-defendants, including the director of the state Water Pollution Control Division and the secretary of the Executive Office of Environmental Affairs, which formally oversaw MDC. That same year, the Conservation Law Foundation (CLF), a New England-based environmental advocacy group that claimed to be stunned by the level of negligence revealed in the Quincy case, lodged its own suit in federal court against MDC as well as EPA for its failure to enforce the Clean Water Act.

Both these suits, however, came after a decade of delay on the part of the MDC to upgrade its system and facilities, during which time some 500 million gallons of barely treated wastewater discharged to the bay each day, while another 3 billion gallons of combined sewer overflows entered its harbor and tributaries each year. After the passage of the Clean Water Act in 1972, the MDC entered into an agreement with EPA to develop a comprehensive plan for sewage management in the region and cease its disposal of sludge into the bay by 1976. Although MDC leadership insisted that secondary treatment would not improve water quality conditions in the bay, the commission nevertheless agreed to upgrade to secondary treatment by 1979. In 1976, MDC completed its Metropolitan Area Wastewater Management and Engineering Study (the so-called EMMA study). A 25-volume report, it recommended 50 infrastructure projects, including site
specific CSO controls in five planning areas, a sludge incineration plant, and secondary treatment upgrades at a total cost of $855 million in 1976 dollars.

However, as a congressionally sanctioned secondary treatment waiver for marine dischargers appeared more likely in the lead up to the 1977 reauthorization, the MDC began to backtrack. With the waiver option a reality, in 1979 MDC submitted an application to EPA that reiterated its long-held position that the mixing and dilution potential of the Bay was more than adequate to render MDC’s sewage discharges harmless. MDC went on to highlight the costs and benefits of secondary treatment. There was no evidence, they argued, that secondary treatment would benefit the marine environment. On the other hand, MDC would save $114 million in construction costs and $14 million in annual operating expenses should it focus instead on expanding its primary treatment facilities, extending outfalls deeper into the sea, and controlling sewage overflows into the bay tributaries and inner harbor (MDC 1979). Thus, by the time of both the Quincy and CLF lawsuits, EPA was still engaged in the technically complex and politically charged assessment of MDC’s case.\textsuperscript{104} For its part, MDC had not even completed facilities planning for any of their proposed projects—a fact they blamed, if disingenuously, on the uncertainty arising from EPA’s protracted waiver review.

The lawsuits precipitated two important early outcomes. First, the state legislature was goaded into passing legislation to replace the failing MDC with a regional authority that had considerably more independence from the state. Indeed, one of the primary court findings in the Quincy case, which was settled by a non-legally binding procedural order in September of 1983, was that MDC, as structured, could not effectively carry out a major clean-up program (Haar 2009). Although MDC collected wholesale fees from district communities—presumably meant to cover the total costs of service—those payments were cycled through the state treasury as general revenue. MDC’s funding was instead dependent on annual

\textsuperscript{104} Ultimately, in 1983 and 1986, EPA rejected both MDC waiver applications.
state budgeting procedures. But sewage treatment had few public advocates and garnered little interest in the legislature—particularly as the economic importance of the state's marine industries declined. MDC's sewage division was consistently outcompeted and chronically underfunded (Haar 2009).

At the same time, because the MDC's ability to raise rates was controlled by the legislature, infrastructure financing was beset by perverse incentives. MDC customers enjoyed some of the lowest rates in the country, primarily as a result of the system's reliance on the ocean for sewage "treatment" (Wald 1986). The large rate increases that major upgrades required were resisted by legislators who were sure to suffer blowback from district communities that saw their sewage utility bills skyrocket.

Taken together, these feedbacks not only impaired MDC's ability to raise capital for new infrastructure projects, but also resulted in a decline in the maintenance and operation of its existing facilities. Throughout the late 1970s, MDC's Nut Island and Deer Island primary treatment plants were frequently understaffed and malfunctioning, in clear violation of MDC’s 1976 NPDES permit that required, at the very least, their proper operation (Dolin 2008; Haar 2009).

In January of 1984 the Massachusetts state legislature took up debate on a bill that would restructure MDC and create a semi-autonomous regional sewage authority— an idea that had been floated by various state leaders since 1972 (Dolin 2008). By November, however, the legislature had yet to take any concrete action. In response to lawmakers' delay and the lack of progress on the voluntary court order, the superior court judge overseeing the Quincy case scheduled a receivership trial for the MDC and issued a moratorium on new hookups to the metropolitan sewer system, essentially halting all district-wide development (Levy and Connor 1992). Although the moratorium was rapidly overturned, it succeeded

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105 It did not help matters that the Commission had also become known as a " patronage dumping ground" and low morale and fairly insurmountable fiscal challenges was not wildly attractive to the region's engineering talent.
in its aim: on December, 19th the legislature created the Massachusetts Water Resources Authority (MWRA), which would assume MDC’s sewage (and drinking water) responsibilities on July 1, 1985.

The MWRA’s structure and powers diverged in important ways from its predecessor. Its enabling act authorized it to independently set and collect rates from municipal customers and use those fees to pay off debt incurred from its tax-exempt revenue bond sales. As opposed to a governor appointed commission, MWRA’s leadership structure consisted of an executive director selected by an eleven-member Board of Directors that represented a range of stakeholder interests, including one elected official from Winthrop and Quincy and three members appointed by the mayor of Boston. The legislation also created an advisory board consisting of one member from each of the authority’s customer communities. The advisory board was charged with reviewing and commenting on MWRA’s capital and operating budgets.

In addition to forcing the hand of state legislators, the citizen suits drew negative public attention to EPA’s conciliatory enforcement stance that had sought to elicit cooperative and voluntary action from MDC, but largely failed. (Massachusetts is presently one of four states that has never assumed NPDES primacy; therefore EPA Region 1 has administered permitting and enforcement in the state since 1972.) In 1984 EPA’s embarrassed regional director urged EPA’s enforcement arm to file a separate federal suit against the MDC and the MWRA, as “successor in interest,” for violations of the Clean Water Act and seek a court-ordered clean-up. On January 31, 1985 EPA did exactly that and included as co-defendants the Commonwealth of Massachusetts and the Boston Water and Sewer Commission (BWSC). BWSC had been created in 1977 by a state enabling act that transferred ownership and management of Boston’s drinking water, stormwater, and sewage infrastructure from the department of public works to BWSC. Much like Philadelphia’s PWD, BWSC’s three commissioners were mayoral appointees
and it was established to operate as a “body politic,” a creature of the state that was “apart and separate” from the City of Boston.106

Soon after EPA filed its suit, CLF petitioned to have the stay on its federal case—enacted to allow the state case to proceed—lifted. CLF also supported consolidating its suit with EPA’s, thereby dropping the agency as a defendant. Against strenuous state opposition, the presiding district court judge, A. David Mazzone, agreed.107 Then on September 5th, 1985, Mazzone answered the fundamental question of liability: which entities were culpable for the numerous Clean Water violations that had taken place over the last decade? MDC had long deflected blame for its own missteps by pointing fingers at the various coastal member communities who tied into MDC’s system, particularly BWSC. Mazzone declared MWRA legally responsible for MDC’s violations (United States v. MDC 1985). Over the next months Mazzone helped broker the first of seven court-ordered long-term planning and construction schedules, with over one hundred milestones and monthly court monitoring. To manage the region’s 500 mgd of wastewater, MWRA committed to constructing a sludge facility by 1991 and new primary and secondary treatment works on Deer Island, with an extended ocean outfall, by 1999.

Importantly, MWRA also assumed full responsibility for the implementation and expense of a CSO control project to comply with federal and state regulations. Unlike in Philadelphia, where the significance of CSO pollution in the local rivers was overshadowed by huge quantities of minimally treated wastewater entering the same waterbodies, CSOs had always been part of the clean-up conversation in Boston because of their proximity to local communities and resources. Although they represented only a small portion of the total pollution entering the bay, CSOs were the leading contributor of BOD and

106 “The Boston Water and Sewer Reorganization Act of 1977” (St. 1977, c. 436, effective July 18, 1977)
107 The state argued that the state process should be given time to work and MWRA had not yet had a fair shake.
bacterial pollutants in the Charles, Neponset and Mystic rivers and numerous CSOs were also adjacent to local beaches and shellfish beds. This meant they were perceived with equal urgency as the sewage discharging from Deer and Nut Islands. Instead of deferring action on CSOs to focus on secondary treatment, in 1987 MWRA entered into an agreement with the court to accept responsibility for controlling “all combined sewer overflows hydraulically connected to MWRA’s system,” including those owned and managed by Boston, Cambridge, Chelsea, and Somerville, the “CSO communities” (MWRA 2007, 5). This decision was made to reduce decision-points, preempt jurisdictional disagreements over funding, and ensure the project stayed on schedule.

A GRAY CSO LONG TERM CONTROL PLAN

In December of 2015 the MWRA completed implementation of its CSO control plan, a $900 million project that spanned twenty years. According to MWRA, the plan has reduced annual overflows from 3.3 billion gallons of mostly untreated sewage per year in 1988 to half a billion gallons annually; 34 outfalls have been closed; overflows at another five outfalls have been nearly eliminated with a 25-year level of control; and 93% of the remaining discharges receive basic treatment including chlorination (MWRA 2017). However, of the 35 separate projects that make up the MWRA’s long term control plan, not one relies on decentralized infiltration technologies, like GSI. Below I explain how both the timing of the court-mandated harbor clean-up and the MWRA’s organizational incentives as a regional wastewater utility discouraged an integrative approach to water pollution management— one that might have led to the application of stormwater retention technologies for CSO control.

108 The Alewife Wetland, which is discussed in this case, is one possible exception to this statement. However, because the wetland was not created for CSO control, I do not include it.
Timing: Availability of Ideas and Policy “Fit”

There is one glaring explanation for why MWRA did not consider the use of infiltration technologies for water pollution control in 1987: they were still highly experimental and not yet accepted by the policy community for CSO control. Certainly, the basic concept of runoff retention and natural treatment was well understood by wastewater engineers and had been tested on small scales. As detailed in Chapter 5, multiple reports in the 1970s and 1980s noted that technologies like porous paving, vegetated swales, and treatment wetlands were considered “promising” and of interest for future research. In 1985, Anne Spirn had also directly made the case for ecological water management for CSO control in a speech at the Boston Public Library on April 30th that even caught the ear of the Massachusetts Governor (Spirn 2000). But “green stormwater infrastructure,” “low impact development”, and structural “best management practices”—all of which would grow in importance and influence after the promulgation of EPA’s 1990 phase I stormwater rules and the concomitant surge in stormwater pollution research funding—were still inchoate in the engineering community that dominated water pollution policy. Furthermore, at this time, retention and infiltration devices conceptually belonged to the domain of stormwater engineering, which was considered an issue distinct and separate from the problem of combined sewer overflows. In the late 1980s, the consensus among engineers and EPA policy-makers was that most viable approach for CSO management was not source control but an end-of-pipe solution that relied on the engineer’s traditional toolkit of tunnels, pipes, and treatment. Where feasible, sewer separation was also advocated. The proposition that large swaths of densely populated urban areas should be retrofitted to absorb stormwater in order to
reduce loads on combined sewers had yet no successful precedent in the US and few vocal or influential supporters. At the same time, MWRA’s mandate reinforced this conceptual divide between stormwater and sewage management. As the agency would reiterate over the next decades, MWRA was not legally responsible for stormwater control. Regardless of its influence on combined sewer performance, stormwater management was a local concern, and one that was intimately connected to local land use policy. Added to this, MWRA was under intense public and judicial scrutiny. It was expected to move quickly and effectively to redress the bay’s pollution problems. If it did not, it risked enormous monetary penalties (up to $10,000 per day).

