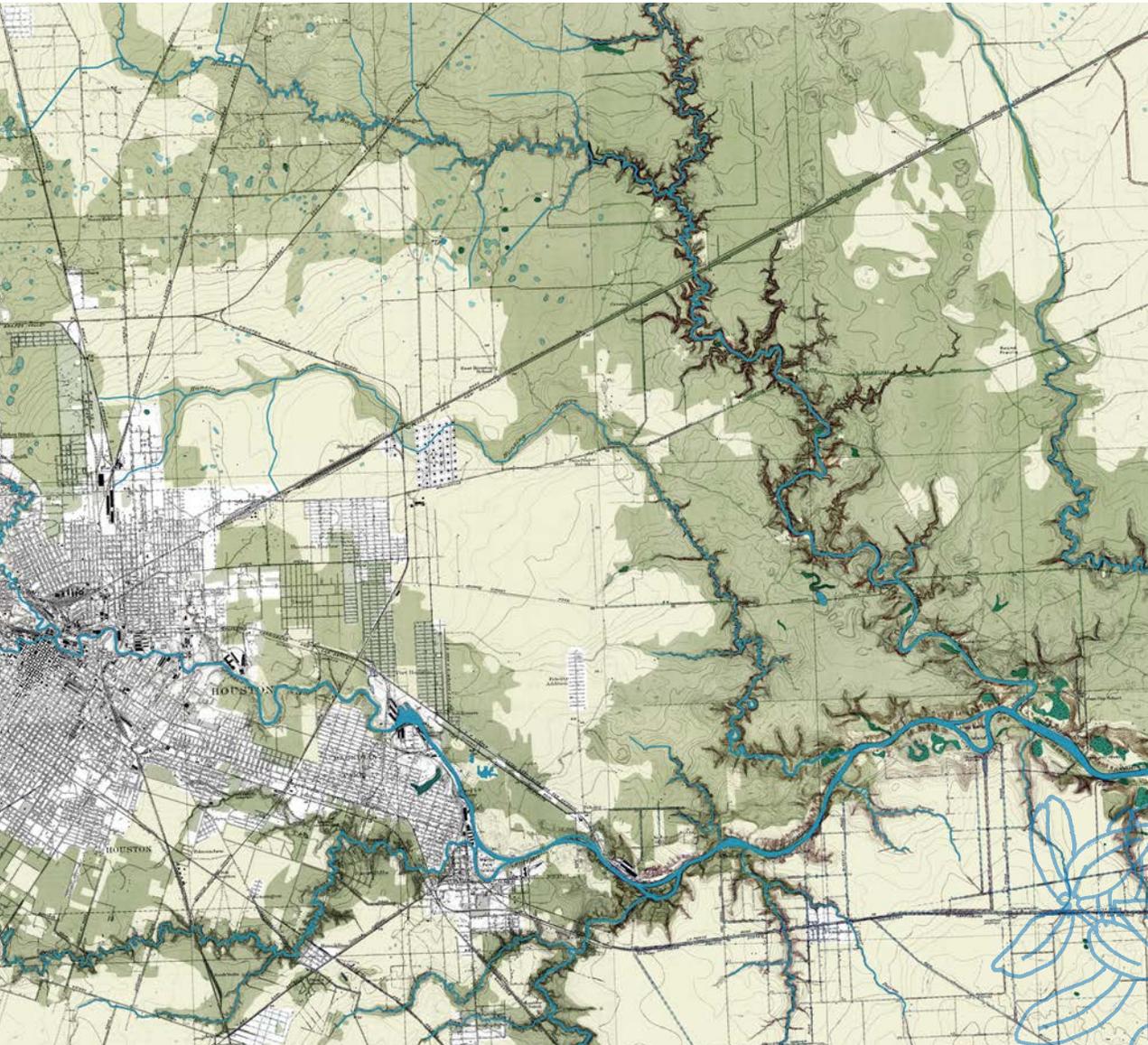


Living With Water™ Houston



January 2020



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RICE KINDER
INSTITUTE FOR URBAN RESEARCH

Letter from the Mayor

Hurricane Harvey, Tropical Storm Imelda and the other four flood events that Houstonians have experienced in the last five years have taught us many lessons, including the strength of our people, gratitude for first responders and our neighbors, and the impact that can be made when we are supported by State and Federal partners. They also highlighted the transformational change that is still needed in our built environment to reduce the risk of, and better prepare us for, flooding events and a changing climate.

In August 2018, at the one-year anniversary of Hurricane Harvey, I announced the City's partnership with 100 Resilient Cities – Pioneered by the Rockefeller Foundation to develop a resilience strategy to help Houston prepare for, withstand, and bounce back from the shocks and stresses that have been and continue to be part of Houston's reality.

When we look back at this moment in our history, we will be able to tell the story of how Houston's resilience journey began through Living with Water efforts. Our relationship with water has defined Houston's growth, culture, economy, and environment.

The Bayou City has a history of relying on our water assets for economic and cultural purposes, but we have an opportunity to further embrace water, while ensuring safety for Houstonians and respect for our natural environment.

The team that spearheaded the Living With Water Houston efforts has developed a set of specific design principles and pathways that not only allow our great city to reduce the risk of flooding, but that also provide multiple benefits centered on equity, regional collaboration, and neighborhood specific solutions.

I am proud to present the work that has built on many local, regional and international efforts and provides a framework and vision to align future climate adaptation. It is my hope that through implementation of these actions in some of Houston's most underinvested communities, we can excel and improve quality of life of Houstonians who need it the most, highlight the value of collaboration with international partners, and establish a framework for the entire City. By focusing on implementing strategies at the neighborhood and City-wide scales, starting with Greenspoint, Independence Heights, and Kashmere Gardens, we can continue to advance recovery, build forward, and become a regional model.



Mayor Sylvester Turner

City of Houston

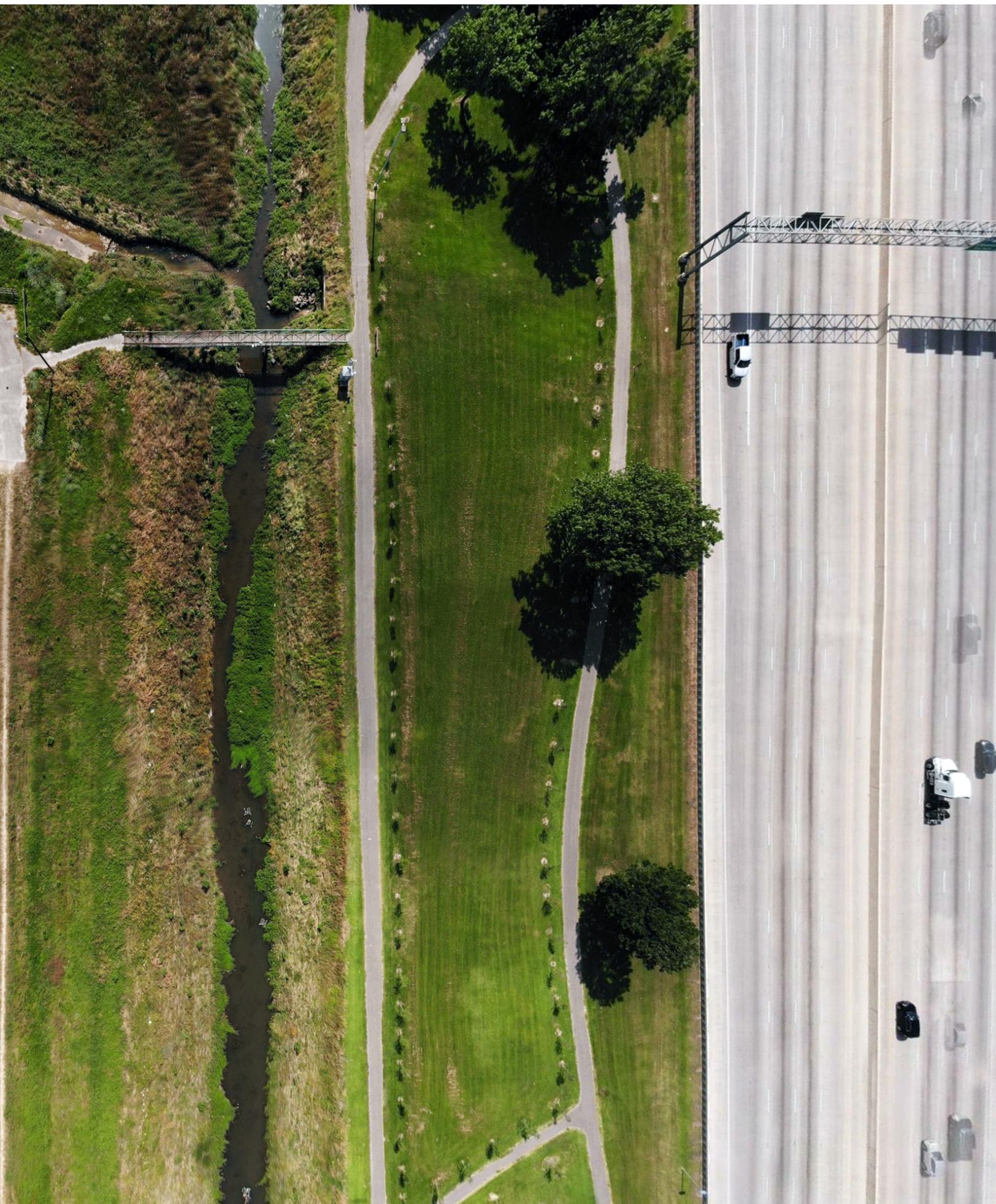


Hunting Bayou, Kashmere Gardens

Buyouts along Hunting Bayou created space to naturalize a portion of the channel, improving water storage while restoring the texture of Houston's environmental fabric. Flood protection projects in Houston must provide multiple benefits.



Hutcheson Park, Kashmere Gardens
Water challenges in Houston are closely related to transportation networks: hardened, straightened channels and constrictions at highway and railroad crossings limit natural flows.





Buffalo Bayou

In addition to the clear health and recreation benefits of improvements along Houston's bayous, restored riparian habitat is ecological infrastructure. Buffalo Bayou successfully withstood and channelled huge volumes of stormwater during Hurricane Harvey, as evidenced by deposits of sand high along the bank.





Homestead Detention Basin

Vast open detention areas, like the 78 acre Homestead Detention Basin north of Kashmere Gardens, provide opportunities for multiple community benefits in addition to flood protection. How could this space become a park?





North Houston Bike Park at Greens Bayou, Greenspoint

Extensive recreational paths and parks already exist or are in the works along Houston's bayous. Living With Water ideas include the extension of these amenities to the places between the bayous, and the design of flood protection strategies that also elevate quality of life and opportunities for equal access to public spaces for all Houstonians.





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Executive Summary

Houston is a vast, diverse, energetic, innovative, and productive city. Although Houston will never be flood-free, its flood risks can be reduced, and through these efforts, its communities can become more livable, equitable, and resilient. Houston has the problem-solving and investment capacity missing in many flood-prone coastal cities. Thus, the question is not if Houston will address its flood challenges, but how.

Living With Water Houston Background

Living With Water is a workshop model that brings together local, national, and Dutch experts representing multiple disciplines to solve site-specific water and resilience challenges alongside local governments, state and federal agencies, and community stakeholders. Living With Water Houston was undertaken as part of the Resilient Houston strategy development process. In August 2018, the one-year anniversary of Hurricane Harvey, Mayor Sylvester Turner, 100 Resilient Cities—Pioneered by the Rockefeller Foundation, and Shell joined forces to name Houston as the 101st member of the 100 Resilient Cities Network, now known as the Global Resilient Cities Network. As part of the development of Resilient Houston, the Mayor's Office for Resilience teamed with The Water Institute of the Gulf, Waggonner & Ball, and the Kingdom of the Netherlands to hold two Living With Water workshops to develop place-specific strategies to reduce flood risk and equip Houstonians to prepare for the next storm. The outcomes of the Living With Water workshops are summarized in the following report and incorporated into the Resilient Houston strategy.

Living With Water Approach

Living With Water is informed by a set of key principles that embrace water as an asset and highlight safety to people, respect for natural systems, and risk reduction to people, places, and capital through multipurpose design and infrastructure. Houston's engineering ingenuity is an important asset, needed to confront the region's increasing storm surge, tidal, riverine/bayou, and stormwater flooding. While the Living With Water process was informed by engineers, it was more broadly design-led, partially influenced by international and non-Texas expertise, and enabled stakeholder, academic, community, architecture, landscape, planning, and ecological expertise to inform its explorations, direction, and recommendations. Living With Water and the overall Resilient Houston strategy development process have yielded a set of principles and

pathways to combine flood risk mitigation with other important considerations and benefits.

Regional Perspective: Bayou City Water

The first Living With Water convening held in November 2018 set the stage for understanding the interrelated nature of water systems across jurisdictional boundaries in the Houston region. This report begins with an exploration of the regional systems, natural and built, that define the Bayou City and an analysis of regional flood risk in the context of climate projections and increasing urbanization. The first Living With Water workshop also focused on reviewing and assessing existing and near-term flood mitigation projects, summarized in a Water Resilience Synthesis Report prepared by the Kinder Institute for Urban Research at Rice University.

Key to the Resilient Houston strategy and Living With Water approach is a recognition that actions to reduce risk and increase resilience can be taken at multiple interconnected scales—from the home, to the block, neighborhood, bayou, city, and region. These scales are interconnected in both the planning process and in this report; the regional systems and the recommendations for systemic resilience outlined at the end of the Bayou City Water chapter provide a framework for the neighborhood-scale design proposals developed in the second Living With Water workshop.

Neighborhood Design Strategies

The second Living with Water workshop in May 2019 brought together local, national, and international experts across multiple disciplines—engineers, hydrologists, planners, ecologists, architects, and landscape architects—for a three-day design sprint to solve site-specific water and resilience challenges. Three Houston neighborhoods—Independence Heights, Kashmere Gardens, and Greenspoint—were selected by the City as focus areas for study. Each neighborhood provides unique design opportunities for reducing flood risk while also sharing common challenges with other flood-prone communities in the region. The Neighborhoods chapters of this report highlight design proposals and recommendations developed for each of the three focus areas



Field visits to study areas

Site documentation was part of all Living With Water events



Living With Water Houston Convening

Study area boundaries under discussion, November 2018



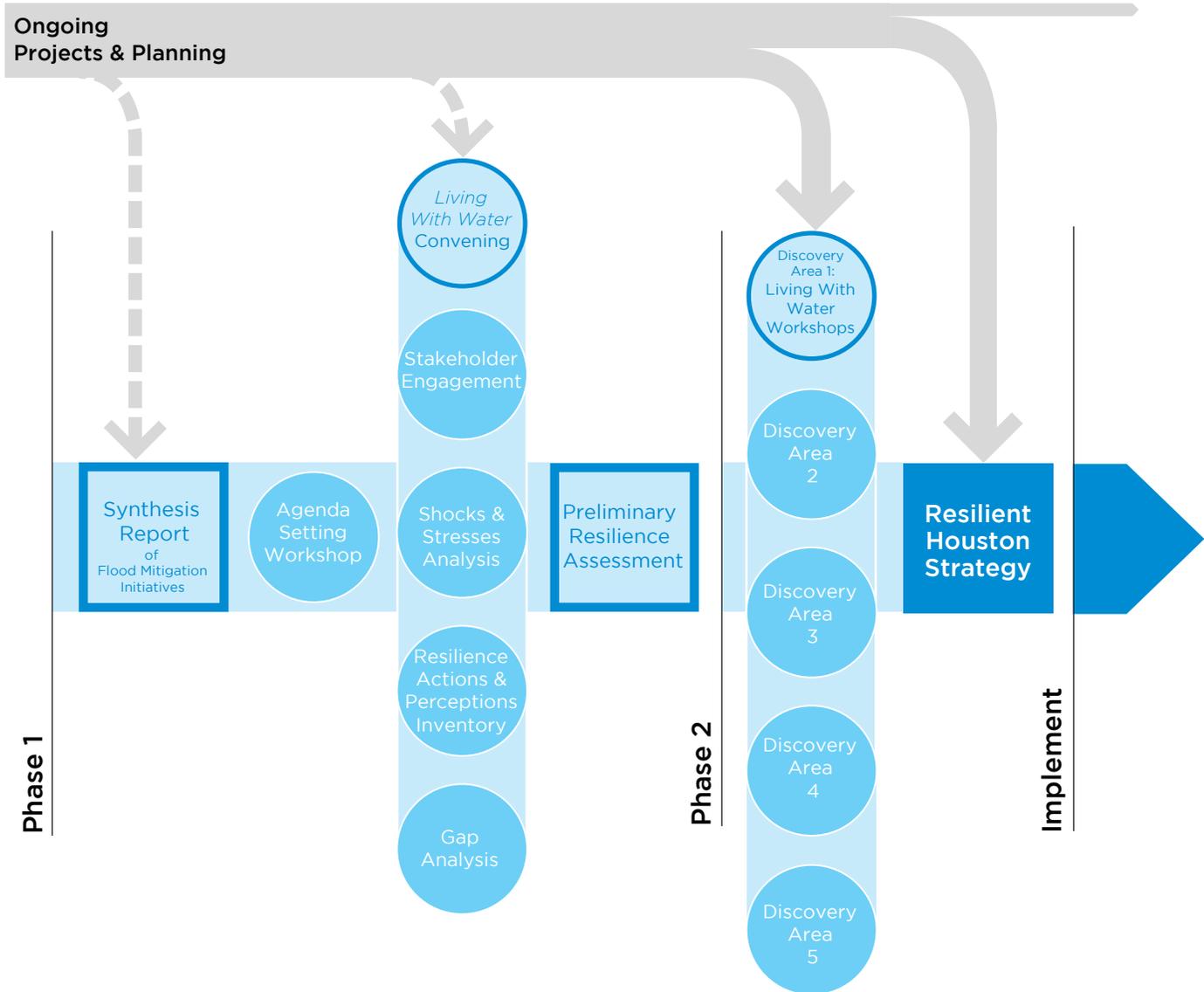
Living With Water Houston Design Workshop

Design iteration during the intensive three day event

during the three-day workshop as well as overall neighborhood-scale recommendations.

Houstonians have experienced the devastation and loss from six federally-declared flooding disasters in the past five years, most notably Hurricane Harvey. While building resilience means more than just preparing for the next storm, Houston's future will be defined in large part by how the region addresses increasing flood risk. The Living With Water workshops provided an opportunity for a deep dive into this critical component of Houston's resilience. While several U.S. cities have participated in both the 100 Resilient Cities Strategy Development Process and Living With Water workshops, Houston is the first city to integrate these two well-established frameworks for advancing city resilience, combining a comprehensive vision for a more resilient Houston with place-based strategies that reduce risk and deliver multiple community benefits.

Living With Water Houston builds on the many local efforts underway to reduce flood risk and provides a framework and illustrative vision for aligning future actions. The strategies presented in this document should be embraced, localized, developed, and deployed to address the increasing riverine/bayou, urban drainage, and storm surge flooding that threatens Houston.



Resilient Houston Strategy Development Process

This diagram shows how the Living With Water workshops were integrated into the overall two-phase Resilient Houston planning process. Phase 1 included gathering data, reviewing existing and proposed plans and initiatives, engaging stakeholders on Houston’s vulnerabilities and their underlying causes, understanding the city’s areas of strengths and gaps, and identifying Discovery Areas for focus in Phase 2. The first Living With Water convening in November 2018 focused on reviewing and assessing existing and near-term flood mitigation projects and provided recommendations for other risk-benefit considerations, project expansions or linkages,

multiple-benefit project enhancements, resilience and equity considerations, and the potential for nature-based additions to existing projects.

During Phase 2 of the Resilient Houston planning process, the City worked with key stakeholders and experts to dive deeper into the Discovery Areas identified in Phase 1 and to develop implementable actions. The second Living With Water workshop in May 2019 developed site-specific solutions to water and resilience challenges in three focus neighborhoods. These recommendations are outlined in this report and incorporated into the Resilient Houston strategy.

Living With Water & Resilient Houston Team**City of Houston Mayor's Office of Resilience**

Marissa Aho

City of Houston, Mayor's Office of Recovery

Stephen Costello, Laura Patino, Ryan Slattery

Waggoner & Ball Architecture & Environment

David Waggoner, Janice Barnes, Andy Sternad, Ramiro Diaz, Lex Agnew, Donald Del Cid, Mac Ball

The Water Institute of the Gulf

Dale Morris, Colleen McHugh, Hugh Roberts, Ryan Clark, Lauren Grimley, Christine DeMyers, Huy Vu

Royal Netherlands Embassy

Bart de Jong

Asakura Robinson

Keiji Asakura, Alexandra Miller, Katie Coyne

Kinder Institute at Rice University

Kyle Shelton, Bill Fulton

HR&A Advisors

Jeff Hebert, Jared Press

Experts from the Kingdom of the Netherlands

Han Meyer, Delft Technical University; Frans Klijn, Deltares; Harold van Waveren, Rijkswaterstaat; Piet Dircke, Arcadis; Stijn Koole, Bosh-Slabbers Landscape Architects; Jaap van der Salm, HNS Landscape Architects; Ruben Hoek, Palmbout Urban Landscapes; Anneloes Nillesen, DeFacto Landscape Architects; Matthijs Bouw, One Architecture

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Thank you to the many partners who supported or engaged in the Living with Water Convening (November, 2018), the Living with Water Workshop (May 2019), or who provided guidance, counsel, targeted expertise, and advice throughout this process. While we cannot capture everyone whose contributions were critical to this effort, special thanks and recognition are nevertheless due to many, including:

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Expert and professional staff of:

TxDOT

Houston Advanced Research Center

Houston-Galveston Area Council

Rice University's SSPEED Center

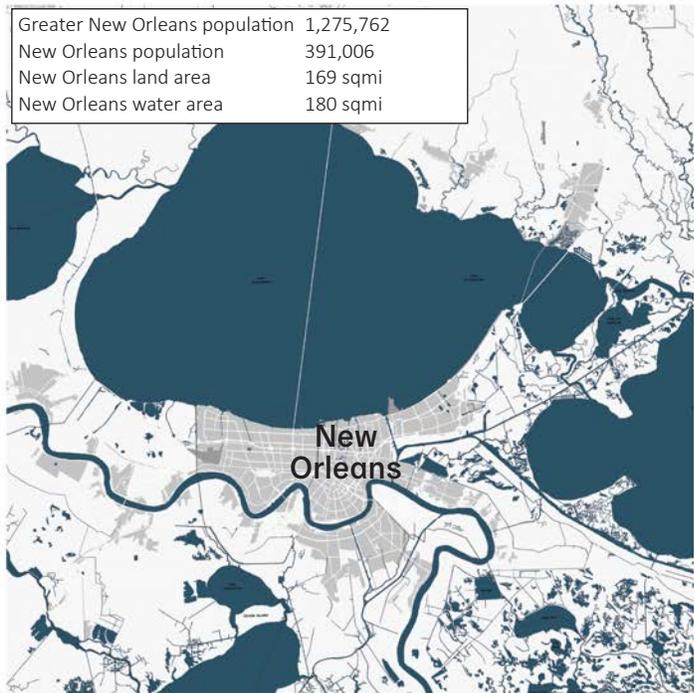
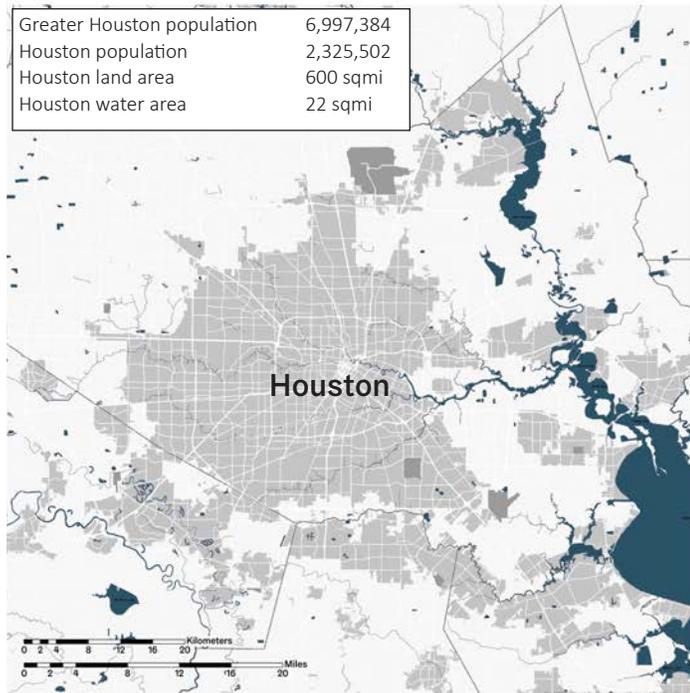
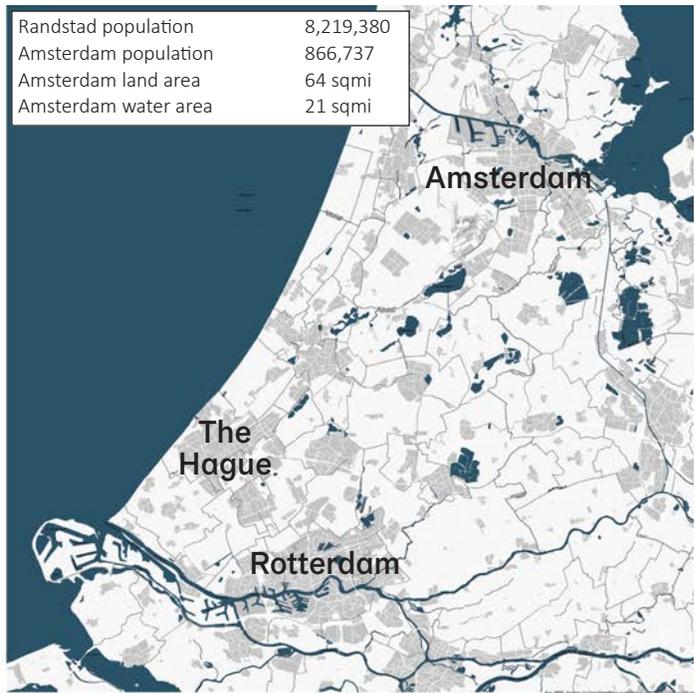
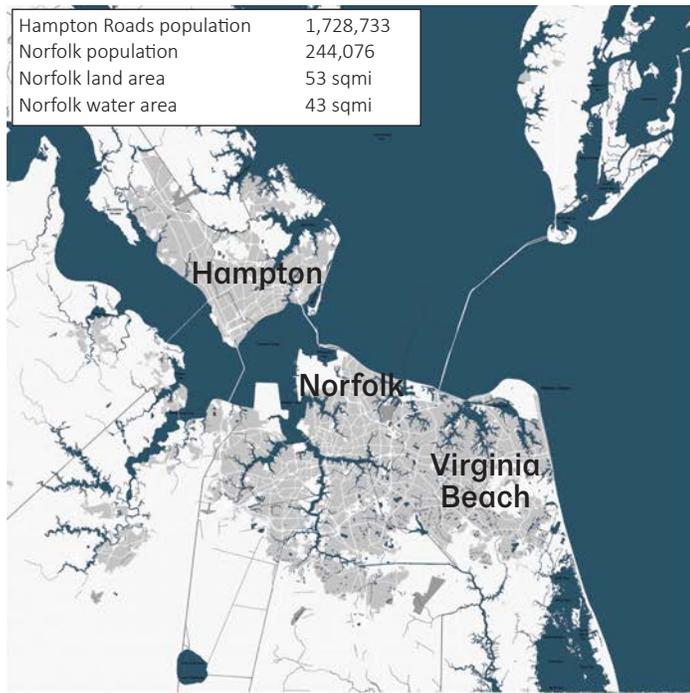
Greater Houston Flood Mitigation Consortium

Buffalo Bayou Partnership

The Greater Houston Partnership

Huitt-Zollars

Texas Southern University



Size Comparison of Houston to New Orleans, the Randstad, and Hampton Roads

Previous Living with Water, Dutch Dialogues workshops have produced substantial funding and resilience efforts for their respective cities. Houston presents a much larger scale than previous cities and subsequently a different set of challenges and opportunities.

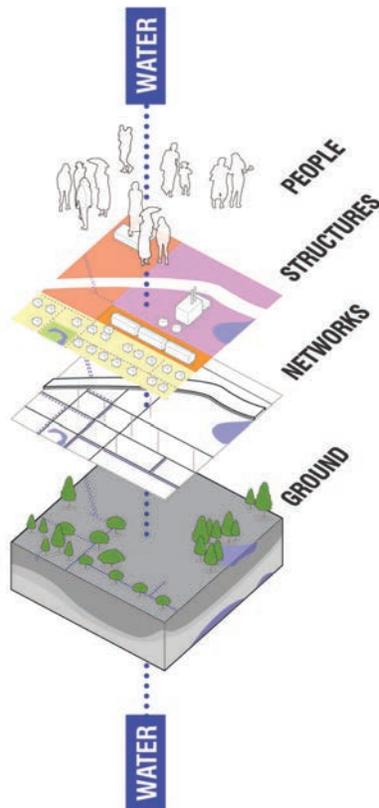
Living With Water™ History

Recovery requires cooperation. Resilience requires vision. These are the important lessons learned in the immediate aftermath of Hurricane Katrina as coastal Louisiana and neighboring regions struggled to address multiple storm-related environmental challenges (coastal surge, subsidence, urban storm water, aging pump and water-management infrastructure) and their related long-term social, economic, and quality-of-life consequences.

Recognizing that recovery efforts in the crucial time after a disaster event are often addressed as discrete, disconnected problems, David Waggoner of Waggoner & Ball, Dale Morris of the Royal Netherlands Embassy (now at the Water Institute of the Gulf), and Paul Farmer, former CEO of the American Planning Association, co-developed a series of stakeholder workshops, called the Dutch Dialogues. These were modeled on the Dutch approach of developing solutions through integrated water management and flood infrastructure planning to enhance safety and spatial quality with multi-benefit investments.

The New Orleans Dutch Dialogues, hosted between 2008 and 2010, seeded the Greater New Orleans Urban Water Plan, a large portion of the New Orleans Resilience Plan, and was instrumental to the \$141 million Gently Resilience District project. Dutch Dialogues were also held in St. Louis and in Tidewater (Norfolk), Virginia, the latter providing crucial input for Norfolk’s successful \$121 million National Disaster Resilience Competition award. The workshop model has been successfully deployed in Los Angeles, Miami, and Hampton, Virginia. A similar workshop strategy was employed in Bridgeport, Connecticut during Rebuild by Design. Most recently a full Dutch Dialogues process was concluded in Charleston, South Carolina. The design driven methodology has led to over \$310 million in combined federal funding awarded to New Orleans, Norfolk, and Bridgeport.

This perspective has transformed how cities approach economic (re)development in relation to water, catalyze water entrepreneurship and job creation through resilience building, and engage citizens to become part of the region’s systemic effort to reduce flooding. The Living With Water™ approach begins the process of shifting water from threat to asset. Living With Water™ is a collection of collaborative Waggoner & Ball projects that address water resilience at multiple scales. Over time, the Living With Water™ approach has grown to encompass an array of projects from planning to buildings.



Planning involves all layers of place, from subsurface aquifers to patterns of human inhabitation.

\$50 million
Rebuild by Design, Bridgeport, CT

\$121 million
Resilience projects in Norfolk, VA
(National Disaster Resilience Competition award)

\$141 million
Gently Resilience District, New Orleans, LA
(National Disaster Resilience Competition award)

Federal funding outcomes or proposals developed through Dutch Dialogues



Team structures maximize knowledge sharing and involve a full spectrum of stakeholders, from government officials to local residents.

Layered Approach

Integrated Scales of Study

A layered planning approach begins with Houston's most basic layer: its physical ground, the land and water upon which infrastructure and inhabitation, history, and culture, are based. To propose effective design solutions, studying the different scales of the Region, Bayou, Neighborhood, Block, and Home are necessary.

Water Based Planning

Safety first. Safety is increased through elevation and redundancy. Multiple lines of defense begin outside the city, in the landscape, and are also structured from within. Sustainable inhabitation is connected to deep geology.

Know where you are. Most of the bayous in Houston have large floodplains, so even those away from the water can still be at risk. Healthy ecology supports a healthy economy and can provide protective benefits. Sustainable infrastructure aligns with ecological function. Water in the region must be understood as a holistic system, man-made and natural in tandem.

Work at multiple scales. Connection between scales is essential. Focus on the smallest scale, understanding larger watershed and system functions. Conflicts between and within layers are acknowledged—culture and technology sometimes produce misalignments—and design solutions begin by asking what lies underneath.

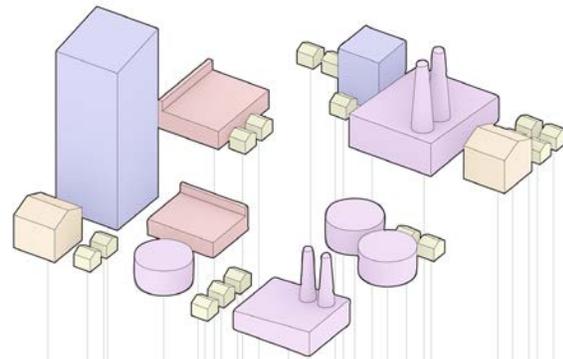
Look Across Boundaries. In Houston, neighborhoods, floodplains, and even the incorporated city area can overlap or misalign. Working holistically requires zooming out to understand the larger systems as a whole.

Pursue multiple benefits. Single-purpose infrastructure is a poor investment.

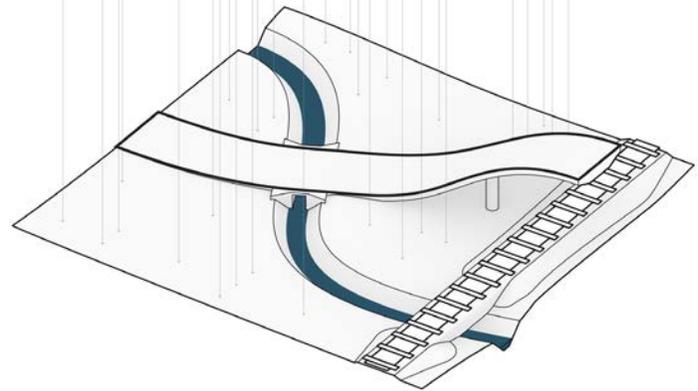
No regrets. Make sure action taken now will not compromise future opportunities. Projects should fit within a comprehensive planning vision, but should be able to operate independently with success. Plans must be adaptable over time.

Looking for Opportunities at Every Layer

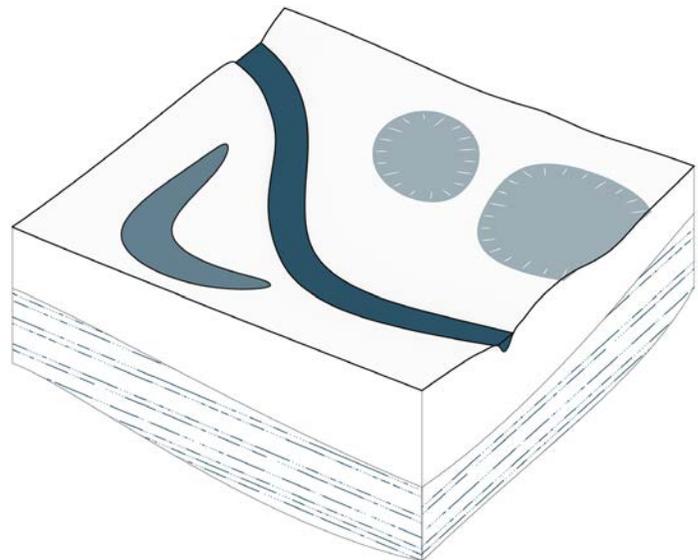
The potential for safe development and living with water depends on understanding each layer, from the foundation to the surface, from bedrock to buildings.



Development and Land Use



Drainage and Infrastructure Networks



Soils and Ecology

Guiding Principles

Houston has already begun to shift its approach to water and flooding, moving from engineering-only to nature-based water management, where water is viewed as an asset, not a threat. Following an analysis of Houston's landscape, water challenges, and social and political context, these Guiding Principles were developed to apply at all scales and for all land uses. They are intended to help guide and further the paradigm shift now underway for all sectors and stakeholders across the region, and they are the basis for more detailed recommendations throughout this report.

GP1. Prioritize safety first

Critical Facilities and access corridors should be elevated or retrofitted. Development should be incentivized to build in flood-safe areas.

GP2. Hold water where it falls

Holding runoff closest to where it starts lessens downstream impact. Once water enters the bayous, it enters another scale of infrastructure and is more difficult to control.

GP3. Educate public & private sectors about water

Especially in areas where flood risk is not immediately apparent, outreach on flood risk, the location of flood-prone land, the function of the bayou system, and the causes of flooding can shape public and private commitment toward water resilience. Solutions and advocacy at every scale require a similar public outreach.

GP4. Align transportation system to waterway functions

In certain cases, improve choke points where transportation crossings (road and rail) obstruct water flows only when upstream downstream areas will not be impacted. Major transportation corridors should manage their own runoff and take on additional detention if possible. Retrofitting parking lots and other paved areas to have plantings and pervious paving lowers the impact highly impervious surfaces have on the speed and volume of runoff entering the drainage system.

GP5. Make Space for Bayous

Constriction in the bayous must be resolved, whether it is in the form of choke points at bridges and culverts or properties located in the floodway. Water must be given space in a way that does not harmfully displace people or amplify downstream flooding. Working in tandem with the Bayou Greenways 2020, new bayou space can become a recreational amenity and the front yard of Houston.

GP6. Bring back the prairie

Prairie conservation efforts in the greater Houston region reduces runoff, preserves a recreational and ecological amenity and lowers the urban heat island effect.

GP7. Increase water storage ambition over time

Climate change, updated storm data and ongoing development makes water storage goals a moving target. Developing water-aware development culture and increasing water storage ambition helps to keep up with increasing future risk.

Regional Perspective

Bayou City Water

The Bayou City is built around systems. Bayous structure the natural system, and transportation—major highways and railroads—organize the built environment. Conflicts between the natural system and the transportation systems often shape the nature of flood risk in Houston. Water, materials, and people are constantly moving across the Houston landscape—sometimes from great distances—and the systems they use to come and go tie all neighborhoods together in sometimes unexpected ways.

For long-term sustainability, the transportation system should realign with the natural system, the basis of the environment that ultimately sustains all life and development. Since regional systems have such great impact on local water issues, an understanding of these large scale connections and flows is key to developing water management solutions within neighborhoods.



Notes:

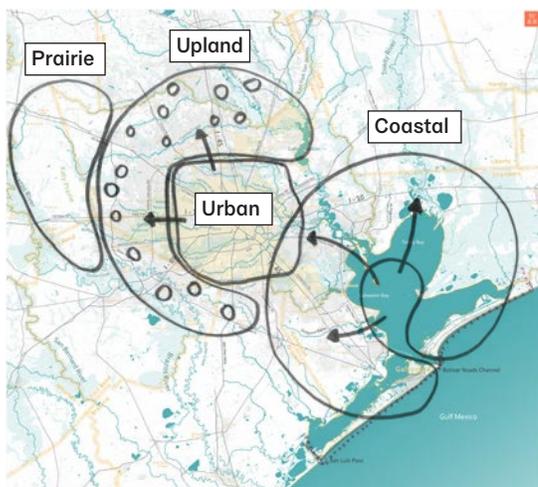
1. Parks & properties shown as “green” are illustrated for conceptual purposes only.
2. All property decisions should be made with community and land owner buy-in.
3. All images are credited to Waggoner & Ball unless otherwise attributed.

Surface and Systems

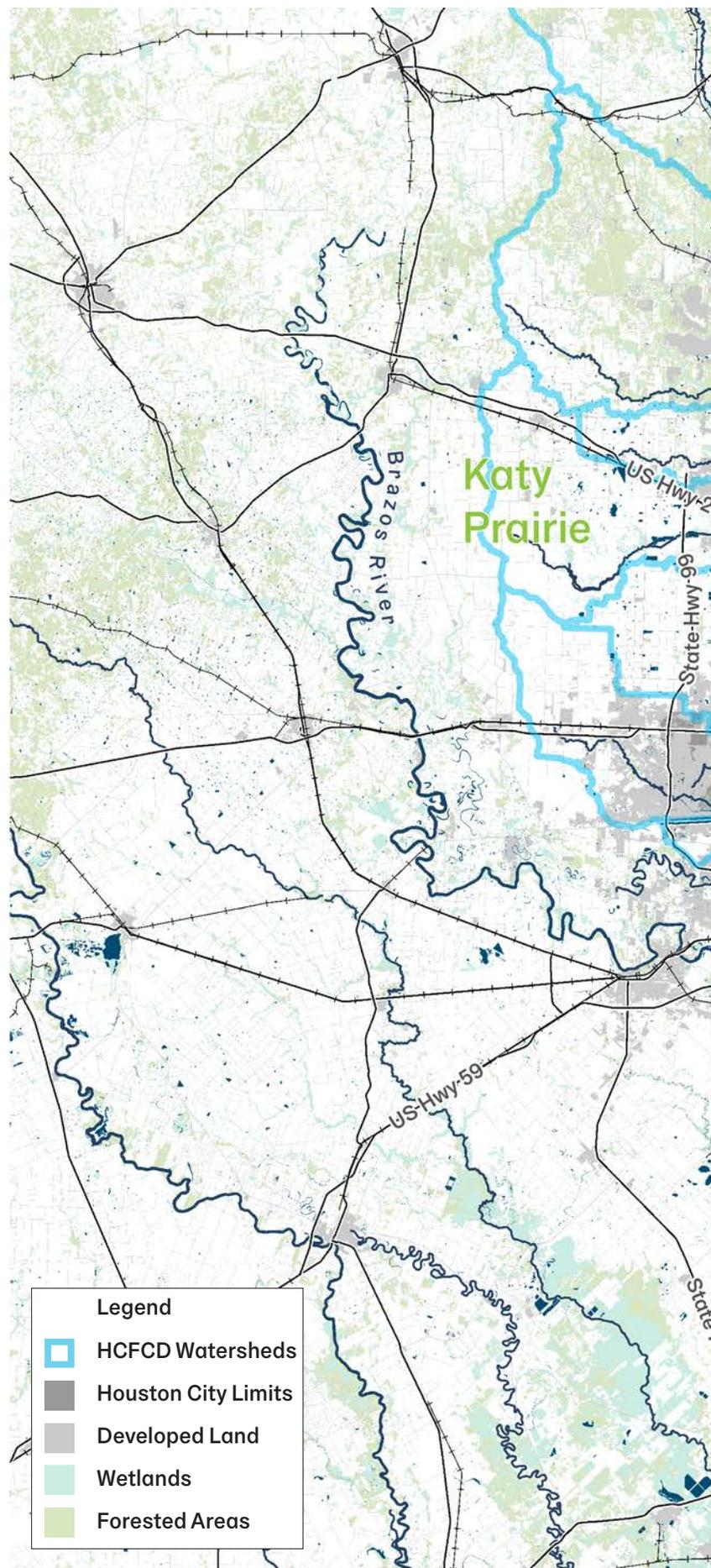
Systems Perspective

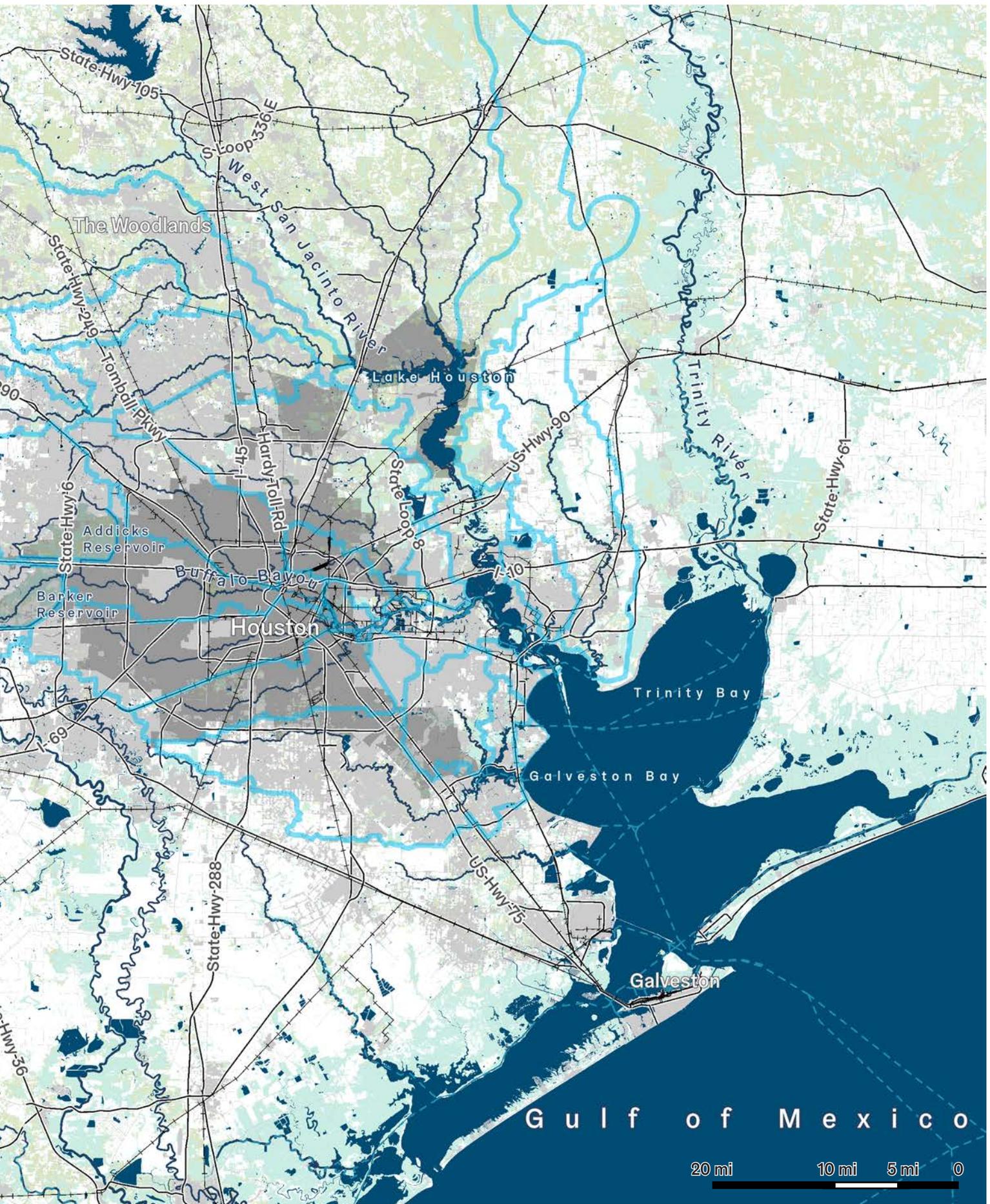
Houston is defined by a system of bayous and transportation corridors. Houston was built on rail lines and bayous and expanded by highways. The rail lines upon which the city of Houston was founded all converge at Buffalo Bayou. As it approaches the bay, Buffalo Bayou turns into a transportation corridor, the Ship Channel, Houston’s gateway to the world. Twelve of Harris County’s twenty two watersheds ultimately empty into the Houston Ship Channel. The intersections of infrastructure and water create both Houston’s economic vitality as well as some of the city’s greatest flood risk challenges. Roads and rail lines can constrain bayous and exacerbate flooding.

Houston contains a variety of landscapes that are all connected by bayous and transportation corridors. Water flows through bayous from prairies to the coast, and highways connect the urban core to the rapidly expanding suburban periphery. All of these landscapes and systems are interconnected; their challenges have upstream and downstream consequences. The flatness of Houston allows flooding in one bayou to impact another. Sea level rise, which threatens the coastal edge, also impacts upstream bayou conveyance. This causes backup and flooding, even at higher elevations. Developmental pressures in the upland periphery have the potential to create more runoff downstream. For any design solution to be successful in Houston, it must work for everything upstream and downstream.



Multiple Zones of the Houston Area





Risk Levels

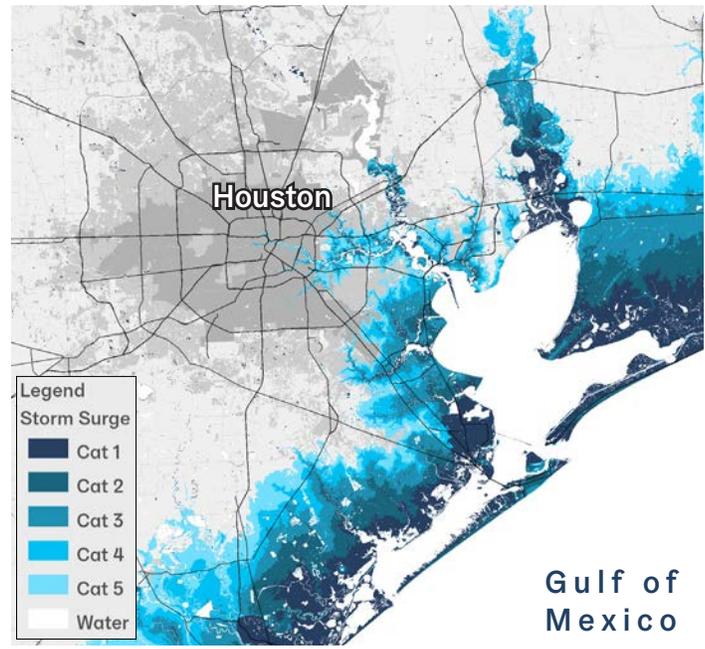
Gulf Coast Storms

Houston’s economic vitality and its greatest source of risk comes from its connection to the Gulf of Mexico. Sitting on the western edge of what is known as hurricane alley, Houston receives at least one major storm almost every decade. Cyclones can impact both coastal areas and bayous upstream. Storm surge has both a direct impact for coastal areas, and an indirect impact for upstream bayous. Key port and industrial facilities along the Houston Ship Channel and Galveston Bay are threatened by storm surge and sea level rise. As an economic gateway to the U.S., Houston’s vulnerability can have a nationwide impact.

Storm surge will only worsen with sea level rise. Due to subsidence and other factors the rate of relative sea level rise in the Galveston Bay area is also significantly higher than the most of the United States. Sea level rise makes resilience a moving target. Immediate widespread action has the potential to ward off future risk.

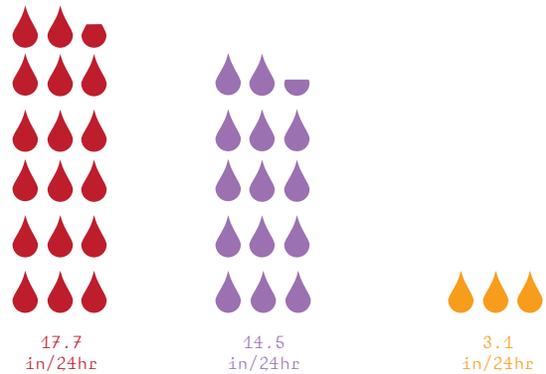
Upstream bayous are also threatened by storm surge and sea level rise. Any increase in downstream water level slows the rate in which the bayous drain. The general flatness of Houston makes even slight increases in sea level have impacts far upstream. Coastal protection measures must similarly exist upstream and across multiple scales and sites.

The risk to Houston’s coast is multifaceted: storm surge risk is compounded by coastal erosion, wetland loss, and degraded water quality, and these factors impact the economic vitality of Houston and the character of Houston’s coast. Currently Houston is considering multiple strategies for coastal protection including a storm surge barrier at the mouth of the Galveston Bay. Each facet of coastal risk must be addressed into the larger resilience strategy for Houston. Coastal protection must be matched with upstream flood mitigation efforts.

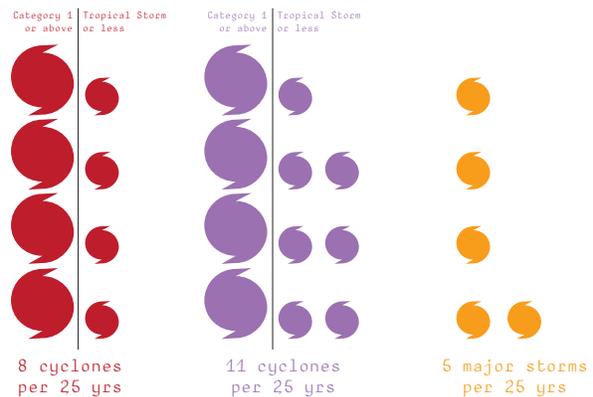


Storm Surge

Risk Comparison Houston / New Orleans / Netherlands



24 Hour Rainfall
(100 yr storm, 1% annual chance)



Historical Storm Occurrence

SOURCES
 NOAA Atlas 14 https://hdsc.nws.noaa.gov/hdsc/pFds/pFds_map_cont.html?bkack=va
<https://en.climate-data.org/europe/the-netherlands/north-holland/amsterdam-3330/#climate-graph>
<https://coast.noaa.gov/hurricanes/>

Gulf Coast Rain

While wind and storm surge can damage property and exacerbate flood risk, the primary threat from hurricanes and tropical storms in Houston is precipitation. Even for Houstonians who live above sea level, tens of thousands of residents are inside bayou floodplains and even floodways. The Gulf Coast is one the wettest parts of the United States, and some of the most intense precipitation events occur around the Houston region. Even weaker tropical depressions can bring intense rainfall. Of the five most intense rain events along the Texan coast, four were classified as tropical storms or less, including Imelda in 2019. Intense rainfall is compounded by a relatively flat landscape, which creates wide floodplains and slow-moving bayous. Climate change is expected to accelerate the trend that Houston is already experiencing: heavy and intense precipitation. These storms are changing what is considered to be a 100-year or 1000-year design storm, used to assess risk and map floodplains. Because of these changes in weather and climate patterns, the boundaries of Houston’s floodplains are expanding – and its resilience strategies must similarly expand.

Stormwater Detention

The need for stormwater detention has always been present in Houston. The Addicks and Barker Reservoirs were built in the 1940’s, designed to alleviate downstream flooding along Buffalo Bayou. After Hurricane Harvey in 2017, additional stormwater detention infrastructure has been planned or built. Along most of the major bayous of Houston, several massive detention basins have begun planning or construction. As precipitation data and floodplain maps are updated post Harvey, these new detention basins compensate for the new risk evaluation. While these new basins will store a tremendous amount of water, property within the floodplain will still remain at risk.

The rapid outward expansion of Houston makes finding space for large scale water storage difficult in some parts of the city. Locations to built infrastructure at the scale of Addicks or Barker Reservoirs are limited, particularly when environmental impacts are factored. The US Army Corps is considering the construction of a third reservoir past Addicks and Barker but its usefulness may be limited due to its location at the top of the watershed. The Greens Bayou watershed still has large parcels of land that are undeveloped and opportunities for water detention. Space to store water becomes more limited closer to downtown. In Houston’s urban core, detention must be achieved through other means.

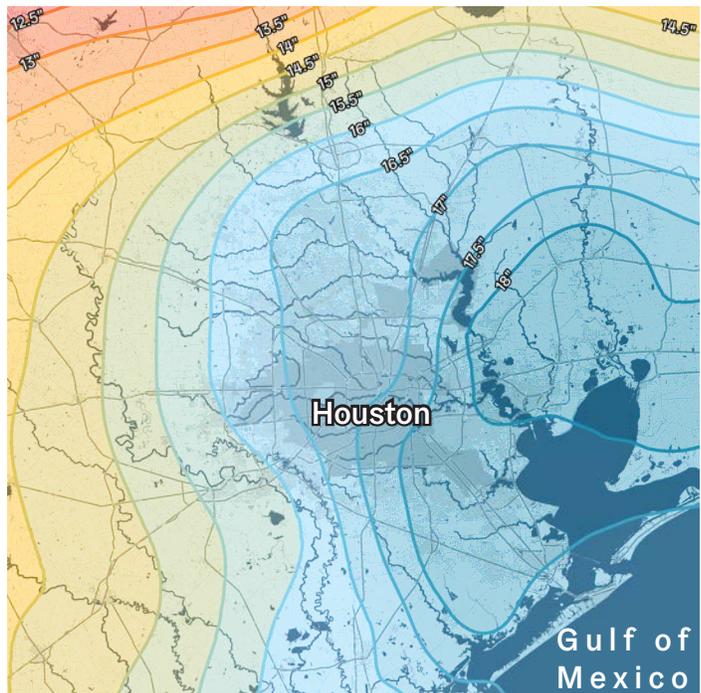


Glen Forest Detention Basin

Greens Bayou has seen some of the most substantial detention basin construction post-Harvey.

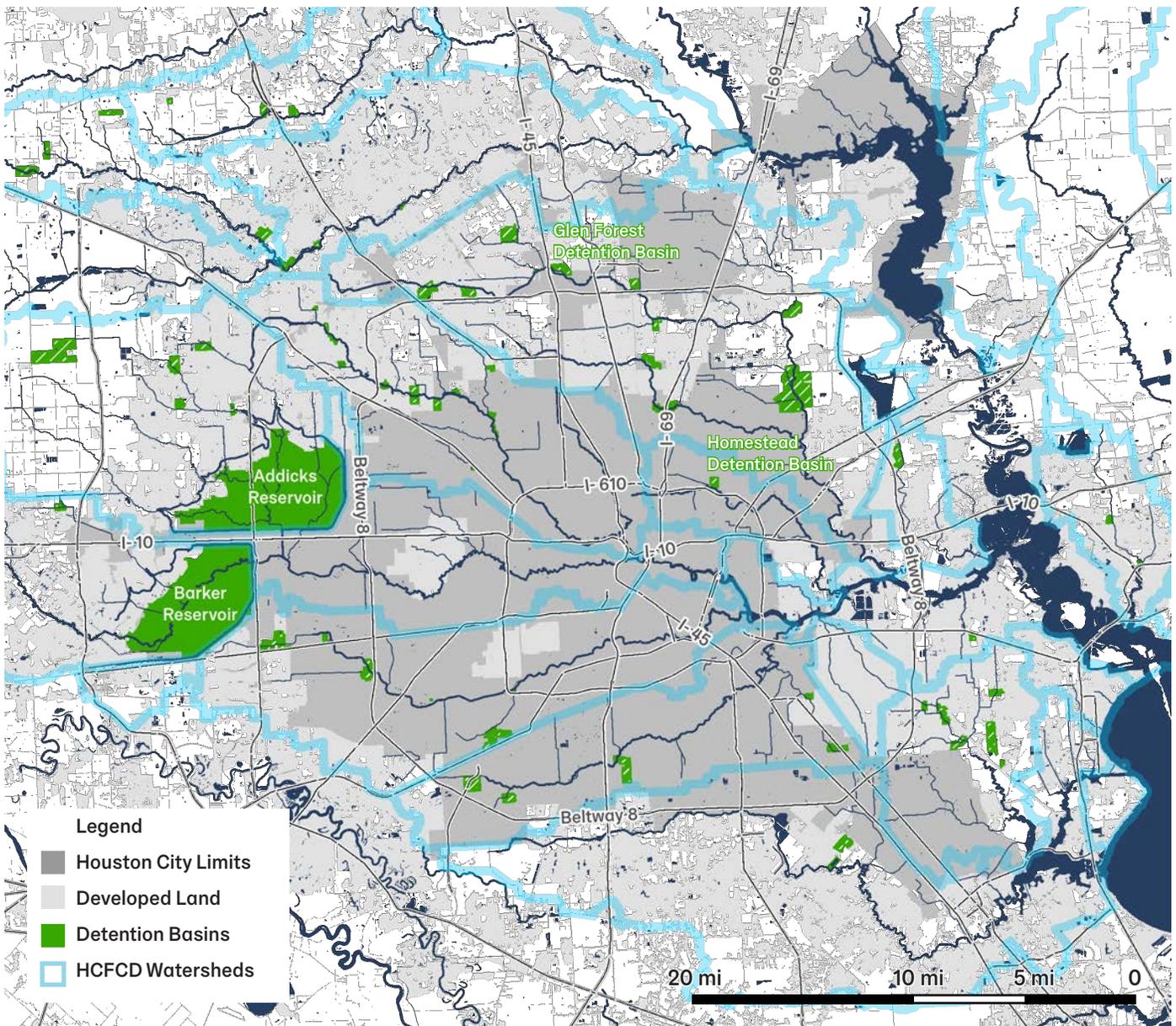


**Homestead Detention Basin
Kashmere Gardens**



24 hour 100 year (1%) Precipitation Event

The greater Houston area receives some of the most intense precipitation events in the US. Study areas are the red outlines.



