Fluid Frontiers:
stormwater management research in the Red Hook Sewershed, Brooklyn

TOWARD A UNIFIED RED HOOK SEWERSHED

fluid frontiers

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Image Source:
Carrie Melago for The Wall Street Journal
"Flooding around Valentino Pier in Brooklyn's Red Hook neighborhood."

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TABLE OF CONTENTS

LIST OF ACRONYMS

BQE	Brooklyn-Queens Expressway
CB	Community Board
CRC	Charter Revision Council
CSO	Combined Sewer Overflow / Outfall
CWA	Clean Water Act
DDWF	Design Dry Weather Flow
DEC	New York State Department of Environmental Conservation
DEM	Digital Elevation Model
DEP	New York City Department of Environmental Protection
DCP	New York City Department of City Planning
DDC	New York City Department of Design and Construction
DOB	New York City Department of Buildings
DOE	New York City Department of Education
DOT	New York City Department of Transportation
DPR	New York City Department of Parks and Recreation
EPA	United States Environmental Protection Agency
FF	Fluid Frontiers
GI	Green Infrastructure
GIS	Geographic Information System
LTCP	Long Term Control Plans
NYCHA	New York City Housing Authority
NYCT	The New York Community Trust
OLTPS	Office of Long Term Planning and Sustainability
RAMP	Recovery, Adaptation, Mitigation, and Planning
RCNY	The Rules of the City of New York
RH	Red Hook
SAVI	Spatial Analysis Visualization Initiative
SES	Sustainable Environmental Systems
SPDES	State Pollutant Discharge Elimination System
SWIM	Stormwater Infrastructure Matters
WPCP	Water Pollution Control Plant
WWOP	Wet Weather Operating Plan
WWTP	Waste Water Treatment Plant
ZIP	Zone Improvement Plan

FF BACKGROUND

Pratt Institute

Pratt Institute, founded in 1887, is a leading art and design college located in Brooklyn, New York. Pratt offers undergraduate and graduate degree programs in architecture, art and design, information and library science, and liberal arts and sciences and enrolls roughly 5,000 students. Pratt's programs are consistently ranked among the best in the country, and its faculty and alumni include renowned artists, designers, and scholars who collectively have produced some of the most innovative and iconic works of our time.

School of Architecture

Pratt's School of Architecture offers a variety of urbanism programs, employs 275 faculty and serves 1,200 students. Faculty and students work in multidisciplinary environments, which encourage independent learning through studio-based curricula and research-oriented thesis programs. Architecture programs strongly reflect New York City issues and the interests of faculty, creating an optimal atmosphere for research, scholarship, and exploring innovative ideas. Theoretical pursuits in the architecture programs involve cultural studies and experimental design methods, with particular emphasis on creative, interdisciplinary responses to a changing society and key issues such as climate change.

For several years the School of Architecture, through its faculty and administrative leadership has fostered collaborations between the undergraduate and graduate programs. The most recent one is *Recovery, Adaptation, Mitigation and Planning (RAMP) Initiative*, a research collaboration in partnership with the Center for Social Inclusion and funded by the Kresge Foundation. RAMP was conducted as a suite of studios/urban labs, workshops and conferences, which began in the summer of 2013 as a way to engage faculty, students and community leaders in disaster preparedness and resiliency research in the aftermath of Hurricane Sandy. The goals of the RAMP Initiative were to:

(1) develop the capacity and delivery system to assist diverse communities and businesses in their recovery from the impacts of Sandy;

(2) strengthen resilience to face future storms by enabling communities to adapt to the inevitability of climate change;

(3) build capacity to undertake the sustained mitigation actions necessary to reduce concentrations of greenhouse gases;

and (4) encourage planning policies that take a sustained, holistic, and synergistic approach to recovery and post-recovery efforts, as opposed to policies predicated on risk denial or based on short term fixes.

The initiative involved several studios and seminars focused on Red Hook, Brooklyn, a neighborhood that was particularly devastated by the storm. RAMP also laid the framework for interdisciplinary research collaborations between the undergraduate architecture and graduate Sustainable Environmental Systems programs. Fluid Frontiers, will follow in the footsteps of RAMP, furthering similar goals in a very specific target area, namely stormwater management in the Red Hook Sewershed.

As reflected in the research team biographies, each team member contributed their own expertise and perspective. Collectively the team brought fresh eyes to the research challenge. Having studied the City's existing water management system, Fluid Frontiers' Primary Investigators, Zehra Kuz and Jaime Stein, have observed that the City is missing a wide spectrum of opportunities to implement water management solutions by failing to engage local communities and private property owners. Jaime and Zehra recognized a need for broader investigation involving the entirety of the public as well as the private sector in the area of concern.

As such, Pratt Institute with the gracious support of the New York Community Trust launched Fluid Frontiers, an interdisciplinary research project that will use Brooklyn's Red Hook Sewershed as a test-case for developing a methodology and a sewershed specific approach by which the City can engage communities in the implementation of alternative water management technologies. The project will help add to the City's efforts and create a multi-tiered, interdisciplinary approach which engages and shares responsibilities in both public and private sectors.

FF PROJECT BRIEF

Problem Statement

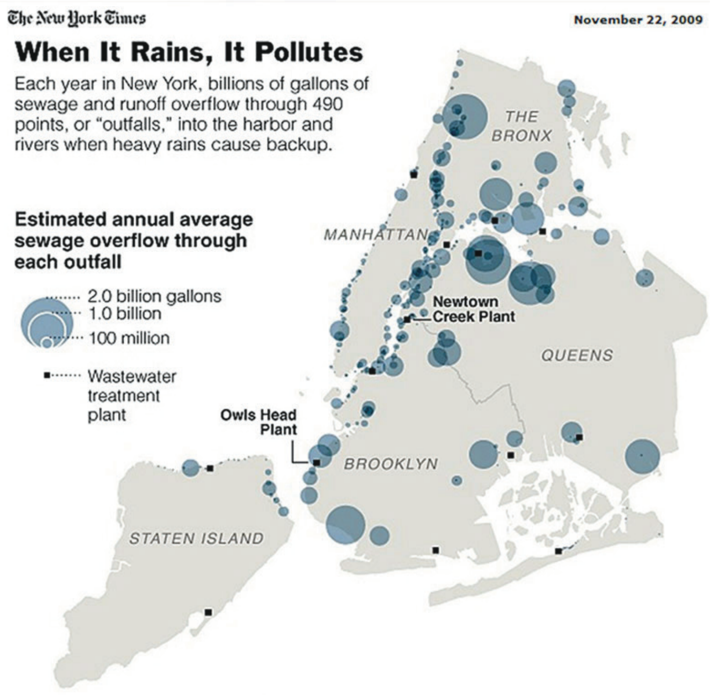
Extreme weather conditions are a key result of Climate Change, with perhaps the greatest harm coming from water-related phenomena, including rising sea levels, groundwater elevations, extreme wet weather patterns (storm/rainfall), and drought. The impacts of rising sea levels, extreme rain, storm surge events, and inland flooding have reached international awareness as waterfront cities worldwide are facing inundation from water. As cities try to cope with these new weather patterns, the limitations of aging infrastructure, including water management and sewer infrastructure present a significant challenge.

This is a particularly important concern in New York City, where Climate Change is affecting densely populated urban areas with ever growing force. More frequent wet weather events coupled with aging, inadequate wastewater infrastructure will result in negative environmental and public health impacts, including the release of raw sewage into surrounding waterways during rainfalls. This release is known as a combined sewer outfall (CSO), a name that references the City's sewage infrastructure consisting of a combined pipe for both sanitary sewers (showers, sinks, toilets) and storm sewers (rainfall). During dry weather this system functions well, but during rain events, rainfall overwhelms the combined pipe and raw sewage is released into surrounding waterways. This release poses significant public health threats to fishers, kayakers, boaters, swimmers, and beach goers, and is a risk to healthy urban living in general.

A 2009 New York Times article reflected on the risk that CSO poses to New York City:

*"One goal of the Clean Water Act of 1972 was to upgrade the nation's sewer systems, many of them built more than a century ago, to handle growing populations and increasing runoff of rainwater and waste. During the 1970s and 1980s, Congress distributed more than $60 billion to cities to make sure that what goes into toilets, industrial drains and street grates would not endanger human health. But despite those upgrades, many sewer systems are still frequently overwhelmed, according to a New York Times analysis of environmental data. As a result, sewage is spilling into waterways."**

As a mega waterfront city with extensive built (impermeable) surface and low lying areas, the coastal waters of Metro New York are especially endangered by extreme wet weather patterns. The City's more than a century old combined sewer infrastructure (aging pipes and inadequate capacity) coupled with urban population growth and ever increasing paved surface area are making efforts to remedy stormwater management problems and comply with the Federal Clean Water Act rather difficult.



*** Text, Image Source:**
Duhigg, Charles. "As Sewers Fill, Waste Poisons Waterways"
The New York Times, 22 Nov. 2009. Web.

New York City is currently in non -attainment of the Clean Water Act, largely due to pollution from CSO. The Act itself has an overarching goal of achieving waters that are fishable and swimmable. Although the City has come a long way in improving the quality of its surrounding water bodies, to this day frequent outfalls of untreated sewage render the City's waterways unfit for primary contact and public use. The City is mandated, through a 2005 Consent Order with the New York State Department of Environmental Conservation, to establish a citywide Long Term Control Plan (LTCP) for the mitigation of CSO as well as ten water body-specific plans. The goal of these plans and their execution is ultimately compliance with the Clean Water Act.

The City's Department of Environmental Protection (DEP) is the responsible city agency in this matter. Long Term Control Plans developed by DEP are a mixture of both standard, hard infrastructure solutions (detention tanks, upgrades to the water pollution control plants) and alternative, green infrastructure (GI) solutions (the use of pervious surfaces, plants, and soils to capture rainwater). Recognizing the need for a formalized approach to alternative water management, DEP's citywide LTCP includes $187 million for GI investment. This is supported by the agency's Green Infrastructure Plan, an ambitious watershed scale plan (released in 2010)* to alternatively manage one inch of rainfall over 10 percent of the City's combined sewer area by 2030. The GI Plan is meant to mitigate CSO in a cost effective way, by harnessing the ability of plants and soils to retain rainwater where it falls.

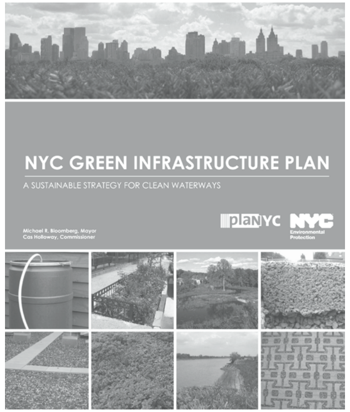
Since the passage of the Plan, DEP has managed to implement GI solutions over 1.3 percent of the City's combined sewer area by concentrating on projects exclusively in the public right of way. (NYC Green Infrastructure: 2014 Annual Report) Their approach is based mainly on infiltration projects within the public domain (such as on streets and sidewalks) and has very limited incentives or programming for private property applications, other than a GI grant program which is only feasible for large institutions. For a variety of reasons, the City's approach will not yield its ultimate goal, and it is clear that the only way to accomplish the Green Infrastructure Plan's stated outcomes is to engage communities in implementing alternative water management strategies on private property.

The situation is dire and urgent, as more frequent and severe rainfall events are expected in New York City. These events will lead to increased CSO, while also revealing other weaknesses and failures in the City's aging sewer system, as was seen in the aftermath of Hurricanes Irene and Sandy in neighborhoods like Red Hook. These weaknesses resulted in standing water, inland flooding, and sewer backups onto streets and private property, bringing the aforementioned public health concerns onto streets and into private homes.

Ameliorating this situation through alternative stormwater management is not without its challenges. One significant challenge area is the need for collaboration between various City agencies. This collaboration is necessary when working with both private property as well as within the public right of way (streets and sidewalks). Recent efforts to promote GI in the City - as seen in the GI Plan and subsequent Grant Program, the Green Roof Tax Abatement, and the online Green Roof Permit application - have attempted to ease the implementation of certain stormwater management strategies, most specifically public right of way bioswales and green roofs. These efforts have succeeded in expanding communication and collaboration between DEP and the Department of Transportation (DOT), Parks Department, Fire Department, Department of Buildings (DOB), and the Department of Design & Construction (DDC), and have encouraged these agencies to acknowledge that implementation of alternative stormwater management projects requires inter-agency cooperation.

In fact, over the past year, DDC has been convening representatives from these agencies, as well as the Department of City Planning (DCP) and Mayor's Office of Long Term Planning & Sustainability (OLTPS), to increase the interagency collaboration required to implement projects within the public right of way. DCP has been a largely silent partner in these collaborations, but with the recent release of their Open Industrial Uses Study they have begun to use zoning as means of dictating water management design guidelines. It is expected that they will continue on this path by focusing on flood-prone areas.