Therefore, it is hardly surprising that MWRA’s CSO engineers did not consider using an experimental stormwater technology in their CSO plan; instead MWRA built on its expertise in conventional wastewater infrastructure and clearly responded to regulatory guidance and expectations. David Kubiac, the MWRA senior project manager who guided the CSO long term plan to completion in 2015, on time and on budget, described MWRA’s CSO plans as a reflection of the “regulatory framework that existed at the time [of planning].” MWRA’s first plan in 1990 conformed to the expectations of EPA’s 1989 CSO Strategy, which was interpreted to require a near total elimination of CSO overflows. To meet this stringent performance standard, MWRA proposed the so-called “Deep Rock Storage Tunnel” (MWRA 2016). Formulated with the assistance of the consultants Metcalf and Eddy, the plan called for the construction of a 16 mile, 25-foot diameter tunnel system buried 400 feet underground (Savage 1994). With a total

Interestingly, an archival review of MDC’s CSO facilities planning process from the early 1980s revealed one public comment that even recommended an infiltration technology. In 1982, in response to MDC’s environmental impact assessment, the author, Ed Reiner, an aquatic biologist in EPA Region I, recommended MDC use hollow grass pavers for bank stabilization along the Muddy River and noted the “added benefit of the filtering capability of the vegetation itself.”

Author interview with David Kubiak, Senior Program Manager, Massachusetts Water Resources Authority, Boston, December 4, 2014.
storage capacity of 350 million gallons, the tunnel would be capable of temporarily storing all the overflows to the rivers and harbor for the vast majority of storm events. Given the regulatory context, MWRA's engineers and regulators agreed that the plan represented the most “effective and cost-efficient approach” (Savage 1994, 402).

However, the tunnel’s price tag— an estimated $1.2 billion ($2.5 billion in 2015 dollars)— was a major concern. Although the final cost would be significantly lower, in 1990 the Boston Harbor Clean-up was expected to cost $7 billion, including the expense of the CSO control program. By this time, the federal construction grant program was being phased out, and MWRA could not count on state support due to resistance from legislators representing communities outside the sewage district (Savage 1994). This meant that MWRA ratepayers would fund the majority of the project’s cost. Experts argued that the entire clean-up would necessitate “quintupling” sewage rates in the 43 member communities (Levy and Connor 1992). A household paying $300 a year for water and sewer services in 1987 was expected to be paying $1,200 in 1995 (Rezendes 1987). These increases would represent a significant financial burden for many ratepayers, particularly low-income customers.

The ensuing public outcry resulted in several legislative efforts to limit MWRA’s rate setting powers. These efforts included a (failed) ballot initiative in 1990 that would have rolled back rates to 1988 levels and required legislative approval of any increases. Then in 1991, two bills were introduced in the state senate to completely remove MWRA’s rate setting powers and increase the governor’s control over agency decision-making (Dolin 2008; Savage 1994). In response, Mazzone, a dogged overseer of the clean-up until his death in 2004, encouraged MWRA to do what it could to lower projected costs but also threatened to use the “vast array of remedial and equitable powers” available to the court to ensure compliance with the court-ordered schedule (quoted in Dolin 2008, 180). In a separate statement, Mazzone also reminded detractors in the
Massachusetts legislature that MWRA was created with a political mandate to accomplish what MDC had been incapable of doing: raising funds to pay for the region’s sewage infrastructure needs (Dolin 2008). Any effort to undo the independence of MWRA’s rate-setting powers, he pointed out, jeopardized the entire clean-up effort.

Had the negotiations that created the 1994 CSO Policy not commenced in 1991, it is likely that MWRA’s court mandate would have pushed the tunnel plan forward, even in the face of affordability concerns. However, the negotiated rulemaking process showed early signs that the new policy would embrace more flexible standards that would allow MWRA to reduce the costs of its project. The policy that emerged in 1994 did just that. Use attainability analysis and the sanctioned “demonstrative approach” allowed MWRA to advocate revisions to state water quality standards—in essence, downgrade standards in particular waterbodies—and devise a long-term plan based on a demonstrated compliance with these new standards, as opposed to a plan solely based on system characteristics (i.e. number of overflows per year).

Thus, the 1994 policy had a very different impact on MWRA than Philadelphia’s PWD. As argued in the previous chapter, in Philadelphia the 1994 National CSO Policy represented a destabilizing “shock,” and it threatened a daunting and completely unplanned-for new set of capital expenses. As a result of the persuasive argumentation of an internal policy entrepreneur, PWD leadership elevated its CSO program from operations to planning. This shift offered PWD the chance to step back, reassess the status quo, and seek out emerging and alternative management paradigms and technologies. For MWRA, the National CSO Policy was not a shock but a reprieve. It allowed the agency to abandon its billion-dollar tunnel plan for something more affordable and responsive to local site conditions. The project was not elevated to planning; it remained an “engineering exercise,” operated under MWRA’s wastewater engineering group in the agency’s operations
division. MWRA was not forced—nor did it have the luxury of time—to hunt for alternative technologies. CSO engineers were also confident that conventional technologies would match or exceed the performance of the tunnel system and would result in substantial savings.

In fact, MWRA’s long-term control plan under the 1994 Policy harkened back to MDC’s comprehensive plans from the early 1980s, which recommended CSO control projects that focused on particular “planning areas.” More technically sophisticated in approach, MWRA’s 1997 LTCP proposed twenty-five—later increased to thirty-five—individual wastewater system improvements that would bring its system into compliance with the amended state water quality standards of the various receiving waters (MWRA 2005). This entirely gray plan included sewer separation, sewer trunk replacement, CSO treatment facility upgrades, and storage tunnel construction—the control alternatives recommended in EPA and DEP 1997 guidance documents. At less than half the price of the tunnel system, these various projects would result in numerous CSO closures and vastly reduced pollutant discharges from the ones that remained. In exchange for changes to some water quality standards, MWRA was able to commit to much more stringent levels of control for sensitive and high priority water bodies. For example, MWRA proposed to build a massive storage tunnel under North Dorchester Bay that would virtually eliminate BWSC’s CSOs in compliance with the Bay’s use

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111 Author interview with David Kubiak, Senior Program Manager, Massachusetts Water Resources Authority, Boston, December 4, 2014.

112 For more on the process of UAA for the Boston Harbor project, see Mann (1999). In a variety of cases, “EPA prefers Variance (instead of partial use) because it is temporary and must be renewed with the expiration of the underlying permit, giving EPA and DEP greater bargaining power to insist on continued planning and implementation efforts by permit holders.”

113 MWRA and its consultant Metcalf & Eddy began work on the new LTCP in 1992. Many public meetings later and with broad-based support, it was completed in 1994. The 1997 Facilities Plan/EIR received state and federal regulatory approvals in late 1997 and early 1998, respectively, allowing MWRA to move the projects into design and construction (MWRA 2005). By this time, MWRA had already achieved a 25% reduction of CSO volume through the implementation of NMCs in its system and those of the CSO communities.
classification"⁴. On the other hand, Fort Point Channel’s use classification was altered to allow CSO impacts 5% of the time and MWRA agreed to upgrade its Union Park treatment facility to mitigate the effects of BWSC-owned CSOs on the channel (MWRA 2003).

**The Organizational Incentives of a Regional Sewage Utility**

The regulatory environment and the absence of well-studied decentralized infiltration technologies are logical determinants of MWRA’s completely “gray” 1990 and 1997 CSO plans. However, over the nearly 20 years that MWRA implemented its CSO control program, the water pollution policy subsystem evolved substantially. As detailed in Chapter 5, in the 1990s EPA promulgated municipal stormwater control regulations; practitioners and advocacy organizations began exploring the use of LID and infiltration technologies in urban areas; support for integrative municipal pollution planning surged, particularly as a means to save cities money; and regulators incorporated these ideas into funding programs and national and state policies. Information on and support for these approaches— as well as on-the ground examples of their implementation— continued to grow into the 2000s. And these developments led to the landmark 2007 Green Infrastructure Statement of Intent, which publicly signaled EPA’s support for the use of GSI to meet federal wet weather regulations.

In the Boston region, stormwater management issues also increased in salience. Boston was one of two Massachusetts cities to receive a Phase I MS4 permit in 1999, and in 2003 EPA began issuing permits for the state’s other 350 municipalities. At the same time, environmental organizations like Save the Bay noted that ongoing stormwater pollution to local beaches was undermining the improvements gained by MWRA’s CSO control work (Save the Harbor 2004).

¹⁴ The level of control is actually for the 25 year storm. It is not total elimination, but EPA has agreed that it currently represents “effective elimination,” given what is feasible. Of course, requirements may change in the future.
MWRA long recognized the impacts of stormwater on its system: during storms, 50% of the flows to its Deer Island sewage plant was runoff. The agency committed millions to sewer separation projects, and yet these projects created new pollution problems as they solved old ones.

However, even as the acceptance of integrative stormwater and CSO control increased within the policy subsystem, and the interconnections between the systems at the local level grew more apparent, MWRA resisted tackling the Harbor's water pollution challenges in an integrative manner. Why, at a time when LID and GSI had been successfully applied in other cities, did MWRA never consider using it in its own CSO control projects?

It is important to note that this question would not make sense had MWRA had been irreversibly locked into its 1997 plan and court schedule. But over the course of the LTCP's implementation, there were numerous junctures where the MWRA had the opportunity to reassess aspects of the plan and its individual projects. Indeed, between 1997 and 2015, MWRA EPA, and DEP made a multitude of court sanctioned changes to the LTCP and the implementation schedule, both small and large. Perhaps the most significant renegotiation occurred in 2006 when the CSO compliance schedule was extended from 2008 to 2015 to allow several major modifications, including project additions that would increase the level of control for the Charles River (MWRA 2017).

There were a number of drivers of LTCP reassessments. For example, in 2001 MWRA faced intense neighborhood opposition to its plan to site a 400 million gallon pumping station near the City Point neighborhood of Boston, and the court agreed to give the MWRA time to come up with an alternate solution (MWRA 2005b). Over three years and multiple public meetings, MWRA devised a replacement plan that increased the size of the North Dorchester Bay storage tunnel, which in turn allowed MWRA to downsize its pump station to a fraction of
the original proposed capacity (15 mgd). Several years later, in response to poorer than expected water quality data, EPA worked with MWRA to improve treatment at its Cottage Farm CSO treatment facility on the Charles River by shunting extra volume through an unused pipe to another part of the system.

Program costs, however, were the most frequent cause of project reassessments. Although the 1997 LTCP was cheaper than the deep tunnel, the expense of the CSO program remained a major concern. Rate increases continued to be a political flashpoint, and by the early 2000s MWRA's CSO program was the agency's single largest capital commitment. Between 2004 and 2008, CSO spending represented 40% of the agency's total estimated spending; the agency anticipated increasing rates by some 30% (MWRA 2005). In its 2004 budget proposal, MWRA noted that it had made "difficult decisions to defer many non-CSO projects to meet its CSO control obligations... and control the financial burdens on its ratepayers" (Massachusetts Water Resources Authority 2005, 12).

On several occasions, when facing potential cost overruns arising from inflationary trends or a new understanding of system conditions, MWRA sought regulatory and court approval to reexamine its approach. Reassessments were also precipitated by "new information" that suggested a "better solution:" a higher level of treatment at a lower cost.