Reservoirs and Detention Basins

Addicks and Barker were some of the largest and earliest detention basins built in the Houston Region. Since Hurricane Harvey, the HCFC has begun the planning and construction of around 70 additional detention basins throughout Harris County.

Houston Precipitation Event Classifications

	2-Year 50% Chance	5-Year 20% Chance	10-Year 10% Chance	25-Year 4% Chance	50-Year 2% Chance	100-Year 1% Chance	500-Year 0.2% Chance
1 hr	2.23 in	2.77 in	3.23 in	3.86 in	4.33 in	4.85 in	6.38 in
24 hrs	5.12 in	6.94 in	8.75 in	11.6 in	14.1 in	17 in	25.5 in
4 days	6.89 in	9.41 in	11.9 in	15.8 in	19.3 in	23.2 in	32.9 in

Harvey 24 hrs
16.07 in*

Harvey 4 days
30.87 in*

Precipitation events for from sourced from the NOAA Atlas 14
*Harvey rain data sourced from the NOAA rain gauge at Houston Intercontinental Airport

Challenges

Growth and Flood Risk

Approximately seven million people live in the Greater Houston area, with the majority living outside of the city boundary. The region has added approximately three million people from 2000 to 2019, nearly doubling in size. Most of that growth and development has occurred outside of the city of Houston, often in unincorporated areas. The rapid pace of development makes flood risk adaptation a moving target. Development in the floodplain, and without adequate stormwater management, leads to increased risk and more runoff downstream. Homes that were previously safe can easily become at risk with any increase in upland runoff. Without adequate standards for development, downstream adaptation becomes necessary. Historic neighborhoods are often the most at risk.

The downstream impacts of upstream development necessitate multi-scalar design solutions. At the largest scale, Houston is a patchwork of jurisdictional bodies. This means that collaboration is part of a strategy to manage development in Houston. At the home and neighborhood scales, a lack of zoning based policy tools means that Houston has to find alternative sources to promote better development practices. Retrofits and adaptations can be a form of growth from within, especially in areas that do not have large spaces for water storage. If development that is insensitive to water continues upstream and in flood prone areas, and retrofitting efforts are avoided or delayed, today's risky neighborhoods become tomorrow's buyouts.

Potential of Water

Shifting land use patterns to become responsive to water provides opportunities in addition to mitigating risk. Water has the potential to provide recreational amenities and create a sense of place. Too often in Houston, neighborhoods are disconnected from the bayous in their own backyards. The revitalization of portions of Buffalo Bayou created a new type of vibrant park space while encouraging nearby redevelopment and investment. Each of Houston's bayous, each running through unique neighborhoods, can provide a unique public experience. The Bayou City's identity is in its bayous.



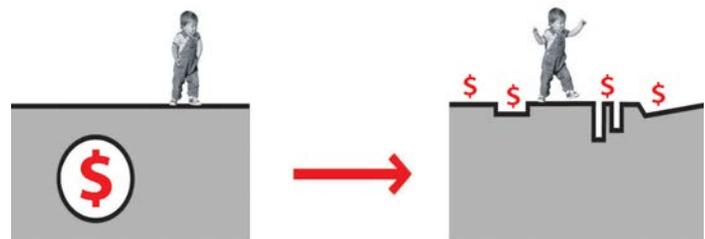
1 Increasingly severe and frequent flooding from intense rainfall



2 Development pressure in low-lying, risky, and ecologically sensitive areas



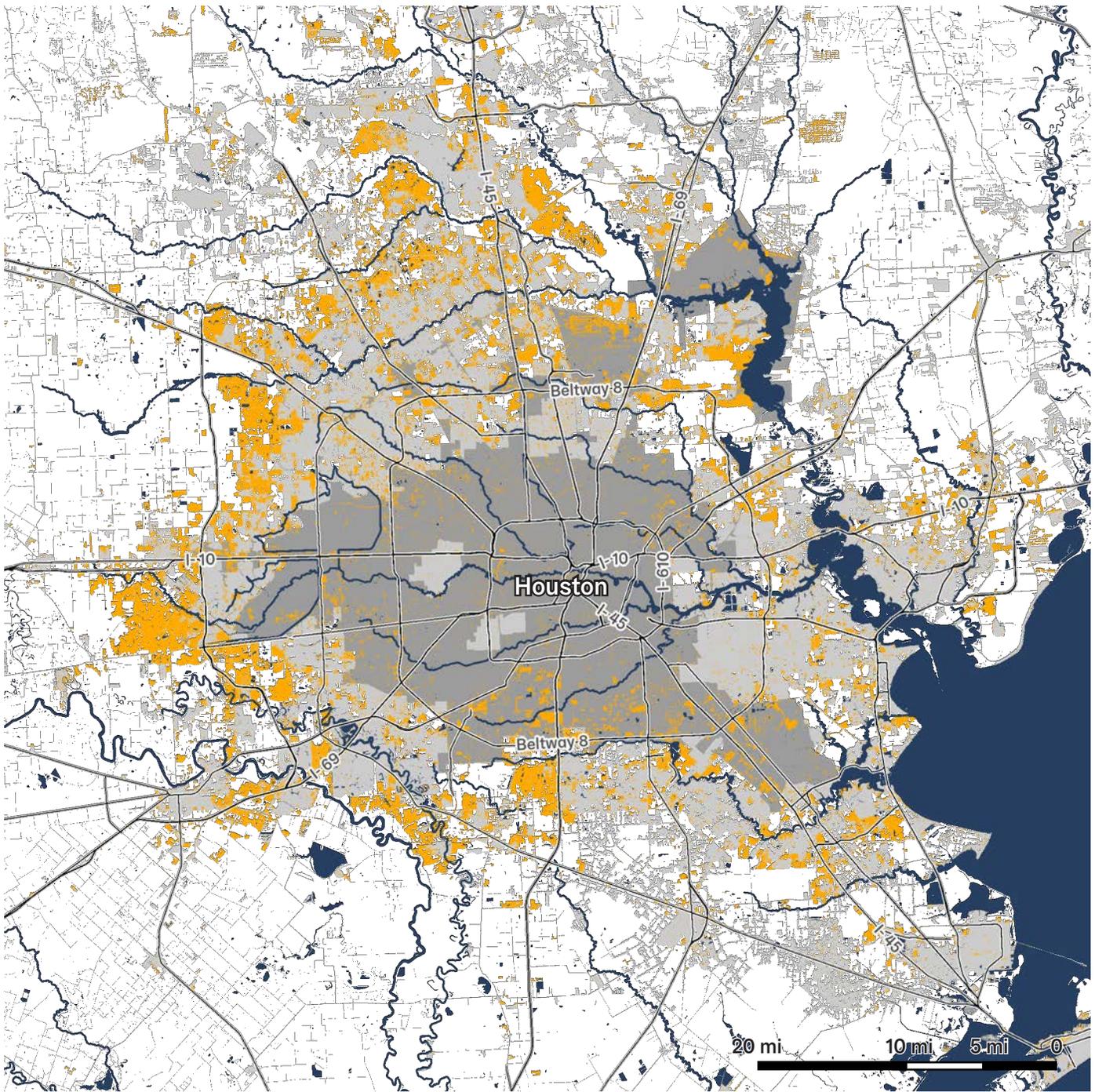
3 Unrealized potential of water as an urban and recreational amenity



Same-Cost Approaches to Water Challenges

Narrowly defined projects may succeed on narrow evaluation, but risk missing greater value.

Image credit: Urbanisten



New Development, 2001 - 2016
Most new development has taken place outside of the Houston city limits.

- Legend**
- Houston City Limits
 - Developed Land
 - New Development 2001-2016

Soils and Ecology

Coastal Prairie

Houston sits on what was once a vast coastal grassland. The same flatness that shapes Houston's floodplain today created the historic landscape of the past. The bayous that run through present day Houston originally meandered across the prairie. Over time, wind eroded traces of those bayou paths into a subtle topography of pimple mounds and prairie potholes. Slight changes in elevation kept some areas dry while other areas turned into wetlands and lakes. The original grasslands of the Texas coast were speckled with pockets of water, each a different microcosm.

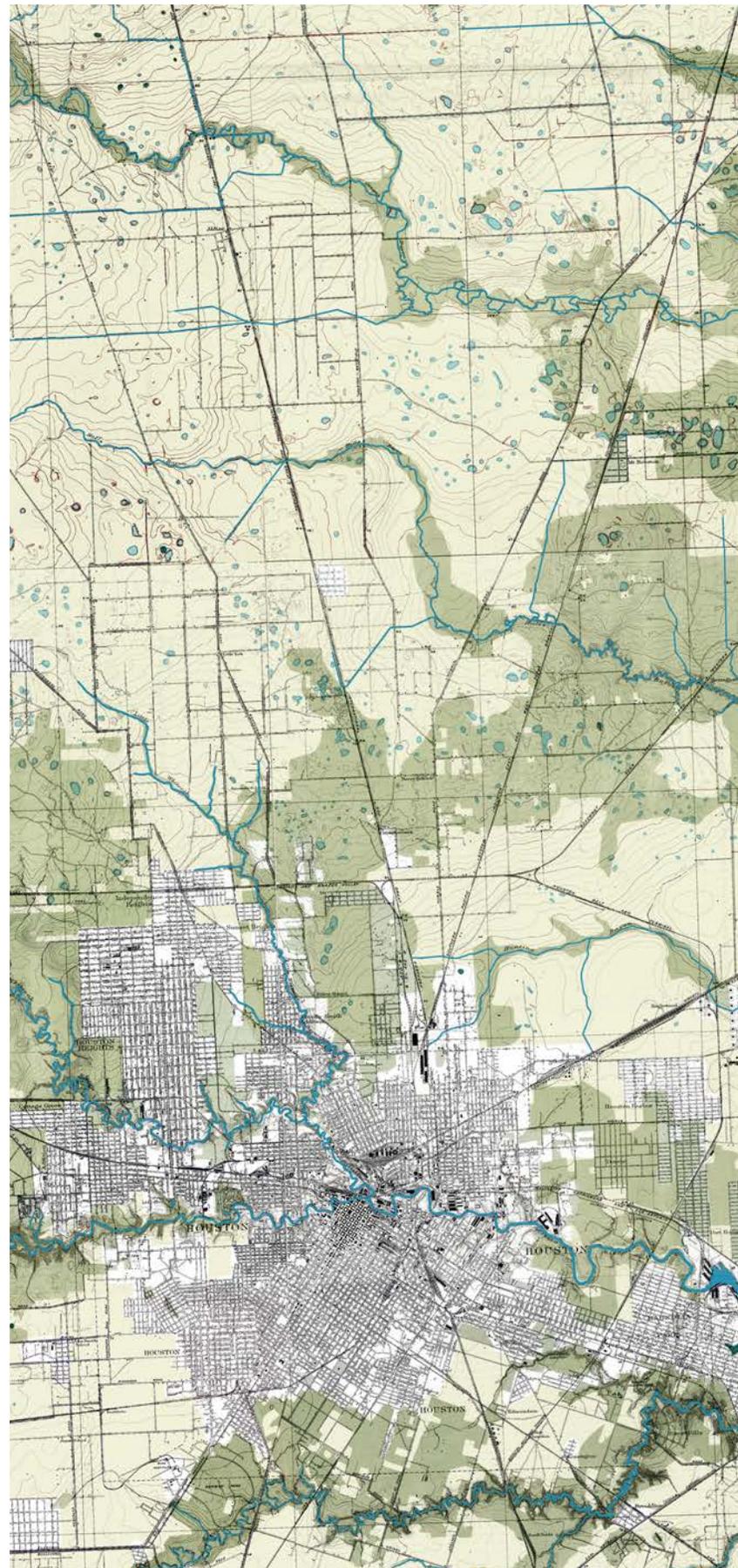
As modern development pressure built over the prairie and channelized the bayou, oxbows and prairie potholes became floodways and floodplains. Without the grasslands the underlying clay soil is largely impervious. Stormwater runoff cannot infiltrate into the ground. Accelerated runoff quickly turns into flooding.



Katy Prairie

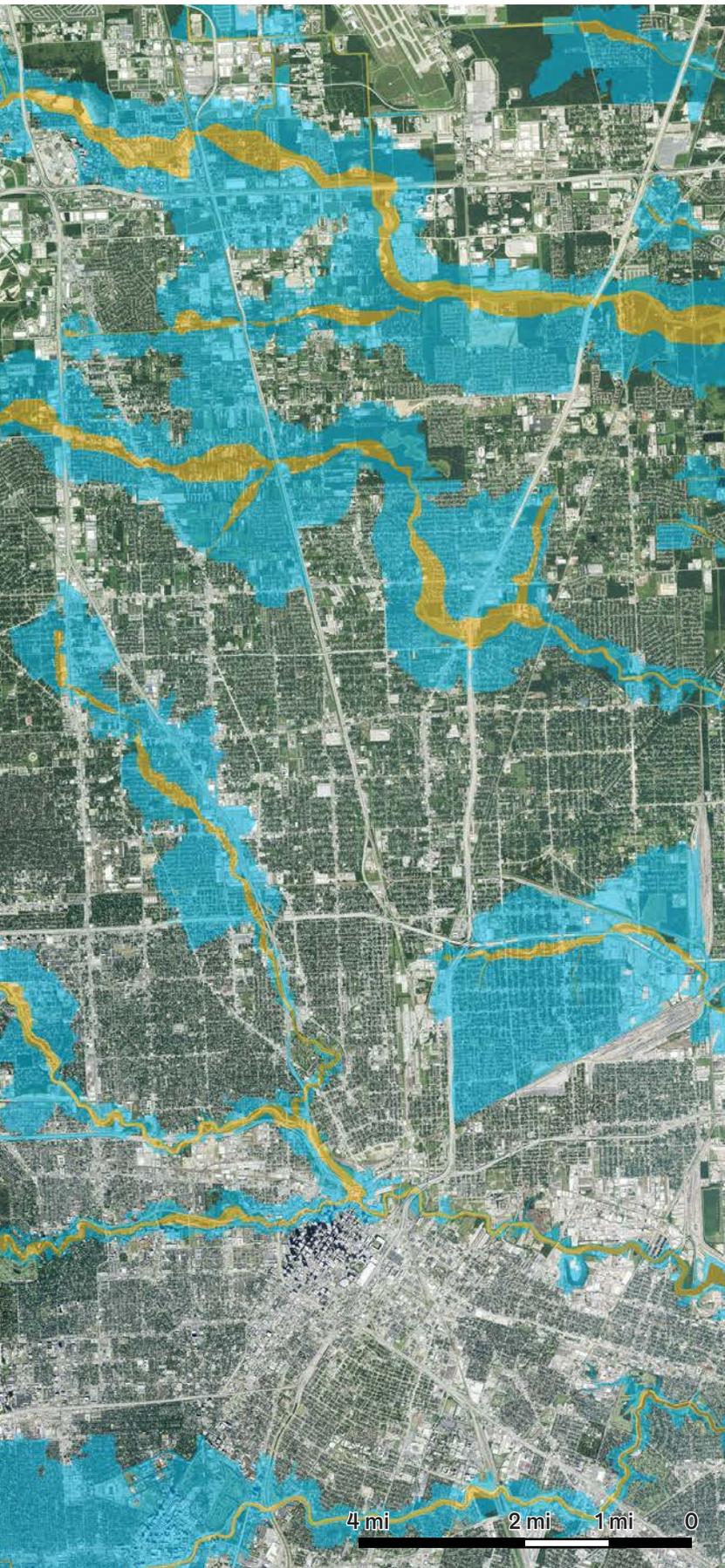
The Katy Prairie conservation areas are some of the last preserved western gulf grassland ecosystems.

photo credit: By Katy Prairie Conservancy - Own work, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=5100822>



1922

Credit: USGS, colorized Waggonner and Ball



Prairie Floodplain

Slight changes in elevation have a similar impact on the floodplain today, shaped by nearly imperceptible changes in topography. Highway and railroad berms can impound water or cause it to back up, thus widening floodplains. Structures built on the remnant paths of old bayous are almost always in the floodway or floodplain. By understanding the historic coastal prairie that Houston was built on, we gain insight into today’s flood risk. The floodplains of the city are the result of the prairie landscape and its systems, even if the prairie is gone.



Hunting Bayou

The recently constructed wetland shelves along hunting bayou resemble the past ecological condition.

Legend:

- Floodplain
- Floodway

Drainage and Infrastructure Networks

Houston is defined by its bayous and highways. These two networks are both vital to the city of Houston: a network of bayous drain the city, and modern transportation infrastructure created the city's economic vitality, which supports its continued expansion. Flood risk in Houston often arises when these two networks collide.

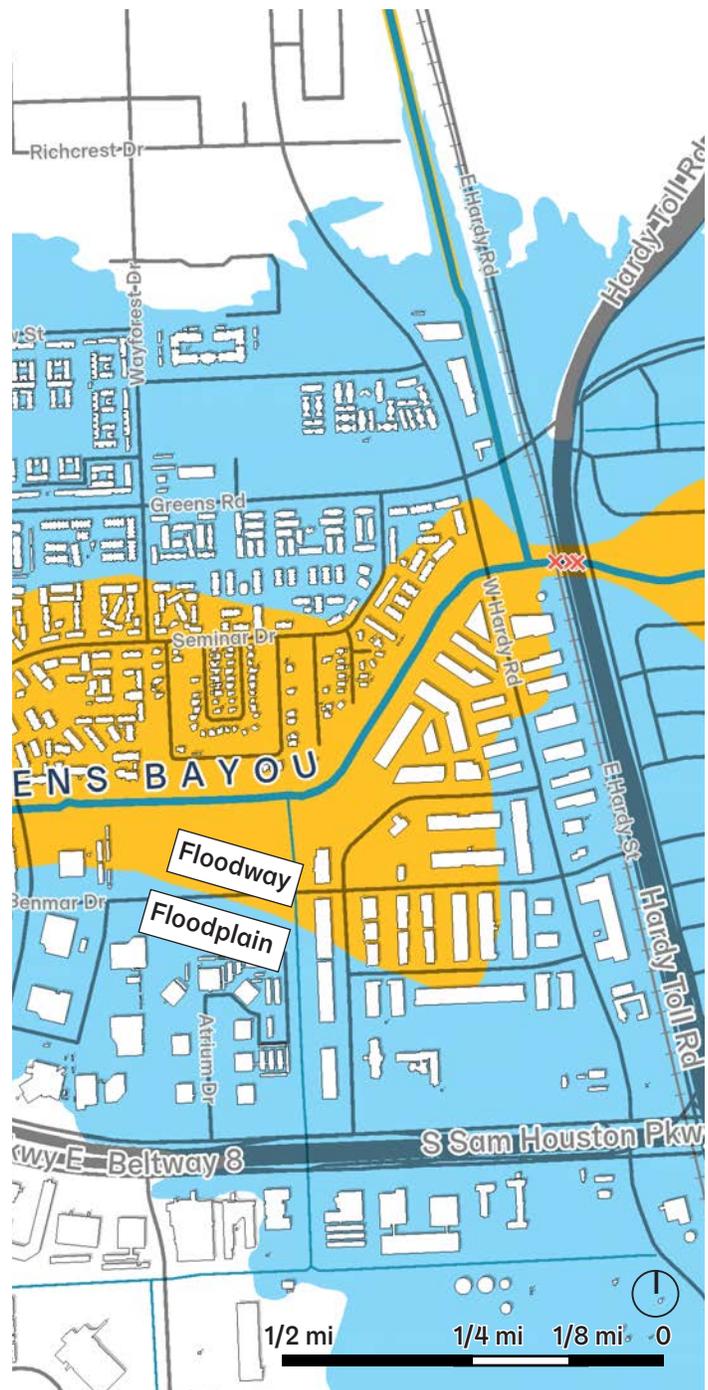
Bottlenecks and Floodways

Intersections between water and infrastructure networks often create bottlenecks in conveyance paths; water has limited ability to pass through a constricted space. Some of the starkest examples of this result from intersections between historic bayous and historic rail lines. Most of these bayou crossings were built well before Houston expanded around them, so flood risk would only become apparent later as those areas developed. Historic rail lines are often characterized by low bridges and small berms. These constrict floodwater and cause floodways and floodplains to expand along the rail corridor.

Wide floodways put people at the most risk. The floodway is defined by FEMA as the channel in which a waterway needs to convey stormwater downstream. Floodways typically have the most developmental restrictions. Legacy homes that find themselves within the floodway as flood insurance rate maps become updated are often most at risk. They deal with both moving water during flood events, and a limited or prohibited ability to rebuild. Constricted and enlarged floodways create problems in both land use/occupation and water conveyance.

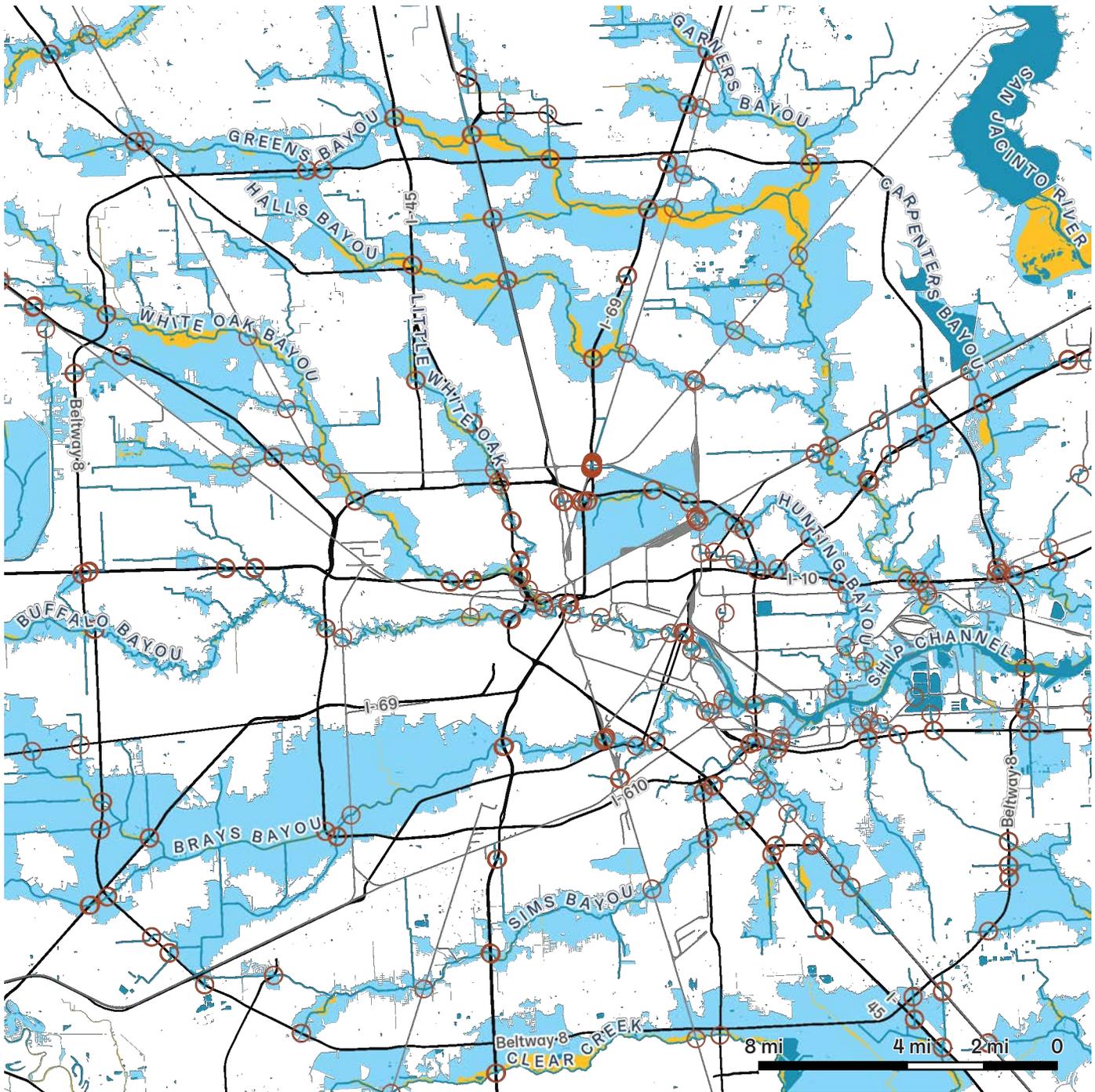
Resolving conveyance issues creates a difficult dilemma. To alleviate any upstream constriction, downstream will have to receive more stormwater. The balancing act of improving conveyance without creating downstream flooding requires a watershed scale level of planning.

Resolving occupation within a floodway is difficult as well. Property buyouts can take time and leave neighborhoods fragmented. Situations are more difficult for renters, who lack the same buyout options as property owners. A concerted housing effort is needed to give relocated residents affordable alternatives. Buyout properties cannot merely be demolished; residents must be able to buy or lease comparable housing in safe areas.



Development in the Floodplain and Floodway

In Greenspoint, a significant amount of buildings and infrastructure were constructed within the floodplain and the floodway of Greens Bayou.



Network Intersections

Intersections between the bayou and transportation networks often amplify flood risk in Houston.

Legend

- Floodplain
- Floodway
- Network Intersection Point

Street and Transit Networks

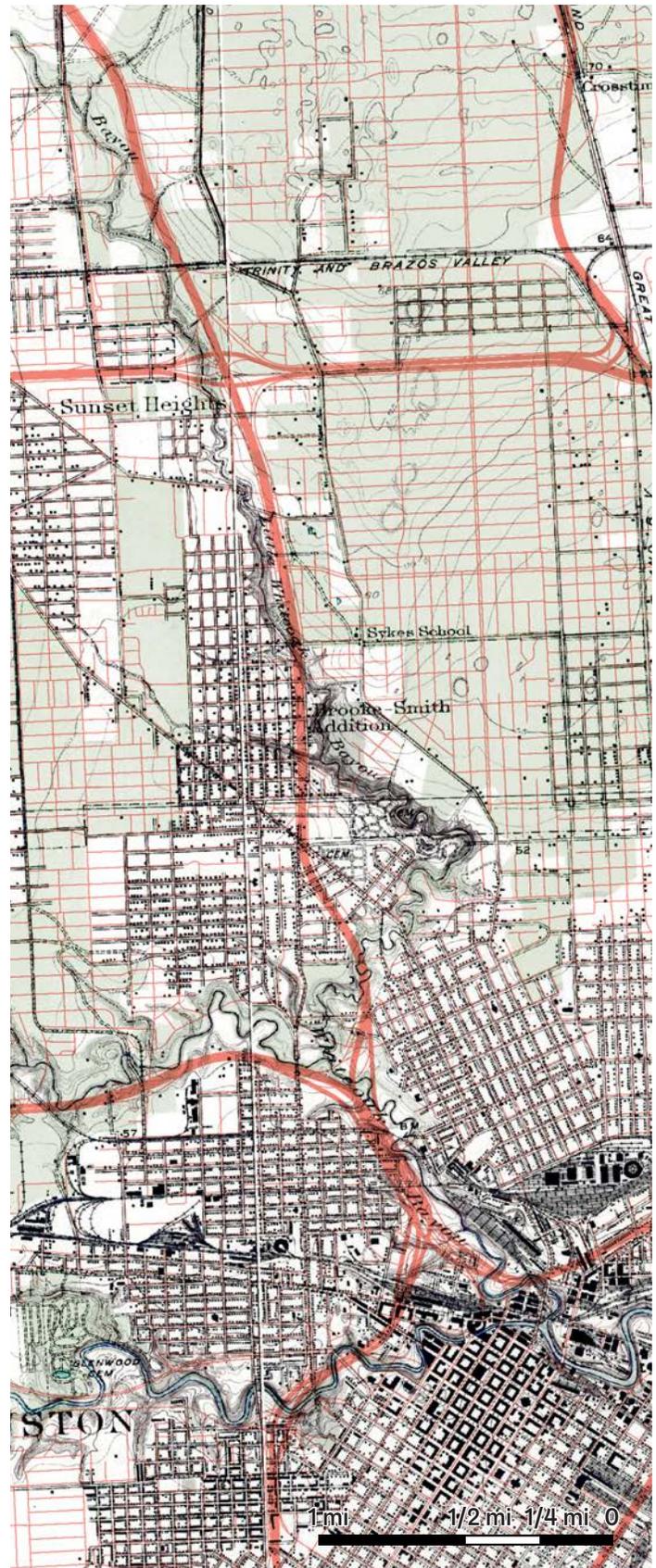
Houston is built on a historic street grid that the highway system expanded over time. Houston's historic neighborhoods were built around established corridors; the highway system was not. Large highways cleave through neighborhoods and the historic street grid. Expansion created disconnection, particularly in the three focus areas. As the city grid grew its adherence to the historic grid diminished. This resulted in the prevalent patterns of suburban subdivisions farther away from the urban cores.

Transportation Expansion

The constantly expanding highway system presents opportunities, as renovation allows for redesign. For example, existing bottlenecks or other problems in the drainage system can be addressed. Culverts can be daylighted and re-naturalized, and constrictions can be alleviated. As public transit becomes more available, opportunities to create safe egress corridors for access and evacuation are more feasible. Neighborhoods can be reoriented around historic street corridors. Expansion also provides the opportunity to resolve problematic intersections. Conversely, expansion of the transportation systems also has the potential to exacerbate flooding.

Interceptor Streets

Streets and other paved areas contribute a significant portion of the city's runoff. For the denser parts of Houston, streets are also the largest swath of space in the public right of way. Between those two factors there is a tremendous opportunity to transform streets from contributors of runoff to vital pieces of detention infrastructure. Creating "interceptor streets" at key junctures around Houston can mitigate the cascade of runoff entering the drainage system. These interceptors streets can be aligned with historic, commercial, and public transit corridors, to provide multiple public amenities in addition to flood risk reduction.

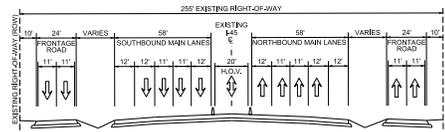


Highways and City Streets

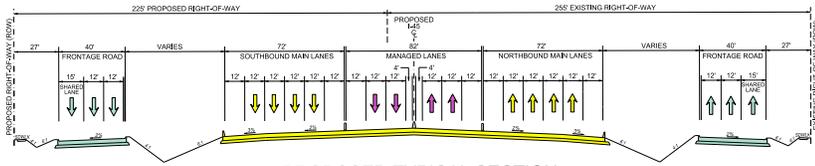
Above: The highway system, shown in orange, disrupts Houston's historic city street grid, dividing neighborhoods and creating boundaries.

Map: USGS

Colorized by Waggoner and Ball



EXISTING TYPICAL SECTION
AIRLINE DRIVE TO SHEPHERD DRIVE



PROPOSED TYPICAL SECTION
AIRLINE DRIVE TO SHEPHERD DRIVE

Existing and Proposed Road Section

The North Houston Highway Improvement Project I-45 Expansion will nearly double the width of the highway. All of the expansion is on the west side of the existing highway.



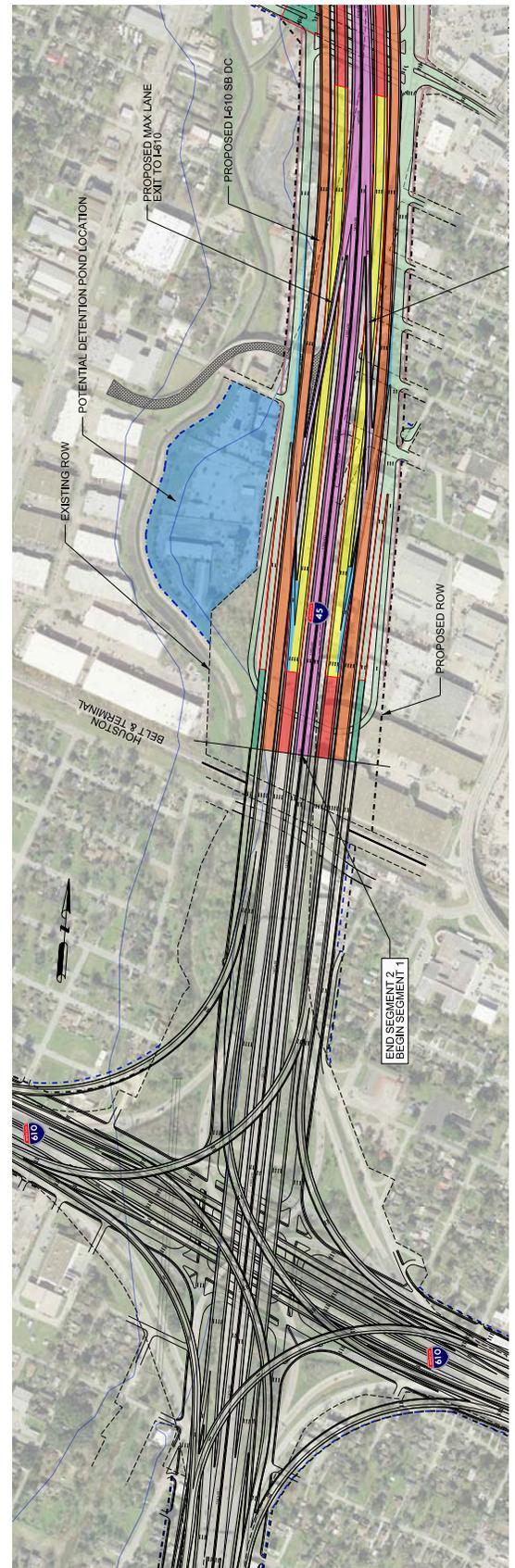
I-45 Crossing at Greens Bayou

Bridge crossings can alter the flow and limit the water storage capacity of bayous.



Interceptor Street Example

The above street is constructed out of pervious material and sits on top of gravel with underground detention cells, and bioswales flanking both sides.



North Houston Highway Improvement Project

Top and Above: The existing highway is planned to increase capacity by adding several driving lanes and frontage roads on either side, which will push into adjacent neighborhoods. Credit: TXDOT

Land Use and Development

Unraveling Houston

Discerning land use rationale, or lack thereof, is critical in Houston. The lack of zoning makes eclectic land use patterns commonplace. A myriad of sources can shape the city form: historic corridors, patchworks of jurisdictions and reinvestment zones, and ever-expanding transportation networks. Without zoning, the toolkit for shaping development must take a corresponding myriad of forms.

Crossing Jurisdictions

Greater Houston includes eight counties, with over 100 cities total, and approximately two million people living in unincorporated areas. Since 2000, Greater Houston has added approximately three million residents, while the City of Houston has limited its annexation efforts. As the Greater Houston area expands, the multitude of jurisdictions expands with it.

Where areas are divided by political boundaries, they are connected through watersheds. For example, Buffalo Bayou spans across three counties, multiple municipalities, and dozens of utility districts. In unincorporated parts of Greater Houston, over 370 municipal utility districts (MUDs) define stormwater infrastructure. For solutions to work across the entire watershed, collaboration is essential.



Historic Corridors

Example of historic multi-modal transit along Texas avenue networks that supported the growth of the city.

Credit: University of Houston Digital Library, Historic Houston Photographs



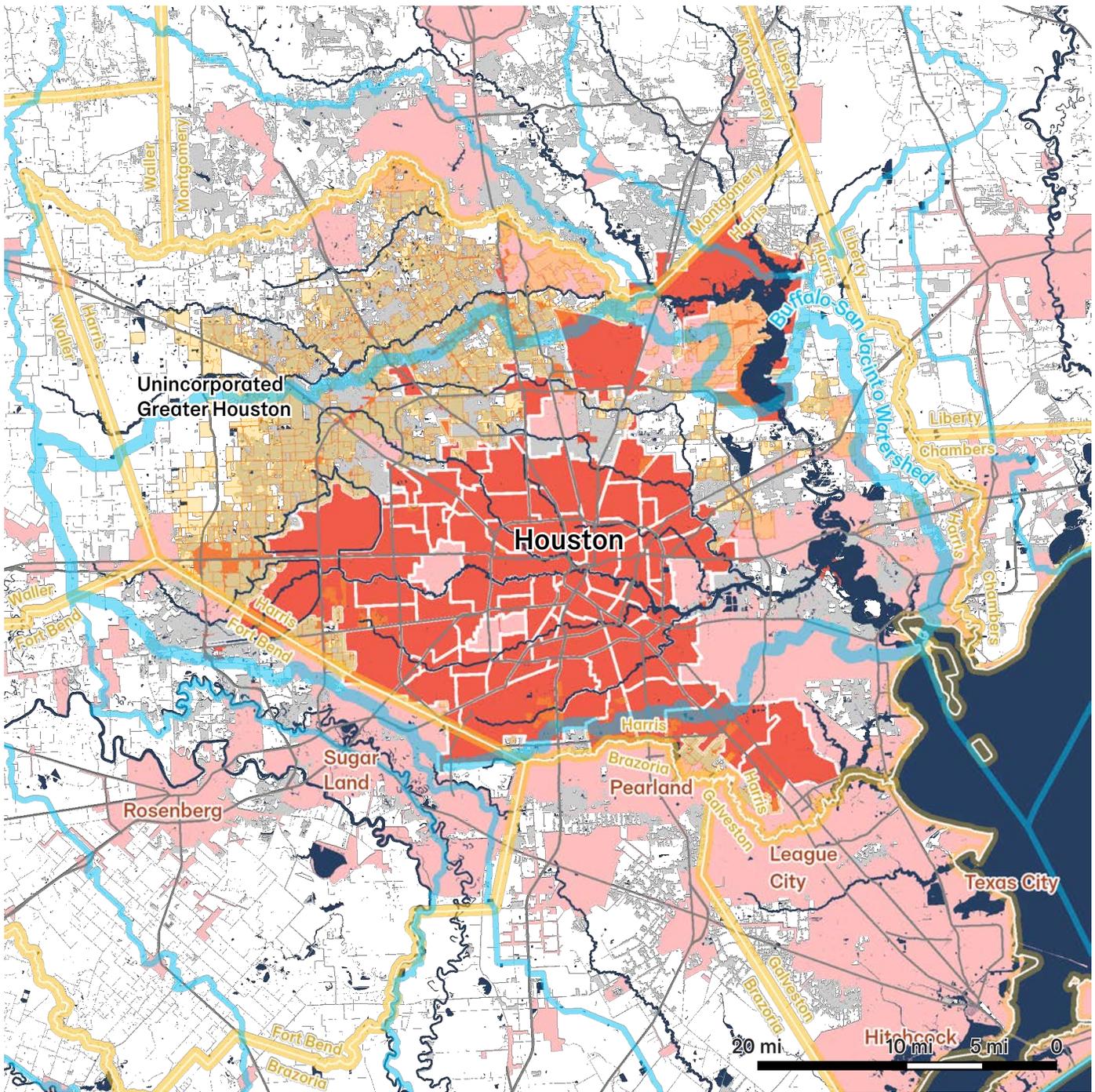
Land Use Patterns

Houston is characterized by eclectic land use patterns.



Land Use Patterns

In Houston neighborhoods, a wide range of land use and building types exist in close proximity, or even within the same parcel



Political Boundaries

Houston (dark red) is split up into 88 super-neighborhoods. Most of Houston is located within Harris County (orange line), although a significant number of Harris County residents live in unincorporated space. Much of greater Houston's unincorporated space is within municipal utility districts, or MUDs (light orange).

Legend

- Houston
- Other Municipalities
- Unincorporated
- Municipal Utility Districts (MUDs)
- County
- HUC-8 Watersheds

Bayou City Water Recommendations

The Bayou City Water Recommendations encompass systemic changes to how Houston operates. Those systemic changes must also work across every scale down to the individual project. These recommendations were developed out of specific neighborhood analyses: local specific issues and opportunities translated into suggestions that can apply to prototypical conditions across the region. They work both top-down and bottom-up: City leaders and agencies can use them to address systemic challenges, and community members can reference them where their neighborhood issues overlap with regional planning.

Short Term:

BC1. Study water system choke points

Constrictions must be dealt with in a way that does not increase downstream flooding. Conveyance increases must be matched with runoff storage, property elevations and retrofits. Alternatively, strategic constrictions can be maintained to lessen downstream flooding.

BC2. Develop watershed and sub-watershed plans

Bayou planning should include “between the bayous,” not just space around the channel itself. New coalitions between jurisdictions must be forged to plan at the watershed level.

BC3. Pilot City, County, and State cooperation at the policy and project level

Leverage access to funding structure and opportunities. Possible Pilot projects include: Buyout funding/property swaps, multi-use detention basins, highway runoff mitigation.

Mid Term:

BC4. No Residents in the floodway (active channel)

Existing single and multifamily residences must be equitably moved out of the floodway. The floodway is crucial to the strategy of making space for the bayou.

BC5. Consider risk mitigation outside of the 500 year Floodplain

Over half of the property damage in Hurricane Harvey happened outside of the 500 year floodplain. As storm data and risk is updated, floodplains will change and areas previously “safe” will become at risk. Preemptive measures can mitigate unforeseen risk.

BC6. Prioritize surface water storage and conveyance

Keeping water above ground and out of pipes is a cost effective and visible strategy with potential for multiple benefits.

Long Term:

BC7. Create “Interceptor Streets”

Streets present some of the largest swaths of public right of way, especially in the denser, fully built out parts of Houston. Stormwater can be managed through innovative street sections and GSI (green stormwater infrastructure) Blue-green streets should align with historic corridors, commercial streets, and public transit routes to provide multiple benefits.

BC8. Use water and water infrastructure to create places with unique character

Each bayou has a different character and set of challenges. Ecological restoration can magnify detention and infiltration and highlight a bayou’s unique character. The massive detention basins being constructed throughout Houston are also opportunities to provide residents with public recreational amenities.

An aerial photograph of a city neighborhood, likely in Houston, with a semi-transparent blue overlay. The image shows a mix of residential and commercial buildings, parking lots, and green spaces. The text is overlaid on the central part of the image.

Neighborhoods

The neighborhood scale in Houston can be defined in many ways: by politics; by residents' shared identity within super-neighborhoods, utility districts and reinvestment zones; by commercial and cultural centers; and by landscape, as watersheds, sub watersheds and floodplains.

This chapter is an overview of the three neighborhood study areas to follow, each with their own specific proposals. The neighborhood recommendations preference the natural, and encompass smaller scales, down to the block, lot and home. In this section, the strategies are prototypical, encompassing recommendations that could be employed throughout Houston. Recommendations at the neighborhood scale fit into the framework of the systemic recommendations featured in the Bayou City Water section.



Study Areas

The neighborhood study areas, identified around three of Houston's super neighborhoods and their surrounding context, were selected by the City of Houston following the Living With Water Convening in November 2018 (see appendix for a summary of the Convening proceedings). Independence Heights, Kashmere Gardens, and Greenspoint represent characteristic challenges and opportunities across the region, and while they each have unique identities, together they serve as valuable prototypes for flood mitigation solutions. Living With Water ideas are intended to support ongoing planning efforts, such as Complete Communities planning processes, within these selected super neighborhoods. Super neighborhood boundaries, or planning units within the city, do not always correspond to the sources of flood risk within them, so the study areas often zoom out to include adjacent watersheds and infrastructure. Design proposals for these study areas were developed during an intensive three day multi-disciplinary design workshop, and all concepts are preliminary: they must be vetted by and elaborated with community stakeholders.

Independence Heights

Independence Heights is a historic neighborhood bounded by I-45 and 610. I-45 both connects Independence Heights to Downtown Houston and creates its flood risk problem by constricting the Little White Oak Bayou. The bayou has the smallest of the study area watersheds and is a tributary to the larger White Oak Bayou. As the Interstate expands in the immediate future, its relation to the bayou and the neighborhood has to be reconsidered.

Kashmere Gardens

Kashmere Gardens is a historic neighborhood located in the upper portion of Hunting Bayou. The bayou has a wide and shallow floodplain impounded by rail yards. Almost every resident of Kashmere Gardens lives within this shallow floodplain. The industrial infrastructure surrounding Kashmere has both flooding and environmental impacts, and so any risk mitigation effort must address both facets.

Greenspoint

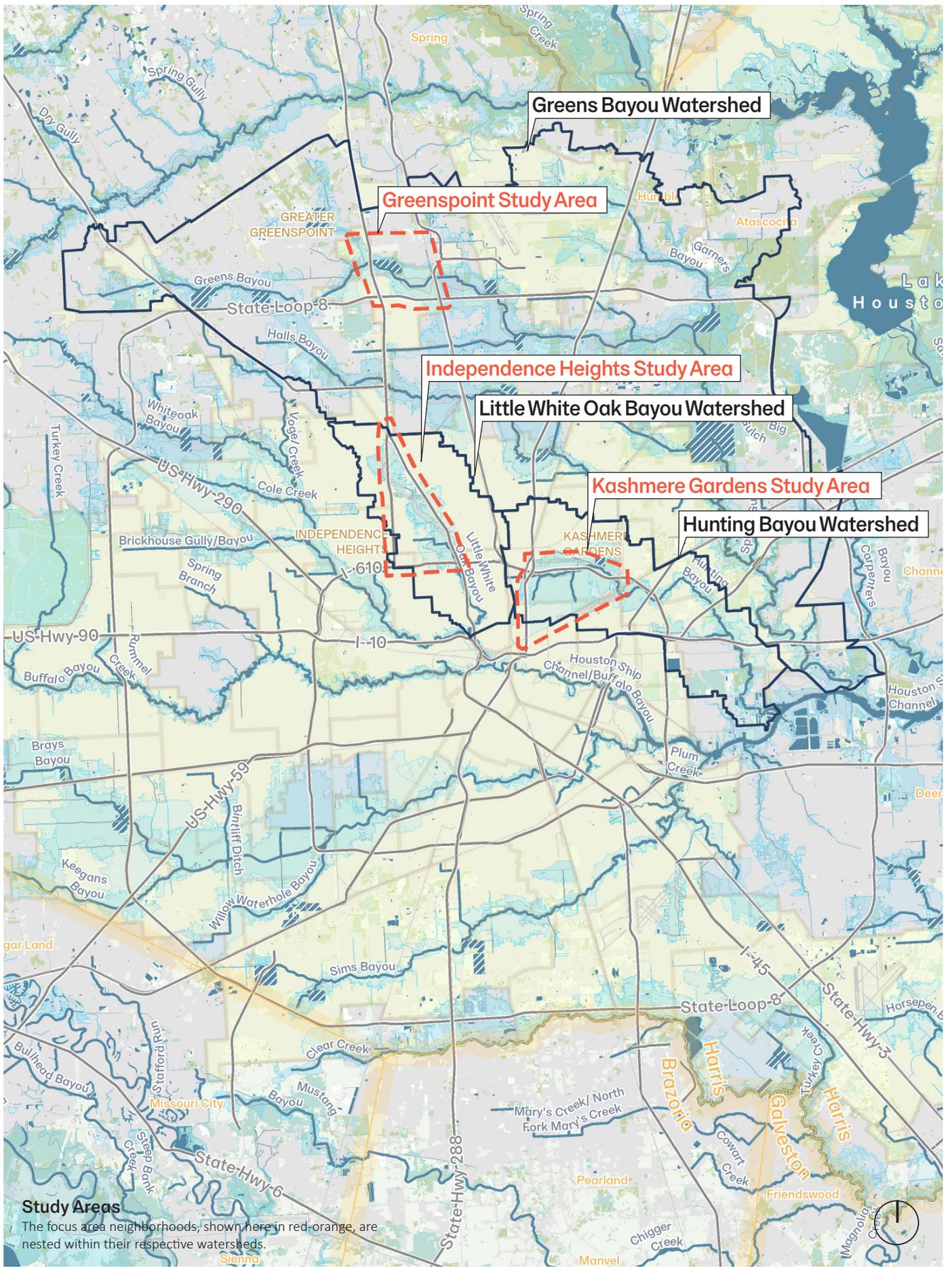
Greenspoint is located near George Bush/IAH Airport on the urban periphery, where office parks coexist with still undeveloped parcels of land. Greenspoint is midway along a much larger bayou than the other two study areas. Its flood risk also manifests itself differently. In addition to a large floodplain, many Greenspoint residents are renters living in multi-family apartments deep inside the floodway, where risk is greater and rebuilding is difficult. Construction of massive detention basins has begun all along Greens Bayou over the last decade. In Greenspoint getting residents equitably out of risk areas must be done in partnership with ongoing stormwater detention and urban redevelopment.

Water Based Planning

Much of Houston is disconnected from the bayous that run through it. That disconnect leads to bayou constrictions, and risky developmental patterns. Water-based planning allows for Houston to reconnect with its bayous and create solutions that span boundaries and scales.

Notes:

1. Parks & properties shown as "green" throughout this report are illustrated for conceptual purposes only.
2. All property decisions should be made with community and land owner buy-in.
3. All images are credited to Waggonner & Ball unless otherwise attributed.



Study Areas
The focus area neighborhoods, shown here in red-orange, are nested within their respective watersheds.



Independence Heights

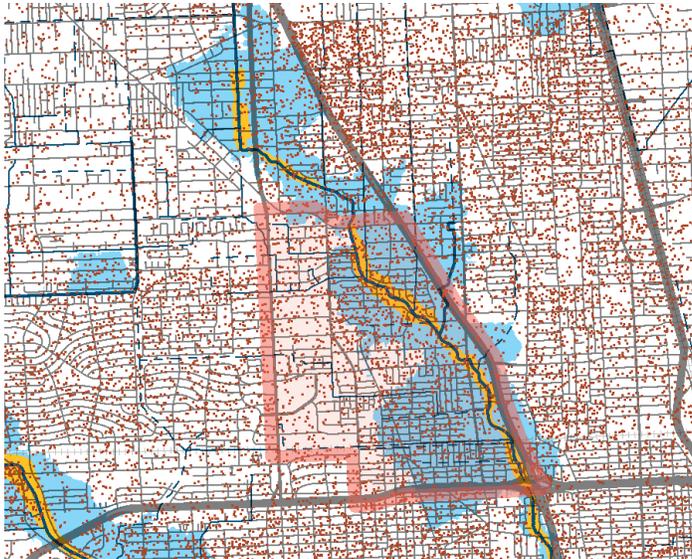


Kashmere Gardens



Greenspoint

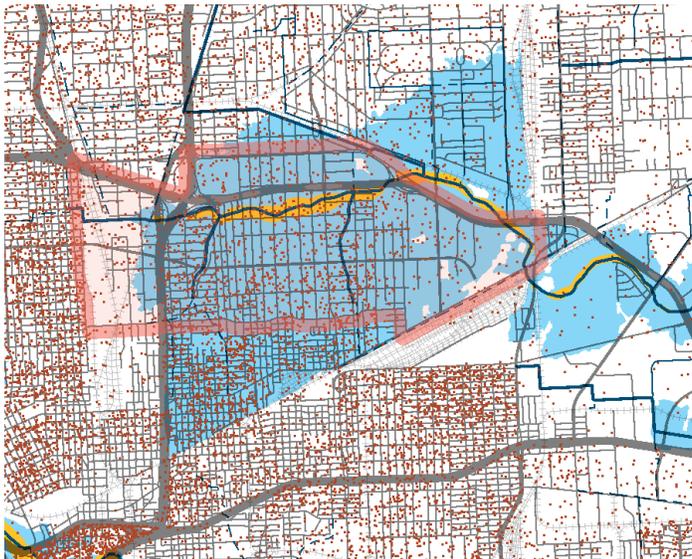
Independence Heights Study Area



Independence Heights Super Neighborhood

Area:	3.40 sq mi
Population Density:	4,000 per sq mi
Population in Floodplains:	≈7,000
Population in Floodway:	≈1,300
Median Income:	\$43,000
Median House Value:	\$139,000

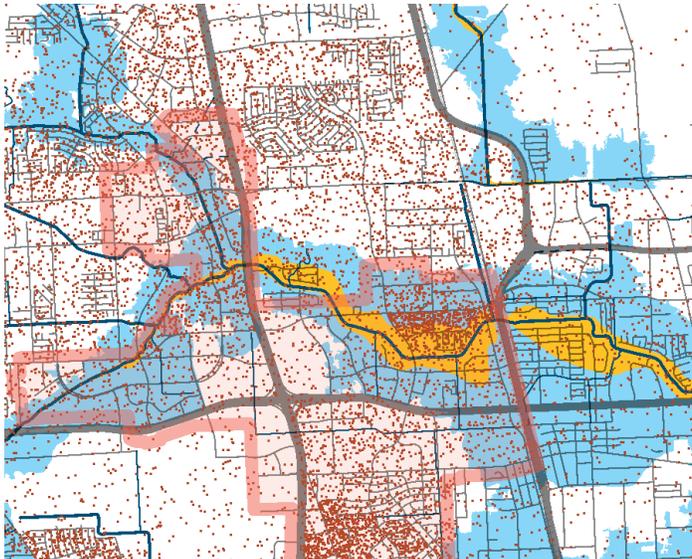
Kashmere Gardens Study Area



Kashmere Gardens Super Neighborhood

Area:	4.03 sq mi
Population Density:	2,500 per sq mi
Population in Floodplains:	≈8,300
Population in Floodway:	≈500
Median Income:	\$23,000
Median House Value:	\$62,000

Greenspoint Study Area



Greenspoint Super Neighborhood

Area:	6.96 sq mi
Population Density:	6,000 per sq mi
Population in Floodplains:	≈12,700
Population in Floodway:	≈4,200
Median Income:	\$34,000
Median House Value:	\$55,000

Legend:

- 10 people
- Floodway
- Floodplain
- Super Neighborhood

Neighborhoods Recommendations

The neighborhood scale recommendations focus on more prototypical strategies that fit within the systemic recommendations in the Bayou City Water Section. They represent resilience tactics that could be reproduced throughout Houston neighborhoods in various contexts and different levels of risk.

Short Term:

N1. Protect cars from flooding

In near term, cars are indispensable in Houston, especially for low to moderate-income populations. Streets are typically the lowest parts of their micro-watershed. Creating elevated/dry areas at the home and neighborhood scales can keep cars dry from nuisance flooding.

N2. Soil-neutral projects

Keep and use all cut/fill on-site (or in-neighborhood) whenever possible. Any infill in the floodplain must be matched with equal or greater volume of detention.

N3. Plant trees

Trees can infiltrate stormwater into the soil, evapotranspire stormwater into the atmosphere, provide shade, and beautify streets.

Mid Term:

N4. Community Buy-In/Buy-Out Property Swaps

Buy outs must be matched with buy ins. Residents living in risky areas should be given affordable alternatives in safer locations within the community. Use home relocations to strengthen communities and protect from flooding

N5. Improve health & environmental quality with water

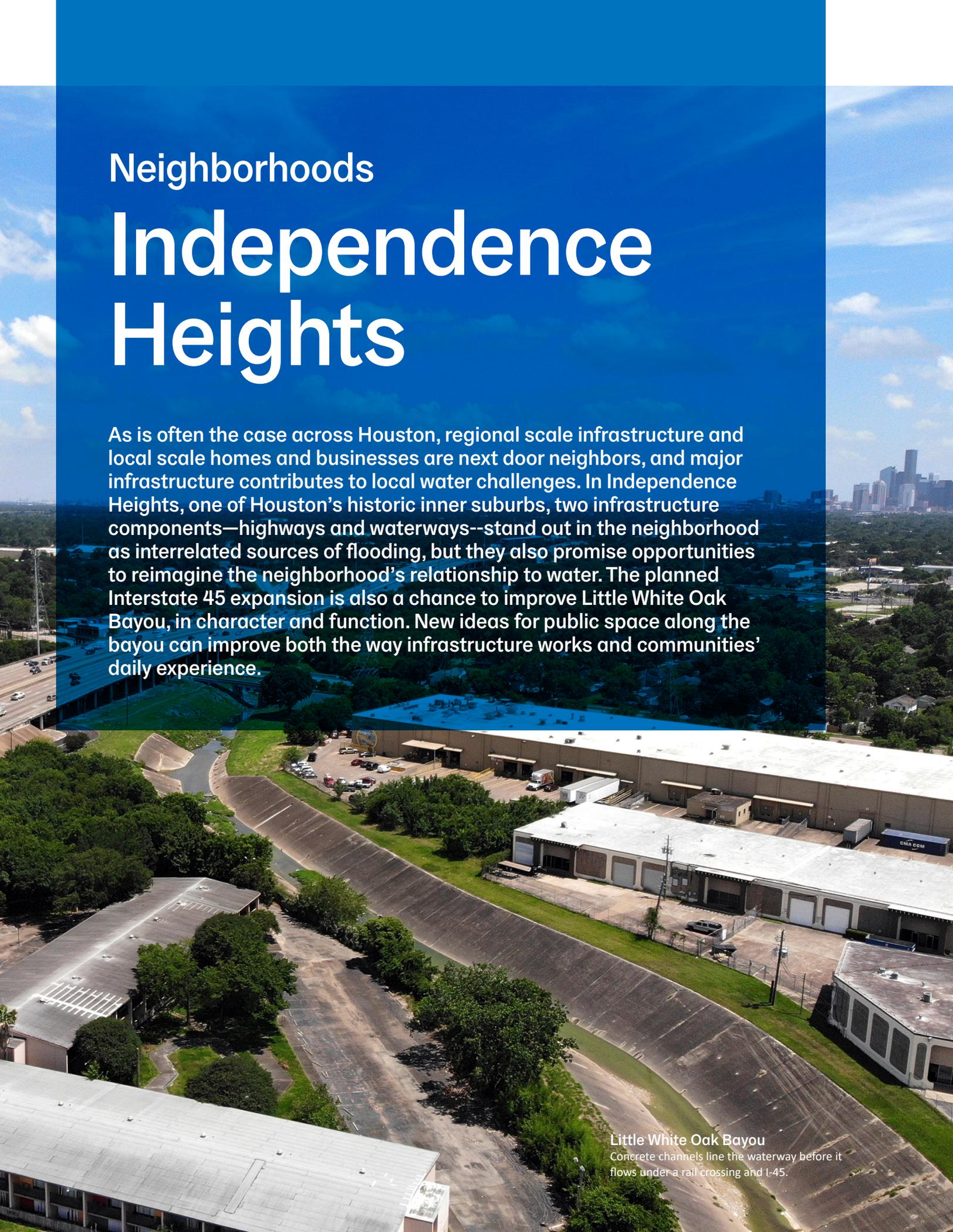
Green stormwater infrastructure must also strive to create benefits beyond stormwater management purposes. Stormwater infrastructure can double as public park spaces, creating recreational opportunities and remediating the air and environment.