The situation is further complicated by New York City's government landscape and recent changes in leadership. During the Bloomberg administration, DEP went through a dramatic shift in promoting GI. This was a result of several factors, but one key reason was OLTPS's role in spearheading the 2008 Sustainable Stormwater Management Plan, an inter-agency collaboration which ultimately informed and enabled DEP's GI Plan. Under the de Blasio administration, OLTPS's role remains somewhat uncertain. The new administration has devoted significant attention to the Office of Recovery and Resilience, an office created to administer federally-funded post-Hurricane Sandy projects, while its position on continuing DEP's work on the GI Plan and ultimately realizing the City's Long Term Control Plans remains unclear. While the de Blasio administration has yet to articulate how it will focus on these issues, it is important to note that the focus and jurisdiction of City agencies may be in flux.



NYC Green Infrastructure Plan (2010) *is an ambitious watershed scale plan to alternatively manage one inch rainfall over 10 percent of the City's combined sewer area by 2030.*

Goals and Objectives

The overarching, long-term goals of the Fluid Frontiers project are to improve public health and help New York City achieve the goals of the Clean Water Act by mitigating CSO. It is expected that, once refined, Fluid Frontiers' methodology will serve as an approach for all of the City's priority waterbodies (Newtown Creek, Alley Creek, etc.), by documenting the water management failures and challenges specific to each sewershed and elucidating the opportunities for alternative water management solutions within the sewershed's building stock. This approach is predicated on the understanding that upland impacts on a priority waterbody are not limited to the watershed of that waterbody but rather (due to the combined sewer system) expand beyond the watershed to the sewershed. The project's Primary Investigators hope Fluid Frontiers serves as a framework for providing all communities with:

_an easily interpreted map that joins many layers of currently fragmented data;

_a sewershed specific toolkit with customized water management interventions in the built environment;

_and the knowledge and resources to steer water management investments and water management goals for new development

Why focus on the sewershed? The term sewershed refers to the service area of a water pollution control plant (WPCP) and is the unit by which all sewer infrastructure is organized. Basically any sanitary flow or rainwater that falls in a sewershed is meant to be treated by the designated WPCP and its supporting infrastructure of storm drains, sewer pipes, outfall sites and interceptors. This area, the sewershed, is the unit by which we propose to conduct our analysis. One can see that the area of the sewershed touches on many different neighborhoods and its boundaries are not dictated by neighborhood lines. For example the sewershed for the Red Hook WPCP, an estimated 3,000 acres touches Red Hook, Gowanus, Bedford Stuyvesant, Boerum Hill, Park Slope, Cobble Hill, Carroll Gardens Prospect Heights and Crown Heights neighborhoods. The flow of rainwater is equally not dictated by neighborhood lines but rather topography. A new development in Carroll Gardens which increases the sewershed's impervious surface will lead to increased CSO's into the Gowanus Canal or inland flooding in Red Hook. This concept, connecting topography and impervious surfaces is central to the FF methodology and builds upon a Red Hook sewershed analysis recently completed at Pratt (Eichen 2014).

As noted earlier, sewersheds are not dictated by neighborhood boundaries. Therefore it was essential that we engaged with all communities within the sewershed in all phases of work including data collection and formation as well as the dissemination of recommendations. As community boards are the smallest most local bodies of government, the Fluid Frontiers team viewed the community boards as significant partners in the development of the research.

A Secondary System

With limited access to the information pertaining to the underground sewer infrastructure, the team focused the research primarily on quantification, analysis, and interventions on the ground plane, specifically topography and buildings. The team has completed a sewershed analysis which quantifies: (1) inputs from extreme rainfall (2) the WPCP's handling capacity (3) stormwater runoff from existing impervious surfaces (4) stormwater capture from existing pervious surfaces (5) the overland flow of stormwater (6) and lastly, the team has quantified the intervention of greatest impact.

Fluid Frontiers proposes that significant opportunities for alternative water management, assuming extreme rainfall, exist in the City's building stock, through interventions on the vertical and horizontal surfaces. The generated maps quantify the overall potential "area" the team has to work with to implement alternative water management strategies. The mapping analysis juxtaposes sewer infrastructure capacity and performance with water management opportunity areas within the built environment. Thereby quantifying the stormwater capture necessary to allow for optimal performance of the primary sewer system while elucidating opportunities for horizontal and vertical surfaces of the built environment to serve as a "secondary system" to capture and manage the necessary amount of stormwater. The current capacity of WPCP's is limited and cannot handle extreme rainfalls which are and will continue to be a climate change challenge for the City. A challenge which FF feels is not being addressed by the City's GI Plan goal of managing 1 inch of rainfall on 10% of the combined sewer area. Our proposed "secondary system" of water management on the built environment aims to fill in this gap.

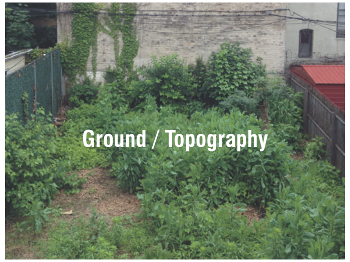


Image Credit
Steve Duncan
ecobrooklyn.com
Vivienne Gucwa

DATA COLLECTION

In order to develop a holistic understanding of the current situation in the Red Hook Sewershed, the Fluid Frontiers team collected information from the past and present on all aspects related to stormwater management within the sewershed.

Analysis of historic land type and use as well as the historic development of the sewer system elucidates the evolution of the built environment and the underlying deficiencies of the sewer system.

Satellite image of Brooklyn with the extent of the Red Hook Sewershed highlighted

VISITING THE PAST

Evolution of Red Hook since the onset of colonization

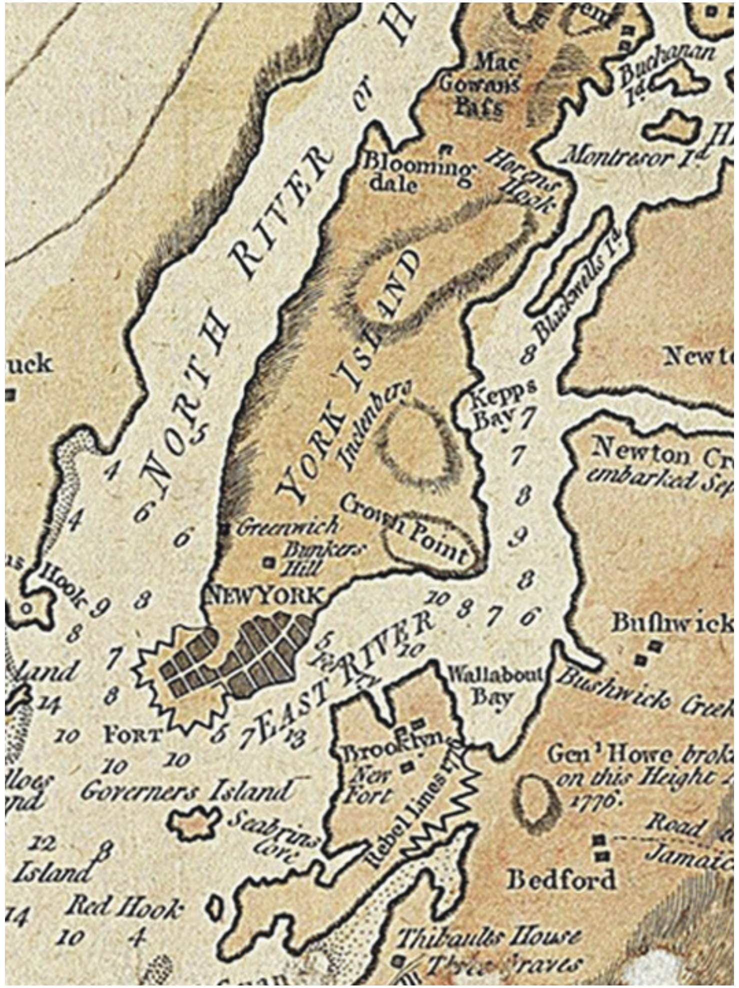
Finding historical maps of the area dating all the way back to the colonization era reveals the extent of land transformation within the New York City region over the course of two hundred years.

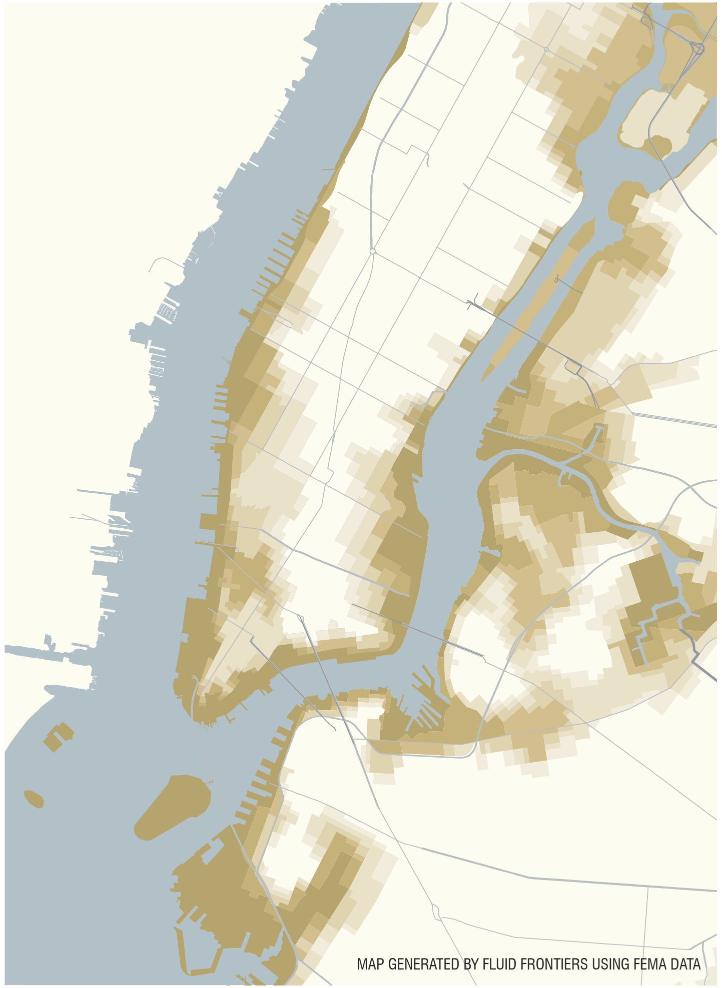
The historic map shown here dated from the mid-seventeenth century depicts New Amsterdam, a small settlement established at the southern tip of York Island (now Manhattan) during the early 17th century. This map renders the topographic formation of Manhattan, flanked by Hudson River on one side and East River on the other, situated across the river from Red Hook, Brooklyn, together forming the New York Harbor. The landmass and the shoreline depicted in the map appear to be drastically different from that of the present. When compared to the Federal Emergency Management Agency (FEMA) map, it is evident that the artificially formed landmass along the shoreline remains the most vulnerable to flooding.

***Left**: Nautical chart and map of the New York Harbor,*

***Right:** Present day New York City with the coastal flood zones highlighted*

Map Source:
John Lodge, Publisher: Bew, John - Norman B. Levinson Map Center, Boston Public Library





Later maps are even more telling; especially, the map on the left, surveyed by the British cartographer, Bernard Ratzer, during 1766-1767, showcases the New York Harbor, Lower Manhattan, Governor's Island and Red Hook, Brooklyn. The area of the present Red Hook Sewershed appears to be entirely green, covered with open farmland divided into parcels, riddled by creeks and canals, and surrounded by beaches and marshlands. There are also few streets (although Flatbush Avenue is recognizable) lined with houses.

The subsequent historical events remarkably changed the built landscape of Brooklyn; the strategic location of Red Hook and Governor's Island in New York Harbor became very important during the American Revolution, as they served a ground for the Battle of Long Island, or also known as the Battle of Brooklyn. The construction of forts in both locations then marked the beginning of land manipulation and transformation of the area.

Another milestone in Brooklyn's development was marked by the City's (Brooklyn's) publication of a plan in 1839, proposing to fill in all of the ponds and elevate the low-laying areas; the plan also included a rigorous street layout for urban development. During the following years, entrepreneurs began to build ports near the Erie, Atlantic and Brooklyn Basins.

The second historic map, which is published by Rand McNally & Co in 1897, a mere ten years after the completion of the Brooklyn Bridge (1883), depicts Brooklyn in the full extent of its municipal boundaries. A year later (in 1898) Brooklyn was annexed into New York City.

These two maps help visualize the extent of transformation from nearly all pervious land-cover to only a few remaining public parks and private gardens within the fully developed urban environment. Comparing both maps (one dating from 1766, the other from 1897) side by side sheds light on the present challenges and threats the Red Hook Sewershed is experiencing with stormwater management. Currently Red Hook Sewershed has 79% impervious surface area.

