Keeping New Orleans Afloat: What can be done to ensure another hurricane the size of Katrina will not destroy the entire city?

by

Daelin Brown

B.A. Journalism
Hampton University, 2022

Submitted to the Program in Comparative Media Studies/Writing in partial fulfillment for the degree of Master of Science in Science Writing

at the

Massachusetts Institute of Technology

September 2023

©2023 Daelin Brown. All rights reserved.

The author hereby grants to MIT a nonexclusive, worldwide, irrevocable, royalty-free license to exercise any and all rights under copyright, including to reproduce, preserve, distribute and publicly display copies of the thesis, or release the thesis under an open-access license.

Authored by: Daelin Brown

May 22, 2023

Certified by: Thomas Levenson
Professor of Science Writing
Thesis Supervisor

Accepted by: Seth Mnookin
Professor of Science Writing
Director, Graduate Program in Science Writing

Keeping New Orleans Afloat: What can be done to ensure another hurricane the size of Katrina will not destroy the entire city?

by

Daelin Brown

Submitted to the Program in Comparative Media Studies/Writing on May 22, 2023 in partial fulfillment for the degree of Master in Science in Science Writing

ABSTRACT

On August 29, 2005, Hurricane Katrina, a Category 3 storm, struck New Orleans. The location of New Orleans makes the city extremely vulnerable to massive storm surges during hurricane season, and the entire city was relying on flood management for their safety. They had a Hurricane and Storm Damage Risk Reduction System (HSDRRS) in place, but the system was not efficient enough for the strength of Katrina's 28-foot storm surge and 55-foot waves. After 50 major levee breaches, New Orleans looked like residents had built a beach in their backyards, with several feet of water breaking right through the levees. The Gulf Coast resembled the largest wave pool in the world, with the 55-foot waves damaging 34 pumping stations and 169 miles of protective structures in the regional HSDRRS. All of these failures caused 80 percent of New Orleans, along with several surrounding neighborhoods, to be underwater for weeks.

Not only were there 1,392 estimated fatalities, but 800,000 housing units were also destroyed or damaged by Katrina, leaving at least 800,000 people homeless. The total damage of Katrina amounted to over $160 billion, making it one of the largest natural disasters in the history of the U.S., and the third deadliest storm in U.S. history. The catastrophe posed two questions: what had gone so wrong for this American city to be destroyed and what needed to be done to make sure that this amount of devastation would not happen the next time a storm hit New Orleans?

Thesis Supervisor: Thomas Levenson
Title: Professor of Science Writing and Documentary

**The Flood**

The famous rock n' roll artist Fats Domino purchased a two-compound home, on what is now known as Fats Domino Avenue, in the Lower Ninth Ward neighborhood back in 1960. He lived in that house in East New Orleans for 45 years. Then Hurricane Katrina hit the city and a boat rescued him out of his home as it was filling with floodwater.

His home has been rebuilt and still sits on Fats Domino Avenue. It's now a studio surrounded by empty lots of grass and abandoned houses that need to be refurbished. The Lower Ninth Ward had been destroyed by Hurricane Katrina. Reverend Richard Bell, a town resident, told *Yale Climate Connections*, "We don't have nothing that we had before Katrina." That was in 2018, and even five years later the damage and emptiness are still prevalent.

Hurricane Katrina was the 11th tropical storm of the 2005 hurricane season, and it formed from remnants of a previous tropical depression that interacted with a tropical wave. It started forming on August 23, 2005, as Tropical Depression Twelve, according to the *Hurricanes: Science and Society*, and at the time, it posed no threat to residents in the Lower Ninth Ward and other neighborhoods in New Orleans.

But on August 25th, Katrina continued to intensify, and about two hours before making landfall on the southern coast of Florida, the storm became a hurricane. Early the next morning, Hurricane Katrina sat over the Gulf of Mexico in a very low shear environment over warm water— conditions that would strengthen the storm. The system experienced periods of rapid intensification for the next two days and at this point, residents in neighborhoods below sea level, like the Lower Ninth Ward, started worrying.