Long Term:

N6. Make flood mitigation decisions that benefit everyone

Share benefits from water equitably, including access to water amenities, affordable development, and improvements to health and environmental quality. Ensure that risk mitigation works for the broad community inclusively and equitably.



An aerial photograph of the Independence Heights neighborhood in Houston. The image shows a mix of industrial and residential areas. In the foreground, there are several large industrial buildings with flat roofs, some with parking lots. A prominent feature is a wide, concrete-lined bayou that runs through the area. To the left, a multi-lane highway (Interstate 45) is visible, with a bridge crossing over the bayou. The background shows a dense residential area with trees and houses, and in the far distance, the Houston skyline is visible under a blue sky with scattered clouds. The text is overlaid on a dark blue semi-transparent background in the upper left portion of the image.

Neighborhoods

Independence Heights

As is often the case across Houston, regional scale infrastructure and local scale homes and businesses are next door neighbors, and major infrastructure contributes to local water challenges. In Independence Heights, one of Houston's historic inner suburbs, two infrastructure components—highways and waterways—stand out in the neighborhood as interrelated sources of flooding, but they also promise opportunities to reimagine the neighborhood's relationship to water. The planned Interstate 45 expansion is also a chance to improve Little White Oak Bayou, in character and function. New ideas for public space along the bayou can improve both the way infrastructure works and communities' daily experience.

Little White Oak Bayou
Concrete channels line the waterway before it flows under a rail crossing and I-45.

Contributors

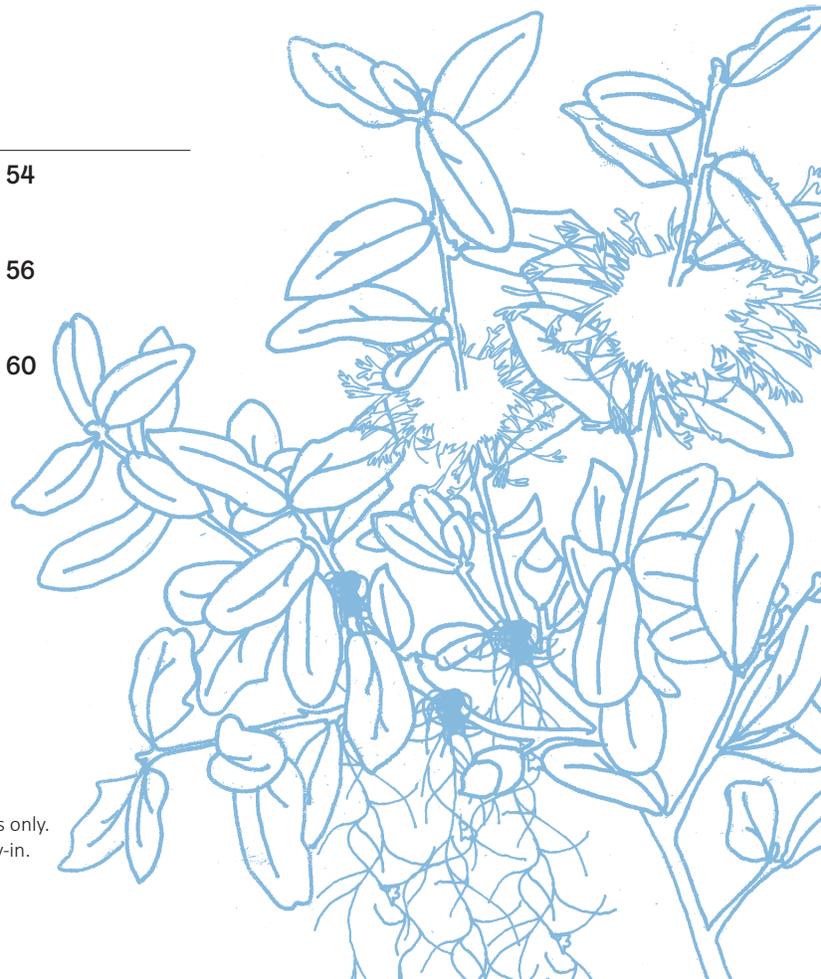
Ramiro Diaz, WBAE; Donald del Cid, WBAE; Keiji Asakura, Asakura Robinson; Stijn Koole, Bosh-Slabbers Landscape Architects; Jennifer Ostlind, City of Houston; Michael Bloom, R.G. Miller Engineers; Burton Johnson, Moffatt & Nichol; Zion Escobar, Sherwood Design Engineers; Lauren Grimley, The Water Institute; Ripendra Awal, Prairie View A&M University; Lisa Graiff, Houston Parks Board; Kyle Shelton, Kinder Institute;

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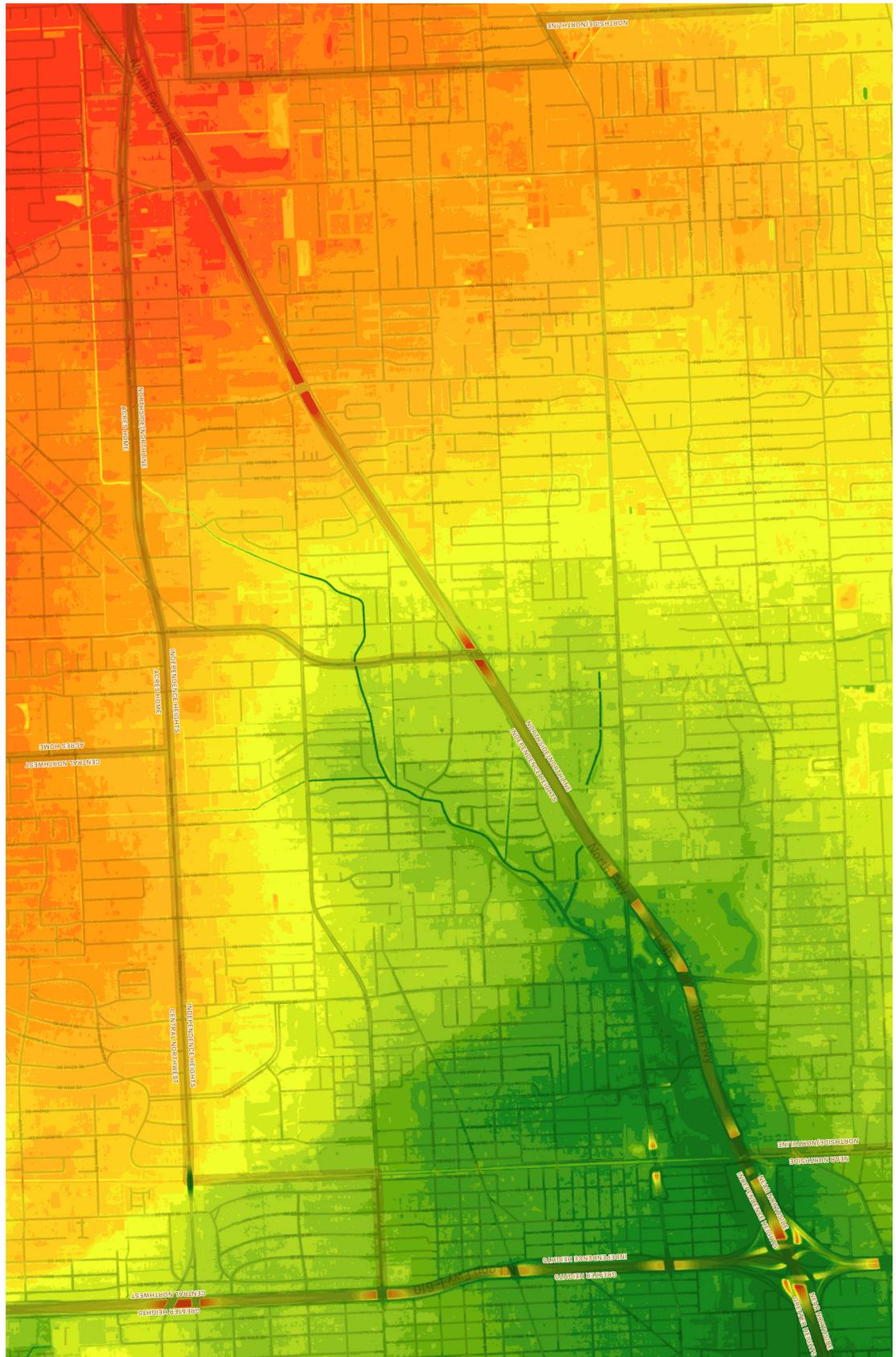
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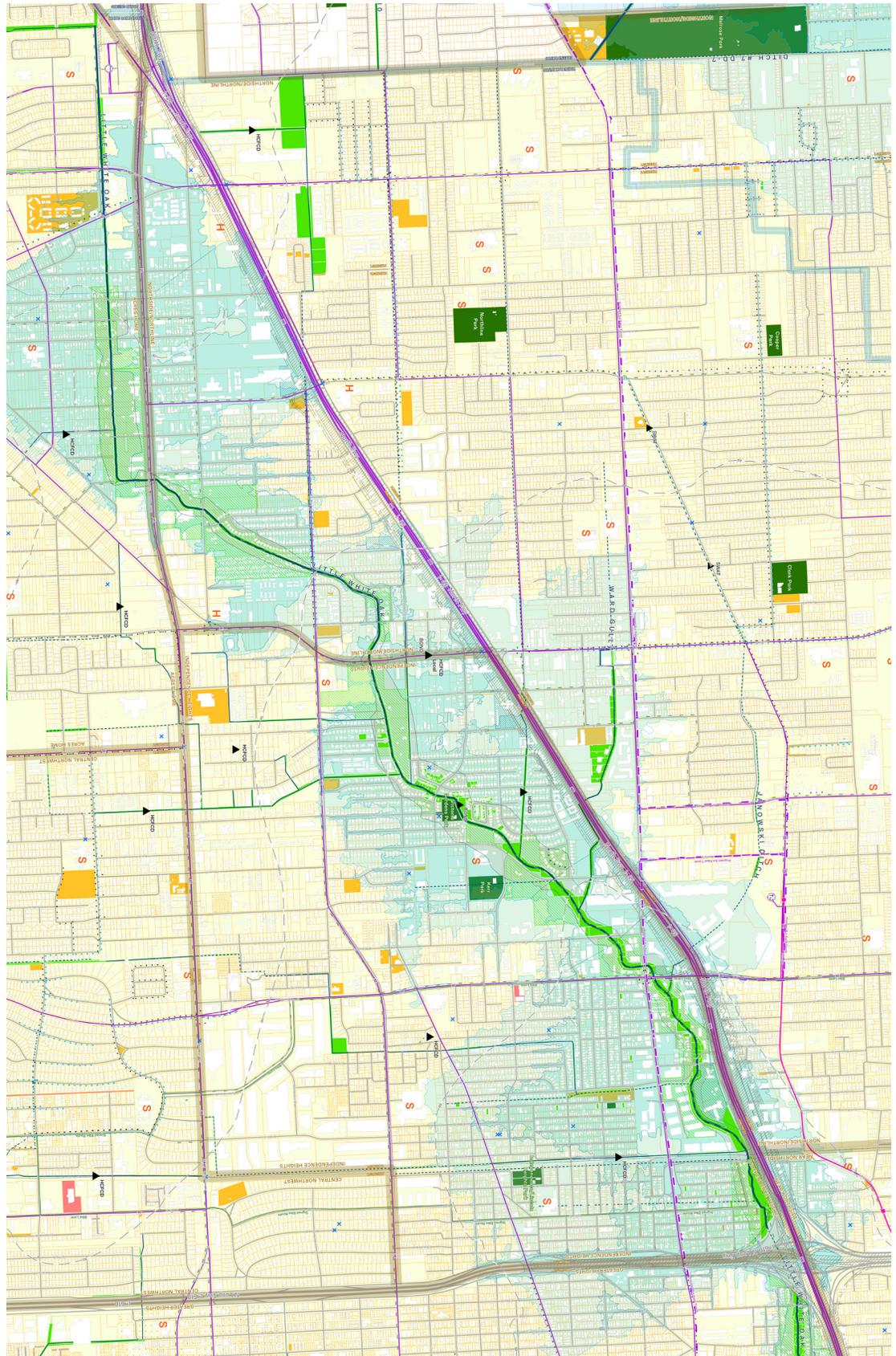
Elevation

Elevation (feet)



Land Use

- LEGEND**
- 10' Contours**
 - 10
 - 50
 - DFIRM**
 - Floodway
 - 100 Year Floodplain
 - 500 Year Floodplain
 - X 311 Flooding
 - Watersheds
 - Waterway Centerlines
 - - - Sewer
 - Major Waterways
 - Minor Waterways
 - Ditches
 - ONGOING PROJECTS**
 - ▲ Active Projects
 - ▨ HCFCDD - Possible Acquisitions
 - ▨ HCFCDD ROW Acquisitions
 - ▨ HCFCDD - Detention Basins
 - 145 - NHHIP**
 - ▨ Frontage Road
 - ▨ Highway; Bridge
 - ▨ Detention Pond
 - Hardy Toll Connector Project**
 - ▨ Hardy Toll Connector Project
 - ▨ Hardy Connector Detention
 - CRITICAL FACILITIES**
 - H Hospitals
 - S Schools
 - TRANSPORTATION**
 - Roads**
 -
 -
 - Rails**
 -
 - BUS & LIGHTRAIL**
 - LRT
 - BRT
 - TC RN Transit Centers
 - PR RN Park Rides Centers
 - LRT Stations
 - PR Corridors
 - Bus Routes
 - Proposed Transit Projects**
 - Light Rail Transit
 - Bus Rapid Transit
 - BIKE**
 - Existing Bikeways
 - MAJOR AREAS**
 - MUDs
 - TIRZ
 - Parks
 - City of Houston Parcels
 - Harris County Parcels
 - Super Neighborhoods
 - Houston City Boundary



Land & Water

History

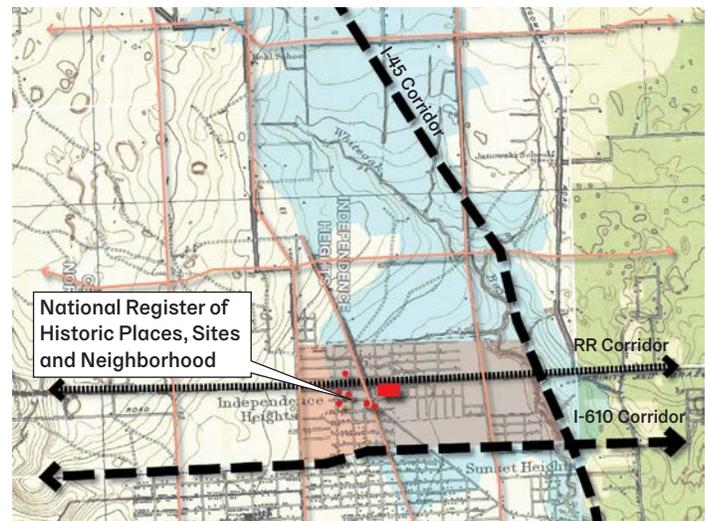
Independence Heights is one of Houston's most historic residential districts, and is the first black municipality in Texas, incorporated as a city in 1915. Until the 1920s, the area remained partially rural. Much of Independence Heights consisted of grass prairies and riparian forest surrounding a mostly unconstrained natural Little White Oak Bayou. In 1929, the growing city of Houston annexed the area.

Listed on the National Register of Historic Places, the Independence Heights Residential Historic District includes 70 acres, bounded by N. Yale St. on the west, E. 34th St. on the north, N. Columbia St. on the east, and the I-610 on the south (shown in the maps at right). The district includes 125 contributing buildings of historic significance. Within the national district, the Starkweather Historic District highlights a block of intact houses on East 31 1/2 Street off Yale St.

By the mid-twentieth century, the area rapidly urbanized, resulting in major disruption to the neighborhood. In the 1950s and 60s, highway construction led to I-45 and I-610, which divided the community and displaced hundreds of residents. Around this time, Little White Oak Bayou was straightened and channelized. The construction of a culvert where I-610 intersected the bayou heavily restricted water flow. Increased impervious land cover, channelization of the bayou, and culvert bottlenecks in the drainage system ultimately increased flood risk in the neighborhood.

Independence Heights is now a super neighborhood that is part of Houston's Northside area.

Reinforcing the historic corridors that initially supported the neighborhood is another critical strategy. Airline Drive can again be the front door to the district. In the future, zones along North Main St and Yale St, on higher ground, can include housing and mixed use development that is appropriate for the area.



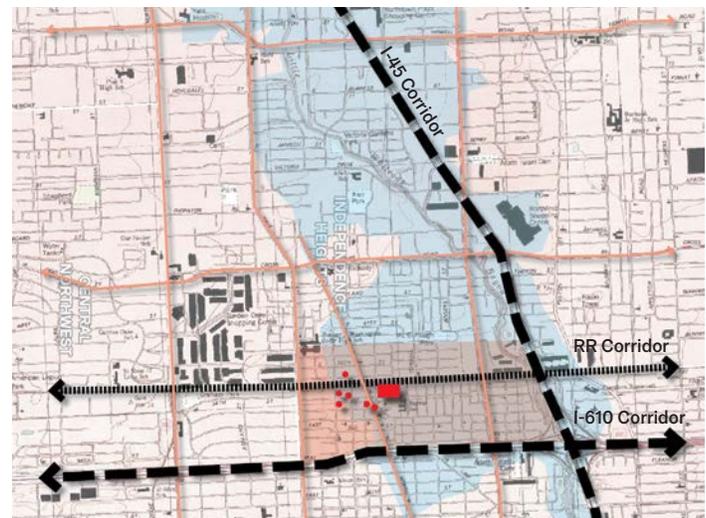
1922

The rural character of Independence Heights, with sparse development and space for the bayou



1955

Increasing development and a segment of I-45 change the character of the neighborhood



1982

The channelized bayou, along with I-45 and I-610, encouraged full development of the area



Urbanization and Roadways

Interstate 45, in the background, separated the neighborhood and displaced residents



Channelization of the Bayou

White Oak Bayou was modified into a concrete lined channel for stormwater conveyance



Historic Character

An older house in a landscape of trees and open space is a remnant of the original neighborhood

Risk & Opportunities

Today

The neighborhood has been plagued by chronic flooding impacted by drainage system constrictions within a wide floodplain. Scattered vacant lots and blighted properties exist throughout the area, though there is increasing development pressure for both empty and developed parcels. However, recent development and redevelopment trends do not tend to align with the historic character of the neighborhood, and residents often do not desire or cannot afford to live in these new developments. Feedback from the community indicates that recent developments have only served to disrupt the area and decrease connectivity between residents.

New development can fit the character of the historic neighborhood by reflecting greater population density on higher elevation, and the architectural style of cottage front porches. The possibility of a “buy-in” strategy could achieve this kind of development while also reducing flood risk and reconnecting the community. A buy-in strategy would consist of a land swap program where residents in high flood risk areas have incentives to invest in the historic neighborhood core, which is at a higher elevation. The flood-prone parcels would then be reserved for water management and landscape restoration projects.

Reevaluating land use is necessary to achieve meaningful flood reduction. Relocation is the clearest way to reduce flood risk exposure to residents. It is possible to reduce the stress of this significant process while also increasing property value within the neighborhood. For example, engaging a third party to build affordable, low-impact, historically-cognizant housing will allow residents to stay with their historic communities and maintain access to their familiar local amenities, such as schools and churches. Public art and signage could also be implemented to bring awareness to and enhance the cultural significance of Independence Heights.

Warehouses and other industrial uses also provide opportunities for neighborhood redevelopment. The facilities on low ground can be used to provide water storage and space for neighborhood parks. On higher ground facilities and/or their land can be re-purposed for housing and related community uses.



Recent Development Patterns

New construction is generally larger than existing houses, and at higher elevations



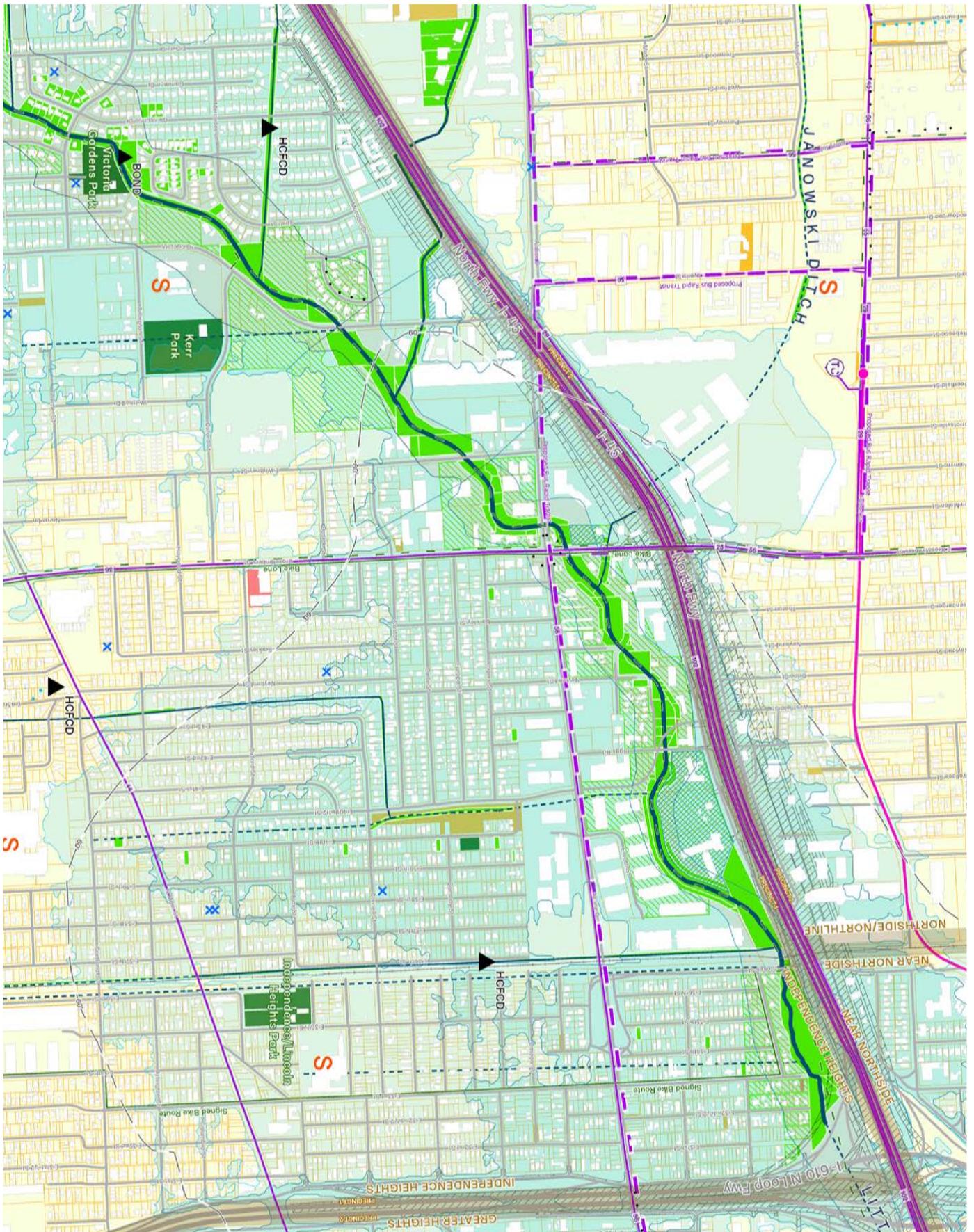
Redevelopment Opportunities

A vacant hotel and parking lot could be redeveloped in a resilient way



Limitations of Drainage System

Obstructions impede flow and cause backup, which can lead to flooding



Floodplain and Development
Floodplain is the light blue overlay and development sites are the yellow parcels



Vacant Land

Unused former parking lot is a large commercial parcel that could be redeveloped



Vacant Commercial Properties

Redeveloped parcels can address neighborhood needs and alleviate flooding



Land Use Patterns

Roads, parking lots, and roofs generate stormwater runoff, which causes flooding



Channelized Bayou

Constricted flow of the waterway means a limited capacity to capture runoff



Impervious Surfaces

Underused parking lots generate stormwater runoff and increase air temperatures



Residential Scale Drainage

Ditches in front of each house capture runoff from roads and driveways

Design Concepts

Stormwater Management

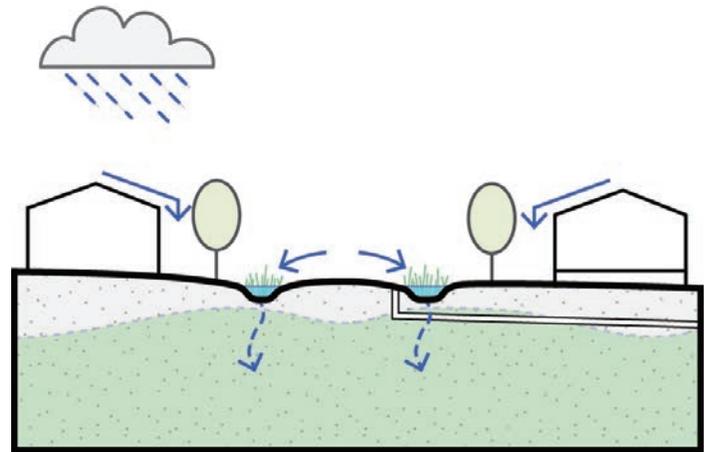
The primary goal is to slow and store runoff, thereby reducing the volume and velocity of stormwater in the drainage system and bayous. It is most effective to begin slowing and storing runoff at the top of the watershed, at higher elevations. This reduces flooding in the lower-lying areas downstream. Interventions to manage stormwater are possible at all scales, from basin to district, neighborhood, street, and individual parcel, business, or home.

Reducing impervious surfaces while increasing tree canopy and vegetative land cover will decrease runoff and the urban heat island effect. Large open areas, such as vacant parcels, parking lots, and even industrial or commercial roofs, are opportunities to slow and store runoff in accommodation with redevelopment and neighborhood re-vitalization.

At the individual lot scale, a range of strategies can intercept and infiltrate runoff before it runs off to the streets. These include permeable paving, French drains, rain gardens, rain barrels, or cisterns. Rights-of-ways, such as streets, boulevards, highways, or utility corridors, can be retrofitted to store and convey water with green infrastructure, while also providing safer connections for pedestrians and bicyclists. Tree plantings, bioswales, and corner curb extensions will help manage water while providing shade and habit, and improving streetscapes.

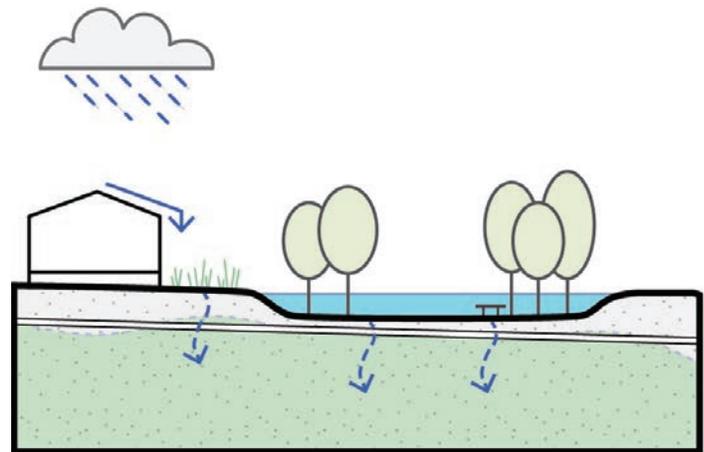
Relationship to Bayou

Little White Oak Bayou is constrained in a concrete channel, with many bottlenecks at road and rail crossings. The current FEMA floodway and risk zones give a clear indication of where the bayou floods its banks. Creating space to restore the bayou's natural course and safely store floodwater is paramount. The bayou drops roughly 40 feet in vertical elevation from the top of the watershed in Acres Homes to the I-610 tunnel. By combining large scale storage with weirs, it may be possible to hold back flood volumes at various stages and elevations, like cascades, along the course of the bayou.



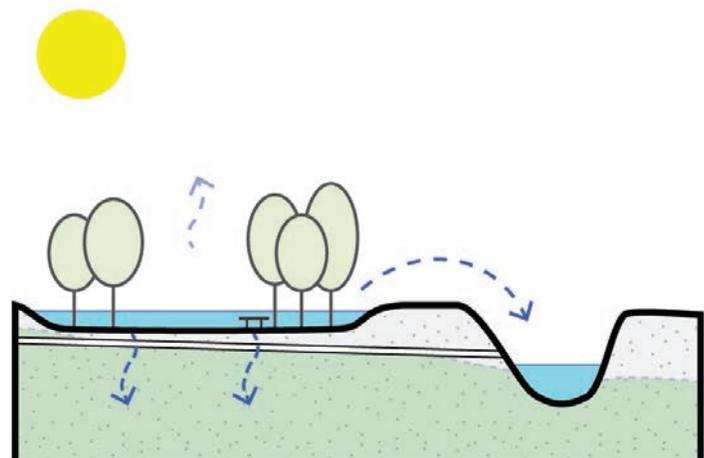
Slow

Rooftops, driveways, streets, parking lots, and sidewalks can be redesigned to catch rain where it falls, allowing some of the water to soak into the ground. Trees and other plants, such as in bioswales, help slow and clean water.



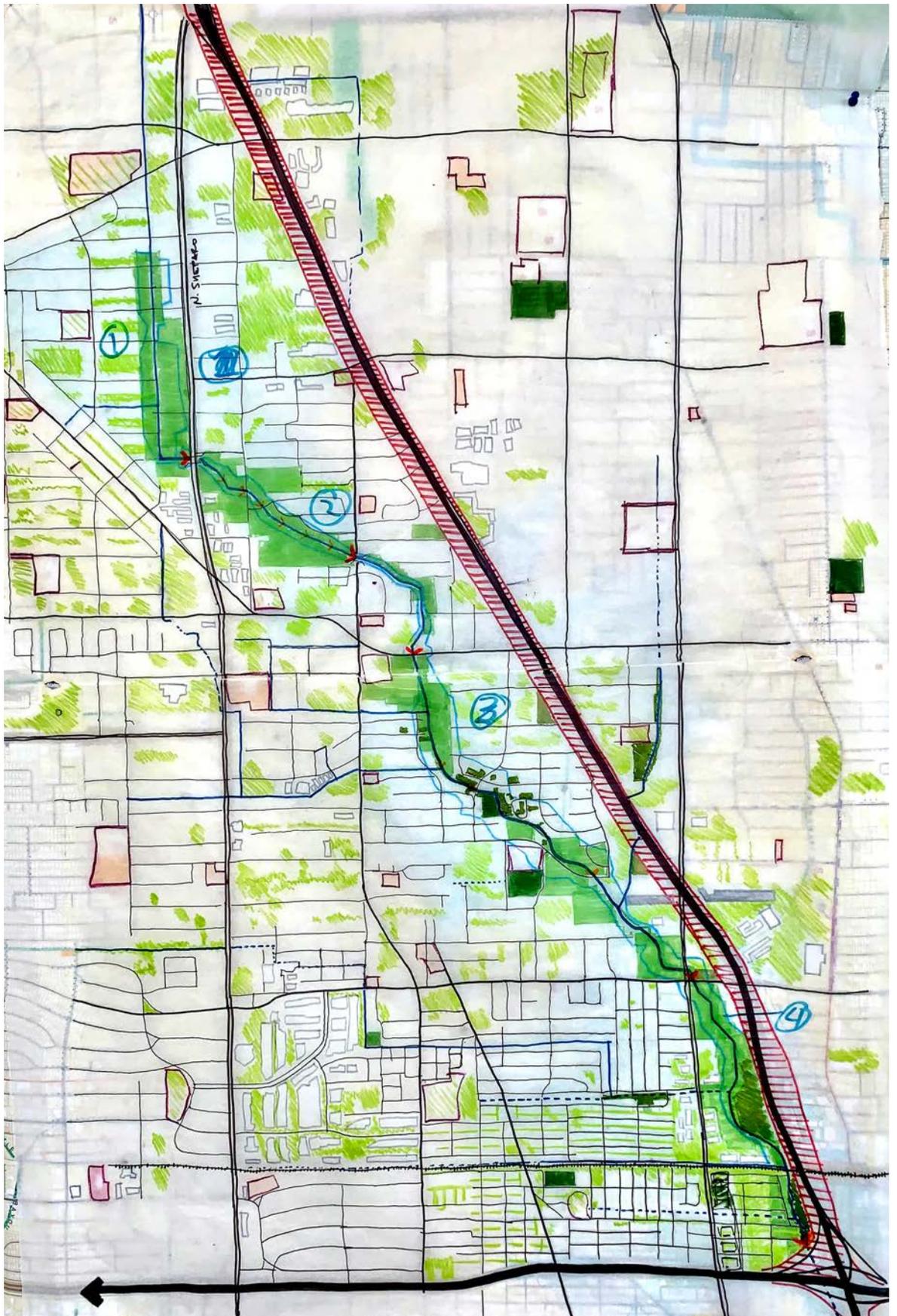
Store

Larger scale spaces to store water temporarily provide additional capacity for runoff during storms. During dry weather, these detention areas can be used for recreation. Stored water can be reused, such as for irrigation.



Discharge (when possible)

If the outfall height of existing pipes is below the water level, due to extreme amounts of rainfall or high tide in the bay, draining water may not be possible. Places to temporarily store water will drain during dry weather or low tide.



Vision Watershed Plan

Vision for Independence Heights managing water at every scale to reduce flooding and create multiple benefits for the neighborhood.

Neighborhood Impacts

At the neighborhood level, the impact of stormwater must be critically examined, and all initiatives must be prioritized. The City has considered widening the bayou, and it is crucial to clarify the intended functions for the spaces around the interstates. Widening the bayou and returning recreational waterfront access to citizens can transform the area into a strong neighborhood pedestrian corridor and provide local identity. The bayou should be considered neighborhood frontage, accessible and communal space, rather than hidden infrastructure.

Around the bayou and within the neighborhood, the quality of space should be enhanced with these interventions. Proposed projects should reinforce the historic core of Independence Heights, key to the neighborhood’s identity. One example would be removing the proposed Frontage Road along I-45 to create a park along the bayou with a berm to both block sound and views of the highway. Complete streets that are safe for all modes of transportation and incorporate green infrastructure would reconnect citizens with the historic corridors and the bayou. Roadway improvements are a major opportunity to include strategies that slow and store water in order to reduce flooding. Maintaining the historic community’s identity while also addressing displacement should be prioritized in each intervention.

The proposed designs transform Independence Heights by redefining Airline Drive as the new front street for the neighborhood, and using the new bayou park to buffer the highway and replace industrial land uses in the floodplain. These changes will greatly improve the resilience of the area. Reinforcing the neighborhood’s historic identity and its relationship to the bayou will create a unique sense of place while demonstrating how retrofitting land use and infrastructure to live with water.

Ecological Benefits

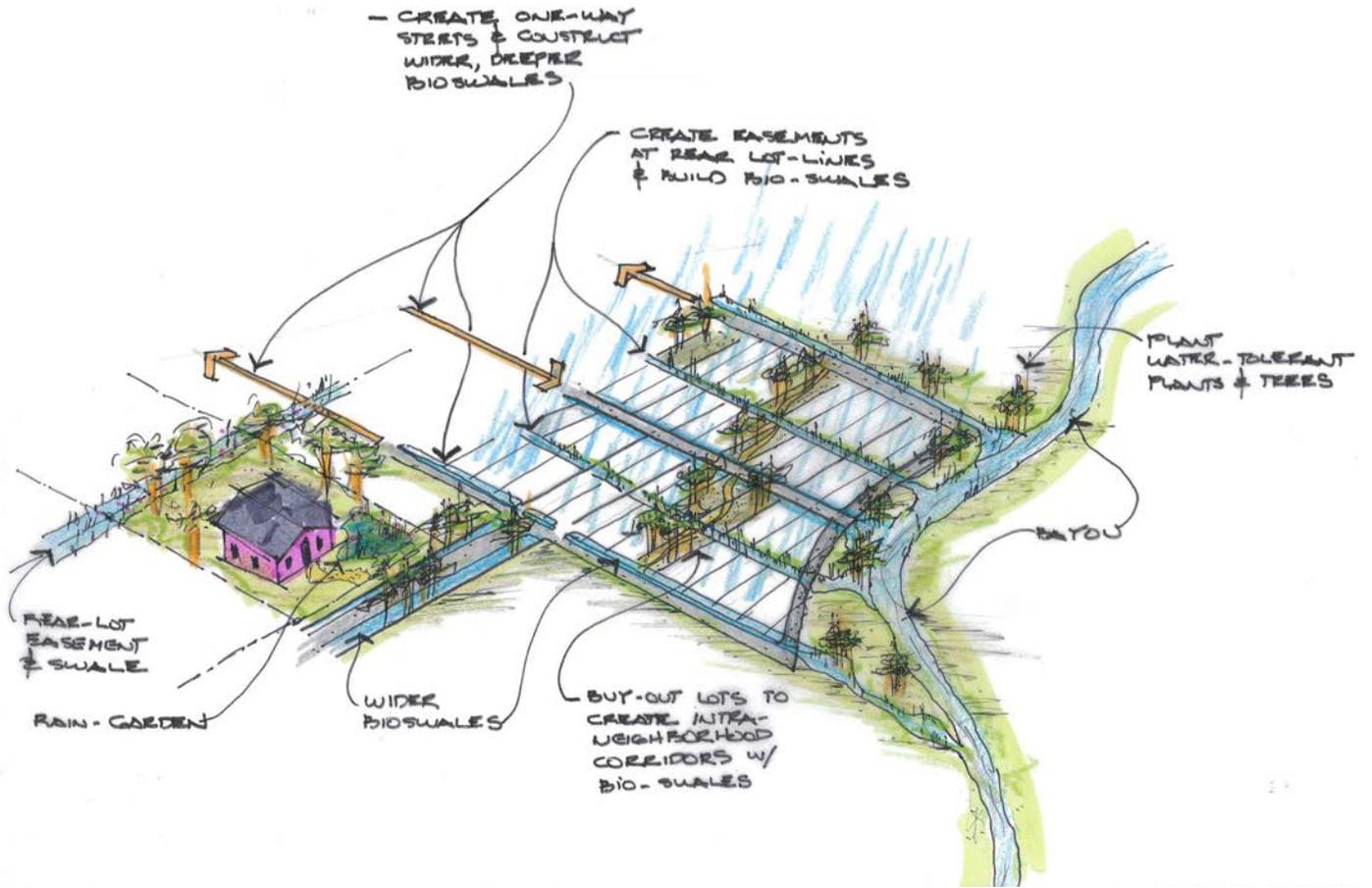
Before human settlement, Independence Heights was a coastal prairie landscape. By implementing an ecosystem-based approach, this neighborhood can be re-imagined as a gradient of prairie landscape types that create an attractive recreational landscape for Houstonians. Re-naturalizing the existing culvert in the planned I-45 expansion has the potential to connect the bayou and surrounding green space to downtown, while also enhancing the quality of space and connectivity in the neighborhood.

Bayou Scale



Examples of Stormwater Management in Parks

Neighborhood Scale



Green Roof



Rain Garden



Bioretention Planters

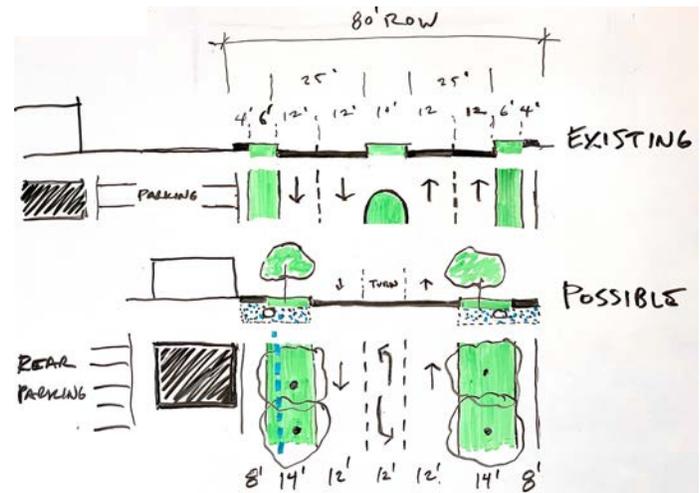
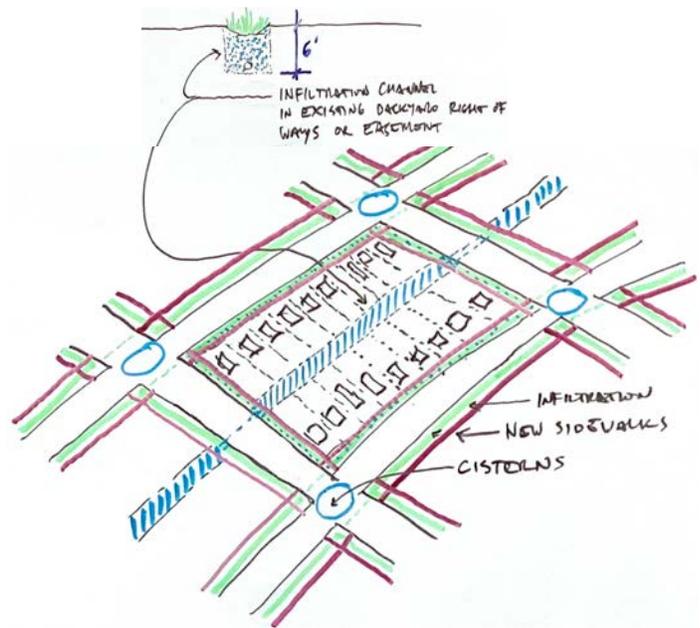


Subsurface Storage

Watershed Strategy

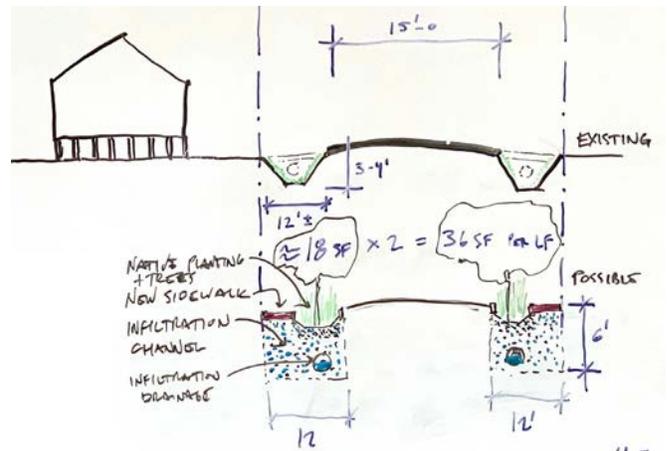
The watershed strategy will reduce flooding and reconnect historic Independence Heights and surrounding neighborhoods to Little White Oak Bayou. The vision for the district includes:

1. **Multi-scale Strategy:** Water management begins at the top of the watershed, at every scale: parcel, street, neighborhood, district. By utilizing open space upstream to detain and infiltrate runoff, flooding is reduced downstream.
2. **Frontage Road Conversion:** The ongoing expansion of I-45 encroaches on the bayou; frontage road along bayou side is re-conceived as park space and traffic flow shifted to Airline Drive
3. **Bayou Cascade:** Vacant land or buyout sites provide large areas for detention to reduce bayou flooding
4. **Airline Drive Water Channel:** Major north/south street is frontage of new bayou park with water channel in median and bioretention along sidewalks



Airline Drive Water Channel

The roadway medians and sidewalks can accommodate green infrastructure that creates multiple benefits



Street and Right of Way Retrofits

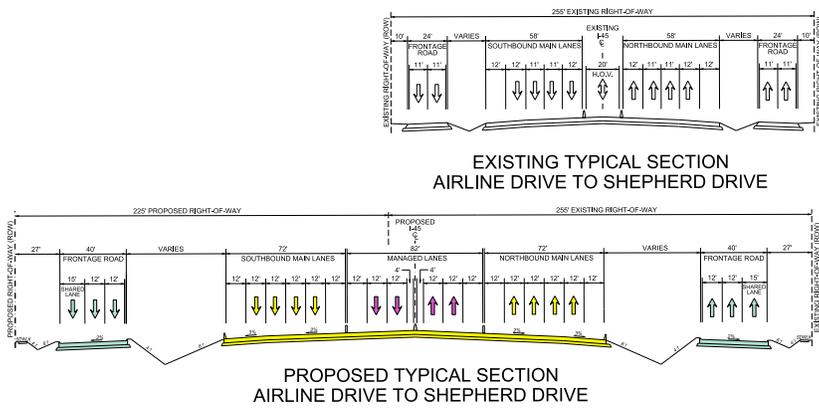
Existing mid-block right of ways, as well as streets, can be rebuilt to slow down and store water underground.



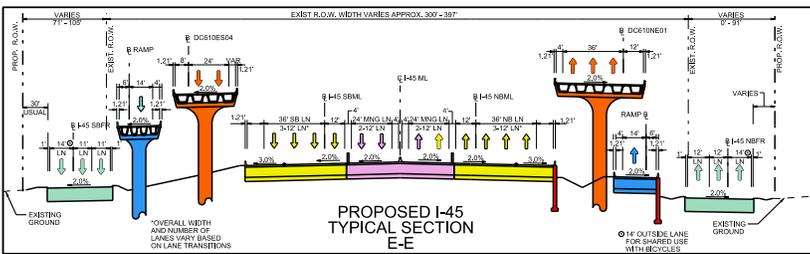
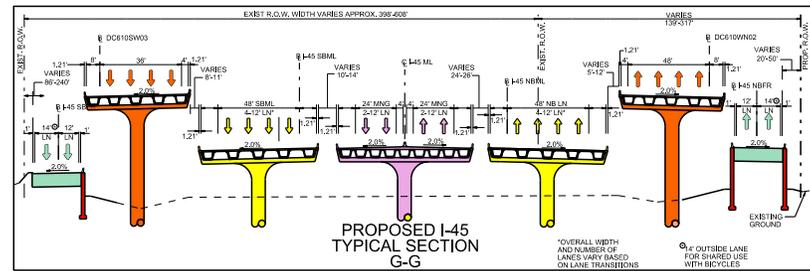
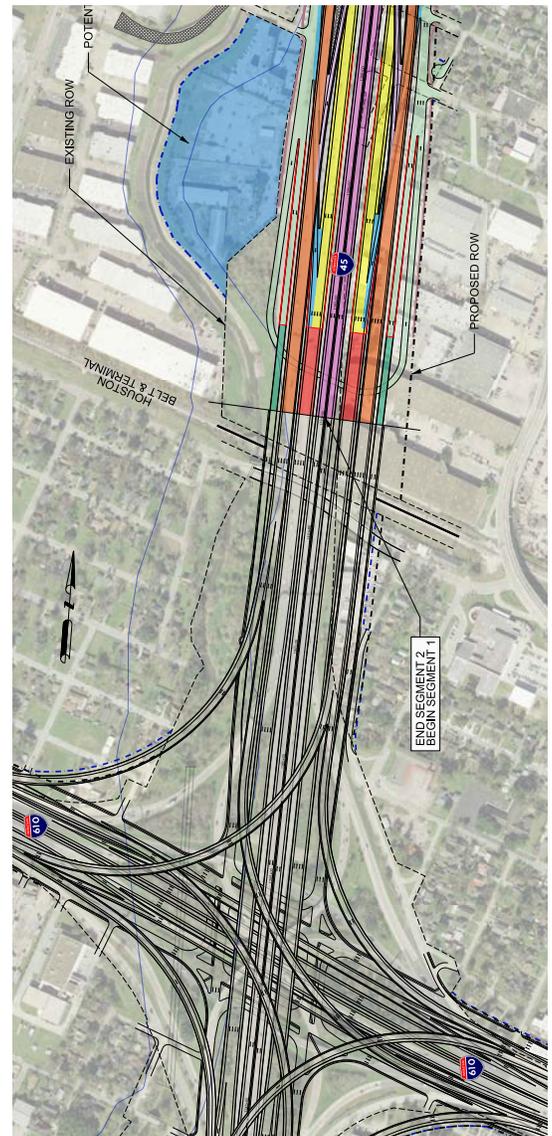
Living With Water Vision

Network of proposed projects that leverage resilient redevelopment, new recreational spaces, and historic preservation in order to store more water and alleviate flooding.

(Parks & properties shown as "green" are illustrated for conceptual purposes only. All property decisions should be made with community and land owner buy-in.)



Existing and Proposed Road Section
 The I-45 portion of the North Houston Highway Improvement Project will nearly double the width of the highway. All of the expansion is on the west side of the existing highway.

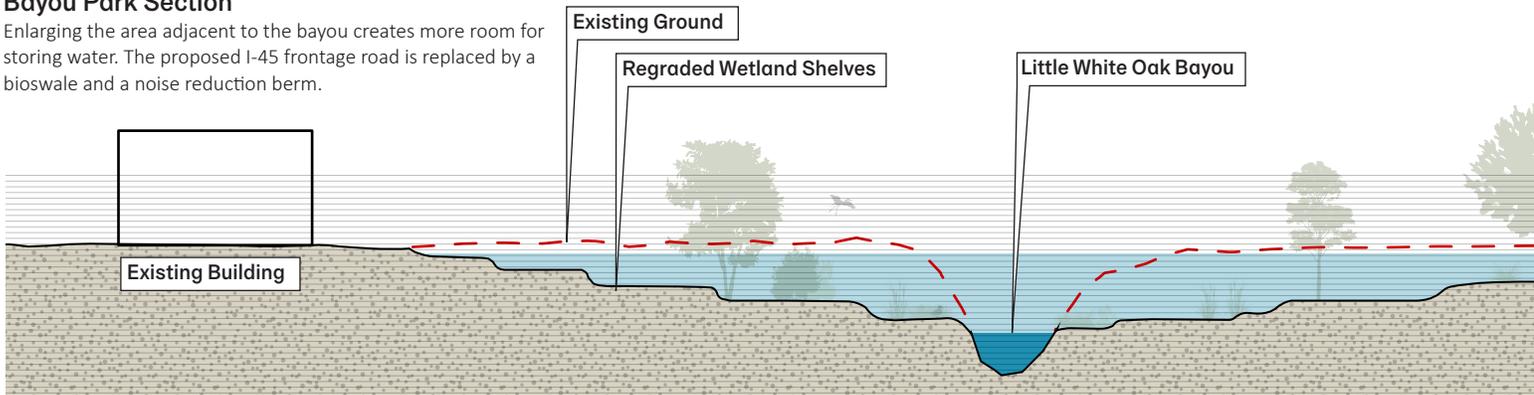


I-45/610 Intersection
 This intersection will be largely rebuilt as part of the proposed I-45 expansion. It creates opportunities to resolve bayou constrictions that exacerbate flood risk in Houston.

I-45 Expansion
 Portions of I-45 from beltway 8 to I-69 will be rebuilt and expanded. In Independence Heights, that expansion will be mostly westward into the neighborhood.

Bayou Park Section

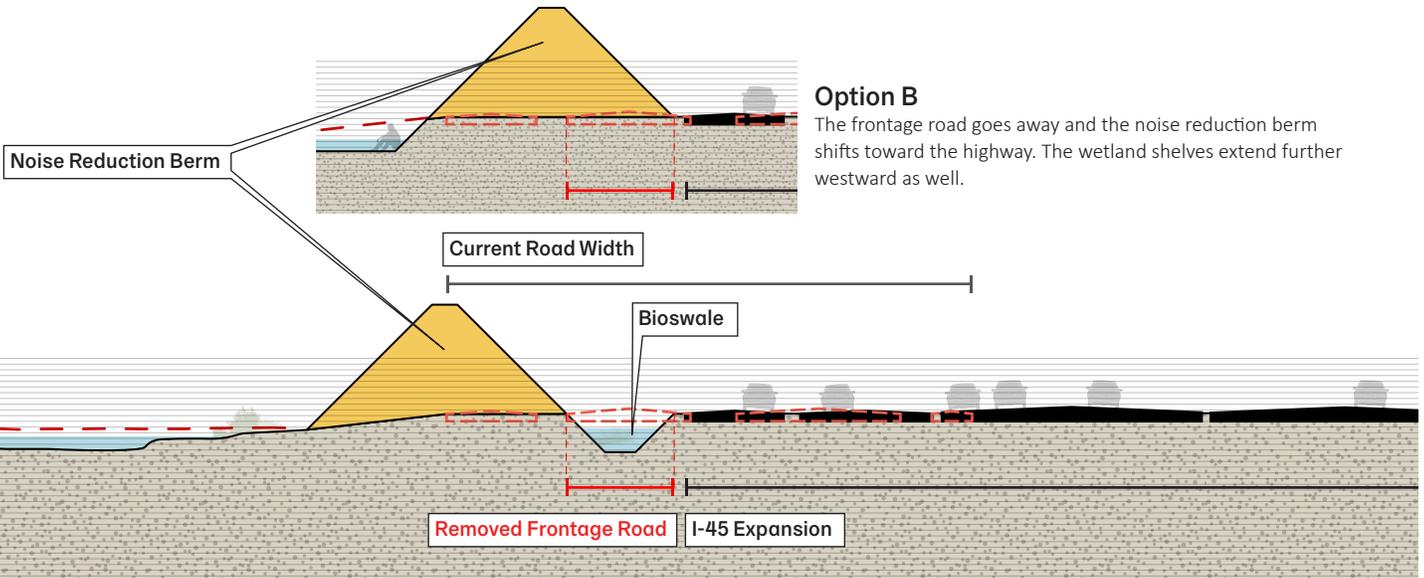
Enlarging the area adjacent to the bayou creates more room for storing water. The proposed I-45 frontage road is replaced by a bioswale and a noise reduction berm.





No Frontage Road Alternative

The frontage road between Crosstimbers St and 610 could be removed to achieve more stormwater storage and provide a buffer between the neighborhood and the highway, with negligible impact to access and the urban environment.



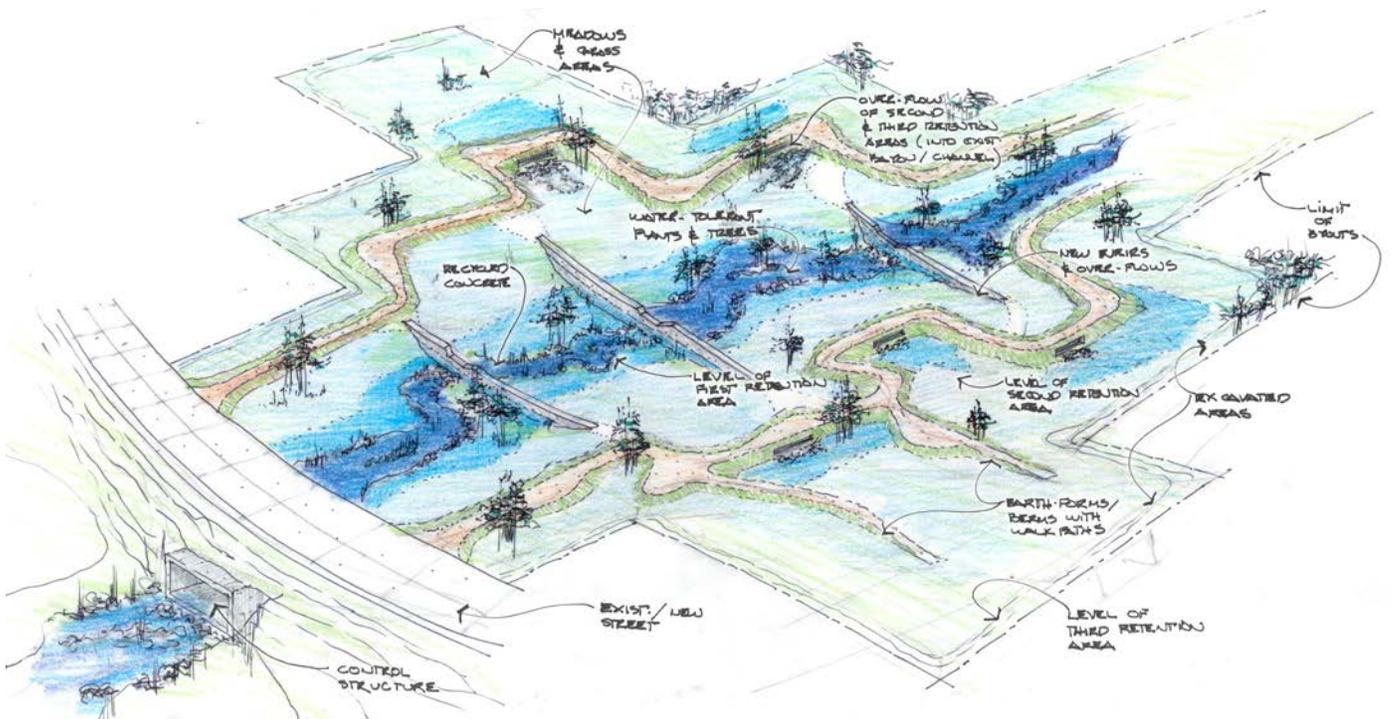
Option B

The frontage road goes away and the noise reduction berm shifts toward the highway. The wetland shelves extend further westward as well.



Room for Water

Vacant land adjacent to the bayou can be used for temporary water storage.



Bayou Cascade

Vacant parcels or buyout lots can slow and store water as well as create ecological benefits.



Impervious Roofs and Parking Lots

Large flat roofs and paved parking lots generate massive volumes of runoff. They can be retrofitted to store water or slow it to infiltrate into the ground.



Example of Weir

A control structure such as a weir can hold back higher water levels to prevent flooding.