Left: *Town of Brooklyn, by Bernard Ratzer (1766)*

Right: *Map of Brooklyn, Rand McNally & Co (1897)*

History of the Sewer System in Red Hook, Brooklyn

Historic Sewer Map of 1902, published by Borough of Brooklyn, City of New York

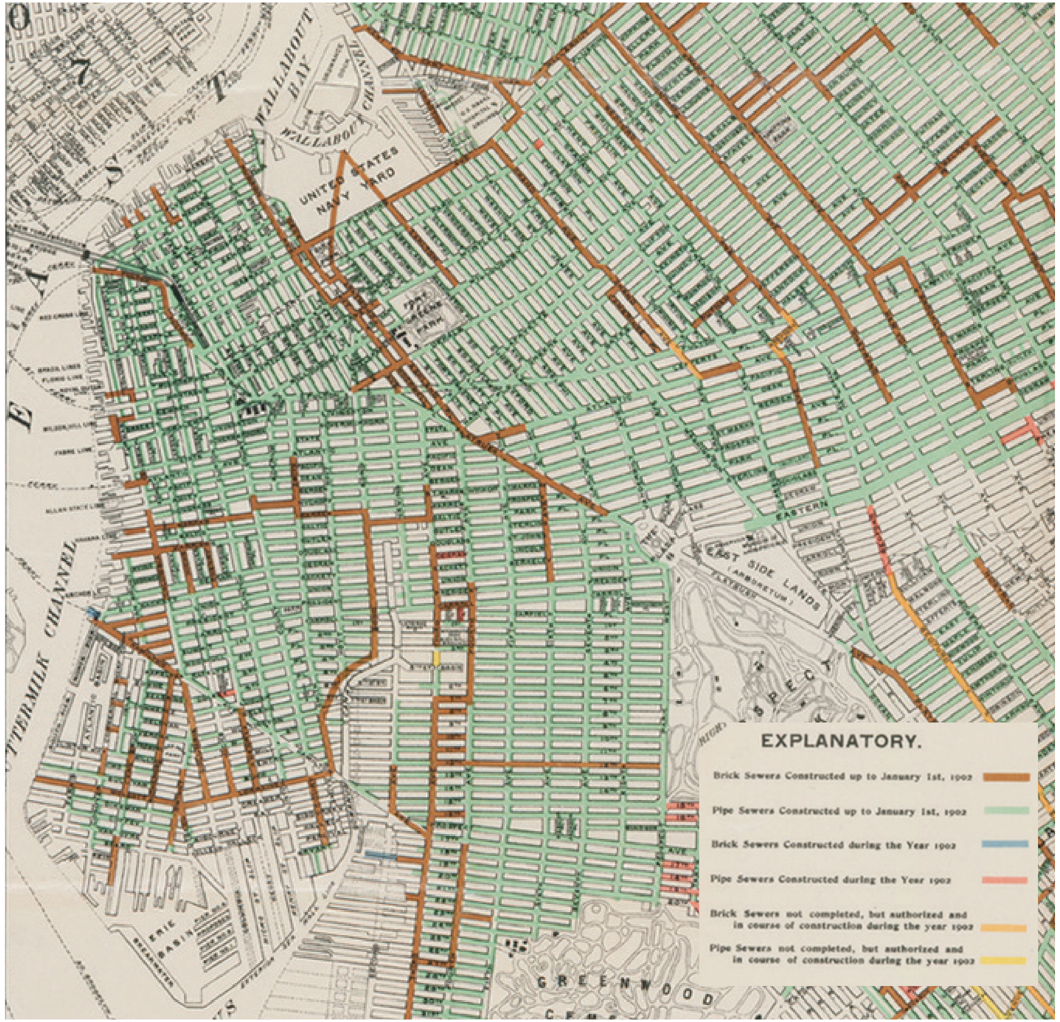
The loss of natural, green and pervious surfaces is not the only burden complicating stormwater management in New York City; there are other invisible challenges. The making process of the City's sewer system is not linear in its planning, building and maintenance. The system is old and incapable of handling the City's current population growth in tandem with extreme rainfall.

Goldman's text covering the origin of planning and implementation of water supply and waste water management in New York City goes back to the early nineteenth century when disease and fire became a great risk for public health. Previously, the supply water came from wells and wastewater was the responsibility of small divisions of local governments, which were paid by private property owners; the poor had only open trenches. This ad-hoc implementation/construction made it impossible to develop an integrated sewer system until later, when the authority over the sewers was transferred from an administrative division of the City to the Croton Aqueduct Department (1830).

Later, from the mid-1850s through the 1860s, New York State turned the city services to regional agencies. It is likely that the planning and construction of the sewer system in Brooklyn was developed following these events.

The onset of urbanization in Brooklyn, especially the area of Red Hook, began with the publication of a masterplan in 1839 and continued with the development of the waterfront as a busy harbor. During the second half of the 19th century, due to the extent of the urban density, Brooklyn centralized its waterworks. The adjacent map, dated 1902, and declared by the 'Office of the President of the Borough, Bureau of Sewers, Borough of Brooklyn, City of New York, renders the completed and planned sewer at the time.

Since the 1920s, Brooklyn has maintained a very high population density. Brooklyn's rapid growth during the last two decades exceeded all the expectations. The current trend of replacing or recycling industrial structures and warehouses into densely populated residential buildings in addition to large scale new construction (e.g. Atlantic Yards) raises concern; urban transformation, coupled with climate change impacts on the inadequate and aging infrastructure implies challenges ahead in the Red Hook Sewershed as in many other coastal, mega cities with the same properties.



Inset showing the Red Hook Sewershed area in greater detail

INSTITUTIONAL FRAGMENTATION

Sewersheds are rather large and their borders are defined by an underground - invisible - network. In order to break down the sewershed into smaller and more workable areas, our team looked at the maps of neighborhoods, assembly districts, community boards, postal ZIP codes, etc. Each entity has a different, arbitrary shape and borders that rarely align. It is, thus, challenging to develop a common vision across the conflicting boundaries or to assign organizational responsibilities for undefined groups. For example, residents of a certain neighborhood can be inspired to pursue a project that would directly contribute to environmental and/or economic betterment of their community.

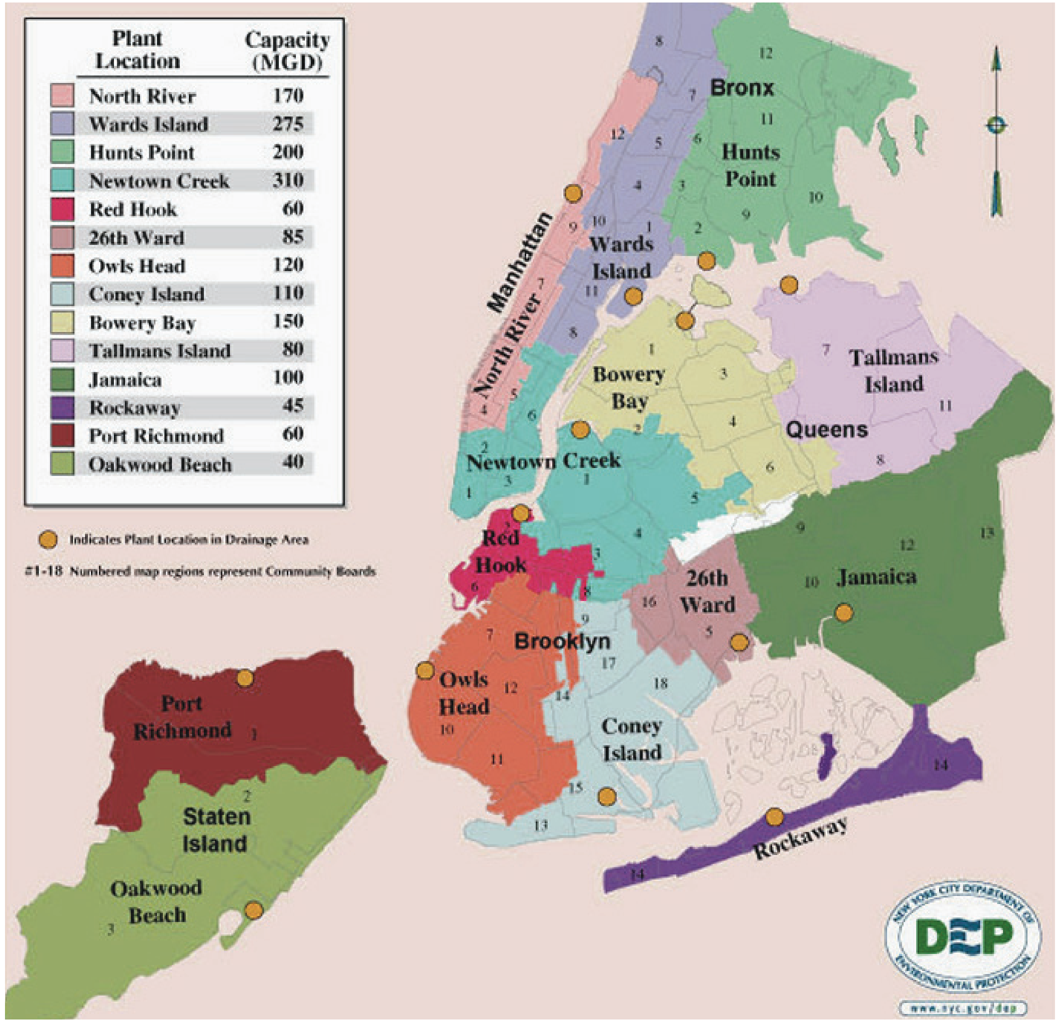
The High Line project in Chelsea, Manhattan is a perfect example of community engagement that transformed a 'challenge' into an 'opportunity' for a neighborhood. Since the 1980s the City's abandoned and rusting section of the original New York Central Rail Road, also known as the West Side Elevated Highway had been central to debates in Mayor Giuliani's office for its demolition. After a long back and forth, a non-profit organization 'Friends of the High Line' was able to raise enough community support and funds for a feasibility study for the project. Later, the conversion of the structure into a public park began during the Bloomberg administration and continued until the last segment to the north was added in 2014.

Although not all of the response was positive, there were numerous benefits, including the revitalization of Chelsea and the rise of property values achieved through the re-purposing of the dilapidated structure. It should be noted that the demolition and removal of the structure would have been very costly. Manhattan's High Line serves as an example of public and private sectors collaborating across political boundaries.

Looking for similarly unifying agents, the team reviewed named boundaries within the Red Hook Sewershed. Some were seemingly arbitrarily drawn, while others were intrinsically ingrained into the perception of the residents. Residents identify themselves with their neighborhoods therefore neighborhood boundaries remain elastic. (E.g. Chinatown and Little Italy, two intertwined neighborhoods in Lower Manhattan where streets are taken over by the expanding group over time.)

While the ZIP codes (Zone Improvement Plan) were developed as a system for the US Postal Service in order to improve the delivery system in 1963, the assembly districts were drawn purely for and by political reasons.

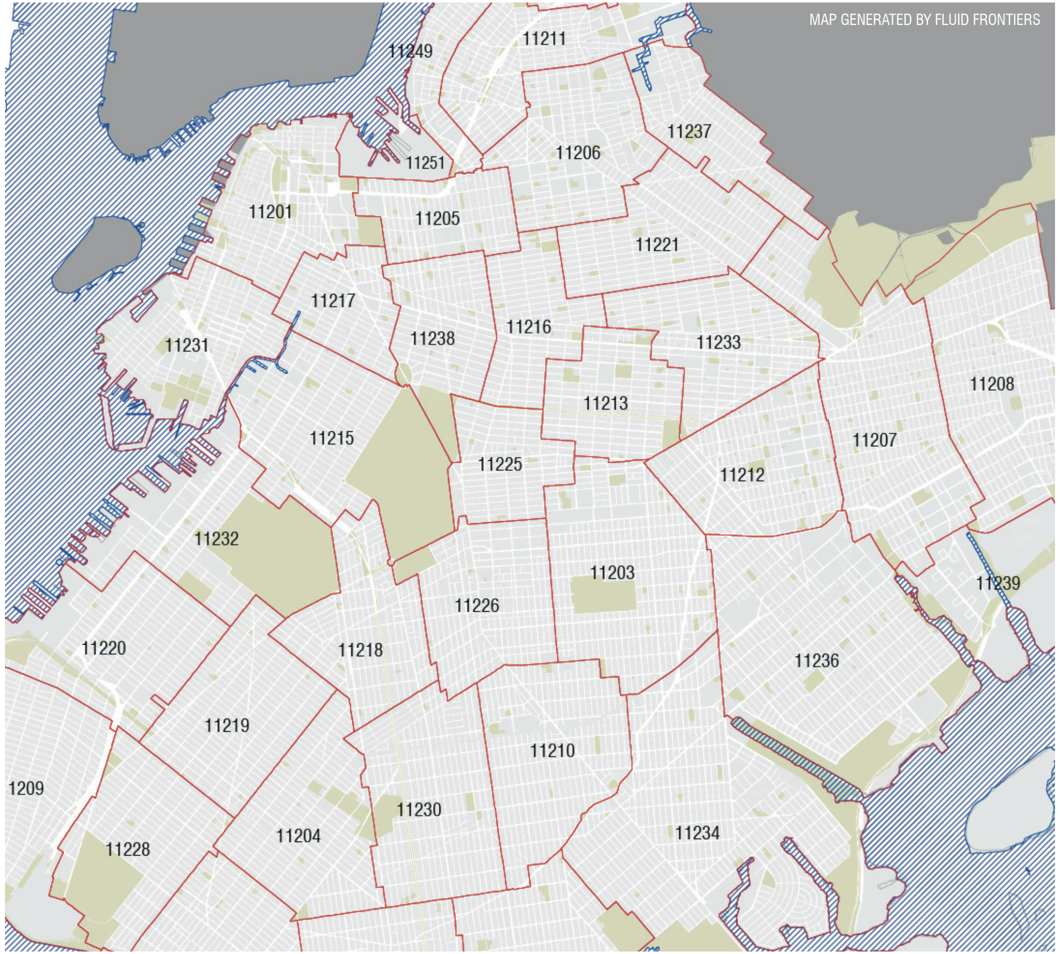
A Sewershed is defined as the tributary area wherein all the waste and stormwater flows to the assigned water pollution control plant (WPCP), one in each of the 14 sewersheds in NYC.