Early on August 28th, Katrina went through a second period of rapid intensification, strengthening the hurricane from Category 3 to Category 5. Then, New Orleans Mayor Ray Nagin ordered a mandatory evacuation of the city. But it was too late. Katrina started moving northwest toward Mississippi and Louisiana on August 29.

The Category 3 hurricane was so large that the winds sustained their strength, causing an abnormal rise of water, called a storm surge, that surpassed the predicted astronomical tides. The storm surge crashed right through the flood walls in the Lower Ninth Ward, filling the neighborhood with water. This is when Fats Domino was rescued by boat from his home.

Unfortunately, not everyone in the city of New Orleans was as lucky as Fats. The location of New Orleans makes the city extremely vulnerable to massive storm surges during hurricane season, and the entire city was relying on flood management for their safety. They had a Hurricane and Storm Damage Risk Reduction System (HSDRRS) in place, but the system was not efficient enough for the strength of Katrina's 28-foot storm surge and 55-foot waves. After 50 major levee breaches, New Orleans looked like residents had built a beach in their backyards, with several feet of water breaking right through the levees. The Gulf Coast resembled the largest wave pool in the world, with the 55-foot waves damaging 34 pumping stations and 169 miles of protective structures in the regional HSDRRS. All of these failures caused 80 percent of New Orleans, along with several surrounding neighborhoods, to be underwater for weeks.

Not only were there 1,392 estimated fatalities, but 800,000 housing units were also destroyed or damaged by Katrina, leaving at least 800,000 people homeless. The total damage of Katrina amounted to over $160 billion, making it one of the largest natural disasters in the history of the U.S., and the third deadliest storm in U.S. history. The catastrophe posed two questions: what had gone so wrong for this American city to be destroyed and what needed to be done to make sure this amount of devastation would not happen the next time a storm hit New Orleans?

**Holding Back the Water**

The Army Corps of Engineers answered that question by building and rebuilding what was promised to be a stronger, more effective set of physical barriers to flooding. The key goal was to improve the HSDRRS to properly direct all the stormwater into Lake Pontchartrain to prevent flooding. Over the past ten years, the Army Corps has attempted to do this by creating a 133–mile Greater New Orleans perimeter flood mitigation system and by improving about 70 miles of interior risk reduction structures.

Immediately following Katrina, their first job was to remove the water. The Unwatering Task Force successfully removed 250 billion gallons of water from the city in 53 days, and the Guardian task force repaired and restored the HSDRRS to pre-Katrina conditions before the 2006 hurricane season. Then, the Interagency Performance Evaluation Task Force (IPET) investigated how and why so many systems within the HSDRRS failed during Katrina.

For the levee system, IPET reported that four of the 50 levee breaches during Hurricane Katrina were caused by foundation-induced failures, while the remainder of the breached levees were caused by waves and water eroding the cement levees. IPET began armoring the levees, which is protecting them from erosion by surrounding the levee area with stones or grass.

Pumping stations are a crucial component of flood mitigation because they pump large volumes of water out of the city. IPET reported that most of the pumping stations were not operating during Katrina because the operators had evacuated, the stations lost power, and the pumps lost their clean cooling water, which stops blockages in the pumps. A pumping station becomes more important as a storm becomes more intense, but the pumping stations in New Orleans had not been designed to operate during major storms, according to the Army Corps.

Once these conclusions were made, federal legislation required the Army Corps to both repair the damaged stations and ensure that the new pumping stations were equipped to withstand a major storm event. To accomplish this goal, Congress provided $14.6 billion to the Army Corps of Engineers. By 2007, the Army Corps spent about $400 million on this project, with the idea of a 100-year storm system contingency plan.

14 years later, in May of 2021, the Army Corps completed a concrete surge barrier, becoming the largest pumping station in the world. But after all of those years of work that had been put into this network of flood management systems, the Army Corps of Engineers has confirmed that the levees are sinking. According to Army Corps spokesman Mathew Roe, “The deterioration is happening faster than projections estimated back in 2007.” The gray infrastructure of the HSDRRS already failed to save New Orleans during Katrina, and with the sea level in New

Orleans rising five to ten millimeters per year due to climate change, the Army Corps doesn't believe these "gray infrastructures" can keep up with the massive amount of erosion that occurs. This leaves New Orleans residents with the same question that they had after Katrina: what can be done to ensure another hurricane will not put the city under water?