The reasons why MWRA did not explore the use of stormwater infiltration techniques during these opportunities for plan modification are primarily related to the agency's structure and authority as a regional sewage and drinking water utility. First, as already explained, stormwater management is not part of MWRA's legal mandate. Although the agency agreed to pay for new local storm drains that were necessitated by sewer separation, the agency also repeatedly emphasized that

115 Author interview with David Kubiak, Senior Program Manager, Massachusetts Water Resources Authority, Boston, December 4, 2014.
116 Interview by phone with Todd Borci, Environmental Protection Agency Region III, November 18, 2015.
it was not responsible for local runoff and strenuously resisted efforts that might undermine this strict division of labor. In a report from 2000, MWRA stated that “while there may be well-matched pro and cons of an expanded role for MWRA as a stormwater management agency, stormwater management is not currently part of MWRA’s mission” (quoted in Dolin 2008, 197). In 2004, as part of its negotiations on the North Dorchester Bay projects, MWRA conceded to community demands that it reroute the separate storm system that discharged to the local beaches—the so-called “Pleasure Bay Storm Drain Improvement Project.” In combination with MWRA’s CSO control projects, this stormwater redirection would “virtually do away with beach closings” around the Bay (MWRA 2005b, 17). But in a 2005 progress report, MWRA again stressed the one-off nature of this agreement and noted that it was entered into with the “important caveat that stormwater control elsewhere in the service area is not the responsibility of MWRA” (MWRA 2005b).

Relatedly, MWRA lacked the internal incentives that made green infrastructure attractive to other communities. In Philadelphia, GSI offered a one-stop-shop to reduce CSOs, while also improving the quality of stormwater discharges and reducing impacts on its drinking water supplies. Because MWRA was not responsible for stormwater, and sourced its drinking water from upland there were no additional benefits to be gained by choosing GSI over a gray technology. Furthermore, potential cost savings— perhaps the one characteristic that might have appealed to MWRA — were more than off-set by risks associated with adopting a land-based control technology. GSI would require the extensive cooperation of a new set of partners, including the local CSO communities and the various agencies therein with authority over construction, development, and drainage. Projects that changed the rules of development and the city landscape would also engage a variety of other citizen stakeholders in planning, design, and

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17 MWRA did have to coordinate with other agencies, but these were well established, streamlined relationships, with, for example, the Boston Conservation Commission (Wetlands Order of Conditions), the Department of Environmental Protection (Waterways Chapter 91 License), and the Army Corps of Engineers.
implementation. The primary reason that the court assigned clean-up responsibilities to MWRA was to avoid the complexity, conflicts, and delays that were part and parcel of cross-jurisdiction and multi-level collaboration. (That is also why the state created a regional sewage authority in 1895!)

In fact, MWRA's experience managing a CSO control project in Alewife Brook, a tributary to the Mystic River, revealed exactly the types of problems that could arise from a land based control project. As part of MWRA's sewer separation work in the City of Cambridge, MWRA and Cambridge were unexpectedly required to devise a plan to manage the resulting stormwater load, which regulators argued could not be sent directly to the brook without violating discharge limits for volume and pollutants. In the early 2000s, MWRA presented Cambridge with plans that called for a large detention basin beneath a derelict plot of DCR land, the Alewife Reservation. Instead, Cambridge and DCR suggested using part of that same land to create a natural wetland that could control the same volume of water—some 3 million gallons. At Cambridge's behest, MWRA agreed to pay for the $3 million project, only to find it swept up in a protracted citizen-led lawsuit. A handful of neighbors argued that the project was an "inappropriate use of parkland," and—ironically—contested its construction under the state wetland protection act. The case lasted 5 years. When the wetland was finally completed in 2013, it was an award-winning example of GSI and an important community asset. Nevertheless, it took over a decade to complete and cost nearly $30 million, a burden shared between MWRA and the City of Cambridge.

As an agency accountable to over 43 different communities, MWRA also had to consider equity when devising its CSO plan. The secondary benefits that arise from GSI are boons to a local utility like PWD, but are actually disadvantages for a regional one. If MWRA were to implement a green infrastructure plan that

\[^{8}\] The Alewife Wetland is the only intervention related to MWRA's LTCP that is green.
would visibly improve the streets of Boston, there would undoubtedly be pushback from the other district communities on MWRA’s advisory board who were footing the bill.\(^9\) As Kubiac noted, all of the local environmental and stormwater benefits that GSI provides are “the obligation of and the interest of that community. They cannot be the interest of MWRA because our interests are defined in state legislation and stormwater is not one of our interests, urban temperature is not one of those interests, etc.”\(^{10}\) Furthermore, if PWD’s plan for Philadelphia falls short of its CSO performance targets, the agency will still have provided enormous secondary benefits to its residents. Meanwhile, MWRA could not justify the costs of a large scale GSI program by pointing to other local benefits, like open space creation or heat island mitigation: “We can’t say to the ratepayers of Framingham, for example, that even though we didn’t achieve the [required] levels of control, at least we are helping out the people of the City of Boston.”\(^{21}\)

Finally, MWRA had no experience building GSI and limited confidence in its performance. Even in 2015, MWRA engineers remained unconvinced that cities like Philadelphia could achieve the CSO reductions they anticipated with GSI. If MWRA was developing its plan in the present day, it still would be reluctant to embrace GSI. This is for all the reasons discussed above, but also because of a continuing lack of confidence about the capability of distributed infiltration technologies to provide high levels of CSO control. For many within MWRA, GSI still represents a black box whose performance and cost effectiveness is deeply

\(^9\) Although the City of Cambridge footed more than half of the Alewife wetland’s bill, MWRA still risked being accused of paying for Cambridge community assets. MWRA has been careful to point out that the wetland was a required “add-on” to the “gray” sewer separation plan for CSO controls. On the other hand, one could argue that the new storm systems built by MWRA in Boston and Cambridge are also community assets (and in fact the MWRA Advisory Board did complain about their construction). However, there again, MWRA could easily argue that the storm drains were a necessary add-on to their CSO separation project. They were also less visible to the public, and less likely to provoke the ire of ratepayers.

\(^{10}\) Author interview with David Kubiac, Senior Program Manager, Massachusetts Water Resources Authority, Boston, December 4, 2014.

\(^{21}\) Ibid.
uncertain until measured post-facto. On the other hand, as Kubiak said: “We know when you put in a pipe what is going to happen. If you put in a storage pipe, and if it is designed properly, it is going to work properly.” Given that MWRA was in a race against the clock to bring its system into compliance, the superiority of gray technology was, and still is, closely related to its predictability.

**The (Potential) Influence of (Potential) Outside Advocates**

For MWRA there were few compelling benefits to choosing GSI over traditional infrastructure, and many potential costs and uncertainties. However, there were other groups who could have advocated, perhaps successfully, for its use in the LTCP. Interviews with a variety of other stakeholders, including federal and state regulators, local environmental organizations, and the CSO communities, suggest that GSI was never part of the CSO control plan conversation, however. Again, timing was an issue: MWRA’s CSO control program was winding down as many of these groups were just learning about GSI and how it could be used as a CSO control measure. (Indeed, the first time many subsystems actors in the Boston region were made aware of this possibility was through the extensive coverage of Philadelphia’s plan after 2009.) The pressure of the court order also exacerbated outsiders’ perception that it was too late to make fundamental changes to MWRA’s plan. Regional EPA officials, who would have had the most leverage to introduce GSI into the plan, reiterated that MWRA was in “a sprint” to meet court milestones: “[The harbor clean-up] was such a political hot potato and there wasn’t the data to say how effective GSI project were.”

Furthermore, each of these outside groups had their own interests to attend to, and GSI was not an obvious way to advance those interests. For example, it is standard policy among state and regional regulators to avoid

122 Author interview with David Kubiak, Senior Program Manager, Massachusetts Water Resources Authority, Boston, December 4, 2014.
123 Author interview by phone with Todd Borci, Environmental Protection Agency Region III, November 18, 2015.
telling local communities how to come into compliance with the Clean Water Act so long as communities demonstrate that they will; and MWRA’s CSO plan promised significant reductions that would meet or even surpass regulatory standards with a high degree of reliability.

Local watershed groups, like the Charles River Watershed Association (CWRA), that sat on MWRA’s citizen advisory committee, were likewise focused on water quality outcomes. Environmental advocates prioritized maximizing overflow reductions as quickly as possible to achieve the goal of fishable and swimmable waters — an objective that was already considered radical for an urban watershed, without adding GSI to the mix. The advisory committee was also quickly mired in the technical minutiae of MWRA’s plan; as one participant noted, there were not obvious opportunities during meetings to bring in “bigger picture questions,” such as how alternative solutions were being used in other parts of the country. In this way, NGOs in Boston were more likely to agree, at least at the time, with EPA’s assessment of MWRA’s approach:

There is the tunnel under the South Boston beaches that is working fantastic. Those beaches have fewer closures than they have ever had all due to that tunnel that holds up to a 25-year storm and pumps it back into sanitary system after the storm. And I can’t say something like that doesn’t work; it works great.

In fact, while GSI is often touted as the “sustainable” solution to urban water pollution, not all environmental advocacy groups have responded to it with equal enthusiasm. As discussed in the following chapter, environmental groups in Portland, a city that was a forerunner in ecological water management, opposed

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124 Author interview by phone with Kate Bowditch, Charles River Water Association, February 25, 2015.

125 Author interview by phone with Todd Borci, Environmental Protection Agency Region III, November 18, 2015.
the city’s efforts to replace conventional CSO controls with GSI because it would delay the clean-up process and produce inferior water quality outcomes, at least in the short run.

Finally, although the CSO communities that worked closely with MWRA and frequently implemented MWRA’s CSO projects may have benefitted from the use of green solutions, aside from the case of the Alewife wetland there is no evidence that anyone advocated for them. In hindsight, Boston in particular could have avoided sewer separation projects that left BWSC with new stormwater discharge obligations had it instead pushed for infiltration projects in its CSO sewersheds. On the other hand, it is fairly easy to see why BWSC would not have perceived this at the time when it was receiving over $300 million of MWRA funding to fix its CSO issues and build brand new storm drains. The fact that BWSC’s 1999 stormwater permit made few demands on the BWSC beyond the removal of illicit sewage connections would have reinforced Boston’s perception that, even with sewer separation, it was getting a good deal.

BOSTON BEGINS ITS GREENING BY LAWSUIT: THE MS4 PERMIT AS GSI DRIVER

Although Boston missed a $1 billion opportunity to begin implementing GSI as part of MWRA’s CSO control plan, GSI came to Boston through another channel: a stormwater enforcement suit brought by CLF in 2010. As already noted, GSI technologies gained prominence as a cost-effective solution to controlling non-point source pollution, including urban runoff. Because of this, one might expect the municipal stormwater permit to be a natural driver of GSI investment in cities. However, the weakness of EPA’s rule means the MS4 permit has yet to live up to this function; historically, Boston’s case was no different. Boston was one of two Phase I Massachusetts communities that were issued MS4 permits in the 1990s. BWSC received the first permit for its 195 stormwater outfalls in 1999, prior to which it was taking few to no actions to reduce pollutants in its stormwater
discharges. However, like most early stormwater permits, BWSC’s MS4 included only boilerplate requirements for low cost, non-structural “best management practices” including street sweeping, catch basin cleaning, and site review for construction projects. As in Philadelphia, the permit’s most resource intensive condition was the identification and removal of sewage laterals that had been illegally connected to storm drains—accidently or otherwise.