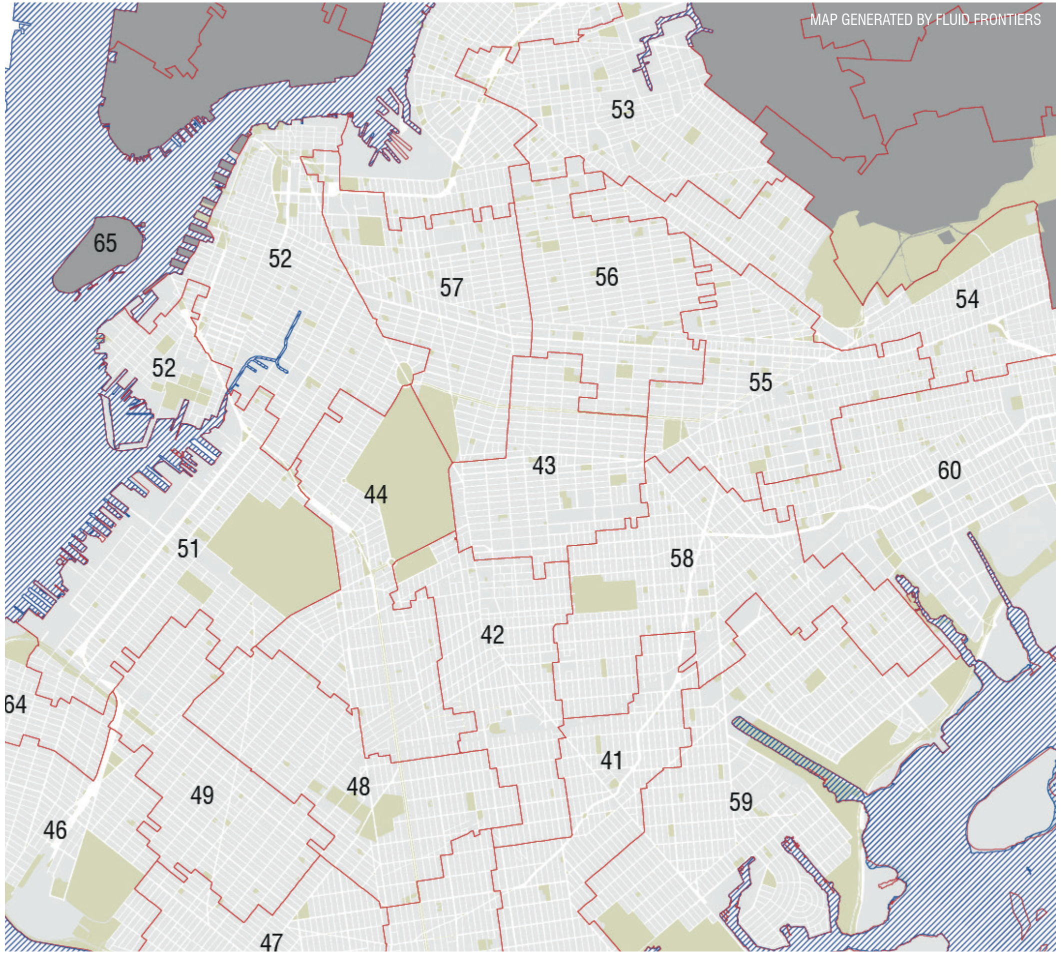
New York City's 14 sewersheds and WPCPs

Map source: *NYC DEP*

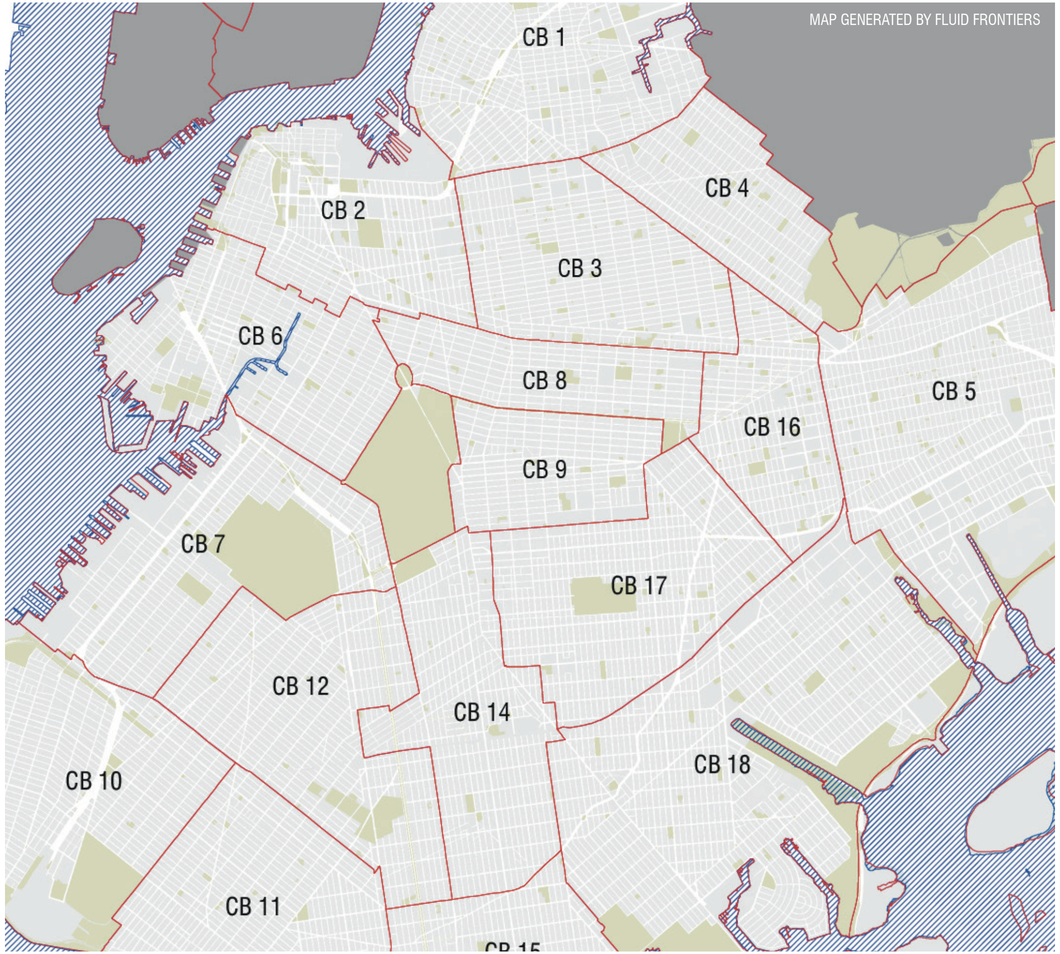
Brooklyn Neighborhoods



Brooklyn ZIP Codes



Brooklyn Assembly Districts



Brooklyn Community Boards

INSTITUTIONAL FRAGMENTATION

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EXCERPT:
New York City Charter as Amended through July 2004, City of New York

Chapter 70 - City Government in the Community
§ 2800. Community Boards

...
d. Each community board shall:

(1) Consider the needs of the district which it serves;

(2) Cooperate with, consult, assist and advise any public officer, agency, local administrators of agencies, legislative body, or the borough president with respect to any matter relating to the welfare of the district and its residents;

(3) At its discretion hold public or private hearings or investigations with respect to any matter relating to the welfare of the district and its residents, but the board shall take action only at a meeting open to the public;

(4) Assist city departments and agencies in communicating with and transmitting information to the people of the district;

(5) Cooperate with the boards of other districts with respect to matters of common concern;
...

Excerpt source:
New York City Charter

"

Community Boards

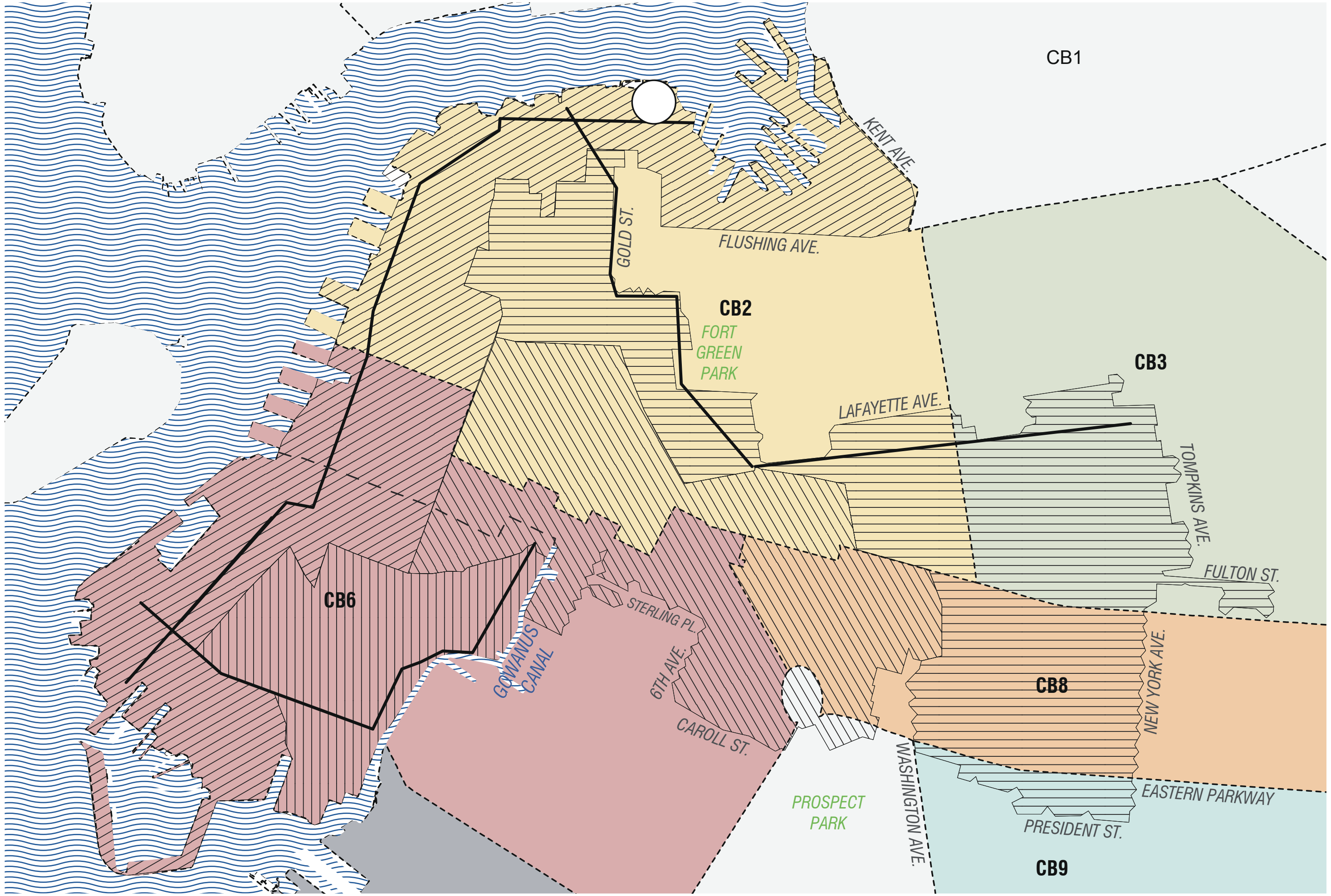
Community Boards (CB's) were initiated in 1951 by the Manhattan Borough President as 'The Community Planning Council'. Since then, the Charter Revision Council (CRC) revised the power and functions of the Community (Planning) Boards (1960s) and formed 59 Community Boards (CB) in the City's five Boroughs (1975). There are 12 Community Boards in Manhattan, 12 in the Bronx, 14 in Queens, 3 in Staten Island and 18 in Brooklyn.

The Community Boards of New York City are advisory groups from various districts which are appointed by the New York City government. Although they have no official authority to enforce laws, Community Boards work in tandem with government agencies on issues that are relevant locally; in addition to land use, zoning and budgetary matters, their role has greatly increased in the Environmental Review processes since 1989.

To further the argument of institutional fragmentation, the FF team superimposed the Community Board boundaries over the Red Hook Sewershed and Sub-Sewershed maps. The Red Hook Sewershed includes five of the 18 Community Boards in Brooklyn: CB2, CB3, CB6, CB8 and a fraction of CB9.

During the investigation FF contacted Community Boards within the sewershed with the intent to exchange information, share observations and build upon local experience. The team soon realized that all Community Boards within the sewershed are connected by both the sewer system and the natural system of topography. However, the residents do not have a clear understanding of this natural and man-made phenomena.