**Bayou Bienvenue Wetlands Triangle**

The Bayou Bienvenue Wetlands Triangle sits at the end of Fats Domino Avenue, bordering the back of Lower Ninth Ward Neighborhood. It is a remnant of the Mississippi River Delta Swamp and extends eastward from New Orleans to Lake Borgne. For the residents in the back of the Lower Ninth Ward, the swamp provided recreation and vital resources, like fish, game, and wood. The dock of the swamp became a social outlet, while people waited to catch fish, alligators, and even turtles for traditional Louisiana stews.

Michael Biros, director of restoration programs for the Coalition to Restore Coastal Louisiana (CRCL), stood on the platform dock looking out at the Bayou Bienvenue. He described the area as a thriving Louisiana swamp, "like a cypress and tupelo forest." It was a very thick forest with aged trees that had not been disturbed and was the home of many ecosystems. "You could take a canoe through and just apparently pull yourself along just by touching trees," said Biros.

But this beautiful forest turned into "the ghost swamp" because of salt water intrusion caused by the Mississippi River Gulf Outlet (MR.GO). Biros said that people now call it "the ghost swamp" because all the wildlife had been killed off, leaving the swamp as empty as the Lower Ninth Ward after Katrina. He explained that on the other side of the Bayou sits more land and then the huge canal, MR. GO. This canal was dug in the sixties as an express shipping route. Ships would no longer have to go all the way down the river, "they could just get a direct route to the Gulf without having to go that extra distance," said Biros.

Although that was beneficial for ships, MR. GO started to destroy everything. The Bayou was all freshwater, until MR. GO made a direct connection of salt water to freshwater, which started the slaughter of the Bayou's ecosystems. The salt water came up the canal and killed the forest off.

“You can still see some of the cypress trees interspersed there, but most were killed from salt water,” said Biros.

The Lower Ninth Ward suffered because of this. Mr. Go was also known as “hurricane highway” because of how it funneled the storm surge into the city. This was a big reason why the Lower Ninth Ward ended up with the most violent flooding during Katrina—excess flood water from Lake Pontchartrain funneled its way into the Bayou Bienvenue. The neighborhood's last hope was the levee that sits between the neighborhood and the Bayou, but the levee was no match for the explosive force of water that flowed through, leaving the neighborhood flooded.

Not only was the levee useless, but it also caused more harm. Biros explained that the neighborhood is about six to eight feet below sea level now, but it wasn’t always like that. When the Bayou Bienvenue was a swamp, it was actually a couple of feet above sea level. Putting up the levees, putting in pumps, and taking the water out with poor drainage caused subsidence and the neighborhood sunk. As environmental groups and fishing coalitions started seeing the problems that these human-built structures caused, they came together and filed a suit against MR. GO. It was finally decommissioned in 2009.

Once the canal was closed off, it cut off the intrusion of salt water into the area. Since then, the area is slowly becoming more freshwater. “We are working to restore some of the cypress and tupelo trees and the ecology back to a functioning swamp,” said Biros. According to the EPA, the holding capacity of water in wetlands helps control flooding as well as a levee would. The cypresses in the forest also act as horizontal levees, creating another buffer to stop water from flooding the Lower Ninth Ward.

To achieve these goals, Biros and his team at CRCL are working with community members of the Lower Ninth Ward to get them into the swamp and help restore it. The residents have the opportunity to get their feet wet and their hands dirty by doing some planting, which helps create a connection to the landscape and the water. In partnership with the five other nonprofit groups in the Central Wetlands Restoration Collective, the community was able to plant 2,600 trees in early 2022.

However, Biros isn't sure that planting trees can completely fix the flooding problem in the Lower Ninth Ward. Since the Bayou is located at the back of the neighborhood, all the water comes to the edge of the Bayou and then hits the levee that was built right behind the water. "So it makes sense to put the canal and the green infrastructure in all this area to absorb some of that extra water," said Biros.