However, in the mid-2000s, attention to stormwater discharges in the Boston region was growing. At this time, EPA was developing a TMDL for nutrients in the Charles River, as well as a state-wide pathogen TDML that would impact the Charles and Neponset. Stormwater was a major source of both these forms of pollution and suspected to be the primary contributor to nutrient phosphorus loading in the lower Charles, which was feeding massive and highly toxic blue-green algae blooms during the summer months. As a result, CLF—the same regional environmental advocacy group that filed the first federal suit against the MDC in 1983—began to look more closely at BWSC’s stormwater program. Since its founding in 1966, CLF’s legal advocacy work has focused on finding ways to bring degraded and impaired water in New England up to the interim standards of the Clean Water Act, i.e. fishable and swimmable. This frequently means identifying, and then attempting to curtail, major sources of pollution. In the case of the Charles River and its bacteria and nutrient impairment, CLF believed BWSC’s system was simply “too big to ignore.”126 Draining over 15,000 acres of land—approximately 57% of the City of Boston—through 595 miles of storm drain, BWSC’s stormwater system discharged to some of the most degraded portions of the Charles River, and was known to convey both stormwater and human wastes from numerous illicit connections. As CLF lawyers looked through BWSC’s records, they were increasingly convinced that BWSC were not doing enough to curtail Boston’s polluted stormwater discharges:

The annual reports every year read like carbon copies of the prior year. They didn’t say: ‘this year, because of our phosphorous impact on the Charles River, we will do X, Y, Z...’ We were hoping to see some evolution, some recognition that the status quo was not acceptable and that there was a path towards cleaner water. We saw none of that...Our view [was] that this was a utility frozen in time. And we said, we think...we can make a case to a judge that this is an entity violating its permit and they could be doing more.  

In February of 2010 CLF sued BWSC for alleged violations of its 1999 stormwater permit, under which BWSC was still operating. (When a new permit should have been in 2004, the overburdened regional office instead took the commonplace path of administratively continuing the original 1999 permit.) From the outside, the case appeared to be a typical enforcement suit. CLF presented BWSC’s own monthly discharge monitoring data that showed numerous water quality violations and CLF argued that BWSC was not implementing its pollution control activities, including its illicit discharge elimination program, to the required “maximum extent practicable.” However, the case included an interesting twist. CLF wanted BWSC to do more than improve its stormwater pollution control efforts; the Foundation also wanted to use the suit as a vehicle to integrate GSI into BWSC’s management practices, which had thus far demonstrated no movement in that direction. In that vein, 2010 CLF also proposed a settlement offer that would see BWSC hire staff who were knowledgeable about GSI, could help the Commission build capacity around the new approach, and would hopefully inspire an effective GSI implementation effort in Boston. 

CLF’s interest in integrating GSI into BWSC’s stormwater activities was influenced by the technology’s growing relevance in the policy subsystem, both

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128 Because of Browner v. Defenders of Wildlife, the first argument was going to be more difficult to establish in court; CLF had far more leverage with the second argument.
locally and nationally. CLF was particularly persuaded by the assessment of local groups, like CRWA, who were becoming vocal advocates for GSI. For example, in 2007 CRWA founded the “Blue Cities Initiative” to promote the use of decentralized infiltration technologies and reduce stormwater pollution entering the Charles River. Anthony larrapino, CLF’s lead attorney on the case, explained: “We [were] seeing people on the ground, in these watersheds, saying: this stuff will work. If we do it in enough places, it will start to solve the problem.” At the same time, CLF’s new focus on GSI was also influenced by emerging national examples. In pre-trial hearings and briefings, CLF referenced GSI’s applications in Philadelphia and the Pacific Northwest, as well as studies and expert analyses that confirmed the technology’s efficacy.

In addition to driving change at BWSC, CLF intended to use the case to advance a particular interpretation of the national stormwater rules that would have more far reaching implications: that the MEP performance standard was commensurate to GSI/LID. In 2011, CLF presented this argument in a 70-page comment, replete with expert testimony, on EPA’s Draft Massachusetts MS4 General Permit. In the comment, CLF reiterated EPA’s own policy position that the MEP standard was meant to continually adapt to new conditions and technological developments, with the goal of meeting water quality standards through successive iterations of permit conditions that incorporated this new information. Given this, CLF went on to argue:

[GIS] practices are widely available, well proven, are generally more effective than conventional infrastructure at pollutant removal and volume reduction, and confer additional benefits to the community and environment. As detailed in attachments...to this comment letter, LID/green infrastructure is the current expression of

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130 CWRA had actually encouraged MWRA to invest in rainwater collection and downspout disconnection, as in Portland and other cities, as early as 2002. But had gotten little traction.
controlling polluted stormwater runoff to the “maximum extent practicable” (“MEP”). (Renahan 2011)

Ultimately CLF did not make this argument in the BWSC MS4 case because it was settled before it could go to trial. The point, however, is that the above interpretation of the stormwater rules structured CLF’s approach to the BWSC suit and made GSI a central, as opposed to peripheral, issue.

In December 2010 EPA intervened in the BWSC case. CLF had been hoping for this development, as EPA’s engagement brought with it substantial resources and significant media attention, and made a settlement more likely. However, it also raised the specter that EPA would focus only on accelerating BWSC’s lackluster progress on controlling its sewage discharges via illicit connections and SSOs, which were the primary reasons EPA joined the suit. However, in a move that was perhaps meant to signal its commitment to advancing green infrastructure for stormwater control, the agency also agreed to pursue CLF’s stormwater complaints and its recommended GSI remedies.

Indeed, the consent decree, which was finalized in August of 2012, went well beyond what CLF had first proposed and required BWSC to make a long-term commitment to implementing GSI in Boston. By 2015, BWSC was to develop a GSI technical manual that assessed a variety of infiltration technologies with applications in the city of Boston; produce plans for three GSI demonstration projects (at Audubon Circle, East Boston’s Central Square, and City Hall Plaza); work with its consultant, CDM, to develop a comprehensive stormwater model for its system; and, most significantly, devise and then enact a long term, i.e. 20-30-year scope, GSI-based stormwater management plan. The latter requirement, called the “Stormwater BMP Recommendations Report,” required BWSC to use GSI to “assure consistency with all applicable wasteload allocations [from TMDLs]... and prevent BWSC’s discharges from causing or contributing to water
quality violations. Importantly, these requirements were included in the decree as remedial measures, as opposed to supplemental environmental projects. EPA thereby established that GSI development was an integral part of BWSC’s ongoing compliance activities—not simply a way of avoiding additional civil penalties (Marks 2015).

For its part, BWSC was largely supportive of the demands made by the decree, and the GSI requirements in particular. In fact, many in the commission viewed the decree as an opportunity to accomplish upgrades and maintenance improvements to its separate sewer system that had been impeded by funding shortages and a lack of political will to increase rates. BWSC’s chief engineer and a 45-year veteran of the commission, praised the consent decree’s ability to force action:

Consent decrees are one of the best things in the world. They make you fund things or go to court. They make you pay attention to a schedule. It’s a rule book or ‘go to jail.’ I love consent decrees. I take that back: I love a reasonable consent decree. And this one has shaped us up quite a bit.

Historically, improvements to BWSC’s stormwater system were particularly challenging because BWSC did not have a stormwater utility that provided a dedicated revenue stream for management activities. Advocates for introducing such a fee had attained little traction because it was broadly perceived as a tax. Indeed, some political leaders in the state, which has been one of the slowest in the nation to adopt stormwater fees, have called them “illegal rain taxes”

133 Author interview with John Sullivan, Chief Engineer, Boston Water and Sewer Commission, January 24, 2015.
134 Author interview with John Sullivan, Chief Engineer, Boston Water and Sewer Commission, January 24, 2015; interview by phone with Todd Borci, Environmental Protection Agency Region III, November 18, 2015.
(Holtzman 2016). Nevertheless, in 2014 BWSC estimated that its compliance with TMDLs would cost $300 million, and the consent decree led the commission to earmark $1 million in 2014 to support a process that would set up a stormwater fee. If instituted, a stormwater fee based on impervious surface area would help BWSC pay for its own required GSI projects while also incentivizing land owners in Boston—including city agencies, like the public works and parks department—to implement GSI on the properties they own and manage.

**PROGRAM UPDATES AND POSSIBLE FUTURE DIRECTIONS**

As of 2018, MWRA and EPA are currently in the CSO post-construction monitoring and performance assessment phase of the long term control plan. This assessment will be completed in 2020. While MWRA's 30 projects have already shown enormous progress in reducing overflows, in some water segments the LTCP projects are underperforming. Climate change, which is bringing heavier and more frequent storms, will also undoubtedly lead to more overflows than anticipated or allowed. Although the period of major CSO investment has wrapped up, the performance of the system may necessitate additional controls after 2020. EPA agrees that another window of opportunity for MWRA to invest in GSI—most likely in partnership with Boston and the other permitted CSO communities—may exist in the near future. MWRA, however, remains opposed to directly managing stormwater and is signaling its expectation that any remaining investments will have to be undertaken and paid for by the local communities.

It is yet to be seen how the consent decree will influence GSI construction in Boston in the long term, but GSI-related activities at BWSC have significantly

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135 Author interview with John Sullivan, Chief Engineer, Boston Water and Sewer Commission, January 24, 2015.
136 Interview by phone with EPA Region I official, April 4, 2018.
137 Ibid.
increased since the decree. BWSC went from being an agency that never talked about GSI, to one that is promoting it on its website, integrating it into policies, and implementing it in projects. BWSC is also in frequent communication with leaders in other cities, including Philadelphia, in an effort to learn about what is working and what is not working. In 2013, BWSC completed its required BMP Guidance Documents and its Phase I Implementation Plan (for its three demonstration projects, which were to be integrated into existing city projects). In 2017, the Central Square Project was completed and included porous paving and subsurface infiltration. The $7 million redevelopment of Audubon Circle broke ground in 2017 and will conclude in 2018. It includes permeable paving, and bioretention devices, including raingardens and tree pits. Efforts to incorporate infiltration devices in the City Hall Plaza redevelopment are ongoing (BWSC 2016).

Of course, the deliverable that is likely to have the most impact is the watershed scale GSI plan. After several years of review and discussion, EPA approved BWSC’s stormwater model report in 2016, which allowed the commission to move forward on their BMP Recommendations Report: a 25-year, “adaptive,” watershed scale stormwater management plan aimed at reducing pollutant loads to meet TMDL requirements. As part of that initiative, BWSC approved a mandatory 1 inch stormwater retention standard for all new and redevelopments within the MS4 service area, including those outside the existing groundwater overlay district. BWSC has also initiated GSI retrofits on five Boston schoolyards; partnered with Boston Parks on a $2.5 million rain garden and gravel filter in Jamaica Plain’s Daisy Park; established three GSI “sub watershed” demonstration sites; and continued to work with the Department of Transportation on their Complete Streets Initiative (BWSC 2016).

138 Author interview with John Sullivan, Chief Engineer, Boston Water and Sewer Commission, January 24, 2015.
The consent decree has also led to other voluntary efforts within BWSC to begin to institutionalize GSI in its practices. In 2014, BWSC hired a GSI specialist and promoted its director of planning to a newly created directorship for planning and sustainability. Ideally, those individuals will operate as internal champions for GSI in BWSC programs and projects. In 2017, the commission also signed a three-year contract with an outside consultant to provide “on call design services” to help BWSC incorporate GSI/LID into other city agency projects, including those of public works, transportation, parks, and the Boston planning and development agency (BWSC 2017b). The creation of a stormwater fee, however, is still under review. Of the approximately $103 million budgeted for sewer, drain, and stormwater capital improvement projects for 2018-2020, $7 million is earmarked for GSI/LID projects (BWSC 2017a).

CONCLUSION
Given that the CSO policy provides one of the strongest drivers to support GSI development in cities, the fact that 1) Boston was forced to address its CSOs at a time when GSI was nascent and 2) that the clean-up was managed by the regional MWRA, which has little to no incentive to adopt land based controls for stormwater management, largely explains the lack of GSI implemented for stormwater control in the City of Boston to date.