Permeable Asphalt

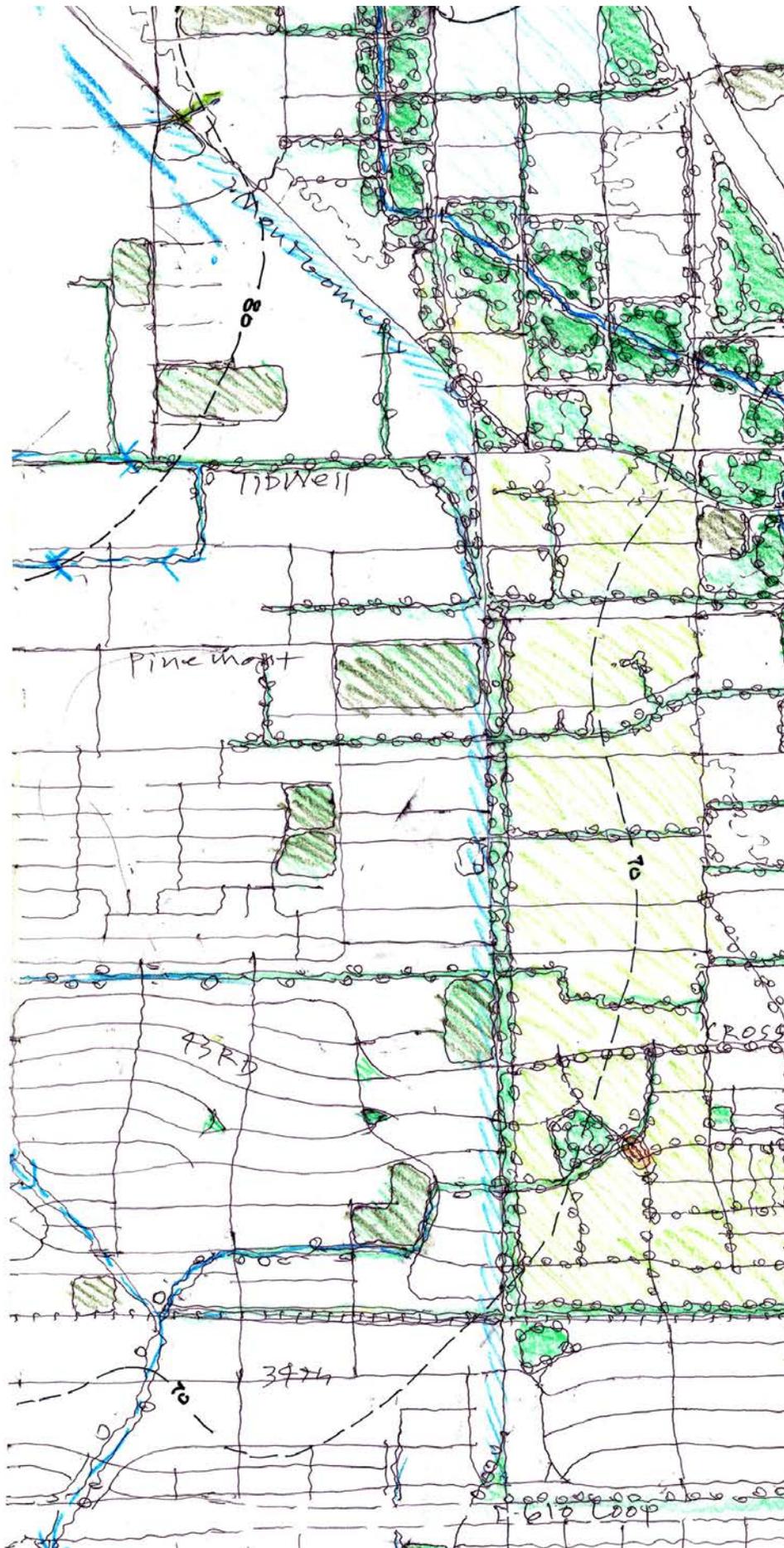
Example of surface that allows water to infiltrate into the ground.

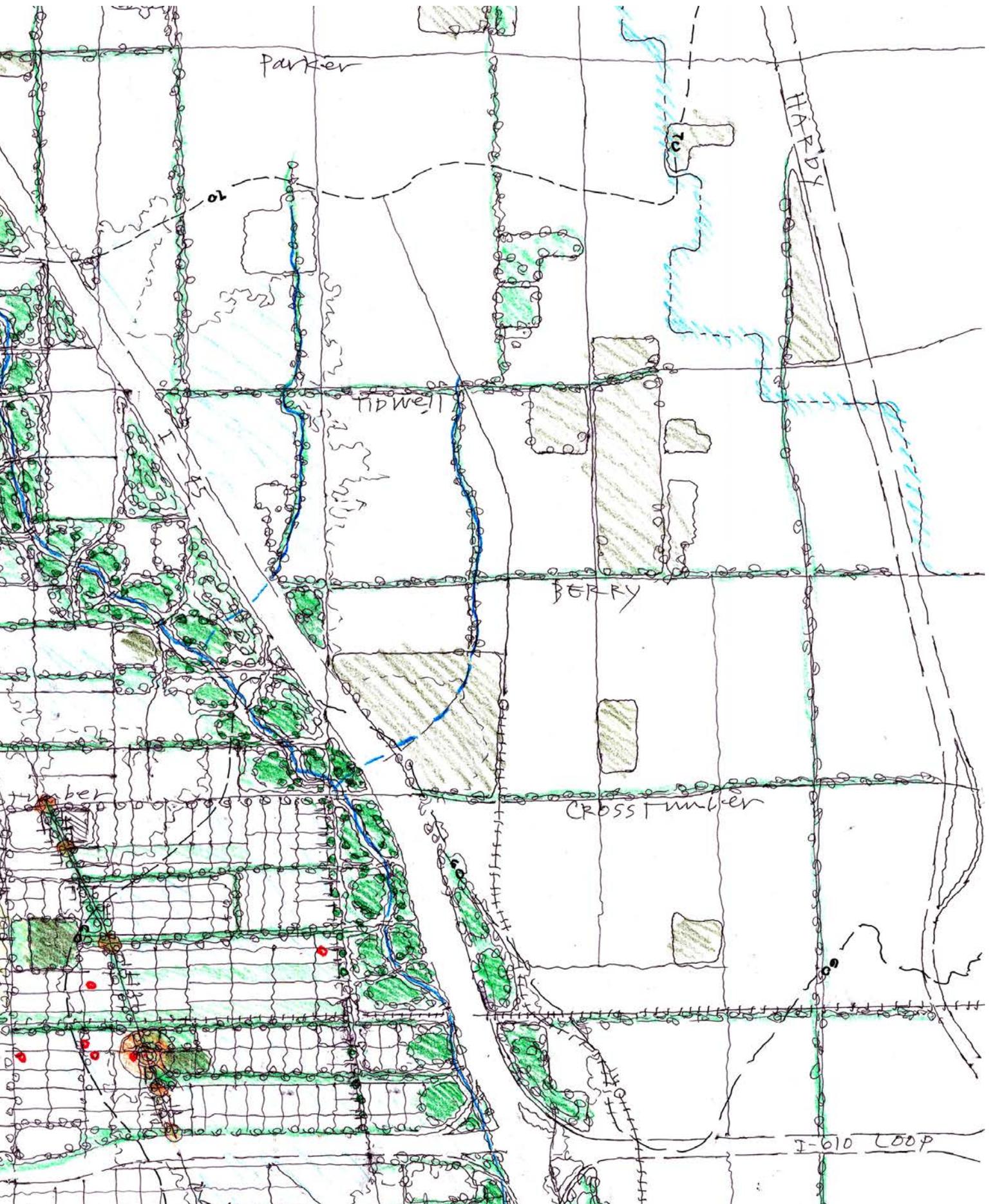
Greater New Orleans Foundation, Waggoner & Ball

Vision

Watershed Vision

The Bayou Park is connected to the rest of Independence Heights by a network of blue green streets extending to Airline Dr.





Preliminary Impact Projections

A storage target for Independence Heights of 25.5 inches of rain was calculated based on the 500 year (0.2% annual chance), 24 hour rain event. The combined Living With Water Strategies in Independence Heights store a projected 11 inches of water in addition to the 6 inches stored by existing infrastructure. The remaining 9.5 inches is left over as residual runoff risk.

Storage Target 25.5 in	Storage Amount (in)	Strategies	
0 in	9.5	RESIDUAL RISK	
	2	Use residential lots Convert industrial & commercial lands	Buyouts
	6	Enhance channels using natural channel design Build regional multi-purpose detention	Major Storage
	1	Build rain gardens, install rain barrels, street-scale bioretention, & green roofs	Local Storage/ Low Impact Development
	1	Enhance channels and bayous	Local Storage/ Low Impact Development
	1	Amend soils, plant native species Add distributed detention & bioretention	Infiltration
	4	Storage: storm sewer, bayous, & channels	Existing Storage and Conveyance
	1.5	Flow into soils	Existing Storage and Conveyance
	.5	Conveyance: ditches, storm sewer, & streets	Existing Storage and Conveyance

Independence Heights Recommendations

Short Term:

IH1. Reconsider standard Frontage Road design

Through working with TXDOT the water impact of the highway expansion can be lessened. In some segments of the I-45 expansion, the boilerplate frontage road design provides limited or no additional access to usable properties and could be removed to improve neighborhood design and safety. That space could be used to detain and remediate stormwater from the highway, provide additional storage along the bayou, and reduce noise pollution from the highway.

Mid Term:

IH2. Consider working with existing bottlenecks only if adequate flood safety can be reached

More flow discharging from the Little White Oak watershed poses direct risks for downtown Houston. Studying a “cascade” approach within the channel and upstream from the I-45/I-610 choke point to provide water storage behind weirs could provide a solution. Vacant, underutilized parcels could be used to create storage capacity and park amenities.

IH3. Create a demonstration “Interceptor Street”

The historic Airline Drive corridor could become the pilot project for an Interceptor Street concept. Underused lanes and medians could be converted into water storage features, which would store the street runoff and intercept water from the surrounding neighborhoods.

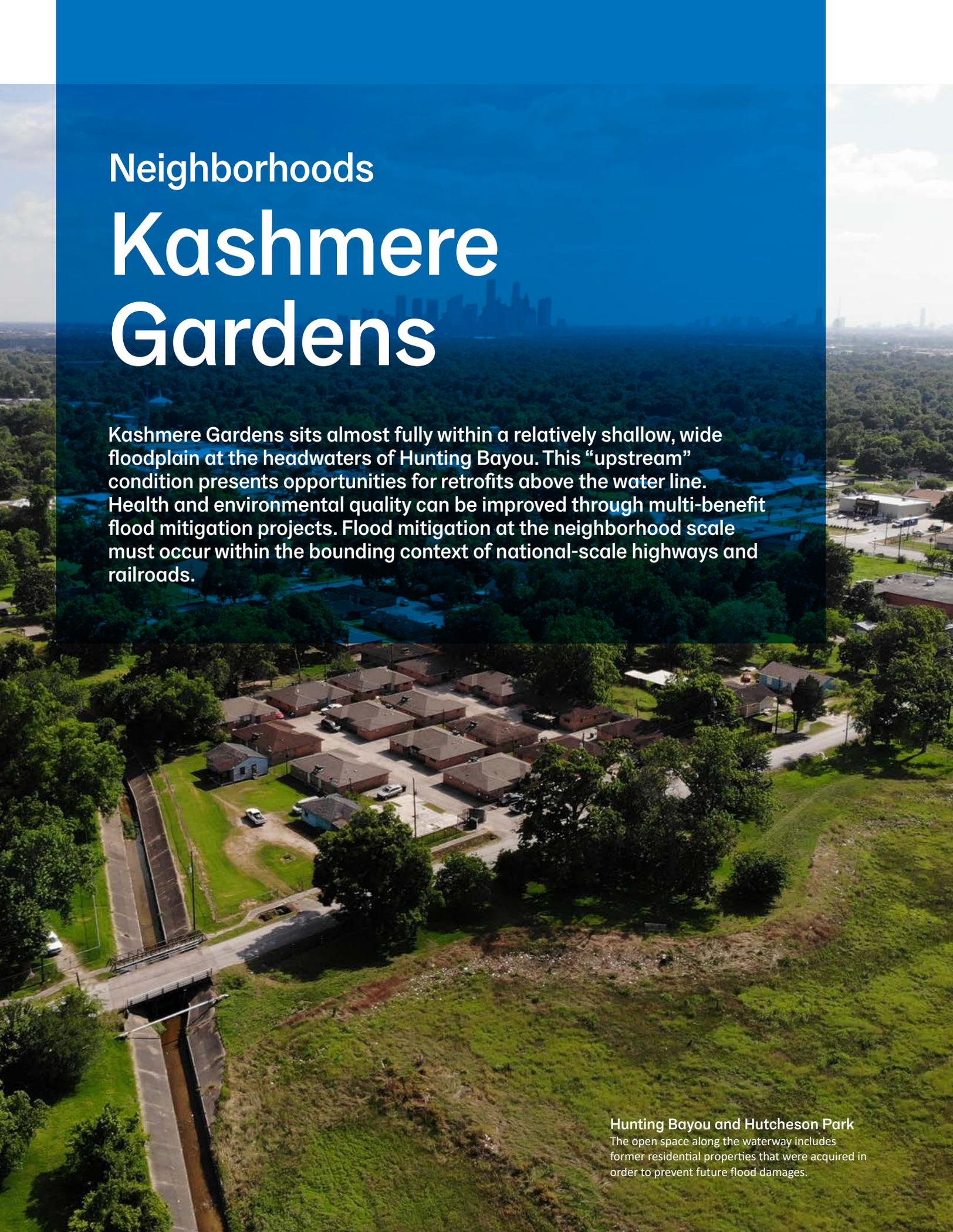
IH4. Retrofit commercial & industrial developments to store water

Parking lots and legacy industrial and warehouse structures create a significant amount of runoff. Retrofitting these structures to store water lessens the speed and volume of stormwater entering the drainage system. Re-purposing these structures and/or their surrounding can unlock neighborhood development potential.

Long Term:

IH5. Strengthen community through interconnections

Focus affordable mixed-use development along historic corridors and bayou parks. Create safe pedestrian and bicycle connections across Little White Oak Bayou, I-610 and I-45 corridors

An aerial photograph of a residential neighborhood. In the foreground, a concrete-lined canal flows through a grassy area. To the right of the canal is a large, open green field, identified as Huteson Park. The middle ground shows a cluster of single-story brick houses with grey roofs, surrounded by trees. In the background, a dense forest of green trees covers a large area. The top of the image is a blue gradient overlay containing text. The city skyline of Houston is visible in the far distance under a clear sky.

Neighborhoods

Kashmere Gardens

Kashmere Gardens sits almost fully within a relatively shallow, wide floodplain at the headwaters of Hunting Bayou. This “upstream” condition presents opportunities for retrofits above the water line. Health and environmental quality can be improved through multi-benefit flood mitigation projects. Flood mitigation at the neighborhood scale must occur within the bounding context of national-scale highways and railroads.

Hunting Bayou and Huteson Park

The open space along the waterway includes former residential properties that were acquired in order to prevent future flood damages.

Contributors

Andy Sternad, WBAE ; Jaap van der Salm, HNS Landscape Architects; Ruben Hoek, Palmbout Urban Landscapes; Tom Jost, Sherwood Design Engineers; Colleen McHugh, The Water Institute; Christine DeMyers, The Water Institute; Ray Devlin, Moffatt & Nichol; Johnny Martin, Moffatt & Nichol; Ali Fares, Prairie View A&M University; Scott McCready, SWA Group; Katie Coyne, Asakura Robinson; Bart de Jong, Netherlands Embassy; Peter Merwin, Gensler

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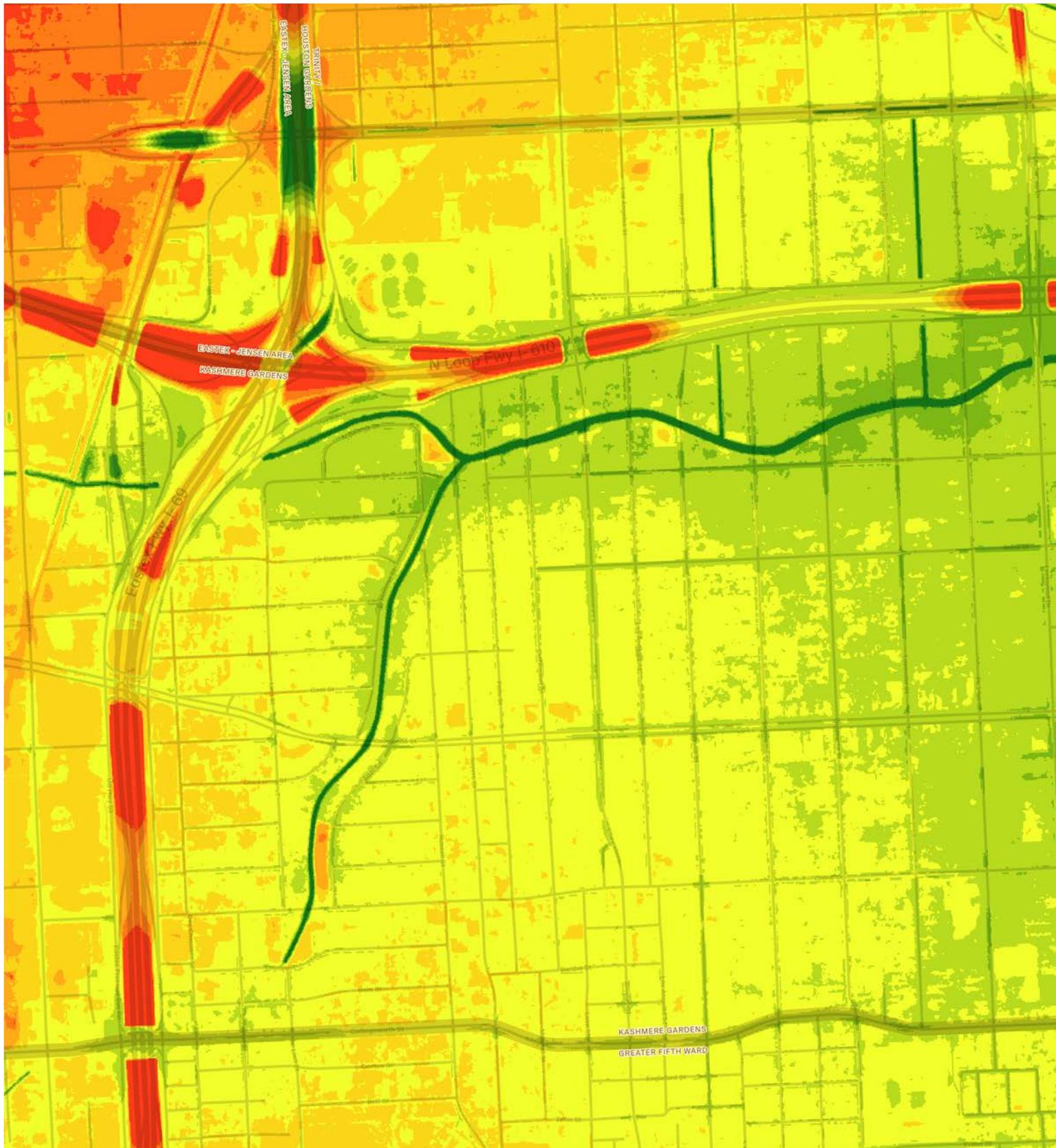
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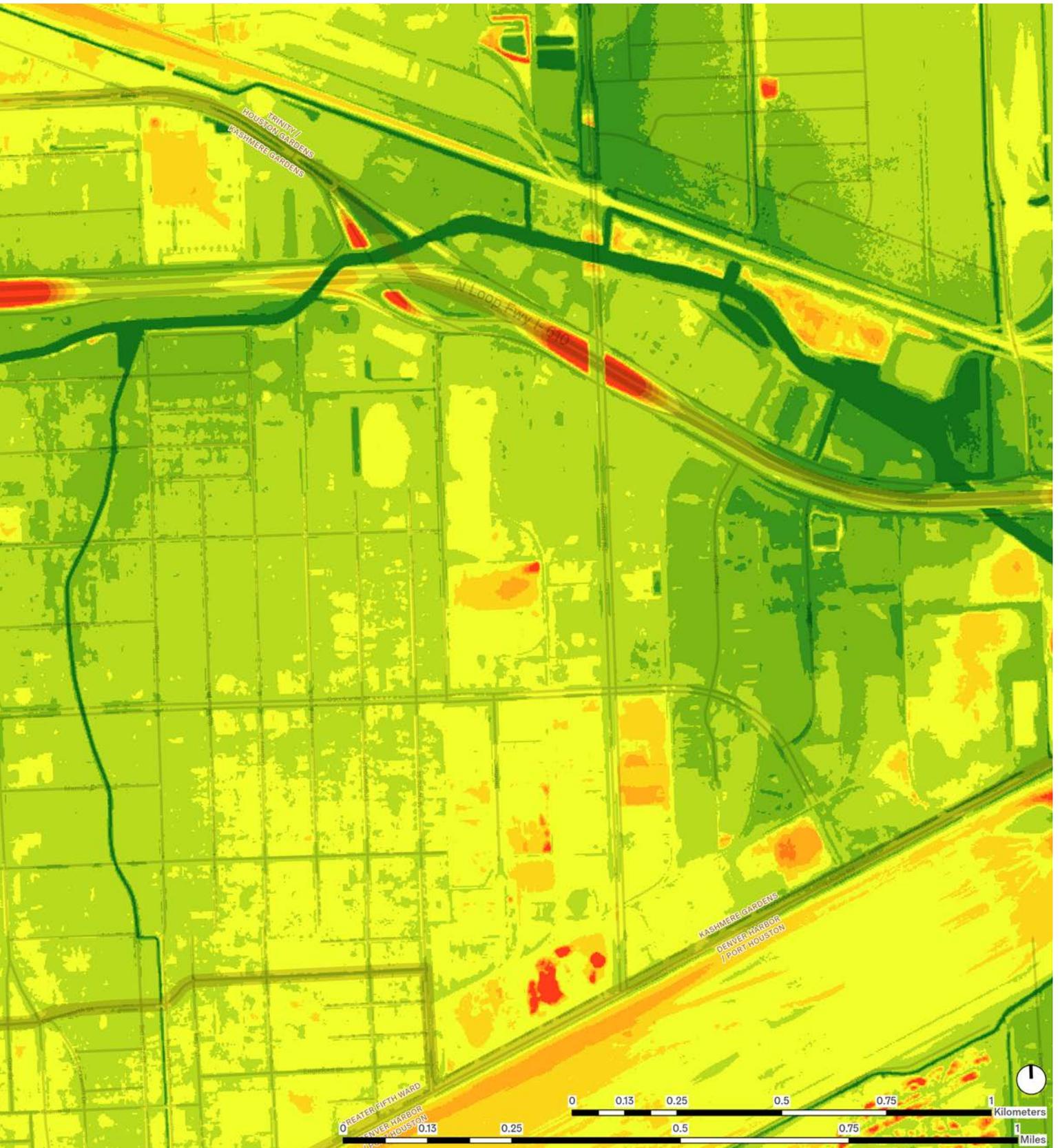
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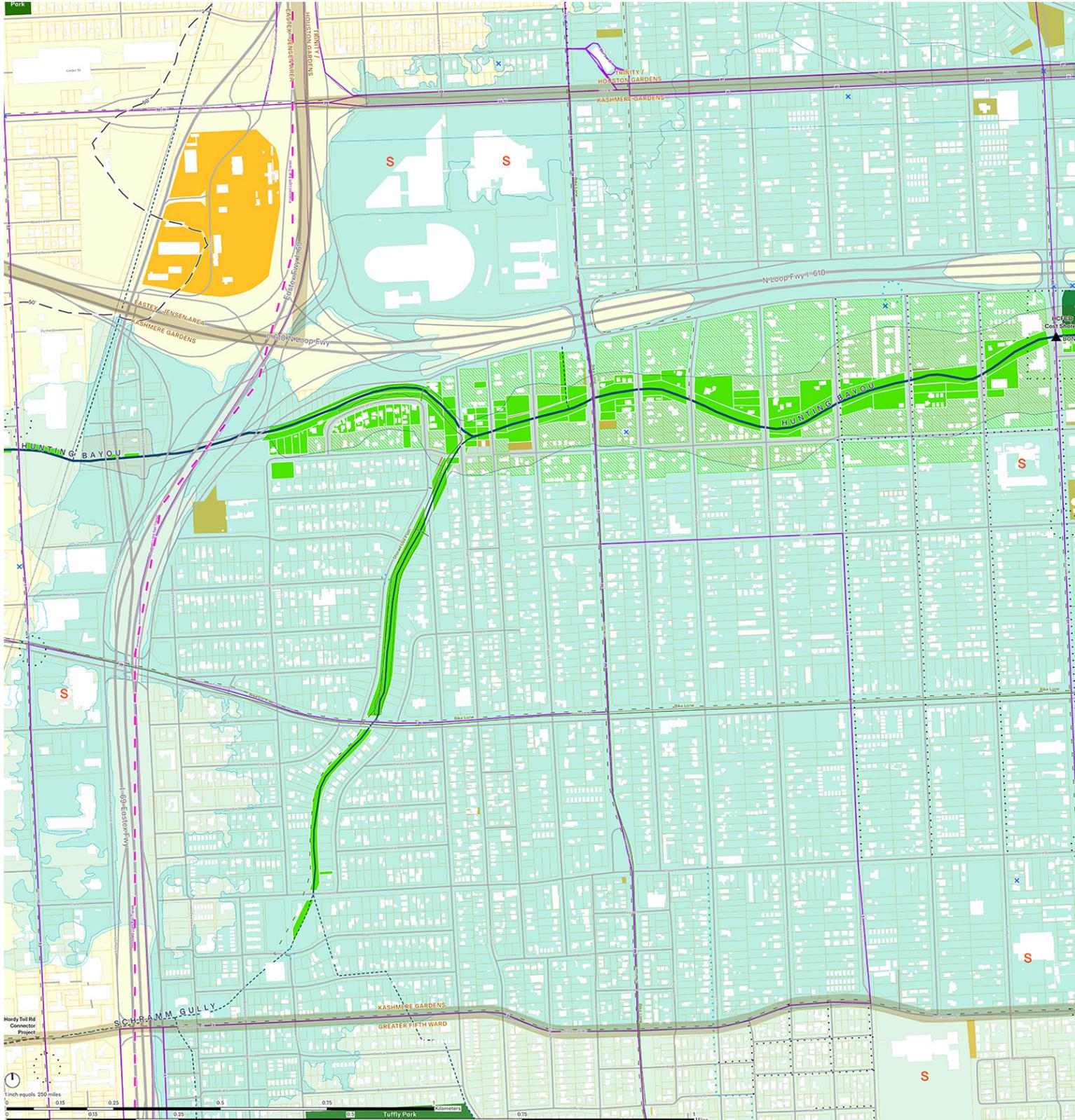


Elevation





Land Use



ONGOING PROJECTS

- ▲ Active Projects
- ▨ HCFCF - Possible Acquisitions
- ▨ HCFCF ROW Acquisitions
- ▨ HCFCF - Detention Basins
- Houston CIP Roadwork
- Houston CIP Drainage

I45 - NHHIP

- ▨ Frontage Road
- ▨ Highway; Bridge
- ▨ Detention Pond
- ▨ Hardy Toll Connector Project
- ▨ Hardy Connector Detention

H
S

- Hospitals
- Schools
- Building Footprints (only for CoH)

TRANSPORTATION

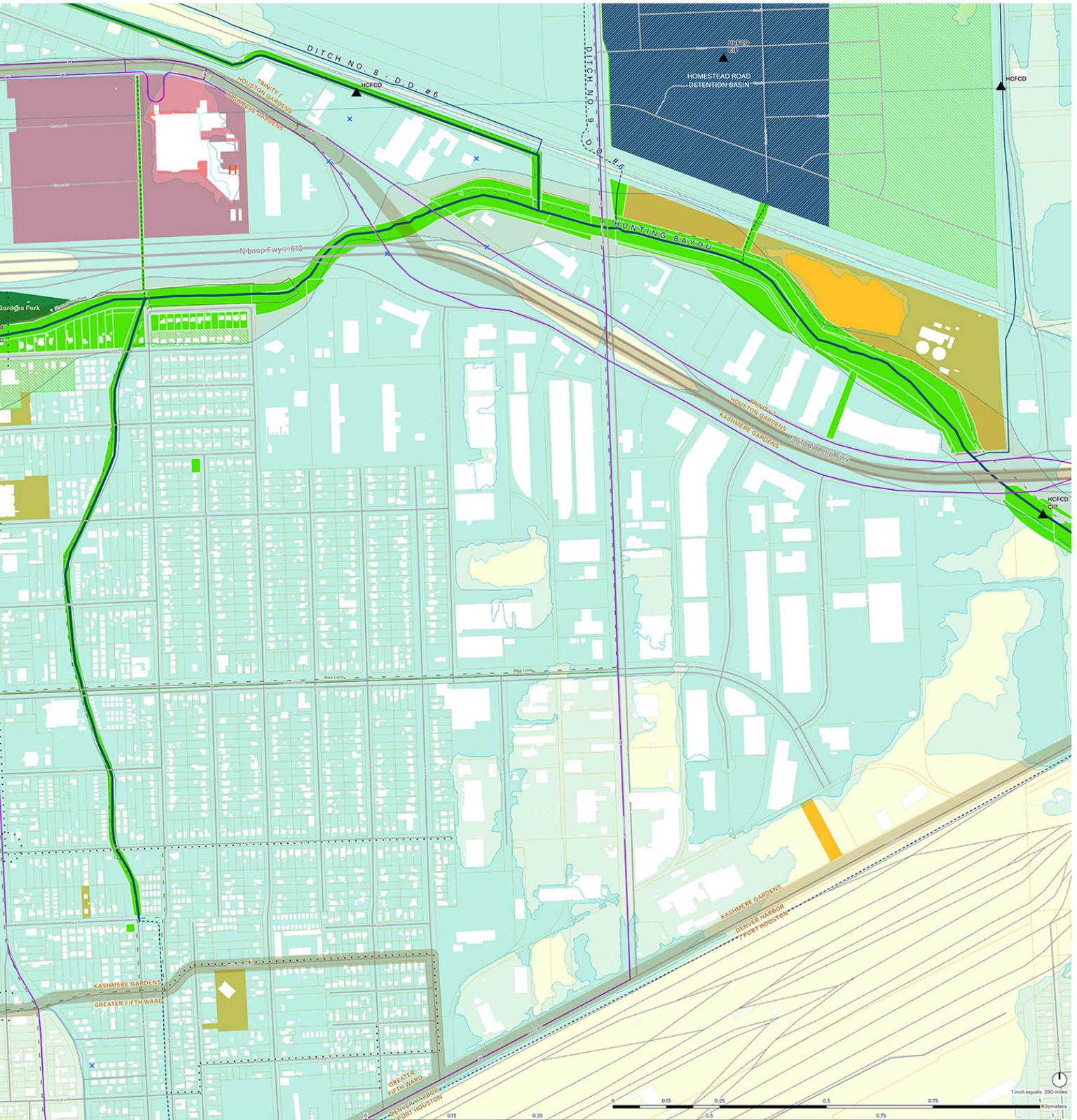
- Roads
- Rails

BUS & LIGHTRAIL

- ▨ LRT
- ▨ BRT
- TC RN Transit Centers
- PR RN Park Rides Centers
- LRT Stations

Proposed Transit Projects

- ▨ Light Rail Transit
- ▨ Bus Rapid Transit
- BIKE
- ▨ Existing Bikeways
- ▨ Houston Bike Plan
- ▨ Parks



Land & Water

Water

Hydrologically, Kashmere Gardens is defined by its relationship to Hunting Bayou. The super neighborhood is wide and flat, with local high and low points but an overall slope of approximately one foot per mile from south to north, towards the bayou. Kashmere Gardens lies almost entirely within the Hunting Bayou 100-year floodplain, which spreads out to encompass parts of Trinity Gardens to the north. The floodplain is impacted by a severe choke point at a railroad crossing near Liberty Road, and is clearly delineated by the relative high ground of the rail yard to the south of the neighborhood. Soil in this area is primarily heavy clay with low infiltration capacity.

The drainage system is primarily made up of an open ditch network with limited underground infrastructure. Drainage system maintenance, both in public rights-of-way and on private property, is uneven: some areas are mowed and well-kept, while others are clogged with vegetation and residential debris.

The gradual slope and location of Kashmere Gardens at the upper reaches of the bayou result in a type of flooding that is widespread but relatively shallow, which presents mitigation opportunities unique to the bayou headwater condition.

Existing Assets & Opportunities

Several flood mitigation improvements have been completed and are underway here, including a major detention basin at Homestead Road to the north of Kashmere Gardens and Project Hunting channel widening and bridge crossing improvements. Some home buyouts have already been completed directly adjacent to Hunting Bayou to allow the excavation of Hutcheson Park. Federal flood damage reduction projects including channel widening and modification, supported by the 2018 Harris County Flood Control District's Bond Program, will improve flood resilience, but are inadequate to fully manage water storage requirements in the face of increased rainfall projections under NOAA's most recent Atlas 14 update.

Analysis of the character and urban form of Kashmere Gardens reveals opportunities to introduce water. The area is defined by a grid of major north/south and east/west streets. Large blocks at the heart of the neighborhood, approximately 500' by 1200', are surrounded by smaller blocks and disconnected fragments

of street grid to the west and south. The neighborhood is primarily low- to moderate-income single-family residential development, with occasional low-rise multifamily complexes and vacant lots interspersed.

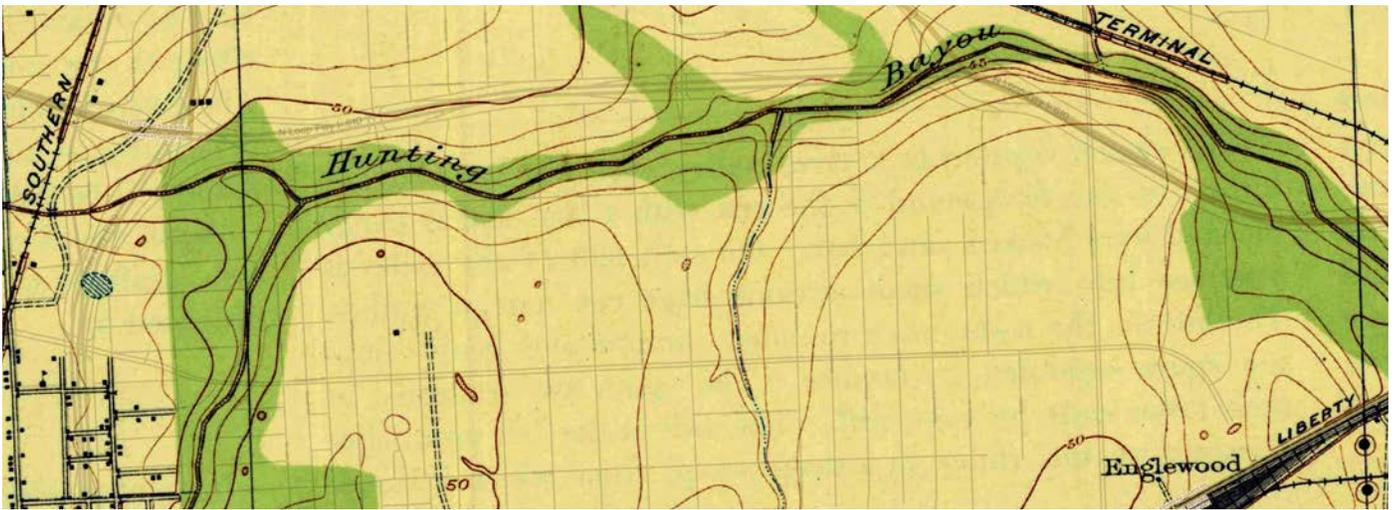
One of the strongest natural assets of Kashmere Gardens is its dense and extensive tree canopy: the impression from the ground and from above is of a true garden city.

Strong community ties—dating back to the Civil Rights era and beyond—are evidenced by the many churches and community centers in the neighborhood, but a lack of park space limits opportunities for outdoor recreation. Kashmere Gardens has a well-defined cultural identity, but lacks a well-defined center or a sense of place commensurate with its historical significance.



Historic Character

Small residences with consistent materials, front porches, and green yards remain throughout the neighborhood, creating a place with a sense of identity.



1922

Kashmere Gardens is largely unoccupied, with the present day street grid overlaid for reference.

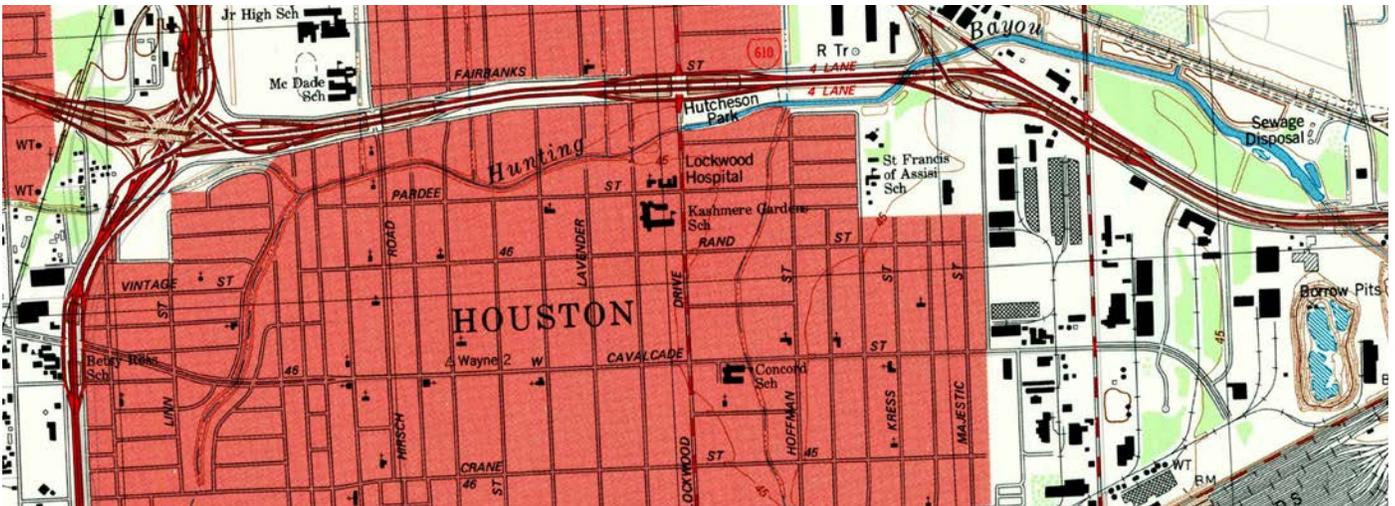
Credit: USGS



1955

Rapid development shows the majority of the area already built out, encroaching on Hunting Bayou.

Credit: USGS



1982

Interstate 610 and I-69 define the boundaries of the area, with a channelized bayou running through.

Credit: USGS



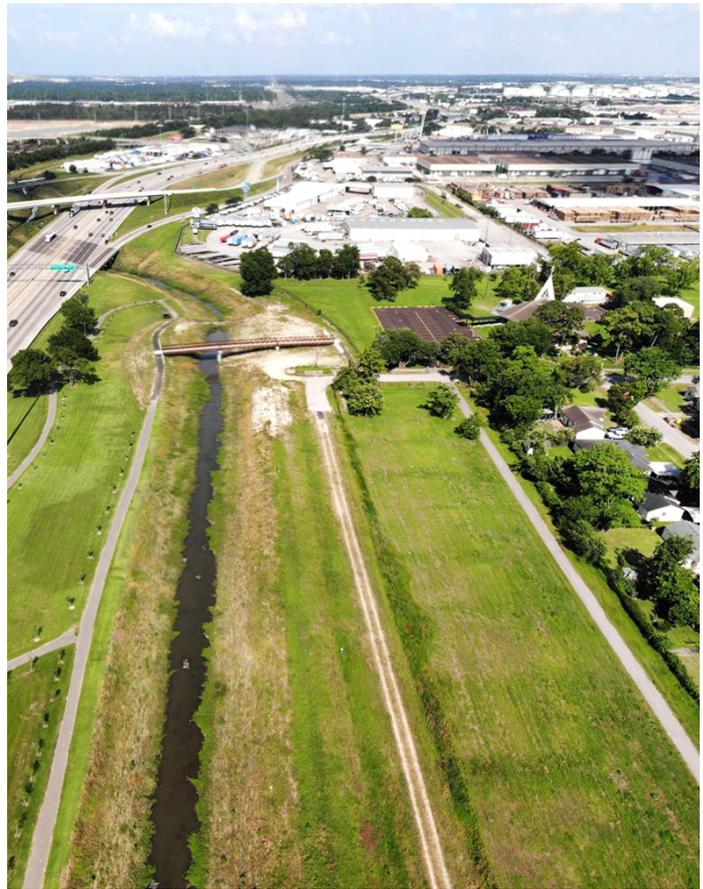
Risk & Opportunities

Kashmere Gardens faces several factors that influence the flood risk to the neighborhood: development of industry over time, channelization of the bayou, and separation from the former natural prairie system. All of these factors influence flood risk in the area compound the two types of local flood risk: bayou/tributary overtopping, local ponding and constriction points.

Environmental & health challenges include freeway noise and air pollution. These factors effect the quality of recreational and residential spaces because of a nonexistent buffer to heavy industrial areas.

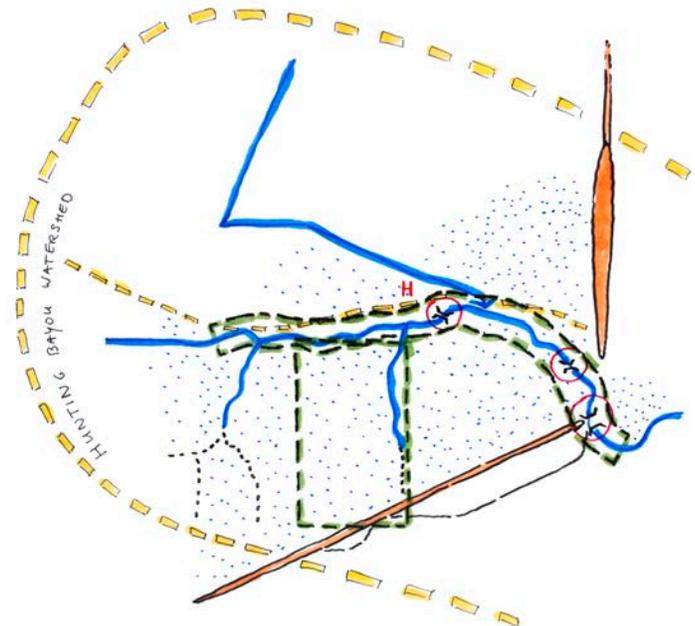
The neighborhood also faces a lack of high quality commercial activity, and is considered a food desert because of lack of affordable or good-quality fresh food. The neighborhood suffers from a general lack of amenities for residents and connectivity.

Water is a means for improvements to resident's quality of life, ecological value, and economic development opportunities within the neighborhood. Integrating water into urban design creates an higher quality environment with a multitude of benefits, from flood prevention being the most primary to the improvement of long term investment prospects.



Major Corridors

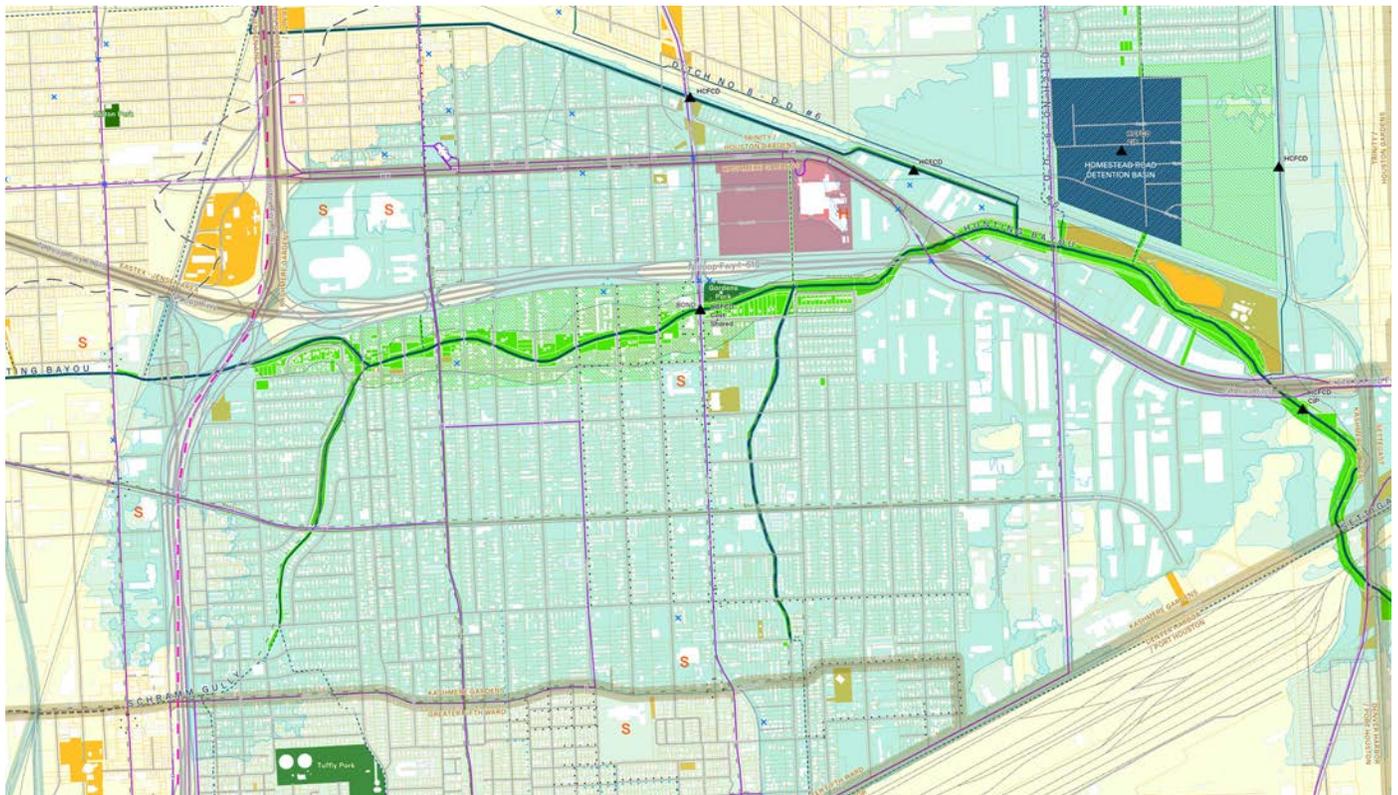
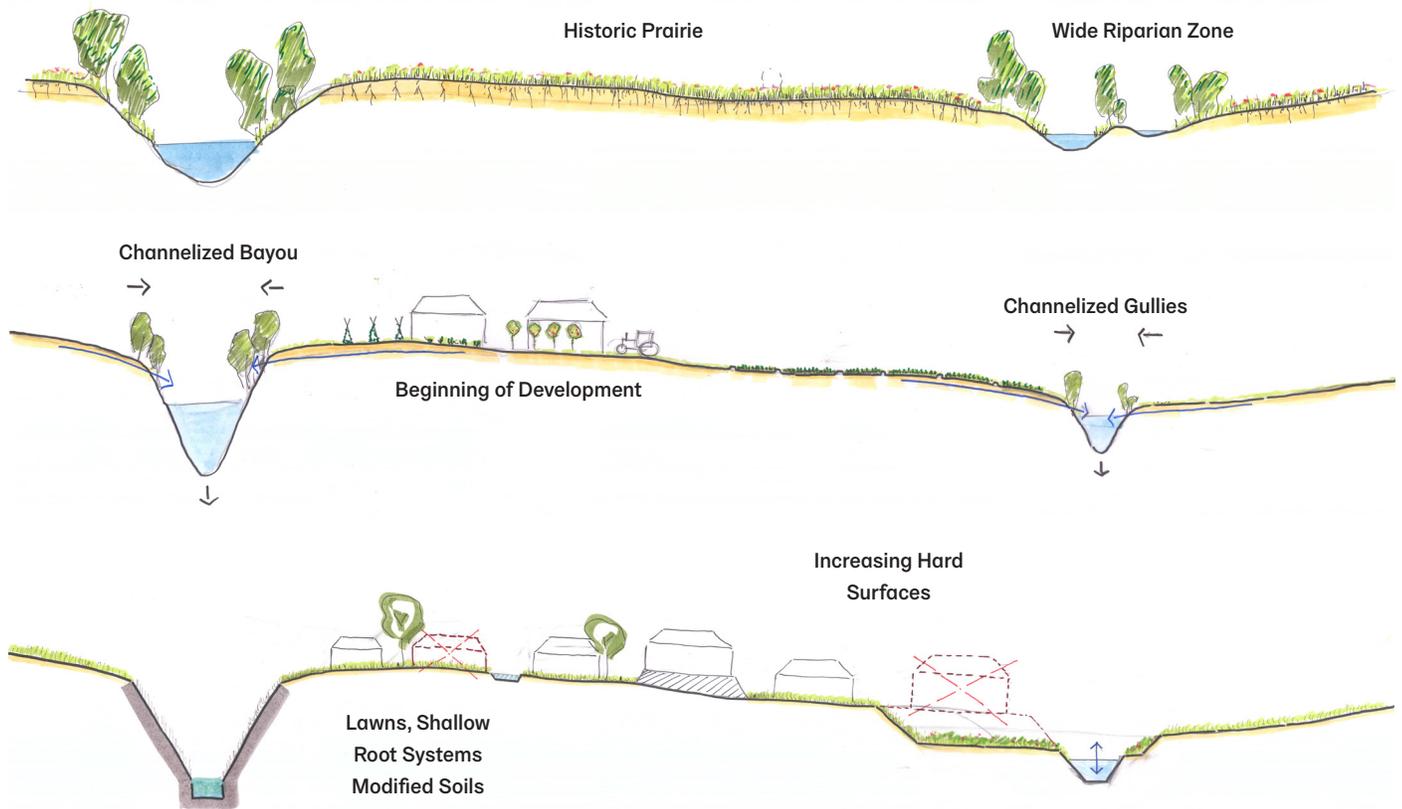
Hunting Bayou, at center, passes underneath I-610, which defines the edge of the neighborhood. The large open area at right includes parcels that were acquired in order to remove buildings vulnerable to flooding.



Man-Made Floodplain

The floodplain's shape is created by the two rail corridors that bound Kashmere Gardens and constrictions along the bayou.

Historic Landscape Development



Floodplain and Development
 Floodplain is the light blue overlay and development sites are the yellow parcels.



Room for the Bayou

This landscape surrounding Hunting Bayou, at center, has an expanded area to hold additional water, along with a pedestrian path adjacent.



Water and Access

A drainage ditch that flows into Hunting Bayou separates the neighborhood, but also creates access as a linear park with a new path.



Hidden Systems

A concrete drainage channel with debris is undervalued, fenced off from adjacent development, which is very close to the water.



Commercial Parcels and Runoff

To alleviate flooding, runoff from roofs and parking lots can be temporarily held in a basin as shown above, while buildings can be elevated.



Drainage System Constrictions

The railway crossings that lead to the rail yard caused modifications to the bayou that significantly limit flow, creating choke points.



Blue, Green, and Gray

Nearby impervious surfaces increase stormwater runoff levels in Hunting Bayou, which weaves through the neighborhood as an open space.

Design Concepts

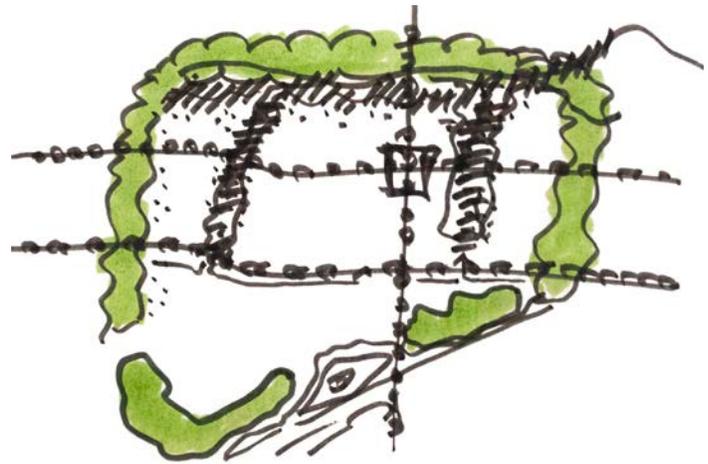
Design concepts in Kashmere Gardens focus on integrating the street network into the bayou network and reorienting occupation within the community. The design concepts at Kashmere range from environmental remediation at the multi-neighborhood scale to elevation retrofits at the scale of the building.

Bayous and Streets Scale

- **Green Collar:** A multifunctional perimeter greenbelt. Perimeter green space to buffer highways and industry. Helps improve air quality, provides space for water storage, and creates sense of gateways or arrival into neighborhood.
- **Interceptor Streets:** slow and store stormwater on streetscapes at a higher elevation in a drainage catchment area. These streets include water management features aimed at slowing water from flowing by gravity to a lower elevation, preventing that area from flooding.

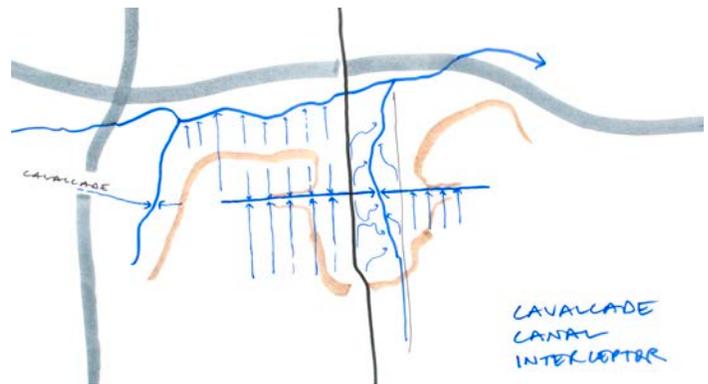
Neighborhood Scale

- **Community Buy In:** A program of voluntary relocations within the neighborhood to make space for Hunting Bayou channel expansion including 313 potential future acquisitions identified by HCFC, 354 vacant residential parcels within the neighborhood, and approximately 70 other properties for other uses, including as park space and potential commercial development.
- **Lockwood Lily Pads:** Flood safety leverages reinvestment opportunities. Schools, hospitals, and new commercial development could be retrofitted over time as dry petals, safe areas of refuge, along an elevated Lockwood Drive stem.



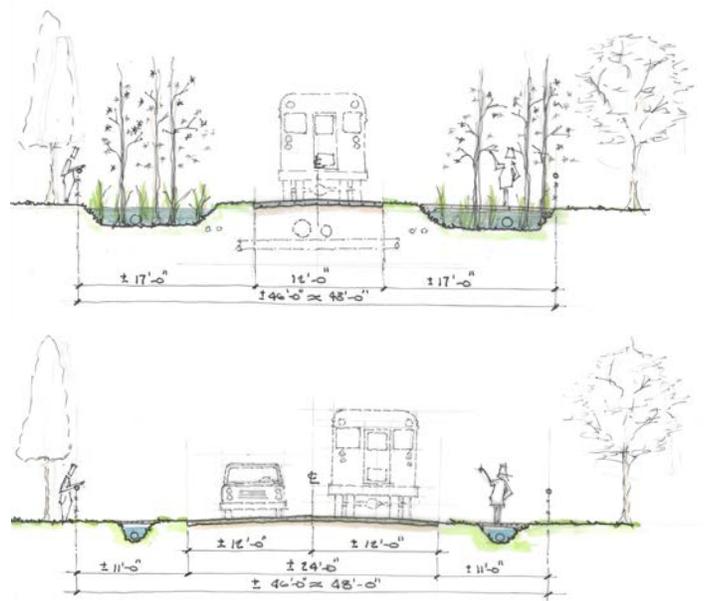
Green Collar

The green collar mitigates the poor air and environmental quality create by the industrial assets that surround Kashmere Gardens



Interceptor Streets

Canal and Cavalcade Street can serve as interceptor streets for the neighborhood.



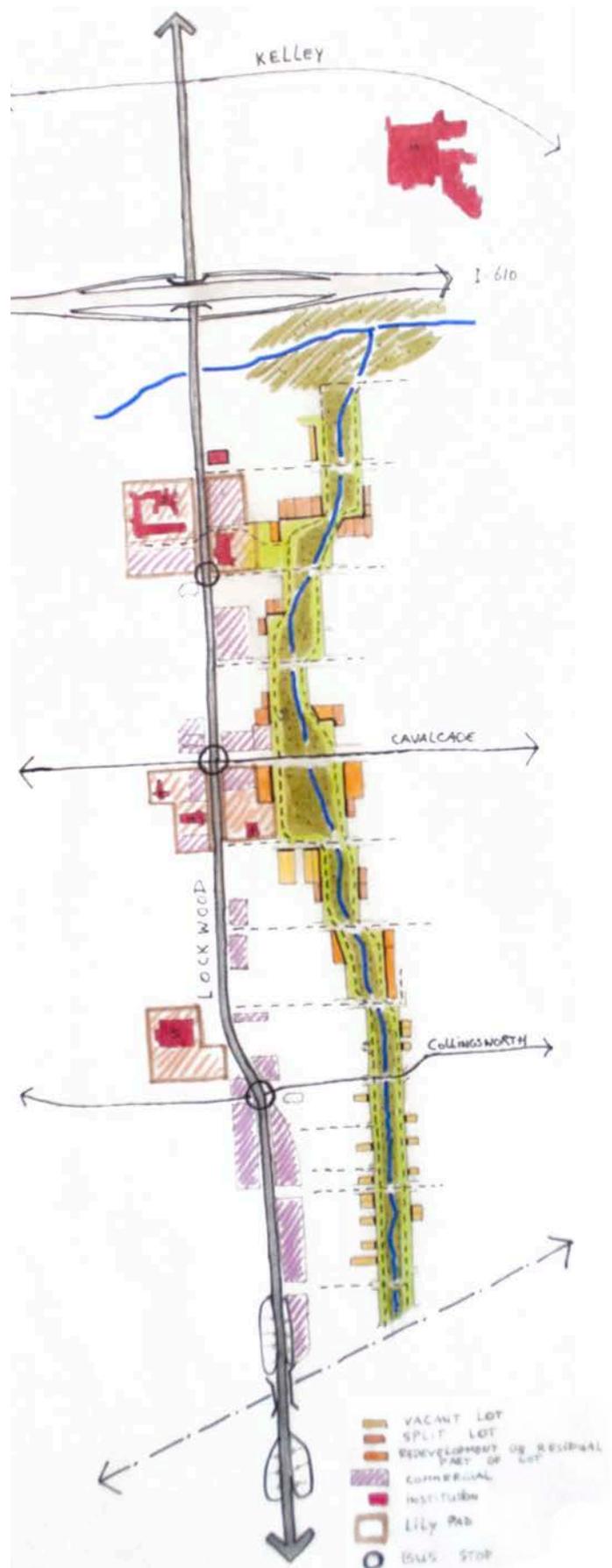
Streetside Storage

Widened ditches and improved plantings can increase water storage where space allows

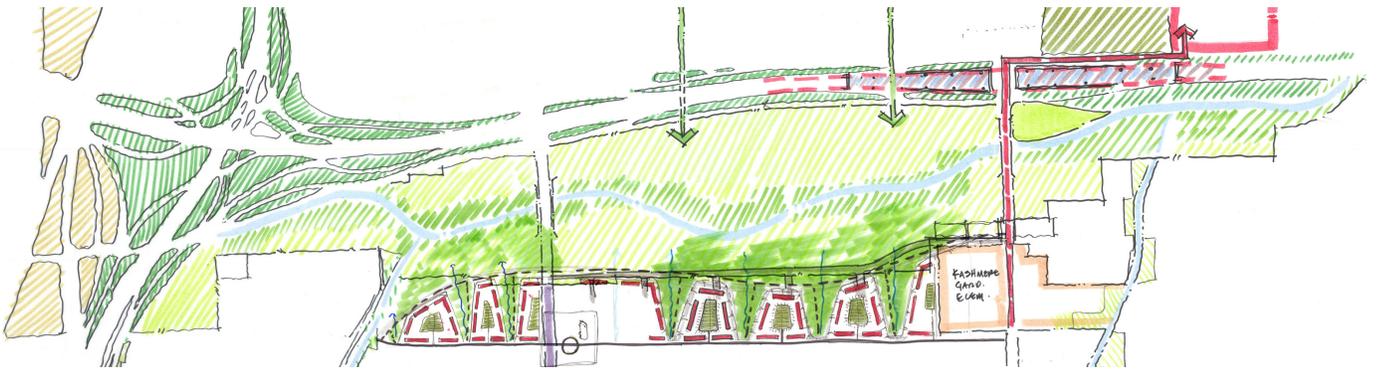
- **Build on Buy In:** Expand parks and space for water storage in alignment with area initiatives. The creation of a tributary park network tied into bayou network helps fill parks deficit in the neighborhood. Water storage in highway rights of way.
- **Micro-watershed planning:** at Schramm Gully, Turkey Run Gully and Tuffly Park. Upland water storage improves system function.
- **Frenchtown Water Grid:** Frenchtown is outside the political boundary of Kashmere Gardens, but sits at the uppermost headwaters of Hunting Bayou. Water that can be stored and managed where it falls improves system function downstream, so Frenchtown can play an important role in the Kashmere Gardens solution.