Combining gray and green infrastructures is a small-scale example of what may be the new approach for mitigating floodwaters in New Orleans. Biros thinks that green infrastructure will accompany the Army Corps' flood systems in a way that could successfully mitigate flooding because the hard infrastructure just isn't working with New Orleans' environment: "What it boils down to in my mind is connecting the types of infrastructure that we built to the landscape into ecological and social context," he said. Biros explained that, historically, the Army Corps has had a way of engaging with the landscape that was heavy-handed. "It was very much like controlling the water from an engineered approach," he said.

He argues that any organization that wants to start infrastructure for flood mitigation needs to take into consideration that this entire area is a delta. "Every single bit of sediment here that wasn't trucked in or shipped in somehow was brought here by flood at some point," Biros continued. "Flooding is kind of fundamental to our landscape." When levees, floodwalls, and other hard infrastructure that prevent flooding get built, there is a disconnect from the foundational truth of what a delta is.

But fortunately, the Army Corps now seem to understand the consequences of building hard infrastructure in the wrong location. Recently, they have been pushing an initiative that they call "engineering with nature," and have begun to build projects that are connected to ecological processes. Biros sees this as a step in the right direction to make sure that New Orleans won't be put in more flood danger by new infrastructure.

“I'm not saying that there isn't a place for hard infrastructure because we can't reverse some of those decisions that we've made in the past,” said Biros, “but we just need to find a way to live with them and to grow from them.”

**The Implementation of Nature-Based Solutions at a National Level**

Nature-based solutions as a response to climate change have become a world wide agenda that the United States is starting to follow, not just in New Orleans, but in other vulnerable cities, too. At the 2015 Conference of the Parties United Nations meeting, 196 parties adopted the legally binding international treaty on climate change called The Paris Climate Agreement. The treaty went into effect in 2016 and its goal was to limit the global warming level to 1.5 degrees Celsius. At the recent November 2022 United Nations Climate Conference, the United Nations discussed the role of nature-based solutions and how they could be successful and bring economic prosperity.

The United Nations implemented an Adaptation Fund to finance several nature-based solutions globally. A project similar to the Bayou Bienvenue was supported by the Adaptation Fund in Mahe and Praslin, the two largest islands in the Seychelles. Both are threatened by sea level rise. Badly functioning wetlands were rehabilitated because they play an important role in decreasing inland flood vulnerability. A natural retaining wall was also built without concrete to store water in the restored upland wetland, which is usually a drier area. So far, the wetlands and retaining wall have prevented disaster.

The American Government has also been slowly developing several analogous nature-based solutions. As reported in *Vox*, the Biden Administration released a roadmap that highlighted five areas for action. These include updating policies to accelerate nature-based solutions, unlocking funding for these programs, leading with federal facilities and assets, training nature-based solutions workers, and prioritizing research, innovation, knowledge, and adaptive learning. The administration published a guide to existing programs that it considers to be nature-based and at the 2022 United Nations Climate Conference, the Biden Administration said, “America is going

all-in on nature-based solutions to fight climate change." They announced funding of over $25 billion for nature-based solutions.

A few cities across the country have started projects, but there are roadblocks. Biros explained that for the Bayou Bienvenue, funding isn't coming soon enough. The Army Corps of Engineers proposed a $3 billion plan for restoring the Bayou Bienvenue Wetlands Triangle and the Lower Ninth Ward community just after Hurricane Katrina. But, according to Biros, the project still has not been started because of the long ongoing dispute between the state and federal government about funding.

In Boston, Gabriel Cira is running into the same issue. Cira has been leading the Emerald Tutu Nature-Based Infrastructure project for three years. "Within the next ten years, there are huge amounts of federal funding that have been allocated for climate adaptation programs," he said, but the catch is that the funds have to be tailored to a specific plan and a specific city's approach to adaptation.

"In Boston, the Army Corps of Engineers has just initiated a little collaborative kind of think tank specific to Boston," Cira explained. After two or three years of investigations, meetings, and reporting from all the local expertise, all of that information is compiled into an Army Corps of Engineers-approved broader initiative. That will then be submitted to Congress, which must approve what would be a giant amount of money for the city to implement that plan.

However, just as in New Orleans, climate organizations start their own projects by relying on grants. While the government analyzes this data in Boston and tries to figure out how to implement something on a large enough scale, projects like the Emerald Tutu project can be done in the meantime.