As seen in Philadelphia, integrative thinking is more likely to emerge in an organization where there are real gains to be achieved through holism. In the case of wet weather pollution control, an integrated agency is more likely to produce integrative problem solving, which naturally leads to GSI. As a regional utility with no responsibility for stormwater management, MWRA had (and still has) next to nothing to gain from using GSI for CSO control. On the other hand, the perceived

139 Author interview with John Sullivan, Chief Engineer, Boston Water and Sewer Commission, January 24, 2015.
costs are high: using GSI would appear to expand MWRA's responsibilities to stormwater, which is not part of its enabling act, and which it has no interest in managing without additional funding; GSI requires cooperation with local municipalities and their various land management agencies, leading to multiple decision points, potential conflict, and delay; GSI would provide secondary benefits (environmental and social amenities) to only a subset of MWRA customers; and finally, because it is not a stormwater utility, MWRA has had no experience with GSI. As of 2015, engineers there still express a deep skepticism about its performance. The fact that on top of all these disincentives, MWRA planned its clean-up and CSO program at a time when GSI was not accepted among regulators as a legitimate control technology was in many ways the final nail in the proverbial coffin.

These were largely uncontrollable factors. That is, even if an exceptionally forward-thinking engineer had emerged to promote GSI within MWRA, it is unlikely she would have had much success. In much the same way that Philadelphia, to some degree, "got lucky" Boston's circumstances were exceptionally "unlucky."

On the other hand, there appeared to be a moment in the early 2000s, when an influential outside advocate, like an environmental NGO aligned with a Boston community group or regional EPA, could have encouraged even a modest modification of the plan to include GSI for CSO control. While counterfactuals are just that, they can be useful in thinking through future strategies for change. The fact that no one did, resulted in the missing of a major window of opportunity—a statement with which some environmental advocates and regional officials now appear to agree. And more specifically, it points to the problematic delay among NGOs and EPA in embracing GSI for CSO control, even as it was spreading in local communities and being shown to dramatically reduce water quantity and improve water quality.
More optimistically for sustainability advocates, GSI has been introduced in Boston through its stormwater permit. Although Boston’s CSO “window” is closing, and the period of major investments is largely concluded, the Boston case shows how environmental advocates have used the MS4 permit to spread GSI in Boston and to advance an interpretation of the Clean Water Act that could lead to greater implementation of GSI under the MS4 permitting process. The stormwater program is still too weak to force major infrastructure investments, but the Boston case begins to provide a sense of how this policy may evolve; and how it might become the next major driver of GSI in cities.
PART IV: FINDINGS
CROSS-CASE COMPARISON WITH PORTLAND AND WASHINGTON DC AND IMPLICATIONS FOR PRACTICE

INTRODUCTION
In the cases of Philadelphia and Boston, I have argued that three key factors— the water legacy system, the timing of local pollution control planning projects vis à vis the evolution of norms in the regulatory policy system, and the activities of a policy entrepreneur— account for the very different levels of GSI in each of those cities' wet weather programs. These two cases lie on opposite ends of the spectrum, however, which limits my ability to understand how the identified variables relate to one another. In particular, what is the relationship between the regulatory system and the local legacy structure? Is there any situation in which a regional utility might adopt GSI, or is the structure overriding? To improve the generalizability of my argument, and also enhance the richness of the conclusions I draw from my primary cases, in this chapter I assess two “shadow” cases. Like Philadelphia and Boston, Portland and Washington DC were chosen on the basis of their outcome variable (i.e. level of adoption of GSI) and both represent “hybrid” green/gray approaches to managing their wet weather pollution challenges. An analysis of the development of the programs in each city appears to confirm the importance of timing and local structure, but also highlights the overriding significance of the regulatory policy community, which can stymie local investment in sustainable technologies and slow innovation (Portland) but also support it in organizations that would not naturally embrace it (DC). I discuss the relationship between all four cases, and link them back to the theories of the institutional change and green innovation outlined in Chapter 2. I conclude with recommendations for cities that are currently in the midst of CSO planning and implementation, and contemplating integrating green controls into their LTCP.
In many respects, the characteristics of urban wastewater and stormwater management in the city Portland Oregon in the 1990s were even more favorable to broad-scale GSI adoption—in response to wet weather regulations—than in Philadelphia. These characteristics included an integrated, local stormwater and sewage utility, the Bureau of Environmental Services (BES); a history of infiltration-based drainage practices; and rainfall patterns and highly permeable soils that were particularly amendable to GSI techniques. BES did indeed emerge as an early innovator in GSI techniques, and continues to require GSI implementation through some of the most rigorous stormwater management requirements for redevelopments and green streets standards in the nation. GSI is also now is widely used in its capital improvement plans. Yet, counterintuitively, BES’ $1.4 billion 20-year CSO control plan, completed in 2011, relies on three large underground tunnels, and includes very little GSI. In the following pages, I show how BES’ leadership in innovative stormwater management was facilitated by its integrated structure, favorable local conditions, and a particularly persistent agency landscape architect; however, an early citizen lawsuit in 1991 wrested away much of BES’ control over its CSO program, and at the time, the Oregon State Department of Environmental Quality (DEQ)—BES’ regulator—was not receptive to green techniques for CSO control. Then in 2001, with the backing of environmental advocates, state regulators stymied BES’ efforts to more deeply integrate GSI into its CSO plan, resulting in the tunnel infrastructure that exists today.

The Portland Bureau of Environmental Services: Primed for Green

In 1983, as part of its “urban services policy” that extended water and sewer services to unincorporated parts of Monmoth County, known as “mid-county” (now East Portland), Portland’s city council transferred wastewater and drainage
Managed under Portland's unusual commission form of city government, BES was tasked with providing “sewer and stormwater services to accommodate future and current needs.”\textsuperscript{40} After the passage of the Water Quality Act in 1987, however, BES established a high-level group, now known as “Watershed Services,” to focus on improving habitats and local water quality in expectation of increasingly stringent stormwater rules. As in Philadelphia, this integrated group contained BES’ stormwater and CSO programs, which were still very small, and several “watershed managers” who were tasked with devising restoration plans for Johnson, Fanno, and Tyron Creeks.

\textsuperscript{40} In Portland, four elected commissioners oversee city administration and also (along with the mayor) comprise Portland City Council. commissioners are responsible for appointing directors to the city agencies they oversee. Until 2000, agency directors could not be fired at will, however.
Although Portland’s Council created BES primarily to improve sewer and drainage conditions in communities east of modern day 82nd Ave, by the early 1990s, demands on BES’s environmental quality services were growing. BES faced a barrage of interconnected regulatory requirements that included the Phase I stormwater program (BES received its first permit from the state in 1995) and CSO Policy; a slew of planned and completed TMDLs for local waterways impaired by wet weather discharges; and the potential federal listing of several species of endemic Willamette River salmon as “threatened” under the Federal Endangered Species Act. The impact of these various pressures on BES, led to what one bureau planner referred to as the “great freak-out of the 199os:” the outcome of which was an urgent conversation among BES leaders on how best to head off these growing water quality problems.

These conversations dovetailed well with the activities and GSI advocacy of a landscape architect within the Bureau, Tom Liptan. Liptan joined BES in 1987 as a customer services representative, but was closely following the agency’s wet weather program developments. Prior to moving to Portland, Liptan had worked on stormwater management in Orlando Florida in the 1970s, a time when the state had just passed new stormwater management regulations in an effort to stem lake eutrophication from nutrient runoff. One of his projects was a parking lot redesign that drained runoff to several vegetated and tree-filled landscape swales, thereby protecting local waterbodies and obviating the need for curbs, gutters and pipes.

In 1989, Liptan was hired by BES’ Watershed Services Group as an environmental specialist for the Johnson Creek watershed. That same year Oregon’s Museum of Science and Industry (OMSI) had plans to move to a new site.

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141 In 1988, Oregon’s DEQ issued the first TMDL in the nation for phosphorus loading in the Tualitin River Basin, which included Portland’s Fanno Creek; numerous other TMDLs for local waterbodies followed over the next decade.
142 Author interview with stormwater manager, Bureau of Environmental Services, Portland, February 10, 2015.
143 Author interview with Tom Liptan, Bureau of Environmental Services, Portland, February 10, 2015.
in the watershed, and build a large parking lot. As a plan reviewer for the project, Liptan quickly saw an opportunity to apply the design he helped pioneer in Orlando to OMSI. His bureau managers supported his ideas, and BES began talks with the Museum to create a water sensitive parking lot design. OMSI was interested and when they ran the numbers they also calculated that the redesign would save them $78,000 in reduced construction costs. Over the next two years, BES worked with OMSI’s engineers and architects and other City departments to bring the vision to fruition in 1992. The result was a lot where surface flow moved away from medians into “mini-linear wetlands,” which the Museum used as an educational installation for its visitors (Liptan 2018).

In 1996, stormwater managers at BES formed a stormwater policy advisory committee comprised of staff from BES and other city agencies to brainstorm policy changes that could improve stormwater related water quality concerns and reduce the obstacles implementation posed by various city codes. Liptan continued to advocate for policies that promoted vegetated, onsite stormwater retention. Recognizing that BES engineers were naturally skeptical about GSI in the absence of data, Liptan also began to build and monitor GSI installations in his yard—including bioswales and raingardens, and then the City’s first green roof on his garage in 1996—so that he could present data to bureau engineers. The retention and pollutant treatment results were often very impressive, which was partly due to the fact that Portland’s natural conditions—well drained soils and frequent light storms—were optimal for GSI performance.144

At the same time, there was some precedent for infiltration technologies in Portland. Since the mid-1900s, public and private landowners had installed dry wells or “sumps”—some 9,000 of them—to provide drainage in regions not served by sewers. Although GSI was quite different than 20-30 deep infiltration wells, conceptually, they relied on the same basic mechanics of stormwater

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144Portland receives an average of 37 inches of rainfall each year, but has a total of 100 days of rain. Storms are typically short and light, which is very different from rainfall patterns on the east coast.
control. It was also helpful that communities to the north like Seattle, were beginning to explore GSI as possible solution to runoff pollution; and that Portland's relatively low density and preponderance of single family, detached homes provided many opportunities for implementation. However, because he still had limited influence in the agency, Liptan also sought out bureau managers who supported his ideas:

Each time I had an idea, I took it to someone who wanted to hear it. I don't know how unique that is. Maybe it's pretty basic: there are people with ideas, and there are people with problems who, if they are smart, will listen. 

In 1997, BES began giving small grants and incentives for private landowners to construct GSI facilities on their properties. Then in 1999, after four years of analysis and debate, BES completed its landmark stormwater management manual (SWMM), which set regulations for all new and redevelopment in the city that impacted an area of land 500 square feet or greater—"it's basically anyone doing anything," one planner said. The regulations went well beyond MS4 requirements, which at the time only focused on controlling runoff volume. Approved by council in 1999— one year after nine local salmon species were formally listed as "threatened"—SWMM mandated that any developers in Portland not only ensure that stormwater was infiltrated on-site to the "maximum extent possible" but also reduced pollutant concentrations through the use of GSI. In 2004, the manual was updated with a "stormwater hierarchy," which prioritized complete on-site infiltration of rainfall with a green, surface infiltration system, like a raingarden, swale, or green roof. Over the next years, GSI implementation in Portland accelerated. In 2003, EPA granted Portland $3.4 million to help

145 Author interview with Tom Liptan, Bureau of Environmental Services, Portland, February 10, 2015.
146 Author interview with stormwater manager, Bureau of Environmental Services, Portland, February 10, 2015.
implement its “Innovative Wet Weather Program” which created 30 new GSI demonstration projects in the city. That same year, Liptan helped create the first green street in Portland (and perhaps the nation), a demonstration project that a BES manager spun into a mandatory program for all the City’s capital improvement projects in 2007. Then a year later former BES commissioner Sam Adams initiated a 5-year program called “grey to green” which dedicated $55 million in public funds to spur the development of green infrastructure and support BES’ 2005 Watershed Management Plan, a holistic vision for water management in Portland.