Other Projects for Future Study

- Detention Basin retrofits: add compatible program & functions (region-wide)
- Phytoremediation for contaminated soils (region-wide)
- Industrial acquisitions and land sculpting near rail constriction to add water storage.
- “Mt. Kashmere” destination for cut-and-fill within neighborhood to reduce transportation expense.
- Jensen Corridor connections to downtown.

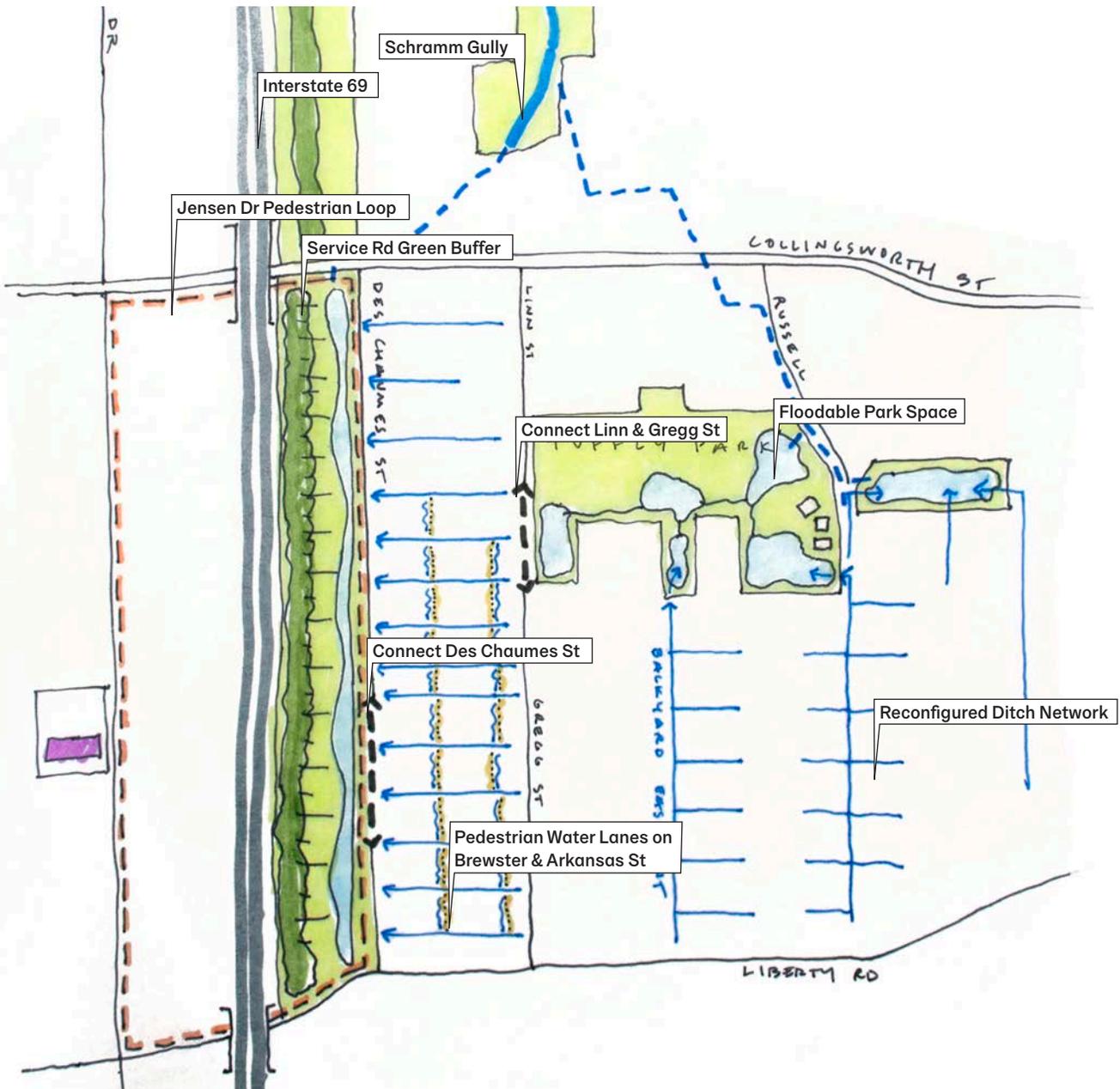


Sub Watershed Planning
 Turkey Run Gully parallels Lockwood Drive



Build on the Buy In

Redevelopment around Buyouts and the Expanded Floodplain (Parks & properties shown as "green" are illustrated for conceptual purposes only. All property decisions should be made with community and land owner buy-in.)



Frenchtown Ice Tray

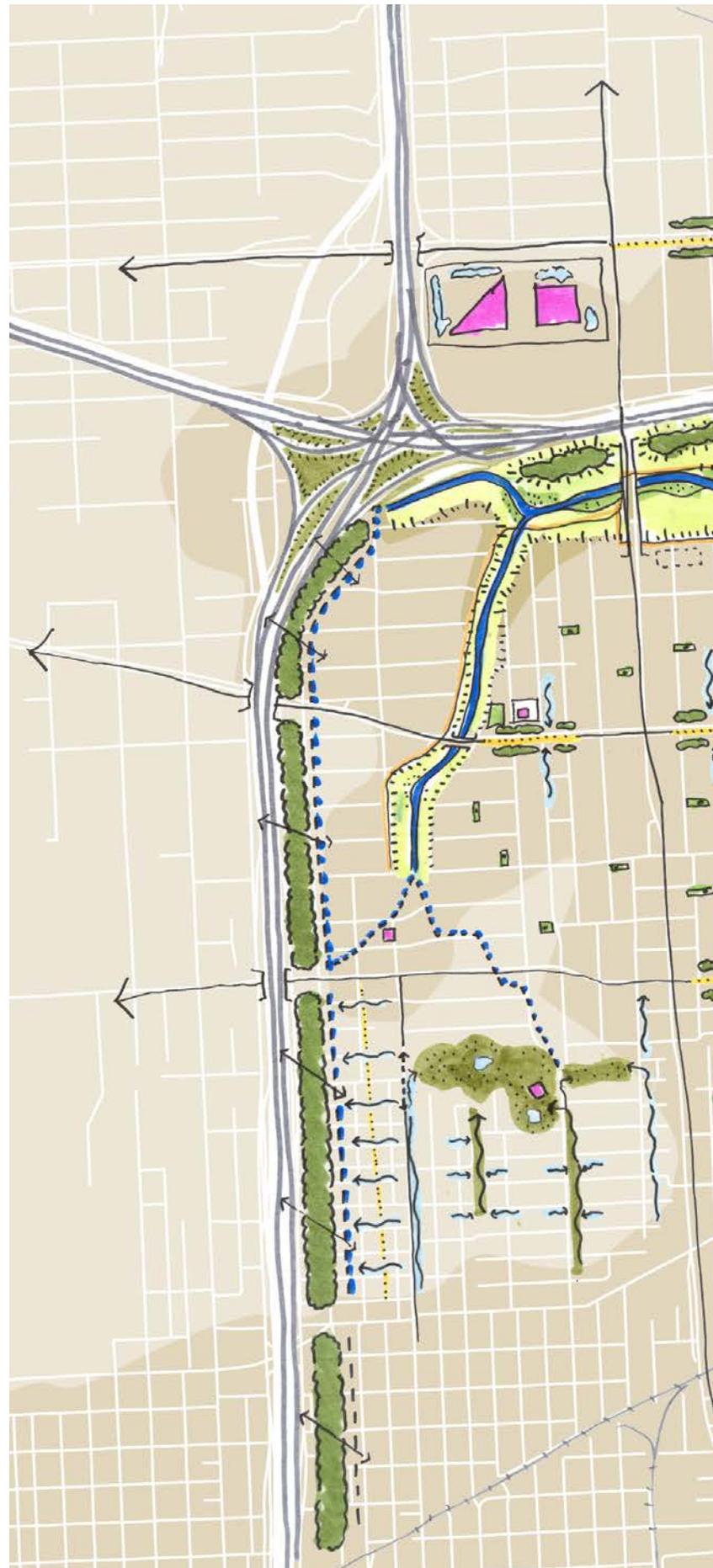
The Frenchtown street network is more dense than required, and some streets could become networks for better pedestrian movement and water storage.

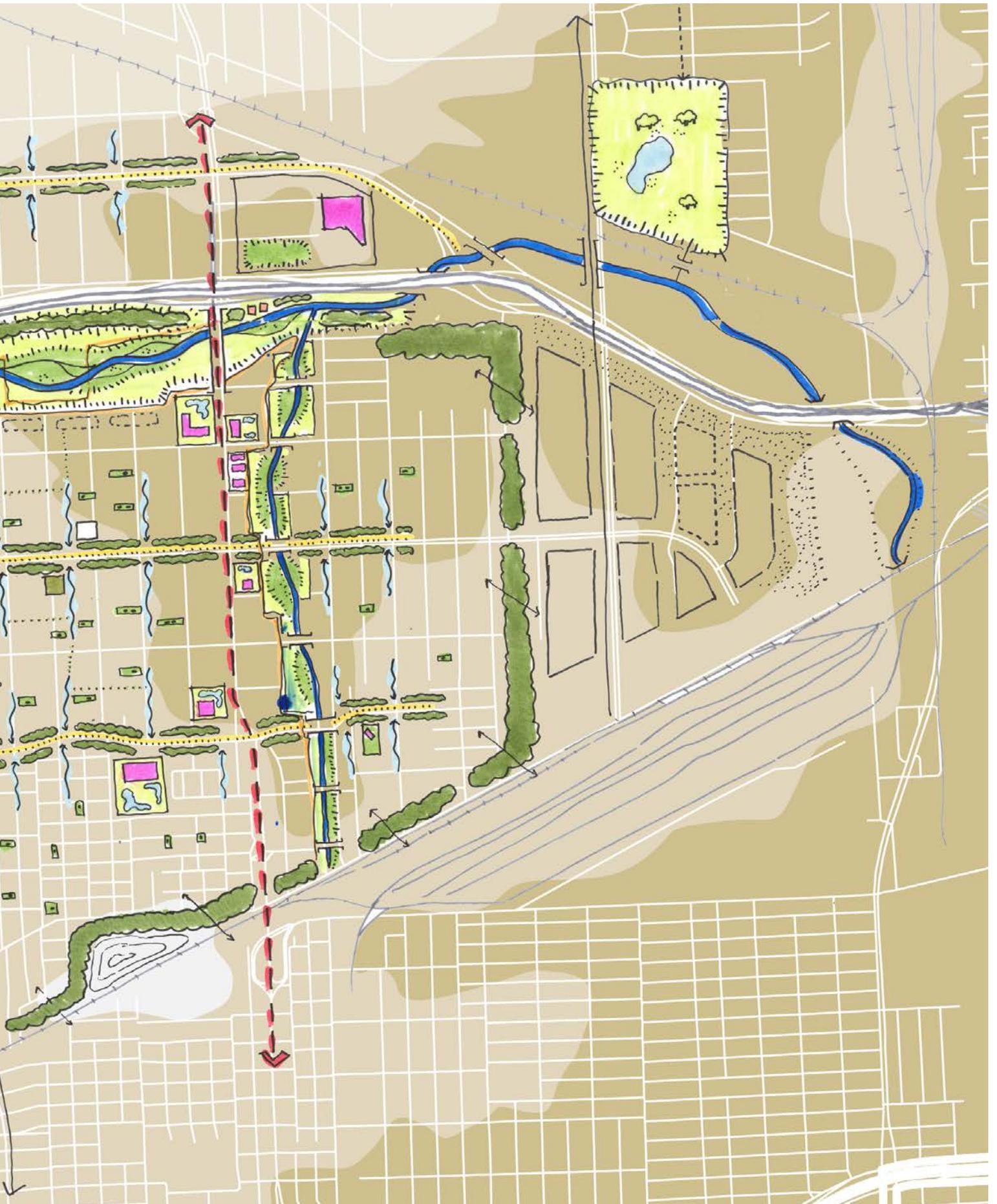
Vision

Resilience in Kashmere Gardens

The individual design concepts form a larger design vision. The pattern of Topography shapes the strategy, interceptor streets hold water on the high ground, and the expanded bayou space occupies the low ground. Each piece is integrated: the lily pads connect to the expanded bayou parks, interceptor streets feed into the “green collar”. (Parks & properties shown as “green” are illustrated for conceptual purposes only. All property decisions should be made with community and land owner buy-in.)

- Legend**
- >48 ft
 - 44-48 ft
 - <44 ft
 - Green Collar
 - Regrading/Detention Basins
 - Lily Pad
 - Interceptor Streets
 - Major Corridors
 - Raised Street
 - Ditch Retrofit





Preliminary Impact Projections

A storage target for Kashmere Gardens of 25.5 inches of rain was calculated based on the 500 year (0.2% annual chance), 24 hour rain event. The combined Living With Water Strategies in Independence Heights store a projected 8 inches of water in addition to the 6 inches stored by existing infrastructure. The remaining 12.5 inches is left over as residual runoff risk.

Storage Target 25.5 in	Storage Amount (in)	Strategies	
25.5 in	12.5	RESIDUAL RISK	
	.8	Industrial buy-out / new storage	Buyouts
	.8	Storage within vacant lots / tributaries	
	.1	Residential lot relocation & redevelopment	
	2.6	Widening / Expansion of bayou	Major Storage
	1.1	IH 69/610 and 610 Interchange	
	1	Federal project / detention / channel	
	.2	Major street improvement: Cavalcade & Homestead	
	.1	Multi-purpose recreational areas (parks, school yards, churches)	Local Storage/ Low Impact Development
	.3	Secondary street improvements	
	.1	Residential cisterns & rain barrels	
	.1	Mid-block easement ditches / French Street	
	.1	Storage within deep lots	
	.5	Retrofit of existing parking lots	Infiltration
	4	Existing infiltration + local storage	Existing Storage and Conveyance
1	Existing Capacity		
0 in			

Kashmere Gardens Recommendations

Short Term:

KG1. Complete Communities planning & process integration.

Kashmere Gardens is a recent addition to Houston's complete communities. This presents an opportunity to integrate that process with Living with Water.

KG2. Community Engagement

The Kashmere Gardens community must be engaged to better understand problems, present potential solutions, discuss if any of these meet their needs and desires, and build new ideas together

Mid Term:

KG3. Further Expand Hunting Bayou

Given Kashmere Gardens' upper reach location, further widening of Hunting Bayou contributes directly to neighborhood water storage and further reduces flood risk

KG4. Property Retrofits

Incremental retrofits are a chance to reduce flooding and improve quality of life simultaneously

KG5. Use park space for water and health

The industrial facilities that bound Kashmere Gardens create a large environmental impact to the neighborhood. A "green collar" around the neighborhood could help remediate that impact and amplify stormwater detention and recreational amenities.

KG6. Create a demonstration Interceptor Street

Kashmere Gardens has multiple types of Interceptor Streets that could be implemented throughout and around the neighborhood: a version on Cavalcade St & Collingsworth St thoroughfares to intercept water as it flows downhill (north) toward Hunting Bayou, a "Water Tray" version in French Town to improve car and pedestrian access in narrow lanes. The existing system of open ditches could be supplemented with new channels and storage shelves

KG7. Incorporate secondary waterways into bayou park network

Incorporating Turkey Run Gully and Schramm Gully can provide more residents with recreational opportunities.

Long Term:

KG8. Apply & expand on Flood Consortium proposal to create elevated access/ egress (stem) and dry protected nodes (lily pads)

Lockwood Lily Pad nodes include community & regional assets: schools, community center, LBJ hospital. Keeping the I-610 underpass dry for egress and access is also critical.

An aerial photograph of the Greenspoint area in Houston, Texas. The image shows a mix of urban and natural features. In the foreground, there's a paved road with a crosswalk and a bridge crossing a waterway. To the right, there's a large residential or commercial complex with several buildings, parking lots filled with cars, and a swimming pool. The background features a large, flat, sandy area that appears to be a detention basin or a large-scale construction site. The sky is overcast with grey clouds. A large blue semi-transparent rectangle is overlaid on the top half of the image, containing the title and introductory text.

Neighborhoods

Greenspoint

In the Greenspoint study area, the neighborhood scale trends toward the global. Located at the urban periphery, water challenges and opportunities are defined by large water infrastructure and detention basins, interstate highways, large commercial redevelopment parcels, and a bustling international airport. Flooding solutions here may tap into cross-jurisdictional funding programs that scale up from private developers to city, county, state, and federal resources.

Greens Bayou with detention basin in the background

Contributors

Janice Barnes, WBAE; Lex Agnew, WBAE; Anneloes Nillesen, DeFacto Landscape Architects; Matthijs Bouw, One Architecture; Piet Dircke, Arcadis; Vince DeCapio, Arcadis; Lynette Cardoch, Moffaat & Nichol; Ram Ray, Prairie View A&M University; Kinder Baumgardner, SWA Group; Huy Vu, The Water Institute; Nichola Springer, Kirksey Architecture; Peter Caldwell, Asakura Robinson; Hugh Roberts, The Water Institute

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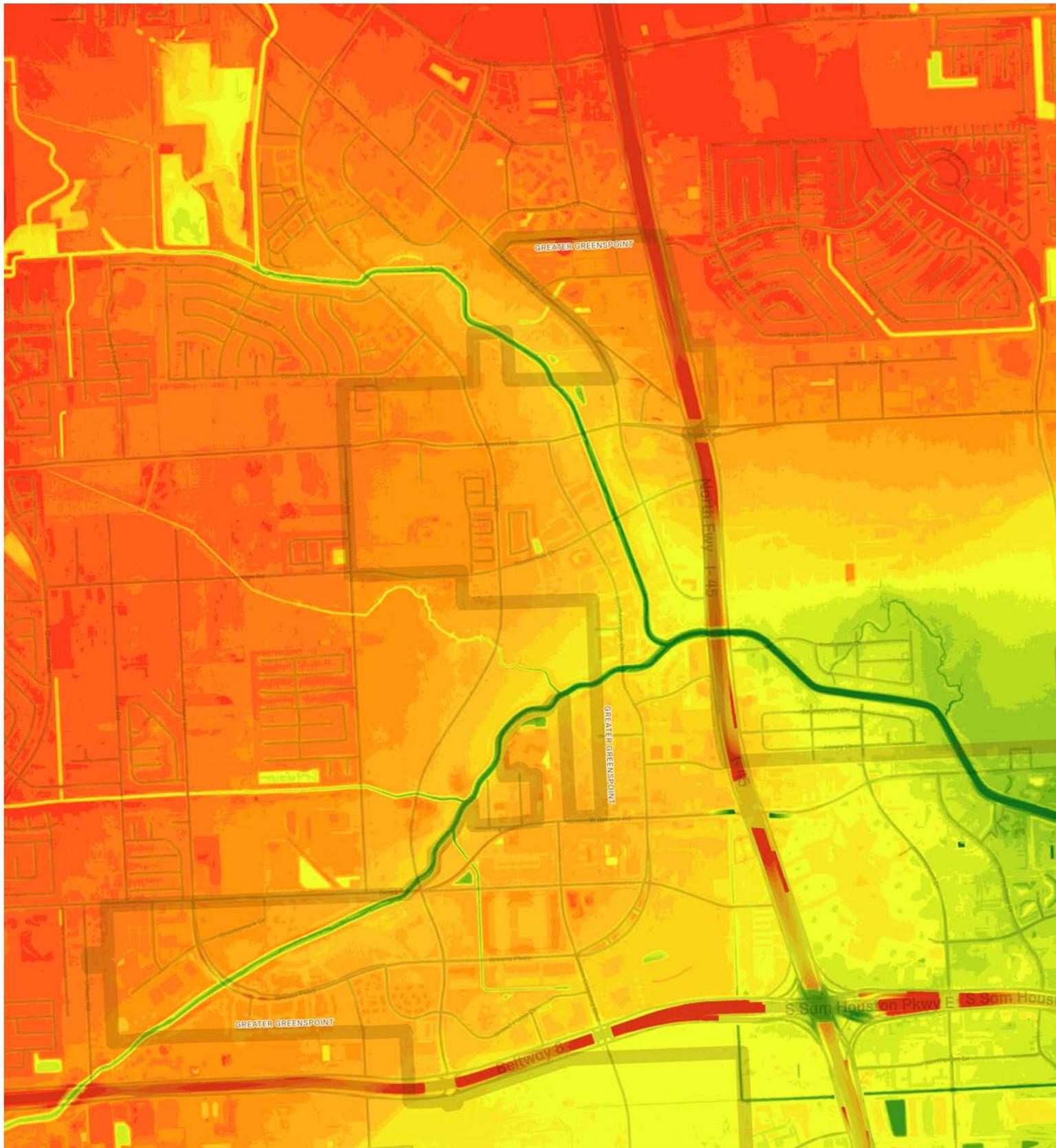
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Risk & Opportunities	102
Design Concepts	104
Vision	108

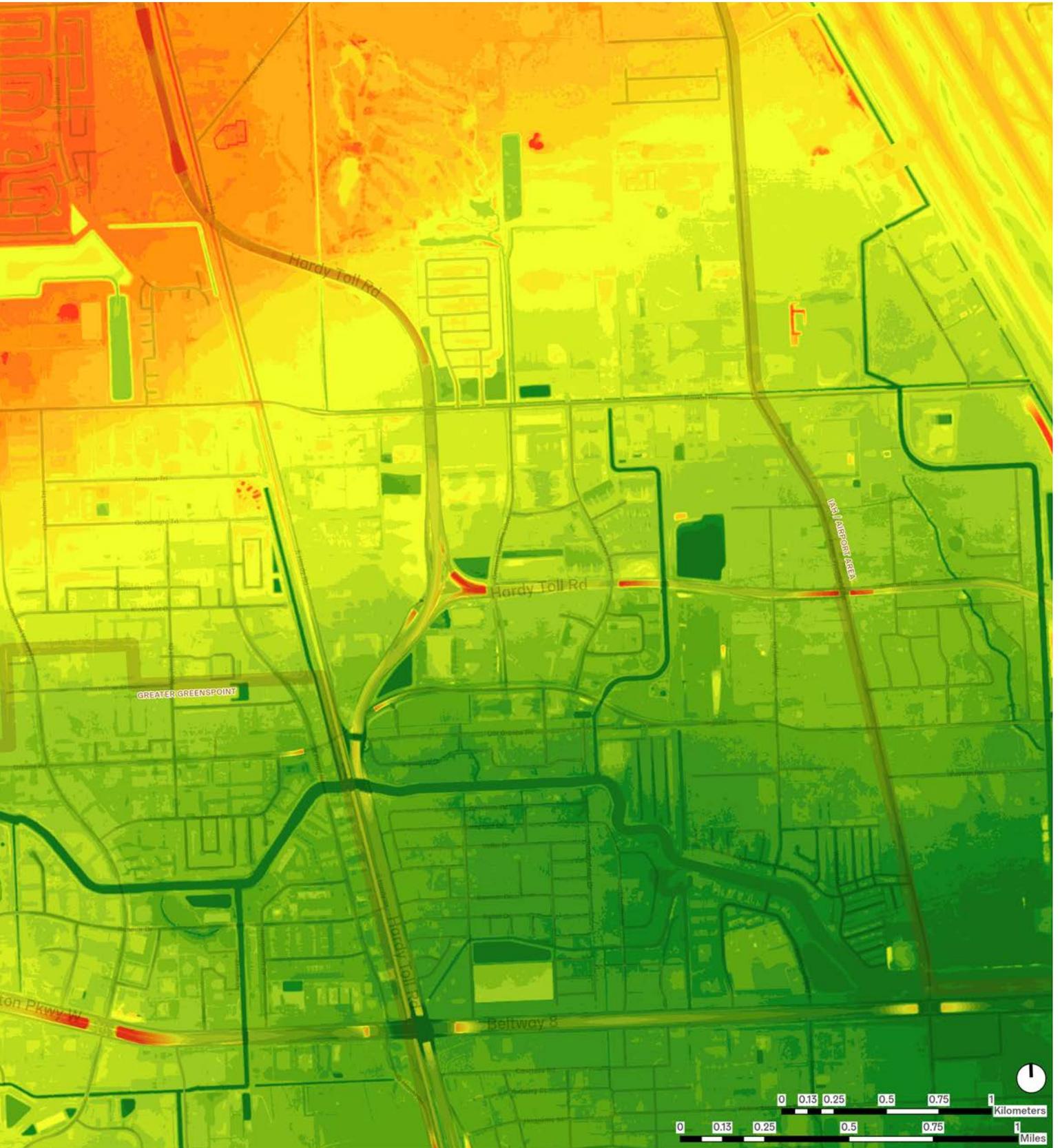
Notes:

1. Parks & properties shown as “green” are illustrated for conceptual purposes only.
2. All property decisions should be made with community and land owner buy-in.
3. All images are credited to Waggonner & Ball unless otherwise attributed.



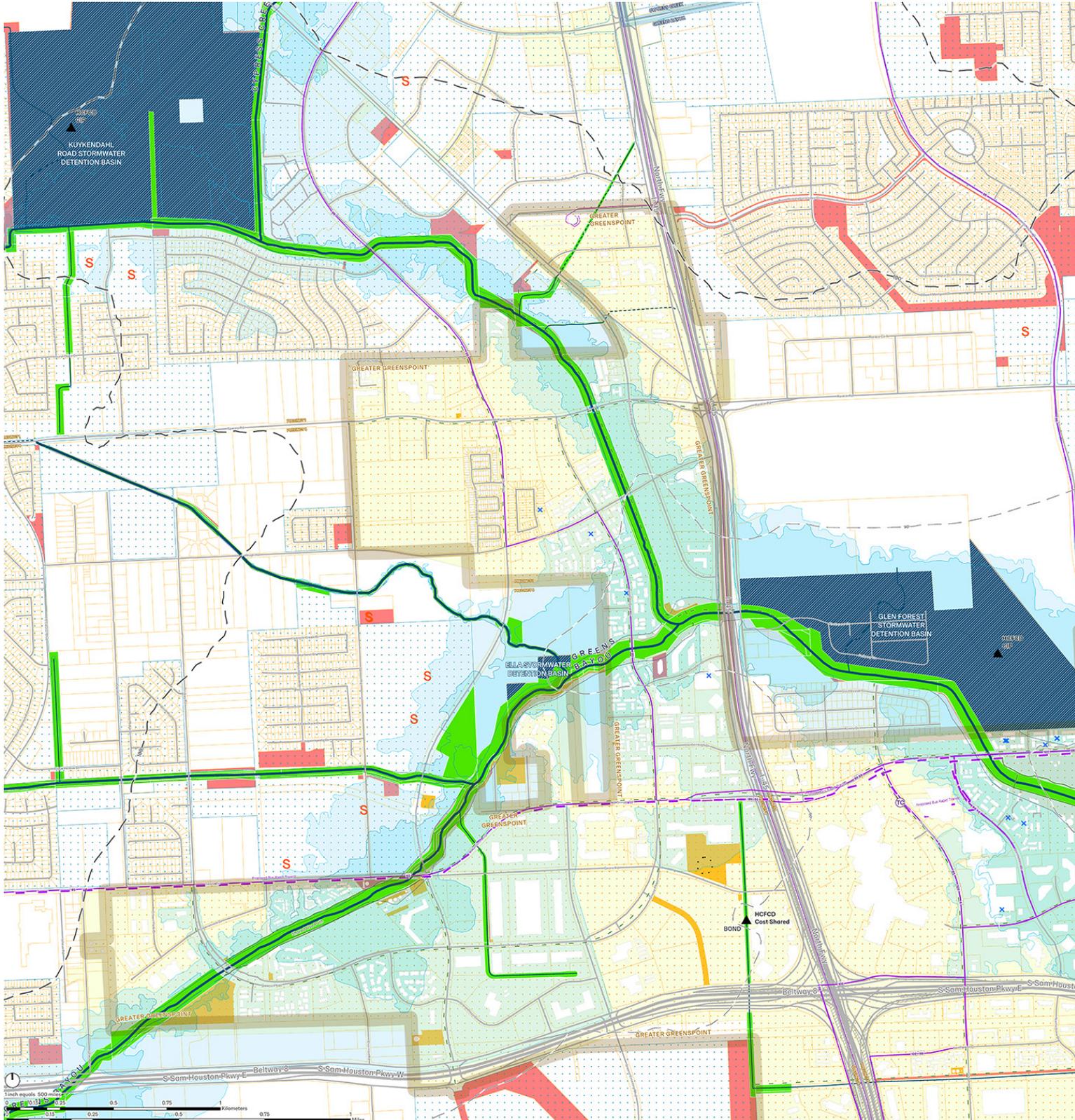
Elevation





Land Use

 City of Houston Parcels	LEGEND	 311 Flooding
 Harris County Parcels		 Watersheds
 Parcels	10' Contours	 Waterway Centerlines
 Super Neighborhoods	 10	 Sewer
 Houston City Boundary	 50	 Major Waterways
 MUDs	DFIRM	 Minor Waterways
 TIRZ	 Floodway	 Ditches
	 100 Year Floodplain	
	 500 Year Floodplain	



ONGOING PROJECTS

- ▲ Active Projects
- ▨ HCFCFD - Possible Acquisitions
- ▨ HCFCFD ROW Acquisitions
- ▨ HCFCFD - Detention Basins
- Houston CIP Roadwork
- Houston CIP Drainage

I45 - NHHIP

- ▨ Frontage Road
- ▨ Highway; Bridge
- ▨ Detention Pond
- ▨ Hardy Toll Connector Project
- ▨ Hardy Connector Detention

H
S

- Hospitals
- Schools
- Building Footprints (only for CoH)

TRANSPORTATION

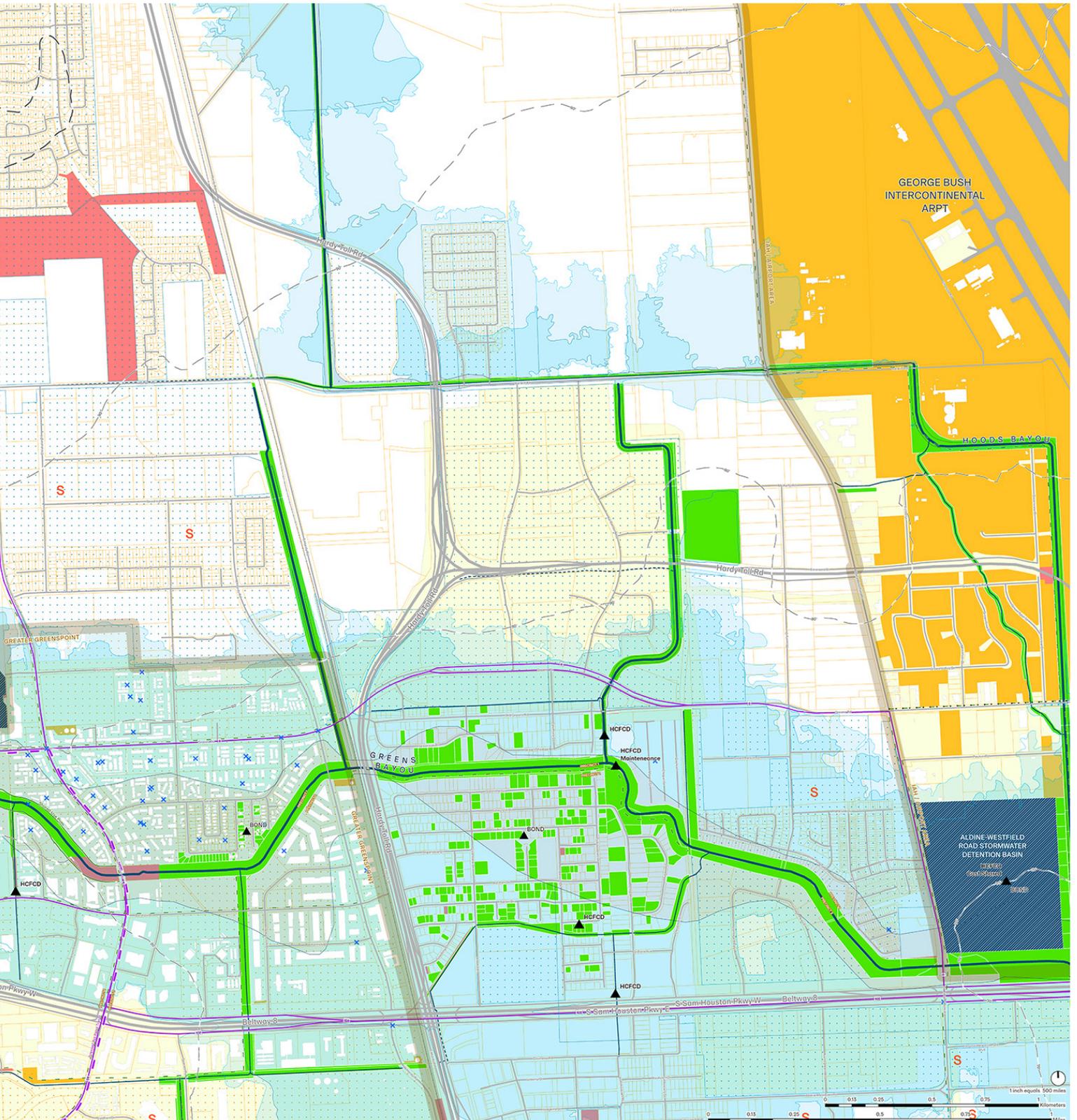
- Roads
- Rails

BUS & LIGHTRAIL

- LRT
- BRT
- Ⓣ RN Transit Centers
- Ⓟ RN Park Rides Centers
- LRT Stations

Proposed Transit Projects

- Light Rail Transit
- Bus Rapid Transit
- BIKE
- Existing Bikeways
- Houston Bike Plan
- Parks

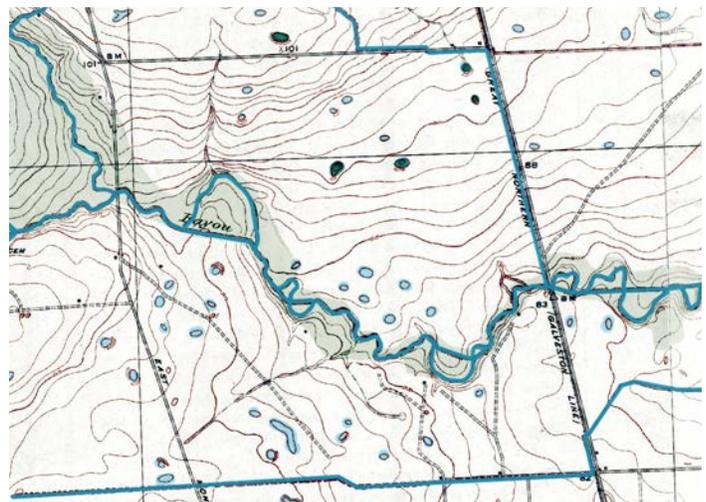


Land & Water

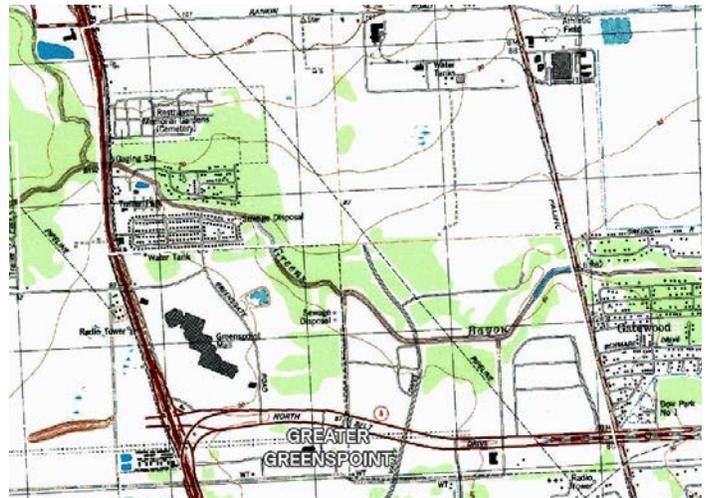
Greenspoint is the northernmost focus area, located midway along Greens Bayou. The area developed in the 1970s as a peripheral suburb. Development originally centered around the Greenspoint Mall, and later a class A highrise office park. Both of those commercial anchors now suffer from vacancy issues. Largely, the district has experienced disinvestment, yet has a range of potential opportunities for resilient redevelopment.

Before the 20th century, Greens Bayou followed a meandering path through a low-lying landscape covered with prairie potholes and other depressions. Around the turn of the twentieth century, portions of Greens Bayou were straightened and channelized, and old pathways were cut off. As people moved to Greenspoint in the 1970s and 1980s, landscape depressions and old bayou paths located within the floodplain were filled in to construct residential and commercial developments. Homes built in these areas were some of the earliest buyout properties, such as the Glen Forest neighborhood. The neighborhood is now the site of an HCFC detention basin.

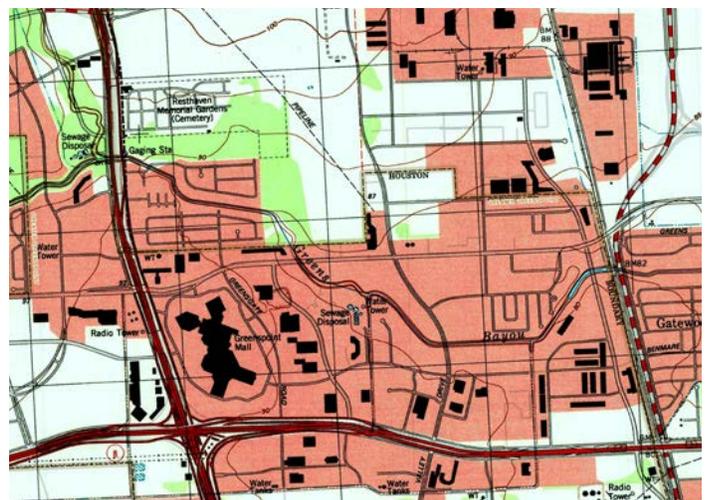
The wide range of land use types that have developed in Greenspoint remain disconnected from each other as well as the historic bayou landscape.



1922
Modification of Bayou Green has begun, surrounded by oxbows and prairie potholes.
Credit: USGS



1982
Predominantly lower density, suburban development exists, including Greenspoint Mall
Credit: USGS



1995
The majority of Greenspoint has been constructed, much of it close to the bayou.
Credit: USGS





Thomas R. Wussow Park

Along Greens Bayou; on the opposite bank are apartment buildings within the floodway.



Greenspoint Mall

The Greenspoint Mall has become predominately vacant; its parking lot is currently used to store carnival equipment. The office park in the background also has high vacancy.



Buyout Neighborhood

Properties that were acquired and demolished create a patchwork of habitation.

Risk & Opportunities

Flood risk in Greenspoint comes from a mixture of constricted waterways and poor developmental patterns. Some of the densest apartment complexes in Houston have been constructed entirely in the floodway. Conversely, parts of Greenspoint and the surrounding area- at higher elevations-remain undeveloped. Chronic flooding plagues these already at-risk renters, threatening to permanently displace them. Surrounding neighborhoods have become a patchwork of occupied and vacant buyout parcels in the floodplain. Greens Bayou has overtopped its banks multiple times from 2014 to 2019, including during Hurricane Harvey in 2017.

Since Hurricane Harvey, construction of large stormwater detention basins has begun along Greens Bayou. Floodplain and precipitation events data is currently being updated to reflect the greater intensity of storms that have occurred recently, such as Harvey. The new stormwater detention basins are intended to address the updated floodplain data.

Even with additional areas for water storage, properties within the current floodplain will remain at risk. The bayou remains constricted, which creates a wide floodplain. This perpetuates the cycle of vulnerability and displacement.

If the bayou system is not taken seriously and given the space it needs, people will remain at risk. Much of Greenspoint will have to learn to live with flooding, unless hydrology across the watershed is drastically changed. Given the high cost of such strategies, vulnerable populations will continue to remain at risk.

Occupational and land use patterns in Greenspoint must change as well. Residents in the floodway have to be moved out, and provided safe and affordable housing. Additionally, the bayou and its floodplain must be given space.

Greens Bayou is a source of identity for Greenspoint, but the neighborhood is disconnected from it. Making Greens Bayou the centerpiece of the neighborhood is best way to reimagine the area. This approach can frame resilient redevelopment with a long term vision for the future.



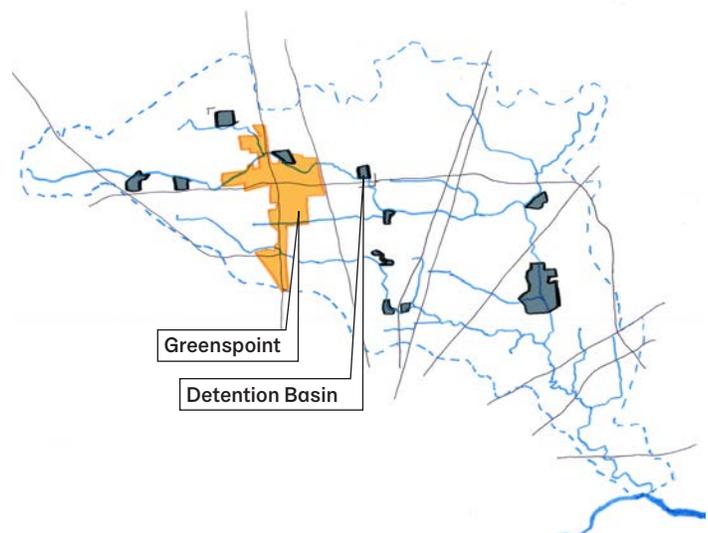
Hardy Toll Road and Railway Choke Point

Constrictions along Greens Bayou cause the floodway to widen dramatically.



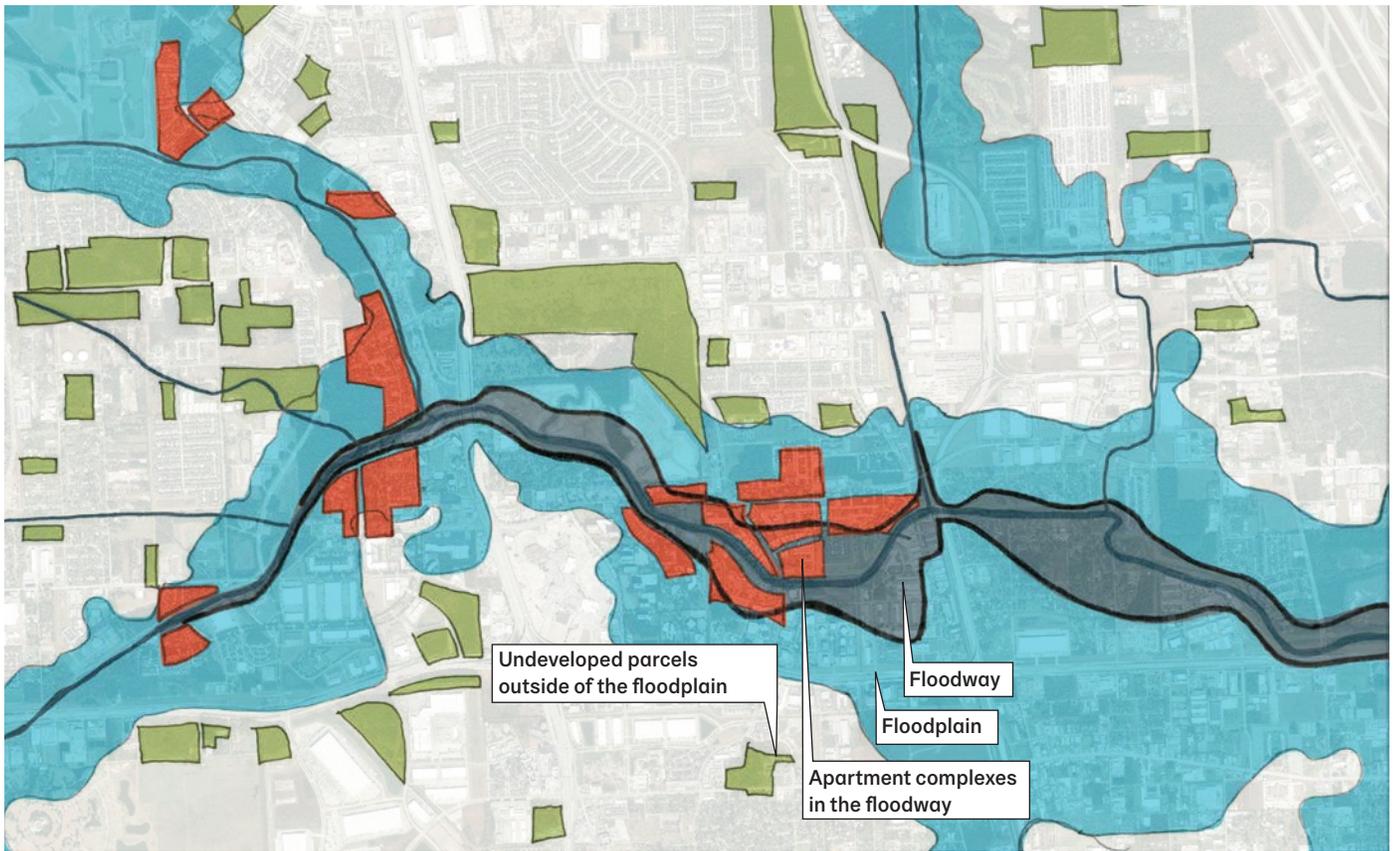
Glen Forest Stormwater Detention Basin

Large detention basin under construction since Hurricane Harvey. (cleared area in background)



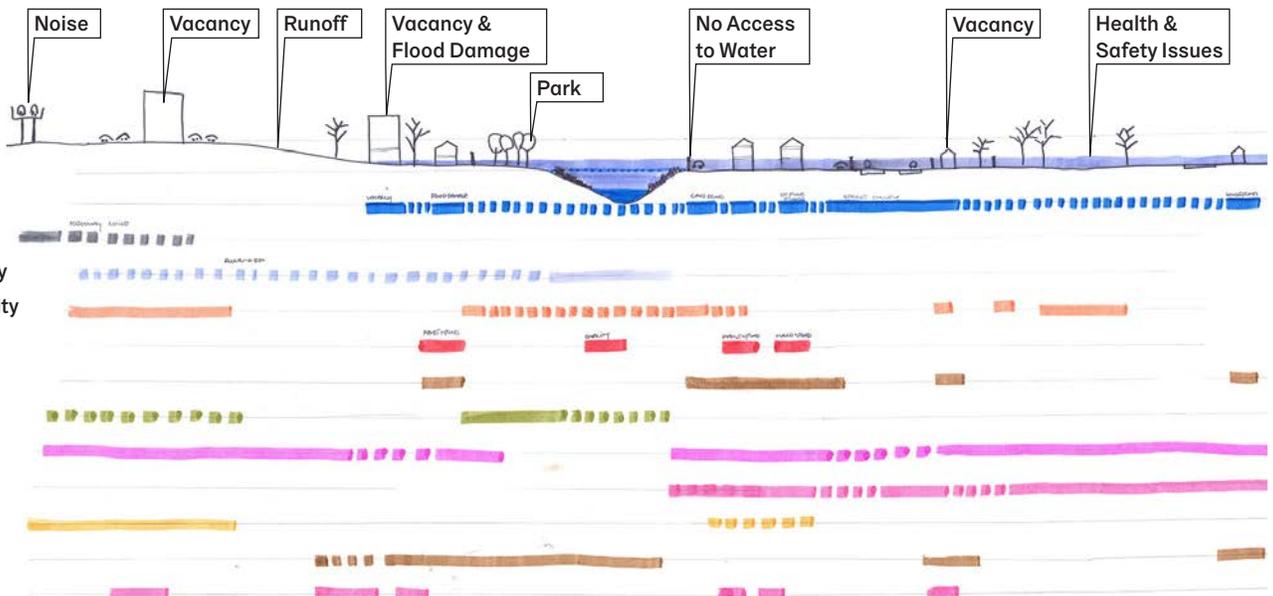
Greens Bayou Watershed

Large detention basins are being constructed throughout the Greens Bayou watershed.



Renters in the Floodway

Dense apartment complexes located in the floodway (orange) put thousands of Greenspoint residents at risk, while large portions of the surrounding area remain undeveloped (green).



Risk Zones

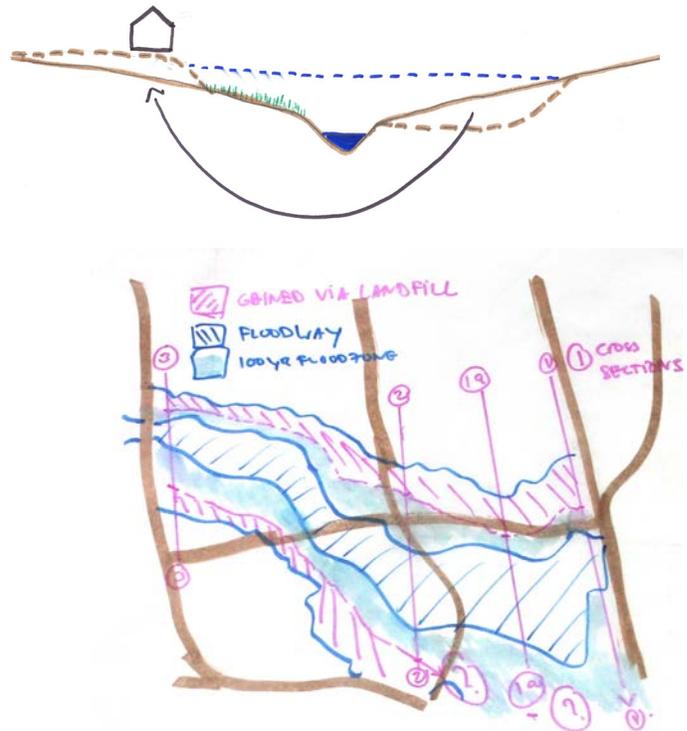
Moving away from the bayou, risks differ along with the character of the neighborhood.

Design Concepts

The Greenspoint design principles focus on redesigning the floodplain and shifting land use patterns. Homes are moved out of the floodway, and the space between housing and the bayou expands. In the new, reclaimed space the floodway is sculpted to become lower and more naturalized, mimicking how it functioned prior to development. This re-naturalized area doubles as a park, which spurs redevelopment and investment along its edge.

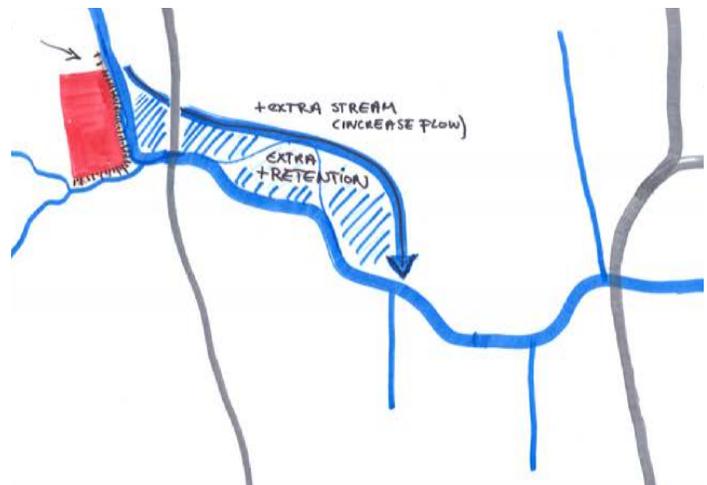
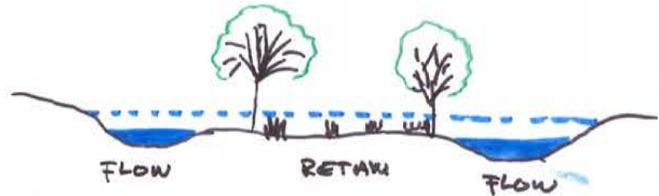
Bayou Scale

- Sculpting the floodplain:** The current floodplain is low and flat. By scouring out the banks through excavation, more floodwater volume can be stored in less area, which reduces the area of the floodplain. The outer edges of the floodplain can be built up as a protective edge in order to locate resilient redevelopment on higher ground, but close to water. The new, enlarged floodplain then becomes a re-naturalized park area that doubles as water storage.
- Additional conveyance paths:** The large floodway in Greenspoint is partially created by bottlenecks where the bayou intersects bridges. At these intersections, the bayou is constricted by culverts or crossings, which limit the volume of water that can flow underneath. Creating additional conveyance paths could alleviate those bottlenecks, and create more room for water. Additional floodwater can be stored in between the conveyance paths.
- Create a unified stormwater/bayou park:** All of the bayou scale design strategies should be integrated into a larger bayou park. The park will connect existing recreational spaces and adjacent neighborhoods, providing much needed ecological and recreational services and access for the greater Greenspoint area.



Sculpting the Floodplain

Lower areas of the floodplain are scoured out, higher areas are built up.

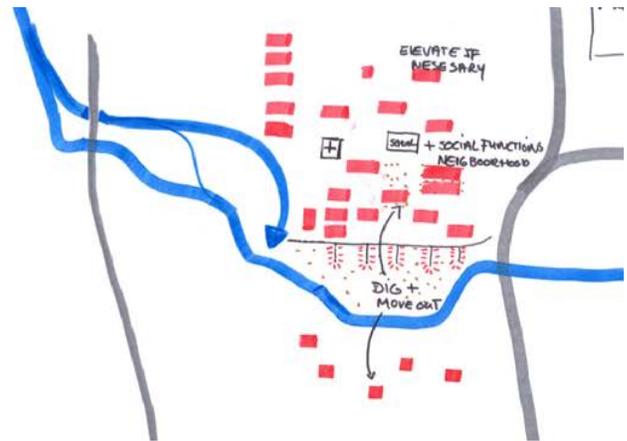


Additional Conveyance Paths

Additional channels for water with storage in between

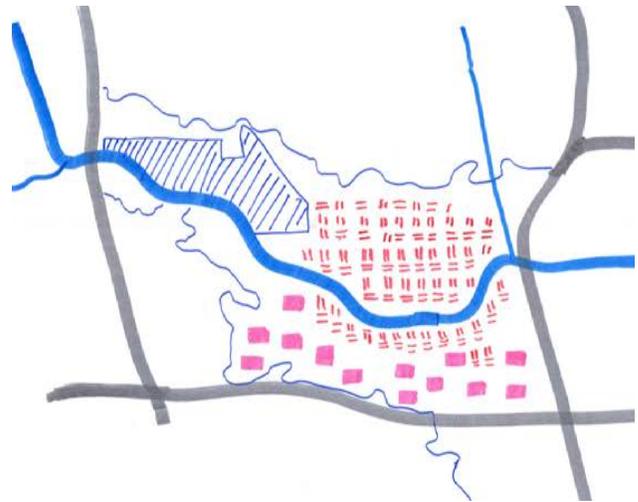
Neighborhood Scale

- Relocation on higher ground:** Relocation will be challenging, politically and socially. However, it must be done, considering that the next flood will most likely force residents out of their current homes. The goal would be to relocate residents in proximity to their current neighborhoods. Greenspoint and the surrounding areas have many undeveloped sites that are at higher elevations, well out of the floodplain. Future homes can be developed in advance so there would be no need for interim housing. Plenty of open land for development exists north and south of the bayou to accommodate resilient housing as well as community services.
- Floodproof buildings:** Along and near the edge of Greens Bayou, properties will still have to be floodproofed. This kind of living with water is expensive, and will only be possible for middle-to-higher income populations. Relying on maintenance alone is unsuitable for current vulnerable populations. Buildings and critical streets are raised out of the floodplain while other areas are retrofitted to withstand inundation.
- Develop along the fortified edge:** The edge of the sculpted floodplain will become the point of entry to the new bayou park. Commercial and residential developments will benefit by their location close to the bayou and new public spaces of the park.



Relocation on Higher Ground

Homes and apartments are moved out of the floodway onto undeveloped land on higher ground.