Looking out at the Harbor from the coastline neighborhoods of Boston, in just a few years, residents will see more land in the Harbor than just the Boston Harbor Islands. The National Science Foundation has funded the Emerald Tutu research project to design and implement

biomass-based coastal protection infrastructure for neighborhoods like East Boston and the Seaport District.

The name of the project echoes a vision proposed 140 years ago by the landscape architect Frederick Law Olmsted. In 1878, he began work on the 1,100-acre connected park system in Boston known as the Emerald Necklace, which he saw as a collective space that could bring nature back into the city. Along with the urban retreat it created, Olmsted designed the system to solve major draining problems. Now, with the ongoing threat of sea level rise, a group of MIT students has brought the idea back to life as an approach to solving coastal urban problems using nature and resiliency.

While Boston contemplates larger scale actions, “the Emerald Tutu project is doing most of its busiest research work to try to prove the efficacy of our system and the fact that the city of Boston should implement on a truly massive scale floating marsh infrastructure like ours,” said Cira.

This approach is in stark contrast to at least one of the giant projects under consideration: a harbor-wide barrier “like a daisy chain of very New Orleans-like seawalls with diagonal levees,” said Cira. On top would be a road connecting several of the Harbor Islands and blocking off the Harbor from Massachusetts Bay and from the ocean. The wall would have a gate, which would be closed when there's a big storm. After seeing how similar systems played out in New Orleans and other coastal cities, “that was really, widely, determined to be a terrible idea,” said Cira. “You’re basically building this massive liability” that will require billions of dollars every year to solve more problems, he added. This is the pattern that is being seen in the Army Corps’ system in New Orleans.

Cost is just a small problem that comes with gray infrastructure, compared to the environmental consequences that are faced. This retention wall in Boston would demolish the ecosystem and the water quality in the Harbor. Cira explained that plants and animals that need tidal flow to eliminate excess nutrients will either not do well or die because of how polluted and non-circulated the water would be if the flow were blocked off. Ultimately, the Sustainable

Solutions Lab, an academic policy consortium for urban scale adaptation, “torpedoed this idea of a gigantic savior-type solution that would save Boston,” said Cira.

In the meantime, though, the Emerald Tutu Project received the necessary funding from the National Science Foundation to complete its smaller-scale nature-based project. It is confronting several obstacles similar to those experienced in post-Katrina New Orleans.

The Emerald Tutu team is now working on making prototypes and launching them in Boston Harbor. The goal is to launch a 40-foot by 20-foot rectangular frame in which they can place prototypes of their naturally derived barriers. It’s an experimental device, so “the most difficult thing is getting permits and permission to launch prototypes because the water is just a place where there's a lot of existing uses and complex territories,” Cira said. They are working to find a location for the experiment in time to build and launch their first test structure this season.

While Boston waits to get its projects going, New Orleans is so vulnerable to flooding. With the risk amplified by climate change, they have no time to spare. Climate organizations and nonprofit groups in New Orleans are taking matters into their own hands. Even though they have not received funding for any large-scale projects yet, The Urban Conservancy, a New Orleans nonprofit, is completing a series of small and affordable nature-based projects to prevent the perpetual flood problem.

**The Hoffman Triangle**

The emptiness of the Lower Ninth Ward reminds visitors of the demolition and destruction caused by Katrina. The Hoffman Triangle carries the memory of the devastating death toll. The Hoffman Triangle neighborhood is located in central New Orleans and sits below sea level between Lake Pontchartrain and the Mississippi River. Once the levees failed during Katrina, the neighborhood was under eight feet of water. Days after the storm, the houses left standing looked like graffiti artists had taken over, spray painting “X-Codes” on home after home. But this was not graffiti. The X-Codes helped the Federal Emergency Management Agency and other rescue

teams establish if a home had been assessed and evacuated. And sadly, most of the time, the X-Codes pointed out how many people were dead in each home.

But even after all the “X-Codes” were cleaned up, the overwhelming devastation lingered in the neighborhood. For years, the neighborhood could not be revived. *The Lens* reported that this was leading to an increased crime rate. Finally, in 2018, 13 years after the storm, the director of The Urban Conservancy, Dana Eness, teamed up with another nonprofit group, Thrive, to help rebuild the neighborhood and figure out a way to manage rainwater.