Conversations with the community board members revealed concerns with issues exclusively within their own drawn boundaries. In other words, connections were hardly made that all five CBs are part of one sewershed and, hence, were one entity. Mostly, residents do not understand that during wet weather communities living in higher elevations (CB2, CB3, CB8 and CB9) contribute to the water-related problems in low lying elevations (CB6) within the Red Hook Sewershed. It was soon confirmed that unifying the Community Boards within the Red Hook Sewershed was the challenge and opportunity.



Sub-SEWERSHEDS & COMMUNITY BOARDS IN RED HOOK SEWERSHED

COMMUNITY BOARDS

- CB2
- CB3
- CB6
- CB7
- CB8
- CB9

SUB - SEWERSHEDS

- North Sewer
- Columbia St Interceptor
- Columbia St Interceptor Addition
- Bond Lorraine

- Interceptor
- Flushing Tunnel

Water Pollution Control Plant

DRAWING GENERATED BY FLUID FRONTIERS

FACTS ON RED HOOK SEWERSHED

Red Hook Water Pollution Control Plant*

The Red Hook WPCP is permitted by New York State Department of Environmental Conservation (DEC) under State Pollutant Discharge Elimination System (SPDES) permit number NY-0027073. The facility is located at 63 Flushing Avenue, Brooklyn, NY, 11205, on a 19-acre site, adjacent to the East River and bounded by Flushing Avenue and Navy Street. The Red Hook WPCP serves approximately 3,054 acres of northwest Brooklyn, including the communities of Red Hook, Gowanus, Carroll Gardens, Cobble Hill, Vinegar Hill, Fulton Ferry, Brooklyn Heights, Downtown, Navy Yard, Clinton Hill, Fort Greene, Boerum Hill, Prospect Heights, and the Crown Heights. Approximately 137 miles of sanitary, combined, and interceptor sewers feed the Red Hook WPCP.

The Red Hook WPCP began operating in 1987 with a step-aeration design capacity of 60 million gallons per day (MGD), and has been providing full secondary treatment since 1989. Treatment processes include primary screening, raw sewage pumping, grit removal and primary settling, air-activated sludge capable of operating in the step aeration mode, final settling, and chlorine disinfection. As shown, these existing processes fully utilize the available space at the site.

As DEC requires in the plant SPDES permit and in accordance with the Wet Weather Operating Plan (WWOP), the Red Hook WPCP has a design dry-weather flow (DDWF) capacity of 60 MGD, and is designed to receive a maximum wet-weather flow of 120 MGD (2 times DDWF), with 90 MGD (1.5 times DDWF) receiving secondary treatment. Flows over 90 MGD receive primary treatment and disinfection. The daily average dry-weather flow during 2007 was 30 MGD. During severe wet-weather events in 2007, the WPCP treated 124 to 137 MGD.

**Information gathered from 'Gowanus Canal Waterbody / Watershed Facility Plan', NYC DEP, 2007*

Plant in operation: 1987
Design Capacity: 60 MGD
Dewatering: Red Hook WPCP
Population Served: 192,050
Receiving Waterbody: Lower East River
Drainage Area: 3,200 Acres
Plant Staff: 55
Maximum Capacity:
120 million gallons per day
Dry Weather Capacity:
60 million gallons per day

Data source:
NYC DEP

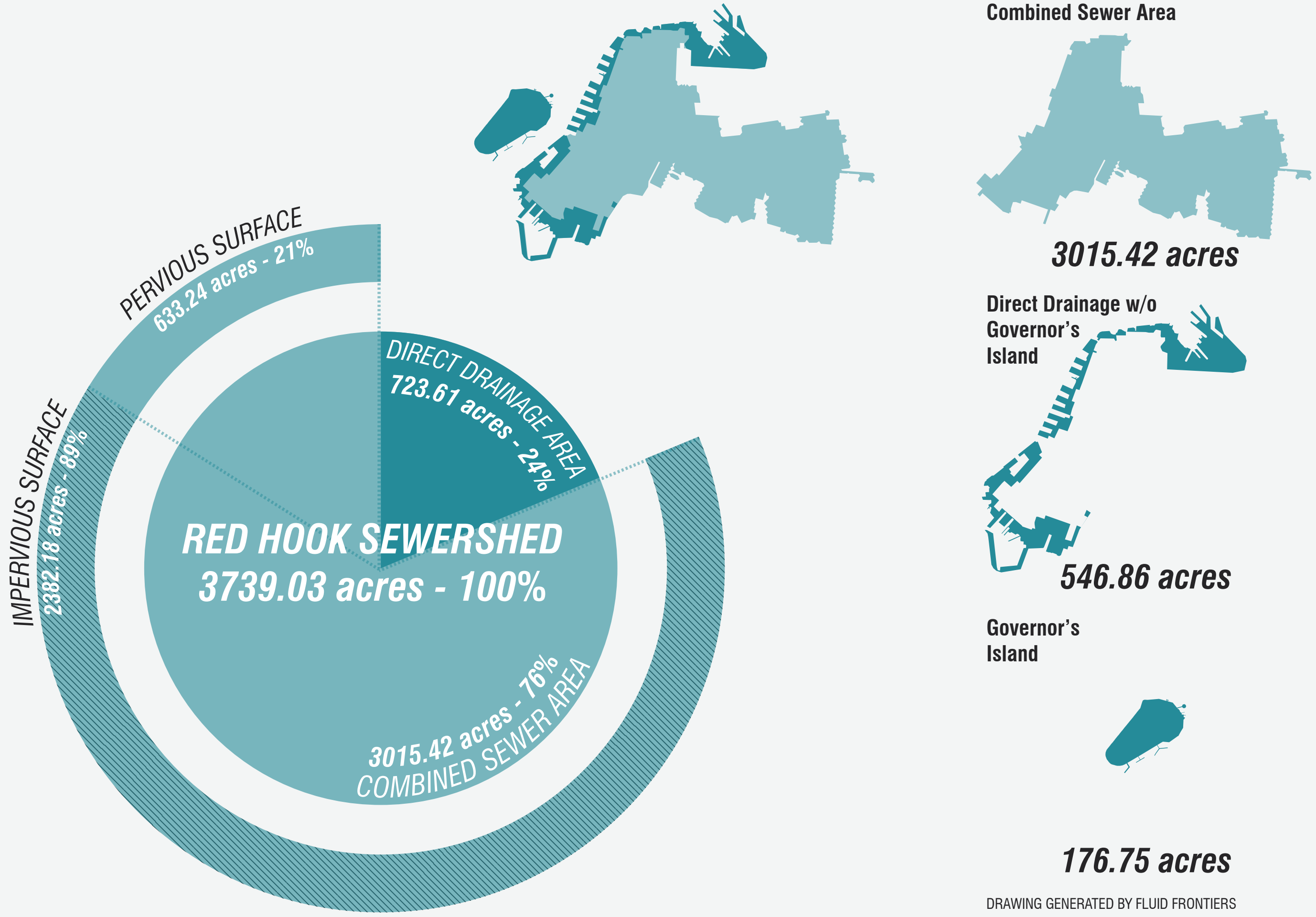
image source
Google Earth

Area Figure on Red Hook Sewershed

The total area of Red Hook Sewershed is approximately 3,740 acres. Of the total area, a direct drainage area including Governor's Island accounts for 24 percent.

For the analysis and calculation of stormwater as showcased in the following chapters of this book, the team focused primarily on the combined sewer area of the Red Hook Sewershed. Since the stormwater that falls on the direct drainage area runs off directly into the harbor, Governor's Island and the shoreline areas were of less concern to the team.

Data Source:
The area data of the Red Hook Sewershed was calculated using the shape files extracted from the ArcGIS software.



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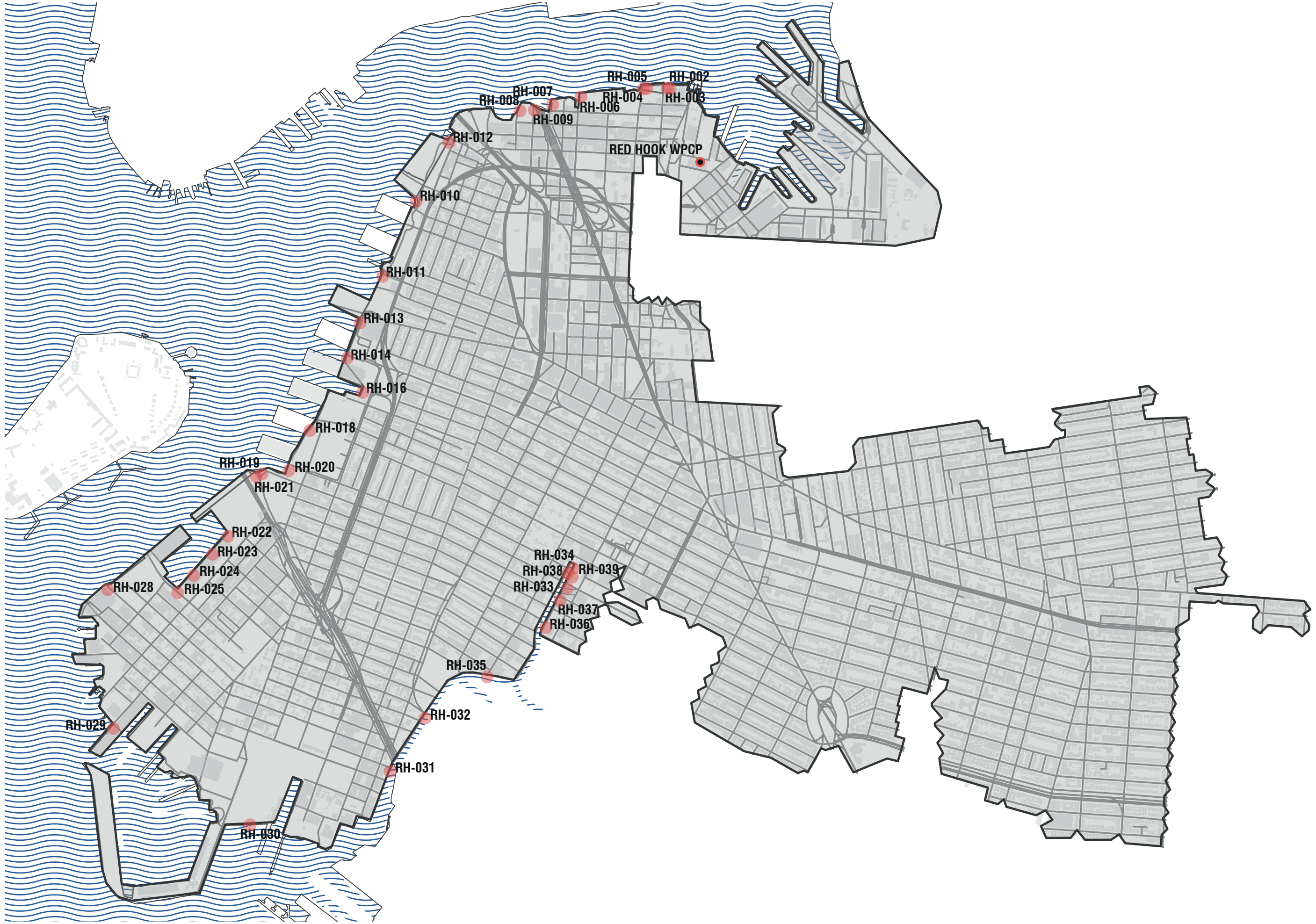
COMBINED SEWER OVERFLOW / OUTFALL (CSO)

As articulated in the project brief section, the City is in non-attainment of the Clean Water Act due to release of untreated sewage into surrounding water bodies. The team completed a thorough area analysis of the sewershed's combined sewer outfall drainage sheds and outfall points. Using geographic information systems (GIS), the team calculated the area for the total sewershed as well as for each outfall drainage shed. The resulting series of maps are displayed on pages 17 - 26. The team views using the lens of the CSO drainage shed as a potential means for prioritizing and locating stormwater management interventions.

The maps depict the drainage sheds for 9 of the sewershed's 39 outfall points. Each outfall point has a corresponding number, the "RH" notates the WPCP.