How Portland Ended Up with Over a Billion Dollars-Worth of CSO Tunnels
Given my claim that local, integrated utilities are more likely to embrace GSI for CSO management, Portland seems like an apt case in point, particularly since BES’s CSO program was being developed and implemented alongside its innovative stormwater work, offering plenty of opportunities for cross pollination of ideas and collaboration. But in February of 1991, Northwest Environmental Advocates (NWEA), an environmental advocacy organization based in Portland, sued the City of Portland and alleged that its 55 CSO outfalls, which discharged a total of 6 billion gallon of overflow per year into the Columbia Slough and Willamette River, were in violation of the Clean Water Act. Although NWEA’s challenge remained in the court system until 1998, the lawsuit instigated the state DEQ to take rapid enforcement action, in the form of Stipulation and Final Order (SFO). Thus, at the end of 1991, Portland began an “early” CSO clean-up to meet stringent control standards. Modified in 1994 after the CSO National Policy was released, the amended SFO required BES to reduce discharges to the Slough, identified as the more sensitive water body, by 99% and to the Willamette by 94%.

At the time, tunnels were the clear choice for control technology, and BES agreed to a plan to build three tunnels, one along the Slough and two on either side of the Willamette. However, to reduce the costs of what would become the
largest public works project in the City's history. BES engineers also investigated opportunities to reduce the size of the Willamette east side tunnel—where the largest CSO events were—by using the landscape for stormwater control. As noted, the widespread use of sumps, the low density of residential developments, and the bureau's mandate for stormwater control made this idea particularly attractive as well as logical to many CSO engineers—particularly if it could bring down the costs for ratepayers. DEQ was skeptical, but grudgingly allowed BES to begin implementation of the so-called “cornerstone projects,” initiated at the same time the agency began construction on the first tunnel along the Slough. 147 Of the four main projects, which included separating creeks from sewers and diverting them into wetlands, the most widely known is the downspout disconnection program, considered “the grandfather” of BES' modern GSI program. 148 Operated from 1993 to 2011, the program disconnected 26,000 roofs from the City's sewers, reducing overflows by 1.2 billion gallons at the cost of only 13 million. 149 Taken together, the source control cornerstone projects reduced CSO discharges by 35% and made up only 10% of the total LTCP budget.

Buoyed by the early successes of the CSO cornerstone projects, in 1996, some managers in the bureau began to consider how they could integrate even more source control measures into plan. As engineers turned to pre-design for the Willamette Tunnels, BES published a technical report on “green solutions” that reviewed various options for land based infiltration practices, including those

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147 DEQ also had some legitimate concerns about groundwater infiltration in the Columbia South Shore Well Field, where Portland sourced its back-up drinking water and where some downspout disconnections were being undertaken along with additional sump installation.
148 Author interview with stormwater manager, Bureau of Environmental Services, Portland, February 10, 2015.
149 BES engineers got the idea from Minneapolis' utility, which ran a downspout program for CSO control in the 1980s. For the first two years BES ran the disconnection program as a voluntary pilot, before city council approved a mandatory program in 1995. Engineers were also concerned about flooding and so they installed 3000 sumps to control excess runoff. It turned out the natural drainage was adequate and the sumps were disconnected.
being piloted in the bureau’s stormwater programs (BES 1997). Then in 1999, the Willamette Pre-design Stakeholder Advisory Committee, composed of representatives of various public interests, also threw their weight behind the plan. In a final report to the bureau, they recommended that BES 1) go forward with the west side tunnel (where flows were more difficult to control with GSI) but 2) reduce the size of the west side tunnel to the maximum extent possible through the use of GSI (Willamette River Stakeholder Taskforce 1999). That same year, BES’s new commissioner, Dan Salzman, a trained civil and environmental engineer, emerged as a major champion of the concept. He encouraged the development of an integrative pollution control report called “The Clean River Plan” that broadly argued for a nine-year extension to the ASFO that would allow BES to refine and implement GSI technologies east of the Willamette; more holistically address the range of pollution concerns plaguing local waterways; and increase the environmental benefit accrued for each public dollar spent.

However, given the bureau’s relative inexperience with GSI, it was difficult for the agency to provide DEQ with performance details or technical specifics. Reflecting the general position of EPA and its risk adversity, DEQ itself remained skeptical and unsupportive of GSI for CSO control. Furthermore, NWEA, which had been successful in achieving a 1998 consent decree that required BES to comply with the terms of the ASFO, came out vehemently against the extension, which they perceived as yet another way to delay environmental improvements to the region. While they supported green techniques for water quality, they called the request for an additional nine years “a fallacy of the highest proportions” (NWEA 2001). When DEQ rejected Portland’s request for a hearing to consider replacing its existing LTCP with the Clean Water Plan, NWEA praised the decision as “putting environment before politics” and ensuring that the CSO clean-up process was in no way slowed-down (NWEA 2001).

150 Author Interview with Dan Vizzini, Portland, Oregon, February 10, 2015.
Moving Past Gray: GSI is Business as Usual in Portland

Portland completed the 14’ west side tunnel in 2006 and the 22’ east side tunnel in 2011, at the total cost of $730 million. Although BES was unable to more comprehensively integrate GSI into its LTCP, it plans to invest heavily in further reductions of CSOs with GSI. This is in line with the current ethos of the agency, as expressed in its Watershed Management Plan (2005), and its recognition of GSI’s cost savings and multiple benefits. The commitment to GSI for future CSO reductions is clearly expressed in BES’ post-2011 CSO facilities plan, in which it plans to manage another 6000 acres of impervious surface of CSS draining to the Willamette with GSI by 2050 (BES 2011). Indeed, even as BES was implementing its largely gray LTCP, it began work on “Tabor to the River” in 2009, a multi-year rehabilitation of a 2,000-acre portion of the CSS drainage area that was deferred due to the costs associated with an entirely gray plan in 2000. The new project, which will address basement flooding, sewer backups, and CSO discharges, relies in part on 500 GSI facilities in the right of way and 100 new private GSI facilities. It will cost over $50 million less than the original, completely gray plan, saving $5 for every $1 spent on green (Liptan 2018).

WASHINGTON, DC: A REGIONAL AGENCY GETS GSI FROM ABOVE

If Portland reveals how the regulatory policy system can stymie local investments in sustainable technologies, the case of DC Water demonstrates the opposite: how changing norms in the policy system can feed back down to the local level and spur sustainable innovation even in organizations where the incentives to employ green technologies are not strong. Indeed in 2016, the DC Water and Sewer Agency (DC WASA), the District’s regional wastewater utility, renegotiated its consent decree with EPA to include GSI in its formerly gray, 2.6 billion-program. Under the new plan, WASA will replace one of its three planned tunnels, and dramatically
shorten another, by capturing stormwater at its source with GSI. Although local NGOs had been pushing the utility to do just that since the early 2000s, these ideas received little traction. Instead, the case shows how the appointment of a new, progressive general manager to WASA in 2009, combined with the regulatory developments around GSI that were taking place at this time, produced this somewhat surprising outcome.

**DC WASA: A Regional Utility with a Gray Plan**

Prior to 1996, wastewater management in Washington DC and the surrounding region was managed by the District's Department of Public Works, under the Water and Sewer Utility Administration. In the interest of establishing a financially independent organization, that could more efficiently meet service, maintenance, and regulatory demands, on April 18th, 1996, the District council enacted “The Water and Sewer Establishment and Department of Public Works Reorganization Act.” As a result of this act, DC WASA was created. An independent authority of the District, WASA is currently governed by an eleven-member board of directors representing its regional service area: six members from the District, two members from Prince George's and Montgomery County, and one from Fairfax County. As in Boston, WASA provides drinking water and wastewater services to its member communities, but is not responsible for local stormwater management. Drinking water is purchased from the US Army Corp of Engineers, which controls the Washington Aquaduct and sources water from a portion of the Potomac, some 20 miles northwest of the city. Wastewater is transported to the Blue Plains Treatment Center, which is capable of treating 1 billion gallons per day, and effluent is discharged south of DC into the Potomac River. Because DC WASA is a District authority, DC residents pay retail fees for water and wastewater services, while the outlying counties are charged wholesale. Since 1985, the *Blue Plain Intermunicipal Agreement* has outlined each party's roles, capacity allocation, and financing responsibilities.
Approximately one-third of WASA’s wastewater system is comprised of combined sewers, built in the 1870s. By the late 1990s, it was estimated that the District’s 59 CSOs were dumping some 1.5 billion gallons of overflow into the Anacostia River, 850 million into the Potomac, and 52 million into its tributary, Rock Creek. Yet by 2000, DC WASA had yet to finalize a long term control plan and was engaged in what environmental groups perceived as “foot dragging.”

On February 2nd of that year, Earth Justice sued DC WASA, on behalf of a slew of clients that included Friends of the Earth, the Sierra Club, and the Anacostia Watershed Association, for injunctive relief and civil fines. The complaint alleged that WASA’s CSO discharges were violating water quality standards and that the agency was not implementing its nine minimum controls, as required by its 1997 NPDES permit.

The environmental advocates also sought to use the lawsuit as an inroad to shape WASA’s CSO control plan. In particular, they lobbied heavily for the agency to reduce its reliance on end-of pipe controls and instead incorporate the GSI/LID technologies that were emerging in the surrounding Chesapeake Bay watershed. Indeed, when presented with WASA’s draft LTCP at the end of 2001, a coalition of environmental groups, which included NRDC, chided WASA for its focus on “storage and treatment” and failure to commit measurable funds to source reduction (DC Environmental Network 2001). In a written response and public testimony, the groups argued for “aggressive implementation of source controls including green infrastructure” (DC Environmental Network 2001, 2). NRDC’s Out of the Gutter, published the following year, echoed these recommendations and exhorted WASA and outlined opportunities for the District to apply land based source controls for stormwater and CSO pollution (NRDC 2002).

151 Interview with environmental advocate, Washington, DC, April 29, 2015.
152 Compliant and consent decree on file with author.
In 2002, however, EPA filed its own suit against WASA and by 2005 had entered into a separate consent decree with the agency covering its long term control plan that largely excluded environmental advocates. Ultimately, and perhaps unsurprisingly given WASA’s structure as a regional utility and inexperience with stormwater management, the resulting plan did not include the application of GSI for CSO control. WASA publicly claimed that they could not achieve predictable levels of control with infiltration practices. However, because its negotiations with EPA were not public, it is not clear the extent to which GSI was actually incorporated into WASA’s alternative analyses. Under the consent decree, WASA committed to a 20 year, entirely gray, tunnel-based system that would reduce discharges to the Anacostia, Potomac, and Rock Creek by 96%. In a concession to environmentalists, WASA, also agreed to commit a little over $3 million to building LID retrofits on its properties and to monitor and report on their performance. Reflecting the growing acceptance of GSI for CSO control within the policy community, in the consent decree, EPA also left the door open to possible green “amendments” to the Potomac and Rock Creek tunnels systems based on the WASA’s monitoring results. (The Anacostia tunnel was given highest priority due to the extent of that river’s degradation, and construction on that tunnel system began immediately.)