Eness wanted to find a sustainable solution to the neighborhood’s perpetual flooding problem, but, she said, “there was a lot of denial about our relationship with water and our proximity to water.” Chuck Morris, the executive director of Thrive, agreed with Eness and knew that the solution needed to address the challenges of rising sea levels and subsidence caused by climate change. Not only was Morris in agreement about water mitigation but Thrive also had a business support accelerator program for businesses of color. “Morris, and I began thinking about a training program specifically focused on green sector skills to get contractors of color and business owners of color entering into this stormwater management sector,” said Eness.

With the perpetual flooding in the neighborhood, the stormwater management sector could bring real growth and financial opportunity to the community. So Enees and Morris looked at how they could create pathways to this sector. They started working together and developing an 18-hour course for businesses to understand the fundamentals of stormwater infrastructure and nature-based solutions.

The Urban Conservancy received a grant for the Hoffman Triangle, specifically to address the vulnerabilities of displacement as a result of climate change, Eness explained. From 2019 to 2021, Eness and her team worked extensively in that area. The area has several vulnerabilities, with a high rental population as well as a high elderly homeowner population. “There's a degree of precariousness and vulnerability to displacement there that was really important for us to address,” said Eness.

Before Katrina, there was no priority in building community green spaces, so one of the first projects to be completed was the community center in the middle of the Hoffman Triangle, called the Sojourner Recruit Neighborhood Center. In the summer, kids from the community fill the neighborhood center at the summer camp that Eness and her team organized. They learn the importance of these green spaces in New Orleans.

This community center is built in a large green space called The Greenway, which was incorporated into the neighborhood a few years after Katrina. Landscape architect Dana Brown designed many of the stormwater management features along The Greenway. It's designed with prairies, bioswales, and permeable paving. The open grassland of a prairie helps soak up the water and slow runoff, while the land depression of bioswales captures stormwater and permeable paving helps hold water underground. These are all small ways to prevent flooding, “but it doesn't really need much of that intervention because there is so much green space to also absorb water,” Eness added.

Eness extended these projects outside of the neighborhood, getting a few famous local businesses involved in stormwater management. Just north of the Hoffman Triangle, the famous soul food restaurant Dooky Chase’s sits on the corner of New Orleans Avenue and Miro Street. Dooky Chase’s was a landmark during the Civil Rights Movement, where many civil rights leaders held meetings and listened to jazz. When Katrina hit and the restaurant had to close, it was a mission for the entire community to rebuild the restaurant. After two years, Dooky Chase’s returned to being a stopping point for politicians and it became the first example of rebuilding something that would contribute to stormwater management. Now when patrons make their way to the front door of Dooky Chase’s, they walk on a permeable brick path that has replaced the concrete sidewalk. In New Orleans, regular concrete paving captures water and then rises since the city is below sea level. In contrast, permeable pavement allows the water to seep into the ground and drain water away from the restaurant.

A few blocks over from Dooky Chase's sits the Parkway Bakery, a tavern famous for their Louisiana po’boys. “They are a great champion of water management, and they were one of the very first,” said Eness. The parking lot behind it is bigger than the restaurant itself, which created

an opportunity for flood management. The cement parking surface was dug up and redesigned to store millions of gallons of water. Now when parking their cars, people drive on gravel and past small rain gardens dispersed among the parking spaces.

Permeable pavement parking lots are also starting to be incorporated into the dozens of active churches in the area. The Urban Conservancy worked with the Jerusalem Church to create opportunities in green infrastructure for young adults ages 18 to 30 in the Thrive Workforce Training Program. The young adults replaced the concrete parking lot and planted several rain gardens in the front of the church along with 14 cypress trees. Eness explained that once the cypress trees are fully grown, they will be able to handle 800 gallons of stormwater each through evapotranspiration, where water travels from the soil through the plant into the atmosphere.