RED HOOK SEWERSHED

Combined Sewer Outfalls (CSO)

Acres:	*3,684.05*
Sq ft:	*160,476,500.72*
Population:	*211,548*
Housing units:	*104,336*
Water vol. in a 1"storm [gal]:	*100,030,352.11*
Water Consumption [mgd]:	*22,365,203.74*

Land Cover [sqft]	
Tree Canopy	*26,294,321.11*
Grass/Shrub	*10,946,648.14*
Bare Soil	*400,761.26*
Buildings	*49,797,651.93*
Roads/Railroad	*24,738,647.42*
Other Paved Srf.	*48,568,005.69*

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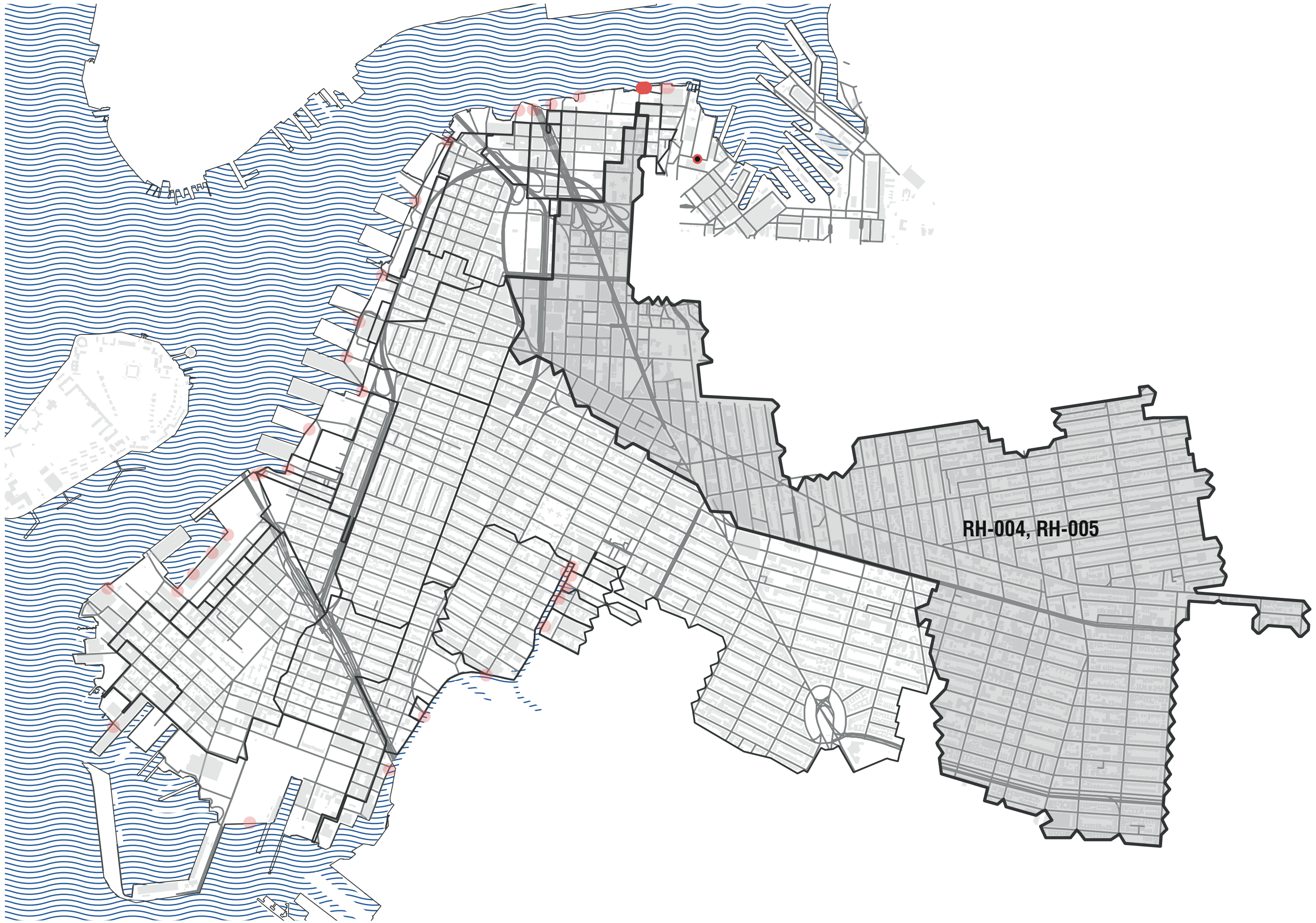

RED HOOK SEWERSHED
Combined Sewer Outfalls (CSO)
RH-004, RH-005

Acres:	*1,253.29*
Sq ft:	*54,593,196.01*
Population:	*98,582.00*
Housing units:	*47,998.00*
Water vol. in a 1" storm [gal]:	*34,029,758.85*
Water Consumption [mgd]:	*10,360,723.40*

Land Cover [sqft]	
Tree Canopy	*9,071,259.22*
Grass/Shrub	*3,086,551.60*
Bare Soil	*64,742.83*
Buildings	*18,871,742.58*
Roads/Railroad	*9,205,528.43*
Other Paved Srf.	*13,932,391.04*

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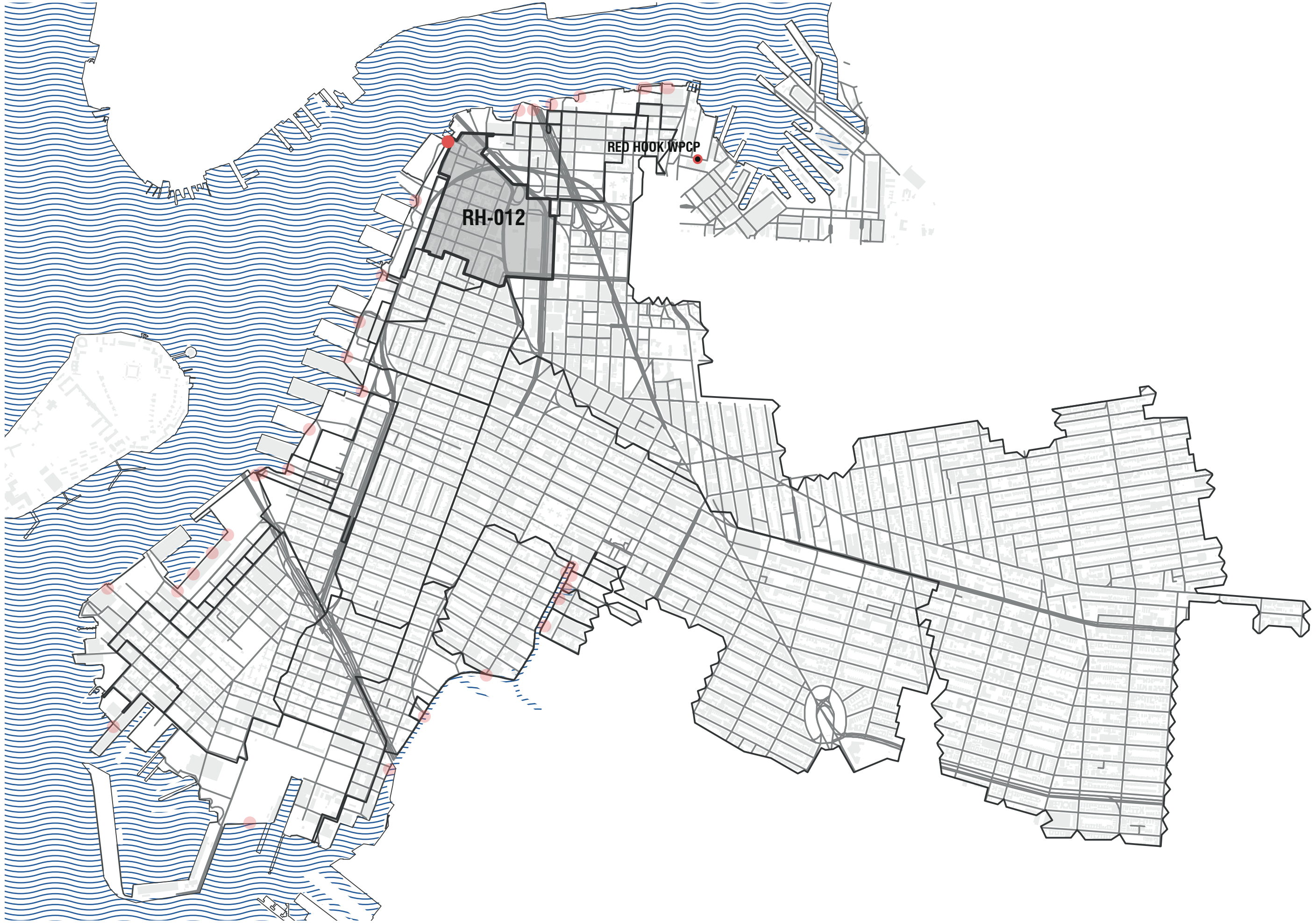

RED HOOK SEWERSHED

Combined Sewer Outfalls (CSO)

RH-012

Acres:	*97.13*
Sq ft:	*4,231,087.21*
Population:	*8,219*
Housing units:	*3,761*
Water vol. in a 1" storm [gal]:	*2,637,377.69*
Water Consumption [mgd]:	*841,708.95*

Land Cover [sqft]	
Tree Canopy	*1,177,319.67*
Grass/Shrub	*133,930.36*
Bare Soil	*0*
Buildings	*1,249,973.22*
Roads/Railroad	*879,667.76*
Other Paved Srf.	*790,112.34*

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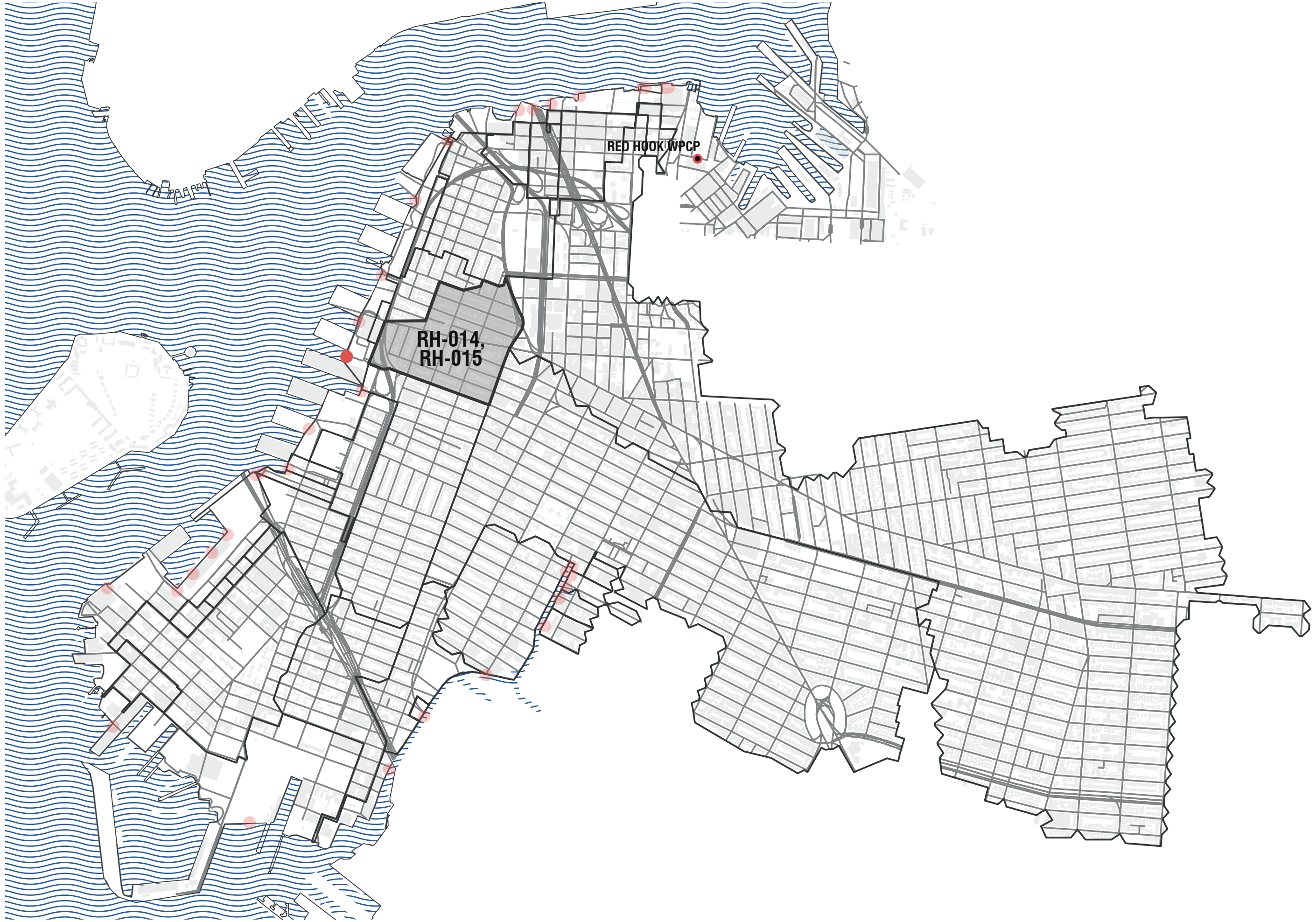

RED HOOK SEWERSHEDS
Combined Sewer Outfalls (CSO)
RH-014, RH-015

Acres:	*89.17*
Sq ft:	*3,884,294.13*
Population:	*7,336*
Housing units:	*4,116*
Water vol. in a 1” storm [gal]:	*2,421,210.01*
Water Consumption [mgd]:	*783,913.25*

Land Cover [sqft]	
Tree Canopy	*948,948.62*
Grass/Shrub	*57,557.74*
Bare Soil	*0*
Buildings	*1,638,120.98*
Roads/Railroad	*521,527.66*
Other Paved Srf.	*718,130.14*