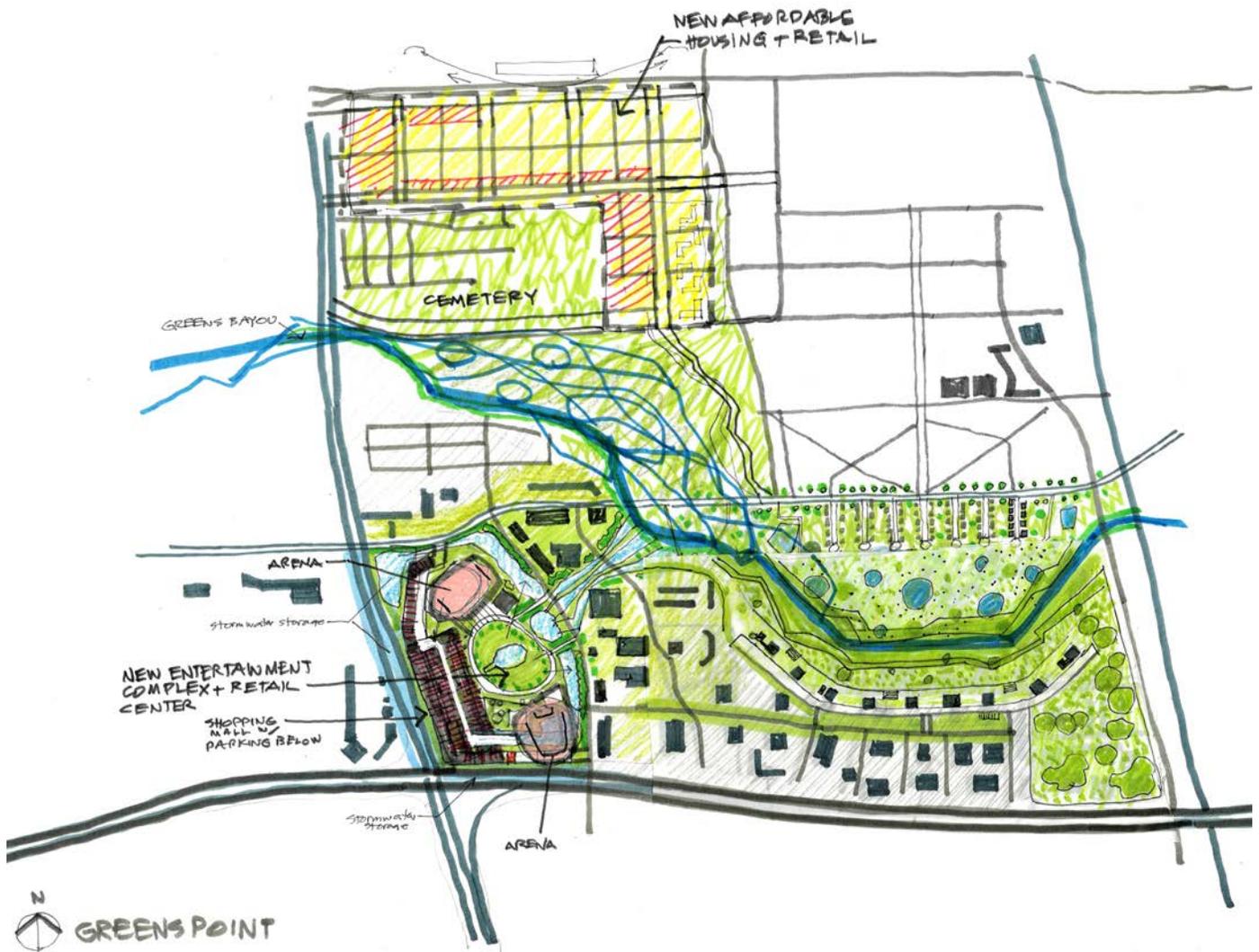
Floodproofing

Areas still within the floodplain are retrofitted to live with water.



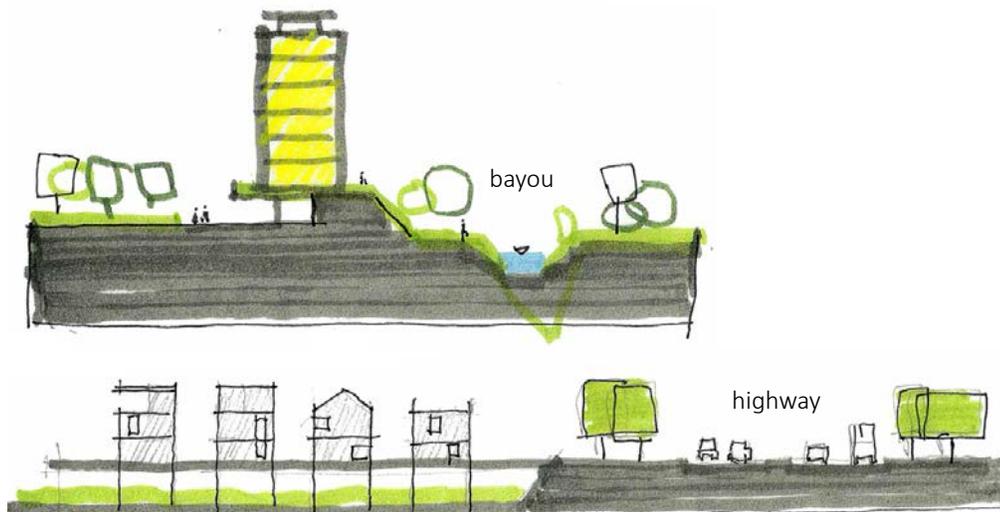
Develop Along the Fortified Edge

The edge of the newly sculpted floodplain is redeveloped.



Future Vision

Plan shows avoiding vulnerable locations by developing on higher ground, retrofitting structures still in the floodplain, and developing along a safer edge of the bayou.



Resilient Redevelopment

Elevated residences and commercial buildings are buffered from the bayou and highways.

Vision

Gateway to Houston

For people flying into Houston via George Bush Intercontinental Airport, Greenspoint serves as the gateway to the city and region. Greenspoint has an important long term future since the airport will remain in its current location. The neighborhood's proximity next to the airport is crucial for investment opportunities. Over time, capital will come to this area as a result of financial incentives such as opportunity zones.

Greenspoint can be seen as a large scale connector due to its assets: the airport, Interstate 45 and Sam Houston Parkway/Beltway 8 highways, and future mass transit expansion such as the light rail along I-45, and bus rapid transit. The currently underused Greenspoint Mall also has the opportunity to become a transit-oriented development. The new bayou park can become the new gateway to the Bayou City.



Connection Diagram

The Greenspoint area is advantageously close to the airport, which would support a future light rail or bus rapid transit line. In parallel, a linear park along Greens Bayou would provide recreational access for residents.

**Vision: Gateway to Houston**

New mixed use towers in the foreground frame a large neighborhood stormwater park that creates more room for the bayou, bordered by resilient housing.

Next Steps

Relocating renters from within in the floodway is the immediate task in Greenspoint. In the long term the mall, office park, greens road and everything along the I-45 corridor, has the potential to redevelop. New transit lines connecting the airport to Houston also offer the potential for transit oriented development. Ensuring that development is done in a way that mitigates both local and downstream risk is critical. Looking towards the future Greenspoint trends toward global connectivity.



Development Vision

An alternate version of a future plan, which includes relocation to higher ground, retrofitting and floodproofing, and development along a safer edge near the bayou.

Greenspoint Recommendations

Short Term:

GP1. Assist renters in relocating from the floodway

Maintain affordable, flood-safe housing options nearby. Much of the land surrounding Greenspoint is still undeveloped and could provide sites for new affordable developments.

GP2. Explore City/County collaborations

Greenspoint is a peninsula in the Houston city boundary. To maximize the flood mitigation options, cross boundary partnerships are required. Many of the sites in which new replacement multifamily residences could be developed are outside of the city boundary.

GP3. Add function & activity to detention basins

Many of the stormwater detention basins around Greenspoint are vast unplanted and unprogrammed spaces that could be integrated with bayou trail networks to create safe public access and recreational opportunities.

Mid Term:

GP4. Explore Public-Private-Partnership opportunities

Multifamily Buy-Ins and commercial redevelopments provide an opportunity for public-private partnerships.

Long Term:

GP5. Reconfigure Greens Bayou as a “Gateway to Houston”

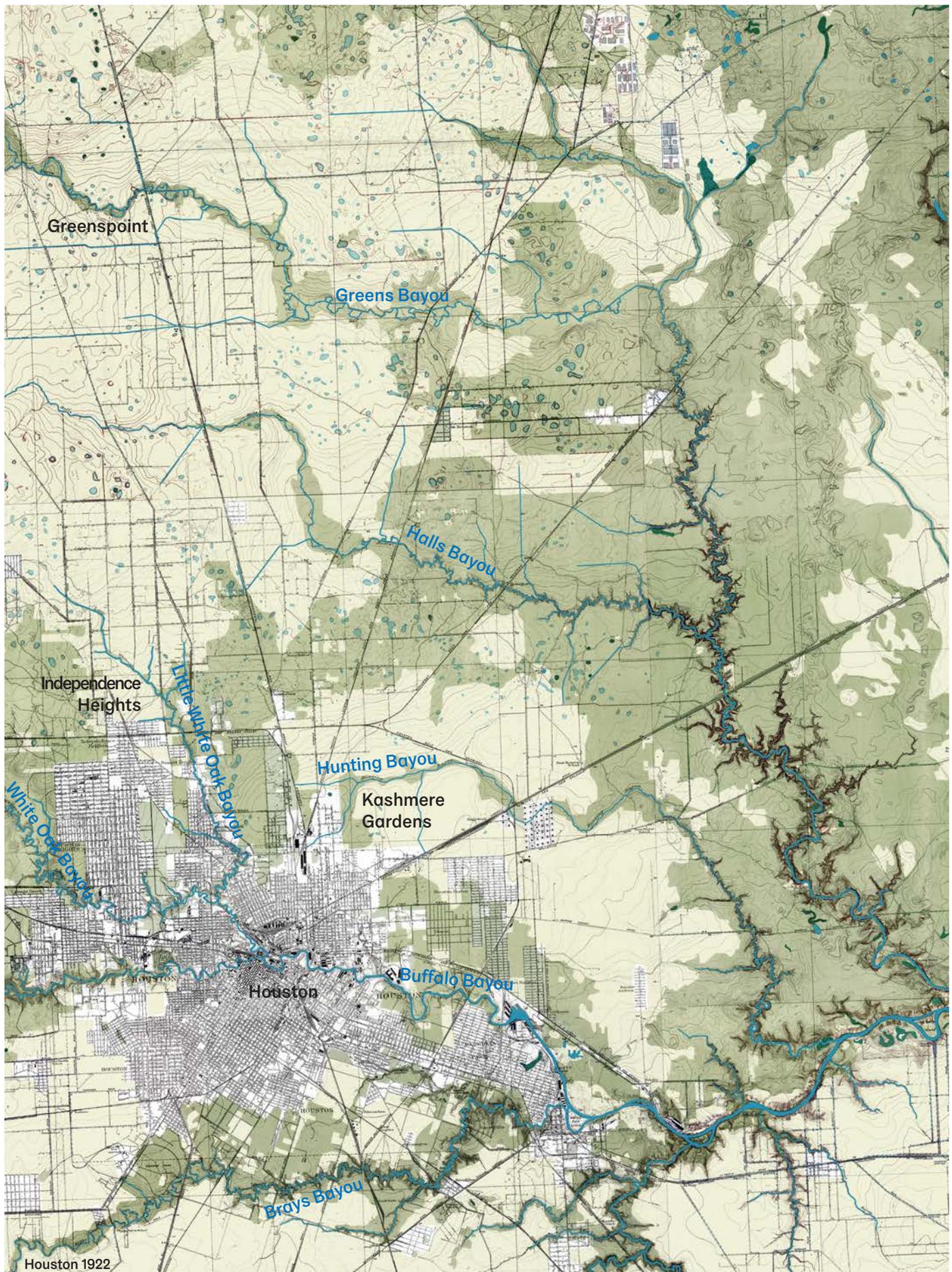
Greenspoint is at the nexus of an International airport and expanding transit corridors. A Bayou park along the Greens Bayou could become the Gateway to Houston. Redevelopment in Greenspoint could be oriented around the bayou park.

GP6. Incentivize & promote development with water

Much of the development in Greenspoint is on high ground and highly impervious especially the derelict mall. Storage here positively impacts everything downstream. Water and water storage can be integrated as character and identity features (branding value & development amenities)

Recommendations Summary





Guiding Principles

Short Term:

GP1. Prioritize safety first

Critical Facilities and access corridors should be elevated or retrofitted. Development should be incented to build in flood-safe areas.

GP2. Hold water where it falls

Holding runoff closest to where it starts lessens downstream impact. Once water enters the bayous, it enters another scale of infrastructure and is more difficult to control.

GP3. Educate public & private sectors about water

Especially in areas where flood risk is not immediately apparent, outreach on flood risk and the location of flood-prone land and the function of the bayou system and the causes of flooding, can shape public and private commitment toward water resiliency. Solutions and advocacy at every scale require a similar public outreach.

Mid Term:

GP4. Align transportation system to waterway functions

In certain cases, improve choke points where transportation crossings (road and rail) obstruct water flows only when upstream downstream areas will not be impacted. Major transportation corridors should manage their own runoff and take on additional detention if possible. Retrofitting parking lots and other paved areas to have plantings and pervious paving lowers the impact highly impervious surfaces have on the speed and volume of runoff entering the drainage system.

GP5. Make Space for Bayous

Constriction in the bayous must be resolved, whether it is in the form of choke points at bridges and culverts or properties located in the floodway. Water must be given space in a way that does not harmfully displace people or amplify downstream flooding. Working in tandem with the Bayou Greenways 2020, new bayou space can become a recreational amenity and the front yard of Houston.

GP6. Bring back the prairie

Prairie conservation efforts in the greater Houston region reduces runoff, preserves a recreational and ecological amenity and lowers the urban heat island effect.

Long Term:

GP7. Increase water storage ambition over time

Climate change, updated storm data and ongoing development makes water storage goals a moving target. Developing water-aware development culture and increasing water storage ambition helps to keep up with increasing future risk.

Bayou City Water Recommendations

Short Term:

BC1. Study water system choke points

Constrictions must be dealt with in a way that does not increase downstream flooding. Conveyance increases must be matched with runoff storage, property elevations and retrofits. Alternatively, strategic constrictions can be maintained to lessen downstream flooding.

BC2. Develop watershed and sub-watershed plans

Bayou planning should include “between the bayous,” not just space around the channel itself. New coalitions between jurisdictions must be forged to plan at the watershed level.

BC3. Pilot City, County, and State cooperation at the policy and project level

Leverage access to funding structure and opportunities. Possible Pilot projects include: Buyout funding/property swaps, multi-use detention basins, highway runoff mitigation.

Mid Term:

BC4. No Residents in the floodway (active channel)

Existing single and multifamily residences must be equitably moved out of the floodway. The floodway is crucial to the strategy of making space for the bayou.

BC5. Consider risk mitigation outside of the 500 year Floodplain

Over half of the property damage in Hurricane Harvey happened outside of the 500 year floodplain. As storm data and risk is updated floodplain will change and areas previously “safe” will become at risk. Preemptive measures can mitigate unforeseen risk.

BC6. Prioritize surface water storage and conveyance

Keeping water aboveground and out of pipes is a cost effective and visible strategy with potential for multiple benefits.

Long Term:

BC7. Create “Interceptor Streets”

Streets present some of the largest swaths of public right of way, especially in the denser, fully built out parts of Houston. Stormwater can be managed through innovative street sections and GSI (green stormwater infrastructure) Blue-green streets should align with historic corridors, commercial streets, and public transit routes to provide multiple benefits.

BC8. Use water and water infrastructure to create places with unique character

Each bayou has a different character and set of challenges. Ecological restoration can magnify detention and infiltration and highlight a bayou’s unique character. The massive detention basins being constructed throughout Houston are also opportunities to provide residents with public recreational amenities.

Neighborhoods Recommendations

Short Term:

N1. Protect cars from flooding

In near term, cars are indispensable in Houston, especially for LMI populations. Streets are typically the lowest parts of their micro-watershed. Creating elevated/dry areas at the home and neighborhood scales can keep cars dry from nuisance flooding.

N2. Soil-neutral projects

Keep and use all cut/fill on-site (or in-neighborhood) whenever possible. Any infill in the floodplain must be matched with equal or greater volume of detention.

N3. Plant trees

Trees can infiltrate stormwater into the soil, provide shade, and beautify streets.

Mid Term:

N4. Community Buy-In

Buy outs must be matched with buy ins. Residents living in risky areas must be given affordable alternatives in safer locations within the community. Use home relocations to strengthen communities and protect from flooding

N5. Improve health & environmental quality with water

Green stormwater infrastructure must also strive to create benefits outside of purely stormwater management. They can create recreational opportunities associated with water and parks, remediate the air and environment.

Long Term:

N6. Make flood mitigation decisions that benefit everyone

Share benefits from water equitably, including access to water amenities, affordable development, and improvements to health and environmental quality. Ensure that risk mitigation works for

Independence Heights Recommendations

Short Term:

IH1. Reconsider standard Frontage Road design

Through working with TXDOT the water impact of the highway expansion can be lessened. In some segments of the I-45 expansion, the boilerplate frontage road design provides limited or no additional access and could be removed to improve neighborhood design and safety. That space could be used to detain and remediate stormwater from the highway, provide additional storage along the bayou, and reduce noise pollution from the highway.

Mid Term:

IH2. Consider working with existing bottlenecks only if adequate flood safety can be reached

More flow discharging from the Little White Oak watershed poses direct risks for downtown Houston. Studying a “cascade” approach within the channel and upstream from the I-45/I-610 choke point to provide, water storage behind weirs could provide a solution. Vacant, underutilized parcels could be used to create storage capacity and park amenities.

IH3. Create a demonstration “Interceptor Street”

The historic Airline Drive corridor could become the pilot project for an Interceptor Street concept. Underused lanes and medians could be converted into water storage features, which would store the street runoff and intercept water from the surrounding neighborhoods.

IH4. Retrofit commercial & industrial developments to store water

Parking lots and legacy industrial and warehouse structures create a significant amount of runoff. Retrofitting these structures to store water lessens the speed and volume of stormwater entering the drainage system. Re-purposing these structures and/or their surrounding can unlock neighborhood development potential.

Long Term:

IH5. Strengthen community through interconnections

Focus affordable mixed-use development along historic corridors and bayou parks. Create safe pedestrian and bicycle connections across Little White Oak Bayou, I-610 and I-45 corridors

Kashmere Gardens Recommendations

Short Term:

KG1. Complete Communities planning & process integration.

Kashmere Gardens is a recent addition to Houston's complete communities. This presents an opportunity to integrate that process with Living with Water.

KG2. Community Engagement

The Kashmere Gardens community must be engaged to better understand problems, present potential solutions, discuss if any of these meet their needs and desires, and build new ideas together

Mid Term:

KG3. Further Expand Hunting Bayou

Given Kashmere Gardens' upper reach location, further widening of Hunting Bayou contributes directly to neighborhood water storage and further reduces flood risk

KG4. Property Retrofits

Incremental retrofits are a chance to reduce flooding and improve quality of life simultaneously

KG5. Use park space for water and health

The industrial facilities that bound Kashmere Gardens create a large environmental impact to the neighborhood. A "green collar" around the neighborhood could help remediate that impact and amplify stormwater detention and recreational amenities.

KG6. Create a demonstration Interceptor Street

Kashmere Gardens has multiple types of Interceptor Streets that could be implemented throughout and around the neighborhood: a version on Cavalcade St & Collingsworth St thoroughfares to intercept water as it flows downhill (north) toward Hunting Bayou, a "Water Tray" version in French Town to improve car and pedestrian access in narrow lanes. The existing system of open ditches could be supplemented with new channels and storage shelves

KG7. Incorporate secondary waterways into bayou park network

Incorporating Turkey Run Gully and Schramm Gully can provide more residents with recreational opportunities.

Long Term:

KG8. Apply & expand on Flood Consortium proposal to create elevated access/egress (stem) and dry protected nodes (lily pads)

Lockwood Lily Pad nodes include community & regional assets: schools, community center, LBJ hospital. Keeping the I-610 underpass dry for egress and access is also critical.

Greenspoint Recommendations

Short Term:

GP1. Assist renters in relocating from the floodway

Maintain affordable, flood-safe housing options nearby. Much of the land surrounding Greenspoint is still undeveloped and could provide sites for new affordable developments.

GP2. Explore City/County collaborations

Greenspoint is a peninsula in the Houston city boundary. To maximize the flood mitigation options, cross boundary partnerships are required. Many of the sites in which new replacement multifamily residences could be developed are outside of the city boundary.

GP3. Add function & activity to detention basins

Many of the stormwater detention basins around Greenspoint are vast unplanted and unprogrammed spaces that could be integrated with bayou trail networks to create safe public access and recreational opportunities.

Mid Term:

GP4. Explore Public-Private-Partnership opportunities

Multifamily Buy-Ins and commercial redevelopments provide an opportunity for public-private partnerships.

Long Term:

GP5. Reconfigure Greens Bayou as a “Gateway to Houston”

Greenspoint is at the nexus of an International airport and expanding transit corridors. A Bayou park along the Greens Bayou could become the Gateway to Houston. Redevelopment in Greenspoint could be oriented around the bayou park.

GP6. Incentivize & promote development with water

Much of the development in Greenspoint is on high ground and highly impervious especially the derelict mall. Storage here positively impacts everything downstream. Water and water storage can be integrated as character and identity features (branding value & development amenities)

Appendix

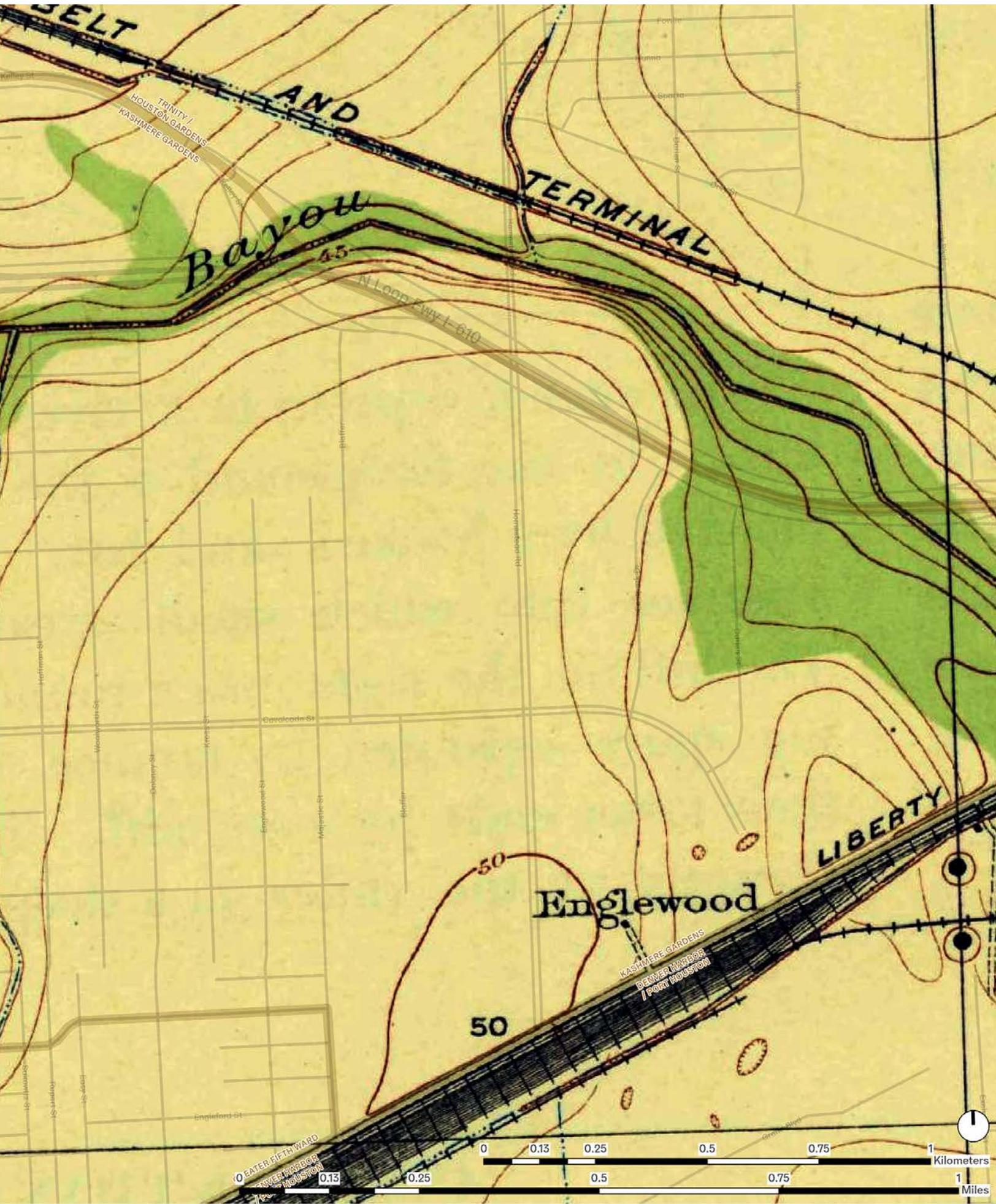
Hunting

Map of Northern Houston, 1922

Credit: USGS

Colorized by Waggoner & Ball

KASHMERE GARDENS
GREATER FIFTH WARD



Convening Summary



December 4, 2018

On November 8-9, 2018, the City of Houston organized a Living with Water Convening as part of its work with 100 Resilient Cities. The intent was to enable high-level policymakers and technical experts from Greater Houston, leaders of Living with Water programs for other North American cities and The Netherlands to think beyond immediate projects, programs and institutional needs.

The purpose of this summary is to acknowledge the work of the Convening, how this work leads to the Living with Water Design Workshop in the Spring of 2019 and to reference the resources shared.

This Convening paralleled the 100 Resilient Cities Agenda-Setting Workshop occurring nearby on Day 1 and included many participants of that workshop on Day 2. The intent was for the events to mutually inform the larger resilience strategy to be developed for the City of Houston.

Building upon the strength of current and near-term flood mitigation projects and plans, and upon Houston's historical strength as a city of engineers, participants were challenged to consider Houston's long-term and aspirational future, and the coordination and integration of spatial, technical, economic, and political support needed to secure that future.

As community design strategies require full stakeholder and citizen co-development, these were not proposed at the convening. Rather, participants sought to understand expert perspectives on community needs and how a cooperative framework for community participation should work in the development of an integrated "water-vision" for Houston.

To do so, participants focused attention toward the ways that Houstonians might best consider future work with water. These included working groups for Regional, Bayou, District and Typologies scales. These discussions drew from the ongoing work across Greater Houston coupled with new questions generated from voices from elsewhere.

The activity set context and simultaneously broadened discussions while identifying new opportunities to collectively improve Houston's resilience. Summaries of key messages from each group follow.

CONVENING INVITEES

Accelerate H2O
 American Society of Civil Engineers, Houston
 Arcadis
 Bloomberg Associates
 Buffalo Bayou Partnership
 City of Houston
 City of Houston - Houston Water
 City of Houston - Planning & Development Dept.
 City of Houston - Public Works Department
 Deltares
 Galveston Bay Foundation
 Greater Houston Flood Mitigation Consortium
 Harris County
 Harris County Engineering Department
 Harris County Flood Control District
 Houston Advanced Research Center
 Houston-Galveston Area Council
 Houston Parks Board
 HR&A Advisors
 Huitt-Zollars
 Katy Prairie Conservancy
 Kinder Institute for Urban Research
 Rijkswaterstaat
 Rice University
 Sherwood Engineers
 SSPEED Center
 Texas A&M University
 Texas A&M University at Galveston
 Texas Southern University
 The Nature Conservancy in Texas
 The Royal Embassy of the Netherlands
 The Water Institute of the Gulf
 Technical University of Delft
 University of Houston
 U.S. Army Corps of Engineers
 Waggoner & Ball Architecture Environment
 Walter P. Moore & Associates



REGIONAL GROUP



The regional group focused upon opportunities to integrate with current work in nearby counties and watersheds, including along the Bravos and San Jacinto rivers, Lake Houston, upper and lower Galveston Bay, and with the U.S. Army Corps' ongoing watershed study. The group outlined key challenges, opportunities and areas for collaborative integration.

KEY MESSAGES

- Develop a region-wide “agency checklist” for project coordination.
- Consider positive and negative upstream and down-stream (full watershed) impacts.
- Short-term land management and acquisition can enable better long term development

BAYOU GROUP



The bayou group discussed how projects and strategies cross watershed and jurisdictional boundaries. The group identified emergent themes for Resilient Houston Phase 2 study, including improving inter-agency communication and widening risk and opportunity lenses when selecting sites for study. The I-45 realignment could be used to pilot inter-agency collaboration.

KEY MESSAGES

- Stronger cross-jurisdiction communication, planning & data collection is needed.
- Multiple factors should guide future investigation (including ongoing coordination, climate projections, project funding and regulatory levers).
- “Space for Bayous” is a theme to explore.

DISTRICT GROUP



The district group focused on issues that increase flood risk and slow recovery for low income residents. A framework for Buyouts (land swaps)/Elevation/Adaptation was outlined to keep flood-prone neighborhoods whole. Health and transit opportunities in sync with water development were identified.

KEY MESSAGES

- New incentives are needed for resilient development.
- “Quick wins” will build trust.
- Flood adaptations should not displace residents outside their neighborhoods.
- Water overlaps equity and environmental justice issues.
- Site-specific and distributed solutions are needed.

TYOLOGIES GROUP



The typologies group outlined land use and policy-based areas for future exploration, including transportation/ infrastructure; residential property (owner & renter); medical/health facilities; commercial property; and public property (parks, parking, schools). On Day 2 the group split up and merged into other groups.

KEY MESSAGES

- Focus on multiple benefits of all policies and land uses.
- Policy guidance should consider subsurface (i.e. aquifer recharge), ecology (i.e. reforestation, the urban canopy), and environmental extremes (i.e. floods, drought).
- Typologies bridge all groups and scales.

REFLECTIONS

The Convening opened Day 2 with an informative summary of the Agenda-Setting workshop including reflections of notable dyads in the ongoing work in Houston. These recognized that Houstonians have:

1. **Workshop and Talk Fatigue.** With many plans, the focus must be on integration and implementation.
2. **Tensions + Boundaries** that require reconsideration for Houston to achieve its potential.
3. **Short versus Long-term** thinking that must balance what is politically doable with aspirational targets.
4. **Big versus Small** perspectives where connections across scales is required.
5. **Inside versus Outside** preferences wherein Houston expertise must be honored while opening up to learning from others.
6. **Practical versus Visionary** thinking that requires balancing the need to immediately implement with the need to plan for a greater future.
7. **A Boundary** between the water issues and everything else such as transportation, economy and equity, that requires new thinking.
8. **The Energy Capitol** of the world and with that leadership capacity could become the Water Management Capitol of the World.

Day 2 concluded with a dialogue in the round for discussion and reflection. Such an approach recognized that the participants were now collaborators in the larger resilience efforts. All perspectives were welcomed, a core principle of the Living with Water model in which the local meets the global in an effort to improve both.

Visiting Dutch experts underscored the complexity of Greater Houston, its physical, political and governance structures, and its strong knowledge and infrastructure foundation. They returned to the workshop's guiding question: **what type of city does Houston want to be?**

They confirmed shared challenges with the Netherlands, including complacency, communications, momentum, awareness, education and the need for steady funding.

Their perspectives encouraged a critical discussion of the region's integration and coordination challenges, and how Houston might think-through alternative models of transportation, economic development, water management and urban form.

Of note, the Dutch see opportunities to learn from Houston's strengths, including emergency management and infrastructure development in a demanding environment.

The intentionality of the Convening was to create a framework of collaboration, to broaden perspectives and to prepare for Houston's next steps in the creation of its resilience strategy.



KEY DUTCH MESSAGES

- Many strong plans and initiatives are already in place; **the challenge is integration.** Houston's diversity suggests a variety of solutions. However, more specific base documentation is needed.
- Texas' spirit of action is admirable. The region should also **consider a long-term 20-30+ year vision plan.**
- Visible progress--including "quick wins"--is needed to **maintain momentum.** There is a limited window of opportunity. Recent successes should be celebrated and promoted.
- Stakeholders need to **develop a common language** (technical, design, political, public), or a lexicon. Maps are part of that lexicon.
- Houston should **invest in communications programs,** across media, to engage citizens, to educate and to inform. This might include the use of television interviews, artist installations, business help desks and more outreach to major industries in the region.
- **Citizens must be central to Houston's strategy.** Be big-hearted in individual cases. Buyouts are minor in the bigger picture.
- **Empower local stakeholders** and respect the common good.
- **Multilevel governance is required,** with action at the lowest level possible, but with common goals and shared values.
- **Stress economic benefits** and multifunctional solutions.
- Houston should anticipate all possible floods, not just the last one. **Look at the long tail of climate projections.** Small elevations matter in flat places.
- **Be prepared for chances to cooperate.** Adaptive means being flexible over time.

NEXT STEPS

With these key messages in mind, the Houston experts in concert with the larger 100 Resilient Cities and Living with Water® teams will continue to investigate the opportunities for further synthesis and resilience-building across Houston’s many ongoing efforts.

While the teams meet with key stakeholders and learn more about community needs, the water experts will further delve into the Convening inputs and outcomes, seeking to identify where and how to create opportunities to leverage water and to integrate investments in process.

Convening input materials include:

- Synthesis Report of Ongoing and Planned Projects produced by the Kinder Institute
- Convening overview and annotated agenda
- Speaker bios and presentations

Next Steps will include:

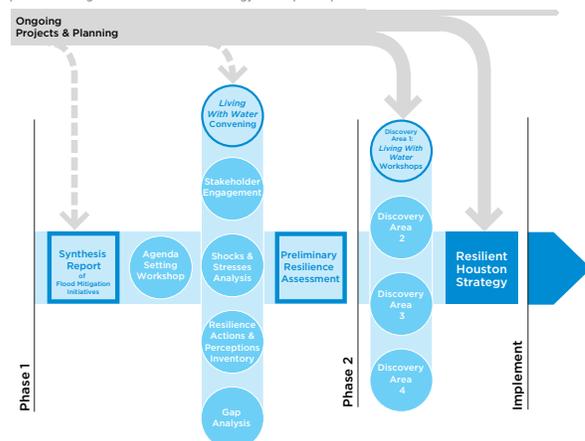
- Incorporate feedback from the Resilient Houston Agenda Setting Workshop and integrate priorities from other discovery areas into a comprehensive Preliminary Resilience Assessment.
- Identify focus geographies and stakeholders for the Living with Water Phase 2 workshop in Spring 2019.
- Identify potential “quick win” projects.
- Identify first and interim steps to strengthen the Houston network and test new collaborations leading toward the Resilient Houston Strategy.

The team would like to thank the City of Houston Mayor’s Office for organizational guidance and the University of Houston Downtown for the convening facility and logistics support as well as the effort of many technical experts who gave time and insights ahead of and across the two days of the convening.

On behalf of the Living with Water Convening Team, **thank you.**



Resilient Houston Strategy Development Process
This diagram shows how the Living With Water planning and design process is integrated into the overall strategy development process.



Resilient Houston Strategy Development Process as related to Living with Water



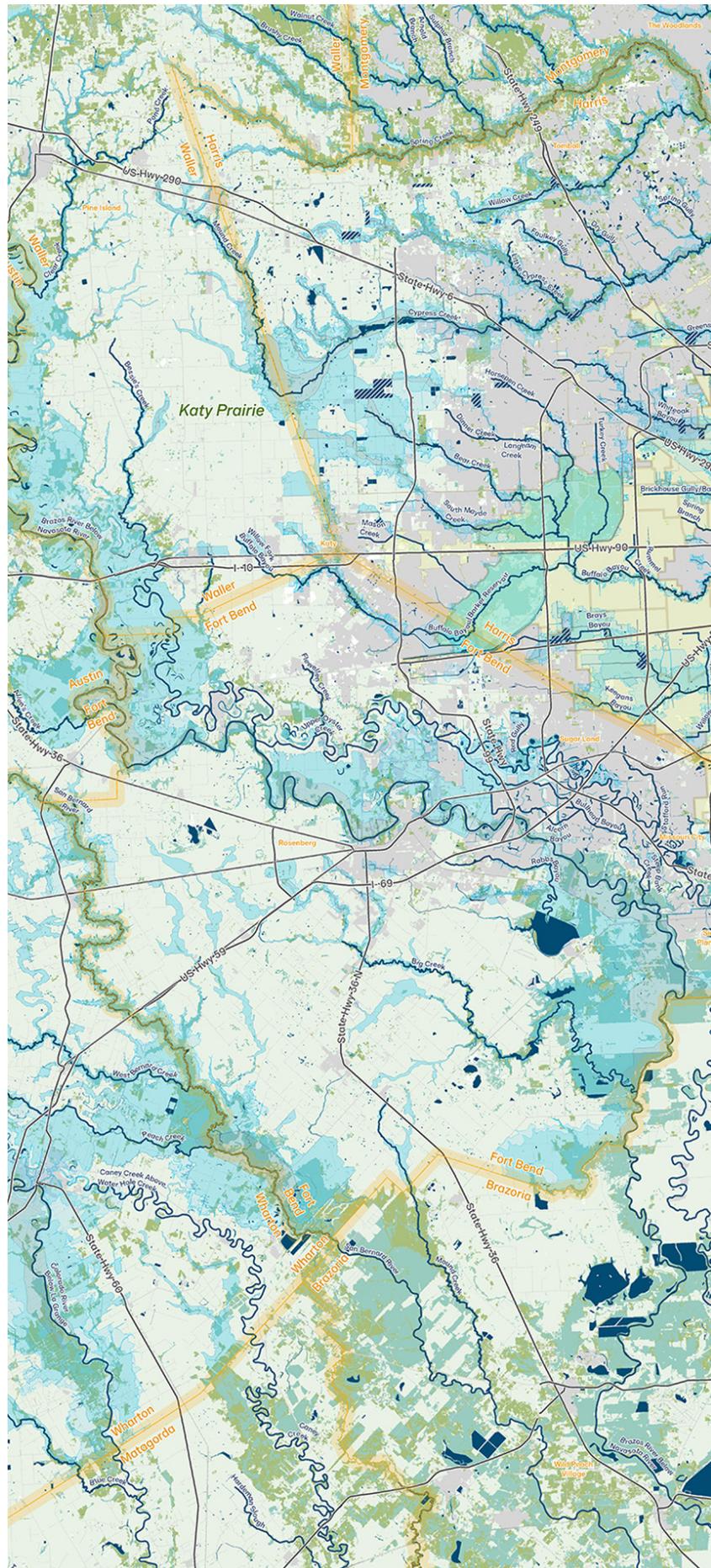
Living with Water Convening Conclusion of Day 2

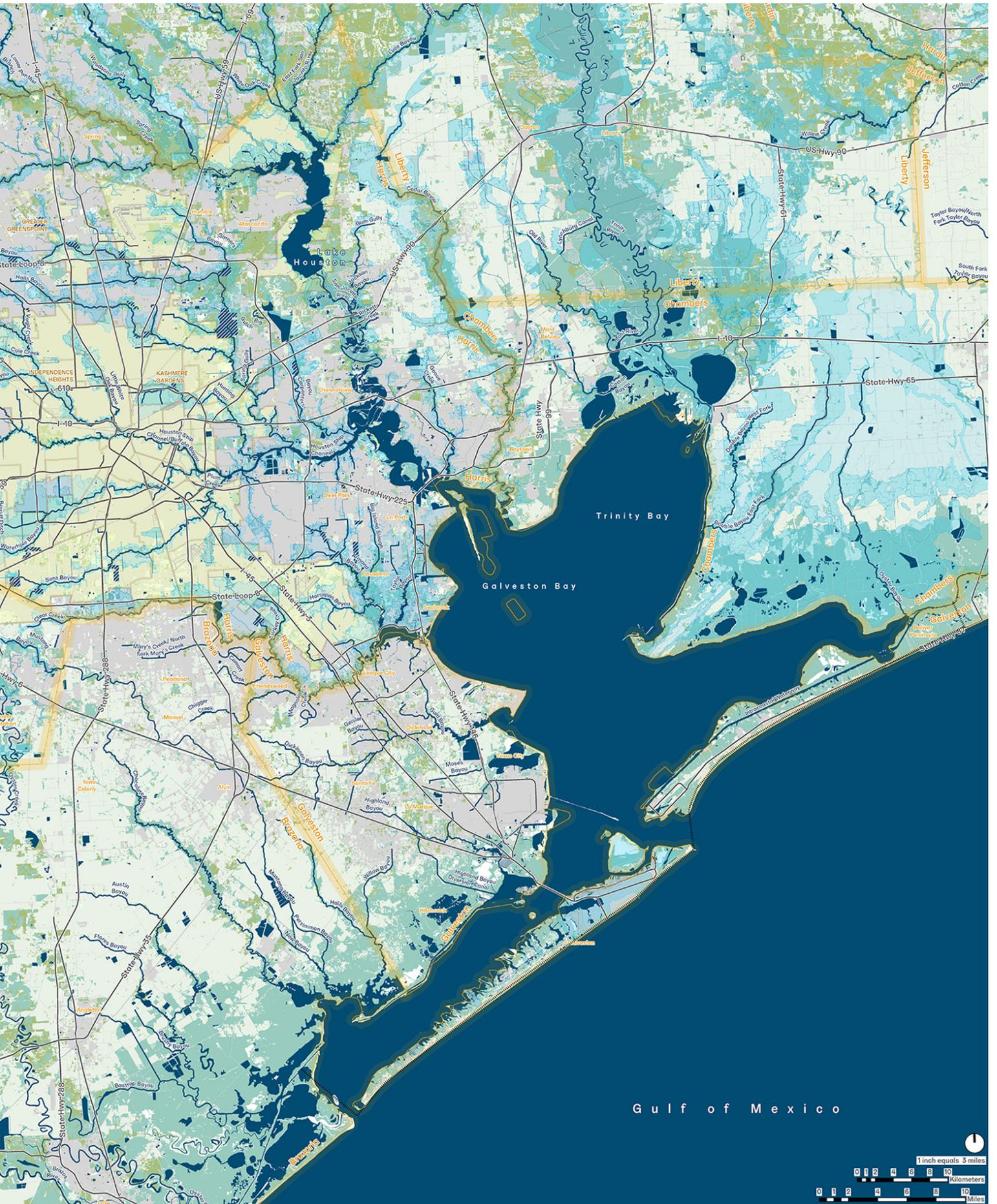
Greater Houston

REGIONAL

LEGEND

- Water
- HCFCF - Detention Basins
- DFIRM
- Floodway
- 100 Year Floodplain
- 500 Year Floodplain
- Rail
- Major Roads
- Super Neighborhoods
- Houston City Boundary
- County Boundary
- Land Type
- Developed Land
- Agricultural, Grassland
- Forest
- Wetland
- Proposed Levee



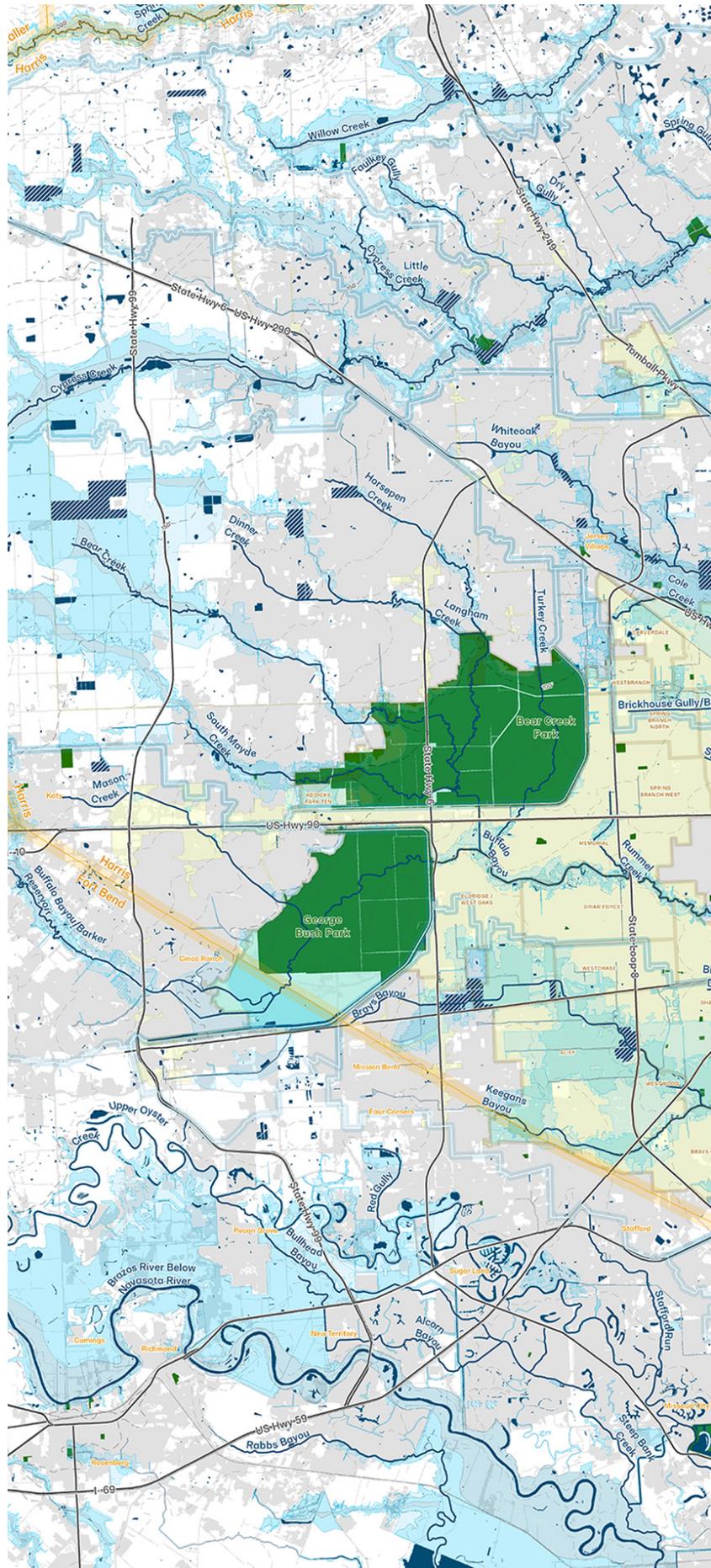


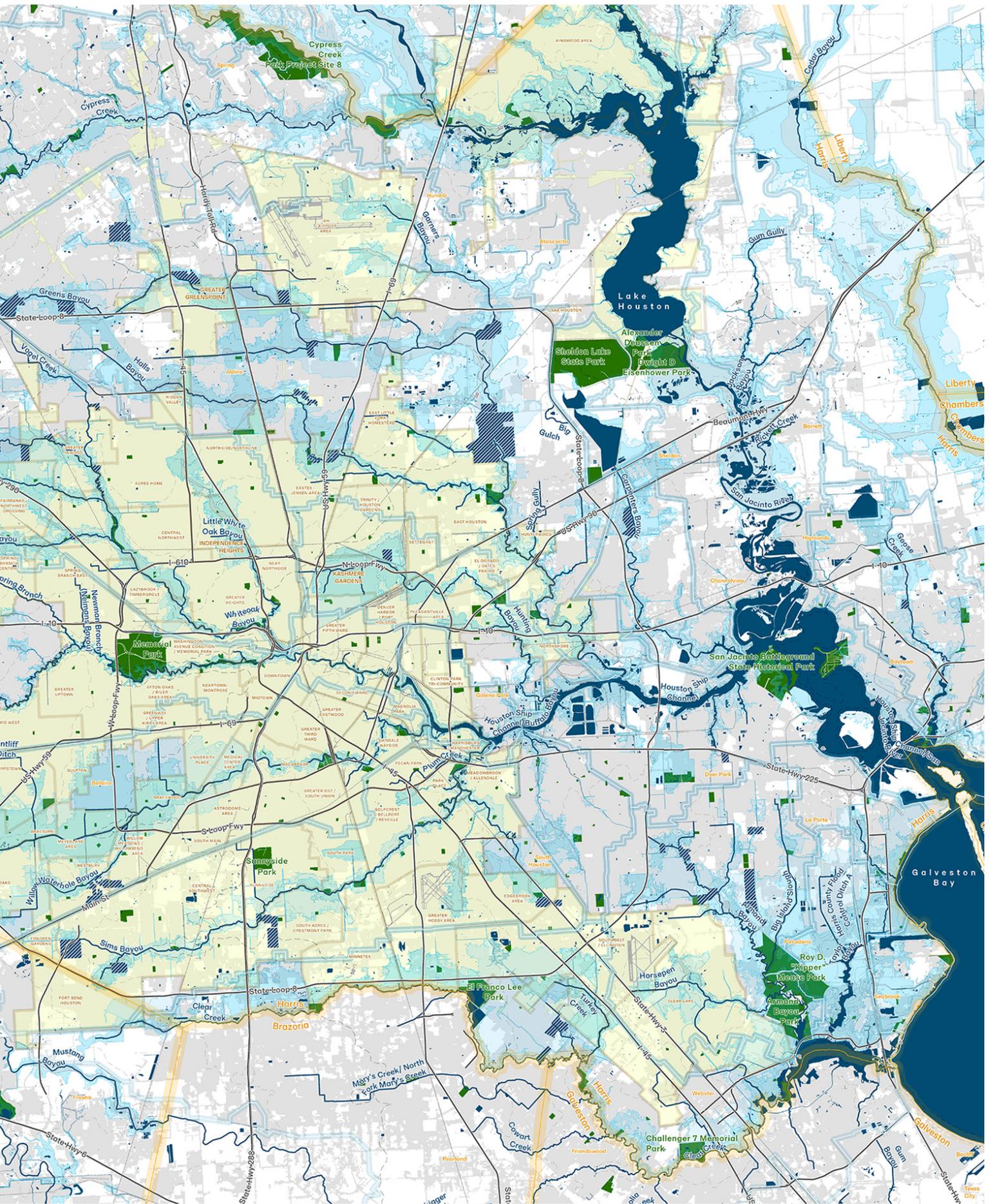
Houston

METRO HOUSTON

LEGEND

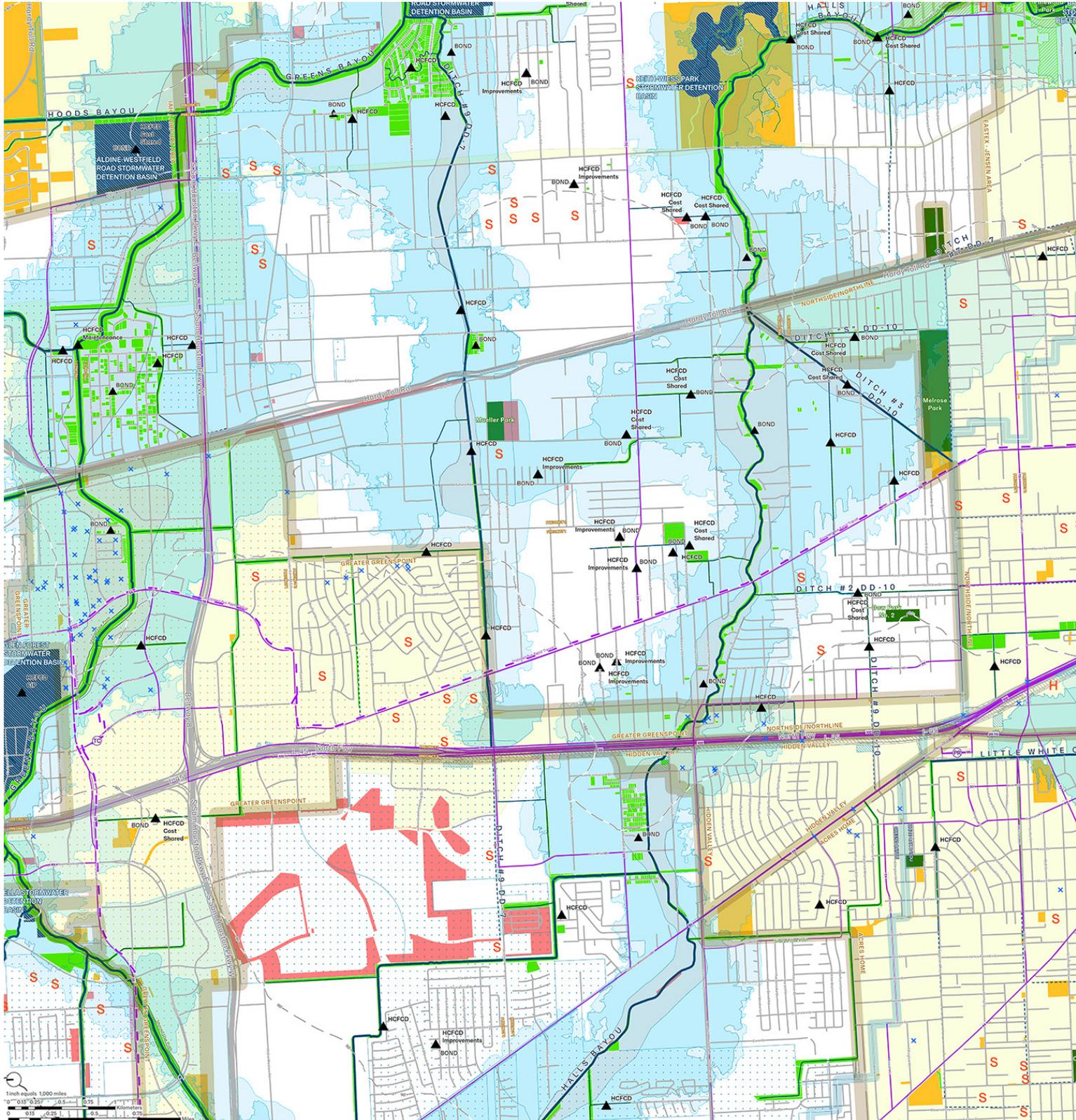
- Water
- HCFC - Detention Basins
- Watersheds
- 10' Contours**
- Contour_inft**
- 10
- 50
- DFIRM**
- Floodway
- 100 Year Floodplain
- 500 Year Floodplain
- Rail
- Major Roads
- Parks
- Super Neighborhoods
- Houston City Boundary
- County Boundary
- Developed Land





Independence Heights

 City of Houston Parcels	LEGEND	 311 Flooding
 Harris County Parcels	10' Contours	 Watersheds
 Parcels	10	 Waterway Centerlines
 Super Neighborhoods	50	 Sewer
 Houston City Boundary	DFIRM	 Major Waterways
 MUDs	Floodway	 Minor Waterways
 TIRZ	100 Year Floodplain	 Ditches
	500 Year Floodplain	



ONGOING PROJECTS

- ▲ Active Projects
- ▨ HCFC - Possible Acquisitions
- ▨ HCFC - ROW Acquisitions
- ▨ HCFC - Detention Basins
- Houston CIP Roadwork
- Houston CIP Drainage

I45 - NHHIP

- ▨ Frontage Road
- ▨ Highway; Bridge
- ▨ Detention Pond
- ▨ Hardy Toll Connector Project
- ▨ Hardy Connector Detention

H
S

- Hospitals
- Schools
- Building Footprints (only for CoH)

TRANSPORTATION

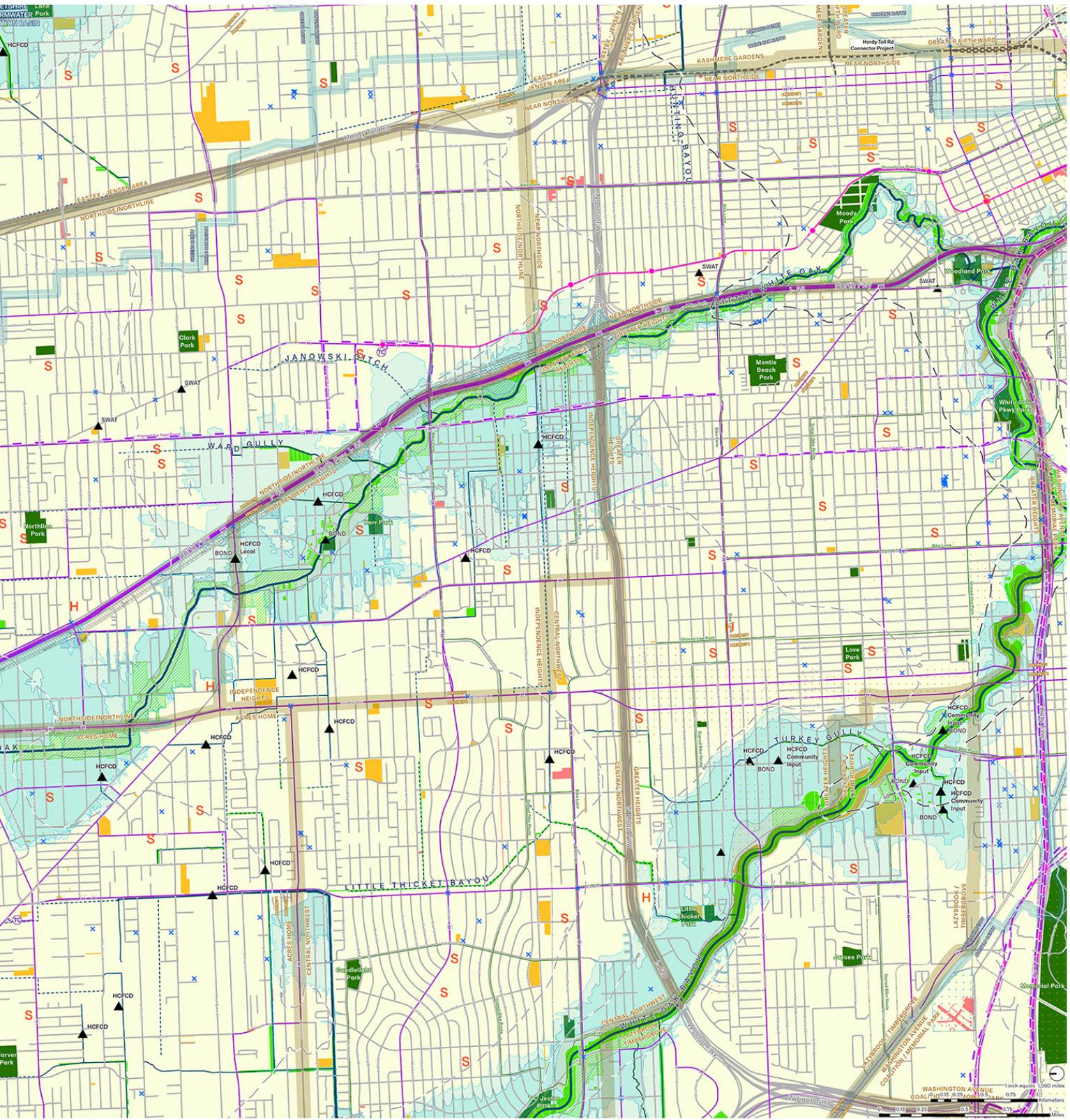
- Roads
- Rails

BUS & LIGHTRAIL

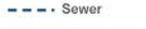
- LRT
- BRT
- TC RN Transit Centers
- PR RN Park Rides Centers
- LRT Stations