Environmental groups were disappointed, particularly because they had hoped to see GSI implemented in the Anacostia Watershed, DC’s “forgotten stepchild” located next to low income, minority neighborhoods suffering from

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153 Earth Justice’s 2000 suit was settled separately in 2003. The resulting consent decree focused on WASA’s implementation of the NMCs. As part of the settlement, however, DC WASA also agreed to undertake a supplemental environmental project, and spend no less than $1.7 million on GSI demonstration projects, an effort by the advocates to begin injecting green source control into WASA’s practices.

154 Interview with environmental legal advocate, Washington, DC, April 29, 2015.
chronic disinvestment. However, they also felt that they had waited long enough for a remedy and grudgingly accepted the outcome.

**Environmental Advocates Push for a Model Stormwater Permit**

GSI advocates, however, had substantially more success in negotiations over DC’s Ms4 permit. The District received its first MS4 permit from EPA in 2001 and was required to establish a stormwater utility. When the permit was set to be renewed in 2004, it was challenged as too lax by many of the same environmental groups engaging DC WASA’s long term control plan. These groups pushed the District needed to move beyond stormwater planning and begin implementing controls to protect local waterways and ensure compliance with local TMDLS. Although an EPA environmental appeals board mediated process failed, EPA Region III and the District Department of the Environment (DDOE)—created in 2006 to manage the stormwater permit and program, among other environmental regulations—reached an agreement in 2007 that committed DDOE to a suite of “best management practices” that included numerous GSI demonstration projects, supportive policy measures, quantifiable goals, and timetables (DDOE 2007).

Considered by many environmental groups to be one of the most stringent set of stormwater requirements in the country at that time, the conditions were formally incorporated into DDOE’s 2011 MS4 permit. By then, however, DDOE had already undertaken numerous source control initiatives, including the adoption go parcel based billing in 2009. And over the next years DDOE devised a variety of incentive programs that encouraged the construction of green roofs, downspout disconnections, raingardens, and other GSI technologies; completed numerous

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155 Interview with environmental advocate, Washington, DC, April 27, 2015.

156 At the time, in an unusual arrangement, the permit was issued jointly to the department of public works, the transportation department, DC WASA, and the department of public health. DC WASA was directed to collect and redistribute stormwater fees to implementing agencies, which it still does to this day.
Determination projects; and established a 1.2-inch retention standard for new development, promulgated in 2013.

**DC Water: A New Leader Injects Green, from Above**

The worlds of stormwater and CSO control collided, when George Hawkins came under consideration to lead DC WASA in the late 2000s. At that time, Hawkins was director of DDOE and had overseen the negotiation of the District’s groundbreaking MS4 agreement and the implementation of GSI-based stormwater control measures and policies. A Harvard trained lawyer, who had held senior positions at EPA and served as executive director of several environmental non-profits, Hawkins looked to bring change to WASA. And change was what WASA’s board wanted. As Pipkin (2017) writes, in the early 2000s DC WASA was known primarily for its poor customer service, and its reputation had been seemingly irrevocably tainted when high levels of lead were detected in its drinking water, setting off a major public health crisis. Now it was promising to raise rates to pay for its extraordinarily costly $2.6 billion (up from 2005 estimates of $1.6 billion) CSO control project whose benefits would be invisible to most ratepayers.

Hawkins was expected to reset WASA and regain public confidence. Calling it a “personal priority,” Hawkins also wanted to carry-over his experience from DDOE and integrate GSI into DC’s CSO control plan (Pipkin 2017). Indeed, he told the board not to bring him on if they did not want to move in that direction, a statement that seemed less outlandish in 2009 than it would have in the 1990s. On September 3rd, 2009, by unanimous vote, the board hired him as the new CEO/general manager. Only days earlier Philadelphia’s PWD had released Green City, Clean Waters.

Until Hawkins took over at DC WASA, the agency had shown no signs of changing course on its gray LTCP. Only one year after Hawkins’ appointment, WASA had been rebranded “DC Water,” with a friendlier logo to match, and the agency began committing millions to GSI demonstration projects on the utilities’
property as local demonstration projects. Having been greenlighted by the board, in 2011 Hawkins also entered into exploratory talks with regulators about a possible consent decree renegotiation and initiated an extensive internal modeling program.

Although I have argued that regional utilities experience higher barriers to GSI adoption than local, integrated utilities, in attempting to incorporate GSI into the DC Water’s CSO control plan, in 2011, Hawkins faced fewer challenges than a regional utility like MWRA would have. First, DC Water was the owner and permittee for all the systems’ CSOs. Second, in 2008, the DC Water Board had attempted to deal with rate equity concerns by establishing a parcel based fee (similar to the one used by DDOE) called the Clean Rivers Area Charge or CRIAC. In this way, only DC property owners would be paying for (and benefitting from) GSI, and that charge was already directly linked to their property’s contribution of stormwater. But most importantly, he faced a very different regulatory policy context. By 2011, Philadelphia’s almost entirely green plan had been approved by the state and would soon be greenlighted by the Region III—the same region that permitted DC. And EPA’s Office of Water, now led by Nancy Stoner, was working on several initiatives to enhance the use of GSI in CSO control plans. GSI was moving mainstream.

Nevertheless, DC Water’s first specific proposal for amending its long term control plan put environmental groups in a “bind.” In 2014, DC Water proposed to replace the entirety of the Rock Creek Tunnel and a portion of the Potomac River Tunnel, but provided few measurable targets other than a commitment to $100 million in spending on GSI. The plan also pushed back the LTCP completion deadline eight years. Environmental groups agreed with DC Water’s argument that GSI was “better and faster” than gray because it provided countless secondary

157 Interview with environmental advocate, Washington, DC, April 27, 2015.
benefits to DC ratepayers and water quality improvements began accruing immediately; but they disagreed that the delay to build GSI, made communities “stronger” by easing their rate burden (DC Water 2014). Environmental groups came out in force against the plan. One environmental advocate argued that DC Water was asking the community to trade a plan with enforceable performance metrics for another that had none and would take eight years longer.158 In public comments, Earth Justice (2014) wrote that plan seemed “driven by financial concerns, not by genuine needs associated with green infrastructure.” EPA appeared to agree, as DC Water went back to the drawing board.

The following year DC Water floated a new plan that responded to many of EPA’s and the environmentalists’ concerns. As shown in Figure 8.2, DC Water removed the GSI spending cap and instead committed to managing the first 1.2” of rain falling on 365 acres of impervious area in the Rock Creek Drainage Area and 133 acres in the Potomac drainage area, allowing for the removal of the Rock Creek Tunnel and the shortening of the Potomac Tunnel, with 96% system wide reduction of CSOs by 2030. The utility adopted Region III’s preference for verification programs, and devised a phased approach to implementation that relied heavily on direct investment in “pilot” neighborhoods, as opposed to redevelopment, incentives, or opportunism. This approach pushed back the implementation schedule by 5 years (from a 2025 completion date to 2030).

However, DC Water agreed to revert to the original gray plan and schedule should it find that it was “impractical” to complete all its specified GSI project (DC Water 2015). DC Water expected that the new plan would cost the same as the original gray plan, but the timeline extension would provide some rate relief.

158 Interview with environmental advocate, Washington, DC, April 27, 2015.
Environmental groups were still displeased by the schedule change, but lauded the plan’s improved specificity (Hammer 2015). EPA approved the plan in late 2015, and on January 14, 2016 DC Water and EPA entered into an amended consent decree. As of 2018, DC Water is currently implementing GSI in the first of two designated pilot neighborhoods in the Rock Creek and Potomac River sewershed, with an anticipated construction completion date of 2019, followed by one year of performance monitoring.

Source: DC Water

Figure 8.2. DC Water Amended CSO Control Plan
EXPLAINING GSI ADOPTION IN THE CASES

In the cases of Boston, Philadelphia, Portland, and Washington DC, the National CSO Policy emerges as the common driver for the transformation of water management practices and investment in green infrastructure. Because the pressure— or punctuation— produced by this policy promised to result in massive expenditures it had a destabilizing effect in water utilities that encouraged some individuals to seek out alternatives approaches. However, each of the cities examined in this dissertation show very different responses to that pressure. While Philadelphia adopted a radically green approach to comply with the CSO policy, Boston’s approach was entirely gray. Portland ended up with a largely gray plan that included some gray elements. DC was on track to spend 2.6 billion on tunnels, but is now looking to a “hybrid” gray-green approach.

In answering my primary research question— why are some cities widely implementing innovative green stormwater technologies and supportive policies, while other cities facing similar pressures are not— I have argued that three variables account for these different outcomes in the face of the same regulatory pressure: the water legacy system, the timing of CSO planning and implementation vis-à-vis evolution in the regulatory policy system, and the activities of a policy entrepreneur. I discuss each of these variables and their interactions in more detail below.

The Legacy System: How Historically Derived Institutions Shape the “Possible”

A central finding of this study is that the structure of water governance and even the physical urban water infrastructure framed the way engineers in these water utilities conceived of their problems and shaped their possible solution set. In local and integrated utilities, with joint responsibility for stormwater and wastewater management, a history of land-based control of stormwater, and internal incentives to find holistic solutions to multiple regulatory demands, GSI was particularly attractive. As evidenced in Portland and Philadelphia, it emerged as a
control option rather naturally, from the “bottom up.” And once it was posed as a serious alternative technology, and subsequently investigated, GSI also appeared to offer a potentially cheaper solution, particularly if the burden of implementation could be shifted to private landowners. The benefits that accrued to neighborhoods and communities from GSI development were also widely perceived as boons because they increased public support, potentially muting political challenges to rate hikes.

Conversely, in the cases of Boston and DC, where stormwater and wastewater is fragmented between the local and regional, the conceptual division between stormwater management and wastewater control was reinforced by the bifurcation of management responsibility between local and regional agencies. Thus, source control was not even entertained by CSO engineers as a tenable alternative and was rarely (if ever) part of the possible set of solutions, or “alternatives,” under consideration for a CSO control program. This had profound implications, because its natural exclusion meant these organizations were not able to objectively assess its advantages and drawbacks. Instead engineers relied on historical experience that told them, as in Boston, that coordination across municipalities would be untenable, public response would be negative, and adopting GSI in any form would signal a new obligation to stormwater management.

Historical institutionalists have long argued that policy never starts from a clean slate; outcomes are structured by existing institutions that inhibit certain choices, while facilitating other. These institutions also include ideologies, that constrain policymakers by limiting the range of options that are considered “acceptable.” In the case of GSI adoption in the US, this argument is clearly on display.

For all the reasons discussed, we should expect GSI to emerge more readily in integrated utilities, and with much more difficulty in regional ones. However, the cases of Washington DC and Portland suggest that what ideas and technical
solutions are considered legitimate in water utilities are not only established by their historic structure, but by developments in the regulatory community, which, by the nature of its enforcement powers, has the ability constrain or promote particular pollution management approaches in cities.

**Timing and Policy “Fit”**

Portland and DC both present interesting counter-points to the structural argument discussed above. That is, if the legacy system was the primary determining factor for adoption of and investment in GSI, we would certainly have expected a much greener CSO plan in Portland, and DC’s about-face would appear highly unusual. Of course, as the cases show, the legacy system is not the only influence on what ideas or technologies are considered reasonable or even possible by engineers in water utilities. Since 1972, water utilities have been spun off from city governments specifically to give them the ability to autonomously respond the proliferation of environmental laws and regulations. Therefore EPA’s regulatory policies are also central to understanding pollution planning decision-making in cities. Indeed, a recent survey found that utilities report “regulatory compliance” as the top driver of their infrastructure investments (Black and Vetch 2013). While EPA does not force cities to use specific technologies or take particular approaches to meet compliance, cities as well as regional and state regulators look to EPA Headquarters for formal guidance, as well as informal cues about what will pass muster. EPA conveys these best practices through wording in policies, through guidance documents, through permit review, and through other formal and informal channels—meetings, conferences, and so forth.