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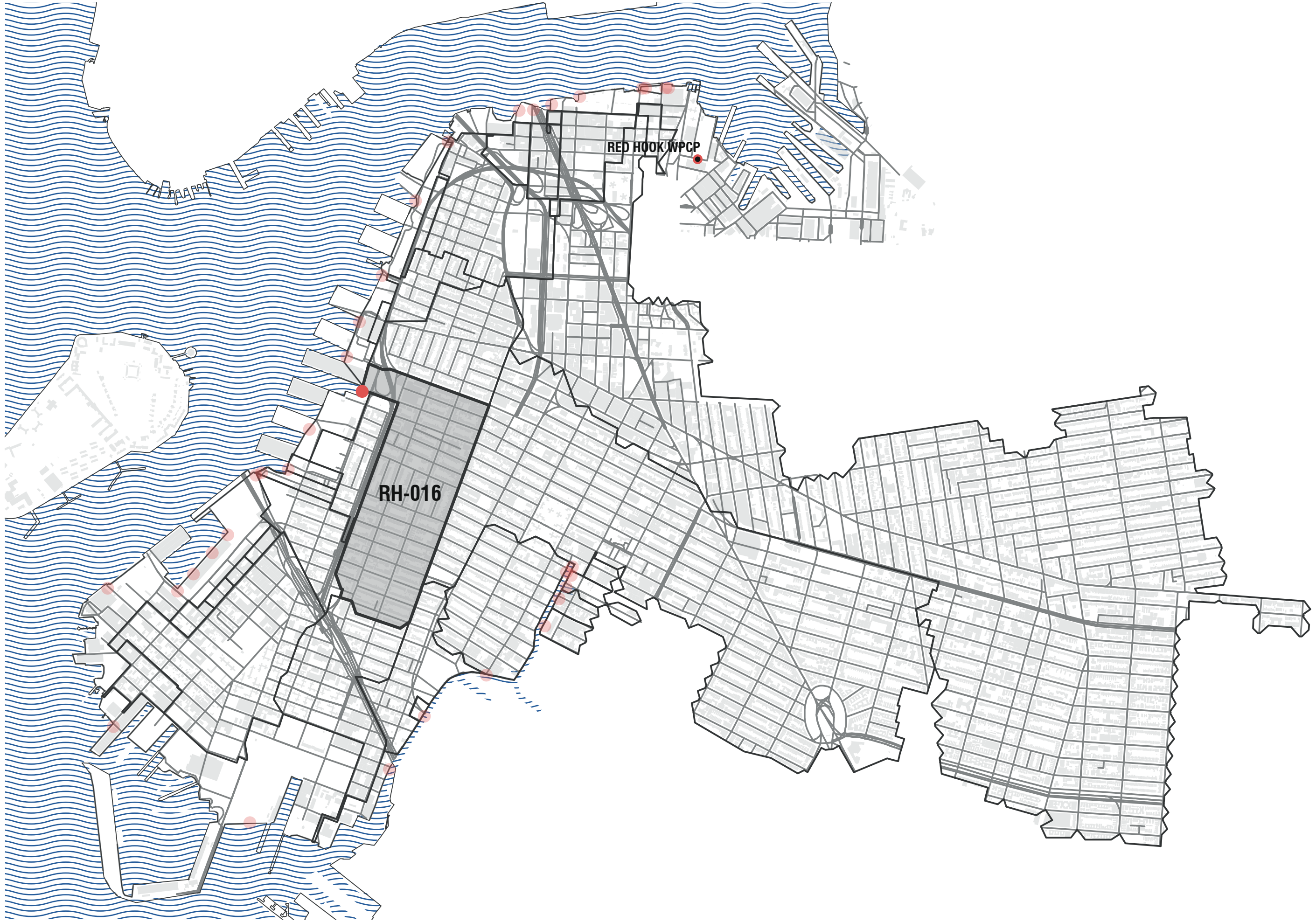

RED HOOK SEWERSHED
Combined Sewer Outfalls (CSO)
RH-016

Acres:	*165.48*
Sq ft:	*7,208,476.25*
Population:	*14,047*
Housing units:	*6,932*
Water vol. in a 1" storm [gal]:	*4,493,283.53*
Water Consumption [mgd]:	*1,422,940.18*

Land Cover [sqft]	
Tree Canopy	*1,905,785.92*
Grass/Shrub	*260,082.72*
Bare Soil	*171.40*
Buildings	*2,607,712.35*
Roads/Railroad	*685,877.62*
Other Paved Srf.	*1,748,809.99*

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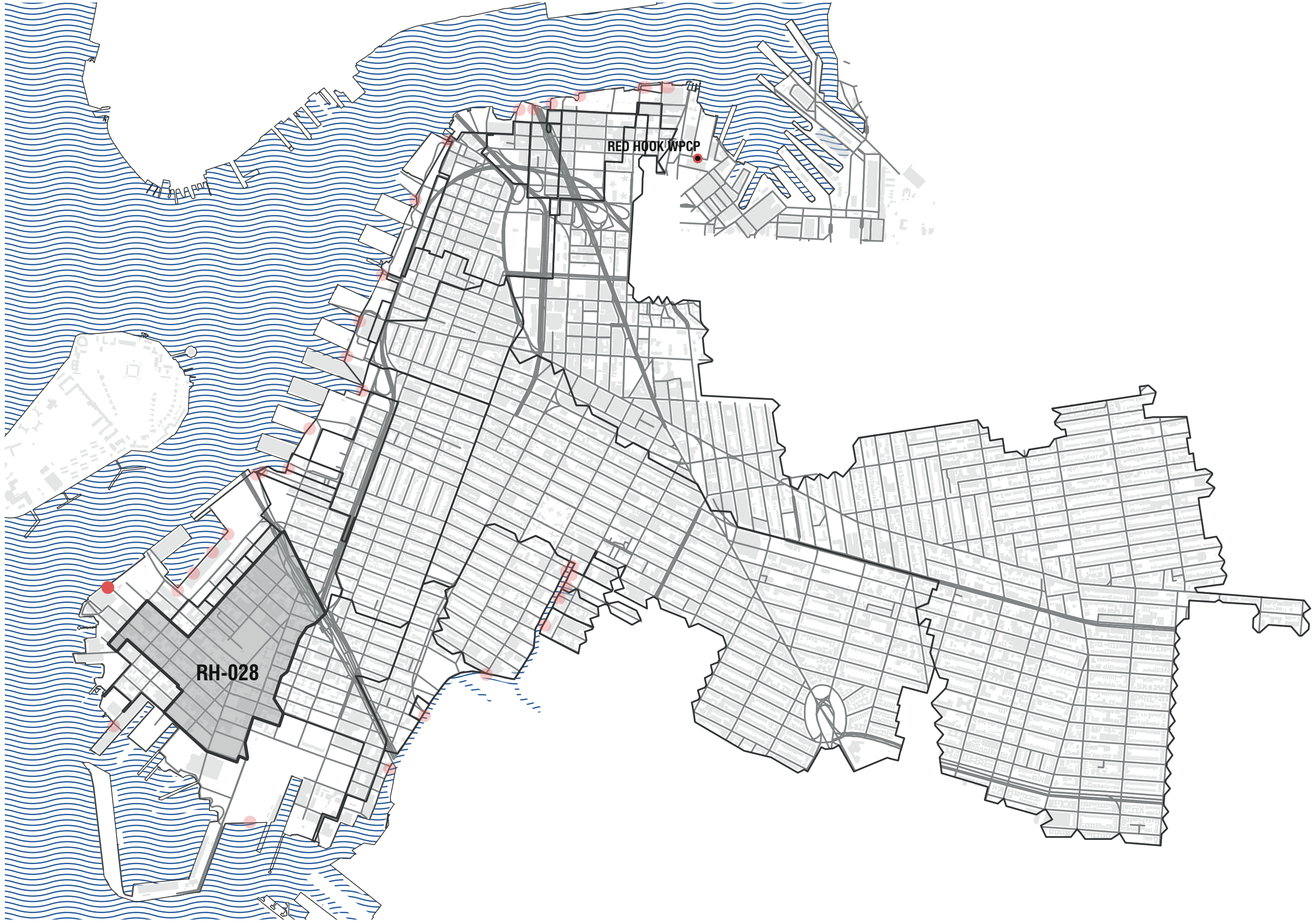

RED HOOK SEWERSHED

Combined Sewer Outfalls (CSO)

RH-028

Acres:	*166.57*
Sq ft:	*7,255,794.11*
Population:	*6,893*
Housing units:	*2,991*
Water vol. in a 1" storm [gal]:	*4,522,778.33*
Water Consumption [mgd]:	*723,549.72*

Land Cover [sqft]

Tree Canopy	*1,075,276.18*
Grass/Shrub	*516,034.38*
Bare Soil	*7,706.17*
Buildings	*1,813,021.37*
Roads/Railroad	*685,877.62*
Other Paved Srf.	*2,356,145.28*

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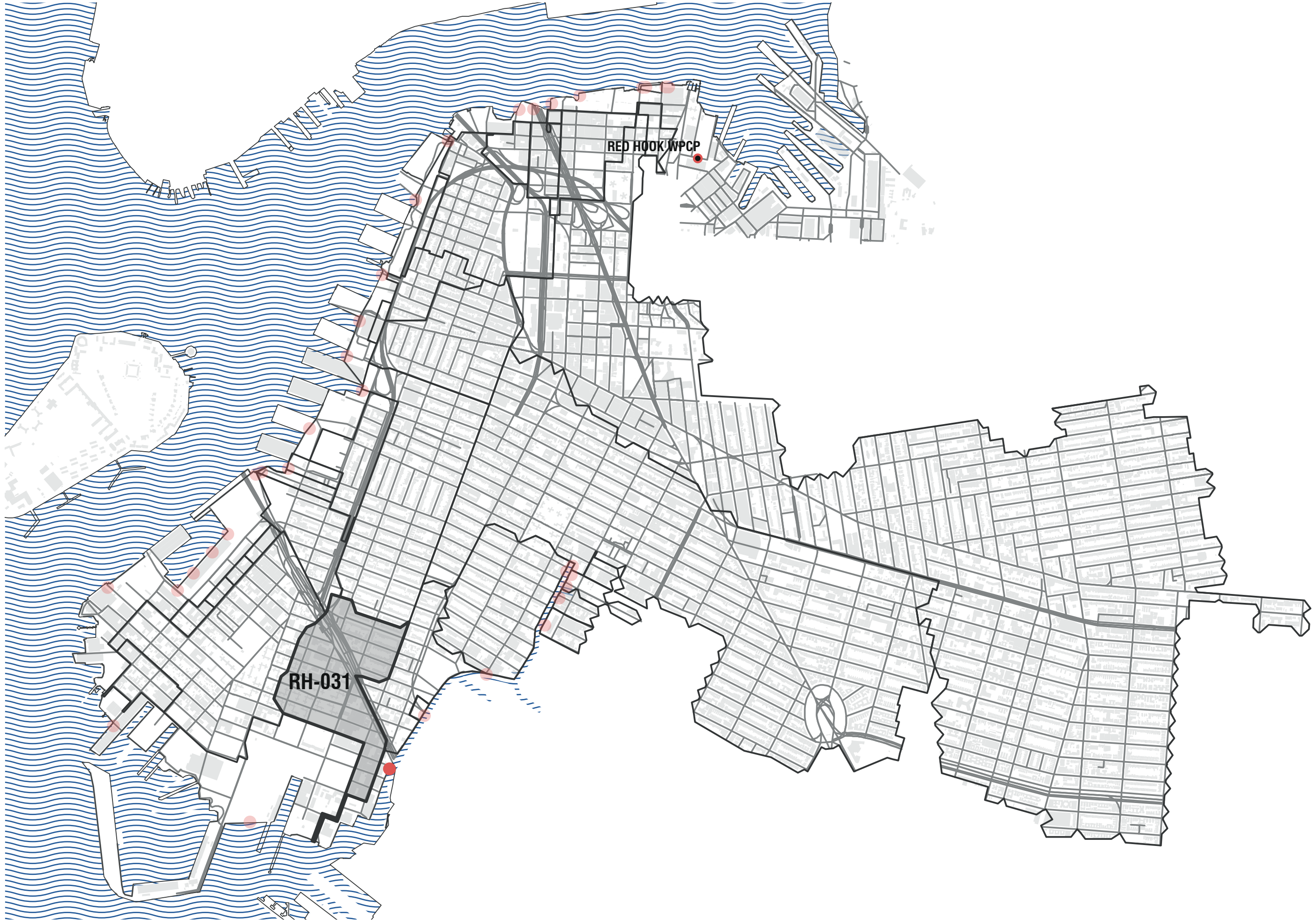

RED HOOK SEWERSHED
Combined Sewer Outfalls (CSO)
RH-031

Acres:	*98.96*
Sq ft:	*4,310,713.33*
Population:	*5,105*
Housing units:	*2,473*
Water vol. in a 1" storm [gal]:	*2,687,011.31*
Water Consumption [mgd]:	*529,309.16*

Land Cover [sqft]	
Tree Canopy	*595,858.94*
Grass/Shrub	*284,244.09*
Bare Soil	*13.86*
Buildings	*1,210,246.69*
Roads/Railroad	*955,073.12*
Other Paved Srf.	*1,259,116.11*