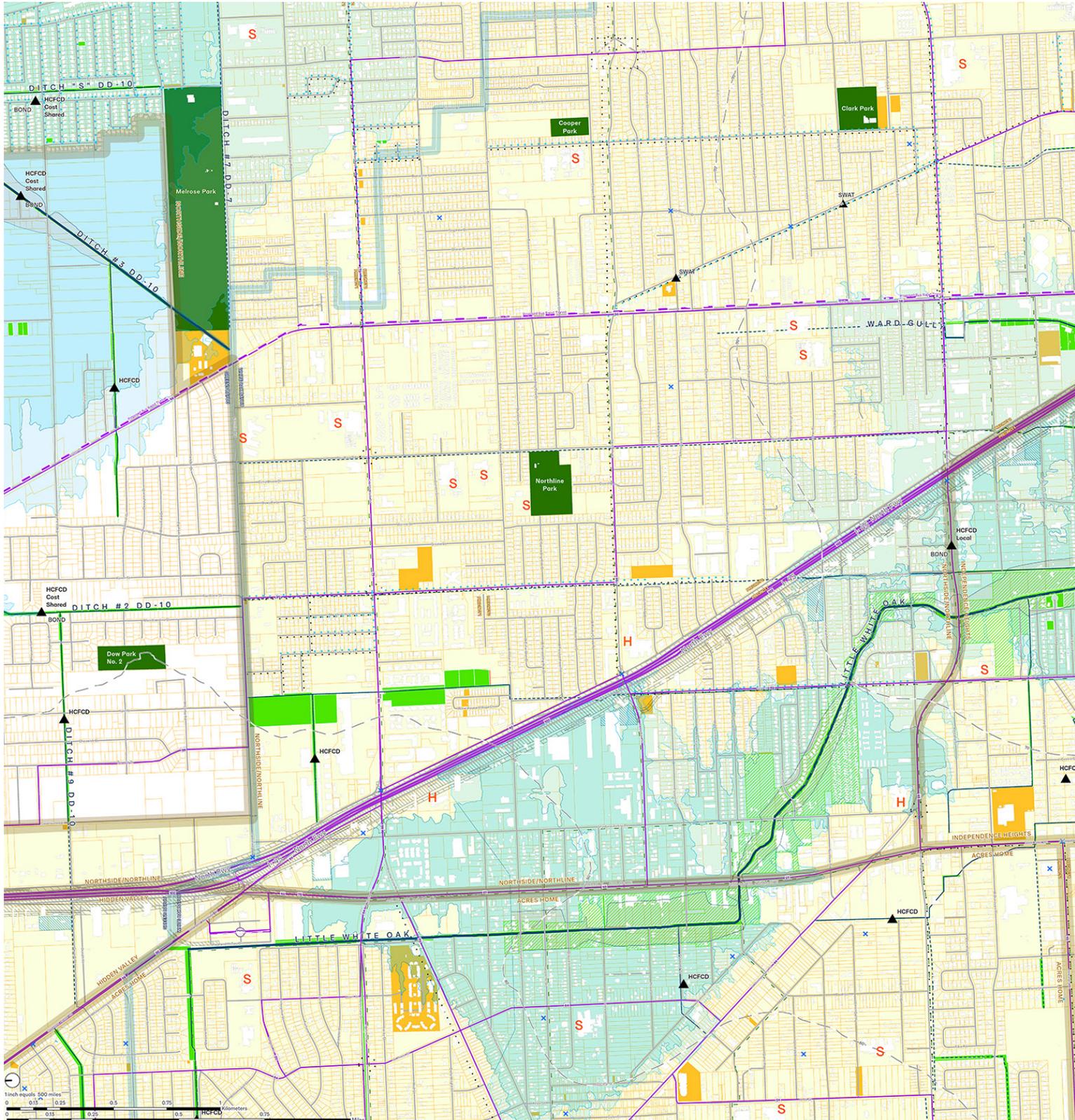
Proposed Transit Projects

- Light Rail Transit
- Bus Rapid Transit
- BIKE
- Existing Bikeways
- Houston Bike Plan
- Parks



Independence Heights

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ONGOING PROJECTS

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- ▨ HCFCO - Possible Acquisitions
- ▨ HCFCO ROW Acquisitions
- ▨ HCFCO - Detention Basins
- Houston CIP Roadwork
- Houston CIP Drainage

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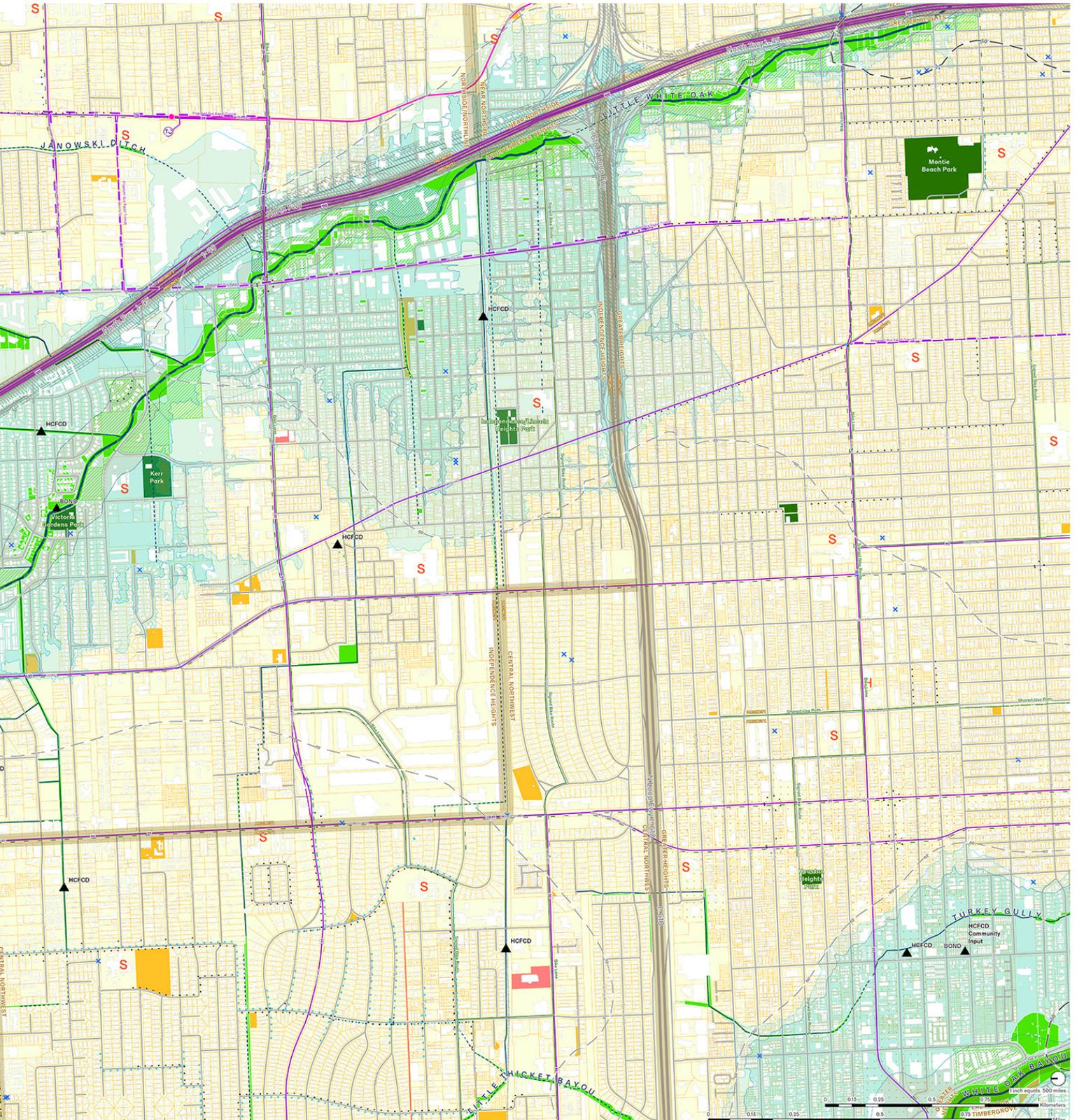
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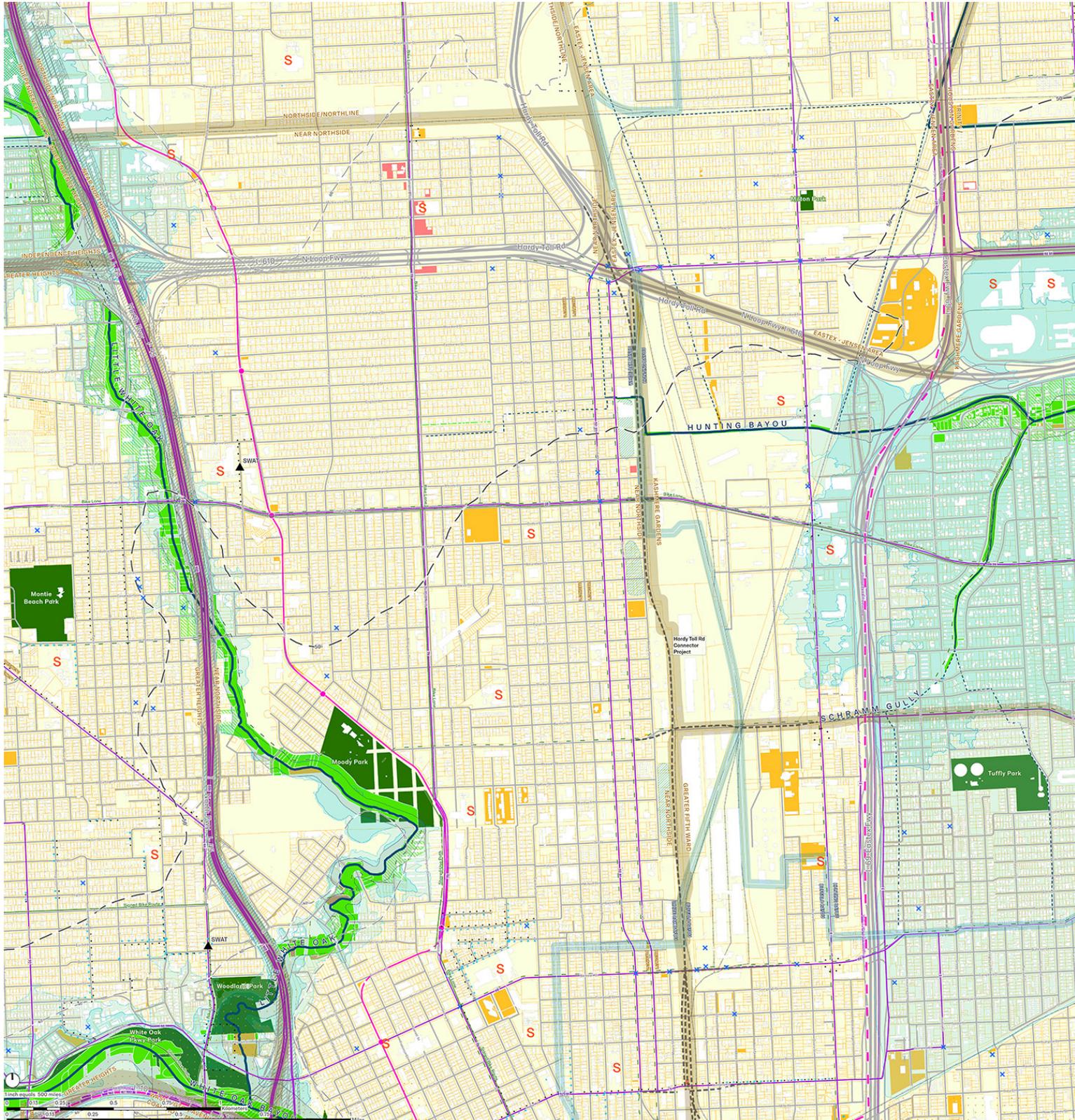
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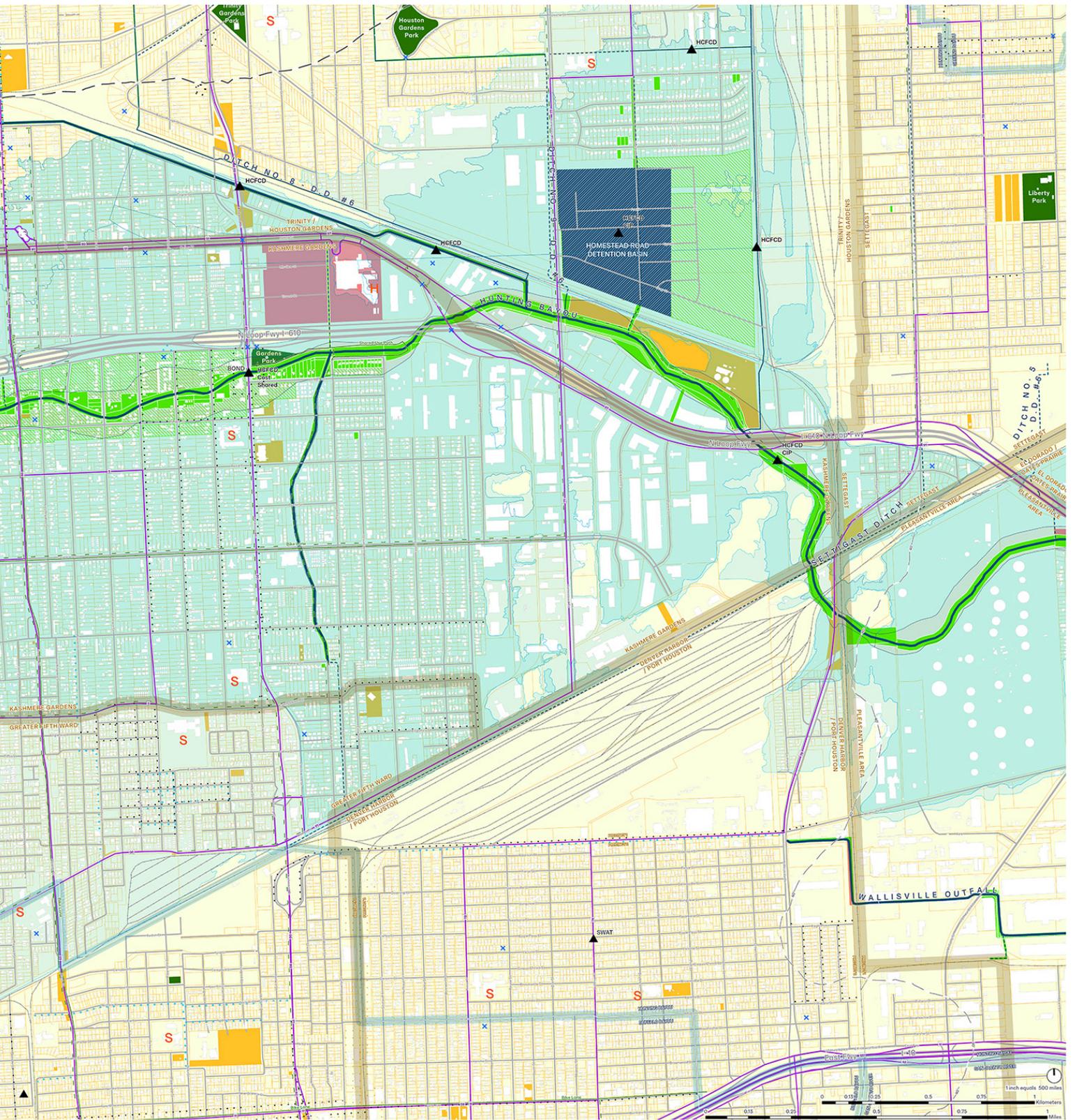
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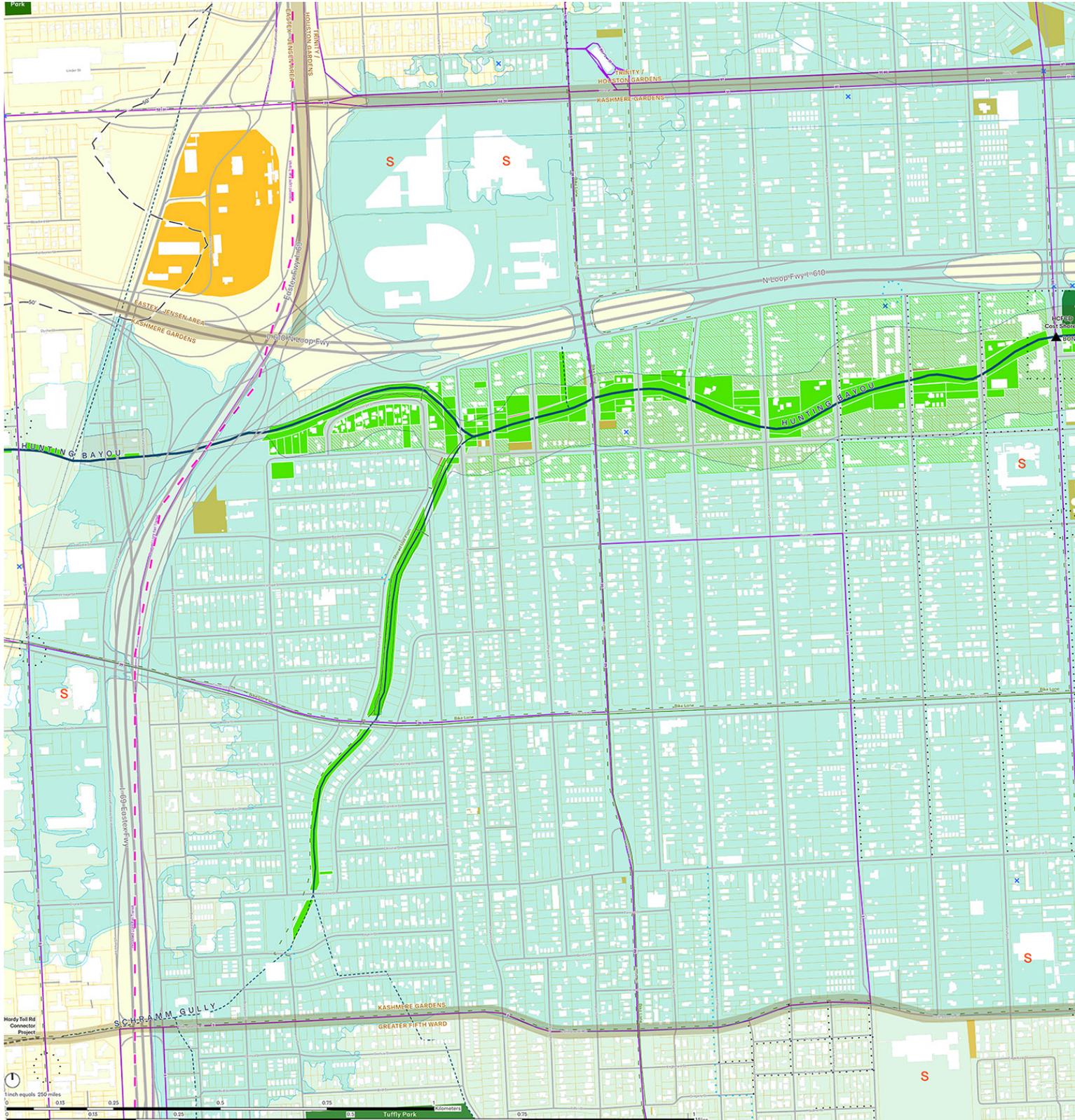


Kashmere Gardens





Kashmere Gardens



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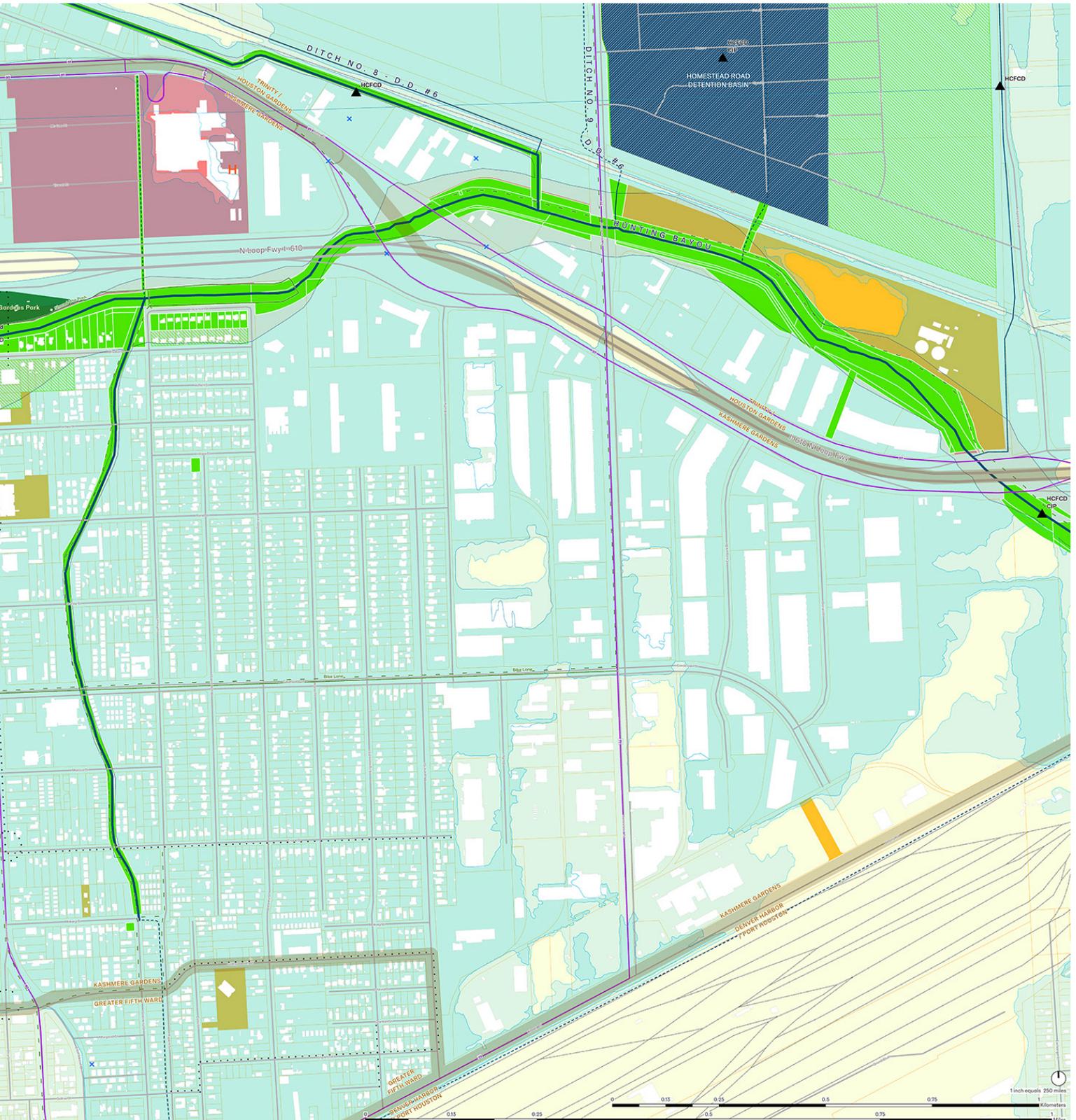
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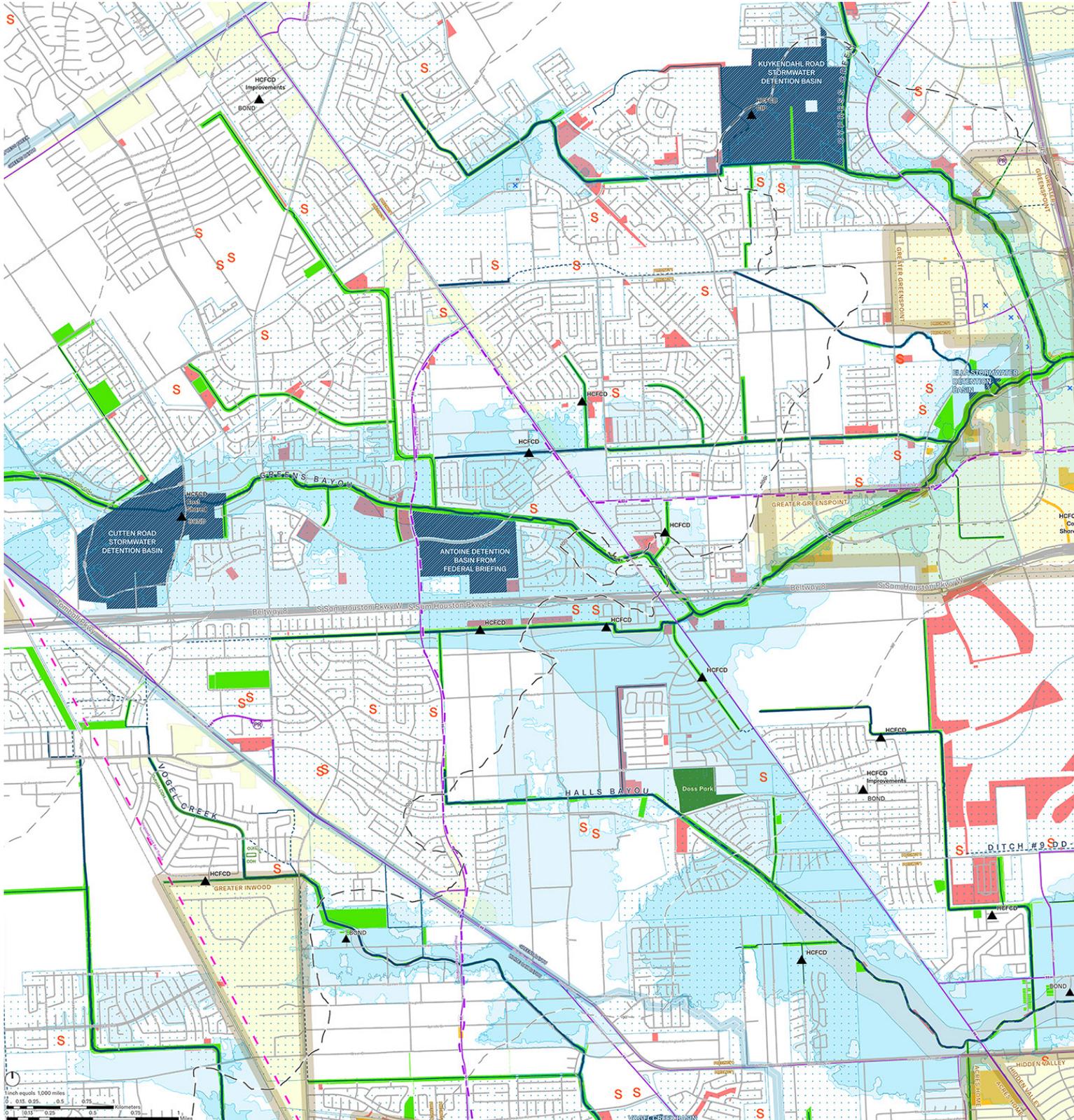
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- ▨ Parks



Greenspoint

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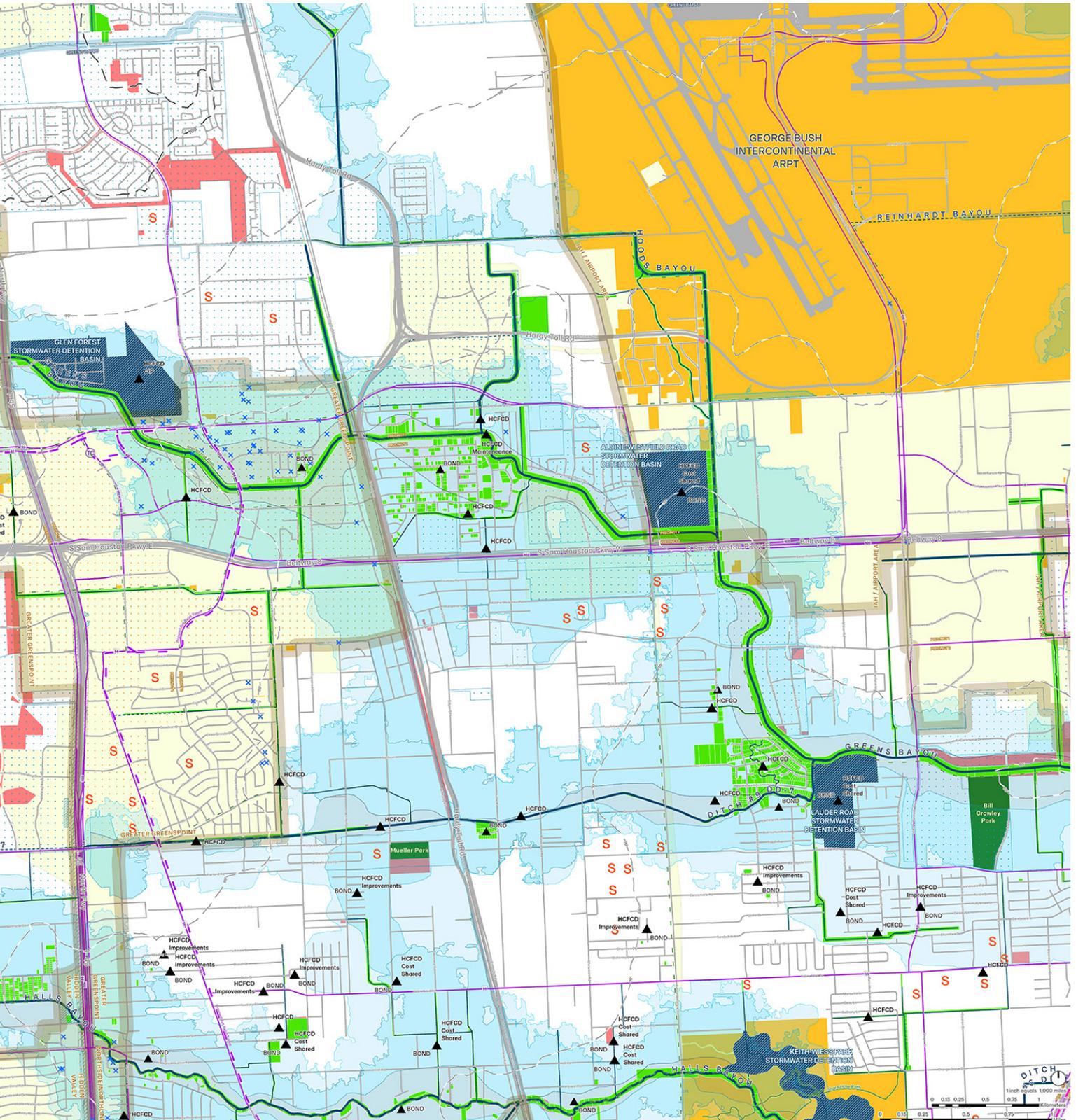
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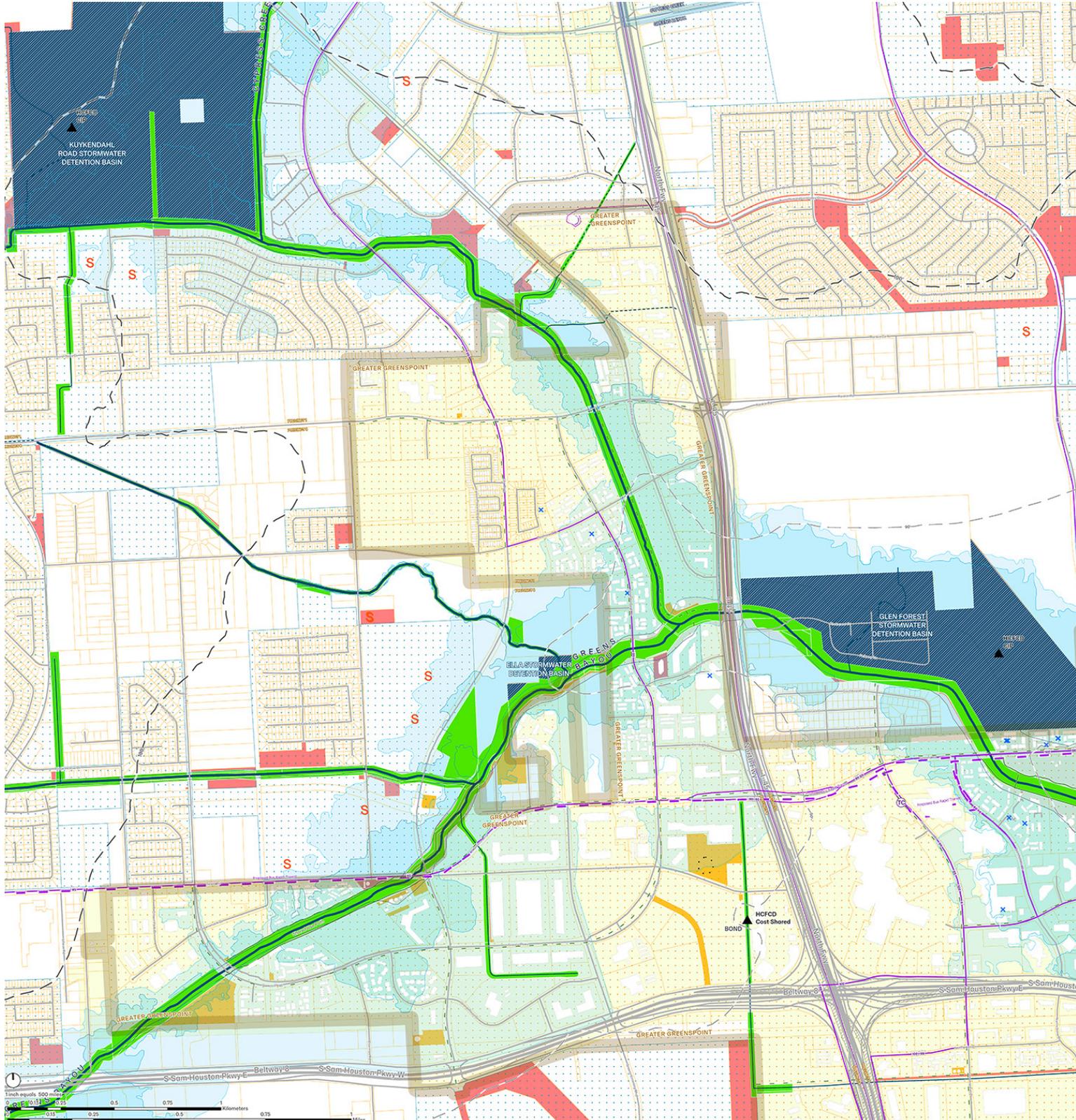
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Greenspoint



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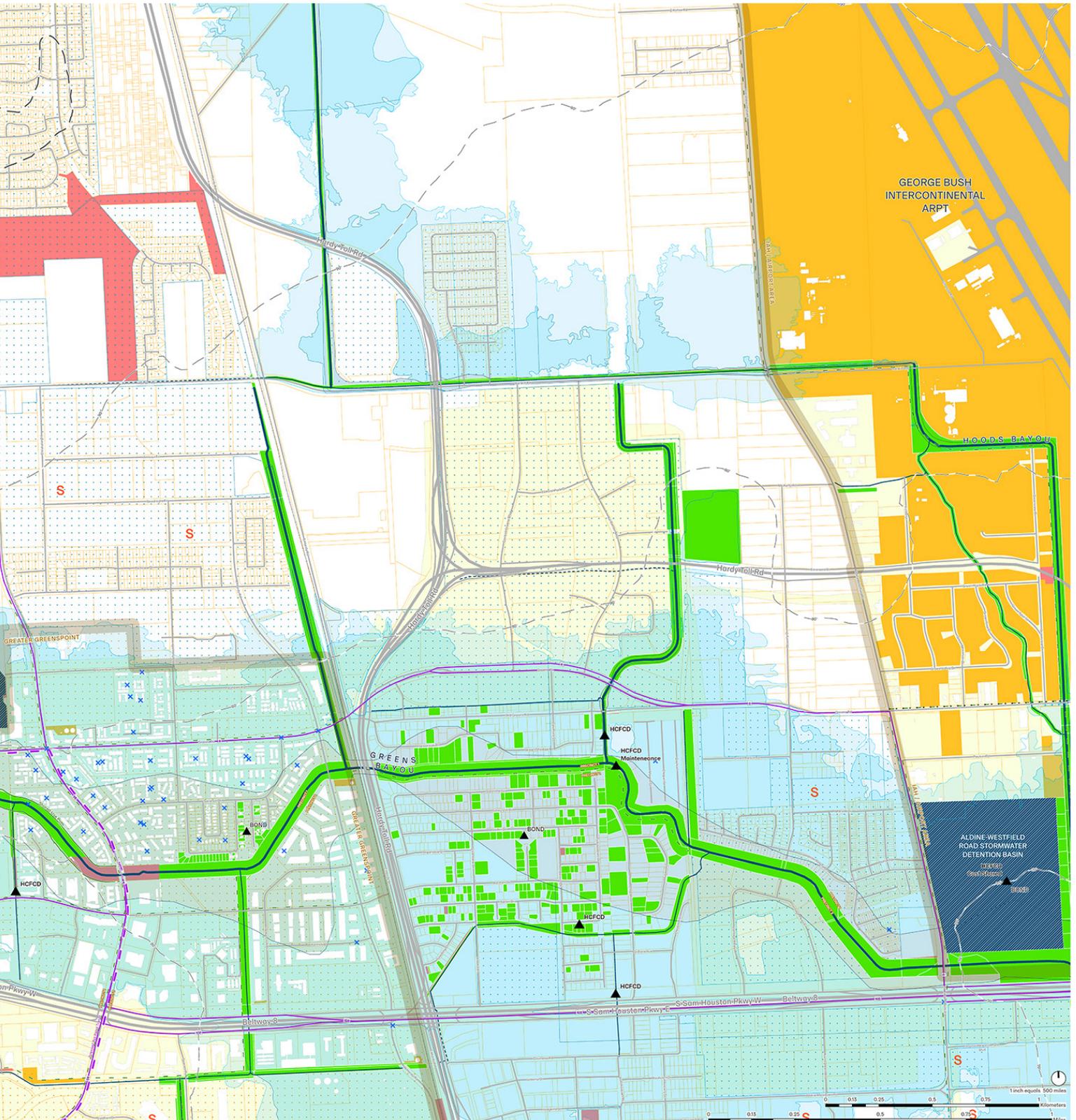
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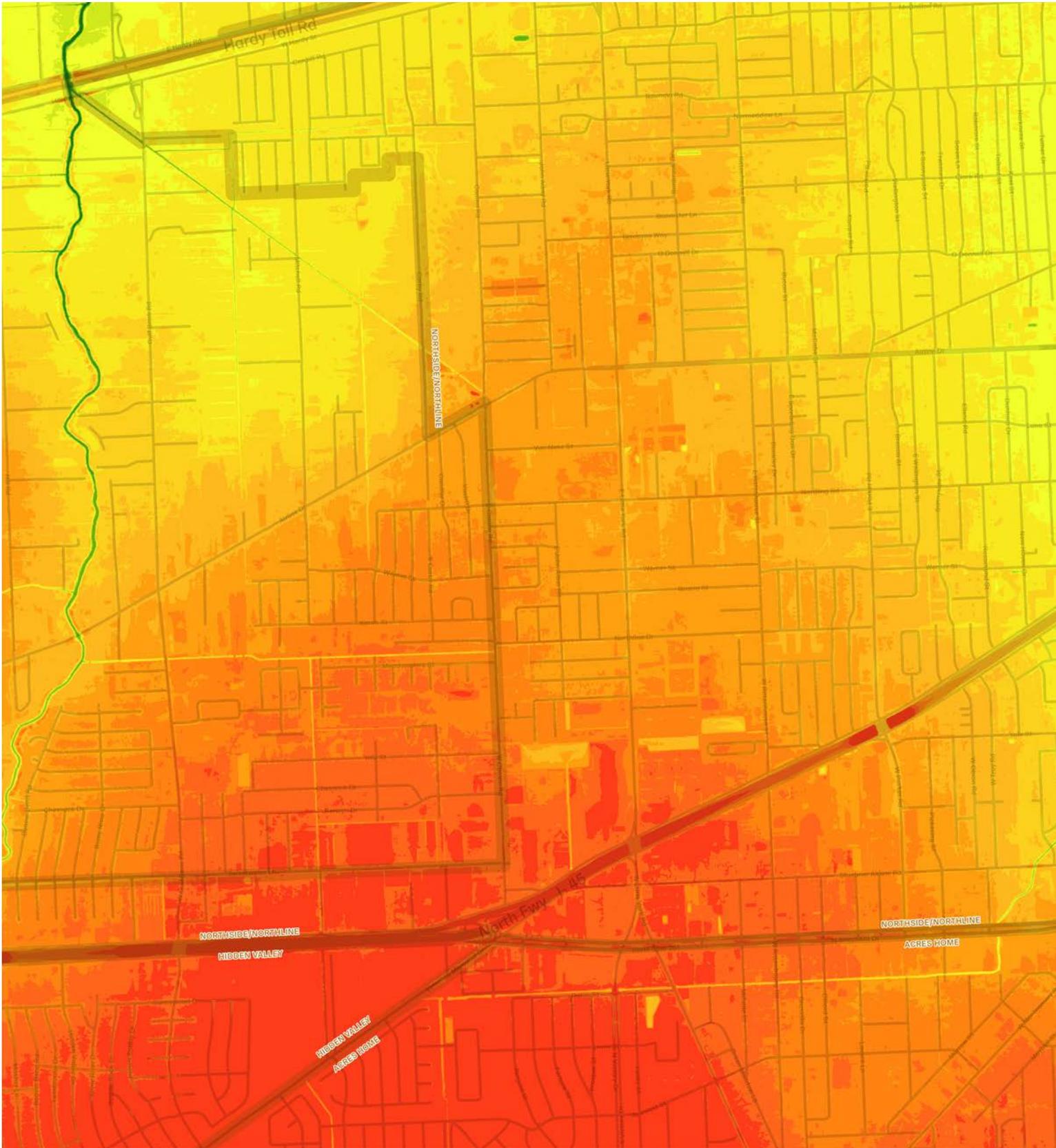
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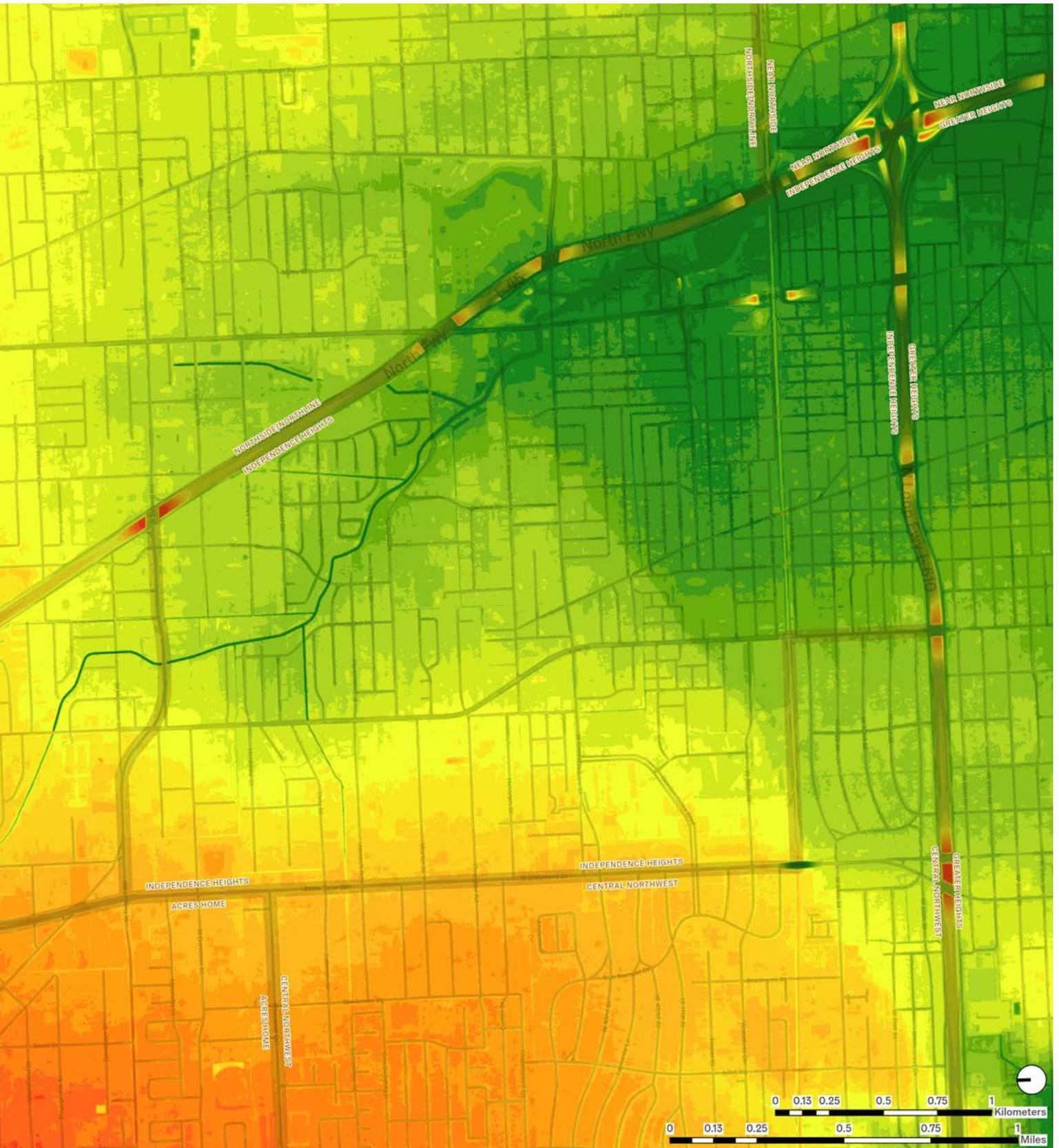
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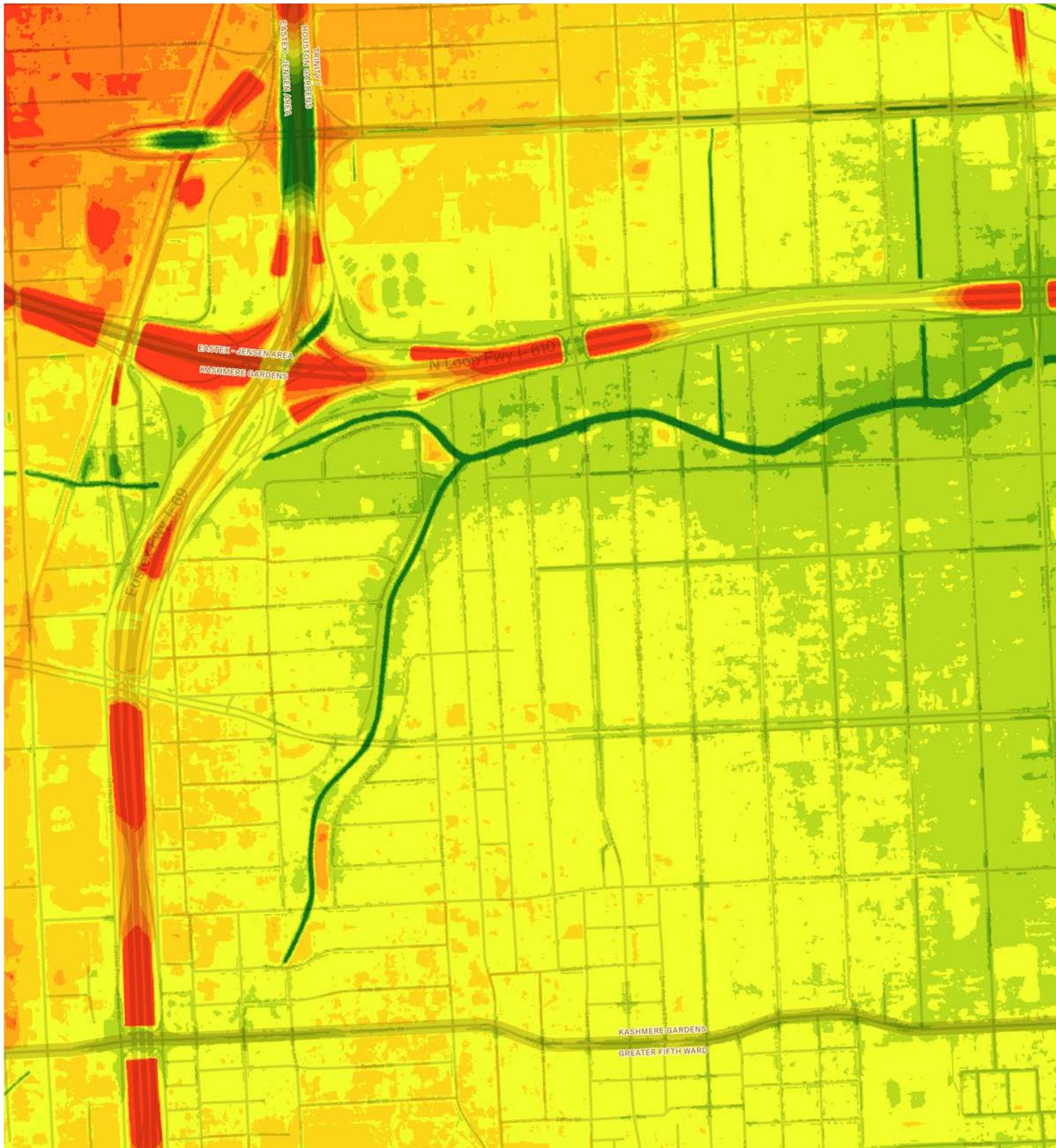