Eness and her team also expanded the initiative to neighborhood residents. The Urban Conservancy set up what they called the Front Yard Initiative. Eness herself went door to door giving out pamphlets for the Front Yard Initiative to educate the community residents on how they could individually reduce flooding. The pamphlet explained that the Front Yard Initiative would be working to replace unwanted concrete and asphalt with plants and soil. Diagrams detailed how these green infrastructures would slow, store, and filter the water while also minimizing subsidence. On the back, the pamphlet told residents that paving more than 40 percent of their front yard is illegal in most New Orleans neighborhoods and gave instructions on how to report paving violations. Anyone moving into a home in New Orleans has to contribute to water management because the excessive use of asphalt and concrete is illegal under the comprehensive zoning ordinance article 23.

**The Impact**

Eness and her team set a goal to create one thousand gallons of stormwater-holding capacity for each lawn, even in this old neighborhood with tiny yards. “If you compare that to what our pumping system manages, which is 450 million gallons, you can see that it isn’t like this will take over,” Eness explained. Given the hydraulics of the New Orleans region, the flooding

problem is not going to go away, but Eness explains that such small nature projects at least help flatten the curve.

Within the neighborhood lines of the Hoffman Triangle, “we've done maybe close to 10 residential projects, which was a combination of kind of surveying [and] asking people what it is that they wanted and needed,” said Eness. In the neighborhood, there was a mix of needs. A few residents just wanted something simple like rain barrels for their homes, while others had serious drainage issues that required bigger projects. Permeable driveways and rain gardens were also installed in houses that were up for sale so that residents could move into a home that follows the Front Yard Initiative.

With 10 years of experience in water mitigation in New Orleans, Eness has realized that the answer is not simply nature-based solutions or infrastructure solutions. “We're looking at ways that these can be complimentary,” she said. “Green infrastructure will never supplant gray infrastructure, but it definitely has a really important role to play in making everything work better.”

The nature-based solutions that have been implemented in the Hoffman Triangle emphasize the idea that anything that can be done to counter the impermeability and the carbon footprint that comes with paving will help.

In Eness’ analysis, the hard engineering approaches of the 20th century and the first part of the 21st century created the problem. Then Katrina hit and forced the city to start to look at things differently. “There's so much potential in creating the millions and millions of gallons of storm-holding capacity in order to slow down what hits our gray infrastructure, what needs to be pumped out, and then gets overwhelmed, which results in that street flooding,” Eness continued. Not only will these green infrastructures do this, but they will also slow down the subsidence by providing the ground with the water it needs to recharge and stop the sinking.

Eness argued that while this green infrastructure is sustainable, it's not a silver bullet. “Even if we green infrastructure every inch that we could in New Orleans, because of how we're situated

below sea level, we would still need our pumping system in order to push the water out," she said. But if green infrastructure can manage and control the amount of water that needs to be pushed out, then the pumping systems would work better and last longer.

These green projects in New Orleans create a buffer that will give these pumping stations time to catch up with the excessive amount of water in a severe event. Catching the first hour of rainfall is important because, Eness explained, when it rains beyond the capacity of the pumps, the water backs up, the streets fill, and the water has no place to go until the pumps can catch up. Eness emphasizes that slowing the water down is so important. "I feel like that really explains to people how you need both," said Eness. "Yes, we need this huge system, but clearly it hasn't worked for years." Eness and her team are focusing on what they can do to counteract the water in the beginning to help the pumping systems stay on track. That's why Eness thinks this project has been so interesting in New Orleans—if it keeps working in the future and is sustainable, it could be very helpful for other places, too. "It's a good microcosm example and it also helps people feel like their little yards matter because every drop matters," said Eness.

The Urban Conservancy finished up these projects before the 2021 hurricane season. Using these green projects as a buffer system to the gray infrastructure proved sustainable after Hurricane Ida hit New Orleans that year. Hurricane Ida hit New Orleans as a Category 4 hurricane with a similar intensity to Hurricane Katrina. According to the *New York Times*, the 200 miles of structural barriers that the Army Corps had rebuilt after Katrina did not fail and floodwaters did not spill over. Although residents experienced power outages and other damages during Ida, the HSDRRS worked properly and reduced so much damage. Government officials called Hurricane Ida the most dramatic test of the HSDRRS since it was updated after Katrina, according to the *New York Times*. Governor John Bel Edwards told the *Times,* "If there's a silver lining, and today it's kind of hard to see that, it is that our levee systems really did perform extremely well."