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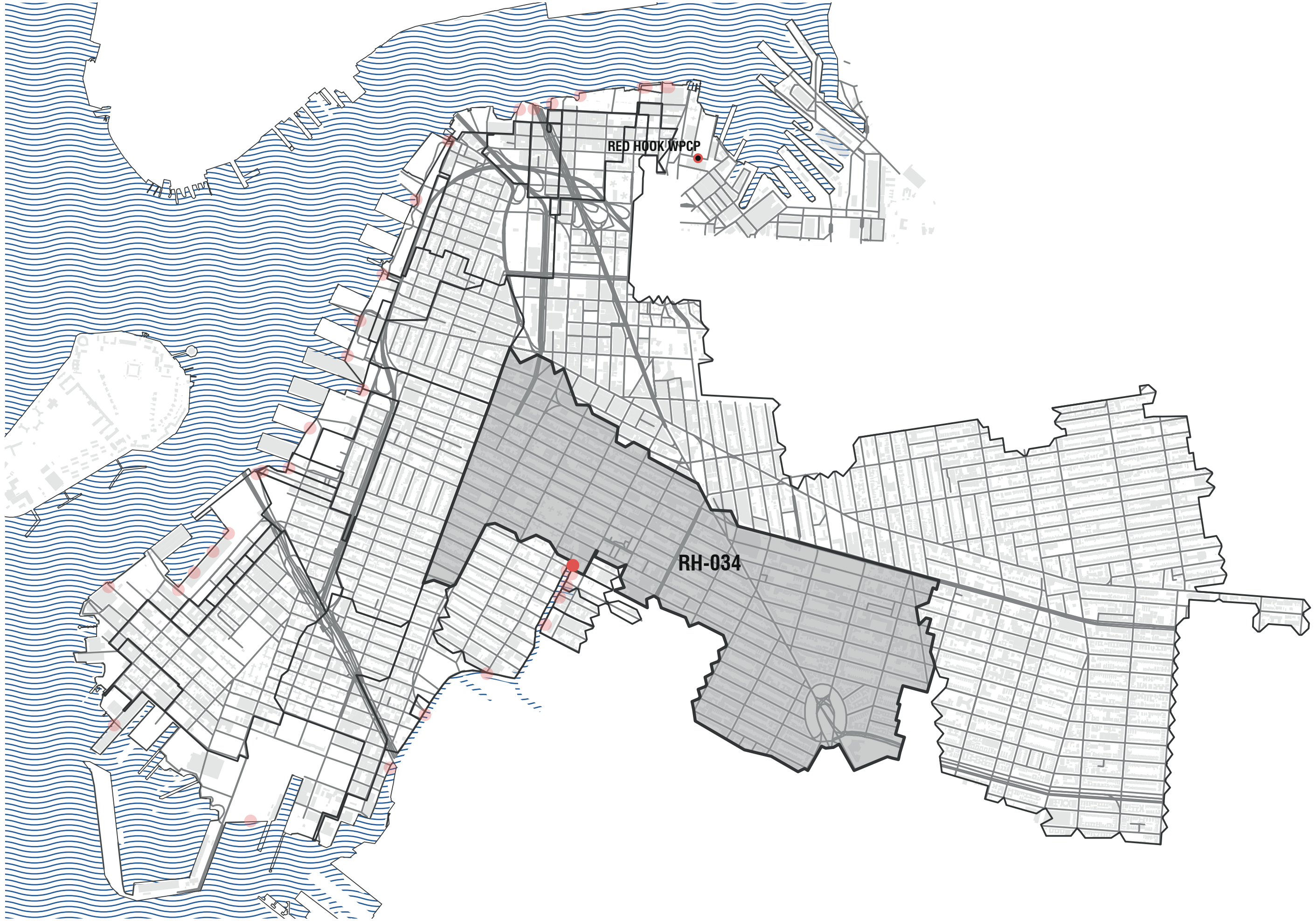

RED HOOK SEWERSHED
Combined Sewer Outfalls (CSO)
RH-034

Acres:	*646.36*
Sq ft:	*28,155,411.83*
Population:	*51,316*
Housing units:	*25,212*
Water vol. in a 1" storm [gal]:	*17,550,206.71*
Water Consumption [mgd]:	*5,344,353.23*

Land Cover [sqft]

Tree Canopy	*5,991,424.81*
Grass/Shrub	*1,331,160.09*
Bare Soil	*21.11*
Buildings	*9,873,802.38*
Roads/Railroad	*4,385,039.52*
Other Paved Srf.	*6,569,029.31*

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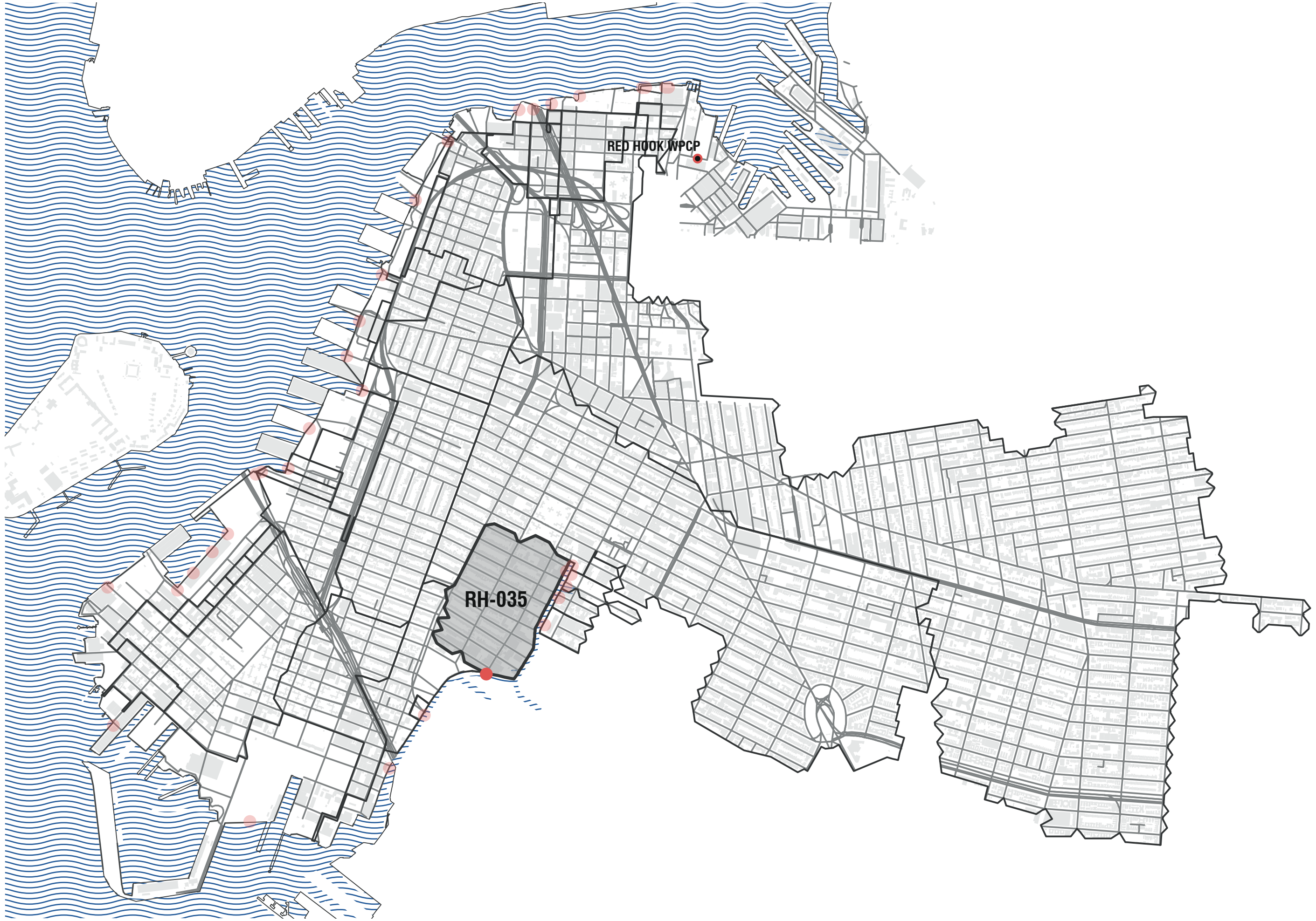

RED HOOK SEWERSHED

Combined Sewer Outfalls (CSO)

RH-035

Acres:	*97.89*
Sq ft:	*4,264,119.36*
Population:	*4,640*
Housing units:	*2,339*
Water vol. in a 1" storm [gal]:	*2,657,967.73*
Water Consumption [mgd]:	*473,067.26*

Land Cover [sqft]	
Tree Canopy	*687,994.98*
Grass/Shrub	*214,044.98*
Bare Soil	*0*
Buildings	*1,506,396.14*
Roads/Railroad	*535,798.95*
Other Paved Srf.	*1,317,640.54*

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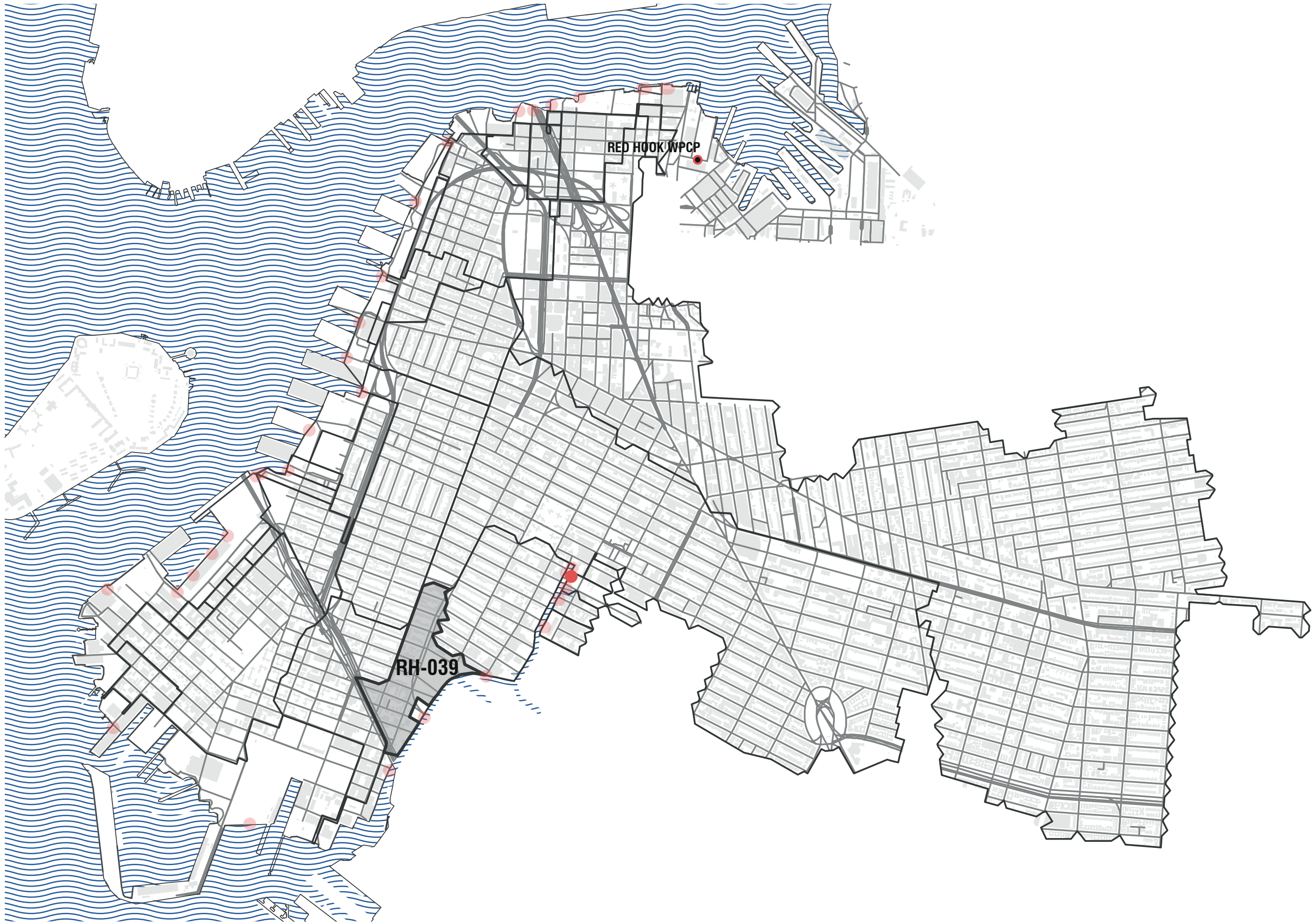

RED HOOK SEWERSHED
Combined Sewer Outfalls (CSO)
RH-039

Acres:	*57.36*
Sq ft:	*2,498,724.53*
Population:	*2,114*
Housing units:	*1,047*
Water vol. in a 1" storm [gal]:	*1,557,538.29*
Water Consumption [mgd]:	*220,512.13*

Land Cover [sqft]	
Tree Canopy	*247,023.07*
Grass/Shrub	*201,784.30*
Bare Soil	*997.41*
Buildings	*677,655.75*
Roads/Railroad	*497,398.92*
Other Paved Srf.	*866,919.40*

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