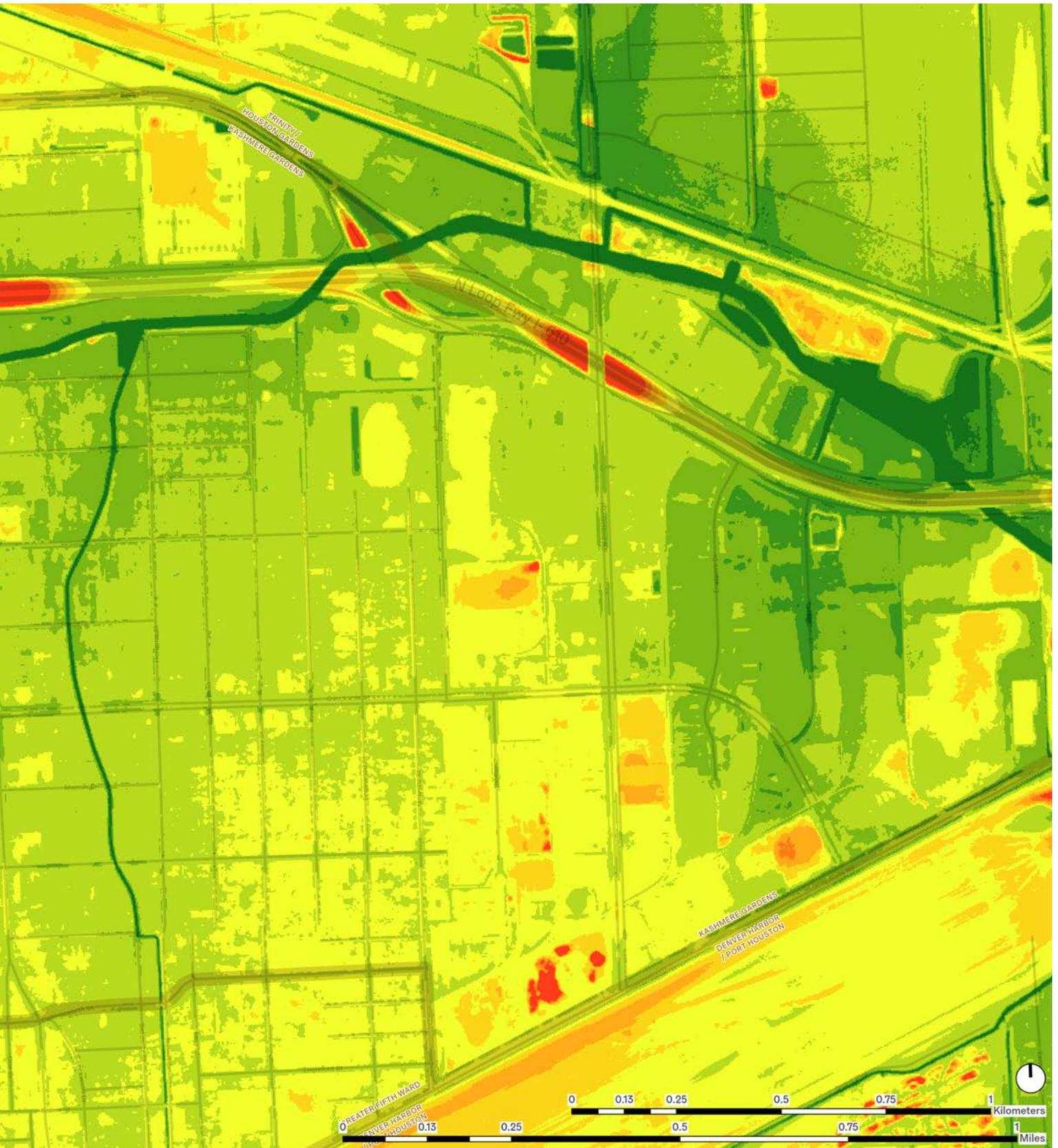
Independence Heights



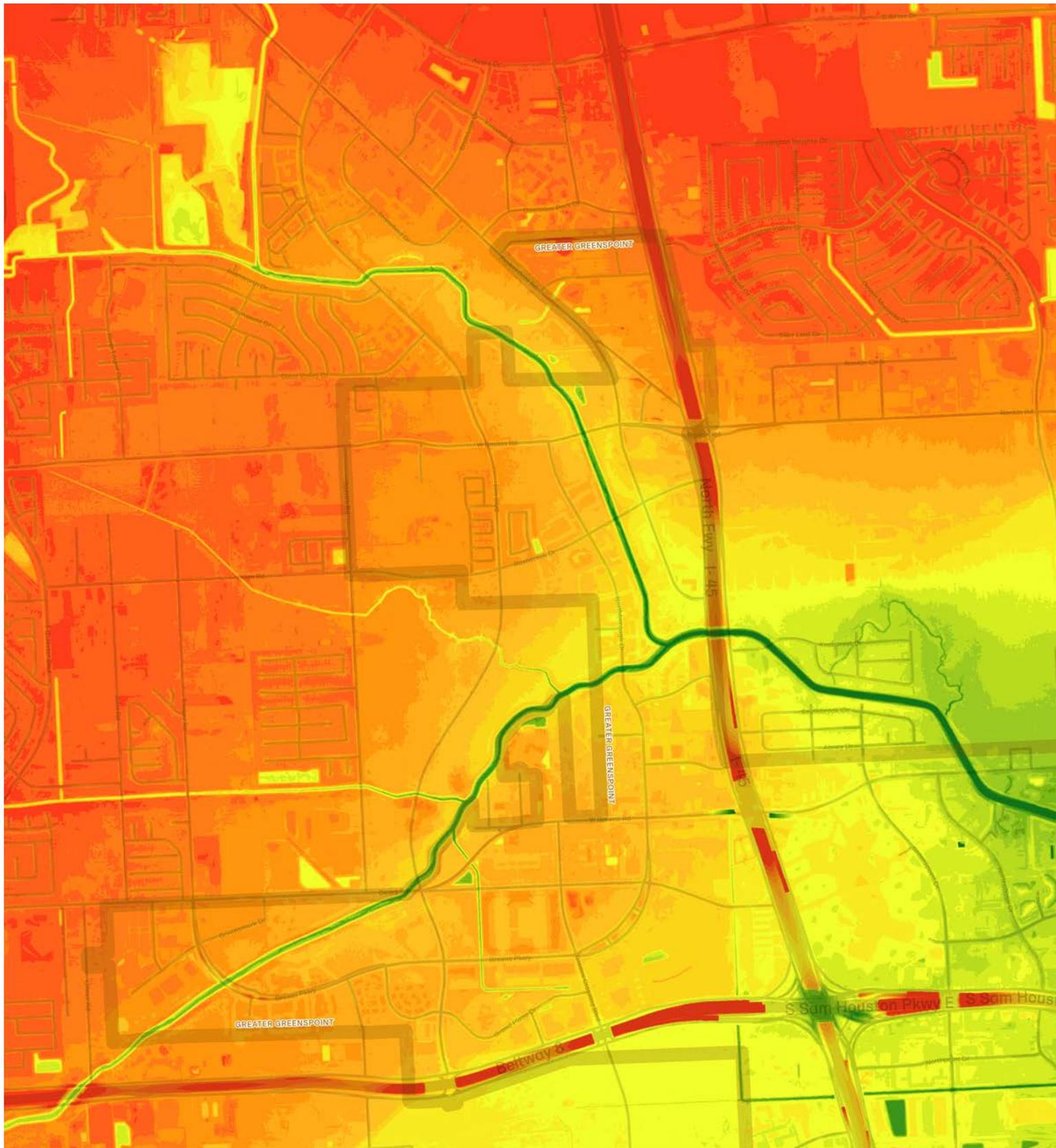


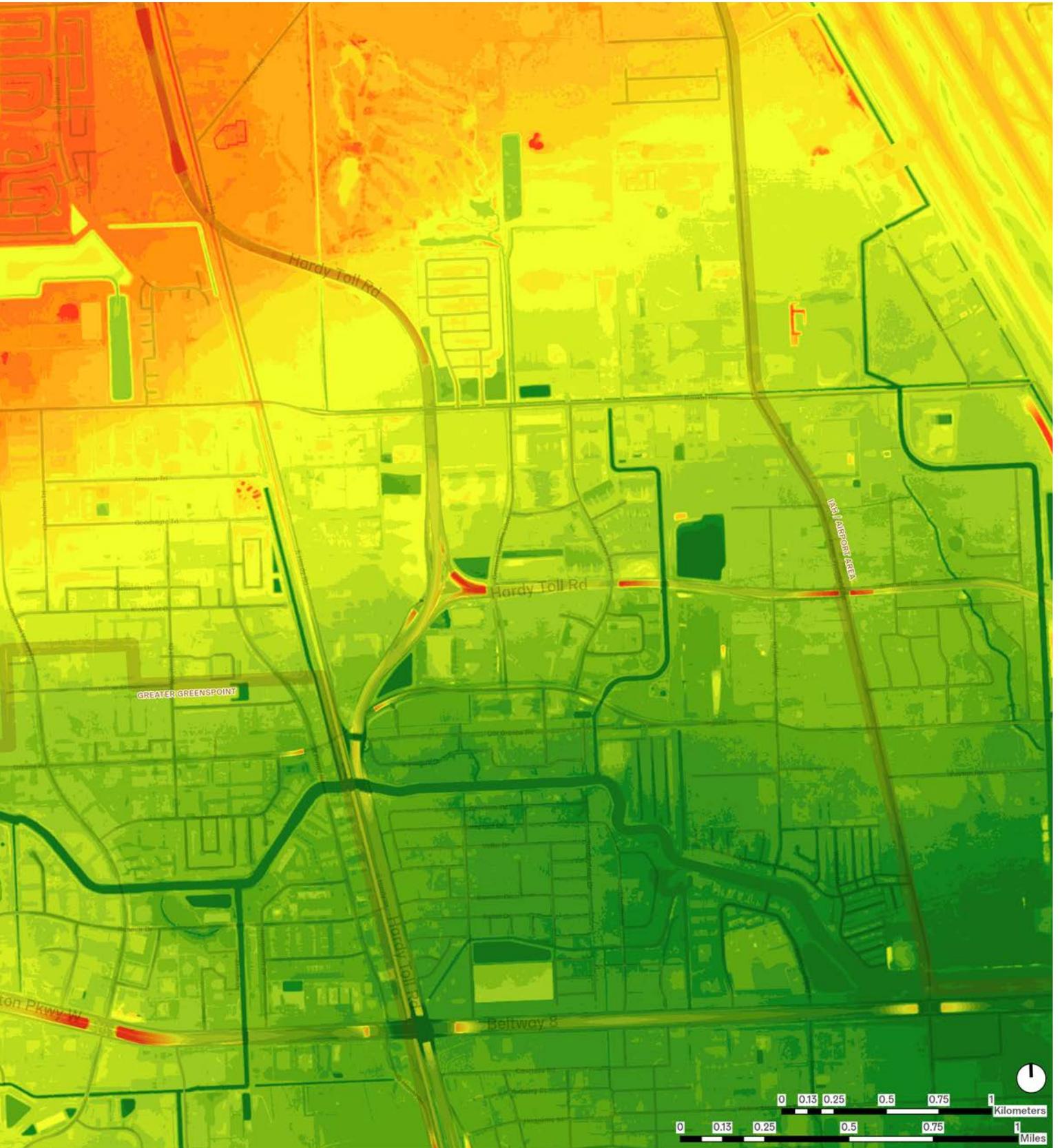
Kashmere Gardens

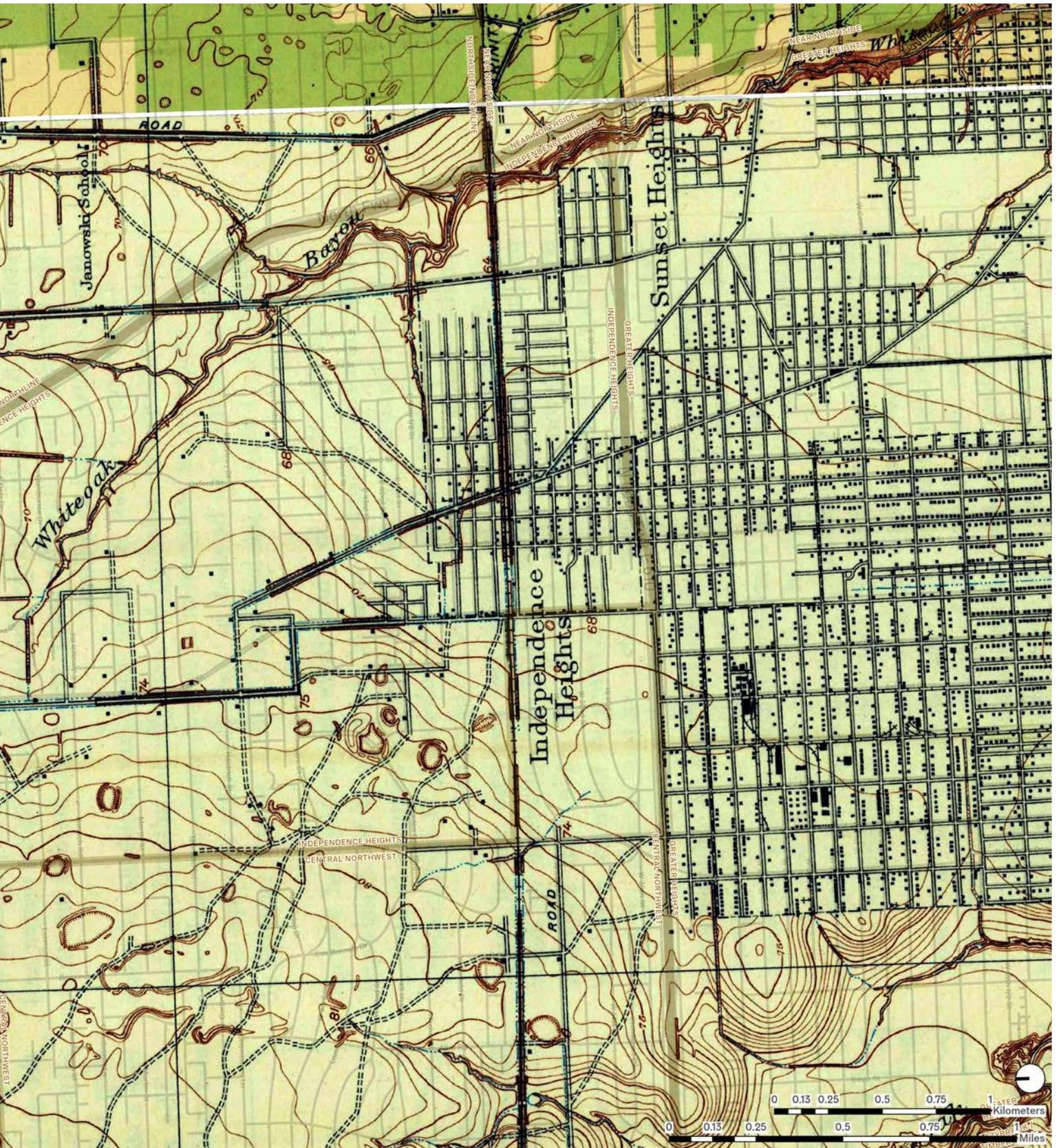




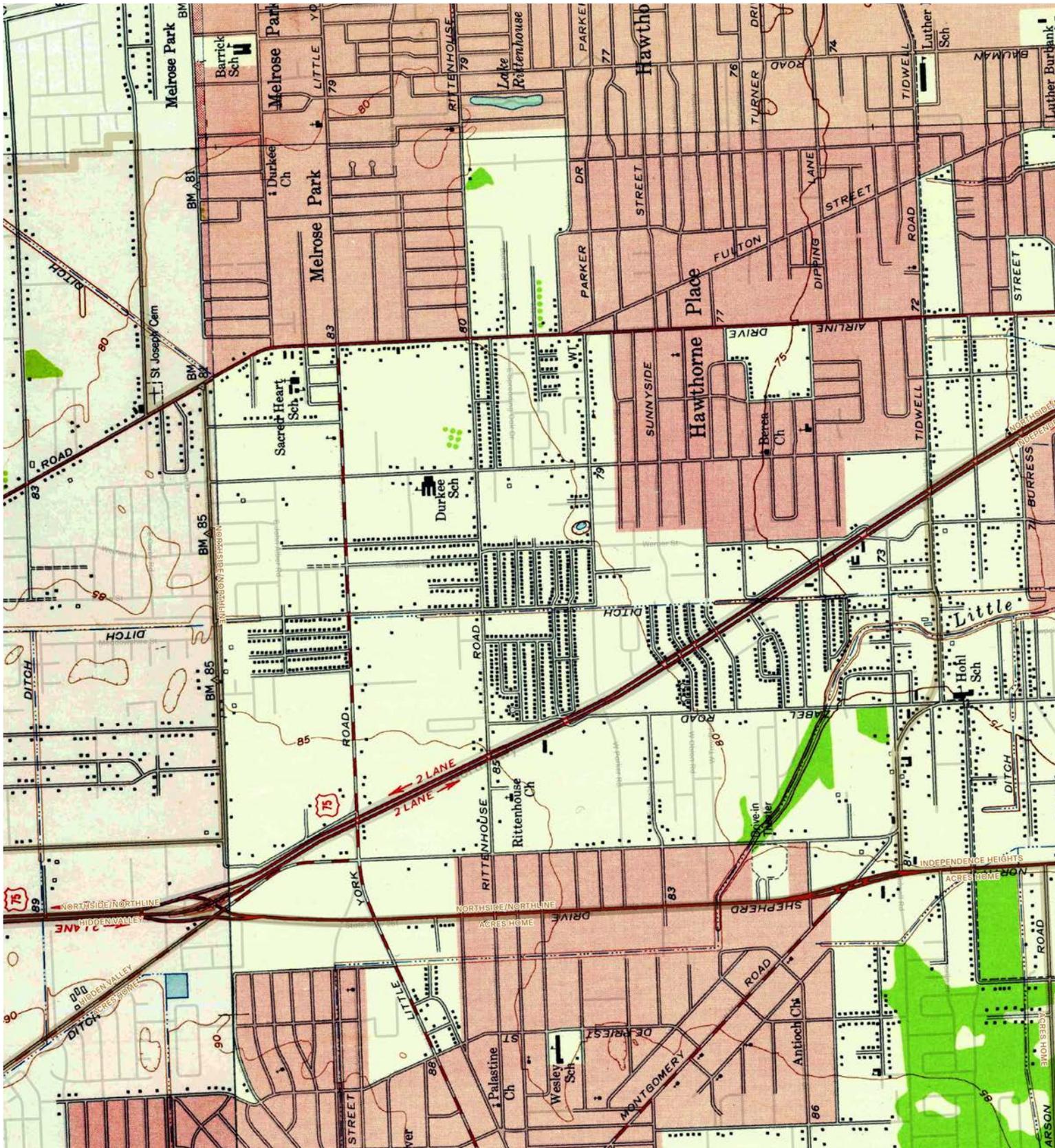
Greenspoint



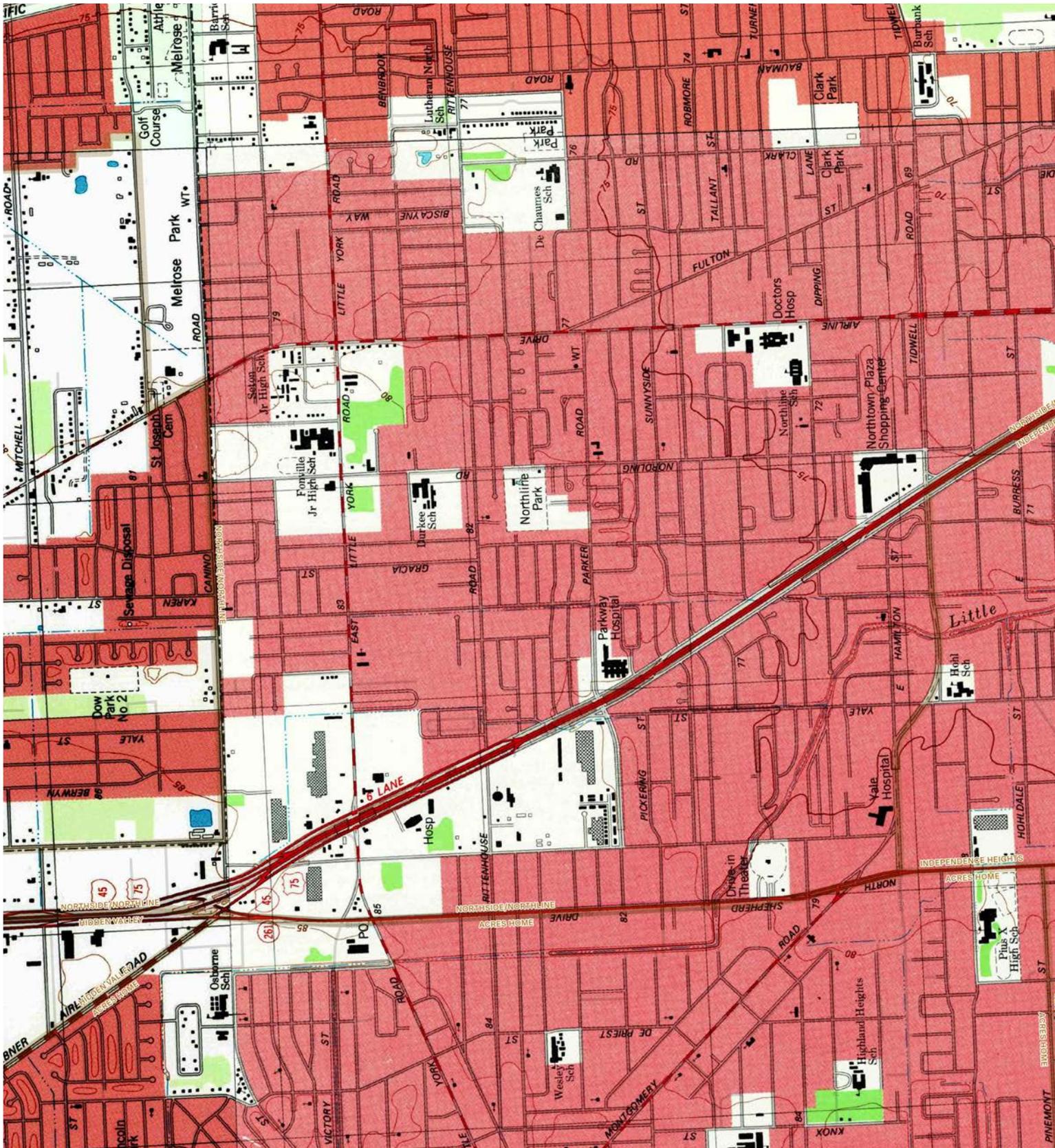


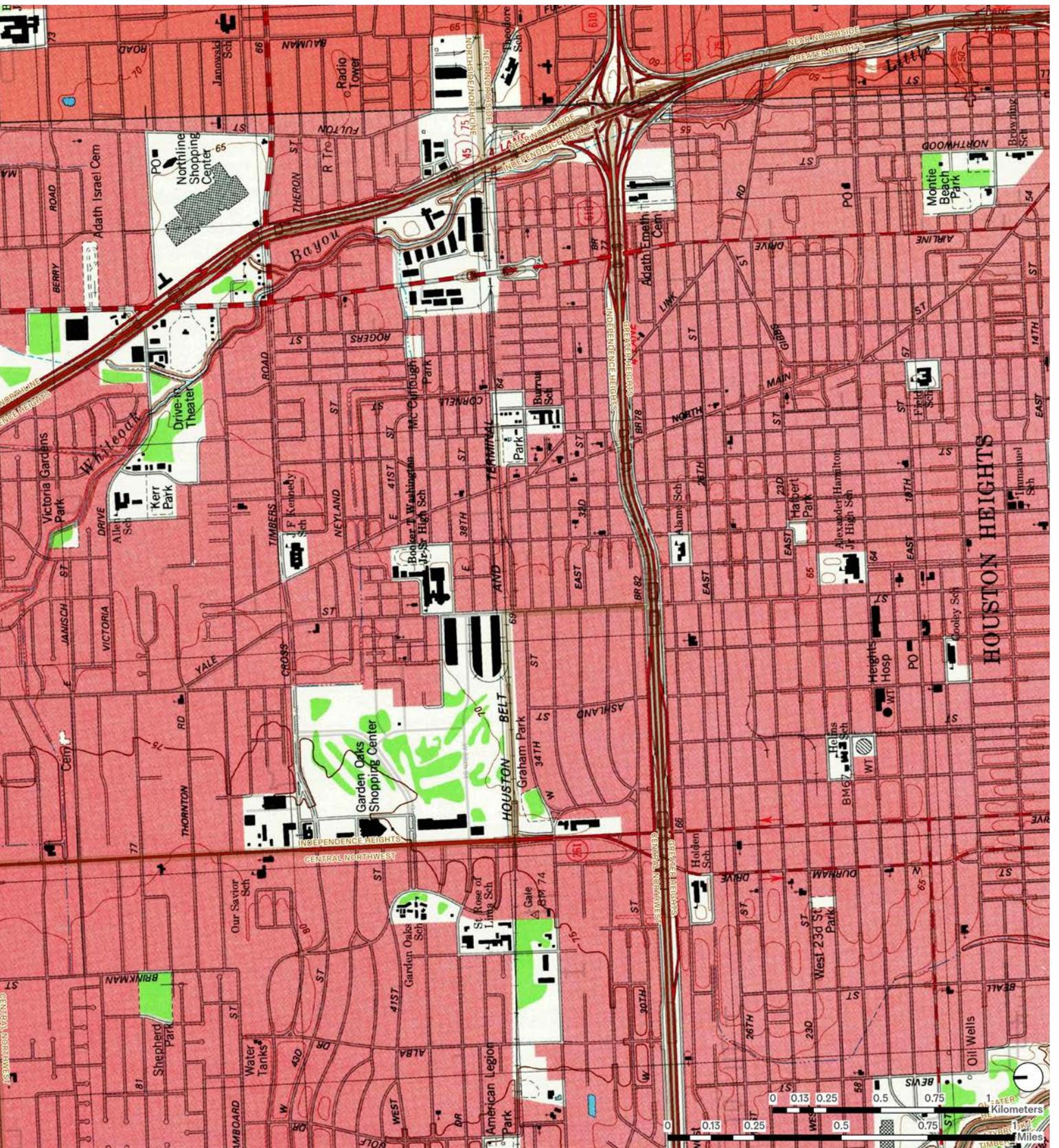


Independence Heights 1955

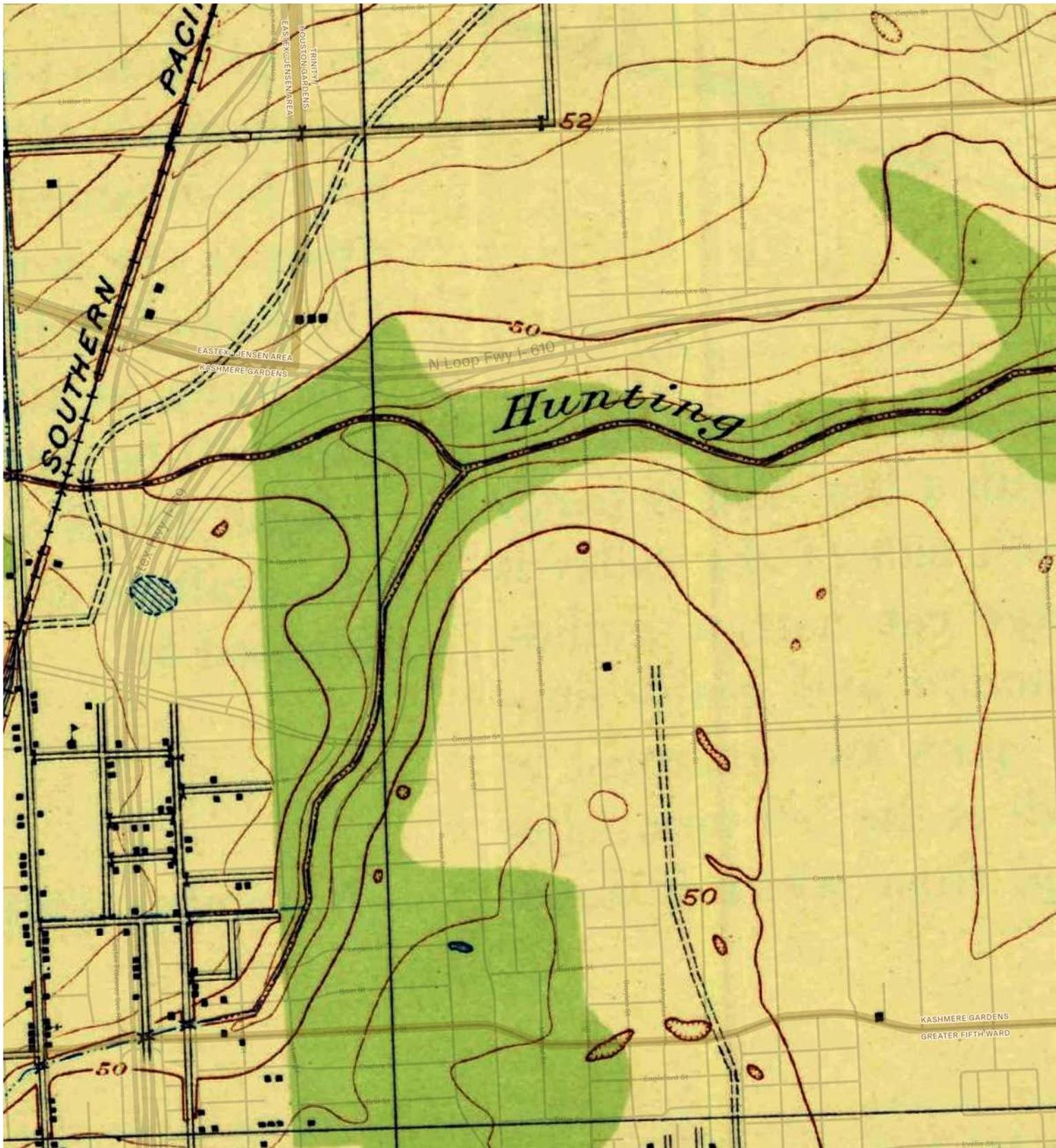


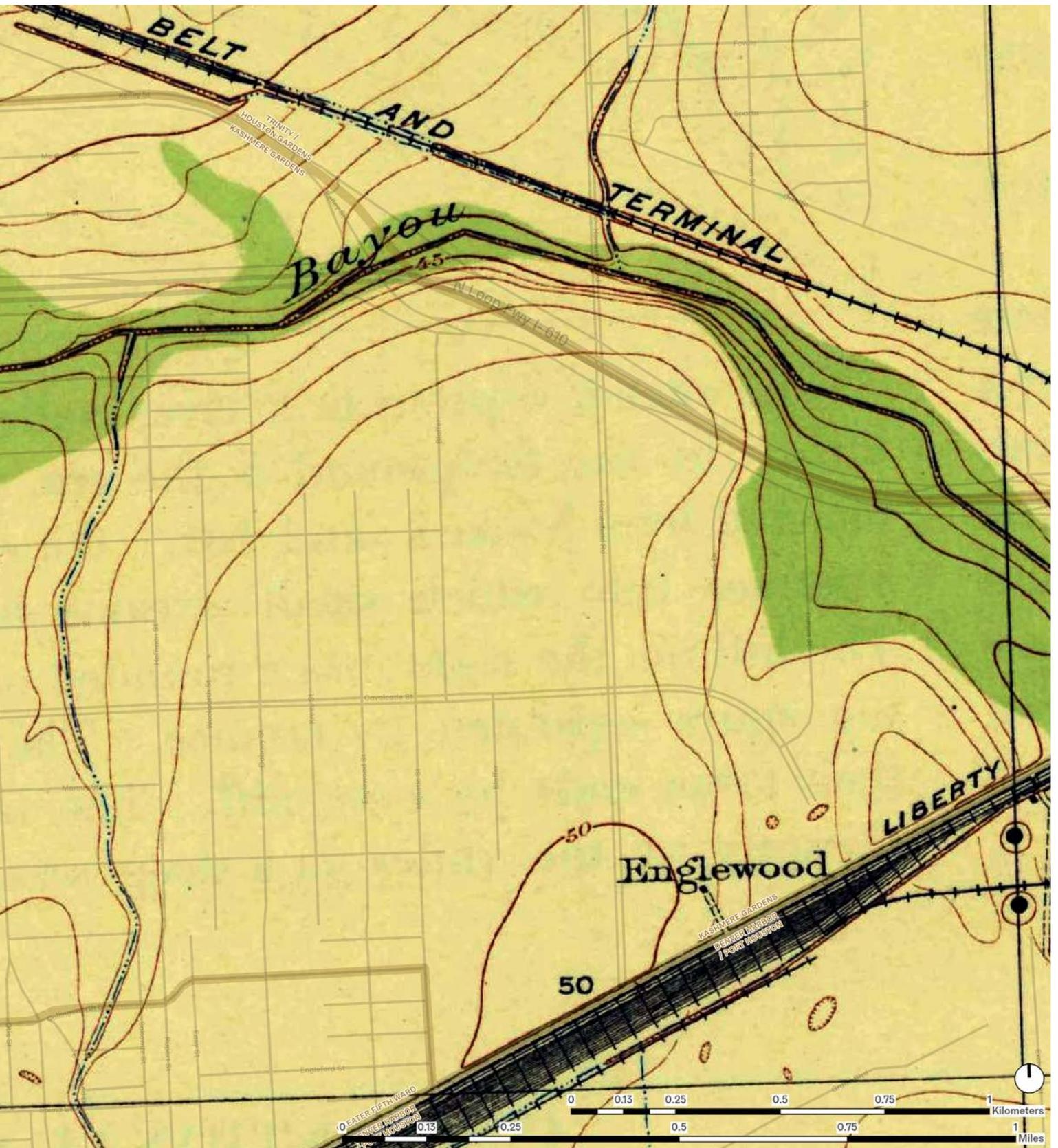
Independence Heights 1982



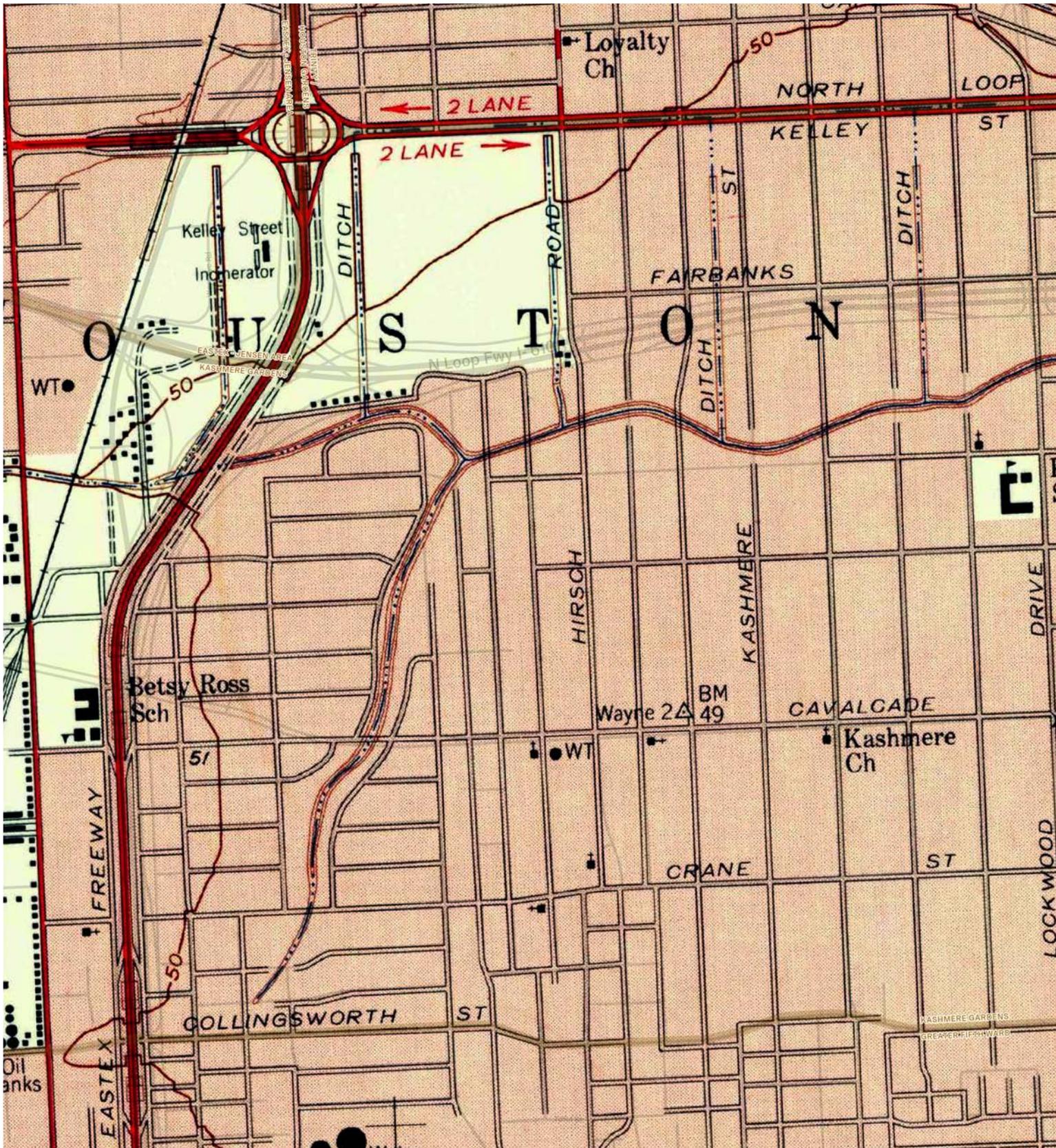


Kashmere Gardens 1922



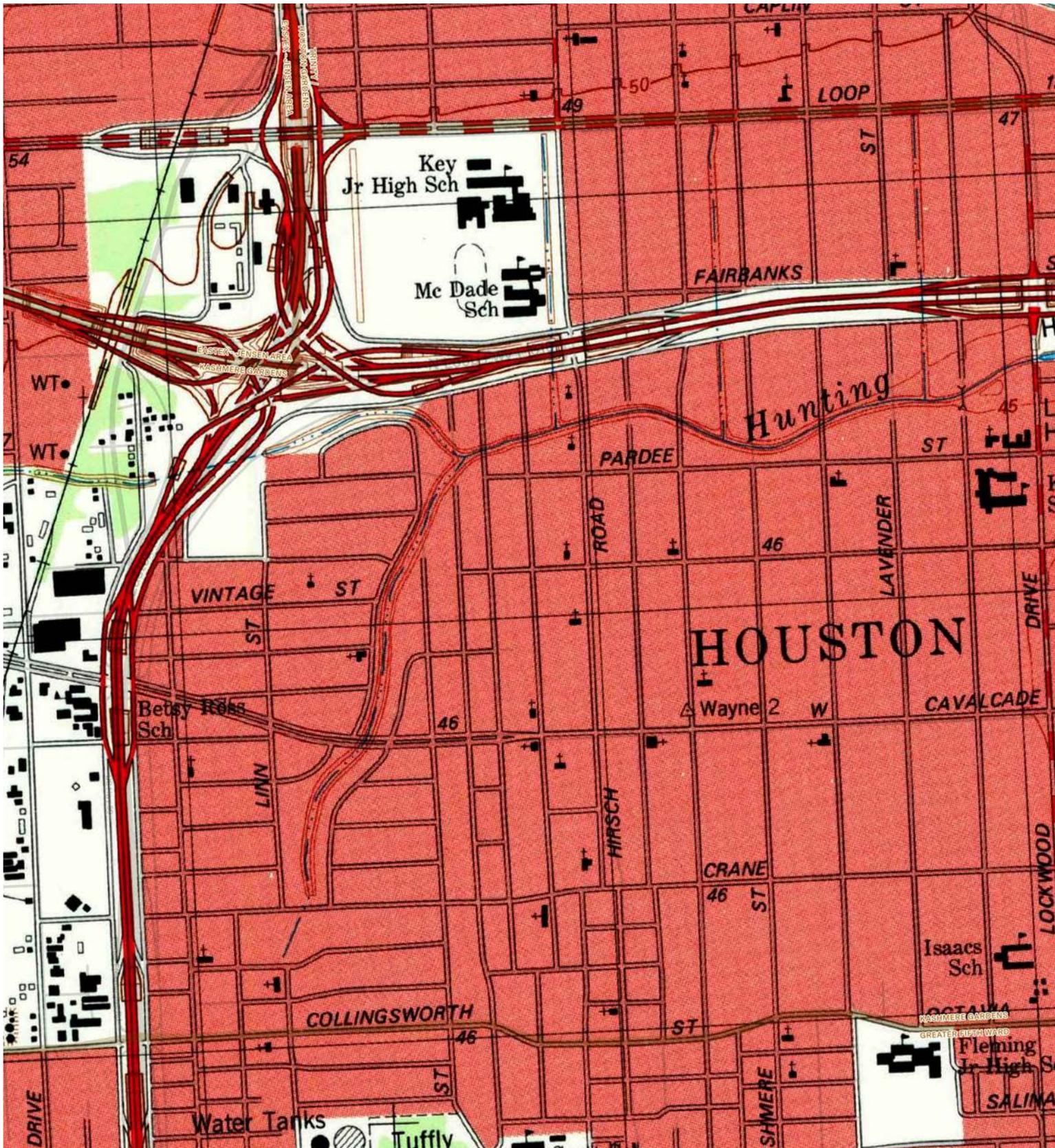


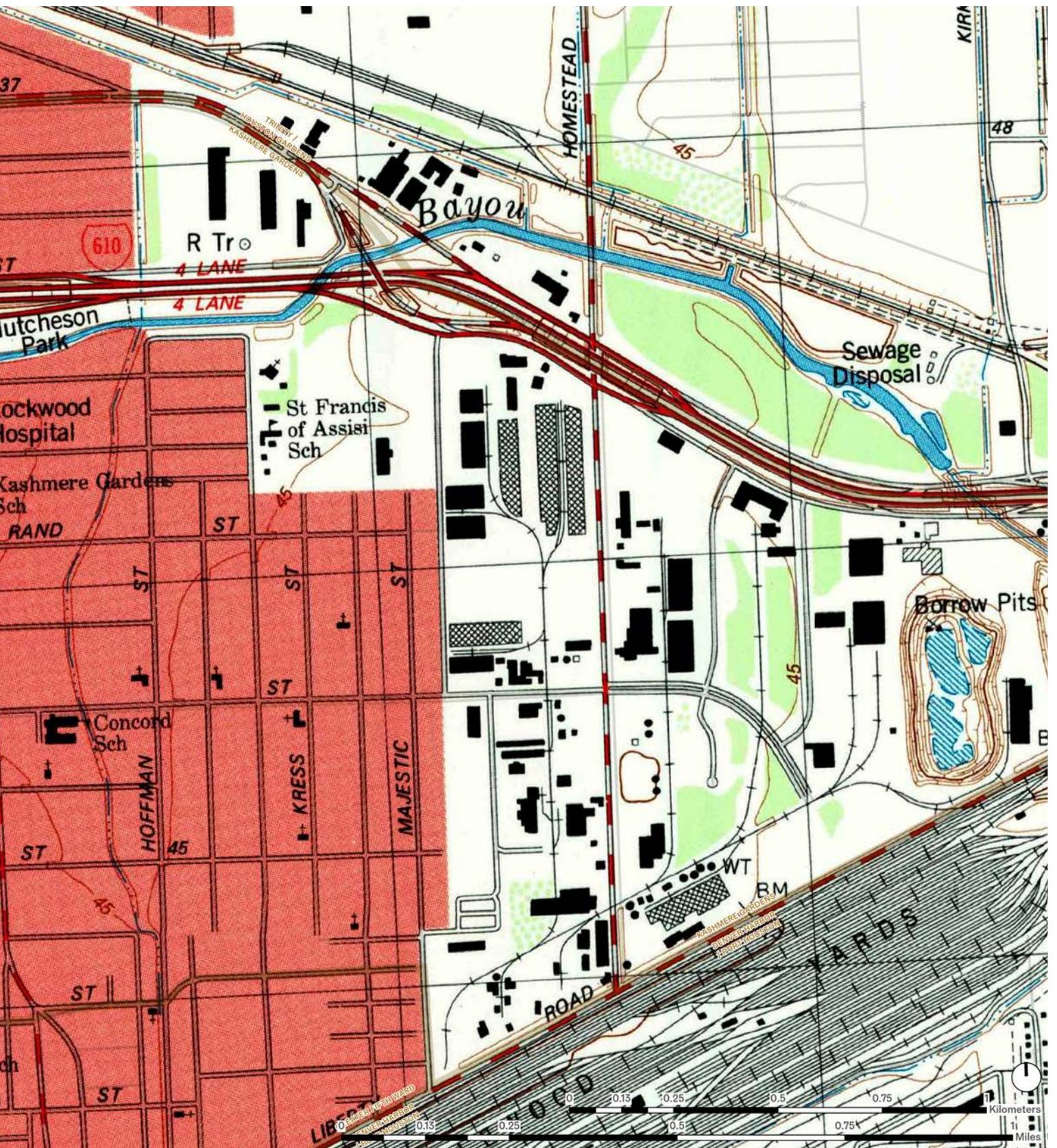
Kashmere Gardens 1955



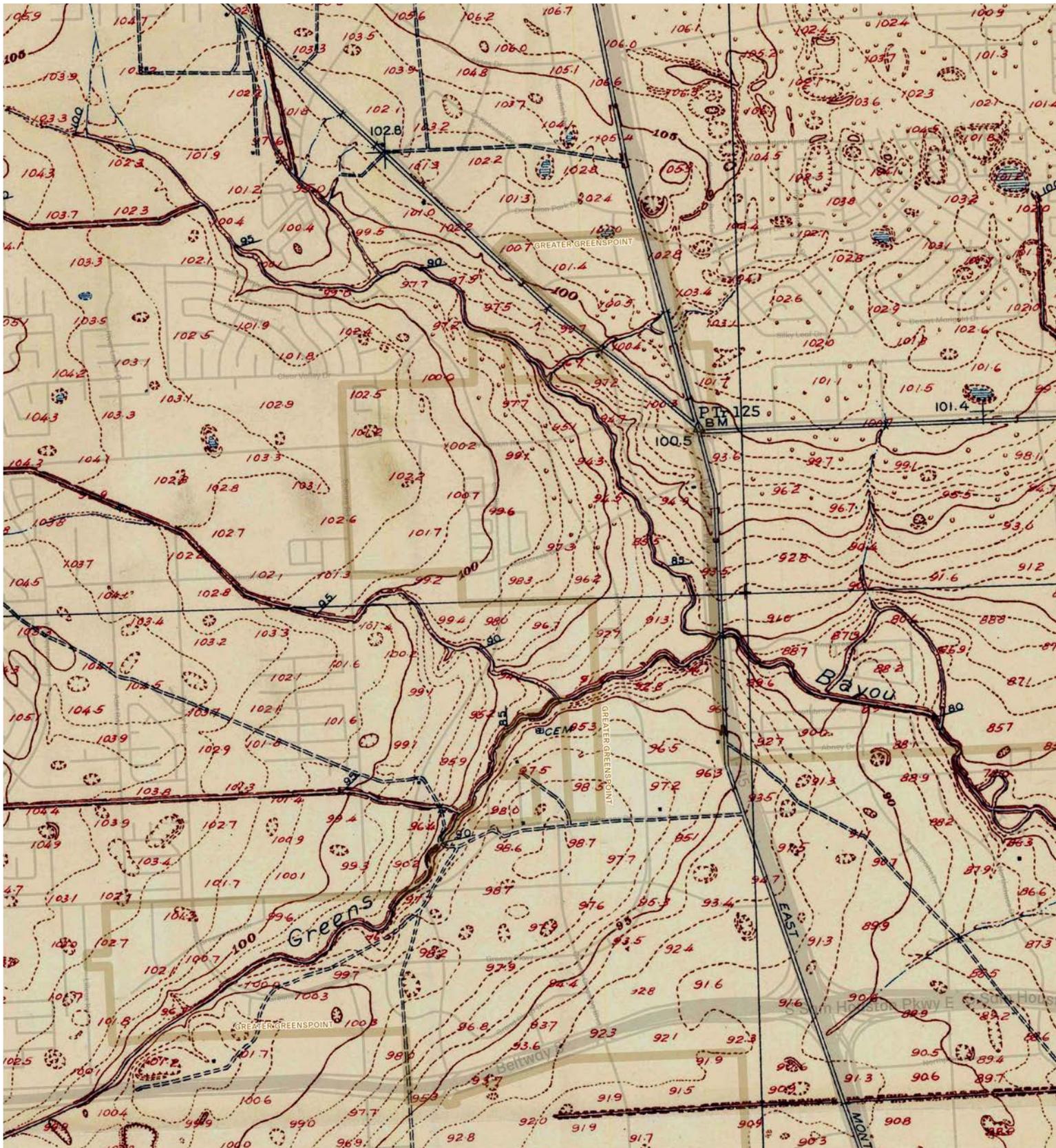


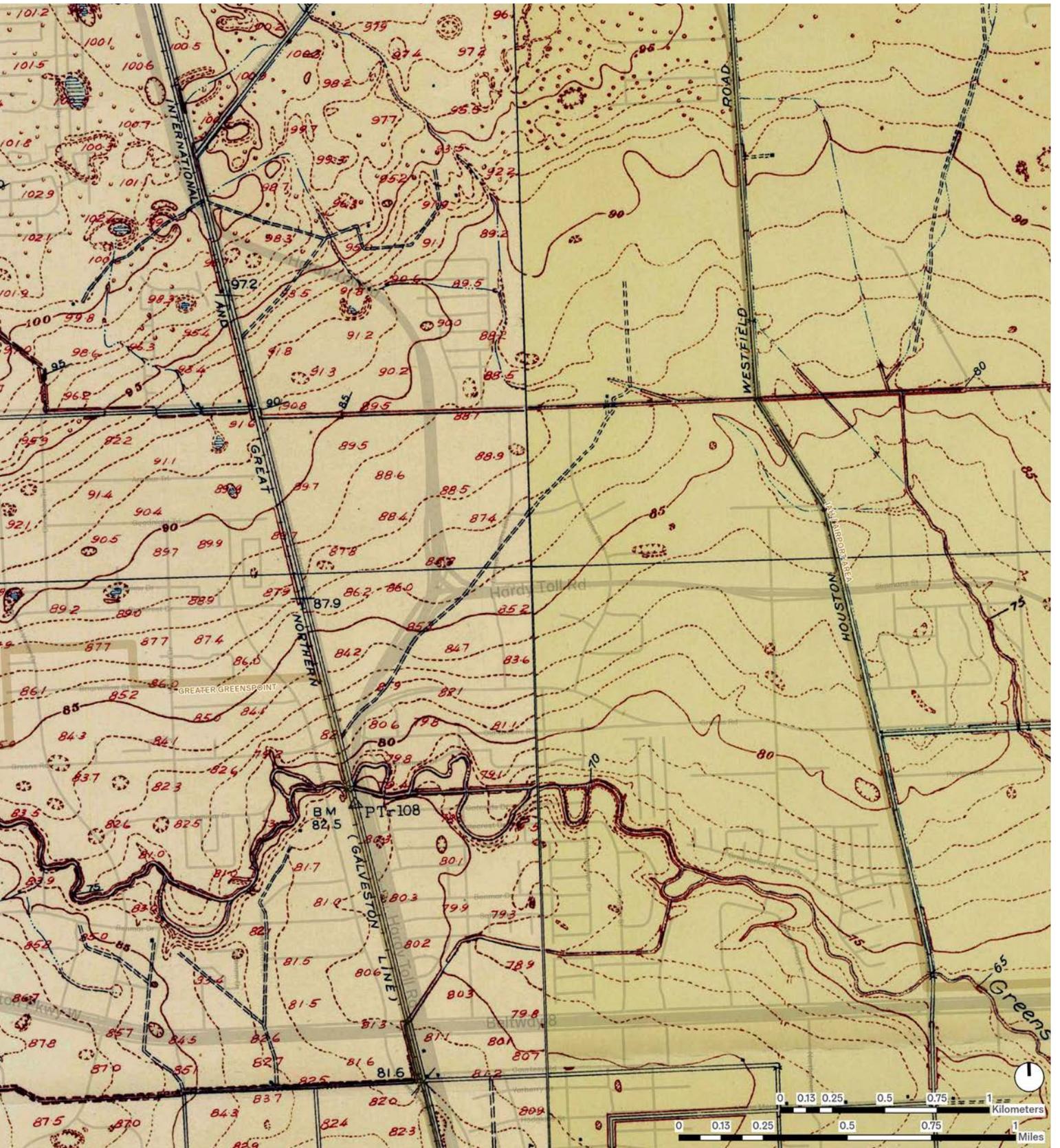
Kashmere Gardens 1982



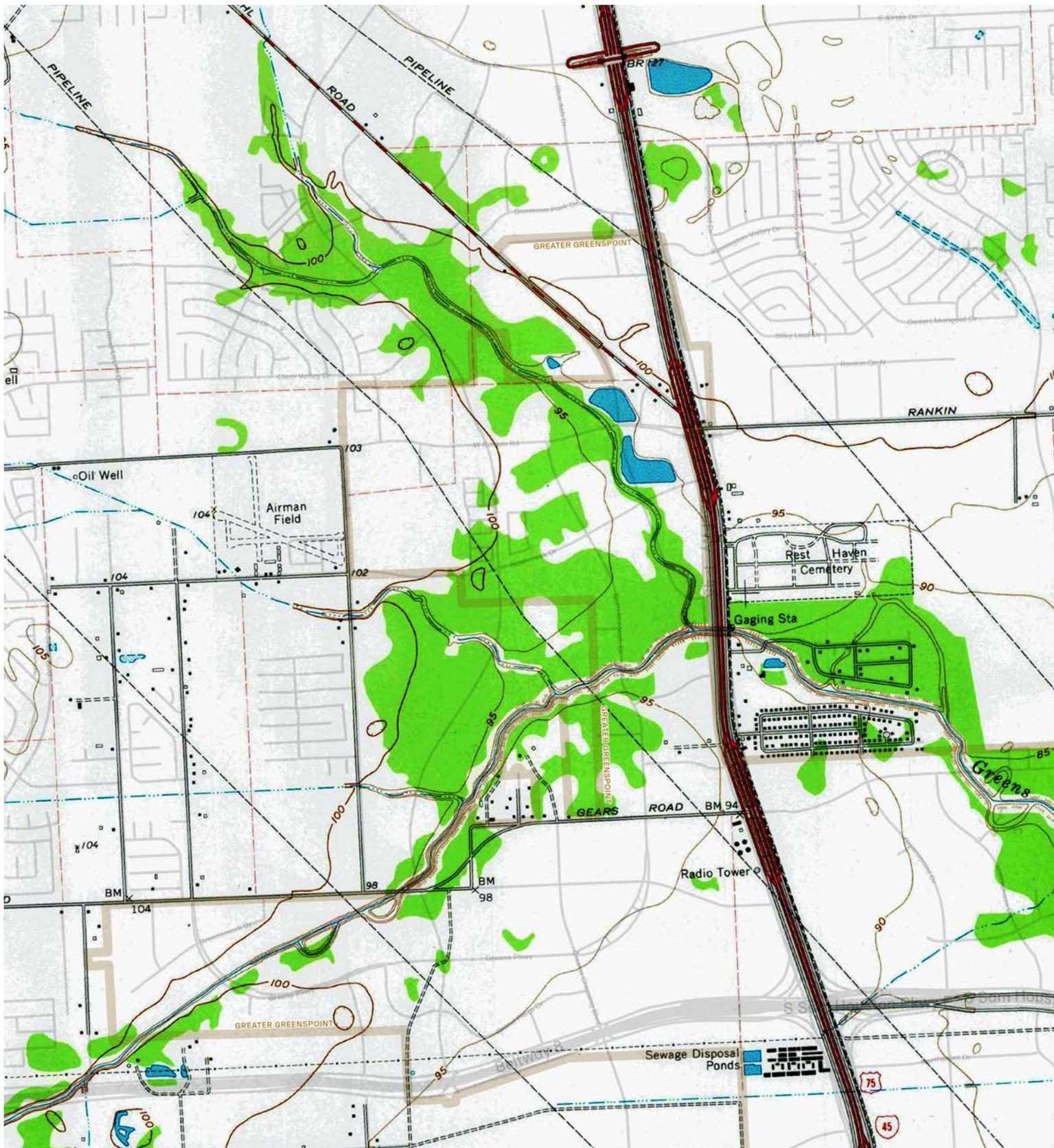


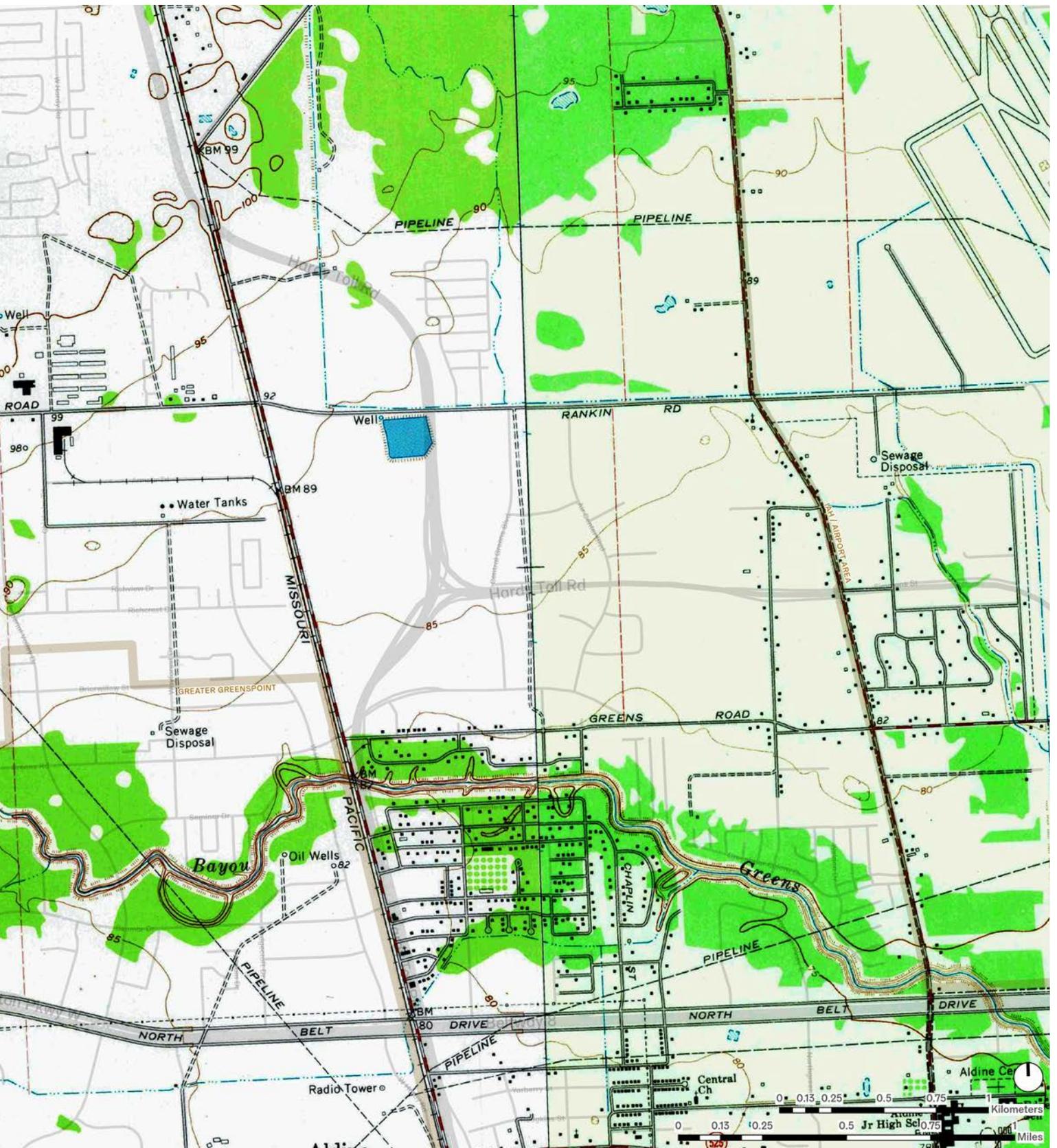
Greenspoint 1922



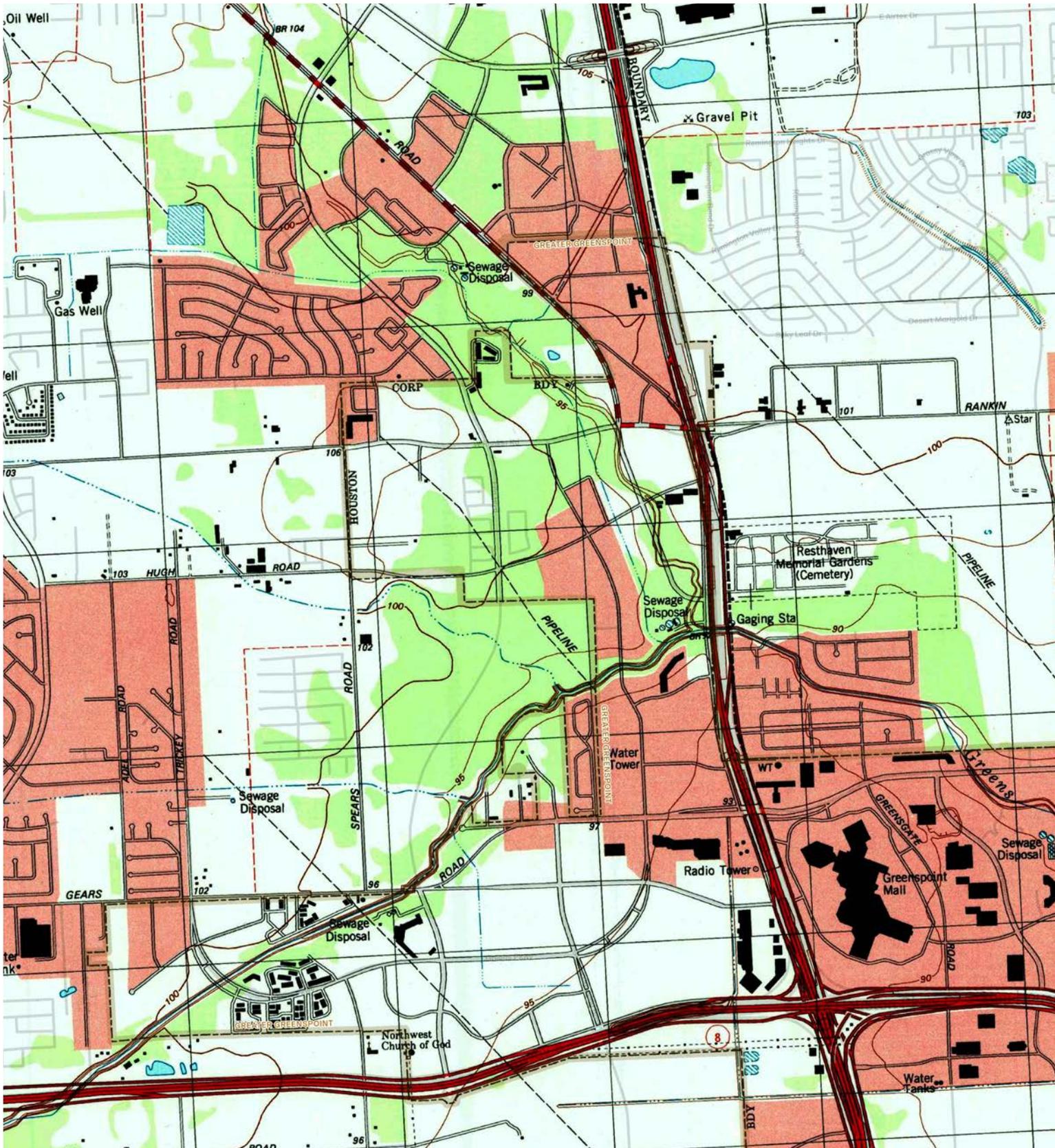


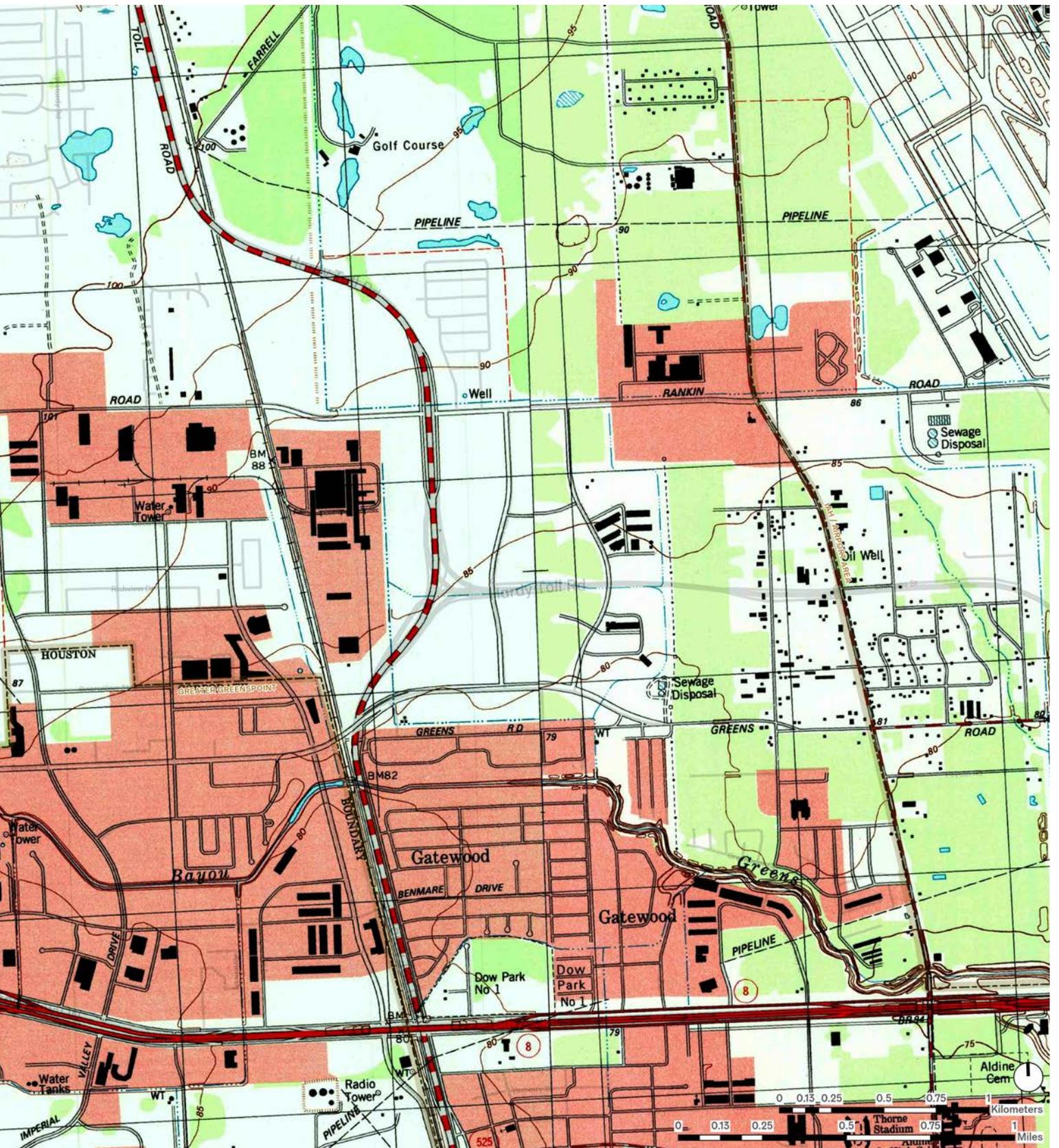
Greenspoint 1967





Greenspoint 1995







Ducks in Detention Basin, North Houston
Ecosystems are alive even in engineered solutions.