Bibliography:

"Article 23 Landscape & Screening." *Article 23 - Comprehensive Zoning Ordinance - City of New Orleans*, czo.nola.gov/article-23/. Accessed 22 May 2023.

"Background Information." *New Orleans District, U.S. Army Corps of Engineers*, www.mvn.usace.army.mil/Missions/HSDRRS/Risk-Reduction-Plan/. Accessed 22 May 2023.

Bryson Taylor, Derrick, et al. "Hurricane Ida Updates: In Ida's Grip, Louisiana Struggles to Assess the Damage (Published 2021)." *The New York Times*, 23 June 2022, www.nytimes.com/live/2021/08/30/us/hurricane-ida-updates#new-orleans-FEMA-levees.

Campbell, Leah. "How New Orleans Neighborhoods Are Using Nature to Reduce Flooding." *Grist*, 14 June 2022, grist.org/guides/how-to-build-a-flood-resilient-community/how-new-orleans-neighborhoods-are-using-nature-to-reduce-flooding/.

*Emerald Tutu*, emerald-tutu.com/about. Accessed 22 May 2023.

Flavell, Christopher. "A Monster Storm Tests New Orleans." *The New York Times*, 1 Sep. 2021, www.nytimes.com/2021/09/01/climate/hurricane-ida-new-orleans.html.

"Increasing Resilience Through Natural Solutions." *United Nations Climate Change*, July 2020, unfccc.int/news/increasing-resilience-through-natural-solutions?gclid=EAIaIQobChMIjfWAjYDD-wIVuf_jBx2BEA5mEAAYBCAAEgJVj_D_BwE.

Jones, Benji. "No One Knows What 'Nature-Based Solutions' Are." *Vox*, 17 Nov. 2022, www.vox.com/down-to-earth/2022/11/17/23460525/nature-based-solutions-climate-change-cop27

"Katrina Meteorology and Forecasting." *Hurricanes: Science and Society*, 2020, www.hurricanescience.org/history/studies/katrinacase/storm/.

"Levees/Floodwalls/Armoring." *New Orleans District, U.S. Army Corps of Engineers*, www.mvn.usace.army.mil/Missions/HSDRRS/Risk-Reduction-Plan/Levees-Floodwalls-Armoring/. Accessed 22 May 2023.

*Nature-Based Solutions Resource Guide - The White House*, Nov. 2022, www.whitehouse.gov/wp-content/uploads/2022/11/Nature-Based-Solutions-Resource-Guide-2022.pdf.

"Outfall Canals and Interim Closure Structures." *New Orleans District, U.S. Army Corps of Engineers*, www.mvn.usace.army.mil/Missions/HSDRRS/Risk-Reduction-Plan/Outfall-Canals-Closure-Structures/. Accessed 22 May 2023.

"Pump Station Repairs and Storm Proofing Overview." *New Orleans District, U.S. Army Corps of Engineers*, www.mvn.usace.army.mil/Missions/HSDRRS/Risk-Reduction-Plan/Pump-Stations-Repairs-Stormproofing/. Accessed 22 May 2023.

Ross, Janell. "The Art - and Controversy - of Hurricane Katrina 'X-Codes.'" *The Washington Post*, 25 Nov. 2021, www.washingtonpost.com/news/the-fix/wp/2015/08/29/the-hurricane-katrina-x-codes-art-politics-controversy-and-now-reform/.

Schleifstein, Mark, et al. "Rising Seas, Stronger Hurricanes: Climate Report Paints Grim Picture for South Louisiana." *NOLA.Com*, 12 Aug. 2021, www.nola.com/news/environment/rising-seas-stronger-hurricanes-climate-report-paints-grim-picture-for-south-louisiana/article_9b8f89cc-f93d-11eb-bb66-9f4f7033c4bf.html.

Interviews:

Biros, Michael (Director of Restoration Programs for the Coalition to Restore Coastal Louisiana) In-Person Interview: January 9, 2023.

Cira, Gabriel (Emerald Tutu Nature Based Infrastructure Project Lead) In-Person Interview: February 20, 2023.

Eness, Dana (Director of the Urban Conservancy) In-Person Interview: January 9, 2023.