But what is considered a best practice changes over time. It changes as new ideas take root in the EPA through internal processes. But it also changes through pressure exerted by external actors, such as NGOs and cities themselves, as they learn from their and other’s experiences. Through the cases and the history of GSI outlined in Chapter 5, we see the contours of 10-15-year process of technological
development and policy integration. GSI was innovated by landscape architects and stormwater engineers in the early 1990s in response to non-point source pollution challenges and new regulatory demands. As early monitoring began to show promising pollution reduction results, these approaches were recognized for their potential to address municipal systems, including combined overflows, and they were diffused through the policy subsystem and elevated to the national level through guidance documents in 2000. However, at this time, several major links were missing that were necessary to begin GSI's integration into regulatory policy for wet weather compliance. The first was the ability to model GSI's performance at the landscape level, which was ultimately solved by EPA's modification of its SWMM modeling tool around 2005. The second missing link was a policy statement from headquarters that sanctioned the use of GSI for CSO compliance. The joint lobbying of an unusual coalition of environmental groups and municipalities produced that breakthrough in 2007, opening up a period of policy integration and refinement that continues to this day.

Because EPA's position on GSI for CSO control is not stagnant, but is evolving, chronology and timing in each of the cases matters. That is, when a city embarked—or in most cases was forced to embark because of litigation—on CSO reduction matters, because whatever was the current position of EPA shaped that city's suite of choices, as well as their ability to modify their plan moving forward. And in fact, while many might assume that it would best to address water pollution problems as quickly as possible, it turns out that cities that began planning and construction in the late 1980s and early 1990s were at a disadvantage because at that time the only way was the gray way. Had Portland begun its planning in 2005, like DC, for example, there is little doubt its CSO plan would look very different today.

On the other hand, “laggard” cities, like Philadelphia and DC were able to benefit from the ongoing legitimation of GSI for CSO control at the time of their planning. (A legitimation that—it should be pointed out—Philadelphia's PWD
helped advance.) In a manner of speaking, they were able to “leap frog,” taking advantage of both technological and policy developments that had increased GSI’s credibility among regulators. Laggards also benefitted from precedents set by other cities. For example, DC certainly benefitted from the precedent established by Philadelphia’s LTCPU approval just as future cities will likely benefit from the precedent established by DC’s consent decree renegotiation.

Finally, EPA’s acceptance of GSI for CSO control helped change its appeal in organizations that would not naturally have embraced it, like DC Water. The cases also show that the regulatory policy system lagged the innovation that was occurring in cities with integrated utilities, like Portland. Ironically, it was EPA and state regulators, and even in some cases environmental NGOs, that stymied “early” investments in sustainable technologies for urban water pollution control. In this way, we begin to see the relationship between timing and structure, that is presented in Figure 8.1.

![Figure 8.1: The Relationship Between Timing and Structure on GSI Adoption and Investment](image)

The reasons for this are clear; regulators at EPA and environmental advocates have historically made decisions based on risk assessments and have
therefore driven communities to attack pollution problems quickly. Both of these inclinations appear problematic in light of my findings, however. New technologies and management regimes always carry with them new uncertainties. While fear of continuing environmental damage is legitimate, the cases suggest that flexibility should be balanced with accountability in a way that lets cities experiment, but not take advantage of that right. In that sense, Philadelphia and DC’s current pollution planning efforts might stand as models for just what such a regulatory approach should look like.

The Policy Entrepreneur

Finally, as many others have observed, institutional transformation does not simply emerge from external shocks, even when there are favorable conditions for change. Instead for change to occur, someone (or several people) must take advantage of the favorable context, and build support for a new way of doing things through story-telling, demonstration projects, and coalition building, among other tactics. In Philadelphia we see the paradigmatic policy entrepreneur in Howard Neukrug, who used the regulatory anxiety produced by the CSO Policy to create a new organizational space to build expertise in alternative approaches. He linked solutions emerging in the stormwater pollution sector to PWD’s own challenges and leveraged the support of internal champions, such as the commissioner of the PWD, and external allies, to see his vision through. Neukrug reflected all three of Kingdon’s criteria for an entrepreneur: a “claim to hearing;” exceptional persistence in the face of naysayers; and useful political connections and strong negotiation skills.

It is also important to note that Neukrug was an insider— an administrator in the organization he set out to change. This appears to be a crucial characteristic, at least early in the stages of innovation. Although political leaders are frequently credited with producing sweeping changes in their cities, all three change agents that emerge in the cases were working within the water utility. Given the
complexity of the work undertaken at water utilities and their independence from local politics, this makes sense. What is somewhat more interesting is that Tom Liptan, Howard Neukrug, and George Hawkins were able to act as entrepreneurs from radically different posts within their organization. While this meant that they had to adjust their strategies, they were all able to accomplish rather dramatic shifts. For example, Liptan had to build relationships with GSI champions within his organization, typically high-level managers, who then went on to advocate for the approach and connect with agency leadership. As a manager, Neukrug was able to bypass many of these steps, but still needed to convey the importance of his idea to the commissioner. Of course, as leader of DC Water, Hawkins was in the ideal position to enact change and had to do far less work to bring the organization along.

The cases also show suggest that the type of "work" the entrepreneur must perform to advance an innovation changes as that technology becomes normalized in the broader community. For example, whereas Liptan had to build a green roof on his own garage to prove the efficacy of GSI in 1996, GSI proponents who came along later needed only to point at the many examples of GSI that already existed and were working effectively. Similarly, whereas Neukrug had to engage in extensive politicking at a time when GSI enforcement was still new among regulators, that type of work does not now have to be done—at least in a similarly intensive way. All of this also points to the fact that outsiders may have increasing success in their efforts to get utilities that are not using GSI to begin implementing it. As the technology becomes more established, resistance to its use and excuses about its uncertainty become moot.

CONCLUSION: MOVING FORWARD WITH GREEN

Many cities currently stand at a billion-dollar, CSO crossroads that can lead to more pipes and tunnels or to GSI. The practical implication of this study is that the most favorable context for GSI for CSO control is cities that have integrated, local
utilities, parcel-based stormwater fees, and retention standards. In cities where these policy tools do not exist, it will be more difficult and costly to implement GSI but will likely still result in costs savings. It may also be possible to introduce the necessary policy tools, particularly once politicians are made aware of the enormous costs of the CSO Policy and the savings that can be achieved by leveraging private land. On the other end of the spectrum, regional utilities like MWRA that do not have a mandate for stormwater management and are servicing numerous jurisdictions will have the trickiest time applying GSI for CSO control. Indeed, the more politically complex the regional system, the less likely that GSI should be considered, at least as a primary control option.

The good news for any city or utility that is looking to introduce green into their CSO plans is that it is no longer the 1990s. There is now tremendous support among regulators to help cities achieve this end. Even for cities and utilities that have already planned or embarked on implementation of a gray control plan, it is not too late for them to introduce green or renegotiate their agreement. DC currently stands as a national example of this. And there is more good news: GSI technology has evolved dramatically in the past ten years, as have supportive modeling tools. Indeed, there is no reason why GSI should not be part of any utility’s alternatives analysis. Whether or not it turns out to be the most desirable control technology to meet that city’s needs, it should be considered. GSI is now officially part of the toolkit.
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APPENDIX A

LIST OF INTERVIEWEES

Boston
Borci, Todd, Enforcement Officer, Office of Environmental Stewardship, US Environmental Protection Agency Region 1 (New England)
Bowditch, Kate, Director of Stewardship, Charles River Watershed Association
Civian, Fred, Stormwater Coordinator, Massachusetts Department of Environmental Protection
Herron, Patrick, Water Quality Monitoring Director, Mystic River Watershed Association
Kubiak, David, Senior Program Manager, Massachusetts Water Resources Authority
Iarrapino, Anthony, Senior Attorney, Conservation Law Foundation
Mande, Pallavi, Director of Blue Cities, Charles River Watershed Association
Reinhart, John, Branch Chief for Industrial Wastewater Policy and Regulations, Massachusetts Department of Environmental Protection
Struzziery, John, Senior Program Manager, Kleinfelder
Sullivan, John, Chief Engineer, Boston Water and Sewer Commission

Philadelphia
Abrams, Glen, Director of Sustainable Communities, Pennsylvania Horticultural Society
Burke, David, Watershed Manager, Pennsylvania Department of Environmental Protection
Cammarata, Marc, Director of the Office of Watersheds, Philadelphia Water Department
Capacasa, Jon, Director of the Water Protection Division, US Environmental Protection Agency Region III (Mid-Atlantic)
Crockett, Chris, Deputy Commissioner of Planning and Environmental Services, Philadelphia Water Department
Davis, J. Barry, Chief Deputy City Solicitor, Office of Regulatory Affairs, City of Philadelphia
Dinsmore, Andrew, Stormwater Team Lead, Office of NPDES and Enforcement, Water Protection Division, US Environmental Protection Agency

Many interviewees were reflecting on experiences at previous jobs and were not speaking on behalf of their listed organization or from their position held at time of interview.
Focht, Mark, First Deputy Commissioner, Department of Parks and Recreation, City of Philadelphia
Gajewski, Katherine, Director of the Office of Sustainability, City of Philadelphia
Levine, Adam, Historical Consultant, Philadelphia Water Department
McGuigan, David, Associate Director, Office of NPDES and Enforcement, Water Protection Division, US Environmental Protection Agency Region III (Mid-Atlantic)
Neukrug, Howard, Commissioner, Philadelphia Water Department
Smullen, Jim, Senior Vice President, CDM Smith
Stober, Andrew, Independent Candidate at for At-Large Seat, City of Philadelphia
Walker, Dana, Permit Review, Office of NPDES and Enforcement, Water Protection Division, US Environmental Protection Agency Region III (Mid-Atlantic)

Portland

Clayton, Amber, Stormwater Retrofits Program Manager, Bureau of Environmental Services, City of Portland
Hynson, Mark, Senior Water Quality Permit Writer, Oregon Department of Environmental Quality
Kunec-North, Michelle, Program Coordinator, Bureau of Planning and Sustainability, City of Portland
Liptan, Tom, Environmental Specialist, Bureau of Environmental Services, City of Portland
Mandilag, Arnel, CSO Engineer, Engineering Services Group, Bureau of Environmental Services, City of Portland
Mango, Patrice, Stormwater Program Manager, Bureau of Environmental Services, City of Portland
Pinney, Mike, Senior Environmental Engineer, Oregon Department of Environmental Quality
Vizzini, Dan, Consultant, Thetus Corporation

Washington, DC

Bezak, Bethany, Green Infrastructure Specialist, Clean Rivers Project, DC Water
Champion, Jonathan, Environmental Protection Specialist, Stormwater Management Division, District Department of the Environment
Chavez, Jennifer, Staff Attorney, Earthjustice
Hammer, Rebecca, Senior Attorney, Natural Resources Defense Council
Hill, Peter, Planning and Restoration Branch Chief, District Department of the Environment
Ray, Carlton, Director, Clean Rivers Project, DC Water
Cross-cutting

Levine, Larry, Senior Attorney, Natural Resources Defense Council
Manion, Brenna, Director of Regulatory Affairs and Outreach, National Association of Clean Water Agencies
Pitrowski, Joe, Gulf of Mexico Task Force, Office of Water, US Environmental Protection Agency
Spirn, Anne, Cecil and Ida Green Professor of Landscape Architecture and Planning, MIT
Stoner, Nancy, Director of the Water Program and Senior Fellow, Pisces Foundation